

**Acculturative stress and neighbourhood sociocultural context:
The role of physiological dysregulation and consequences for
psychological distress and well-being**

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A thesis submitted for the degree of PhD in Biosocial Research

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Date of submission for examination: October 2025

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Acknowledgements

I would like to express my gratitude to my supervisors, family and friends who have supported me throughout my PhD journey.

To Dr Nicolas Geeraert, the training and guidance you have given me throughout my time as a PhD student, and before, has been invaluable. Your passion for cross-cultural research and your dedication to supporting students and colleagues, both at Essex and internationally, has been inspirational.

To Professor Alita Nandi, thank you for training me to use and analyse panel data and for sharing your incredible depth of knowledge on the subject.

To Professor Meena Kumari, thank you for your support and encouragement since the beginning of my studentship. Together with Dr Geeraert and Professor Nandi, you have helped to keep my PhD journey on track whenever I met an obstacle or setback.

Thanks to the ESRC-BBSRC Soc-B Centre for Doctoral Training for funding my studentship and for the biosocial training. Across the semesterly workshops, it has been fascinating to see the development of so many incredible PhD projects across Essex, UCL and Manchester.

To Toby, your love and support over the last seven years has filled me with happiness, which has given me the ambition and motivation needed for this PhD journey. You have shown me that everything will be alright when I have you by my side.

To my parents, you have always been, and will forever be, the greatest inspiration for the way I want to live my life. Speaking to you both always brings me joy, and you always know what I will need to keep me going (a shipment of Cornish pasties will do the job).

To the PhD students and staff of the Department of Psychology and ISER, completing most of my PhD remotely has not always been easy, but you have made me feel part of the community. For that I am particularly grateful to Kavya, Priyasha, Anna, Chloe, and Paige.

Finally, my primary physiological data collection would not have been possible without the kindly granted funding from BBSRC and EssexLab or without the assistance of a fantastic team of psychology students: Manishika Pawaia, MJ Bautista, Edita Rockute, Karina Vainauskaite, Rajasvee, Malgorzata Szymanska, Amna Ayub, Rupalee Das, Larice Wilmer, Liya Tasfiya, Saffron Muskett, Sevim Yorulmaz, Tereza Vetrovska, Isabella Domenico Semeghini, and Alisa Kolehmainen.

Abstract

Acculturative stressors are unpleasant events that can occur for individuals who have substantial engagement with multiple cultural groups, particularly in contexts where one group is subject to discrimination and othering. These stressors can occur at many layers of context from national laws to neighbourhood and interpersonal interactions. This thesis focussed on how neighbourhood and interpersonal acculturative stressors and resources relate to physiological dysfunction, psychological distress and well-being. Chapters 2 and 3 assessed ethnic density, which is the proportion of people who share your ethnicity in your local area. Low levels of ethnic density could indicate a higher prevalence of acculturative stressors for racialised minorities, whereas higher levels of ethnic density can provide sources of cultural affirmation, neighbourhood social cohesion and social support. Chapter 2 used data from the Health and Retirement Study, which is a longitudinal study of older adults in the US. Chapter 3 used a sample of adult ethnic minority respondents from the UK Household Longitudinal Study. Across both chapters there was evidence that higher ethnic density longitudinally predicted less psychological distress and better well-being for some groups. In each chapter several potential mediators of those associations were assessed, including social cohesion, social support, allostatic load, and discrimination. All those measures prospectively predicted the psychological outcomes, but there was little support for any of them acting as mediators. Chapter 4 assessed the associations between acculturative stress, physiological dysregulation, and psychological distress using primary data from 1st generation migrants living in England. Vagally-mediated Heart Rate Variability (vmHRV) reactivity was measured to capture physiological responses to stressor tasks. Both acculturative stress and vmHRV reactivity were found to predict concurrent psychological distress.

1. Introduction

Worldwide, approximately 300 million people, or 3.7% of the global population, live outside their country of birth (United Nations, 2025) and approximately 10-20% of the global population live in countries where their ethnic, religious and linguistic group is a minority (Phillips, 1997). In many nations, members of minority groups experience marginalisation and discrimination through current and historic legislation and persisting racist or xenophobic attitudes and behaviours (Grant, 2022). So, it is important to understand how discrimination, migration, and intercultural relations may influence physiological and psychological health. Cross-cultural psychologists have considered how many layers of social context influence psychological distress through both intercultural relations and cultural adaptation, but these effects have rarely been considered in relation to physiological dysfunction (Ryder et al., 2021; Scholasko et al., 2021; Ward & Geeraert, 2016).

Acculturative stress

Acculturation is the process of engaging with multiple cultural groups and adapting to their behaviours, attitudes, and identities (Ward & Geeraert, 2016). Acculturation can be experienced voluntarily, as is often the case for immigrants, or involuntarily, which is more often the case for refugees and native people (Berry et al., 1987). When someone moves to a new country, they will usually acculturate to the dominant culture of the country they settle in, which is their settlement culture. However, it can also be important to maintain and develop the cultural characteristics of the country that they or their ancestors grew up in, which is their heritage culture (Sun et al., 2020; Ward & Geeraert, 2016). Individuals who move to another country are *1st generation migrants* and their children are *2nd generation migrants*. Just as for 1st generation migrants, it can be important for 2nd generation migrants to develop both settlement and heritage acculturation.

Acculturative stressors are negative experiences that can occur for individuals who have substantial interactions with multiple cultural groups. When individuals do not perceive themselves to have the cognitive, social, or physical resources to cope with those stressors, they experience acculturative stress, which may detrimentally impact their psychological or physiological health (Cohen et al., 2016; Sirin et al., 2013). Acculturative stress is typically measured, rather than directly measuring acculturative stressors, because the same situation may be appraised as stressful by some individuals and not others. For instance, most people who have acculturative experiences do not experience considerable acculturative stress (Rudmin, 2009; Ward & Geeraert, 2016). Likewise, immigrants are often found to have less psychological distress than non-immigrant groups (Luthra et al., 2020; Rudmin, 2009).

Most measures of acculturative stress use self-report instruments that capture participants' the negative appraisal of acculturative stressors. Consequently, these measures can have substantial conceptual overlap with measures of both acculturation and of psychological distress (Rudmin, 2009). So, when measuring acculturative stress care needs to be taken to ensure that its measurement does not overlap with the other variables of interest.

Some domains of acculturative stress occur more frequently for individuals with low settlement acculturation. This may include language stress, which can occur when someone is first using a new language or dialect, and cultural isolation, which refers to the stress of living or working in an area where few people share your cultural identities. This can also include intercultural relations stress or bicultural stress, which both refer to the tensions and conflicts that can occur when communicating with people whose levels of acculturation (i.e., their behaviours or attitudes) differ from your own (Meca & Schwartz, 2024; Sun et al., 2020). These domains of acculturative stress may be more common for 1st generation migrants who have recently moved to a new country. However, many of these can also be experienced both by 1st generation migrants who have been experiencing acculturation for many years and by

their descendants who were socialised in the settlement cultural context. These groups may experience acculturative stress because their heritage or settlement acculturation is low or because they engage with people who share their heritage or settlement culture but disapprove of or misunderstand their behaviours and attitudes that are more typical in the other culture. Discrimination can also be considered a type of acculturative stress. There are various forms of discrimination that are relevant to people experiencing acculturation, such as perceived discrimination and negative context of reception. Perceived discrimination refers to individuals' experiences of harassment or unfair treatment during specific social encounters (Meca & Schwartz, 2024). Whereas negative context of reception refers to feeling that your heritage cultural group are not welcome or are less likely to succeed than other people in your settlement country. Some definitions of acculturative stress refer specifically to the experiences of 1st generation migrants and their immediate descendants whose heritage cultures are seen as foreign by the dominant cultural group in their settlement country (Meca & Schwartz, 2024). However, many of the previous examples of acculturative stress could be experienced by anyone who has substantial interactions with multiple cultural groups or who lives in a context where their cultural ingroup experiences marginalisation or discrimination.

Allostatic Load

Under stressful conditions healthy physiological systems maintain optimal functioning through allostasis (Robertson et al., 2015; Sterling & Eyer, 1988). Allostasis occurs by multiple physiological systems stimulating and inhibiting each other to regulate the stress response. Repeated or chronic stressors result in increasing dysregulation in each of these systems. This multi-system physiological dysregulation, called allostatic load, can be initiated by a maladaptive generation of stress hormones (i.e., cortisol and epinephrine) causing physiological harm. These stress hormones are known as primary mediators, along with dehydroepiandrosterone, and pro- and anti-inflammatory cytokines. Allostatic load in

primary mediators can be characterised by prolonged or inadequate physiological responses or lacking adaptation to recurring stressful stimuli. In combination, these primary mediators influence cellular functions that facilitate allostasis. Inappropriate levels of primary mediators require other systems to adjust their functioning to avoid tissue or organ damage. This phase of multi-system physiological dysregulation occurs when levels of metabolic, immune, and cardiovascular biomarkers are at sub-clinical levels, which are known as secondary outcomes. Tertiary outcomes that result from physiological systems experiencing allostatic overload are disease (e.g., diabetes and heart disease) and mortality (Juster et al., 2010; McEwen, 1998, 2006; McEwen & Seeman, 1999). Studies have found that compared to individual biomarkers, multi-system measures of allostatic load are stronger predictors of morbidity and mortality (Guidi et al., 2021; Juster et al., 2010), but findings on the prospective associations between allostatic load and psychological health have been mixed (Guidi et al., 2021; Juster et al., 2011; Lindfors et al., 2006; Read & Grundy, 2014).

Cardiac Vagal Control and Reactivity

In addition to allostatic load, which is typically interpreted as the cumulative impact of stress on physiological dysregulation, physiological measures of acute stress responses can also help to explain variation in psychological distress and well-being. When a stressor is appraised to be a threat the two branches of the Autonomic Nervous System; the Parasympathetic Nervous System and the Sympathetic Nervous System typically react reciprocally (Campbell & Wisco, 2021). The parasympathetic activity withdraws, and the sympathetic activity increases to heighten physiological arousal, which enables individuals to respond quickly and appropriately to stressful situations. The longest cranial nerve in the parasympathetic system is the vagus nerve, which extends from the brain stem to several major organs in the neck, chest and abdomen (H.-R. Berthoud & Neuhuber, 2000). Crucially, one of these organs is the heart. Vagus nerve activity typically plays an inhibitory role on

cardiac activity when mammals are at rest to enable them to conserve energy (Porges, 2023). This mechanism, which may occur through vagus nerves that originate in the ventral vagus nucleus in the brainstem, is known as the *vagal brake*. However, during the inhalation phase of the respiratory cycle this vagal activity is inhibited, which results in an increase in heart rate during inhalation. Heart rate then decreases again during exhalation when ventral vagal control is recovered. This respiratory informed heart rate variation is referred to as *Respiratory Sinus Arrhythmia* (RSA; Quigley et al., 2024) and the vagal nerve's inhibitory influence is referred to as *cardiac vagal control* (Balzarotti et al., 2017). Individuals with greater cardiac vagal control experience larger variations in their heart rate across the respiratory cycle, which can be measured as *vagally-mediated Heart Rate Variability* (vmHRV; Baumeister-Lingens et al., 2023). Greater resting vmHRV, indicates that someone has better physiological regulation and would be more likely to be able to appropriately respond to environmental demands. Accordingly, resting vmHRV has been associated with lower psychological distress (Beauchaine et al., 2019; Koch et al., 2019). Likewise, some studies have found that a greater reduction in vmHRV during a stressful task is also associated with better psychological health (Rottenberg, Clift, et al., 2007; Shinba, 2014). However, that association is less consistent across studies than the link between resting vmHRV and psychological health because the most adaptive physiological response may vary across stimuli (Adolph et al., 2025; Beauchaine et al., 2019).

Weathering Theory

The Weathering Theory posits that opportunities for good health are constrained by one's position within varying, nested, and intersecting social, physical, and economic environments that are based on historical and present structural inequalities, such as racialised identities and economic privilege (Geronimus, 1992; Geronimus et al., 2020). For an adult US sample, Geronimus et al. (2006) found that disparities in allostatic load between

White and Black people persisted after personal affluence was accounted for and this difference increased with age. Poor White people had lower allostatic load (suggesting lower cumulative stress) than poor and rich Black people, and Black women experienced higher and earlier allostatic load increases than Black men and White women (Geronimus et al., 2020). These findings emphasise how one's position in intersecting socioeconomic structures can influence physiological health. Past and present racist and xenophobic policies and procedures have resulted in some racialised ethnic minority groups being more likely to live in more deprived neighbourhoods than the dominant ethnic group in many countries including the US and UK (Bécares, Nazroo, Albor, et al., 2012; Lukes et al., 2019; Rothstein, 2017; Sharkey, 2008). In the US and the UK, the dominant ethnic group are non-Hispanic White and White British respectively. Neighbourhood deprivation can refer to areas that have lower economic opportunities; such as lower wages; or poorer access to resources; such as worse proximity to healthcare providers and schools; or unhealthy environments; such as poor housing quality or air quality; or higher levels of crime (T. Smith et al., 2015a). Worse access to opportunity and resources in more deprived neighbourhoods may lead to their residents experiencing worse psychological health and well-being than residents of more affluent neighbourhoods (Erdem et al., 2015; Knies et al., 2020; Salvatore & Grundy, 2021).

However, Weathering theory also argues that negative effects of marginalisation and economic disadvantage can be mitigated through individuals engaging with others who share their marginalised ingroup identities (Geronimus et al., 2020). This can help individuals to experience a sense of belonging and help to form new support networks as alternatives to the ones that they are being systematically excluded from.

Ethnic Density

The proportion of a neighbourhood who share an individual's ethnic group identity, known as ethnic density, may be particularly important for the health of racialised minorities

and migrants. Ethnic density reflects the proportion of people in an individual's surroundings who may share their cultural heritage or experiences, such as being racialised, marginalised or othered by the dominant cultural group. In neighbourhoods with higher ethnic density, individuals may experience better social support, more cultural affirmation and more opportunities for heritage cultural maintenance (Doucerain, 2018; Geronimus et al., 2020). They may also be less likely to experience several domains of acculturative stress, such as discrimination and cultural isolation. However, previous reviews have found mixed results on the associations between ethnic density and physiological and psychological health (Bécares et al., 2018; Kershaw & Albrecht, 2015). Ethnic minority groups are often more likely to live in more deprived neighbourhoods. Thus, when analysing ethnic density it is important to adjust for neighbourhood deprivation to avoid the negative effects of deprivation from counteracting any positive social effects of ethnic density (Abraído-Lanza et al., 2016; Bécares et al., 2018; Kershaw & Albrecht, 2015). Likewise, the positive effects of lower deprivation and greater access to local resources may appear weaker for ethnic minority groups if ethnic density is not considered. "Healthier" less deprived neighbourhoods may have lower ethnic density and be less likely to have culturally relevant resources, such as religious organizations and cultural goods (Adkins-Jackson et al., 2022; Bécares, Nazroo, Albor, et al., 2012). The strength and direction of the association between ethnic density and psychological health has been found to vary across ethnic groups and national contexts (Bécares et al., 2018). For example, in the UK, studies have found differences across minority ethnic groups and between *generations* (e.g., between 1st generation migrants and respondents born in the UK; Dorsett et al., 2019; Knies et al., 2016). Differences across studies may result from ethnic density being calculated using a variety of different geographic scales and definitions of ethnic group. Differences between ethnic groups and generations, both within and across contexts, may be a consequence of variation in the

severity and duration of the structural racism and acculturative stress that each group has experienced (Bécares et al., 2018; Schofield et al., 2018). Unequal access to financial resources or pre-existing cultural resources may also make the formation and maintenance of neighbourhood social cohesion and social support networks easier for some groups than for others (Knies et al., 2016).

Mediators

Several potential mechanisms have been proposed to explain how ethnic density may influence psychological distress and well-being. For instance, higher ethnic density may encourage stronger neighbourhood social cohesion and better social support, and it may also reduce resident's exposure to discrimination or experiences of cultural isolation (Bécares et al., 2018).

Neighbourhood Social Cohesion

Ethnic density is thought to influence health through individuals being more likely to get along with and be supported by people who share their identities (Kershaw & Albrecht, 2015). Likewise, ethnic density can act as a reverse proxy for the acculturative stressor of being isolated from people with shared cultural experiences. That stressor can then lead some individuals to experience the acculturative stress of cultural isolation.

Neighbourhood social cohesion, hereafter called *social cohesion*, refers to the extent to which individuals feel that they belong in their neighbourhood and feel that the people in their neighbourhood are trustworthy, helpful and friendly. As such, social cohesion could be considered as a reverse proxy for cultural isolation where individuals who feel that they do not belong in their neighbourhood could be experiencing cultural isolation. A systematic review found that measures of neighbourhood social context tended to be positively associated with psychological health (Cramm & Nieboer, 2015; Padeiro et al., 2021). In one study the association between neighbourhood deprivation and psychological distress became

non-significant when social cohesion was included in the analysis (Erdem et al., 2015). Yang et al. (2018) found that social cohesion partially mediated the relationship between neighbourhood ethnic density and self-rated health for Black, but not Hispanic, respondents in Philadelphia. This difference may be due to Hispanic Americans being more likely to be migrants and to have migrated from a wide variety of heritage cultures across which social cohesion may be less likely to develop.

Social Support

Social support has also been proposed as a mechanism through which ethnic density may influence psychological health (Bécares et al., 2018). As ethnic density is a reverse proxy for the acculturative stressor of being isolated from people with shared cultural experiences, low ethnic density may create the conditions whereby people are more likely to experience intercultural relations stress with people who do not share their cultural experience, attitudes, or behaviours. Likewise, high ethnic density would be more likely to create the conditions for supportive and positive intercultural relations. For acculturating individuals, measures of perceived positive and negative social support from family and friends will in part measure their experience of intercultural relations stress. A few studies have found a positive association between ethnic density and social support (Almeida et al., 2009; Tseng et al., 2021). Social support from family and friends has often been found to be associated with better health outcomes (Egan et al., 2008). However, evidence for the role of social support as a mediator between ethnic density and psychological distress has so far been mixed across ethnic groups and between studies (Das-Munshi et al., 2010; Shell et al., 2013; Vogt Yuan, 2007).

Discrimination

Ethnic density may also influence psychological distress and well-being through experiences of discrimination being less likely for people living in neighbourhoods that have

higher ethnic density. Those associations between ethnic density, discrimination and psychological health have been found in both the US and the UK (Bécares et al., 2009; Das-Munshi et al., 2010; English et al., 2014). However, support for the mediating role of discrimination has been mixed across those two contexts and between ethnic groups (Bécares, 2014; Shell et al., 2013). One study in the UK found tentative evidence that the association between discrimination and psychological distress might be stronger in higher ethnic density neighbourhoods (Nandi et al., 2020). If discrimination is also less common in those neighbourhoods, then experiencing it might be more unexpected and consequently have a greater impact on psychological distress.

Physiological Dysfunction

Chronic stress and recent life stress, such as neighbourhood social disorder, have been found to predict lower vmHRV (Kaliush et al., 2021; Mellman et al., 2018), which in turn has been found to be associated with higher levels of inflammatory markers and depression (Koch et al., 2019; Williams et al., 2019). As such, resting vmHRV may be a biological pathway through which stressors influence physiological and psychological health (Berger & Sarnyai, 2014). In contrast, higher social contact has been found to prospectively predict higher resting vmHRV (Gouin et al., 2015), which could indicate that social support may also mediate an association between ethnic density and vmHRV. Allostatic load as a more general symptom of physiological dysregulation could also mediate the relationship between neighbourhood composition and psychological health. A supportive neighbourhood environment could reduce exposure to stressors, which would then result in lower allostatic load and better psychological health. In the opposite direction, neighbourhood deprivation has been found to predict higher allostatic load and it has been proposed that weaker social cohesion may mediate that relationship (Ribeiro et al., 2018, 2019). Another study also found

that allostatic load mediated the relationship between neighbourhood deprivation and perceived physical and psychological health (Prior et al., 2018).

Biopsychosocial Pathways

As indicated in the previous sections, the relationship between ethnic density and psychological health may be mediated by a biopsychosocial pathway including several social and biological factors. The relationships between some of these mediators have previously been tested. For instance, social cohesion has been found to be positively associated with social support (Cho, 2022) and to predict levels of allostatic load (Barber et al., 2016; Carbone, 2020; C. A. Mair et al., 2011; van Deurzen et al., 2016). Likewise, social support has consistently been found to be negatively associated with allostatic load (Larrabee Sonderlund et al., 2019). However, previous studies have not assessed the full biopsychosocial pathway from ethnic density to psychological distress through social cohesion, social support, and physiological dysfunction.

Moderators

Despite those potential biopsychosocial pathways, not everyone who experiences the acculturative stressors related to lower ethnic density has poor psychological health. This may be because for some people pre-existing social networks or physiological responses may buffer the effects of those stressors (Daches et al., 2019).

Vagally-Mediated Heart Rate Variability Reactivity

As previously mentioned, reduced cardiac vagal control in response to stressful situations can increase heart rate and enable appropriate responses to alleviate stressors. Consequently, some studies have found that individuals who experience greater reductions in cardiac vagal control in response to stressor tasks, measured as vmHRV reactivity, have better psychological health (Rottenberg, Clift, et al., 2007; Shinba, 2014). However, the

strength and direction of the association between vmHRV reactivity and psychological health has been found to vary depending on the type of stressor task and participants' level of exposure chronic stress or previous trauma (Adolph et al., 2025; Beauchaine et al., 2019; Daches et al., 2019; Gouin et al., 2014; Stange et al., 2017).

To explain the role of trauma and chronic stress, Boyce and Ellis (2005) proposed that individuals differ in their *biological sensitivity to context*. They argued that people who have greater biological sensitivity (e.g., greater reductions in vmHRV in response to stressors) can experience better psychological health in positive and supportive contexts than people who have lower sensitivity. However, in contexts of trauma or severe chronic stress, people with greater sensitivity may instead experience worse psychological health outcomes than people with lower sensitivity. So, in the context of vmHRV reactivity, a blunted response may be more adaptive when individuals are experiencing severe acculturative stress, but a greater reduction in vmHRV may be more adaptive for people who are experiencing less or no acculturative stress.

In a sample of racialised minority, 1st generation migrant participants, Doucerain et al. (2022) elicited a stress response using a task where participants recounted their experiences of discrimination. They found that higher resting vmHRV and less negative vmHRV reactivity predicted higher settlement acculturation. They argued that the positive consequences of higher resting vmHRV, such as better self-regulation and social functioning (Beauchaine et al., 2013; Laborde et al., 2018; Thayer et al., 2009), are required for making good social connections in a new cultural context and thus help to develop settlement acculturation. Additionally, they found that the negative association between perceived discrimination and settlement acculturation was weaker for participants with less negative vmHRV reactivity. They argued that participants with lower vmHRV reactivity were less emotionally affected by their experiences of discrimination, which would help them to

continue to engage with their settlement cultural context. More adaptive physiological responses to discrimination and other acculturative stressors may also facilitate healthier coping behaviours and better psychological health. A couple of studies have found that the associations between vmHRV and psychological distress were stronger when participants were experiencing more life stress (Gouin et al., 2014; Stange et al., 2017). These findings indicate that adaptive physiological responses may be especially important for people who are experiencing more severe acculturative stressors.

Social Support

As previously described, ethnic density may influence psychological health through the formation of social support networks. However, pre-existing levels of social support may also moderate the associations between acculturative stressors and psychological health. Moderation effects are often found when measures of social support are designed to investigate people's perceptions of whether they would receive quality support from their friends and family if they needed it. However, measures that look at the size of networks or the frequency of social interactions do not tend to find moderation and instead just find a direct effects of social support on psychological health (Cohen & Wills, 1985; Ditzen & Heinrichs, 2014; Rueger et al., 2016; Rui & Guo, 2022). In relation to allostatic load, a pair of studies found social support had a moderation effect. Allostatic load was only predicted by neighbourhood poverty and chronic discrimination for participants who perceived low emotional support from their family and friends (Brody, Lei, Chae, et al., 2014; Brody, Lei, Chen, et al., 2014).

Gaps

The influence of ethnicity and generation on how ethnic density influences physiological and psychological health is under researched (Geronimus et al., 2020). Several studies have examined whether the strength of ethnic density effects on psychological health

and well-being vary across ethnic groups (Bécares et al., 2018; Das-Munshi et al., 2010; Halpern & Nazroo, 2000; Hong et al., 2014; Yang et al., 2018). However, few studies have tested whether either ethnic density effects vary across generations (e.g., between 1st generation migrants and respondents born in the country; Schofield et al., 2018) or whether ethnic density effects interact with both ethnicity and generation (Dorsett et al., 2019; Knies et al., 2016; Y. Yan et al., 2019).

The mechanisms through which ethnic density influence psychological health have been examined in a number of studies but a potential biopsychosocial pathway connecting these mediators has not been tested (Shell et al., 2013; Vogt Yuan, 2007; Yang et al., 2018). Furthermore, each mechanism requires reinvestigation to establish whether effects replicate in other contexts.

Allostatic load has yet to be considered as a mediator between ethnic density and psychological health. However, the observed associations between allostatic load and both social cohesion and social support do indicate that allostatic load may have a role in the pathway from ethnic density to psychological health (Barber et al., 2016; Carbone, 2020; Larrabee Sonderlund et al., 2019; C. A. Mair et al., 2011; van Deurzen et al., 2016). Additionally, allostatic load has previously been found to mediate the association between neighbourhood deprivation and psychological health (Prior et al., 2018).

Previous studies have found that vmHRV reactivity and experiences of stress interact in their prediction of psychological health (Daches et al., 2019; Gouin et al., 2014; Muhtadie et al., 2015; Stange et al., 2017), but none have tested whether the associations between acculturative stress and psychological distress are moderated by vmHRV reactivity. Individual differences in vmHRV reactivity may explain why the biosocial pathways between ethnic density and psychological health may apply for some people but not others.

Thesis Outline

This thesis assesses how neighbourhood sociocultural context and interpersonal acculturative stress influence the psychological distress and well-being of migrants and ethnic minorities in the US and England. Each chapter then examines the possible mediating or moderating roles of interpersonal resources and physiological dysregulation.

Chapters 2 and 3 focus on neighbourhood ethnic density effects, which have previously been found in both US and UK samples, but the mechanisms through which ethnic density predicts psychological health may vary by country, ethnic group, or generation (Abraído-Lanza et al., 2016; Bécares et al., 2018; Kershaw & Albrecht, 2015; Nandi et al., 2020; Shaw et al., 2012). The ethnic groups within each country have different histories of migration and experiences of discriminatory legislature, so differences between the two contexts are anticipated but the size and direction of those differences is not hypothesised (Muttarak, 2011; Rumbaut & Portes, 2001).

Chapter 4 uses a sample of 1st generation migrants in the England to investigate whether physiological regulation moderates the associations between acculturative stress and psychological health.

Chapter 2

Chapter 2 utilises data from the University of Michigan's Health and Retirement Study (HRS), which is a US longitudinal survey of adults over 50-years-old (Health and Retirement Study, 2006, 2008, 2010, 2012, 2014, 2016, 2023; RAND Center for the Study of Aging, 2017, 2021a, 2021b, 2021c, 2023a, 2023b, 2023c). This sample enabled the examination of the ethnic density effect for US born respondents as well as older 1st generation migrants who may have lived in the US for many years. HRS has also been linked to US Decennial Census and American Community Survey statistics, which were summarised into small geographies called *census tracts* (Ailshire et al., 2020). Each census

tract included 1,200–8,000 people, or approximately 400–3,200 households (Lofquist et al., 2012; U.S. Census Bureau, 2012). For Chapter 2, census tracts were considered as the neighbourhood context, and measures of ethnic density and neighbourhood deprivation were derived from the US Decennial Census and American Community Survey.

Chapter 2 uses structural equation modelling (SEM) to test a longitudinal biopsychosocial mediation pathway between ethnic density and psychological well-being, where psychological well-being is measured as life satisfaction. The biopsychosocial pathway comprises of five steps from ethnic density, through social cohesion, social support and allostatic load, to psychological well-being.

For these analyses, six waves of HRS, from 2006–2016, were pooled into three waves each including all the variables of interest. These three pooled waves enabled the partial longitudinal analysis of the hypothesised biopsychosocial pathway. In that analysis the indirect effect from ethnic density to psychological well-being is assessed, as are the direct and indirect effects between each set of three adjacent steps along the hypothesised biopsychosocial pathway. Chapter 2 then analyses a cross-lagged panel model to assess the direct effects between each pair of variables in that pathway.

Chapter 3

Chapter 3 examines the ethnic density effect for ethnic minority adults in England using data from Understanding Society, The UK Household Longitudinal study (UKHLS; University of Essex, Institute for Social and Economic Research, 2024). In England, the dominant ethnic group forms a larger proportion of the population (White British: 79.8% in 2011, 73.5% in 2021; Office for National Statistics, 2011, 2021) than in the US (non-Hispanic White: 63.4% in 2011 and 59.3% in 2021; National Centre for Education Statistics, 2024). Additionally, compared to the UK, ethnic groups tend to be more segregated across neighbourhoods in the US, and comparatively residential segregation is particularly high for

Black people in the US (Bécares, Nazroo, Jackson, et al., 2012; Elbers, 2021; Iceland et al., 2011; C. F. Mair et al., 2010; Peach, 1999). Consequently, in England the distribution of ethnic density is very different for White British people compared to other ethnic groups (Knies et al., 2016). So, Chapter 3 only compares ethnic density effects across the most prevalent ethnic minority groups in England. Like Chapter 2, the ethnic density effects are also compared across 1st generation migrant and UK born groups. In chapter 3, ethnic density is measured using Lower Layer Super Output Areas (LSOA), which each include between 400 and 1,200 households (Office for National Statistics, 2022). As such, the LSOAs used in Chapter 3 have a similar population size to some of the US census tracts included in Chapter 2.

In contrast to Chapter 2 which focuses on interrogating the indirect effects between ethnic density and psychological well-being through the hypothesised biopsychosocial pathway, Chapter 3 focusses on the direct longitudinal effects between ethnic density and psychological distress over two to three-year periods between 2009 and 2019. Chapter 3 then assesses whether those associations change once social cohesion, social support, and discrimination are included as mediators and neighbourhood deprivation, individual characteristics, and a series of acculturative stress related measures are included as potential confounders. Chapter 3 uses moderated multilevel modelling instead of the SEM used in Chapter 2. That enabled survey weights to be included to allow the analyses to be more representative of the population and robust standard errors were implemented to adjust for UKHLS' clustered and stratified survey design.

Chapter 4

Chapter 4 analyses a primary data sample of 1st generation migrants living in England and shifts focus from ethnic density to acculturative stress. Following on from the assessment of physiological dysregulation (allostatic load) in Chapter 2, and of domains of acculturative

stress and psychological distress in Chapter 3, Chapter 4 assesses whether physiological regulation (vmHRV reactivity) interacts with acculturative stress in their prediction of psychological distress. Primary data collection in a biometric laboratory enabled Chapter 4 to assess the role of physiological regulation in response to stressor tasks using vmHRV reactivity.

The findings presented in this thesis have several key implications and contributions to the literature. The longitudinal associations between ethnic density and psychological distress and well-being are assessed across Chapter 2 and 3, whereas those effects have previously only been assessed cross-sectionally when comparing the effects across ethnic groups and generations. In Chapter 2, for the first time, allostatic load is assessed as a mediator on the pathway between ethnic density and psychological well-being. In that chapter ethnic density, social cohesion, social support, allostatic load, and psychological well-being are all assessed at multiple timepoints and earlier values of each measure are adjusted for in the analysis, which effectively controls for any unmeasured confounders that may predict both the predictor and outcome of each of the paths in the structural equation model. In addition to testing the longitudinal associations between ethnic density and psychological distress, Chapter 3 also considered the role of various domains of acculturative stress, which have been largely missing from the literature on ethnic density. Chapter 4 then goes further with the novel assessment of whether vmHRV reactivity and acculturative stress interact in their predictions of psychological distress.

Collectively, the chapters in this thesis contribute to the understanding of how and when acculturative stressors and neighbourhood sociocultural context may influence the physiological and psychological health of individuals with migration histories or minority ethnic identities.

2. Longitudinal Pathways Between Ethnic Density and Well-being Among Older Adults in the US: Assessing a Biopsychosocial Serial Mediation Model

The average life expectancy at birth for Black Americans in 2021 (70.8 years), was approximately 5 ½ years lower than for White Americans (76.4 years). This gap had increased by a year since 2019 and was similar to the gap in 2000 (Arias et al., 2022; Dwyer-Lindgren et al., 2022). Increasingly, researchers and the public are acknowledging that these differences are the result of structural racism (Dwyer-Lindgren et al., 2022). Bailey et al. (2017, *p.* 1453) described structural racism as “the totality of ways in which societies foster racial discrimination through mutually reinforcing systems” such as housing, education and healthcare systems. Structural racism has produced and proliferated inequalities in access to resources, which can have an excessive burden on the physical and psychological health of racialized minorities (Adkins-Jackson et al., 2022; Rothstein, 2017). At the level of the neighbourhood, this can relate to inequalities in access to hospitals, schools, employment and healthy environments (Dimick et al., 2013; Jacobs, 2011; Jbaily et al., 2022). The present study examines how neighbourhood social environments differ across ethnic groups for older adults in the US. The study then assesses on how those differences may influence individual’s social support, physiological functioning and psychological well-being.

Weathering Theory and Allostatic Load

Geronimus (1992) proposed the Weathering Theory to explain the effects that structural racism and other forms of marginalisation have on individuals (Geronimus et al., 2020). In addition to the direct health consequences of inequalities in the physical environment, Geronimus et al. (2020) proposed that racialised minorities could experience an excessive burden of stress resulting from chronic exposure to structural racism. Such chronic experiences of stress can then lead to dysfunctional physiological stress responses and poorer health outcomes.

The physiological dysregulation caused by the accumulation of chronic stress has been labelled *allostatic load* (McEwen, 1998). When operationalising allostatic load, researchers typically employ a panel of several biomarkers that represent a range of physiological systems, such as the neuroendocrine, cardiovascular and metabolic systems. Allostatic load can then be calculated as a summary score of the level of dysregulation across that panel of biomarkers by either averaging their standardised values or counting the number of biomarkers that surpassed a high-risk threshold for each respondent (Beckie, 2012). Measures of allostatic load that include indicators from multiple physiological systems can be better than individual biomarkers at predicting morbidity and mortality (Guidi et al., 2021; Juster et al., 2010). However, thus far findings have been mixed on whether allostatic load prospectively predicts psychological health and well-being (Guidi et al., 2021; Juster et al., 2011; Lindfors et al., 2006; Read & Grundy, 2014).

In a US sample, Geronimus et al. (2006) found that White respondents had lower allostatic load than Black respondents even after controlling for household affluence. In addition, they found that allostatic load increased earlier and faster for Black women than for Black men and White women. This finding highlighted how multiple identities can contribute to the extent of weathering that one experiences.

Ethnic Density

The Weathering Theory also argued that the negative effects of structural racism can sometimes be partially mitigated through social identity safety and cultural affirmation (Geronimus et al., 2020). Local populations with shared minority identities can form alternative support frameworks that provide protection not afforded to them by societal structures. The social benefits of shared identities are also supported by theories of acculturation (Benet-Martínez, 2018) and social psychology (in-group bias: Fischer & Derham, 2016; parochial altruism: J.-K. Choi & Bowles, 2007). In neighbourhoods where a

higher proportion of people share an individual's racialised identity, more neighbours may have had similar experiences of structural racism. This proportion has been referred to as *ethnic density*. Higher ethnic density may indicate that more people in the neighbourhood may benefit from establishing alternative social and economic support networks, which could buffer some of the negative impacts of structural racism. These effects have been observed in positive associations between ethnic density and neighbourhood social cohesion, which is a measure of how much an individual feels that they belong in their neighbourhood and that their neighbours are friendly and helpful (Hong et al., 2014; Yang et al., 2018).

Neighbourhood social cohesion, referred to as *social cohesion* from here on, has previously been found to predict allostatic load (Robinette et al., 2018), life satisfaction (E. S. Kim et al., 2020; Mejía et al., 2017), positive affect (Lee, 2020), and depression (Baranyi et al., 2020; Y. J. Choi & Ailshire, 2024; Shell et al., 2013). E. S. Kim et al. (2020) argued that social cohesion may influence health and well-being through several mechanisms. They suggested that social cohesion can be developed through individuals having greater engagement with other members of their community, such as through participation in community organisations. These community networks can then facilitate the dispersal of health information and encourage adherence to healthy behavioural norms. Additionally, where residents of a neighbourhood perceive better social cohesion, they will be more able to make collective efforts to advocate for neighbourhood improvements. E. S. Kim et al. (2020) also argued that in neighbourhoods with higher social cohesion, individuals could also receive more emotional and instrumental support from their neighbours and be more likely to perceive that their neighbours would be willing to provide support when needed. Others have also attributed some of the positive effects of social cohesion to its effect on social support (E. Y. Choi, 2024; Y. J. Choi & Ailshire, 2024; Yu et al., 2019), but this is rarely empirically tested. However, Stephens and Bakhshandeh Bavarsad (2025) did recently find that perceived

social support mediated the relationship between social cohesion and three measures of well-being.

Current Study

In the current study, longitudinal Structural Equation Modelling (SEM) was used to assess how neighbourhood ethnic density relates to psychological well-being through a proposed biopsychosocial pathway including social cohesion, social support, and allostatic load.

These analyses were conducted using the Health and Retirement Study (HRS), which is a longitudinal panel survey of adults over the age of 50 in the US. The first HRS survey was conducted in 1992, and a new wave of data is collected biennially. For each wave from 2006 to 2016, dry blood spots were collected from alternating halves of the sample (Health and Retirement Study, 2013a, 2013b, 2015a, 2015b, 2017a, 2020; J. K. Kim et al., 2023)¹. To conduct longitudinal analysis that includes biomarker data for both halves of the sample, pairs of waves must be pooled together. The 2006 wave can be pooled with the 2008 wave, as can 2010 be paired with 2012, and 2014 with 2016.

The biomarkers obtained from the dry blood spot samples in combination with anthropometric and blood pressure measurements can be used to produce measures of allostatic load.

In the same waves that respondents completed dry blood spots collections, their half of the sample also completed a Psychosocial and Lifestyle Questionnaire, which included questions on social cohesion, social support and several measures and psychological well-

¹ This study used Early Release data from the Health and Retirement Study, (2014 & 2016 Biomarker Data), sponsored by the National Institute on Aging (grant number NIA U01AG009740) and conducted by the University of Michigan. These data have not been cleaned by the University of Michigan and may contain errors that will be corrected in their Final Public Release version of each dataset.

being (J. Smith et al., 2023). In the present study, psychological well-being was measured using life satisfaction. Life satisfaction allows individuals to weigh up the importance of each part of their life (e.g., health or financial stability) and provide an overall cognitive assessment of how much life is meeting their own standards and expectations (Diener et al., 1985). Life satisfaction has been found to prospectively predict psychological and physical health outcomes, such as depression symptoms, physical functioning, and mortality (E. S. Kim et al., 2021). Life satisfaction has also been identified by the World Health Organisation as a key metric that governments and policy makers should use alongside financial considerations when making policy decisions (E. S. Kim et al., 2021; WHO, 2013).

Without adjusting for other neighbourhood sociodemographic characteristics, the coefficient for ethnic density would not just represent the potentially beneficial factors of social identity safety and social support, but it would also represent the effects of structural inequality in access to resources between ethnic groups. If more people in a neighbourhood have an ethnic identity that a society rewards with greater economic privileges and resources, then that neighbourhood is more likely to have greater access to those resources and improved health outcomes. As such, differential effects of ethnic density between ethnic groups could be a marker of structural racism in that society. To disentangle those two opposing effects of ethnic density, we have adjusted for other neighbourhood sociodemographic characteristics in our analyses. Various inequalities in neighbourhood affluence and deprivation can be observed in the US using data from the US Decennial Census and the American Community Survey (Timberlake, 2007). We have used measures of neighbourhood deprivation that are recorded in US Census and American Community Survey data including: percentage of the neighbourhood that are living below the poverty threshold, percentage who are unemployed, median household income, percentage of female-headed

households, and percentage with specific levels of educational attainment (Ailshire et al., 2020).

Hypotheses

Hypothesis 1. Ethnic density indirectly positively predicts life satisfaction for older adults in the US through a biopsychosocial serial mediation pathway of social cohesion, social support, and allostatic load (see Figure 2.1 for all hypothesis 1 pathways).

Hypothesis 1.a. Ethnic density positively predicts later social cohesion.

Hypothesis 1.b. Social cohesion positively predicts later social support.

Hypothesis 1.c. The positive longitudinal association between ethnic density and social support is mediated by social cohesion

Hypothesis 1.d. Social support negatively predicts later allostatic load.

Hypothesis 1.e. The negative longitudinal association between social cohesion and allostatic load is mediated by social support.

Hypothesis 1.f. Allostatic load negatively predicts later life satisfaction

Hypothesis 1.g. The positively longitudinal association between social support and life satisfaction is mediated by allostatic load.

Hypothesis 1.h. A significant indirect effect will be found between ethnic density and life satisfaction through mediators of social cohesion, social support and allostatic load.

Previous research has found that associations between ethnic density and both social cohesion and life satisfaction can vary by ethnic group and *generation* (Bécares, 2014; Hong et al., 2014; Knies et al., 2016). In this study generation refers to whether respondents were born outside the US (also known as 1st generation migrants) or if they were US born. Alternative SEM models have been run to determine if the model fit statistics substantially improve when the analysis is grouped by ethnic group or by generation.

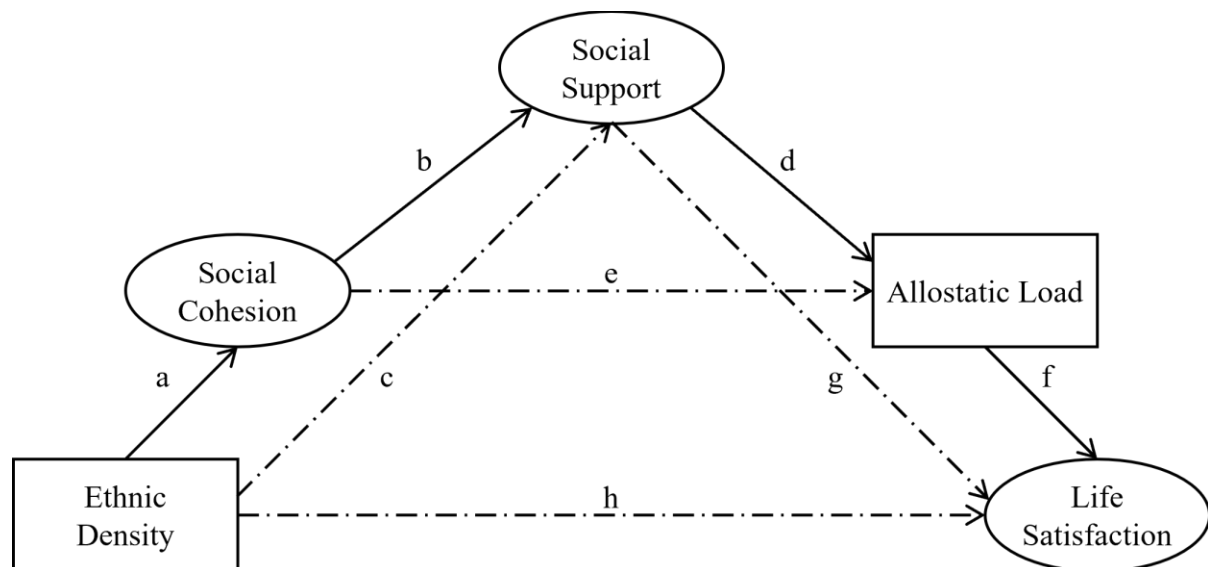
Hypothesis 2. Ethnic group moderates the proposed biopsychosocial serial mediation pathway, so a SEM specified with ethnic group as a grouping variable will have substantially better fit (change in CFI < -0.01) than a model with no grouping variable.

Hypothesis 3. Generation moderates the proposed biopsychosocial serial mediation pathway, so a SEM with a “US born” dummy variable specified as the grouping variable will have substantially better fit (change in CFI < -0.01) than a model with no grouping variable.

We do not have a priori expectations for how those groups will differ from each other, but if Hypotheses 2 or 3 are supported, then Hypothesis 1 will be separately tested for each group of the relevant grouping variable using the partial effect coefficients for that group.

Figure 2.1

A Biopsychosocial Model.



Notes. Letters a-h represent the specific direct (solid arrows) or indirect effects (dashed arrows) hypotheses that form Hypothesis 1. See Hypotheses section for further information.

Structural equation modelling (SEM) was used to test these hypotheses. Ovals represent latent measures that were assessed in the measurement and structural models, whereas rectangles represent measures that were included as individual items in structural models.

Data and Methods

Data and sample

HRS has a total sample of 37,000 respondents who are surveyed every two years on a wide range of topics including: health behaviours; life events; and economic, social, and psychological resources (Sonnegga et al., 2014). In addition, half the sample were requested to complete the Psychosocial and Lifestyle Questionnaire and to provide dried blood spot samples every four years from 2006 to 2014 with the other half sampled every four years from 2008 to 2016 (J. K. Kim et al., 2023; J. Smith et al., 2023).

Since beginning in 1992, HRS's sample has been regularly refreshed with new cohorts of adults in their early 50s. Cohorts are sampled using a stratified and clustered multi-stage area probability design with African American and Hispanic households sampled at twice the rate of White households. Averaged across cohorts from 1992 to 2010, the baseline response rate was 73% and the proportion who responded to each subsequent wave was above 85% (Health and Retirement Study, 2017b; Sonnegga et al., 2014).

University of Michigan Health Sciences/Behavioural Sciences obtained Institutional Review Board approval for the HRS protocols. For the present study, the authors obtained approval from their institutional Ethics Committee to use HRS Restricted census tract level geographic data [ETH2223-0106]. Additionally, HRS granted the authors a Restricted Data Agreement to use the University of Michigan's virtual desktop environment (MiCDA) to access HRS respondent's census tract codes and linked US Decennial Census and American Community Survey² data.

² The Contextual Data Resource (CDR): US Decennial Census and American Community Survey Data, 1990-2018, Version 2.0 as of September 2020, was developed by Jennifer Ailshire, Sarah Mawhirter, and Eun Young Choi at the USC/UCLA Center on

Measures

Predictor

Neighbourhood Ethnic Density. The US Decennial Census and American Community Survey provide summary statistics at various geographic levels. Neighbourhood characteristics can be estimated using small geographic regions called census tracts, which usually include a population of between 1,200 to 8,000 people (U.S. Census Bureau, 2012). In HRS, the census tract level neighbourhood data includes the proportion of the population that are Hispanic, non-Hispanic White, non-Hispanic Black, and non-Hispanic Asian and Pacific Islander (Ailshire et al., 2020). Those variables were then compared to HRS respondent's self-identified ethnicity to create an ethnic density variable that records the proportion of people in their census tract neighbourhood that share their ethnicity in each wave of HRS. HRS only includes a small sample of non-Hispanic Asian and Pacific Islander respondents who completed the survey measures used in this analysis. So, we only included non-Hispanic White, non-Hispanic Black, and Hispanic respondents in our analyses. See the Covariates subsection on Neighbourhood Socioeconomic Characteristics for more information on how the census tract variables were computed for this study.

Mediators

Neighbourhood Social Cohesion. HRS contains four items that we assigned to a latent measure of social cohesion. These measure the trustworthiness, friendliness, and helpfulness of the neighbourhood as well as respondents' sense of belonging in their neighbourhood (Banks et al., 2024). Respondents answered on a seven-point Likert scale where 1 represented the best social cohesion and 7 was the worst. For one item the scale anchors were 1 (*I really feel part of this area*) and 7 (*I feel that I don't belong in this area*). Several studies have used

equivalent measures of neighbourhood attachment and social disorder (Cho, 2022; Mujahid et al., 2007; Prattley et al., 2020; Sampson et al., 1997). For this study, all social cohesion items were reverse coded so that higher values represented better social cohesion.

Social Support from Friends. HRS includes three questions that represent respondents' perceived social support from friends. Items included: 'how much do they really understand the way you feel about things?' Each question was coded from 1 (*a lot*) to 4 (*not at all*). These questions related to friends in general, so respondents may have answered with reference to friends who live inside or outside their local neighbourhood. The items were reverse coded before they were assigned to a social support latent variable where higher values indicate greater social support from friends.

Allostatic Load. This study uses the average value of eight standardised biomarkers that have previously been used to operationalise allostatic load in HRS (Ding et al., 2019; Pak & Kim, 2021; Stephan et al., 2016; Suh et al., 2019). This version of allostatic load includes markers of three physiological systems. Cardiovascular functioning was measured by systolic and diastolic blood pressure; metabolic functioning was measured by glycosylated haemoglobin, high-density lipoprotein cholesterol, total cholesterol, waist circumference and c-reactive protein; and kidney function was measured by cystatin-c. When this selection of items is used some researchers label the measure *cardiometabolic risk* instead of allostatic load (Shartle et al., 2022) because cystatin-C has also be classified as a metabolic marker (Stephan et al., 2016) and no primary mediators of allostatic load are included in the measure (Juster et al., 2010; McCrory et al., 2023).

To compute allostatic load we employed the approach used by Stephan et al. (2016). First, the natural log was calculated for the blood-based biomarkers (high-density lipoprotein cholesterol, total cholesterol, glycosylated haemoglobin, c-reactive protein, and cystatin-c) to reduce skewness. Then z-scores were calculated for all eight items, and the sign of high-

density lipoprotein cholesterol was reversed so that higher values on all items corresponded with worse physiological regulation. The mean of the eight items was then used as our measure of allostatic load. Higher values of allostatic load represent greater physiological dysregulation. A more common method to calculate allostatic load is to count the number of biomarkers for which each respondent is in the most dysregulated quartile of the sample. We have not used that method because the Poisson distribution of the count measure would not be appropriate for an endogenous variable when testing structural models with Full-Information Maximum Likelihood (FIML) estimators in the R package ‘lavaan’ (Posit team, 2024; R Core Team, 2024; Rosseel, 2012). Importantly however, previous studies have found that different techniques for calculating allostatic load often produce equivalent results, so using the standardised measure will not prevent the findings of this study from being compared to other studies using allostatic load measures (Y. Li et al., 2019; McLoughlin et al., 2020).

Outcome

Life Satisfaction. In HRS, subjective psychological well-being is measured using Diener et al.'s (1985) satisfaction with life scale. That scale includes five items measured on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The first item is “In most ways my life is close to ideal”. In 2006, the items were measured on a 6-point Likert scale with the reversed anchors (i.e., 1 = *strongly agree* and 6 = *strongly disagree*). The 2006 items were reverse coded before the items from all waves were standardised to make the scores comparable across waves.

Moderators

Ethnicity. Our hypotheses predict that respondents in higher ethnic density areas will have healthier values across the measures included the biopsychosocial pathway because they are exposed to fewer stressors. However, some minority ethnic groups may be more likely to

experience structural racism and discrimination, so living in an area with higher ethnic density may be more protective for them than for other groups (Bécares, 2014; Hong et al., 2014; Knies et al., 2016; Mitchell et al., 2020). So, we tested the effect of grouping our analyses by ethnicity to distinguish the effects of ethnic density from the effects of having a particular racialised ethnic identity. For Hypothesis 2, respondents were split into three ethnic groups that match the definitions of the ethnic density variable: Hispanic, non-Hispanic Black, and non-Hispanic White. For Hypotheses 1 and 3, ethnicity was measured using two dummy variables: Hispanic (0 = *Not Hispanic*; 1 = *Hispanic*), non-Hispanic Black (0 = *Not non-Hispanic Black*; 1 = *non-Hispanic Black*).

Generation (US Born). Compared to 1st generation migrant respondents, US born respondents may identify more strongly with the ethnic groups recorded in the ethnic density data because they may have had more experience of being racialized through that identity (i.e., being treated by others as a member of a racialized ethnic group). Whereas 1st generation migrant respondents may be more likely to identify with other migrants, or with people who share more of their cultural practices such as people with the same religious beliefs or same country of birth. The people in those groups may be better placed to support respondents' sociocultural adaptation and access to institutional and community resources (Bécares, 2014; Knies et al., 2016; Luthra et al., 2020). As such, ethnic density may have a weaker effect for 1st generation migrants. Being born in the US will be captured by a dummy variable (0 = *1st generation migrant*; 1 = *US born*). For Hypotheses 1 and 2 this dummy variable is included as a control variable, but for Hypothesis 3 it is used as a grouping variable.

Covariates

Year of Birth and Gender. Year of birth and gender were used as covariates in our analysis. A previous study found that both age and gender can significantly predict allostatic

load in the HRS sample (Suh et al., 2019). We represented gender as a dummy variable (0 = *male*; 1 = *female*). HRS uses the SAS date format, which means that year of birth has been centred on 1960. Respondents before that year have a negative year of birth and respondents born after 1960 have a positive year value (Bugliari et al., 2022).

Years in Education. HRS respondents reported how many years they spent in education. This continuous variable was used as a proxy for socioeconomic status and it has previously been found to predict allostatic load in the HRS sample (Ding et al., 2019). We had considered including a measure of equivalised household income as a covariate in our analysis, but that variable was omitted due to having a high percentage of missing data in our sample.

Neighbourhood Socioeconomic Characteristics. The census tract level of the linked US Decennial Census and American Community Survey data includes multiple measures of objective neighbourhood affluence or deprivation. Miles et al. (2016) constructed a 5-item unidimensional time-invariant measure of neighbourhood deprivation using exploratory and confirmatory factor analyses on American Community Survey data. This model included median household income, education level, proportion of the population over 15 years old who were unemployed, proportion of female-headed households with children under 16 years old, and proportion of household with income below the federal poverty threshold. Neighbourhood education level was calculated by adding the proportion of residents who had high-school degrees to double the proportion of the neighbourhood with a college degree (Miles et al., 2016). We included each of these five measures of neighbourhood deprivation as covariates in our model.

If respondents' census tract identifier was missing in any wave, then their most recent previous census tract identifier was used instead. In the final analysis, 14,590 of 29,412 respondents were not missing census tract identifiers in any of the three pooled waves (see

the Analytical Sample section for more information on the pooled waves). However, those identifiers had to be imputed for 14,822 respondents. Of these respondents, 8,831 were missing census tract identifiers from all three pooled waves, 3,004 were only missing them for the third pooled wave, 2,978 were missing them from pooled waves 2 and 3, and 10 were missing other combinations of pooled waves. The imputed census tracts were extracted from waves that were on average 7.31 years earlier ($SD = 3.18$) for pooled wave 1, 9.47 years earlier ($SD = 4.20$) for pooled wave 2, and 11.50 years earlier ($SD = 5.34$) for pooled wave 3.

Analytical Sample

As outlined in the introduction, from 2006 to 2016, HRS split their sample into two halves for the purposes of collecting dry blood spots and the Psychosocial and Lifestyle Questionnaire. One half of the sample completed those measures in 2006, 2010, and 2014 and the other half completed those measures in 2008, 2012, and 2016. To include all those respondents in our longitudinal analyses, we pooled together pairs of waves. The 2006 wave was merged with the 2008 wave, the 2010 wave was merged with the 2012 wave, and the 2014 wave was merged with the 2016 wave. This resulted in our longitudinal analysis consisting of three pooled waves with a gap of four years between the start of each wave (Health and Retirement Study, 2006, 2008, 2010, 2012, 2014, 2016; RAND Center for the Study of Aging, 2017, 2021a, 2021b, 2021c, 2023a, 2023b).

The population estimates and sociodemographic information obtained from the linked American Community Survey data in HRS are only available as five-year running averages with 2005-2009 being the first available period (Ailshire et al., 2020). For each pooled wave, we used the five-year average that was centred on the year between the two surveys (i.e., 2005-2009, 2009-2013, 2013-2017). This results in a one-year overlap in the neighbourhood sociodemographic data between one wave and the next, which will increase the interdependency between each wave if respondents remain in the same neighbourhood from

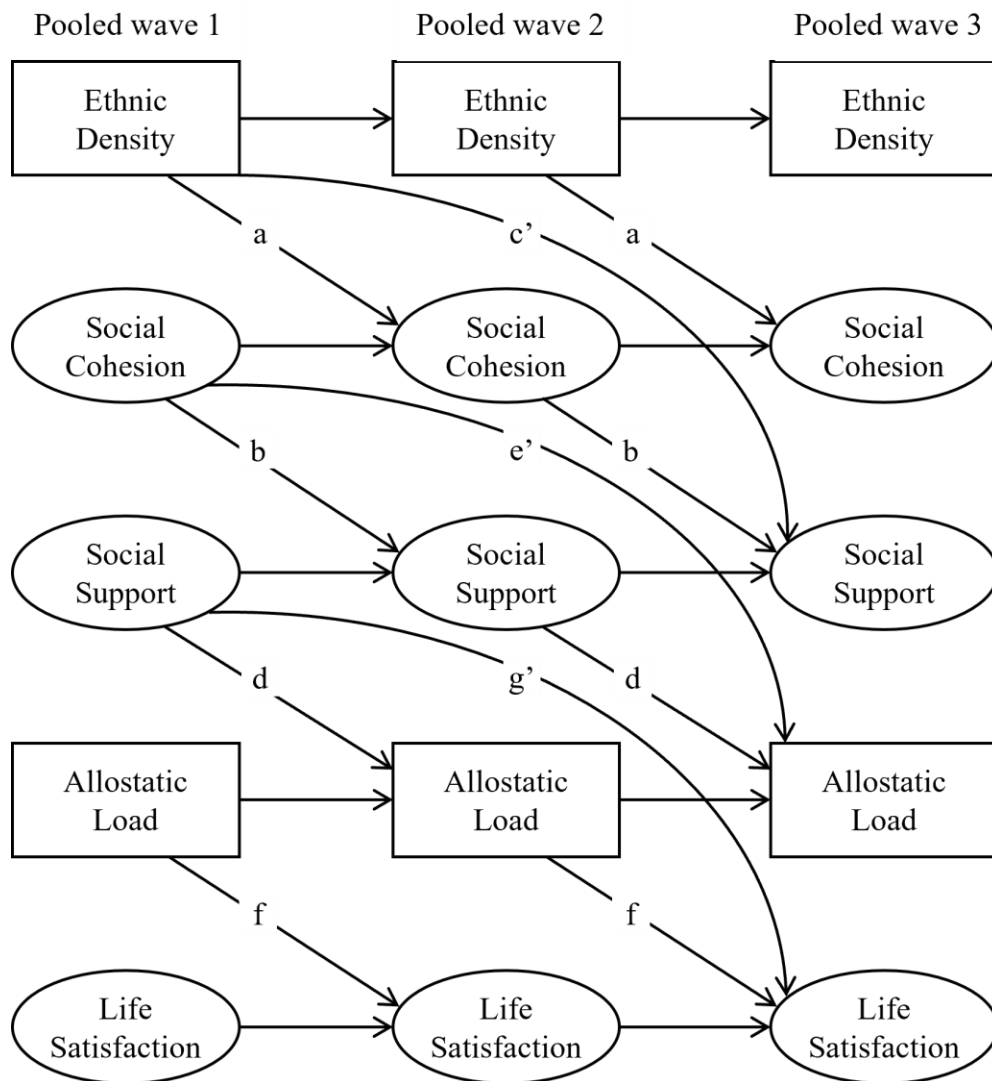
one pooled wave to the next. However, due to the overlap only being one year, the last year of sociodemographic data used in one pooled wave is before the first HRS survey of the next pooled wave begins. This means that all variables are collected in the same order as they appear in the hypothesized longitudinal biopsychosocial serial mediation pathway.

Analytical Strategy

Our analyses focused on a hypothesised biopsychosocial serial mediation pathway between ethnic density and life satisfaction through social cohesion, social support, and allostatic load (See Figure 2.2). All parts of Hypothesis 1 were tested using a single structural equation modelling (SEM) model. This serial mediation pathway was tested on the three pooled waves that were defined in the previous section. A fully longitudinal analysis of the full mediation pathway (Hypothesis 1.h) would require five waves, so our analysis of that hypothesis was only partially longitudinal. In contrast, all of Hypotheses 1.a – 1.g were fully longitudinal. Consequently, only indirect effects could be calculated for the full serial mediation pathway, but direct and indirect effects could be calculated for Hypotheses 1.c, 1.e, and 1.g.

Figure 2.2

SEM of the Hypothesised Biopsychosocial Serial Mediation using Three Pooled Waves.



Note. Ovals represent latent measures that were assessed in the measurement and structural models, whereas rectangles represent measures that were included as individual items in structural models. Only the direct effects between the variables in the biopsychosocial serial mediation pathway are shown in this figure. In the SEM model, all biopsychosocial variables were specified to correlate with each other within each wave. Additionally, the biopsychosocial variables in pooled waves 2 and 3 were specified to be predicted by time-invariant confounders (non-Hispanic Black, Hispanic, US born, female, birth year, years in education) and time variable neighbourhood sociodemographic confounders (income,

education, unemployment, poverty, female-headed households) measured in the previous wave. The paths between variables were constrained to be equal across waves. Ethnic density and allostatic load were each measured using a single item. Social cohesion, social support, and life satisfaction were specified as latent variables with 4, 3, and 5 items respectively.

Hypothesis 1.h indirect effect = $a \times b \times d \times f$. Hypothesis 1.c indirect effect = $a \times b$;

Hypothesis 1.e indirect effect = $b \times d$; Hypothesis 1.g indirect effect = $d \times f$. Hypothesis 2 and 3 were tested using ethnic group and US born as a grouping variables respectively.

We also controlled for the value of each biopsychosocial measure in the previous pooled wave (i.e., auto-regression coefficients). This partially adjusts for any unmeasured confounders that influenced the baseline value of each measure and accounts for any impact that the measures had on each other earlier in each respondent's life. Within each pooled wave, all measures were also allowed to covary with each other, which accounts for any time specific confounders. The inclusion of auto-regression coefficients and within-wave covariation allows the longitudinal paths between constructs to be solely interpreted as the effect of one pooled wave on the next (Cernat, 2024; Preacher, 2015). A set of time-invariant covariates (education, age, gender, subjective socioeconomic status, ethnicity, US born) and time varying measures of neighbourhood deprivation were also controlled for in the estimation of each construct in each pooled wave.

To test Hypotheses 2 and 3, the previously defined model was reanalysed after grouping by ethnicity and generation respectively.

As a sensitivity analysis to assess alternative temporal directions we also assessed a cross-lagged panel model (CLPM) where all biopsychosocial variables were allowed to predict each other in the following wave. All analyses utilized the structural equation

modelling functions of the R package ‘lavaan’ (Posit team, 2024; R Core Team, 2024; Rosseel, 2012).

Results

Descriptive Statistics

Descriptive statistics were examined for all respondents that had neighbourhood data (between 2005 and 2013) and either dry blood spot data or survey data (between 2006 and 2016). Descriptives statistics (see Table 2.1) were examined separately for each ethnic group (non-Hispanic Black, non-Hispanic White, and Hispanic).

In the sample, 75.56% of respondents were non-Hispanic White, 15.03% were non-Hispanic Black, and 9.41% were Hispanic. Approximately 95% of non-Hispanic respondents were US born compared to 45% of Hispanic respondents. Hispanic respondents had the lowest mean years of education ($M = 8.62$, $SD = 4.75$), which was two years fewer than non-Hispanic Black respondents ($N = 10.80$, $SD = 3.68$) and four years fewer than non-Hispanic White respondents ($N = 12.53$, $SD = 2.89$).

Ethnic density (the proportion of people in a neighbourhood census tract who share a respondent’s ethnic group identity) tended to be higher for non-Hispanic White respondents, who on average shared their ethnicity with three quarters of their neighbourhood. In contrast, the average ethnic density for non-Hispanic Black and Hispanic respondents varied between only 53% and 58% across the three waves. Across waves, social cohesion tended to be higher for non-Hispanic White respondents than for non-Hispanic Black or Hispanic respondents. Whereas social support was slightly higher for non-Hispanic Black respondents and lower for non-Hispanic White respondents compared to Hispanic respondents. In each wave, non-Hispanic White respondents had the lowest mean allostatic load with Hispanic respondents’ mean always slightly higher. The mean for non-Hispanic Black respondents was consistently the highest and always at least 0.16 standard deviations higher than the mean for non-

Hispanic White respondents. Life satisfaction tended to be highest for non-Hispanic White respondents and lowest for non-Hispanic Black respondents.

Compared to non-Hispanic Black and Hispanic respondents, non-Hispanic White respondents tended to live in neighbourhoods that had a smaller proportion of female headed households, lower levels of poverty and unemployment, and higher levels of income and education.

Table 2.1

Descriptive Statistics.

variable		Non-Hispanic White	Non-Hispanic Black	Hispanic	Total
/wave	<i>stat.</i>	(<i>N</i> = 22,224)	(<i>N</i> = 4,420)	(<i>N</i> = 2,768)	(<i>N</i> = 29,412)
US born	%	95.39	94.84	44.80	90.55
female	%	55.74	60.52	57.23	56.60
birth year	<i>M (SD)</i>	1932 (13)	1934 (13)	1937 (13)	1933 (13)
education	<i>M (SD)</i>	12.53 (2.89)	10.80 (3.68)	8.62 (4.75)	11.90 (3.46)
ethnic density					
01	<i>M (SD)</i>	76.92 (21.51)	56.17 (32.22)	56.32 (31.65)	71.86 (26.05)
02	<i>M (SD)</i>	74.80 (22.19)	55.15 (31.88)	57.69 (32.01)	70.23 (26.19)
03	<i>M (SD)</i>	73.30 (22.50)	53.92 (31.78)	58.13 (31.69)	68.96 (26.23)
social cohesion					
01	<i>M (SD)</i>	5.60 (1.08)	5.08 (1.29)	5.14 (1.36)	5.49 (1.15)
	<i>N</i>	10,859	1,743	1,231	13,833
02	<i>M (SD)</i>	5.64 (1.11)	4.95 (1.35)	5.13 (1.40)	5.52 (1.19)
	<i>N</i>	8,740	1,332	986	11,058
03	<i>M (SD)</i>	5.59 (1.13)	4.82 (1.43)	4.98 (1.47)	5.44 (1.24)
	<i>N</i>	6,656	1,063	826	8,545
social support					
01	<i>M (SD)</i>	3.05 (0.63)	3.11 (0.62)	2.95 (0.68)	3.05 (0.63)
	<i>N</i>	10,258	1,636	1,090	12,984
02	<i>M (SD)</i>	3.05 (0.64)	3.12 (0.61)	2.96 (0.68)	3.05 (0.64)
	<i>N</i>	8,228	1,239	870	10,337
03	<i>M (SD)</i>	3.04 (0.63)	3.08 (0.61)	2.92 (0.67)	3.03 (0.63)
	<i>N</i>	6,167	948	718	7,833
allostatic load					
01	<i>M (SD)</i>	-0.04 (0.50)	0.14 (0.57)	0.06 (0.51)	0.00 (0.51)

variable		Non-Hispanic White	Non-Hispanic Black	Hispanic	Total
/wave	<i>stat.</i>	(<i>N</i> = 22,224)	(<i>N</i> = 4,420)	(<i>N</i> = 2,768)	(<i>N</i> = 29,412)
	<i>N</i>	10,734	1,888	1,348	13,970
02	<i>M (SD)</i>	-0.03 (0.48)	0.15 (0.53)	0.04 (0.47)	0.00 (0.49)
	<i>N</i>	8,705	1,611	1,162	11,478
03	<i>M (SD)</i>	-0.04 (0.46)	0.12 (0.52)	0.03 (0.48)	-0.01 (0.47)
	<i>N</i>	6,911	1,313	1,028	9,252
life satisfaction					
01	<i>M (SD)</i>	5.05 (1.30)	4.68 (1.33)	4.94 (1.36)	4.99 (1.32)
	<i>N</i>	10,973	1,791	1,268	14,032
02	<i>M (SD)</i>	4.96 (1.34)	4.56 (1.35)	4.86 (1.40)	4.90 (1.36)
	<i>N</i>	8,831	1,350	1,016	11,197
03	<i>M (SD)</i>	5.14 (1.29)	4.74 (1.31)	5.04 (1.39)	5.08 (1.31)
	<i>N</i>	6,715	1,083	857	8,655
neighbourhood sociodemographic					
income					
01	<i>M (SD)</i>	7.10 (3.10)	4.95 (2.45)	5.50 (2.72)	6.62 (3.09)
02	<i>M (SD)</i>	6.73 (3.04)	4.72 (2.44)	5.27 (2.66)	6.29 (3.03)
03	<i>M (SD)</i>	6.94 (3.13)	4.79 (2.45)	5.46 (2.63)	6.48 (3.11)
education					
01	<i>M (SD)</i>	1.13 (0.24)	0.96 (0.23)	0.88 (0.28)	1.08 (0.26)
02	<i>M (SD)</i>	1.16 (0.24)	0.99 (0.23)	0.91 (0.28)	1.11 (0.25)
03	<i>M (SD)</i>	1.19 (0.23)	1.03 (0.22)	0.95 (0.27)	1.14 (0.25)
% unemployed					
01	<i>M (SD)</i>	6.97 (3.81)	12.41 (7.34)	8.94 (4.67)	7.97 (4.99)
02	<i>M (SD)</i>	9.46 (4.92)	15.70 (8.35)	12.34 (5.61)	10.67 (6.07)
03	<i>M (SD)</i>	6.25 (3.72)	11.46 (6.72)	8.37 (4.26)	7.23 (4.74)
% poverty					
01	<i>M (SD)</i>	11.88 (8.92)	24.25 (14.45)	22.48 (14.17)	14.74 (11.66)
02	<i>M (SD)</i>	13.77 (9.84)	26.16 (14.37)	24.20 (13.84)	16.61 (12.14)
03	<i>M (SD)</i>	13.17 (9.28)	25.05 (13.77)	22.58 (12.47)	15.84 (11.43)
% female headed households					
01	<i>M (SD)</i>	6.46 (4.46)	13.60 (8.10)	10.30 (6.22)	7.90 (5.96)
02	<i>M (SD)</i>	6.42 (4.54)	12.80 (7.30)	10.42 (6.30)	7.75 (5.76)
03	<i>M (SD)</i>	5.87 (4.16)	11.60 (7.19)	9.59 (5.59)	7.08 (5.34)

Notes. *stat.* = descriptive statistics. For analyses using year of birth, 01/01/1960 is represented as year 0, but dates are reported in this table. Education was measured as years of education.

Main Analysis

To confirm that the proposed serial mediation analysis model was appropriate it was compared to a series of simpler models that included either fewer variables or fewer model constraints. Those models are presented in Appendix A Model Comparisons. The fit statistics for proposed serial mediation analysis model for testing Hypothesis 1 ($\chi^2(1444) = 17739$; CFI = .940, RMSEA = .034, SRMR = .067, BIC = 1145890) compared favourably to the simpler alternative models and all fit statistics indicated the model had at least marginal fit.

The structural paths of the serial mediation model are presented in Table 2.2. Ethnic density had a strongly positive auto-regressive term. In support of Hypothesis 1.a social cohesion was significantly positively predicted by previous ethnic density, as well as by its auto-regressive term. Social support from friends was significantly positively predicted by social cohesion four years earlier, supporting Hypothesis 1.b, but not by ethnic density eight years earlier. However, in partial support of Hypothesis 1.c, we found a significant indirect effect from ethnic density to social support through social cohesion, but the total effect of ethnic density was not significant.

In predicting later allostatic load, the auto-regressive term of allostatic load was positive and significant, but the total, direct, and indirect effects of social cohesion were not significant. As such, we did not find support for Hypothesis 1.e. Hypothesis 1.d was also not supported because allostatic load was not significantly predicted by social support in the previous wave. However, Hypothesis 1.f was supported as life satisfaction was negatively predicted by allostatic load in the previous wave. Life satisfaction was also significantly positively predicted by life satisfaction in the previous wave and by the direct and total effects of social support two waves earlier. However, the indirect effect from social support to life satisfaction was not significant, which did not support Hypothesis 1.g.

Hypothesis 1.h was also not supported because the indirect effect of ethnic density on life satisfaction through all mediators was not significant.

Neighbourhood Sociodemographic. The structural paths between the covariates and the serial mediation constructs are also presented in Table 2.2. Ethnic Density was significantly negatively predicted by neighbourhood income and the proportion of female-headed household. Greater social cohesion was significantly predicted by higher levels of education, lower unemployment, and a lower proportion of female-headed households in the neighbourhood. However, social support was not predicted by any of the neighbourhood variables. Allostatic load was predicted to be significantly lower for respondents in neighbourhoods that had higher incomes, more education, or a lower proportion of female-headed households. The only neighbourhood variable that predicted life satisfaction was the proportion of female-headed households: respondents that lived in areas of with a higher proportion of female-headed households were more likely to have lower life satisfaction.

Time Invariant Confounders. Neither generation nor gender were significant predictors of ethnic density. In contrast, year of birth positively predicted ethnic density, showing younger people had higher ethnic density in later waves. Interestingly, non-Hispanic Black respondents were more likely to live in lower ethnic density neighbourhoods whereas Hispanic respondents were more likely to live in higher ethnic density neighbourhoods in later waves. Years of education also negatively predicted ethnic density.

Social cohesion was significantly predicted by all demographic controls, except Hispanic ethnicity. Social cohesion was higher for respondents who were older, female, US born, or more educated. Non-Hispanic Black ethnicity negatively predicted social cohesion but positively predicted social support. Female respondents were more likely to report better social support from friends as were younger respondents and those with more years of education. Generation and Hispanic ethnicity were not significant predictors of social

support. Respondents who were non-Hispanic Black, male, or less educated were more likely to have higher allostatic load. Non-Hispanic Black, older, and less educated respondents were more likely to have lower life satisfaction. Whereas Hispanic respondents were more likely to have higher life satisfaction.

Table 2.2
Serial Mediation Analysis.

variable	ethnic density			social cohesion			social support			allostatic load			life satisfaction		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
direct effects															
ethnic density (lag 1)	.940	.002	***	.044	.039	***	—	—	—	—	—	—	—	—	—
ethnic density (lag 2)	—	—	—	—	—	—	.018	.030	—	—	—	—	—	—	—
social cohesion (lag 1)	—	—	—	.422	.012	***	.040	.005	***	—	—	—	—	—	—
social cohesion (lag 2)	—	—	—	—	—	—	—	—	—	-.021	.004	—	—	—	—
social support (lag 1)	—	—	—	—	—	—	.592	.010	***	-.002	.005	—	—	—	—
social support (lag 2)	—	—	—	—	—	—	—	—	—	—	—	.03	.024	**	3
allostatic load (lag 1)	—	—	—	—	—	—	—	—	—	.538	.010	***	-.0	.019	***
life satisfaction (lag 1)	—	—	—	—	—	—	—	—	—	—	—	.56	.009	***	4
indirect effects															
ethnic density (via social cohesion)	—	—	—	—	—	—	.002	.001	***	—	—	—	—	—	—
social cohesion (via social support)	—	—	—	—	—	—	—	—	—	.000	.000	—	—	—	—
social support (via allostatic load)	—	—	—	—	—	—	—	—	—	—	—	.00	.001	—	0
whole serial mediation	—	—	—	—	—	—	—	—	—	—	—	.00	.000	—	0
total effects															
ethnic density (via social cohesion)	—	—	—	—	—	—	.019	.030	—	—	—	—	—	—	—
social cohesion (via social support)	—	—	—	—	—	—	—	—	—	-.022	.004	—	—	—	—
social support (via allostatic load)	—	—	—	—	—	—	—	—	—	—	—	.03	.024	**	4
neighbourhood sociodemographic															
income (lag 1)	-.013	.000	***	.007	.004	—	.015	.002	—	-.031	.001	***	.00	.005	7
education (lag 1)	.002	.003	—	.034	.057	**	.014	.031	—	-.025	.019	*	.01	.059	0

variable	ethnic density			social cohesion			social support			allostatic load			life satisfaction		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
unemployment (lag 1)	-.003	.010		-.021	.225	*	.007	.115		.005	.069		-.0	.221	
poverty rate (lag 1)	.000	.006		-.009	.135		-.010	.071		-.005	.044		.00	.135	
FHH (lag 1)	-.005	.010	*	-.052	.221	***	.016	.112		-.017	.069	*	-.0	.216	*
time invariant confounders															
Non-Hispanic Black	-.011	.001	***	-.075	.034	***	.019	.015	*	.045	.010	***	-.0	.030	**
Hispanic	.012	.002	***	-.015	.040		-.005	.020		.004	.011		.01	.037	*
US born	.001	.001		.035	.038	***	.014	.019		.013	.011		-.0	.036	
female	-.001	.001		.023	.017	***	.110	.009	***	-.046	.006	***	-.0	.017	
birth year	.011	.000	***	-.032	.001	***	.040	.000	***	.001	.000		.01	.001	*
years in education	-.008	.000	***	.063	.003	***	.023	.002	**	-.040	.001	***	.05	.003	***

Notes. lag 1 = predictor was measured one pooled wave before the outcome was measured, lag 2 = predictor was measured two pooled waves before the outcome was measured, FFH = Female-headed household, _ = path not included in SEM. * $p < .05$; ** $p < .01$; *** $p < .001$

Cross-Lagged Panel Model

To examine whether any relationships between the variables in our hypothesised biopsychosocial pathway may have the reverse temporal direction to the direction we modelled in the serial mediation, we ran a cross-lagged panel model (CLPM). In the CLPM each variable in the biopsychosocial pathway was specified to be predicted by all the other time-varying constructs from the previous wave (i.e., lag = 1) and by all the time invariant confounders (see Table 2.3 for structural paths). The CLPM had at least marginal fit across all fit statistics ($\chi^2(1431) = 17507$; CFI = .941, RMSEA = .033, SRMR = .062, BIC = 1145774).

In the CLPM most of the paths that were significant in the serial mediation model remained significant. Ethnic density was predicted by no biopsychosocial variables apart

from itself. Whereas life satisfaction was predicted by all the biopsychosocial variables. Social cohesion and social support were both predicted by all biopsychosocial variables apart from allostatic load and ethnic density respectively. Allostatic load was only significantly predicted by its autoregressive term and life satisfaction.

In the CLPM the same patterns of relationships were found between the biopsychosocial variables and all the neighbourhood variables as were found in the serial mediation model, except that the proportion of female-headed households in the neighbourhood was not predictive of life satisfaction in the CLPM.

Compared to the serial mediation model, the CLPM only showed a few small differences in the relationships between the time invariant confounders and the biopsychosocial variables. In the CLPM, female respondents were not found to be more likely to have higher social cohesion and years of education was no longer a significant predictor of social support. Additionally, female and non-Hispanic Black ethnicity were significant predictors of life satisfaction in the serial mediation model but not in the CLPM.

Table 2.3*Cross-Lagged Panel Model.*

variable	ethnic density			social cohesion			social support			allostatic load			life satisfaction		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
cross-lagged paths															
ethnic density	.940	.002	***	.047	.040	***	.005	.019		.009	.012		.030	.037	***
social cohesion	-.002	.000		.403	.013	***	.035	.005	***	-.001	.003		.053	.010	***
social support	.004	.001		.052	.016	***	.592	.010	***	-.003	.005		.029	.016	***
allostatic load	-.002	.001		-.014	.019		-.015	.010	*	.536	.010	***	-.049	.020	***
life satisfaction	.004	.000		.066	.008	***	.041	.004	***	-.027	.002	***	.558	.010	***
neighbourhood sociodemographics															
income	-.013	.000	***	.005	.004		.013	.002		-.029	.001	**	.009	.005	
education	.002	.003		.029	.057	*	.012	.031		-.025	.019	*	.006	.058	
unemployment	-.003	.010		-.022	.225	*	.007	.115		.004	.069		-.012	.221	
poverty rate	.000	.006		-.010	.135		-.010	.071		-.004	.044		.006	.135	
FFH	-.005	.010	*	-.053	.221	***	.016	.112		-.016	.069		-.011	.216	
time invariant confounders															
Non-Hispanic Black	-.011	.001	***	-.070	.034	***	.022	.016	**	.047	.010	***	-.006	.031	
Hispanic	.012	.002	***	-.014	.040		-.007	.020		.007	.011		.029	.038	***
US born	.001	.001		.038	.038	***	.015	.019		.012	.011		-.012	.036	
female	-.001	.001		.012	.017		.108	.009	***	-.046	.006	***	-.014	.018	*
birth year	.011	.000	***	-.030	.001	**	.043	.000	***	-.001	.000		.022	.001	*
years in education	-.008	.000	***	.054	.003	***	.017	.002		-.037	.001	***	.054	.003	***

Notes. FFH = Female-headed household.

* $p < .05$; ** $p < .01$; *** $p < .001$

Moderation Models

Next, we tested whether the pathways in the serial mediation model were moderated by ethnic group (Hypothesis 2) or generation (Hypothesis 3). We found that the Robust CFI fit of the model without moderation ($\chi^2(1444) = 17739$; CFI = .940, RMSEA = .034, SRMR = .067, BIC = 1145890) was higher than the fit for either of the models that were grouped by ethnic group ($\chi^2(4304) = 38454$; CFI = .916, RMSEA = .040, SRMR = .080, BIC =

1131886), or generation (Model 29) ($\chi^2(2916) = 21632$; CFI = .937, RMSEA = .034, SRMR = .071, BIC = 1145048).

That indicates that neither grouping variable moderated the structural paths, which does not support Hypotheses 2 or 3. Consequently, it is more appropriate to interpret the results of the serial mediation model with no groups, which were reported in the previous sections, than it would be to interpret the results of the moderated models.

Sensitivity Analysis

Due to the complexity of the serial mediation analyses used in this study and software limitations, it was not possible to weight the analysis to account for the differential probability of being selected into the sample or remaining in the sample for each subsequent wave. This will mean that the sample is likely to be less representative of the population of older adults in the US than if design and attrition weights had been used. In Appendix A Model Comparisons we compared the descriptive statistics of the sample with and without survey weights applied. None of the variables included in our proposed biopsychosocial pathway varied substantially between the unweighted and weighted samples. However, the samples did differ across some sociodemographic measures, which may have acted as confounders of some relationships in the biopsychosocial pathway.

The inclusion of census tract neighbourhood sociodemographic variables in our models reduced the sample size from 39,827 to 29,412 respondents. This substantial difference in sample size could have impacted both the power of the analysis and the demographic composition of the sample. In the Appendix A we have assessed the impact of restricting the sample and controlling for the neighbourhood sociodemographic variables (for descriptive statistics of the unrestricted sample see Table A.4 and Table A.5; for analysis results see Table A.6 and Table A.7). We found that there were very few substantive

differences between the results of the models assessed in Appendix A and the results of our main serial mediation analysis presented in Table 2.2.

Discussion

Summary

The present study used structural equation models to assess a longitudinal biopsychosocial pathway between ethnic density and life satisfaction, through social cohesion, social support, and allostatic load, for older adults living in the US.

We also tested the indirect and total effects between each set of three adjacent variables in that biopsychosocial pathway. We found a significant indirect effect of ethnic density predicting social support through social cohesion (Hypothesis 1.c). Higher ethnic density significantly predicted greater social cohesion (Hypothesis 1.a), which in turn significantly predicted social support (Hypothesis 1.b). However, social support did not predict later allostatic load, which did not support Hypothesis 1.d. That non-significant pathway also resulted in both the indirect effect between social cohesion and allostatic load through social support and the indirect effect between social support and life satisfaction through allostatic load not being significant. Those results did not support Hypothesis 1.e and 1.g respectively. In support of Hypothesis 1.f, allostatic load negatively predicted life satisfaction.

As allostatic load was not predicted by social cohesion measured eight years before or by social cohesion measured four years before, the overall indirect effect from ethnic density to life satisfaction through the serial biopsychosocial pathway (Hypothesis 1.h) was not significant. These results opposed the findings of previous studies. For example, Brooks et al. (2014) found that support from friends predicted lower allostatic load in older adults, and Robinette et al. (2018) found that social cohesion measured in the 2006/2008 pooled wave of

HRS negatively predicted cardiometabolic risk in 2010/2012. However, in agreement with our findings, Andrews et al. (2024) detected no association between social cohesion measured in the 2012 wave of HRS and allostatic load measured in 2016. The physiological measures used in Robinette et al. (2018) and Andrews et al. (2024), each shared the same six items with our measure of allostatic load. So, the items that differed between our measures may have been responsible for the differences between our findings. The two items in our measure of allostatic load that were in neither of the other two studies were cystatin-c and waist circumference. Both of the other two studies included body mass index and Andrews et al. (2024) included the ratio between total to high-density lipoprotein cholesterol and Robinette et al. (2018) included pulse and smoking status.

The significant longitudinal relationships between ethnic density and social cohesion reaffirm the findings of Bécares (2014) and Hong et al. (2014) who found links between ethnic density and social cohesion for some ethnic groups. An indirect effect from ethnic density to social support through social cohesion was significant, but the direct and total effects between ethnic density and social support were not significant. This finding partially conflicts with Das-Munshi et al. (2010) who found that for some ethnic minority groups in the UK, ethnic density positively predicted the practical support they received from their closest contact. In the present study, the lack of direct effects between ethnic density and social support may be a consequence of the social support questions referring to friends in general and not specifically referring to friends who live in the respondent's local area. It is plausible that ethnic density may influence perceived social support from friends in respondents' local areas, but it is very unlikely that ethnic density would have the same influence on perceived social support for friends who live outside those areas.

Many researchers have previously proposed that social support is one of the key pathways through which social cohesion relates to health and well-being (E. Y. Choi, 2024;

Y. J. Choi & Ailshire, 2024; E. S. Kim et al., 2020; Yu et al., 2019), but few have previously tested the longitudinal association between social cohesion and social support from friends, which we found to be significant. We also found that social support from friends positively predicted life satisfaction measured eight years later, which is consistent with the results from previous studies (Chen & Feeley, 2014; Siedlecki et al., 2014; B. Yan et al., 2016).

Our finding that life satisfaction was predicted by allostatic load four years earlier, has the reverse direction to the relationship between life satisfaction and allostatic load that has been found in several previous studies (An et al., 2023; Boehm et al., 2016; Boylan & Ryff, 2015; Rouch et al., 2014). We used a cross-lagged panel model (CLPM) to test that reverse temporal direction, as well as the reverse temporal direction of all the relationships across the full serial mediation pathway. In the CLPM, all the variables in the serial mediation pathway were specified to predict all other variables in the next pooled wave (i.e., four years later). This analysis also enabled us to assess whether the relationships that were not detected with eight-year time lags may be observed when the time lag was only four years.

All the non-significant eight-year lagged relationships in the serial mediation model were also non-significant in the CLPM. However, in the CLPM, ethnic density did predict life satisfaction four years later, whereas in the serial mediation model, the indirect effect of ethnic density on life satisfaction was not significant. This lack of an indirect effect was primarily due to missing direct effects along the proposed mediation pathway, but it could also be because ethnic density may be only associated with life satisfaction over a shorter timescale. This possibility was supported by D. Li et al. (2021) who found that in a UK sample, where most respondents were White, the negative relationship between ethnic diversity and subjective well-being reduced over time.

The results for the paths in the serial mediation model that had four-year lags were replicated in the CLPM. However, several paths that were only included in the CLPM were

also significant. Life satisfaction was predicted by all the other biopsychosocial variables. Social cohesion was predicted by all those variables except allostatic load. Social support was additionally predicted by allostatic load and life satisfaction. In the CLPM the longitudinal associations between allostatic load and life satisfaction were found in both directions, which extends the finding of previous studies that only assessed the relationship in one direction (An et al., 2023; Boehm et al., 2016; Boylan & Ryff, 2015; Rouch et al., 2014).

We also proposed that the pathways included in Hypothesis 1 would be moderated by ethnic group (Hypothesis 2) and by generation (Hypothesis 3), These moderators were tested by comparing the fit statistics of serial mediation structural equation models with and without grouping variables. The models with grouping variables did not have substantially better model fit than models with no grouping variables. As such, these results did not support Hypothesis 2 or 3. This is inconsistent with several previous studies that have found differences between ethnic groups and generations in the associations between ethnic density and social cohesion (Bécares, 2014; Hong et al., 2014) or life satisfaction (Knies et al., 2016). However, those studies did not test whether the fit of their structural models were significantly worse without the grouping variables, and where SEM was not used, they did not test whether the individual effect estimates for each group were significantly different from each other. However, Yang et al. (2018) did find that their separate estimates for non-Hispanic Black and Hispanic respondents were not significantly different from each other in their analysis of the associations between ethnic density, self-rated health, and social capital, where social capital was operationalised using similar items to the measure of social cohesion that we used in this study.

Strengths and Limitations

This study analysed a novel longitudinal biopsychosocial pathway that tested how neighbourhood conditions predict future perceptions of social support, allostatic load and life

satisfaction. We tested both between group and longitudinal invariance of latent variables in confirmatory factor analyses and of structural paths in SEM.

Testing the predictive function of four- and eight- years lags between timepoints provided evidence for long-term associations between some of these variables. However, these large lags will have missed any associations that occur at shorter time-lags, such as D. Li et al.'s (2021) finding that neighbourhood ethnic diversity had a weaker association with life satisfaction for each year that passed since a change in ethnic diversity.

The main serial mediation analysis conducted for this study used a sample of over 28,000 respondents and the models that were grouped by ethnicity had at least 2,500 respondents in each group. Despite the impressive size of the overall sample, the current analyses had some issues with missing values and statistical power. For instance, due to missing data, only 777 Hispanic respondents had social cohesion variables and only 673 Hispanic respondents had social support variables in the third pooled wave. Using full information maximum likelihood estimation and robust standard errors enabled us to include all those respondents in the overall model, but the power of estimates using those variables would have been substantially lower. This may have limited the potential of this study to detect real differences between the ethnic groups.

In this study the definitions of ethnic groups (non-Hispanic White, non-Hispanic Black, and Hispanic) were determined by the census tract population data that was available from the US Decennial Census and the American Community Surveys. Previous research has found that the predictive utility of ethnic density measures can be influenced by how they are defined. For instance, Bécaries (2014) found that ethnic density positively predicted social cohesion for Puerto Rican respondents when ethnic density was measured to include all Latino residents, or all Latin American immigrant residents, but not when ethnic density only referred to Puerto Rican residents. In the present study, the operationalisation of ethnic group

may have impacted both the estimates for the relationships between ethnic density and the other biopsychosocial variables as well as the lack of evidence for the moderating role of ethnic group on the serial mediation pathways. As such, future research is required to establish whether these estimates differ when other classifications of ethnic groups are used.

Several previous studies have found that gender and age moderate some of the associations tested in this study. A couple of studies have reported that the associations between social relationships (including social cohesion and social support) and allostatic load were weaker in the oldest respondents among older adults (Seeman et al., 2004; Shartle et al., 2022), but the direction of gender differences in the association between emotional support and allostatic load has been inconsistent between studies (Seeman et al., 2002, 2004). In a sample of older adults living in France, Rouch et al. (2014) found that life satisfaction prospectively predicted metabolic syndrome measured seven years later for women but not for men. However, none of these studies indicated that the direction of the effects differed across ages or between genders, so not specifying these interactions in our model should have only impacted on the size of observed effects and not their direction.

The SEM analyses used in this study did not separate within- and between-respondent variation, which means that we cannot determine how much of each estimate reflects the influence of changes that occur within an individual between survey waves and how much of each estimate is a result of differences between individuals (Mulder & Hamaker, 2021). Future studies should use Random Intercepts Cross-Lagged Panel models or related techniques to separate these estimates into within- and between-subject variation.

Conclusion

This study tested a novel biopsychosocial pathway using longitudinal serial mediation SEM over a period spanning 2006–2016 for a sample of older adults in the US. We did not find support for the indirect effect of ethnic density on life satisfaction through our proposed

biopsychosocial pathway. However, we did find that ethnic density directly predicted social cohesion measured 4-years later and indirectly predicted social support measured 8-years later. Life satisfaction was found to be predicted by allostatic load measured 4-years earlier and social support measured eight years earlier. We also found that the relationships in the model did not substantially vary between ethnic groups (non-Hispanic White, non-Hispanic Black, and Hispanic) or by generation (1st generation migrant and US born).

3. Differences in Longitudinal Associations Between Ethnic Density and Psychological Distress Across Migrant Generations and Ethnic Minority Groups in England

Previous studies in the UK have found that psychological distress varies across ethnic groups and across generations (e.g., between UK born and foreign-born respondents; Dorsett et al., 2019). Existing research has also shown that migration history, racialised identities, and intercultural environments are connected to individuals' experiences of psychological distress (Bécares et al., 2018; Jeffery et al., 2024; Nandi et al., 2020). Some of those studies found that individuals who shared their ethnic identity with a higher proportion of the people in their local area, known as *ethnic density*, experience better health outcomes — the *ethnic density effect* (Bécares et al., 2018; Halpern & Nazroo, 2000). This could be explained by higher ethnic density neighbourhoods providing more opportunity for cultural affirmation and belonging as well as fewer experiences of discrimination for migrants and racialised ethnic minorities (Bécares, 2014; Geronimus et al., 2020). Studies have also explored whether neighbourhood social cohesion and social support mediate the relationship between ethnic density and psychological distress (Bécares et al., 2018; Halpern & Nazroo, 2000). Acculturative stressors, which are potentially stressful experiences that can occur when engaging with multiple cultural groups (Miller, Kim, et al., 2011), may also influence psychological distress. Higher ethnic density may be indicative of places where many acculturative stressors are less likely to occur, which could explain associations between ethnic density and psychological distress. However, previous studies that have investigated ethnic density effects have not interrogated the influence of acculturative stress.

No consensus on the ethnic density effect has been found across studies to date, which may reflect differences in the measures, sample designs and analysis techniques that have been used across studies. Many of the studies were based on cross-sectional surveys, which

makes it difficult to begin to establish any temporal relationships between ethnic density and psychological distress. Additionally, as far as we are aware, only one previous study has simultaneously examined whether ethnic density effects differed both across ethnic groups and between generations in the UK context (Y. Yan et al., 2019). However, their analysis was cross-sectional.

In the present study we tested the ethnic density effect using survey data from Understanding Society, the UK Household Longitudinal Study (UKHLS), and census data from the decennial Census for England and Wales. We examined whether ethnic density or changes in ethnic density over time predict later psychological distress for six ethnic minority groups in England. Specifically, we tested whether those relationships vary across ethnic group or between respondents born in or outside the UK. We then examined whether those associations were robust to the inclusion of potential confounders including measures of acculturative stressors and stress as well as mediators including neighbourhood social cohesion, social support, and discrimination.

Historical Context

The social, political and economic conditions that push, or pull, an individual to move to a new country may have enduring impact on their health and the health of their offspring. So, here we briefly summarise the history of migration to the UK.

There have been centuries of migration to the UK, through trade, empire, enslavement, and industrialisation. But, for each of the largest ethnic minority groups in the UK today, the most prominent phases of migration occurred in the 20th Century after the Second World War and after former British colonies secured independence (Shankley et al., 2020). This study focusses on six of these ethnic groups: Indian, Pakistani, Bangladeshi,

Black Caribbean, Black African, and White Other³. Each has a different history of phases of migration to, and reception within, the UK. However, every individual has their own unique experiences of migration, which can vary substantial from these broad trends.

At a time of labour shortages in the UK, the British Nationality Act (1948) classified everyone born in a dominion of the empire as “Citizen of the United Kingdom and Colonies” to encourage migration to the UK (Small & Solomos, 2006). However, later acts increasingly restricted citizenship rights for these citizens. For example, the Commonwealth Immigrants Act (1962) introduced quotas to restrict the migration of people from former British colonies to the UK (Shankley & Byrne, 2020). Then the Immigration Act (1971) and the British Nationality Act (1981) restricted the right of these citizens to live in the UK to only those whose parents or grandparents had been born or registered in the United Kingdom, which revoked the rights of most ethnic minority Citizens of the United Kingdom and Colonies (Hatton & Wheatley Price, 1999; Shankley & Byrne, 2020; Tyler, 2010). The implementation of the 1971 Act coincided with the UK joining the European Communities, so as immigration rights were being granted to citizens of those countries, they were being taken away from many Citizens of the United Kingdom and Colonies (Hatton & Wheatley Price, 1999).

There were two key phases of migration of Indian people to the UK in the second half of the 20th century (Stopforth et al., 2021). The first phase was in the 1950s and 60s, following partition and independence in 1947. Then in a second phase Indian people moved to the UK from several East African countries, predominantly Kenya and Uganda. That phase occurred in the late 1960s and 1970s when those countries became independent from the UK and were hostile towards Asian residents whose families or ancestors had predominantly moved to East Africa during British colonial rule (Cosemans, 2022). As of 2011, there were

³ These groups are labelled and categorised based on the 2011 Census of England and Wales. Except White Other, these groups were over-sampled in the Understanding Society Ethnic Minority Boost Sample (see Methods section for further details).

1,413,000 people living in England and Wales who identified as Indian. 807,000 were 1st generation migrants, of whom 38% had moved to the UK prior to 1981 and 42% had arrived in the UK since 2001 (see Table 3.1).

The first major phase of migration of Pakistani people to the UK also occurred at the start of the 1960s with many gaining employment in textile factories (Stopforth et al., 2021). However, when the textile mill production declined, competition for the remaining jobs increased. This created resentment among white British workers towards migrant workers. In the 1970s and '80s, a second phase of migration occurred when those Pakistani workers were joined by their families. In 2011, 56% percent of the 1,124,000 Pakistani people living in England and Wales were born in the UK. Of Pakistani 1st generation migrants, 60% had moved to the UK before 2001 and 40% had moved to the UK between 2001 and 2011 (see Table 3.1).

After a smaller 18th century phase of Bangladeshi people migrating to the UK to work in ports as seamen, the next phase of economic migration from Bangladesh reached its peak after Bangladesh became independent from Pakistan in 1971. Many migrants of that period were then joined by their families in later decades (Stopforth et al., 2021). Of the 447,000 Bangladeshi people living in England and Wales in 2011, 48% were 1st generation migrants. Only 19% of the Bangladeshi 1st generation migrants had moved to the UK before 1981, 47% moved between 1981 and 2000, and 35% had moved since 2001 (see Table 3.1).

One phase of Black Caribbean migrants arrived in the UK during World War II to volunteer in the armed forces or work in industry (Stopforth et al., 2021). Labour shortages in the UK following the war led to the largest phase of migration of Black Caribbean people to the UK. Of the 1st generation Black Caribbean migrants living in the UK in 2011, 61% had moved to the UK by 1981 (see Table 3.1). Many Black Caribbean people faced substantial discrimination and harassment in the UK (Shankley & Rhodes, 2020; Small & Solomos,

2006) and The Windrush scandal was painful for many. The Windrush scandal followed the UK government's introduction of the "hostile environment" policy from 2012 (Taylor, 2018) and the Immigration Act (2014). The Home Office had previously destroyed thousands of migration records, which meant that many Black Caribbean people who had arrived in the UK as children following World War II, had no evidence of their legal right to live in the UK (JCWI, 2024). This led to hundreds of 1st generation Black Caribbean people being incorrectly identified as undocumented, losing access to public and services, being detained, or being deported from the UK. A study found that following both the introduction of the Immigration Act (2014) and following the 2017 media coverage of the scandal, 1st generation Black Caribbean respondents reported increased psychological distress compared to White respondents (Jeffery et al., 2024).

There have been several phases of Black African people migrating to the UK from different African countries. In the late 19th Century seamen migrated to UK ports from Nigeria and Somali (Stopforth et al., 2021). From the 1970s many Black African people arrived in the UK to seek asylum from countries including Angola, Congo, Eritrea, Ethiopia, Nigeria, Somalia, Uganda, and Zimbabwe. Later asylum seekers faced more hostile laws that led to many becoming homeless or financially insecure. Since the 18th Century, and increasingly so after World War II and in the 21st Century, education has also been one of the most prominent reason why Black African people to move to the UK (Daley, 1998; Nunn & Price, 2005). In 2011 there were 323,000 UK born and 666,000 1st generation Black African people living in the UK with 60% of the 1st generation migrants having moved to the UK since 2001 (see Table 3.1).

"White Other" refers to people who identified as White in the 2011 Census of England and Wales but did not identify with any UK nationality, Irish, or Gypsy or Irish Traveller identities (GOV.UK, 2024). People who identified with the White Other ethnic

group have very heterogeneous cultural backgrounds. In the 2011 Census, there were 24 countries that were the birthplace of at least 1% of White Other 1st generation migrants in England and Wales (Office for National Statistics, 2014)⁴. As of 2011, 71% of 1st generation migrant who identified as White Other had moved to the UK since 2001 (see Table 3.1). This phase of migration was predominately from central and eastern European countries that joined the European Union in either 2004, such as Poland and Lithuania, or 2007, such as Romania (Office for National Statistics, 2015).

Table 3.1

England and Wales Population of Six Ethnic Groups in 2011 by Migration Generation and Year of Arrival.

Ethnic Group	Generation ('000 people)		Year of arrival (% of 1 st generation)		
	UK born	1st Generation	Pre-1981	1981–2000	2001–2011
Indian	606	807	38	20	42
Pakistani	631	493	28	32	40
Bangladeshi	232	215	19	47	35
Black Caribbean	358	237	61	20	19
Black African	323	666	5	35	60
White Other	360	2126	10	19	71

Note. Table is adapted from Table 1 and Figure 1 in Office for National Statistics, (2015) and (Office for National Statistics, 2014).

Structural Racism

Structural racism refers to the many ways in which current and historic societal prejudices and governance at the national, local and institutional levels have produced inequalities in access to resources and wealth between different ethnic groups (Bailey et al.,

⁴ The number of countries that were the birthplace of at least 1% of the 1st generation migrants who identified with each of the other ethnic groups in this section were: Black African = 18, Black Caribbean = 12, Indian = 5, Pakistani = 2, Bangladeshi = 2 (Office for National Statistics, 2014).

2017; Brown, 2018). Inequalities in labour market participation and income are evident across ethnic groups in England and Wales. In 2017–19, Indian, Pakistani, Bangladeshi, and Black African working age adults had significantly lower employment rate than White British adults after controlling for several other sociodemographic characteristics (e.g., age, qualifications, and marriage status; Mirza & Warwick, 2024). For each ethnic group those differences were significant for both men and women and for both UK born and 1st generation migrants. For both Black Caribbean and White Other working age adults, sociodemographic characteristics mostly explained their differences in employment compared to White British working age adults. A comparison of mean equivalised household labour market earnings across ethnic groups in the UK in 2015–19, found that Indian, White British, and White Other adults had relatively higher earnings than Black African and Black Caribbean adults. Then Pakistani and Bangladeshi adults had the lowest mean household earnings at approximately 50% of the household earnings of White British adults (Mirza & Warwick, 2024).

Inequalities have also been observed in housing quality. Analysis of the 2011 Census and English Housing Survey found lower housing disadvantage among UK born White British people (9%) than for any other ethnic groups across generations (housing disadvantage was measured as overcrowding, no central heating, or shared bathroom or kitchen; Lukes et al., 2019). For each ethnic group, 1st generation migrants who had moved to the UK before 1991 had the least housing disadvantage followed by those who were UK born. In contrast, migrants who had moved to the UK since 2007 had the worst housing disadvantage for all ethnic groups. Across migration dates, housing disadvantage was particularly high for Bangladeshi (pre-1991: 35%; 2007–11: 54%) and Black African (pre-1991: 34%; 2007–11: 46%) people. A greater disparity across migration dates was found for both Indian (pre-1991: 12%; 2007–11: 46%) and Black Caribbean (pre-1991: 14%; 2007–11:

36%) people. That may be because for Indian and Black Caribbean 1st generation migrants, some of the main phases of migration were in 1950s and 60s, substantially before 1991. This may indicate that, despite various local authority policies and private rental practices marginalising 1st generation migrants since the Second World War, migrants who moved to the UK earlier have over time benefited from better housing conditions compared to more recent migrant groups (Lukes et al., 2019).

Weathering

The Weathering Theory argues that through experiencing structural racism and other forms of discrimination, racialised and marginalised minorities can experience earlier and more severe health deterioration as they age (Geronimus, 1992, 2023). A study that used 1999 and 2004 Health Survey for England data found that Black Caribbean, Indian, Pakistani, and Bangladeshi people were all more likely to report fair or poor general health than the White reference group (in that study White Other people were included in the White reference group and Black African people were not included in the analysis; Smith et al., 2009). In that study, those differences were significant for both 1st generation and 2nd generation respondents (i.e., people who migrated to the UK and their children).

Disparities in psychological distress have been consistently found across levels of area deprivation in Great Britain over the last 30 years (Zhang et al., 2023). Area deprivation generally refers to the extent to which the people living in an area have inadequate access to economic and healthcare resources or to safe and healthy environments. The UK Government have previously published several editions of their indices of multiple deprivation (IMD), which ranked areas in England based on measures of seven domains: income; employment; education, skills and training; health and disability; crime; barriers to housing and services; and living environment (T. Smith et al., 2015a). A study that linked the 2004 edition of that IMD to the 2007 Citizenship Survey of England and Wales found that approximately 70% of

Bangladeshi respondents and 60% of Pakistani, Black Caribbean, and Black African respondents lived in the 40% most deprived areas (Bécares, Nazroo, Albor, et al., 2012). The areas that Indian respondents lived in were more equally spread across levels of deprivation, but still 40% of Indian respondents lived in the 60% most deprived areas. The minority ethnic groups that are more likely to live in areas of greater deprivation will disproportionately experience the detrimental effects that deprivation can have on psychological health (Kershaw et al., 2024).

However, Weathering Theory also proposes that the stress of racism or marginalisation can be partially alleviated through social identity safety and cultural affirmation (Geronimus et al., 2020), which refer to the sense of feeling valued and belonging when engaging with cultural in-groups (Barrera et al., 2025; Cundiff et al., 2018; Steele, 1988; Steele et al., 2002).

Ethnic Density

Individuals with racialised identities may be more likely to experience social identity safety and cultural affirmation in neighbourhoods that have higher ethnic density. Those experiences may contribute to neighbourhood social cohesion, herein called *social cohesion*, which is a measure of how friendly, trustworthy and helpful neighbours are perceived to be and how much an individual feels that they belong in their neighbourhood (Buckner, 1988). Social cohesion and social support have previously been proposed as mechanism through which ethnic density may support psychological health (Bécares et al., 2018; Halpern & Nazroo, 2000).

However, studies have found inconsistent associations between ethnic density, social cohesion and psychological distress across ethnic groups, generations, and definitions of ethnic density. A meta-analysis found that the association between ethnic density and psychological health outcomes varied across national contexts and between ethnic groups

(Bécares et al., 2018). One study using a UK based sample found that ethnic density positively predicted social cohesion for Indian and Bangladeshi respondents, but not for Pakistani, Black Caribbean, or Black African respondents (Bécares et al., 2011). Another study found that social cohesion negatively predicted psychological distress for Indian, Pakistani, and Bangladeshi respondents but not Black Caribbean or Black African respondents (Chum et al., 2022). A third study tested the full mediation pathway, but they used a measure of social capital that combined social cohesion with perceived neighbourhood problems of vandalism and teenagers hanging around on streets (Bécares & Nazroo, 2013). Their results for Indian respondents matched the other two studies, but they found that ethnic density predicted social capital positively for Pakistani respondents and negatively for Bangladeshi and Black Caribbean respondents. Alike Bécares et al. (2011), that association was not significant for Black African respondents. They also found that social capital negatively predicted psychological distress for all groups. Additionally, the association between ethnic density and psychological distress was only significantly positive for Indian respondents and significantly negative for Bangladeshi respondents. However, both associations lost significance once social capital was included in their model. It is not clear whether the different associations found across these studies were due to the differences in their measurement of social cohesion and social capital or due to other disparities in their target populations, sample designs, or analysis techniques. Additionally, none of these studies examined whether ethnic density effects differed across generations. One study that did test a cross-sectional interaction between ethnic density and generation for multiple minority ethnic groups in the UK found a significant interaction between ethnic density and generation for Pakistani, Bangladeshi, and Indian respondents, but not for Black Caribbean or Black African respondents (Y. Yan et al., 2019). They found that ethnic density positively predicted psychological distress for 1st generation Pakistani, Bangladeshi, and Indian respondents but

that association was not significant for any other groups. That study showed that ethnic density effects may vary across generations and between ethnic groups. The differing results between the previously mentioned studies that did not test those interactions could have been caused by their samples having different proportions of 1st generation migrants and UK born respondents for each of the ethnic groups. The present study tested the moderating role of both ethnic group and generation on ethnic density effects to help to establish whether any of the previously identified effects could be replicated in a longitudinal analysis.

Acculturative Stress

Psychological distress may also vary between 1st generation migrants and UK born people with racialised identities due to the extent to which they experience a variety of different acculturative stressors. Acculturative stressors are negative experiences that can result from interacting with multiple cultural groups. If an individual does not perceive themselves to have the physical or psychological resources to cope with those stressors, then they will experience acculturative stress, also known as cultural stress (Cohen et al., 2016; Sirin et al., 2013). Acculturative stress has often been split into several domains based on the different stressors that can instigate the stress. Those domains include: social isolation, intercultural relations, discrimination, negative context of reception, and language skills (Benet-Martínez & Haritatos, 2005; Meca & Schwartz, 2024).

Higher ethnic density may be indicative of places where many acculturative stressors are less likely to occur, which could explain why associations have been found between ethnic density and psychological distress. As ethnic density relates to the likelihood of have a shared cultural experience with neighbours, it can act as a reverse proxy for the acculturative stressor of being isolated from people with shared cultural experiences. That stressor could then lead some individuals to experience the acculturative stress of cultural isolation, which is most often experienced by people who live, work, or study in places where

few people share their culture background. Lower levels of social cohesion could be considered as a proxy for cultural isolation stress because people with low social cohesion feel that they do not belong in their neighbourhood and are dissimilar to their neighbours. In low ethnic density areas individuals may have fewer shared cultural experiences, attitudes, and behaviours with their neighbours, which may make them more likely to experience intercultural relations stress. Intercultural relations stress refers to the stress of trying to balance or combine multiple cultural identities when communicating with different cultural groups, such as your heritage culture (i.e., the culture of the country that you or your family moved from) and the dominant and minority cultures of the country you live in. In contrast, in higher ethnic density areas individuals may be more likely to be able to develop supportive and positive intercultural relations. Consequently, for individuals experiencing acculturation, measures of perceived positive and negative social support from family and friends could act as a proxy for their experience of intercultural relations stress. Conceptualising social cohesion and social support as inverse proxies for domains of acculturative stress that could be triggered by low ethnic density is in keeping with previous studies that considered those measures as mediators between ethnic density and psychological distress (Bécares et al., 2018; Bécares & Nazroo, 2013; Halpern & Nazroo, 2000).

Ethnic density could be a proxy for the likelihood that someone would experience othering or interpersonal discrimination in their neighbourhood, which are stressors that can make people feel the acculturative stress of discrimination. Discrimination has also previously been considered as a mediator between ethnic density and psychological distress (Bécares, 2014).

The relationship between ethnic density and psychological distress could also be confounded by respondents' earlier experiences of acculturative stress, such as negative context of reception stress. Negative context of reception stress refers to how welcomed 1st

generation migrants feel in the country they have moved to or how likely they think it is that people with their cultural background could be successful in that country (Meca & Schwartz, 2024). Individuals who experienced a negative context of reception when they moved to the UK may be less likely to want to engage with the dominant cultural group (Meca & Schwartz, 2024; Ozer & Schwartz, 2021) and consequently more likely to move to areas with higher ethnic density. Likewise, experiencing lower ethnic density when first living in the UK could also lead individuals to experience negative context of reception stress. As individuals who experience a more negative context of reception may also be more likely to report higher psychological distress, controlling for negative context of reception in an analysis of the relationship between ethnic density and psychological distress could account for differences in how respondents' earlier experiences of life in the UK impacted their levels of psychological distress.

Language proficiency could also confound the relationship between ethnic density and psychological distress. To avoid experiencing language stress, people who have more difficulty communicating in English may be more likely to live in areas where more people speak their first languages, which may also be areas of higher ethnic density for some migrant groups. Likewise, living in an area with higher ethnic density may also reduce the number of opportunities that some 1st generation migrants have to develop their English proficiency (Chiswick & Miller, 2005). Having low English proficiency may also limit employment opportunities in the UK and make it difficult to manage the daily administrative tasks such as paying utility bills and tax. Those difficulties can also cause language stress and increase psychological distress.

The Present Study

The present study used data from the first nine waves (2009–2019) of Understanding Society, the UK Household Longitudinal Study (UKHLS), to assess the longitudinal

association between ethnic density and psychological distress for six minority ethnic groups in England (University of Essex, Institute for Social and Economic Research, 2024b)⁵. This study also examined how change in ethnic density over two- to three-year periods predicted psychological distress at the end of each period. As the beneficial associations between ethnic density and psychological distress are thought to partially occur through higher ethnic density neighbourhoods providing greater social cohesion and social support and fewer experiences of discrimination, we additionally assessed whether the partial effect estimates (also known as Average Marginal Effects [AME]) for ethnic density were robust to the inclusion of each of those variables in the analysis (Das-Munshi et al., 2010). We also tested the potential confounding role of individual and neighbourhood characteristics, including several domains of acculturative stressors and acculturative stress. The only domain of acculturative stress that was measured with dedicated survey questions in UKHLS was negative context of reception. However, we have used several other measures as acculturative stressor proxies for the domains of discrimination and language stress and as acculturative stress proxies for the domains of cultural isolation and intercultural relations.

Previous studies that have investigated the association between ethnic density and psychological distress in England have either run cross-sectional analyses, used large geographic areas to measure ethnic density (e.g., Middle Layer Super Output Area (MSOA) or Ward), or did not test whether the relationship between ethnic density and psychological distress varied across both generations (i.e., between for 1st generation migrant and UK born respondents) and ethnic minority groups (Das-Munshi et al., 2010; Dorsett et al., 2019;

⁵ This study uses data from Understanding Society, which is an initiative funded by the Economic and Social Research Council and various Government Departments, with scientific leadership by the Institute for Social and Economic Research, University of Essex, and survey delivery by the National Centre for Social Research (NatCen) and Verian (formerly Kantar Public). The research data are distributed by the UK Data Service. Fieldwork for the web survey was carried out by Ipsos MORI and for the telephone survey by Kantar.

Halpern & Nazroo, 2000; Nandi et al., 2020; Propper et al., 2005; Y. Yan et al., 2019). In contrast, the present study assessed how the longitudinal relationships between ethnic density and psychological distress varied across generations and ethnic groups using a smaller geographic unit to define ethnic density. We used Lower Layer Super Output Areas (LSOA), which, compared to larger units, may better approximate the size of neighbourhoods that people imagine when they think about their neighbourhood.

Hypotheses

We expect that ethnic density and change in ethnic density will both significantly positively predict prospective psychological distress. We expect that the strength of both associations will vary across ethnic groups and generations, but we do not have a priori expectation regarding how the groups will differ from one another. We primarily utilise the interaction coefficients to determine whether the strength of the relationship between the ethnic density variables and psychological distress significantly vary between ethnic groups or across generations. We additionally calculate average marginal effects (AME) for each combination of ethnic group and generation to assess whether the hypothesized relationships are significant for each sub-group.

To examine the robustness of these associations and to probe their boundary conditions, we test models that control for social cohesion, social support, discrimination, neighbourhood deprivation, language difficulty, negative context of reception, and several sociodemographic variables.

Methods

Data and sample

UKHLS is a panel survey that started data collection in 2009 (University of Essex, Institute for Social and Economic Research, 2024b). All members of responding households

in the initial wave and their descendants constitute the core sample members who are eligible for interviews at approximately one-year intervals if they are still in the UK. Anyone who joins one of those households is also eligible for interviews for as long as they are living with core sample members to provide full household context. All 16+ year olds⁶ are eligible for the main interview and information is collected about different aspects of their lives, with a large set of questions being asked every year to allow for measurement of change. However, some questions that are not expected to change very quickly are asked less frequently to manage respondent burden. Social cohesion, one of the key variables for the present study, was asked in waves 1, 3, 6, and 9, so our analyses mostly used data from those waves.

Understanding Society obtained ethical approval from the University of Essex Ethics Committee (Institute for Social and Economic Research, 2024). For the present study, the authors obtained approval from their institutional Ethics Committee to use Understanding Society Special Licence Access Census 2011 Lower Layer Super Output Areas data [ETH2223-0107].

Measures

Predictor

Ethnic Density. Lower Layer Super Output Areas (LSOA) are census geographies that each contain between 400 and 1,200 households (Office for National Statistics, 2022). For each decennial census year, most recently 2021, the Office for National Statistics released datasets that report the population of each LSOA stratified by ethnic group (Office for National Statistics, 2001, 2011, 2021). Using LSOAs as proxies for neighbourhoods, this was linked to UKHLS to calculate the proportion of each respondent's LSOA neighbourhood

⁶ 10–15-year-olds are eligible for a shorter self-completion questionnaire and 0–9-year-olds are not directly interviewed but information is collected about them from their parents and guardians.

who shared their ethnicity in the year that they were interviewed⁷ (University of Essex, Institute for Social and Economic Research, 2022). Between decennial census years, the ethnic density of neighbourhoods in UKHLS was approximated based on the assumption that the ethnic density of each LSOA will have a linear trajectory between one census and the next (Lacey & Speizer, 2022).

Outcome

Psychological distress. In each wave of UKHLS, respondents completed the 12-item General Health Questionnaire (GHQ-12; Goldberg et al., 1997). The GHQ-12 items were each asked on a 4-point Likert scale where higher values corresponded to higher psychological distress. The present study uses Understanding Society's published "Likert" summary of the GHQ-12 items. To construct that measure, each item was rescaled to range from 0 to 3 and then all items were added together to form a summary score. In the sub-sample used for our main analysis, the items had excellent internal reliability ($\alpha = .90$).

Moderators

Ethnic Group. UKHLS measured self-reported ethnicity, which was designed to be compatible with the ethnic group categories used in the 2011 Census for England and Wales (Burton et al., 2008). In the present study, the five ethnic groups that were designed to be oversampled in the Ethnic Minority Boost Sample (EMBS; Indian, Pakistani, Bangladeshi, Black Caribbean, Black African), along with White Other, are compared to test how the associations between ethnic density and psychological health vary between these groups. For this analysis, those who reported their ethnic group as "mixed Black Caribbean and White" or

⁷ For each wave, interviews take place over two years for the General Population Sample (GPS) and the Ethnic Minority Boost Sample (EMBS) of UKHLS, but the same individuals are still interviewed at approximately one-year intervals thus resulting in overlapping fieldwork periods. This means that within each wave, respondents were linked to estimated ethnic density data from two different years depending on the year that they were interviewed.

“mixed Black African and White” were combined with Black Caribbean and Black African groups, respectively. These grouping may be appropriate because those respondents are likely to largely share the benefits of ethnic density with regards to social identity safety and cultural affirmation and they may also share experiences of racism in the UK.

Generation. Respondents born outside the UK (i.e., 1st generation migrants) may differ from respondents born within the UK in terms of the ethnic density of the areas they live in, their psychological health and the role of co-ethnic social networks on their psychological health and well-being (Knies et al., 2016; Nandi et al., 2020). Respondents born within the UK grew up socialised in British culture and so are more likely to consider people in the UK as their reference population for their cognitive assessments of their satisfaction with their life and their well-being. Whereas people born in other countries will be more likely to consider people born in those countries as their reference group when making cognitive assessments of their well-being, at least for the first few years after migration (Nandi et al., 2020). So, being born in the UK could confound the relationship between ethnic density and psychological distress. A dummy code was used where 0 = 1st generation migrant and 1 = UK born, and this was interacted with ethnic group to examine the differences in the relationship between ethnic density and psychological distress by ethnic group and generation.

Mediators

Social Cohesion. UKHLS included a measure of social cohesion adapted from Buckner's (1988) Neighbourhood Cohesion Instrument, using 8 of the original 18 items, in waves 1, 3, 6 and 9. The items included ‘I borrow things and exchange favours with my neighbours’. The items were asked on a 5-point Likert scale from 1 (*Strongly Agree*) to 5 (*Strongly Disagree*), which were then reverse coded, and their mean value was calculated to produce the published measure which is used as the mediator. Therefore, higher values

indicate greater cohesion. The internal reliability of social cohesion in each wave was also included in the published variable labels ($\alpha_{\text{wave1}} = .88$, $\alpha_{\text{wave3}} = .86$, $\alpha_{\text{wave6}} = .88$, $\alpha_{\text{wave9}} = .88$; University of Essex, Institute for Social and Economic Research, 2024).

Social Support. In waves 2 and 5, respondents were asked six questions, three positive and three negative, about their perceived social support from three sources: their partner, family, and friends (J. Smith et al., 2023), if those relationships existed. Positive social support questions included “How much can you open up to them if you need to talk about your worries?” and negative questions included “How much do they criticise you?”. While the questions did not specifically refer to cultural behaviours, any criticism or support of cultural behaviours would inform respondents’ answers. All questions were asked on a scale from 1 (*a lot*) to 4 (*not at all*). For this study the items were reverse coded so that higher values of *positive social support* refer to better experiences of support and higher values of *negative social support* refer to worse experiences of support.

For each source, the mean of a respondent’s answers to the three positive (negative) questions was calculated, and then the mean of those means was computed for the final measure of positive (negative) social support. This meant that the three sources could be weighted equally in the final measure even if items were missing from any source. Additionally, respondents with only one or two sources were not penalised in this measure because some respondents may receive the same amount of support from one source as others received from three. The internal reliabilities of positive social support sources were all good ($\alpha_{\text{Partner}} = .82$, $\alpha_{\text{Family}} = .83$, $\alpha_{\text{Friends}} = .84$) and negative social support sources were adequate ($\alpha_{\text{Partner}} = .72$, $\alpha_{\text{Family}} = .71$, $\alpha_{\text{Friends}} = .73$).

Discrimination. In waves 1, 3, 5, 7, and 9, a subset of respondents was asked about their experiences of discrimination and harassment⁸. They were asked if they had avoided, felt unsafe, or been insulted or attacked in any place in the last 12 months. If they did have any of those experiences, they were asked to provide a reason. For this study we have split those reasons into those that relate to acculturative stress and those that do not. Acculturative reasons were ethnicity, nationality, religion, language or accent, and dress or appearance. The items relating to feeling unsafe could be seen as a measure of stress whereas the other items referred only to whether stressors occurred and not to whether those events made respondents feel stressed. For each wave, a dummy variable was derived to indicate whether they had experienced acculturative discrimination in the last 12 months (0 = *no reported acculturative discrimination*; 1 = *reported acculturative discrimination*).

Confounders

Index of Multiple Deprivation. As areas of high ethnic minority concentration are also more likely to be areas with higher levels of deprivation which can also impact psychological distress, it is important to control for area level deprivation. Separate indices of multiple deprivation have been created for each UK nation, and they are not directly comparable. So, as explained later, we restrict our analysis to England, where most ethnic minorities reside. The English Index of Multiple Deprivation is measured at the LSOA level and includes the following seven domains: income, employment, education, health, crime, housing and services, and living environment. As with ethnic density, neighbourhood deprivation can be linked to UKHLS data using respondents' LSOA codes.

⁸ Respondents were asked the discrimination questions if they were in the extra five-minute sample, which consisted of Ethnic Minority Boost Sample (EMBS; who were by design from high ethnic minority density areas), a subset of ethnic minority respondents in the General Population Sample (GPS) from low ethnic minority density areas, and a random subset of all GPS respondents (McFall et al., 2019).

The English Index is updated every few years with the most recent updates occurring in 2007, 2010, 2015, 2019, and 2025 (McLennan et al., 2019, 2025). The data used in our analyses (i.e., waves 1, 3, 6, and 9) were collected between 2009 and 2019. We used the 2015 measure of IMD for all waves because that is the first version to use 2011 LSOA codes and the data for that version is based on the 2012/13 tax year or the 2011 Census, which predates the majority of the UKHLS data that will be used in our analysis (Ministry of Housing, Communities & Local Government, 2015; T. Smith et al., 2015b). Only using IMD 2015 also avoids the potential loss of precision that would result from merging two or more complex indices. The IMD 2015 dataset includes log-“exponential” summary scores for each domain and also ranks every LSOA based on those values (for further details see T. Smith et al., 2015b). We used the log-“exponential” scores because they had a more normal distribution and a similar range to the outcome measure. In this measure higher values indicate greater deprivation. The health deprivation domain was omitted from our final IMD measure because its calculation includes the prevalence of mood and anxiety disorders which would include data from UKHLS respondents (T. Smith et al., 2015b). While we only use one measure of IMD, if respondents moved, their IMD may differ between waves.

Language Difficulty. In waves 1 and 5, respondents were asked if English was their first language. If it was not, respondents were asked if they had any difficulty speaking in English during day-to-day activities or reading formal documents in English. However, only a sub-set of respondents were asked those questions in wave 5⁹. As such, the wave 5 answers were only used if wave 1 was missing (see Analytical Strategy for further details on missing data). This ensured that for most respondents, the variable could be an appropriate

⁹ In wave 5, respondents were only asked those questions if they were in extra-five minutes sample or if they had first moved to the UK in the three years before wave 1 began (McFall et al., 2019; University of Essex, Institute for Social and Economic Research, 2024a).

confounder in all analyses. If respondents reported that English was their first language, or they reported having no English difficulties, they were assigned 0 in the language difficulties dummy variable. If they had any difficulties, they were assigned 1.

Negative Context of Reception. In wave 7, respondents who were born outside the UK were asked two questions that could measure negative context of reception. Each question could be answered on a scale from 1 (*strongly agree*) to 5 (*strongly disagree*) where higher values indicated a more negative reception. One question was “In general, the UK is a hospitable or welcoming country for people from your country of birth”, which was referred to as *negative reception* for this study. The other item was “In general, people from your country of birth can get ahead in the UK if they work hard”, which was referred to as *unfair context* for this study. These questions were adapted from the Causes and Consequences of Socio-Cultural Integration Processes among New Immigrants in Europe study (Diehl et al., 2016). The two items only had a correlation of $r = .41$, so they were separately included in analyses rather than combining them into a composite measure. These items were only measured once, so for the purposes of this study they were treated as time invariant and included as confounders for all outcome waves, but only in an analysis that excluded UK born respondents.

Reason for Migrating to the UK. In wave 7, 1st generation migrant respondents were asked why they migrated to the UK. They could choose multiple options which included: for work, joined or moved with family members, education, political, or “simply wanted to”. For some ethnic groups there were too few responses in some of these categories, so we created a dummy variable to indicate if respondents *migrated for family* reasons (= 1) or not (= 0). Migrated for family was only measured once, so for the purposes of this study it was treated as time invariant and included as a predictor for all outcome waves, but only in an analysis that excluded UK born respondents.

Age and Sex/gender. At the time of each interview, age is measured in years. In Understanding Society, during the household grid portion of the survey, one household member identifies whether each respondent is male or female. That is then confirmed by asking each respondent directly during their annual interviews. The present study adapted a variable that was derived by Understanding Society. In their variable respondents were identified as male, female, missing, or “inconsistent” if their records were not consistent. No respondents with missing or inconsistent data met our inclusion criteria (see Chapter 3 Analytical Strategy), so a “female” dummy coded variable was created (0 = *male*, 1 = *female*).

Marriage Status. For each wave, a detailed marriage and partnership status variable was converted into a dummy variable for whether respondents were either married, in civil partnership, or living with their partner (all coded as 1), or not (coded as 0). This dummy variable was used rather than a more detailed measure because some levels of that measure would have very few respondents for some combinations of ethnic group and generation.

Employment. Information on respondents’ main labour force status and their hours of employment were used to produce a dummy variable for employment (0 = *not employed*; 1 = *employed*). As with marriage status, more detailed categories (e.g., unemployed, retired, student) had too few respondents in some combinations of ethnic group and generation.

Highest qualification. A three-level categorical variable was derived to represent respondents’ highest level of qualification. The levels were: University degree level or higher (reference level), advanced (i.e., A-levels, Diploma in higher education or equivalent), and Secondary education or less.

Health conditions. In each wave respondents reported whether they had been diagnosed with any new conditions in the last year and whether they still had any of those newly diagnosed conditions. Respondents were not asked in subsequent waves if they still

had those conditions so for all subsequent waves respondents were assumed to still have those conditions. We created a dummy variable for each wave (1 = *reported still having any conditions up to and including that wave*; 0 = *no conditions*). The following conditions were included in our measure: asthma, arthritis, congestive heart failure, coronary heart disease, angina, heart attack or myocardial infarction, stroke, emphysema, hyperthyroidism, hypothyroidism, chronic bronchitis, any liver conditions, cancer or malignancy, diabetes, epilepsy, high blood pressure, multiple sclerosis. Respondents were also asked if they had been diagnosed with depression, but this was not included in our derived measure because it is also a measure of our outcome variable, psychological distress. Additionally, from wave 6 respondents were asked if they had been diagnosed with any “other” conditions. “Other” was also omitted from our measure because it could include psychiatric conditions.

Equivalised Household Income. Equivalised household income can be used to compare economic well-being and access to goods and services for households with different numbers of adults and children, which generally adjusts for economies of scale. A common scale used to equivalise household incomes is the Organisation for Economic Co-operation and Development’s (OECD) adjustment scale where a value of 1 is assigned to the first person in a household and then 0.5 is added for each additional person that is at least 14-years-old and 0.3 is added for each person under 14-years-old (Hagenaars et al., 1994). UKHLS data includes the OECD adjustment scale value for each household. To derive our measure of equivalised household income, we divided UKHLS’ net household income variable (which includes imputed values for missing income information) by the OECD adjustment scale value (Hagenaars et al., 1994; University of Essex, 2022).

Sample Design and Analysis Sample

Here we describe the design of UKHLS samples and our analysis sample. UKHLS comprises of a nationally representative sample of private households in the UK, called the

General Population Sample (GPS), and the Ethnic Minority Boost Sample (EMBS). The EMBS was designed to oversample ethnic minorities in areas of high ethnic minority concentration and to attain at least 1000 individual interviews from each of Indian, Pakistani, Bangladeshi, Black Caribbean and Black African groups (R. Berthoud et al., 2009). EMBS also included other ethnic minorities who were screened in those target areas. Both GPS and EMBS were clustered and stratified (for further details about their sampling procedures see Appendix B: Understanding Society Sample Design). In wave 2, the surviving members of the long running British Household Panel Survey were added. Then in wave 6, the Immigrant and Ethnic Minority Boost Sample were added.

For the present study, the measures were primarily extracted from waves 1, 3, 6, and 9 of UKHLS. These waves were chosen because they include social cohesion. Social Cohesion was also measured in wave 12, but that wave was not included because EMBS had experienced substantial attrition by wave 12 (Cabrera-Álvarez & Lynn, 2023). While, in wave 6 the Immigrant and Ethnic Minority Boost Sample did refresh these sample sizes, those new respondents were not asked the social cohesion questions in that wave, so that sample was excluded from the longitudinal analysis.

Only respondents who were living in England when they answered waves 1, 3, 6, and 9 were included in the sample because each UK nation used a different set of criteria and methods to calculate their indices of multiple deprivation and as such they are not directly comparable (Ijpelaar et al., 2017; Scottish Government, 2020; T. Smith et al., 2015b; Statistics for Wales, 2019). Additionally, LSOA census areas are only created for England and Wales and the census units used in Scotland and Northern Ireland relate to different population sizes than LSOA (Ijpelaar et al., 2017; Scottish Government, 2021). In wave 3, 95.78% of respondents who identified with one of the over sampled ethnic minority groups

lived in England. So, the exclusion of Scotland, Wales and Northern Ireland did not substantially reduce the samples size for those key groups of interest for the present study.

Analytical Strategy

To test the longitudinal relationships between ethnic density and psychological distress we used moderated multilevel modelling with interaction terms specified between ethnic group, generation, and measures of ethnic density. The variables and waves used in our analyses are presented in Table 3.2. Respondents appear in the sample once for each Table 3.2 “Measurement Wave” column for which they have complete data. For this study, each of those appearances will be referred to as a “response”. Each respondent may have up to three responses in the analysis sample if they have valid data for all variables in the relevant waves.

For each response, the outcome (psychological distress [GHQ-12]) was measured in waves 3, 6, or 9, and the predictor (ethnic density) and a mediator (social cohesion) were measured in waves 1, 3, and 6 respectively, and referred to as lagged variables (e.g., lagged ethnic density). Additionally, change between the predictor wave and the outcome wave was calculated for ethnic density and social cohesion, which were referred to as change variables (e.g., change in ethnic density). As responses were included from multiple waves we included a wave indicator in the analyses to account for any wave specific associations.

Social support variables were measured in the waves between the predictor and outcome waves. Discrimination was measured in two of the outcome waves, waves 3 and 9, but it was not recorded in wave 6 so the measurement from wave 5 was used instead. All three variables were theoretically considered as potential mediators of the relationship between ethnic density and psychological distress. All time-varying confounder variables were measured in the same waves as the predictor and were referred to as lagged variables.

As each respondent may be included up to three times, multilevel modelling was used to account for the interdependence of repeated observations from the same individual. That interdependence arises because each time an individual completes a wave, their answers will reflect elements of their personality, health, or life history, which will mean that their measures in later waves are dependent on their earlier responses. Additionally, as some respondents share households, and as multiple households were selected from the same areas (PSU), individuals within each household and PSU are expected to have shared experiences.

Table 3.2

Summary of analysis strategy.

Variables	Model	Measurement Wave		
Outcome				
psychological distress		3	6	9
Predictor				
lagged ethnic density	1+	1	3	6
change in ethnic density	1+	Between 3 and 1	Between 6 and 3	Between 9 and 6
Moderator				
ethnic group	1+	Time invariant/Fixed		
generation	1+	Time invariant/Fixed		
Mediator				
lagged social cohesion	1+	1	3	6
change in social cohesion	1+	Between 3 and 1	Between 6 and 3	Between 9 and 6
positive social support	3	2	5	NA
negative social support	3	2	5	NA
discrimination	4	3	5	9
Confounder				
lagged IMD	1+	1	3	6
sex	1+	Time invariant/Fixed		
lagged psychological distress	1+	1	3	6
lagged age	1+	1	3	6
lagged marriage status	1+	1	3	6
lagged employment	1+	1	3	6
lagged highest qualification	1+	1	3	6
lagged health conditions	1+	1	3	6
lagged equivalized household income	1+	1	3	6

language difficulty	2	Time invariant/Fixed
negative reception	2	Time invariant/Fixed
unfair context	2	Time invariant/Fixed
reason for migrating to the UK	2	Time invariant/Fixed

Note. Model refers to the model numbers that the variable is included in, with + referring to that model number and all subsequent models. The Measures section details how each variable was coded for this study.

In the design of both GPS and EMBS, the samples were stratified to ensure that they contained a wide variation in values for several sociodemographic characteristics. As such, adjusting for strata in an analysis improves precision by accounting for that variation and consequently reducing the standard errors of the other effects estimated in the analysis. In contrast, PSU were randomly selected within strata so there will be less variation within those PSU than in the general population. This means that accounting for PSU in analyses can increase the standard errors of estimates in analyses. Neither adjusting for strata nor PSU should impact the coefficients estimated in an analysis.

Most statistical software assume that the data have been drawn from a simple random sample, but using the “mixed” command in Stata, we were able to adjust the computation of standard errors to reflect that the analysis sample was clustered (StataCorp, 2025b; West et al., 2022). However, that command cannot adjust for the stratification of the sample, which means that the calculated standard errors will be more conservative as a result.

The EMBS sample intentionally oversampled minority ethnic groups, which meant that they had a higher selection probability than the rest of the population. If the statistic being estimated varies systematically between ethnic groups in England, the estimated statistic will be biased in favour of groups with higher selection probability. Similarly, systematic differences between respondents and non-respondents may result in biased estimates. In wave 1, the GPS had a household response rate of 57% and the EMBS had a

household response rate of 40% (Institute for Social and Economic Research, 2021). Among wave 1 adult GPS respondents, 68.9%, 53.7%, and 44.4% completed waves 3, 6 and 9 respectively, and among wave 1 EMBS adult respondents, 58.9%, 42.5%, and 31.3% completed waves 3, 6 and 9 respectively (Cabrera-Álvarez & Lynn, 2023). For each wave, Understanding Society publish longitudinal weights, which, when applied to the analysis, account for and correct the bias arising due to unequal selection probabilities as well as non-response and attrition from the first wave until the specified wave (e.g., the final wave of analysis).

Weighted analyses have only been validated for two-level multilevel models (StataCorp, 2025a), so we used responses as the first level and then chose the second level based on which level accounted for the highest proportion of variability in the outcome variable, psychological distress. The intraclass correlation coefficient (ICC) was .49 within respondents but only .19 within households, so respondents were taken as the second level. We additionally adjusted the standard errors to be robust to clustering within PSU.

Separate weights were applied to each level of the model. Respondents' longitudinal weights for the first outcome wave, wave 3, were used as their respondent level weight. Then to calculate response level weight the longitudinal weight for each response's outcome wave was divided by their wave 3 longitudinal weight to calculate the inverse probability of that respondent responding to that particular wave conditional on their respondent level weight. For example, for a response with psychological distress measured in wave 6 and the predictor, confounders, and mediators measured in waves 3-6, the respondent level weight would be their wave 3 longitudinal weight, and their response level weight would be calculated as their wave 6 longitudinal weight divided by their wave 3 longitudinal weight. Consequently, their respondent level weight would account for the unequal selection probability, non-response at wave 1, and wave-on-wave nonresponse between waves 2 and 1,

and 3 and 2. Their response level weight would instead account for their relative probability of wave-on-wave nonresponse between waves 4 and 3, 5 and 4, and 6 and 5. In this example, the respondent level would be weighted “0” if the respondent had not participated in wave 1 or 2, or if they were not part of the GPS or EMBS samples. The response level would be weighted “0” for any of those reasons or if the respondent had not participated in wave 4, or 5. They would instead have a missing value at the response level if they did not respond to wave 6 and at both levels if they did not respond to wave 3. Responses with missing or “0” values were dropped from the analysis sample because the “mixed” Stata command can only handle positive values.

Random intercepts were specified at the respondent level and all variables in each model (see Table 3.2 and Figure 3.1 for variable lists), except the outcome variable, were included as fixed effects (StataCorp, 2025a). To compare effect sizes of the combined contribution of the fixed effects across models, we used the Marginal R^2 for mixed effect models (Klein & Linden, 2024; Nakagawa & Schielzeth, 2013).

Main Analysis Model

The Main Analysis Model (Model 1) primarily assesses the longitudinal relationship between both lagged- and change in ethnic density and psychological distress. As previous studies have found that the relationship between ethnic density and psychological outcomes can vary across ethnic groups and across generations (Bécares et al., 2018), three-way interactions between each ethnic density variable, ethnic group, and generation were included in the model.

A potentially important variable included in the Main Analysis Model was IMD. IMD may be positively correlated with both ethnic density and psychological distress and could have a substantial impact on the interpretation of ethnic density (Bécares et al., 2018; Nandi et al., 2020). Without controlling for IMD, ethnic density may act as a proxy for differing

levels of inequality and marginalisation between ethnic groups (e.g., structural racism). When IMD is controlled, measures of ethnic density may instead represent healthy experiences of cultural affirmation, social cohesion and social support. To assess the influence of IMD on the fixed-effects coefficients, two simple preliminary models were analysed and reported in Appendix B Preliminary Models. The first of those models, Model 1.1, only included outcome wave, lagged- and change in ethnic density as predictors of psychological distress. Then the second model, Model 1.2, additionally adjusted for lagged IMD.

Lagged- and change in social cohesion were also included in the Main Analysis Model (Model 1) because social cohesion may mediate the association between ethnic density and psychological distress (Bécares, 2014). When neighbours share a social identity, particularly a marginalised social identity, they may be more likely to trust, support, and identify with those neighbours, which could promote better psychological health (i.e., lower psychological distress). If social cohesion were a mediator, then including social cohesion in the analysis might influence the size of the fixed effects coefficients and AME for measures of ethnic density. So, to assess whether those estimates are robust to the inclusion of social cohesion two further preliminary models were run. The first of those models, Model 1.3, included the variables that had been included in Model 1.2 as well as the three-way interactions between ethnic group, generation and lagged or change in ethnic density. Then the final preliminary model, Model 1.4, adjusted for social cohesion. The results of those models are detailed in Appendix B Preliminary Models.

Model 1 also controlled for lagged age, lagged marriage status, sex, lagged employment, lagged education, lagged health conditions, and lagged equivalised household income because each of those variables may predict both ethnic density and psychological distress. An individual's age, marriage status, and sex, could potentially influence where they are likely to live and those characteristics could also be associated with psychological

distress. As ethnic density may correlate with IMD, individuals with higher incomes and more opportunity, indicated by employment and higher qualifications, may be less likely to live in those areas and less likely to experience psychological distress. Individuals with health conditions may require more practical support from their family, which may also mean that they are more likely to live in higher ethnic density areas.

Finally, Model 1 also controlled for lagged psychological distress, which partially accounted for any earlier exposure to unobserved characteristics that may influence both ethnic density and psychological distress.

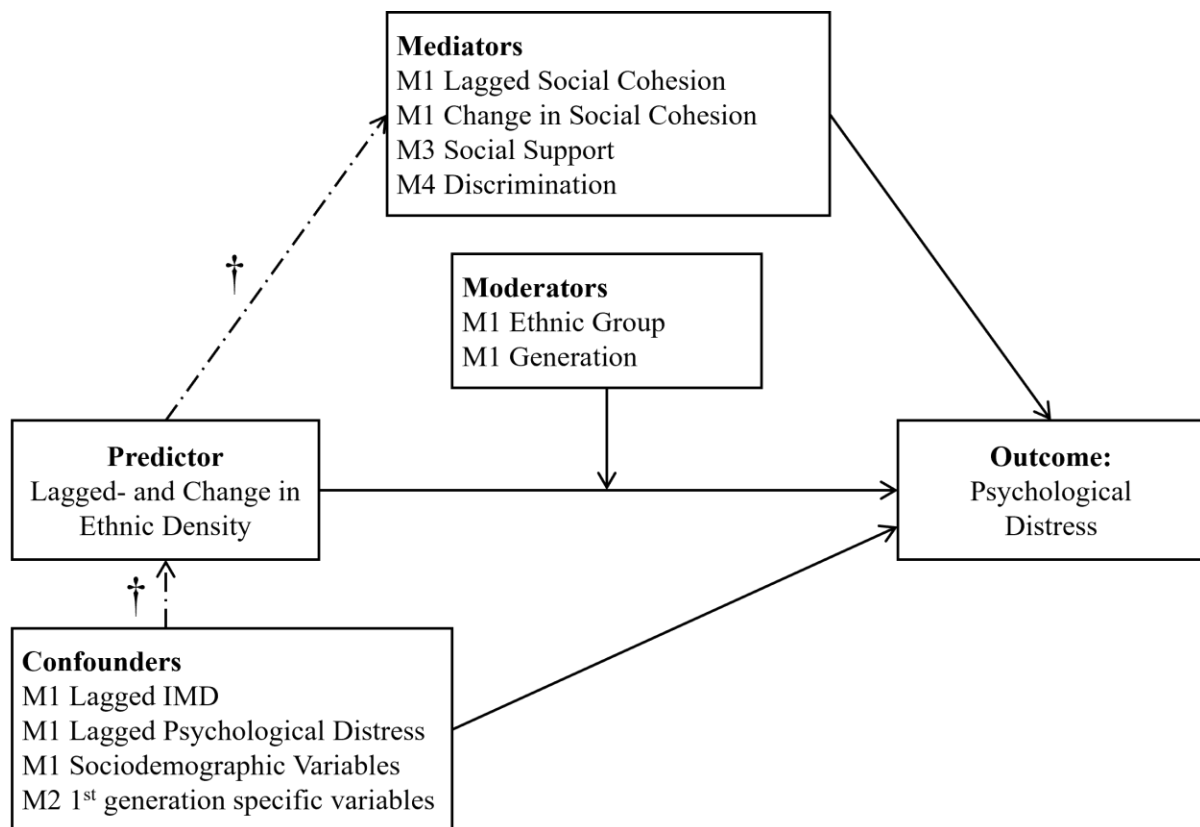
Additional Models

To examine the role of other potential acculturative stressor and acculturative stress proxies, additional models were tested taking the Main Analysis Model (Model 1) as the base model. The variables included in Model 1 and the additional models are summarised in Figure 3.1. The variables introduced in the additional models have been identified as potential mediators or confounders based on when they were measured and on their theoretical relationship with ethnic density and psychological distress. Confounder variables are measured concurrently with, or ideally before, the measurement of the focal predictor variables (i.e., lagged and change in ethnic density) and they are expected to influence both the value of the focal predictor and the value of the outcome variable (i.e., psychological distress). If a confounder variable is not controlled in an analysis, spurious relationships may be estimated between the focal predictor and the outcome variable (Andrade, 2024). Mediator variables are ideally measured after the predictor has been measured but before the measurement of the outcome variable because theoretically the predictor is expected to influence the mediator which in turn is expected to influence the outcome variable (Cain et al., 2018). To test whether each variable is acting as either a confounder or a mediator variable, we would have to run further analyses, such as the SEM analyses used in Chapter 2.

However, the focus of this chapter is not on testing whether the additional analysis variables are mediators or confounders. The hypotheses instead focus on whether the partial effects (also referred to as average marginal effects [AME]) and interaction effects for the associations between measures of ethnic density and psychological distress are robust to the inclusion of the Additional Analysis variables.

Figure 3.1

Variables included in the Main Analysis Model and Additional Models.



Note. † Indicates theoretical relationships that are not tested in this chapter. M = Model. All variables included in Model 1 (M1) were also included in all additional models (i.e., M2, M3, M4). Sociodemographic variables: sex, lagged age, lagged employment, lagged education, lagged marriage status, lagged health conditions, and lagged equivalised household income. 1st generation specific variables: language difficulty, negative reception, unfair context, and reasons for migrating to the UK.

1st Generation Model (Model 2). *Main Analysis Model excluding UK born respondents + 1st generation specific acculturative stress and acculturative stressors and reasons for migration.*

Additional confounders were identified that were relevant for 1st generation migrants only. For Model 2, these were *added* to the Model 1 specification, but with the sample restricted to only include 1st generation migrants. The additional confounders were language difficulty, negative reception, unfair context, and reasons for migrating to the UK. As explained in the Introduction, experiencing English language difficulties or a negative context of reception in the UK may both be linked to an increased likelihood of moving to higher ethnic density areas and to higher levels of psychological distress. Similarly, respondents who moved to the UK for family reasons may also have been more likely to settle in areas of higher ethnic density. Only including 1st generation migrants reduced the sample size from 4,023 to 2,460 responses. Of those responses, 560 were missing their reason for migration and the negative context of reception variables, and 45¹⁰ other responses were missing at least one of these variables, and fewer than five were missing language difficulties. Consequently, these analyses included 1,852 responses across 854 respondents. The descriptive statistics for this sample are presented in Appendix B Table B.4.

Social Support Model (Model 3). *Main Analysis Model excluding responses in wave 9 + positive and negative social support.*

In this model, positive and negative social support were added to the Model 1 specification because social support has previously been considered as a mechanism that may explain associations between ethnic density and psychological distress (Bécares et al., 2018). As social support items were only recorded in waves 2 and 5, this set of models only included

¹⁰ These values were rounded to avoid cell sizes of less than five responses, which could increase the risk of respondent reidentification.

responses where the outcome was measured in wave 3 or 6. Of the 4,023 responses included in the main analyses, 3,272 responses had outcomes in waves 3 or 6. Of these, only 36 were missing either positive social support or negative social support, which meant that 3,236 responses from 2,181 respondents could be included in these models. As explained in the Measures section, positive (negative) social support was derived from up to three sources of positive (negative) social support: partner, family, and friends. For each source there were three positive (negative) items. In this sample, only 20 responses were missing items from their positive social support sources and 34 were missing items from negative support items. For both positive and negative social support, 1,257 were missing the partner source, 166 were missing the family source, and 174 were missing the friend source. Eight responses were additionally missing negative social support, but not positive social support, for either the partner or friend source. The descriptive statistics for this sample are presented in Appendix B Table B.6.

Discrimination Model (Model 4). *Main Analysis Model excluding White Other respondents + discrimination.*

Previous studies have found evidence that for some groups, individuals may be more likely to experience discrimination in neighbourhoods that have lower ethnic density, so discrimination may mediate the association between ethnic density and psychological distress (Bécares, 2014; English et al., 2014).

Discrimination items were only asked to a sub-set of respondents, which included very few White Other respondents. So, White Other respondents were omitted from the sample used for Model 4. Compared to the main analysis sample, 890 responses by White Other respondents were omitted, another 800¹¹ responses were omitted because those

¹¹ These values were rounded to avoid cell sizes of less than five responses, which could increase the risk of respondent reidentification.

respondents were not in the sub-sample that were asked these questions, and less than five responses were otherwise missing. This meant that the sample used for these analyses included 2,333 responses from 1,376 respondents. The descriptive statistics for this sample are presented in Appendix B Table B.9.

Interim Models. As has already been shown in this section, some of the responses included in the Main Analysis Model (Model 1) were missing data in the variables that were included in the additional models. When comparing the Main Analysis Model to each additional model, it would be unclear whether differences in their results were due to changes in sample size or due to the inclusion of the additional variables. To be able to discern between those causes, the Main Analysis Model was repeated using each of the reduced samples, but without including the additional variables in the analysis. The results for those interim models are summarised in the following Results section, and then presented in full in Appendix B: Additional and Interim Analyses.

Results

Descriptive Statistics

The final analytical sample included 4,023 responses from 2,204 respondents who had valid data for the variables described in the analytical strategy. For each ethnic group included in the sample, weighted descriptive statistics were calculated separately for respondents born in the UK and for 1st generation migrant respondents (See Table 3.3). The lagged and outcomes measures of psychological distress (GHQ-12) both varied across ethnic groups and generation. 1st generation migrant Black African respondents reported the lowest psychological distress (outcome: $M = 9.71$, $SD = 5.57$; lag: $M = 9.64$, $SD = 5.54$), whereas UK born Black African respondents reported the highest of all groups (outcome: $M = 12.97$, $SD = 6.75$; lag: $M = 12.66$, $SD = 5.63$). As expected, lagged ethnic density tended to be lower for White Other, Black Caribbean, and Black African respondents ($6.55\% \leq Ms \leq 10.31\%$)

and higher for Indian, and Bangladeshi respondents ($11.25\% \leq Ms \leq 19.34\%$), and highest for Pakistani respondents (1st generation: $M = 20.93\%$, $SD = 21.77\%$; UK born: $M = 27.74\%$, $SD = 24.29\%$). However, each group's mean and standard deviation of ethnic density were very similar in magnitude. For each group the mean change in ethnic density between analytical waves (2-3 years) was between -1.15% for 1st generation Bangladeshi respondents and 0.96% for UK born Black African respondents.

Social cohesion was fairly stable across waves and relatively similar between ethnic groups and generations with the mean scores of lagged social cohesion only varying from 3.14 for UK born Black African respondents and 3.78 for 1st generation Pakistani respondents. Likewise, neither positive nor negative social support substantially differed between ethnic groups or across generations. The percentage of respondents who reported experiencing discrimination varied between 10.81% for 1st generation Black Caribbean respondents and 34.53% for UK born Pakistani respondents.

There was considerable variation in the proportion of respondents who moved neighbourhoods, as measured by a change in LSOA, across ethnic groups and generations. Only 7.89% of responses from 1st generation Black Caribbean respondents reported moving neighbourhoods between their predictor and outcome wave, whereas 22.09% of responses from 1st generation Indian respondents did.

More than half of all 1st generation migrant respondents move to the UK for family related reasons (59.07%). 84.34% of 1st generation Pakistani respondents moved to the UK for family reasons, whereas only 44.76% of 1st generation White Other respondents moved to the UK for family reasons. In both measures of negative context of reception, 1st generation Black Caribbean respondents reported the most negative context of reception (negative reception: $M = 2.19$, $SD = 1.02$; unfair context: $M = 2.11$, $SD = 0.90$) and 1st generation Pakistani respondents reported the lowest values (negative reception: $M = 1.62$, $SD = 0.71$;

unfair context: $M = 1.69$, $SD = 0.68$). Experiencing English language difficulties was most common among 1st generation Bangladeshi respondents (27.55%). In comparison no 1st generation Black Caribbean respondents reported any English language difficulties.

Index of Multiple Deprivation (IMD) scores, where higher values indicate more deprivation, were on average lower for White Other respondents and higher for 1st generation Black African and Bangladeshi respondents and for Pakistani respondents (see Table 3.3). Lagged equivalised household monthly income was highest among White Other respondents (1st generation: £1,600; UK born: £1,800) and lowest among Pakistani respondents (£900).

Across the weighted sample approximately half of respondents were female (51.77%), but 74.80% of UK born Black African respondents were female and only 41.11% of 1st generation Indian respondents were female. Between ethnic groups and across generations, mean age varied from 28.90 for UK born Pakistani respondents to 54.28 for 1st generation Black Caribbean respondents. For all ethnic groups, except White Other, being married, having a partner or living as a couple, was more common among 1st generation migrants than UK born respondents. Employment was most common for White Other respondents and least common for Pakistani respondents. White Other respondents also had the highest prevalence of degree level education (44.50%) whereas secondary education or lower was the highest education qualification for over half of UK born Bangladeshi respondents (52.56%) and 1st generation Black Caribbean (56.86%) respondents.

The proportion of respondents with a health condition was 58.02% for 1st generation Black Caribbean respondents, which was much higher than the average of 27.72% across groups. 1st generation Black Caribbean respondents were also the group with the highest mean age, so that may explain their higher prevalence of health conditions.

Table 3.3*Weighted Descriptive Statistics.*

variable	stat.	Indian		Pakistani		Bangladeshi		Black Caribbean		Black African		White Other		Total
		<i>(N_{rw} = 942)</i>		<i>(N_{rw} = 508)</i>		<i>(N_{rw} = 248)</i>		<i>(N_{rw} = 678)</i>		<i>(N_{rw} = 564)</i>		<i>(N_{rw} = 987)</i>		
		1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	
unweighted	<i>N_{rw}</i>	550	358	272	323	142	118	287	546	430	108	779	110	4,023
	<i>N_r</i>	301	187	162	188	87	77	162	285	265	54	386	50	2,204
weighted	<i>N_{rw}</i>	574	368	222	286	110	138	214	464	458	106	884	103	3,927
outcome wave														
3	%	43.78	42.07	44.28	43.78	44.00	44.56	43.63	37.75	46.45	33.21	48.27	47.98	44.11
6	%	32.09	34.38	32.09	33.54	32.77	30.68	33.29	34.60	31.04	30.01	31.73	32.46	32.49
9	%	24.12	23.54	23.63	22.68	23.23	24.76	23.08	27.66	22.51	36.77	20.00	19.56	23.40
GHQ-12														
lagged	<i>M</i>	10.27	11.29	11.81	12.37	11.40	11.76	11.99	11.87	9.64	12.66	10.78	11.71	11.12
	<i>SD</i>	5.48	5.84	6.13	6.51	4.72	6.99	6.63	5.98	5.54	5.63	4.78	5.88	5.73
outcome	<i>M</i>	10.24	11.57	11.74	12.52	11.61	11.88	11.51	12.32	9.71	12.97	10.79	11.62	11.20
	<i>SD</i>	5.46	5.84	6.64	6.67	4.70	7.26	6.26	6.56	5.57	6.75	4.61	5.62	5.85
ethnic density														
lagged	<i>M</i>	17.29	15.78	20.93	27.74	19.34	11.25	7.68	8.04	10.31	7.58	8.62	6.55	13.03
	<i>SD</i>	15.48	14.98	21.77	24.29	19.74	16.37	5.43	6.86	8.90	7.84	7.07	5.99	14.54
Δ	<i>M</i>	-0.79	0.11	-0.25	-0.13	-1.15	0.40	-0.38	-0.32	0.28	0.96	0.18	0.15	-0.10
	<i>SD</i>	5.72	5.71	7.25	7.90	7.04	1.67	1.44	2.03	4.09	3.77	3.27	2.05	4.73
Mediator														
social cohesion														
lagged	<i>M</i>	3.68	3.44	3.78	3.63	3.74	3.57	3.57	3.39	3.43	3.14	3.43	3.60	3.51
	<i>SD</i>	0.59	0.67	0.64	0.76	0.70	0.59	0.64	0.70	0.75	0.59	0.66	0.75	0.69
Δ	<i>M</i>	-0.02	-0.07	-0.07	-0.07	0.05	-0.05	-0.01	0.00	-0.06	-0.07	-0.03	-0.05	-0.04
	<i>SD</i>	0.66	0.62	0.64	0.73	0.76	0.77	0.61	0.73	0.74	0.69	0.68	0.65	0.69
social support†														
positive	<i>M</i>	3.23	3.14	3.18	3.23	3.20	2.92	3.10	3.09	3.22	2.96	3.23	3.15	3.18
	<i>SD</i>	0.54	0.52	0.54	0.56	0.56	0.65	0.63	0.61	0.57	0.61	0.53	0.48	0.56
	<i>N</i>	440	288	225	265	118	99	230	435	359	82	613	84	3,238
negative	<i>M</i>	1.93	1.94	1.84	2.09	1.97	1.96	1.85	1.99	2.08	1.99	1.86	1.82	1.94
	<i>SD</i>	0.60	0.50	0.58	0.64	0.61	0.51	0.60	0.59	0.55	0.56	0.46	0.47	0.55
	<i>N</i>	439	288	225	265	117	99	230	435	359	82	613	84	3,236
acculturative discrimination†	%	20.46	25.68	25.04	34.53	21.21	27.17	10.81	14.55	26.10	22.62	NA	NA	22.34
moved neighbourhood†	<i>N</i>	417	216	212	226	119	91	217	425	331	79			2,333
	%	22.09	11.43	14.36	14.72	18.99	8.03	7.89	16.69	21.91	17.58	26.63	18.07	18.90
Confounder – 1 st generation migrant specific variables†														
migrated for family†	%	64.11	NA	84.34	NA	78.35	NA	75.76	NA	56.77	NA	43.76	NA	59.07

variable	stat.	Indian ($N_{rw} = 942$)		Pakistani ($N_{rw} = 508$)		Bangladeshi ($N_{rw} = 248$)		Black Caribbean ($N_{rw} = 678$)		Black African ($N_{rw} = 564$)		White Other ($N_{rw} = 987$)		Total
		1 st	UK	1 st	UK	1 st	UK	1 st	UK	1 st	UK	1 st	UK	
		gen.	born	gen.	born	gen.	born	gen.	born	gen.	born	gen.	born	
	<i>N</i>	436		198		112		228		294		619		1,887
negative context of reception†														
negative reception	<i>M</i>	2.05	NA	1.62	NA	2.18	NA	2.19	NA	2.00	NA	2.04	NA	2.02
	<i>SD</i>	0.71		0.71		1.09		1.02		0.93		0.85		0.86
	<i>N</i>	435		195		109		222		297		618		1,876
unfair context	<i>M</i>	1.93	NA	1.69	NA	2.02	NA	2.11	NA	1.82	NA	1.82	NA	1.87
	<i>SD</i>	0.62		0.68		1.06		0.90		0.78		0.75		0.76
	<i>N</i>	436		195		109		231		298		612		1,881
English difficulty†	%	9.99	NA	19.78	NA	27.55	NA	0.00	NA	3.93	NA	15.66	NA	7.47
	<i>N</i>	550		272		142		287		430		777		4,004
Confounder – neighbourhood and individual sociodemographic														
lagged IMD	<i>M</i>	21.35	23.64	31.94	32.15	30.89	27.35	26.40	26.00	29.66	25.42	18.09	14.46	24.42
	<i>SD</i>	11.29	13.71	13.24	14.79	13.53	14.90	12.51	12.42	12.45	15.82	11.81	10.41	13.64
lagged equivalized household income (£10,000 lag)	<i>M</i>	0.13	0.14	0.09	0.09	0.10	0.14	0.10	0.12	0.10	0.11	0.16	0.18	0.13
	<i>SD</i>	0.10	0.09	0.05	0.08	0.09	0.09	0.19	0.11	0.07	0.07	0.16	0.20	0.12
female	%	41.11	43.16	43.57	52.31	41.78	56.06	60.28	59.90	53.98	74.80	55.35	44.24	51.77
lagged age	<i>M</i>	44.49	31.07	40.49	28.90	35.97	34.58	54.28	35.00	37.04	37.76	40.02	42.49	38.59
	<i>SD</i>	14.16	9.25	12.66	9.06	10.41	17.08	15.21	12.11	13.91	11.29	14.11	13.58	14.32
lagged married/partner	%	83.54	45.46	81.69	49.89	79.45	44.20	44.37	35.02	50.97	21.71	66.75	71.00	58.47
lagged employed	%	65.24	69.34	55.30	46.29	65.31	62.78	59.85	63.83	59.77	75.62	75.65	70.11	65.25
lagged education degree	%	42.53	41.32	42.14	33.61	38.44	12.00	15.57	19.71	37.08	36.31	43.26	55.10	36.08
advanced	%	27.27	33.29	18.93	26.06	21.95	35.44	27.57	38.41	39.88	50.19	25.92	29.69	30.59
≤ secondary	%	30.20	25.39	38.92	40.33	39.61	52.56	56.86	41.88	23.05	13.50	30.82	15.21	33.33
lagged health condition	%	33.52	21.01	36.35	18.03	34.45	24.83	58.02	33.67	20.95	27.60	18.49	43.92	27.72

Note. N_{rw} = # responses across waves, N_r = # unique respondents, stat. = descriptive statistics,

gen. = generation, lag = value in the analytical wave prior (wave 1, 3, or 6) to the outcome

wave (wave 3, 6, or 9), Δ = change between lag wave and outcome wave, IMD = Index of

Multiple Deprivation. † Variable was not included in the main analysis but was analysed

using a sub-sample (see Appendix B for sub-sample descriptive statistics), NA = data was

either completely missing (e.g., variables that are only relevant for 1st generation migrants) or

the sub-sample that responded was too small to be include in any analyses (e.g., discrimination for White Other respondents).

Main Analyses

For the Main Analysis Model (Model 1), the Average Marginal Effects (AME) of lagged- and change in ethnic density were calculated for each generation of each ethnic group and are presented in Table 3.4 Panel A. The estimated fixed effects coefficients for lagged and change in ethnic density, ethnic group, generation and their interaction terms are presented in Table 3.4 Panel B. Panel B also includes the estimates for wave, IMD, lagged and change in social cohesion, and lagged psychological distress. To make Table 3.4 more compact and to make it easier to compare between ethnic groups and across waves, the ethnic groups are presented in separate columns. In other words, in these tables, the columns represent ethnic group and not separate models.

In the Main Analysis Model, positive change in ethnic density (i.e., an increase in ethnic density) only significantly negatively predicted psychological distress for Black Caribbean respondents, and UK born Pakistani and Black African respondents. Change in ethnic density was not significant for the reference group (i.e., UK born Indian respondents) or any other groups. Likewise, being born in the UK, compared to being 1st generation, did not significantly predict psychological distress for Indian respondents, and 1st generation Indian respondents were not significantly more or less likely to experience poor psychological distress than 1st generation respondents who identified with any other ethnic group. In accordance with those average marginal effects (AME), the two-way interaction between change in ethnic density and ethnic group was significant for Black Caribbean respondents. In other words, the association between change in ethnic density and psychological distress was significantly stronger for Black Caribbean respondents than for Indian respondents. Additionally, the three-way interaction including change in ethnic density

was significant for Black Caribbean respondents, which indicates that the association between change in ethnic density and psychological distress was stronger for UK born Black Caribbean respondents than for 1st generation Indian respondents. However, no other interactions were significant. The only significant AME for lagged ethnic density was for UK Born White Other respondents and that association only marginally passed the $<.05$ significance threshold. However, the relevant interactions between lagged ethnic density and ethnic group did not reach significance for White Othe respondents.

For the Main Analysis Model (Model 1), the AME for change in ethnic density were plotted in Figure 3.2 to depict how the estimates vary and overlap between ethnic groups and generations. The significant two-way interaction between change in ethnic density and ethnic group for Black Caribbean respondents, compared to the Indian reference group, can be seen in Figure 3.2. Likewise, that figure also shows how, in the three-way interaction, the association between change in ethnic density was stronger for UK born Black African respondents than for 1st generation Indian respondents.

A post-hoc comparison was conducted to test the interaction between generation and change in ethnic density for Black African respondents. This found that UK born Black African respondents were only predicted to have significantly lower psychological distress than 1st generation Black African respondents when change in ethnic density was ≤ -2.75 percentage points. However, only 4.87% of 1st generation- and 2.45% of UK born Black African respondents had a greater reduction in ethnic density than that. As such, for most changes in ethnic density that were really experienced, generation did not significantly predict psychological distress for Black African respondents.

To examine how the estimated relationships between measures of ethnic density and psychological distress may be influenced by the inclusion of potential confounders, mediators, and moderators, four simpler preliminary models were assessed. The first model

(Model 1.1) only included change in ethnic density and lagged ethnic density. The second model (Model 1.2) included IMD and then the third model (Model 1.3) included interactions between each measure of ethnic density and both ethnic group and generation. The fourth model (Model 1.4) included lagged- and change in social cohesion to examine whether the ethnic density coefficients would be influenced by the presence of a possible mediator. Before the interaction terms were introduced in Model 1.3, neither lagged- nor change in ethnic density significantly predicted psychological distress, which is likely explained by those variables only being significant for very few groups in Models 1.3 and 1.4 and the main analysis model. None of the AME, or interaction terms for the ethnic density variables were substantively changed when lagged and change in social cohesion were included in Model 1.4. A notable difference between the results for Model 1.4 and the Main Analysis Model is that change in ethnic density only became a significant predictor of psychological distress in the main analysis model following the inclusion of lagged psychological distress and a series of potential confounders. These full results for each of these models are included in Appendix B Additional and Interim Analyses.

Table 3.4

Average Marginal Effects (Panel A) and Fixed Effects Coefficients (Panel B) for Model 1.

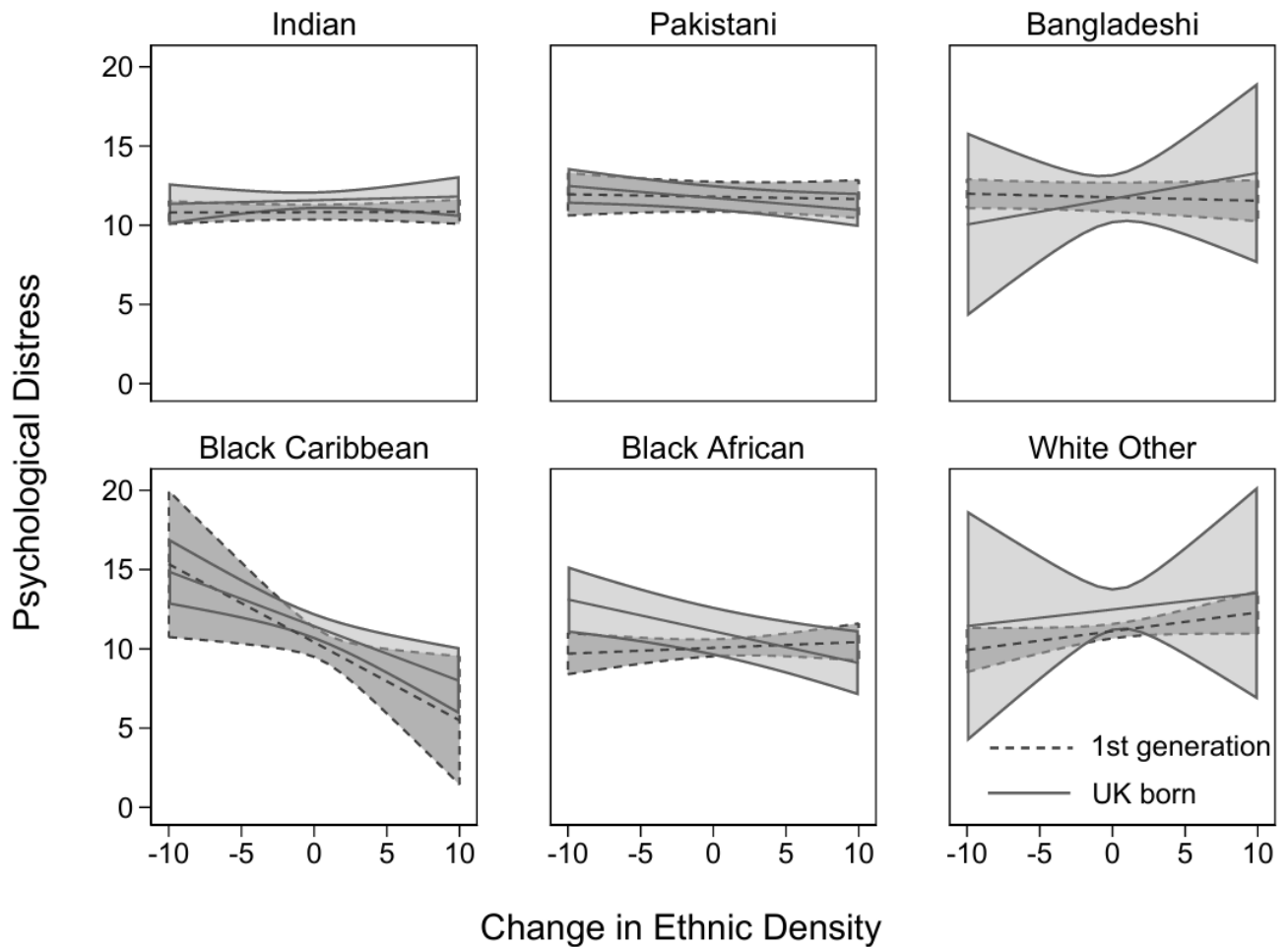
Panel A		Indian			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
variable	gen.	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p
Δ ethnic density	1 st gen.	0.00	0.03	.936	-0.02	0.04	.728	-0.02	0.03	.494	-0.49	0.22	.023*	0.04	0.06	.517	0.12	0.07	.072
lagged ethnic density	1 st gen.	0.01	0.01	.521	-0.01	0.02	.521	0.01	0.02	.426	-0.07	0.08	.410	-0.01	0.03	.866	0.02	0.02	.452
Δ ethnic density	UK born	0.02	0.06	.697	-0.08	0.04	.047*	0.16	0.28	.566	-0.35	0.10	<.001***	-0.20	0.07	.005**	0.10	0.35	.767
lagged ethnic density	UK born	-0.01	0.02	.550	0.02	0.02	.263	0.00	0.03	.948	-0.01	0.05	.843	-0.13	0.07	.062	0.15	0.08	.048*
Panel B		reference group†			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
variable		b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p
intercept		7.12	0.89	<.001***															
Δ ethnic density		0.00	0.03	.936															
lagged ethnic density		0.01	0.01	.521															
UK born		1.05	0.58	.068															
ethnic group					1.23	0.71	.085	0.89	0.66	.178	0.60	0.95	.633	-0.58	0.55	.291	0.16	0.41	.699
Δ ethnic density X UK born		-0.02	0.03	.361															
lagged ethnic density X UK born		0.02	0.06	.746															
Δ ethnic density X ethnic group					-0.02	0.05	.737	-0.03	0.04	.574	-0.50	0.22	.023*	0.03	0.06	.591	0.12	0.07	.111
lagged ethnic density X ethnic group					-0.02	0.02	.363	0.00	0.02	.861	-0.08	0.08	.357	-0.01	0.03	.666	0.01	0.03	.748
UK born X ethnic group					-1.54	1.02	.130	-1.01	1.35	.453	-0.80	1.14	.482	1.66	1.06	.117	-1.44	0.97	.138
Δ ethnic density X					-0.08	0.09	.344	0.16	0.29	.575	0.13	0.25	.608	-0.26	0.11	.022*	-0.03	0.36	.924
UK born X ethnic group																			
lagged ethnic density X					0.05	0.04	.123	0.01	0.04	.786	0.08	0.10	.416	-0.10	0.08	.200	0.16	0.08	.060
UK born X ethnic group																			
wave 6		-0.18	0.24	.446															
wave 9		0.06	0.25	.793															
lagged IMD		0.01	0.01	.117															
lagged social cohesion		-0.76	0.19	<.001***															
Δ social cohesion		-1.34	0.18	<.001***															

Note. Marginal $R^2 = .27$. # = model number. † Reference group: 1st generation Indian with mean lagged and change in ethnic density. Δ = change between lagged wave and outcome wave. gen. = generation, AME = average marginal effect. Model 1 additionally controlled for sex, lagged age, lagged employment, lagged education, lagged marriage status, lagged health conditions, lagged equalised household income, and lagged psychological distress.

* $p < .05$; ** $p < .01$; *** $p < .001$

Figure 3.2

Association between change in ethnic density and psychological distress grouped by generation and ethnic group in the Main Analysis Model (Model 1).



Note. Dashed lines show average marginal effect (AME) for 1st generation migrants in each group and the 95% Confidence Intervals at each value of change in ethnic density. Solid lines show AME and 95% CI for UK born respondents. Estimates are from Model 1 (see Table 3.4). Model 1 controlled for wave, IMD, social cohesion, lagged psychological distress, sex, lagged age, lagged employment, lagged education, lagged marriage status, lagged health conditions, and lagged equivalised household income.

Additional Analyses

A series of additional models were analysed to examine whether the AME of lagged- and change in ethnic density and their related interactions terms that were estimated in the Main Analysis Model were robust to the inclusion of several proxies for acculturative stressors and acculturative stress.

1st Generation Migrants

The analysis was repeated solely for 1st generation migrants to assess the confounding role of four variables that were specific to 1st generation migrants (1st Generation Model: Model 2, Table 3.5; for descriptive statistics see Appendix B Table B.4). The additional variables in this model were perceived negative reception, perceived unfair context, English language communication difficulties, and whether respondents migrated to the UK for family reasons. However, none of these variables had a significant relationship with psychological distress. Additionally, none of the partial effects or interaction terms for the measures of ethnic density, ethnic group, and ethnic group were significant in this model. The only significant AME was for the relationship between change in ethnic density and psychological distress for Black African respondents.

To probe the differences in the results between the Main Analysis Model and the 1st Generation Model an interim model was tested using the Main Analysis Model specification of variables and the 1st Generation Model's sample (see Appendix B Table B.5). This model showed that the differences could be attributed to restricting the sample to only respondents that answered the migration specific questions, rather than to adjusting for migration specific variables in the model. As the 1st generation specific variables neither significantly predicted psychological distress nor impacted the associations between the ethnic density variables and psychological distress, there is no evidence that those variables acted as unmeasured confounders in the Main Analysis Model.

Table 3.5

Average Marginal Effects of Lagged- and Change in Ethnic Density (Panel A) and Fixed Effects Coefficients (Panel B) after adjusting for Acculturative Stressors and Reasons for Migration (Model 2).

Panel A variable	Indian			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p
Δ ethnic density	-0.01	0.03	.742	0.03	0.04	.500	-0.01	0.04	.805	-0.66	0.40	.102	0.09	0.04	.049 *	0.08	0.07	.227
lagged ethnic density	.017	.017	.332	.003	.017	.848	.016	.018	.350	-.082	.087	.348	.017	.031	.584	.040	.030	.181
	<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>	
	435	202		195	97		109	59		218	104		293	145		602	247	
Panel B variable	reference group†			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
	b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p
intercept	7.54	1.27	<.001 ***															
Δ ethnic density	-0.01	0.03	.742															
lagged ethnic density	0.02	0.02	.332															
ethnic group				0.86	0.74	.251	0.68	0.71	.340	1.13	1.09	.301	-0.80	0.56	.154	0.03	0.47	.947
Δ ethnic density X ethnic group				0.04	0.05	.449	0.00	0.04	.989	-0.65	0.40	.107	0.10	0.05	.060	0.09	0.08	.220
lagged ethnic density X ethnic group				-0.01	0.02	.588	0.00	0.02	.994	-0.10	0.09	.268	0.00	0.03	.986	0.02	0.04	.503
migrated for family	0.01	0.23	.971															
negative reception	-0.03	0.16	.869															
unfair context	0.21	0.17	.230															
English language difficulty	0.04	0.39	.918															

Note. Marginal $R^2 = .30$. N_{rw} = number of responses across waves, N_r = number of unique respondents, AME = average marginal effect, Δ = change between lagged wave and outcome wave, IMD = English Index of Multiple Deprivation score excluding health domain, GHQ-12 = psychological distress.

† Reference group are 1st generation Indian with mean lagged and change in ethnic density. Reference categories for other variables were wave 3, migrated for reasons other than family, no difficulty communicating in English. This model also included all confounders that were included in Model 1.

* $p < .05$; ** $p < .01$; *** $p < .001$

Social Support

The Main Analysis Model (Model 1) was next repeated to include positive and negative social support to assess whether the associations between ethnic density and psychological distress were robust to the inclusion of these measures of social support (Social Support Model: Model 3). Respondents were only asked to complete the social support measures in waves 2 and 5, so only outcomes measured at waves 3 and 6 could be included in this analysis. In the Social Support Model, neither the simple effect of generation nor any of the interaction terms were significant (see Model 3, Table 3.6; for descriptive statistics see Appendix B Table B.6). The only significant simple effect of ethnic group was for 1st generation Pakistani respondents who were more likely to have higher psychological distress than the reference group (1st generation Indian respondents). Like the Main Analysis Model, change in ethnic density significantly predicted psychological distress for UK born Black Caribbean respondents. But unlike the Main Analysis Model, that association was not significant for UK born Black African respondents. Both positive and negative social support significantly predicted psychological distress. As expected, psychological distress tended to be higher for respondents with more negative social support and less positive social support.

An interim model (see Appendix B Table B.7, and Table B.8) was assessed to understand the cause of the differences in results between the Main Analysis Model (Model 1) and the Social Support Model (Model 3). That analysis revealed that the differences between the Main Analysis Model and the Social Support Model could be attributed to the sample restrictions rather than to adjusting for the social support variables.

Table 3.6

Average Marginal Effects of Lagged- and Change in Ethnic Density (Panel A) and Fixed Effects Coefficients (Panel B) after Adjusting for Social Support (Model 3).

Panel A		Indian			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
variable	Gen.	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p
Δ ethnic density	1st gen.	-0.02	0.04	.603	-0.05	0.05	.345	0.00	0.03	.963	-0.54	0.29	.067	-0.01	0.07	.865	0.13	0.06	.053
lagged ethnic density	1st gen.	0.00	0.01	.725	-0.01	0.02	.468	0.02	0.02	.293	-0.09	0.08	.264	0.00	0.04	.940	0.01	0.03	.707
Δ ethnic density	UK born	0.04	0.08	.612	-0.06	0.05	.160	0.17	0.27	.524	-0.33	0.14	.014 *	-0.01	0.11	.892	0.02	0.47	.965
lagged ethnic density	UK born	-0.01	0.02	.817	0.03	0.02	.138	0.01	0.04	.764	0.01	0.04	.801	-0.11	0.11	.296	0.14	0.09	.111
		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>	
	1st gen.	439	298		225	159		117	85		230	161		359	258		613	385	
	UK born	288	187		265	185		99	76		435	283		82	54		84	50	
Panel B		reference group†			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
variable		b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p
intercept		7.34	1.31	<.001 ***															
Δ ethnic density		-0.02	0.04	.603															
lagged ethnic density		0.00	0.01	.725															
UK born		0.90	0.59	.131															
ethnic group					1.92	0.84	.022 *	0.76	0.63	.229	0.97	0.94	.301	-0.88	0.61	.149	0.34	0.42	.421
Δ ethnic density X UK born		0.06	0.09	.491															
lagged ethnic density X UK born		-0.01	0.03	.700															
Δ ethnic density X ethnic group					-0.03	0.06	.616	0.02	0.05	.715	-0.52	0.30	.079	0.01	0.08	.931	0.14	0.07	.051
lagged ethnic density X ethnic group					-0.02	0.02	.423	0.02	0.02	.517	-0.10	0.08	.246	-0.01	0.04	.847	0.01	0.03	.864
UK born X ethnic group					-2.10	1.12	.061	-0.45	1.40	.748	-1.50	1.15	.193	1.53	1.08	.156	-1.02	1.04	.328
Δ ethnic density X UK born X ethnic group					-0.08	0.12	.516	0.11	0.29	.692	0.15	0.34	.668	-0.06	0.16	.683	-0.17	0.48	.733
lagged ethnic density X UK born X ethnic group					0.05	0.04	.176	0.00	0.05	.965	0.11	0.10	.241	-0.10	0.12	.397	0.14	0.09	.140
positive social support		-0.85	0.22	<.001 ***															
negative social support		1.17	0.22	<.001 ***															

Note. Marginal R² = .30. AME = average marginal effect, gen. = migrant generation, Δ = change between lagged wave and outcome wave, *N_{rw}* = number of responses across waves, *N_r* = number of unique respondents. † Reference group are 1st generation Indian with mean lagged and change in ethnic density. This model also included all confounders that were included in Model 1. * *p* < .05; ** *p* < .01; *** *p* < .001

Discrimination

The Main Analysis Model (Model 1) was repeated after adjusting for discrimination (Discrimination Model: Model 4). White Other respondents were excluded from this sample because very few White Other respondents were asked the discrimination questions. In the Discrimination Model, discrimination significantly predicted psychological distress, which indicated that respondents who experienced discrimination were more likely to later report worse psychological distress (see Model 4, Table 3.7; for descriptive statistics see Appendix B Table B.9).

Compared to the Main Analysis Model, change in ethnic density was no longer a significant predictor for UK born Pakistani or 1st generation Black Caribbean respondents in the Discrimination Model, but change in ethnic density remained a significant predictor for UK born Black Caribbean and UK born Black African respondents.

The partial effect of UK born remained significant, and the partial effects for ethnic group became significant for Pakistani respondents. That indicates that 1st generation Pakistani respondents were more likely to report worse psychological distress than the reference group (1st generation Indian respondents). The interaction between change in ethnic density and ethnic group was no longer significant for Black Caribbean respondents and the interaction between generation and ethnic group was significant for Pakistani respondents. As in the Main Analysis Model (Model 1), the interaction between change in ethnic group, UK born, and ethnic group was significant for Black African respondents.

To establish whether differences between the Main Analysis Model and the Discrimination Model were due to changes in the sample or the inclusion of discrimination, an interim model was analysed (see Appendix B Table B.10). The results of the Discrimination Model were not substantively different from that interim model. So, the differences between the Main Analysis Model and the Discrimination Model can be

attributed to the reduction in the sample size rather than to the influence of adjusting for discrimination.

Supplementary Analysis

As the differences between the Full Analysis Model and the Discrimination Model, could be attributed to differences in sample size, the analysis was repeated after replacing discrimination with a different measure of exposure to discrimination that was answered by a wider sample of respondents. For that measure, respondents were asked how often racist attacks occurred in their neighbourhood. The full results for that analysis are presented in Appendix B Supplementary Analysis Neighbourhood Racism. In agreement with the Discrimination Model, those results showed that adjusting for measures of discrimination did not substantively alter the estimated relationships between measures of ethnic density and psychological distress.

In Appendix B Supplementary Analysis, we included two further models to assess the robustness of the findings from the Main Analysis Model. In the first of these models, we assessed whether ethnic density was only related to psychological distress for respondents who did not have other another source of cultural engagement that could prevent cultural isolation. That other source of cultural engagement was a measure of how easily respondents could visit family members. Ease of visiting family members was specified to interact with lagged- and change in ethnic density in a model that omitted the other interaction terms that were included in the Main Analysis Model. The interaction between ethnic density and ease of visiting family was not significant, which indicated that the relationship between measures of ethnic density and psychological distress were not conditional on whether respondents could easily visit their family members.

For the final Supplementary Analysis model, we reran the Main Analysis Model specification on a sample that excluded any responses from respondents who moved

neighbourhood between their predictor wave (i.e., when lagged ethnic density was measured) and their outcome wave (i.e., when psychological distress was measured). In that model none of the AME for lagged- and change in ethnic density were significant, which may indicate that the significant relationships in the Main Analysis Model reflected the influence of moving to a new neighbourhood rather than the experience of ethnic density changing in a neighbourhood over time.

Table 3.7

Average Marginal Effects of Lagged- and Change in Ethnic Density (Panel A) and Fixed Effects Coefficients (Panel B) after Adjusting for Discrimination (Model 4).

Panel A variable	Gen.	Indian			Pakistani			Bangladeshi			Black Caribbean			Black African		
		AME	SE	p	AME	SE	p	AME	SE	p *	AME	SE	p	AME	SE	p
Δ ethnic density	1st gen.	-0.01	0.04	.747	-0.02	0.05	.709	-0.01	0.04	.689	-0.77	0.43	.076	0.06	0.06	.346
lagged ethnic density	1st gen.	0.01	0.02	.397	-0.02	0.02	.292	0.02	0.02	.271	-0.10	0.08	.238	0.02	0.03	.497
Δ ethnic density	UK born	0.05	0.08	.553	-0.05	0.04	.183	0.12	0.23	.617	-0.55	0.16	<.001 ***	-0.24	0.07	.001 **
lagged ethnic density	UK born	-0.01	0.03	.666	0.03	0.02	.187	0.02	0.04	.633	0.00	0.06	.982	-0.09	0.08	.222
		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>	
	1st gen.	417	247		212	126		119	74		217	127		331	211	
	UK born	216	119		226	146		91	63		425	220		79	43	
Panel B variable	reference group†	b	SE	p	Pakistani			Bangladeshi			Black Caribbean			Black African		
		b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p
intercept		7.04	1.25	<.001 ***												
Δ ethnic density		-0.01	0.04	.747												
lagged ethnic density		0.01	0.02	.397												
UK born		1.40	0.64	.030 *												
ethnic group					1.82	0.88	.039 *	1.12	0.88	.201	0.79	1.10	.473	-0.87	0.59	.139
Δ ethnic density X UK born		0.06	0.08	.480												
lagged ethnic density X UK born		-0.03	0.03	.363												
Δ ethnic density X ethnic group					-0.01	0.06	.916	0.00	0.05	.970	-0.76	0.44	.082	0.07	0.07	.332
lagged ethnic density X ethnic group					-0.03	0.02	.178	0.01	0.02	.784	-0.11	0.09	.188	0.01	0.03	.842
UK born X ethnic group					-2.87	1.17	.014 *	-2.26	1.67	.177	-1.45	1.31	.266	1.29	1.19	.279
Δ ethnic density X UK born X ethnic group					-0.09	0.10	.398	0.07	0.25	.776	0.16	0.46	.738	-0.36	0.13	.005 **
lagged ethnic density X UK born X ethnic group					0.07	0.04	.062	0.02	0.05	.644	0.12	0.11	.249	-0.09	0.09	.303
discrimination		1.53	0.32	<.001 ***												

Note. Marginal $R^2 = .29$. AME = average marginal effect, gen. = migrant generation, Δ = change between lagged wave and outcome wave, N_{rw} = number of responses across waves, N_r = number of unique respondents. † Reference group are 1st generation Indian with mean lagged and change in ethnic density.

Reference categories for other variables were wave 3, migrated for reasons other than family, no difficulty communicating in English. This model also included all confounders that were included in Model 1. * $p < .05$; ** $p < .01$; *** $p < .001$

Discussion

Summary

This study examined whether psychological distress was prospectively predicted by ethnic density, which is a measure of the proportion of people in a neighbourhood who shared a respondent's ethnic identity. We combined three longitudinal periods (waves 1–3, 3–6, 6–9) in moderated multilevel model analyses and tested whether two measures of ethnic density predicted psychological distress at the end of each period. *Lagged ethnic density* represented ethnic density at the start of each period and *change in ethnic density* was measured between the start and end of each period. As different ethnic minority groups in the UK have had different histories of migration to and settlement in the UK, we tested whether lagged- and change in ethnic density interacted with ethnic group and (migrant) generation when predicting psychological distress. We also controlled for lagged psychological distress to adjust for any baseline confounding, which meant that the other variables could then be interpreted as predictors of change in psychological distress. Change in ethnic density was found to significantly negatively predict psychological distress for Black African, Black Caribbean, and Pakistani respondents who were born in the UK as well as for 1st generation migrant Black Caribbean respondents. However, change in ethnic density did not significantly predict psychological distress for any other groups and lagged ethnic density was only significant and positive for UK born White Other respondents. Additionally, the interaction terms between change in ethnic density, generation, and ethnic group indicated that the relationship between change in ethnic density and psychological distress for UK born Pakistani respondents was not significantly different from non-significant coefficient that was found for the reference group (1st generation migrant Indian respondents). Likewise, the interactions that included lagged ethnic density revealed that the relationship between lagged ethnic density and psychological distress for UK born White Other respondents was not

significantly different from the reference group's non-significant coefficient. Whereas significant interaction terms for Black Caribbean respondents and UK born Black African respondents supported the veracity of the significant negative estimates for change in ethnic density for those groups. As explained in the introduction to this chapter, we did not hypothesise about the specific patterns of the interactions between ethnic group, generation, and ethnic density because the role of ethnic density may vary across groups for many different reasons, such as extent of structural and interpersonal discrimination that each group has experienced, or the availability of cultural and financial resources. However, the years covered by the waves of this study included the then UK Government's introduction of their "hostile environment policy" in 2012 which caused the Windrush Scandal that threatened and troubled many Black Caribbean people in the England (JCWI, 2024; Jeffery et al., 2024; Taylor, 2018). That may have meant that the data was collected at a time when, compared to other ethnic groups, Black Caribbean people could find the most benefits of ethnic density through protection from discrimination and through cultural affirmation, social cohesion, and collective action.

Lagged- and change in social cohesion were also included in the main analysis. Respondents with better perceived social cohesion in their neighbourhood were more likely to have lower psychological distress, and respondents who experienced an increase in social cohesion were also more likely to report lower psychological distress. This supports the results of previous studies that found beneficial associations between social cohesion and psychological distress (Bécares & Nazroo, 2013; Chum et al., 2022). Analyses that are detailed in Appendix B Preliminary Models, revealed that the associations between ethnic density variables and psychological distress were mostly robust to the inclusion of social cohesion.

Several additional models were tested to examine whether the associations between ethnic density and psychological distress were robust to the inclusion of other potential moderators, confounders and mediators.

First generation migrants' motivation for moving to the UK and experience of settling in the UK may influence the neighbourhoods that they end up living in, whether that is through choice or external pressures. So, an additional set of analyses were conducted where only 1st generation migrants were included in the sample and an additional set of potential confounders were included in the model. Those measures were: reason for migration, experience of negative context of reception in the UK, and English language difficulties. However, none of those variables significantly predicted psychological distress and they did not substantively impact the associations between ethnic density and psychological distress. The lack of positive association between the negative context of reception variables and psychological distress conflicts with previous research findings (Cano et al., 2015; Schwartz et al., 2018), but previous studies had all used different operationalisations of the variables.

Social support has previously been posited as a mechanism through which ethnic density may influence psychological distress (Bécares et al., 2018). For people who regularly engage with multiple cultural groups, measures of positive and negative social support with close contacts (e.g., spouse, family, and friends) may also be an indicator of their experience of intercultural relations or bicultural stress. Respondent's disagreements with their close contacts regarding cultural behaviours and attitudes may be captured in their reporting of more negative social support or less positive social support. Of the UKHLS waves that were used in this study, social support was only measured in waves 2 and 5, so it could only be considered as a mediator for outcomes in waves 3 and 6. Psychological distress was found to be significantly higher for respondents with higher negative social support or lower positive social support, which corroborates the findings of previous studies (Mulvaney-Day et al.,

2007; Stephens & Bakhshandeh Bavarsad, 2025). The inclusion of social support in the analyses did influence the average marginal effects of ethnic density for some groups, but those differences were evaluated to be due to the sample being restricted rather than being a consequence of adjusting for social support. In agreement with our findings, Das-Munshi et al. (2010) found that, in England, social support did not mediate the associations they found between ethnic density and common mental health disorder risk.

Discrimination is another mechanism that has previously been proposed to explain how ethnic density may influence psychological distress (Bécares, 2014; English et al., 2014). Previous studies have found that experiences of discrimination may be less common in areas of higher ethnic density, which could be protective against psychological distress. In the present study (acculturative) discrimination measured whether, in the previous 12 months, respondents had experienced discrimination related to their ethnicity, nationality, religion, language or accent, or dress or appearance. We found that discrimination predicted psychological distress, but the inclusion of discrimination in the analyses did not substantively alter the associations between the measures of ethnic density and psychological distress. These results support with the findings of Das-Munshi et al. (2010), who found that a measure of discrimination did not mediate the association between ethnic density and common mental health disorder risk.

To assess whether change in ethnic density was only predictive of psychological distress for respondents who moved neighbourhood between the start and end of that change period, we ran a supplementary analysis which excluded respondents who moved neighbourhood. An analysis using that restricted sample did not find any of the associations between change in ethnic density and psychological distress that had been found in the main analysis. This indicated that the relatively small changes in ethnic density that occur in most neighbourhoods over the course of two or three years are not sufficient to be associated with

changes in psychological distress. Whereas people with ethnic minority identities who move to a neighbourhood of higher ethnic density may be more likely to experience a decrease in their levels of psychological distress.

Strengths and Limitations

This study examined whether the longitudinal associations between ethnic density, measured at the LSOA level, and psychological distress vary in the UK across ethnic groups and generations. Previous studies have focused on some of these aspects (Das-Munshi et al., 2010; Dorsett et al., 2019; Halpern & Nazroo, 2000; Nandi et al., 2020; Propper et al., 2005), but none to the authors' knowledge have combined them all. This approach has enabled a more nuanced understanding of how the effects of ethnic density vary across these groups. The use of longitudinal data also facilitated the analysis of changes in ethnic density, which has not been directly assessed in previous studies. The inclusion of lagged psychological distress, measured in same wave as lagged ethnic density, in our final model accounted for any unmeasured factors that may correlate with both lagged ethnic density and the outcome measure of psychological distress. The inclusion of lagged psychological distress in the model thus provides a stronger case for the possible causal relationship between ethnic density and psychological distress.

The analyses also used longitudinal weights to account for unequal probabilities of both selection into the sample and of continuing to respond to each subsequent wave, which should result in the analyses being more representative of ethnic minority populations in England. UKHLS' clustered sampling procedure was also accounted for in these analyses to provide robust standard errors. Finally, this study also addressed several potential mechanisms through which ethnic density may predict psychological distress and considered the role of several domains of acculturative stressors and acculturative stress in moderating, mediating, or confounding that relationship.

Despite UKHLS recruiting a large sample for each of the ethnic groups included in this study, the sample sizes for the present study became substantially smaller because respondents were required to participate in particular pairs of waves to be eligible for inclusion in the sample (i.e., wave 1 and 3, wave 3 and 6, or wave 6 and 9). Additionally, the use of longitudinal weights further restricted the sample to only include respondents who had completed every wave from wave 1 to the wave that the outcome variable was measured in. The final sample included particularly small samples of Bangladeshi, UK born Black African, and UK born White Other respondents. The Ethnic Minority Boost Sample (EMBS) of UKHLS was not designed to recruit an equal number of UK born and 1st generation migrants. So, discrepancies between the sample sizes of each group are likely due to their relative prevalence in the population of England. For example, the majority of 1st generation Black African and UK born White Other migrants arrived in the UK since 2000, so most UK born children of those 1st generation migrants would not have been adults when the sample was recruited or when the data was collected (see Table 3.1 for summaries of the UK population in 2011). Larger sample sizes for each generation of each ethnic group would have been able to provide more reliable results for the three-way interactions used in this study. Additionally, a larger sample size of respondents in each group who moved neighbourhood between waves would have enabled us to fully test the study hypotheses on respondents who moved neighbourhood, which was not possible due to the limited sample included in the present study. A larger sample would also make it possible to fully test each mediation pathway and to examine whether those pathways vary by ethnic groups or generation. For instance, Chum et al. (2022) recently found that associations between social cohesion and psychological distress vary across ethnic groups in England, which we could not assess in the present study.

The definitions of ethnic groups used in this study were based on the 2011 Census of England and Wales. However, these groups may not be the most appropriate groups to use

when conceptualising ethnic density as a measure of cultural in-group density. For instance, 1st generation migrants in the UK who identified as White Other or Black African were born in dozens of different countries. So, individuals who identify with the same ethnic group may not identify each other as cultural in-group members. In previous studies, researchers have assessed the role of ethnic group definitions by testing the association between ethnic density and health outcomes for multiple different definitions of ethnic group. For example, one study considered the role of ethnic density for 1st generation and US born respondents who identified with one of three different groups of Latino Americans: Cuban Americans, Puerto Ricans, and Mexican Americans (Bécares, 2014). They also measured ethnic density in three ways: the proportion of own ethnic group, Latino ethnic group, and Latino American Immigrant ethnic density. They found that the effects of ethnic density varied across groups and across definitions of ethnic density.

The present study also did not address how religious identity or behaviours may influence how individuals' experience ethnic density. Sharing a religious identity with neighbours may have similar effects to sharing an ethnic identity and places of worship may be locations where people can experience strong social cohesion and social support within their neighbourhood. Previous studies that used UKHLS data have grouped respondents by combinations of religious and ethnic identity to create less heterogeneous groupings (Nandi et al., 2020). However, in the UK local area census data is not disaggregated by both ethnic group and religious identity. Likewise, it is not possible to estimate the proportion of a neighbourhood that share a particular combination of ethnic identity and generation, which could have been a more appropriate measure of ethnic density.

There are also many other methods that can be used to estimate the proportion of people who share ingroup identities or to estimate the proportion of people who may share experiences of marginalisation. Alternative metrics include indices of segregation, which

consider how the ethnic density of neighbourhoods are distributed across a larger metropolitan area (Iceland et al., 2011). For instance, living in a neighbourhood with low ethnic density within a metropolitan area of high ethnic density could be more beneficial than living in an area of low ethnic density within a wider area that also had low ethnic density (Kershaw et al., 2024).

The measure of ethnic density used in this study used data from three decennial censuses (2001 – 2021) and ethnic density for inter-census years was linearly imputed. However, it is possible that ethnic density may not linearly change across these time periods so the actual ethnic density and change in ethnic density of respondents' LSOA areas may have been somewhat different from the imputed values.

Conclusions

The present study found that when measured at the LSOA level, the strength of the relationship between ethnic density and psychological distress varied across ethnic minority groups and between people who moved to the UK and people who were born in the UK. Change in ethnic density over a two- or three-year period was found to predict psychological distress at the end of that period for Black Caribbean and UK born Black African respondents. A series of possible confounders including domains of acculturative stressors and acculturative stress, and potential mediators including social cohesion, and social support were used to examine the robustness of the associations between ethnic density and psychological distress. None of these were found to substantially impact that association, so future studies with larger samples will be required to be able to assess the causes and mechanisms of the ethnic density effect.

4. Acculturative Stress and Vagally-Mediated Heart Rate Variability Reactivity Predict Psychological Distress

In the UK, over recent years visa requirements have frequently changed for international students and other 1st generation migrant groups (Migration Advisory Committee, 2024; Sumption et al., 2025), which adds an additional layer of worry to the often-stressful experience of moving to a new country and adapting to a new culture. The present study investigates whether those stresses, or physiological responses to acute stressors, predict psychological distress.

Acculturative Stress

In the framework of the Cultural Stress Theory (Meca & Schwartz, 2024), cultural stresses result from 1st generation migrants and their immediate descendants engaging with multiple cultural groups within a context where they are viewed as “foreigners” and subjected to discrimination or othering. Discrimination, negative context of reception and bicultural stress are all examples of cultural stresses. Negative context of reception is a measure of how much an individual perceives that they are both unwelcome in a country and less likely to have opportunities to succeed because of their cultural heritage. Bicultural stress, also known as intercultural relations stress, refers to the tensions that one can experience when negotiating multiple cultural identities and interacting with each of those cultural groups. Bicultural stress may be worse when there are larger attitudinal and behavioural differences between the cultures that one is negotiating, whereas perceived discrimination and negative context of reception will be worse when one group has experienced to a history of structural racism or xenophobic discrimination from the other group (Meca & Schwartz, 2024).

Depression symptoms have been predicted by perceived discrimination (J. Kim & Tong, 2020), negative context of reception (Schwartz et al., 2014), and bicultural stress (Romero et al., 2007), as well as by a latent variable of cultural stress that combined those

three constructs (Schwartz et al., 2015). These concepts have also been referred to as acculturative stress. Acculturative stress has variously been defined as a subset of bicultural stress (Romero & Piña-Watson, 2017), or as a umbrella term for a wide range of cultural stresses across different domains and levels of context (Benet-Martínez & Haritatos, 2005). The latter operationalization of acculturative stress was used for the Riverside Acculturative Stress Inventory, which includes five domains: language skills, work, intercultural relations, discrimination, and cultural isolation (Benet-Martínez, 2003). Alike other measures of cultural stress, studies that have used the Riverside Acculturative Stress Inventory have found acculturative stress to be associated with measures of psychological health (Merced et al., 2022; Miller, Yang, et al., 2011).

UK Context

Since 2019, there have been large fluctuations in the total number of people moving to the UK each year. The annual total dropped from 788,000 in 2019 to 662,000 in 2020 due to the COVID-19 pandemic, before rising to an annual record of 1,326,000 in 2023, which is approximately 1.9% of the total UK population. That total then fell to 948,000 in 2024 (Office for National Statistics, 2024; Sumption et al., 2025). The increases in total immigration from 2020 were partly due to several key changes to immigration laws and the UK being one of the first countries to reopen to international students after the COVID-19 pandemic (Migration Advisory Committee, 2024). In 2021, the UK reintroduced a Graduate Visa route that enabled graduates to remain in the UK for up to two years after their studies, and for up to three years for research students. This provided security to prospective international students. This new route appears to have been particularly appealing for international students with partners or children as the percentage of student visas that were issued to dependents rose from 3.97% in 2019 to 23.71% in 2023. (Home Office, 2025). The then Conservative UK Government responded to this by banning the dependents of taught

international students, as well as care workers, from moving to the UK from the start of 2024 (Sumption et al., 2025). This is likely to have caused substantial stress to many international students and care workers entering the UK who were consequently separated from their family support networks.

Cardiac Vagal Control

When a stressful event is being experienced, physiological responses are coordinated through the two branches of the autonomic nervous system (ANS), the parasympathetic nervous system (PNS), known as the *rest and digest* system, and the sympathetic nervous system (SNS), known for the *flight or fight* response (Campbell & Wisco, 2021). PNS principally influences heart rate through the vagus nerve, which is the longest cranial nerve connecting the brain to the heart and several other major organs (H.-R. Berthoud & Neuhuber, 2000). The Polyvagal theory argues that mammals developed functional separation of the vagus nerve into two pathways. The dorsal vagal pathway refers to nerves that originate in the dorsal motor nucleus of the vagus, and the ventral vagal pathway refers to nerves that originate in the ventral vagus nucleus (which also known as nucleus ambiguous; Porges, 2023). When mammals are at rest, ventral vagal control persistently reduces their heart rate from a higher rate that is set by the heart's pacemaker, the sinoatrial node. However, when challenged, ventral vagal control withdraws to increase heart rate and allow them to be alert and react appropriately. When a threat persists, the SNS is activated to enable a fight or flight response. In cases of extreme threat, trauma, or risk of death, cardioinhibitory dorsal vagal fibres can be activated. When coupled with reduced ventral vagal control, this activation can induce bradycardia (a slowing of heart rate), which may be the cause of death feigning in some mammals and sudden death in infants and adults. Following traumatic experiences, individuals can often experience autonomic dysregulation.

The dorsal vagal pathways promote digestive processes, so their dysfunction can be seen in the development of gut conditions (Porges, 1995, 2023).

Polyvagal theory also argues that through vertebrate evolution, facial structures used for emotional expression were increasingly connected to the ventral vagus nucleus via intraneuronal connections. These connections created a *social engagement system* that incorporates both emotional expression and cardiac activity (Porges, 2003, 2011, 2023). This system allows mammals to express and vocalize cues of safety or threat to social partners. Cues of threat and safety can be interpreted without conscious awareness, which Polyvagal theory refers to as neuroception (Porges, 2022), and activity in the social engagement system and ventral vagal pathway can be withdrawn or increased accordingly. For instance, the social engagement system includes the neural regulation of middle ear muscles. When those muscles are tensed they tighten the eardrum, which dampens low frequencies sounds and makes the high frequencies in the range of human speech more discernible (Porges, 2003). The expression of positive primary emotions, such as happiness, through facial movement and vocalization may relate to an increase in ventral vagal activity, which reduces heart rate and increases heart rate variability. In contrast, negative emotional expression may be linked to ventral vagal withdrawal which increases heart rate and reduces heart rate variability (Porges, 1995).

The influence of vagal control on the heart, known as *cardiac vagal control*, can be estimated by tracking heart rate variation over the course of respiration (Balzarotti et al., 2017). We previously mentioned that activation in the ventral vagal pathway reduces heart rate when a stressor is not being experienced. However, during inhalation cardiac vagal control is also inhibited, which allows heart rate to increase (Shaffer et al., 2014). Individuals with stronger cardiac vagal control will experience a larger change in heart rate between inhalation and exhalation. In contrast, those with weaker cardiac vagal control will have

smaller decreases in heart rate whilst their cardiac vagal control is uninhibited during exhalation. This pattern of heart rate variation over the course of respiration is called *respiratory sinus arrhythmia* (RSA; Laborde et al., 2017). Various measures of heart activity can utilize the characteristics of RSA to measure cardiac vagal control (see Chapter 4 Methods for further detail). In this paper, we refer to those measurements as *vagally-mediated Heart Rate Variability* (vmHRV; Baumeister-Lingens et al., 2023), where higher values indicate stronger cardiac vagal control. Higher vmHRV at rest has been associated with lower levels of anxiety and depression (Beauchaine, 2015; Muhtadie et al., 2015; Pham et al., 2021), as well as better social functioning and prosocial behaviour (Beauchaine et al., 2013; Piejka et al., 2024). As part of their Generalised Unsafety Theory of Stress, Brosschot et al. (2017) proposed that lower resting vmHRV could be a marker of chronically disinhibited stress responses. Their theory stipulates that by default we assume that our environment is unsafe, which inhibits vagal activity, unless we receive clear signals of safety. However, through early life development and maturation, we learn how to detect safety in complex social situations and in solvable challenges. By adulthood safety can be perceived in most situations, which can inhibit the default stress response and maintain a high vmHRV. However, some people may be less able to detect those safety signals and consequently experience generalised unsafety and develop chronically low vmHRV.

In addition to measuring vmHRV at rest, measuring the change in vmHRV between relaxed conditions and stressful tasks can provide greater insight into how individuals' cardiac vagal control responds to threat. Change in vmHRV is known as vmHRV reactivity. vmHRV can either decrease, increase, or remain stable in response to a stressful task, so we have used the term *negative vmHRV reactivity* to refer to the extent to which vmHRV reduces between a rest period and a stressful task. More negative vmHRV reactivity has been associated with greater emotional sensitivity (Muhtadie et al., 2015) and active coping

(Porges, 2011; Wagner & Abaied, 2015). However, the association between vmHRV reactivity and psychological distress has been inconsistent across studies. For cognitive or social tasks, where active coping is appropriate, a more negative vmHRV reactivity has been associated with less psychological distress (Rottenberg, Clift, et al., 2007; Shinba, 2014). However, when stressors promote negative emotions in situations where active coping is not appropriate, and passive coping and emotional regulation may be more adaptive, less negative vmHRV reactivity has been linked to less psychological distress (Berntson et al., 2016; Fortunato et al., 2013; Gouin et al., 2014; Levine et al., 2016). However, there have also been studies that have found no significant effects or the reverse effects for both negative emotion tasks and cognitive tasks (Adolph et al., 2025; Beauchaine et al., 2019; Brush et al., 2020; Bylsma et al., 2014; Rottenberg et al., 2005).

One reason why results may be inconsistent across studies is that different physiological responses may be more adaptive depending on whether participants were experiencing chronic stress. Boyce and Ellis (2005) proposed that individuals may differ in their *biological sensitivity to context*. In other words, some people may tend to have stronger physiological responses to all stimuli, whereas others tend to have weaker responses. In protective or safe environments without chronic stressors, greater biological sensitivity, such as more negative vmHRV reactivity, may enable individuals to appropriately respond to stressors and consequently experience better psychological health. However, in contexts of chronic stressors or trauma, having a strong physiological response to every stressor may be detrimental to psychological health. As such, in stressful environments lower biological sensitivity may be protective. Whereas, in low stress environments, people with lower biological sensitivity may not experience the potential psychological benefits of their context.

Boyce and Ellis (2005) argued that individual differences in biological sensitivity to context are formed during early development, but they proposed a U-shaped relationship

between early life exposure to stress and biological sensitivity. They proposed that individuals who have very safe and supportive environments will develop high levels of reactivity so that they can benefit from that environment. Likewise, people who experience trauma during their early development also have high physiological reactivity so that they can be vigilant and respond appropriately to extreme threats. Whereas individuals who experience moderate stress during early life will develop lower biological sensitivity. Those individuals may then have a higher threshold for responding to stressors, which means that they can cope better with the stressors of everyday life.

Several studies have found that exposure to chronic stressors or stressful life events interact with vmHRV reactivity in predicting psychological distress, but not always in ways that agree with the theory of biological sensitivity to context.

Gouin et al. (2014) devised a passive coping negative emotion task where they asked students to think about whatever worried them most. Students who experienced more negative vmHRV reactivity were more likely to report higher psychological distress, both cross-sectionally during a period of low stress, and longitudinally in the week before an exam. However, there was a larger difference in psychological distress across levels of vmHRV reactivity during the stressful period, than during the period of low stress. That interaction, is in keeping with the biological sensitivity to context theory, as the stronger physiological responses were more detrimental to psychological health during periods of chronic stress (Boyce & Ellis, 2005). However, unlike that theory, even during the period of lower stress, more negative vmHRV reactivity was less adaptive than blunted reactivity. That may be because some life stressors could have been present even during their low stress period, which would have prevented the more negative vmHRV reactivity from being adaptive. Gouin et al. (2014) proposed an alternative explanation. They argued that because their task asked participants to worry about the future without a real threat being present

greater emotional regulation and passive coping, indexed by less negative vmHRV, were the most adaptive responses to that task. They might agree that in periods of greater stress more negative vmHRV is even less adaptive, but even during periods without any stressors they would not expect more negative vmHRV to be the most adaptive strategy.

These findings appear to contrast with Stange et al. (2017), who found that participants with less negative vmHRV reactivity in response to an emotional stressor, a sad film clip, were more likely to experience worse depression symptoms six months later. They also found that experiencing more stressful life events was a predictor of depression symptoms for participants with less negative vmHRV reactivity, but not for participants with more negative vmHRV reactivity. Their sad clip was from the emotional climax of the film *The Champ* (Zeffirelli, 1979), in which a distraught boy reacts to seeing his father die. Stange et al.'s (2017) findings indicate that people with greater emotional sensitivity and more negative vmHRV reactivity in response seeing someone in emotional distress, may be better able to cope with a range of stressful life events. The results of this study, in part, agree with the biological sensitivity to context theory because a more negative vmHRV reactivity is the most adaptive response when participants have experienced few stressful life events. However, rather than more negative vmHRV reactivity becoming maladaptive for people experiencing more stressful life events, a less negative vmHRV reactivity instead becomes even more maladaptive during those periods.

Gouin et al.'s (2014) task related to worrying about a possible future event, whereas Stange et al.'s (2017) task prompted participants to empathize with someone who was experiencing a traumatic event. The divergent results of the two studies may indicate that a more negative vmHRV reactivity may be appropriate for real or simulated stressful events that require active coping and emotional sensitivity, whereas a smaller vmHRV reactivity may be adaptive for hypothetical events where emotional regulation is more adaptive.

Despite the differences between those two studies, both studies found that the association between vmHRV reactivity and psychological distress was stronger when people were experiencing more stress in their lives. However, further studies are required to identify the boundary conditions for when more negative vmHRV reactivity is adaptive and when it is not.

Vagally-Mediated Heart Rate Variability Reactivity to Acculturative Stress

Few studies have empirically tested how acculturative experiences relate to vmHRV reactivity and psychological measures (Gouin et al., 2015). Doucerain et al. (2022) found that vmHRV reactivity, in response to a task where participants were asked to recall their experiences of discrimination, moderated the association between perceived discrimination and settlement acculturation (a measure of participants' endorsement of mainstream culture). They argued that less negative vmHRV reactivity indicated that participants had greater emotional regulation and therefore were less emotionally affected by their experiences of discrimination and could more comfortably continue to engage with the settlement culture.

A recent study found that immigrant stress significantly predicted resting vmHRV measured 9 months later (Armah et al., 2024). In that study immigrant stress was measured using a subscale of the Hispanic Stress Inventory that included items reflecting discrimination, negative context of reception, and bicultural stress as well as concerns about deportation (Cervantes et al., 1991). Another study found that resting vmHRV interacted with political climate stress to predict anxiety symptoms. Political climate stress is a form of cultural stress that measures how concerned Black and Latina mothers were about the potential impacts of news and political actions on their family's opportunities in the US and the potential threat of immigration officials and police (Hale et al., 2024; Roche et al., 2018). For mothers with low resting vmHRV, there was a significant positive association between political climate stress and anxiety symptoms. However, that relationship was not significant

at high resting vmHRV, which may indicate that individuals with high vmHRV are able to adaptively react to experiences of political climate stress to protect their well-being. In contrast, participants with low vmHRV may not have sufficient regulation of their social engagement system to be able adaptively react to stressors, which may lead to negative psychological health outcomes. These studies found associations between various forms of acculturative stress and resting vmHRV. However, further research will be required to assess whether those findings are translatable to other acculturative stresses or to vmHRV reactivity.

The Present Study

In this study, we extended the use of vmHRV reactivity within the cultural stress literature. We examined vmHRV reactivity in relation to acculturative stress, measured using the Riverside Acculturative Stress Inventory (Benet-Martínez, 2003), and psychological distress, measured using the 12-item general health questionnaire (GHQ-12; Goldberg, 1972). Previous studies have found that acculturative stress (Sirin et al., 2013) and vmHRV reactivity (Hamilton & Alloy, 2016) independently predict psychological distress. However, to the authors' knowledge no previous studies have examined whether acculturative stress and vmHRV reactivity interact in their prediction of psychological distress.

As previously discussed, the relationship between negative vmHRV reactivity and psychological distress may vary depending on whether active or passive coping, and emotional sensitivity or emotional regulation, are the more adaptive response to the study's stressor tasks (Berntson et al., 2016; Gouin et al., 2014). The present study used two negative emotion stressor tasks, where active coping and emotional sensitivity should be adaptive, so we expect that more negative vmHRV reactivity will be associated with lower psychological distress (Stange et al., 2017).

Hypotheses

In line with the previous research findings, less acculturative stress (Sirin et al., 2013) and more negative vmHRV reactivity (Adolph et al., 2025; Stange et al., 2017) were expected to predict less psychological distress.

Hypothesis 1. Acculturative stress positively predicts concurrent psychological distress.

Hypothesis 2. vmHRV reactivity in response to a stressor task positively predicts concurrent psychological distress.

All hypothesized associations may be confounded by several sociodemographic and behavioural measures (namely gender, age, physical activity, subjective social status, and life stressors; see Covariates section in Measures for further details). So, all hypotheses were tested while controlling for those variables. Attentionally, all tests of hypotheses relating to vmHRV reactivity adjusted for resting vmHRV (Doucerain et al., 2022; Muhtadie et al., 2015).

The strength of the association between vmHRV reactivity and psychological distress has previously been found to be stronger when participants are experiencing more stress in their lives (Gouin et al., 2014; Stange et al., 2017), so we expect acculturative stress to interact with vmHRV reactivity in predicting psychological distress. However, theories and empirical evidence conflict in their expectations for the shape of that interaction.

The theory of biological sensitivity to context would indicate that compared to participants who experience a blunted response (i.e., less negative vmHRV reactivity) to an acute stressor, more negative vmHRV reactivity would be associated with lower psychological distress when acculturative stress is low, but with higher psychological distress when acculturative stress is high. However, empirical results from two previous studies indicate that the same level of physiological reactivity will be more adaptive for people

experiencing either high or low acculturative stress, but the benefits of the more adaptive approach will be more pronounced at higher levels of acculturative stress (Gouin et al., 2014; Stange et al., 2017). We expect that emotional reactivity and active coping, indexed by more negative vmHRV reactivity, will be the more adaptive responses to both stressor tasks. However, if emotional regulation and passive coping were instead the most adaptive responses (Beauchaine et al., 2019; Gouin et al., 2014), less negative vmHRV reactivity would be associated with lower psychological distress and that association would be stronger at higher levels of stress.

Another pattern of interactions could be expected if chronic experience of acculturative stressors leads to dysregulation of the ventral vagal system (Loeb et al., 2021; McEwen, 2007). In the current study, physiological dysregulation may present as less negative vmHRV reactivity in response to the stressor tasks and higher psychological distress. The relationship between acculturative stress and psychological distress may be weaker for those participants with less negative vmHRV reactivity because they experience psychological distress irrespective of their current levels of stress. In contrast for participants with less dysregulation, indicated by more negative vmHRV reactivity, would generally have lower psychological distress, but their level of psychological distress would be more strongly associated with their level of acculturative stress.

Hypothesis 3. Acculturative stress and vmHRV reactivity interact in their prediction of concurrent psychological distress. However, there are multiple conflicting possible hypotheses for the shape of that interaction.

The relationships proposed in Hypotheses 1–3 are also expected to hold when psychological distress is measured in a follow-up survey, rather than on the day that participants completed the stressor tasks.

Hypothesis 4–6. Acculturative stress (H4), vmHRV reactivity (H5), and their interaction (H6) prospectively predict psychological distress when the latter is measured in a follow-up survey.

If Hypotheses 3 and 6 found significant interaction effects between acculturative stress and vmHRV reactivity, then we would assess Hypotheses 1, 2, 4, and 5 based on the partial effects for the hypothesised relationships. For Hypothesis 1 (and 4) we would also determine the values of vmHRV reactivity for which acculturative stress is a significant predictor of psychological distress (at follow-up). Likewise for Hypothesis 2 (and 5) we would determine the values of acculturative stress for which vmHRV reactivity is a significant predictor of psychological distress (at follow-up).

Methods

Participants

Between May and December 2024, 1st generation migrants who moved to the UK when aged 18 or older ($N = 228$; 60.09% females) with mean age of 28.02 ($SD = 7.49$, range = 18–61) each participated in a biometric laboratory session. Participants were tested in groups ranging from one to seven participants ($M = 3.37$, $SD = 1.40$). Participants were recruited through established mailing lists as well as through posters and leaflet distributed in the local area and snowball sampling. Individuals with cardiac devices, such as pacemakers, were not eligible to participate. All participants were asked to refrain from consuming caffeine, drinking alcohol, smoking, or intensive exercise for 2 hours before their laboratory session. Sixteen participants engaged in at least one of those behaviours (caffeine: $N = 10$, smoking or alcohol: $N = 6$, intensive exercise: $N = 6$) and a further five participants engaged in moderate exercise in the two hours before their laboratory session. Those 21 participants were retained in the analysis. A sensitivity analyses was conducted to include a dummy variable representing prohibited behaviour (see Descriptive Statistics section for further

details). However, those results did not meaningfully differ from the main analyses, so they are not presented here.

Of the 228 participants, 60.96% responded that their heritage culture, which is the national culture that their family would most identify with other than British, was within Asia, 17.98% identified with an African culture, 13.16% with a European culture, and 7.89% with an American culture. Figure 4.1 provides further details about the countries and sub-regions that participants identified with. More than half of participants also identified with an Asian ethnic group (Asian $N = 125$; Black $N = 38$; White $N = 35$; Multiple ethnic groups $N = 15$; Other ethnic groups $N = 15$).

Figure 4.1

Number and Percentage of Participants by Heritage Culture Region.

Region	# Countries	# Participants	
		<i>N</i>	%
Africa			
Nigeria	1	32	14.04
Rest of Western and Northern Africa	3	4	1.75
Central, Eastern, and Southern Africa	5	5	2.19
Africa Total	9	41	17.98
Americas			
Central and Southern America	3	9	3.95
North America	3	9	3.95
Americas Total	6	18	7.89
Asia			
India	1	67	29.39
Pakistan	1	15	6.58
Rest of Southern Asia	6	13	5.70
Central and Eastern Asia	5	24	10.53
South-Eastern Asia	5	12	5.26
Western Asia	3	8	3.51
Asia Total	21	139	60.96
Europe			
Western Europe	7	16	7.02
Eastern Europe	9	14	6.14
Europe Total	16	30	13.16
Global Total	52	228	100

Most of the 228 participants in the laboratory sample had already completed, or were studying for, a master's degree (highest qualification level: PhD = 22, master's = 127, undergraduate = 63, at least secondary school level qualifications = 14, other = 2). One-hundred and thirty-nine participants were students, of whom 37 were also employed. Of the non-student participants, 63 were employed, 25 were unemployed and looking for work, and one participant's employment status could not be categorised.

Participants were asked to complete a follow-up survey one month later. The follow-up survey was completed by 186 participants (81.59 % of laboratory sample) on average 42.73 days ($SD = 18.26$) after they completed the laboratory session. Ethical approval for this study was granted by an ethics committee at the authors' university (ETH2324-0116).

Procedure

The present study aimed to evaluate how 1st generation migrants' responses to acculturative stress relate to their experience of psychological distress. However, the authors could not find any existing stressor tasks that addressed many domains of acculturative stress. So, Doucerain et al.'s (2022) Discrimination Recall Task, was adapted to ask participants to consider any forms of acculturative stress that they had experienced since moving to the UK. Our novel task closely relates to the stress we intended to evaluate so it should have greater external validity than more generic tasks (Beauchaine et al., 2019). However, using a novel task does make it more difficult to compare our results with previous studies. So, to supplement this novel task, participants first completed another stressor task, a sad film clip, which has previously been found to induce a vmHRV response (Yaroslavsky, Bylsma, et al., 2013). A meta-analysis found that the direction of the association between vmHRV reactivity and measures of psychopathology depended on the emotional valence of the stressor tasks, so the sad film clip was chosen to match the negative valence of the acculturative stress recall task (Beauchaine et al., 2019).

All participants completed consent forms before being fitted with electrocardiograph (ECG) and galvanic skin response (GSR) sensors. A Shimmer 3 ExG device was used for the measurement of vmHRV with one electrode attached to each clavicle and another attached to the left hip. A second Shimmer 3 ExG device was used for the measurement of respiratory rate with one electrode attached to each mid-auxiliary line at the sixth inter-costal space and another attached to the right hip (Shimmer Sensing, 2018).

During initial testing, a sampling rate of 1024Hz was used for both ExG devices in accordance with the recommendations from Beauchaine et al.'s (2019) meta-analysis. However, the devices were found to be liable to failure when recording at that rate, so a sample rate of 512Hz was used instead. That was still above the minimum sampling rate of 256Hz advised by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996). A Shimmer 3 GSR+ sensor was also used to record skin conductance. Only the data collected from the first Shimmer 3 ExG device was used in the present study.

Participants completed two stressor tasks, which were each preceded and followed by different 5-minute clips from a nature documentary, *Alaska's Wild Denali* (Hardesty, 1997). One of those clips has previously been used as a neutral stimulus to aid relaxation (Rottenberg, Ray, et al., 2007). These relaxation and recovery durations had previously been used in other studies (Levine et al., 2016; Volpe et al., 2019).

The first stressor task was a 171 second clip from *The Champ* (Gross & Levenson, 1995; Zeffirelli, 1979). This clip has been widely used to evoke sadness and physiological reactivity (Gilman et al., 2017; Gruber et al., 2014; Yaroslavsky, Rottenberg, et al., 2013).

For the second task, participants were first shown a definition of acculturative stress alongside some examples. They were then asked to think for five minutes about their own experienced of acculturative stress since moving to the UK. This task was adapted from

Doucerain et al.'s (2022) study, which instead asked about experiences of discrimination. After those five minutes, participants were given five minutes to write down what they had thought about during that task.

Next, participants answered a survey that included questions on their physical health, demographic information, neighbourhood social cohesion, social support, discrimination, acculturative stress, and psychological distress. Before participants left the laboratory, they were debriefed, their physiological sensors were removed, and they were paid. Participants were awarded a £20 voucher for participating in the laboratory session plus reimbursement for parking or for their bus fare. One month after the experiment, participants were invited to complete an online follow-up survey that included a subset of the items that were in the baseline laboratory survey. Participants who completed the follow-up survey were entered into a lottery to win a £25 voucher, where one voucher was awarded for every ten participants.

Measures

Outcome

Psychological distress. Psychological distress was measured in both the initial survey and in the follow-up survey using the 12-item general health questionnaire (GHQ-12), which is measured on a 4-point scale with different anchors for each question (Goldberg, 1972). The mean of the 12 items was calculated for each participant and higher values related to worse psychological distress. Both the baseline ($\alpha = .91$) and follow-up ($\alpha = .92$) measures had excellent reliability.

Predictor

Acculturative Stress. Fifteen items were adapted from Riverside Acculturation Stress Inventory (Benet-Martínez, 2003; Benet-Martínez & Haritatos, 2005) to refer to the British context and to refer to difficulties with work, university, or school instead of just work related

problems. Participants responded to all items on a 7-point Likert scale (1 = *strongly disagree*; 7 = *strongly agree*). The mean of these items was calculated for each participant and the measure had good reliability in both the baseline ($\alpha = .81$) and follow-up survey ($\alpha = .88$).

Moderator

vmHRV Reactivity. Vagally-mediated Heart Rate Variability (vmHRV) can be operationalised in several different ways, which can be grouped into frequency domain and time domain methods. In the frequency domain, vmHRV can be measured using High-frequency heart rate variability (HF-HRV) (Laborde et al., 2017). Common time domain measures include Root Mean Square of Successive Differences (RMSSD) and peak-valley respiratory sinus arrhythmia (pvRSA). They are all principally measures of the ventral vagus nerve's influences on heart rate, but each has limitations or confounders. HF-HRV is influenced by respiration rate, RMSSD is influenced by sympathetic nervous system activity (Berntson et al., 2005; Laborde et al., 2017; Thomas et al., 2019), and pvRSA requires a measurement of respiration to compare inter-beat intervals (IBI) across respiratory phases (Grossman et al., 1990). A review of HRV and cardiac vagal tone recommended that studies should analyse both frequency- and time-domain measures to compensate for the limitations of each measure (Laborde et al., 2017). So, for this study we have calculated both HF-HRV and RMSSD.

Throughout the laboratory session, ECG data was collected from participants (see Procedure section). QRS peaks were identified using the program Acqknowledge to calculate the inter-beat interval (IBI) between each successive QRS peaks for each participant for each stimulus (Biopac Systems, Inc., 2024b, 2024a). Using the R package 'RHRV', any spurious IBIs were removed and two measures of vmHRV were computed (Rodríguez-Liñares et al., 2011; RStudio Team, 2020). IBI were identified as spurious if they relate to a heartrate less than 25, greater than 200, or the IBI exceeds an adaptive cumulative mean threshold

(Rodríguez-Liñares et al., 2011; Vila et al., 1997). Each stimulus was divided into 30 second epochs and the frequency domain measure of HF-HRV was calculated using a Fast Fourier Transformation and selecting the high frequency range as $0.12 \leq \text{Hz} \leq 0.4$. For each epoch, the time domain measure of RMSSD was also calculated. The laboratory session included two stressor stimuli which were each preceded by a neutral stimulus. For both RMSSD and HR-HRV measures of vmHRV, an average vmHRV was calculated for each stimulus. Then vmHRV reactivity was calculated for each stressor as vmHRV during that stressor minus vmHRV during the preceding neutral stimulus.

Covariates

Gender and age. vmHRV has previously been found to vary by age and between men and women (Beauchaine et al., 2019; Quigley et al., 2024) and both age and gender have been associated with psychological distress (Bell, 2014). Participants identified their gender when they signed up to the study. They then reported their age during the initial survey at the end of the laboratory session.

Physical Activity. Physical fitness can impact vmHRV and vmHRV reactivity (Aubert et al., 2003; Brush et al., 2020) and regular exercise has been linked to better psychological health (Denche-Zamorano et al., 2022; Schuch et al., 2018). So, in the initial survey, participants were asked how many days in a typical week they did vigorous or moderate activities and how long they did those activities for on a typical day. Those measures were then multiplied to create a value of hours of exercise per week.

MacArthur Scale of Subjective Social Status. Subjective social status has previously been associated with measures of psychological distress (Euteneuer, 2014). Participants were presented with a picture of a ladder with ten rungs that represented where people stood in UK society with higher rungs indicating a higher social status (Adler et al.,

2000). They were then asked to position themselves on that ladder based on their economic circumstance, education and job.

Life Stressors. The number of life stressors an individual experiences has previously been found to predict psychological distress (Stange et al., 2017). It is feasible that individuals who are experiencing worse acculturative stress may also be more likely to be experiencing other life stressors than people who are not experiencing acculturative stressors. Participants were asked to select the stressors they had experienced in the last year from a list of stressors with the additional option to tick “other” and to describe their other stressors. A count score was computed for each participant based on the number of the following non-acculturative life stressors that they had experienced: mourning a friend or family member, family member's poor health, family member's alcohol or drug problems, financial strain, housing problems, criminal or legal issues, caring for ill family members, concerns for a nation¹², or problems with housemates or neighbours.

Analysis Plan

The primary analyses in this project were novel, so we do not have a clear a priori expectation for the effect size. We originally planned to continue to recruit participants until we had a valid data from 171 participant in the laboratory session, which would have achieved 90% power to detect a medium effect size ($f^2 = 0.15$) for a multiple regression with 15 predictors. However, it was not possible to assess all the physiological data before the end of data collection, so we overrecruited to avoid the cross-sectional analyses being underpowered. Of the 228 participants who completed the laboratory session, valid

¹² “concern for a nation” was based on write-in responses where fewer than five participants indicated that they were worried about the political situation or war in one of the countries that they culturally identified with. This could be considered a form of culture stress. However, it does not have conceptual overlap with our measure of acculturative stress, which focusses on interpersonal stressors.

physiological data was attained from 205 participants. One-hundred-and-eighty-six participants completed the follow-up survey, of which 166 had valid physiological data.

The linear relationships and interactions proposed in the hypotheses were tested using hierarchical regression models. The models were run once for each type of vmHRV (i.e., RMSSD and HF-HRV). The variables were added in steps. Step 1 included covariates (age, gender, subjective social status, weekly hours of physical activity, life stressors). In step 2, acculturative stress was added. Step 3 included vmHRV during the first neutral film clip (baseline RMSSD or baseline HF-HRV), change in vmHRV between the first neutral film clip and the sad film clip (sad film Δ RMSSD or sad film Δ RSA), and change in vmHRV between the second neutral film clip and the acculturative stress recall task (recall task Δ RMSSD or recall task Δ RSA). Finally, the interaction terms between acculturative stress and each measure of change in vmHRV were added in Step 4.

A set of hypotheses and an analysis plan were pre-registered for this study before data collection began. However, it was necessary to amend that analysis plan to account for issues with data collection and other methodological issues. Those amendments are detailed in the Appendix C Preregistered Analyses section and the analyses were also repeated there to match the pre-preregistered analysis plan as closely as possible (see Appendix C Table C.3 and Table C.4).

Results

Descriptive Statistics

The descriptive statistics and bivariate correlations between continuous variables are presented in Table 4.1. Bivariate correlations between the two measures of vmHRV are presented in Appendix C Table C.2. Valid vmHRV data was successfully collected from 205 out of 228 participants. Bivariate analyses found that participant's weight ($t(29.58) = 2.28, p = .030$) and BMI ($t(33.61) = 2.52, p = .017$) were significantly higher among participants

with vmHRV data ($M_{\text{weight}} = 69.53$, $SD_{\text{weight}} = 15.09$, $NA_{\text{weight}} = 4$; $M_{\text{BMI}} = 24.60$, $SD_{\text{BMI}} = 4.93$, $NA_{\text{BMI}} = 4$) than among those with missing vmHRV data ($M_{\text{weight}} = 63.03$, $SD_{\text{weight}} = 12.71$, $NA_{\text{weight}} = 0$; $M_{\text{BMI}} = 22.61$, $SD_{\text{BMI}} = 3.40$, $NA_{\text{BMI}} = 0$), but no other sociodemographic, physiological or psychological variables significantly differed between those groups. A multivariate logistic regression was not significant, which indicates that the observed variables could not predict the pattern of missing vmHRV data ($\chi^2(11, N = 220) = 16.57, p = .121$). That model included all the non-physiological measures that were included in our main analyses, as well as weight, height, medication usage, and engagement in prohibited pre-laboratory session behaviours.

To be included in the longitudinal analyses, 186 of the 228 participants also completed the follow-up survey. Bivariate analyses found that participants were more likely to complete the follow-up survey if they were female ($\chi^2(1, N = 228) = 5.52, p = .019$), had high baseline acculturative stress ($t(63.57) = 2.70, p = .009$), had more negative sad film ΔvmHRV (sad film $\Delta\text{RMSSD} = t(51.59) = -2.29, p = .026$; sad film $\Delta\text{HF-HRV} = t(72.22) = -2.50, p = .015$), or were taking any medication ($\chi^2(1, N = 228) = 4.79, p = .029$). Two multivariate logistic regressions that included either RMSSD or HF-HRV measures and all the other variables that were included in each of the main analyses, as well as weight, height, medication usage, and pre-activities session activity, significantly predicted whether participants completed the follow-up survey (including RMSSD variables: $\chi^2(14, N = 197) = 32.22, p = .004$; including HF-HRV variables: $\chi^2(14, N = 197) = 30.12, p = .007$). In the model including RMSSD variables, participants were estimated to be more likely to have completed the follow-up survey if they had experienced fewer life stressors in the twelve months before the baseline survey (OR = 0.69, 95% CI [0.47,0.99]), or more negative sad film ΔRMSSD (OR = 0.92, 95% CI [0.86,0.98]). In both models, participants were more likely to have completed the follow-up survey if they reported higher perceived acculturative

stress (RMSSD model: OR = 1.79, 95% CI [1.12, 2.86]; HF-HRV model: OR = 1.87, 95% CI [1.17, 2.99]).

Participants' weight and medication usage were the only two variables that predicted either missing vmHRV data or attrition and were not included as control variables in the main analyses. The main analyses were rerun to include those variables as predictors in the first step of each model, but they made no difference to the interpretation of the results, so those analyses have not been reported.

Table 4.1*Bi-variate Correlations and Descriptive Statistics.*

variable	<i>N</i>	<i>M</i>	(<i>SD</i>)	2	3	4	5	6	7	8	9	10	11	12	13	14
1.baseline RMSSD	211	36.46	(20.08)	.92***	.92***	.91***	-.18**	-.22**	-.11	-.09	-.11	-.22**	-.19**	.00	-.03	-.01
2.sad film RMSSD	210	37.40	(20.30)		.93***	.89***	.22**	-.27***	-.13	-.06	-.06	-.23***	-.19**	-.06	-.03	-.03
2 nd neutral clip	208	37.02	(21.15)			.91***	.04	-.40***	-.14*	-.10	-.11	-.21**	-.17*	-.04	-.01	-.04
3.RMSSD																
4.recall task RMSSD	208	36.62	(19.41)				-.01	.01	-.12	.00	-.06	-.26***	-.18*	-.05	-.01	-.04
5.sad film ΔRMSSD	210	0.90	(8.09)					-.12	-.03	.08	.14	-.02	.00	-.14*	.02	-.03
6.recall task ΔRMSSD	206	-0.48	(8.65)						.05	.25***	.19*	-.09	.03	.00	.02	.01
7.acculturative stress	228	2.92	(1.00)							.20**	.19*	.05	.13*	-.18**	.03	.26***
8.GHQ-12	228	2.22	(0.67)								.58***	-.09	.04	-.23***	-.18**	.16*
9.GHQ-12 at follow-up	186	2.17	(0.65)									.00	.07	-.11	-.05	.07
10.age	228	28.02	(7.49)										.44***	-.03	.07	.09
11.years in UK	228	2.20	(4.33)											-.05	.01	-.02
12.SSS	228	5.31	(1.87)												-.03	-.21**
13.exercise hours	224	9.17	(10.95)													.02
14.life stressors	228	1.68	(1.20)													

Note. Baseline RMSSD refers to RMSSD during the first neutral film clip., GHQ = 12-item General Health Questionnaire (psychological distress), SSS =

MacArthur Scale of Subjective Social Status. Bivariate correlation between RMSSD and HF-HRV measures of vmHRV are presented in Appendix C Table

C.2.

* $p < .05$. ** $p < .01$. *** $p < .001$

Multiple Regression Analysis

Cross-sectional Multiple Regression Analysis

To test the cross-sectional hypotheses, baseline psychological distress (GHQ-12) was predicted in a series of multiple linear regressions where additional variables added in each subsequent step of the analysis.

Step 1 of the model only included control variables, which were all potential confounders of the relationships between acculturative stress, vmHRV reactivity, and psychological distress (see Table 4.2). Age did not significantly predict psychological distress in our sample, but psychological distress was significantly higher for female participants, participants with lower subjective social status, fewer hours of exercise, or more life stressors. In Step 2, acculturative stress was added to the model. Acculturative stress significantly positively predicted psychological distress. In Step 2, life stressors was no longer a significant predictor of psychological distress, but all other control variables remained significant for Step 2. In Step 3, vmHRV predictors were added (see sections on RMSSD or HF-HRV below) and Step 4 included the interaction between acculturative stress and the vmHRV predictors. Acculturative stress and all the control variables retained their significance level from Step 2 to Step 4.

RMSSD. To test the hypotheses using the RMSSD measures of vmHRV, three measures of RMSSD were added in Step 3. One measure was the RMSSD during the first neutral stimulus, which will be referred to as *baseline RMSSD*. The other two measures were measures of RMSSD reactivity between stimuli. The first of these will be referred to as *sad film Δ RMSSD* for the change in RMSSD between the first neutral stimulus and the sad film clip. The second reactivity measure was the change between the second neutral stimulus and the acculturative stress recall task, which will be referred to as *recall task Δ RMSSD*. Neither baseline RMSSD nor sad film Δ RMSSD significantly predicted psychological distress.

However, recall task Δ RMSSD significantly positively predicted psychological distress, which indicates that participants with lower psychological distress tended to have larger reductions in RMSSD between the second neutral stimulus and the acculturative stress recall task. In Step 4, when the interaction between each Δ RMSSD score and acculturative stress were included in the model, acculturative stress ($\beta = 0.15, p = 0.026$) and recall task Δ RMSSD ($\beta = 0.24, p = 0.001$) remained significant predictors of psychological distress, but the interactions were not significant. However, Step 4 did not explain a significantly greater proportion of the variance in psychological distress than did Step 3, so all hypothesis tests were based on Step 3. All standardised effect sizes for predictors in Step 3 are presented in Figure 4.2.

HF-HRV. The same sequence of models was then tested using the HF-HRV measures (see Table 4.3). The control variables and acculturative stress all followed the same pattern of associations across each step as in the previous model. Likewise, baseline HF-HRV, sad film Δ HF-HRV, and both interactions were not significant predictors of psychological distress. In contrast to the findings for RMSSD, recall task Δ HF-HRV was only a significant predictor of psychological distress in Step 4. However, Step 4 will not be included in the disjunction hypothesis testing because neither Step 3 nor Step 4 significantly improved the explained variance compared to the previous step.

Table 4.2

Multiple linear regression of Psychological Distress on Control Variables (Step 1), Acculturative Stress (Step 2), RMSSD during the 1st Neutral Stimulus and the Change (Δ) in RMSSD between each Neutral Stimulus and the Next Stressful Stimulus (Step 3), and Interaction of Acculturative Stress and RMSSD (Step 4).

variable	Step 1: control variables				Step 2: + acculturative stress				Step 3: + RMSSD				Step 4: + Interaction			
	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>
intercept	2.10	0.07	[1.96, 2.23]	***	2.10	0.07	[1.97, 2.23]	***	2.08	0.07	[1.95, 2.21]	***	2.09	0.07	[1.95, 2.22]	***
age	-0.01	0.01	[-0.02, 0.00]		-0.01	0.01	[-0.02, 0.00]		0.00	0.01	[-0.02, 0.01]		0.00	0.01	[-0.02, 0.01]	
female	0.22	0.09	[0.04, 0.39]	*	0.21	0.09	[0.04, 0.38]	*	0.24	0.09	[0.06, 0.42]	**	0.23	0.09	[0.06, 0.41]	**
SSS	-0.07	0.02	[-0.12, -0.03]	**	-0.07	0.02	[-0.11, -0.02]	**	-0.07	0.02	[-0.11, -0.02]	**	-0.07	0.02	[-0.11, -0.02]	**
exercise (hours/week)	-0.01	0.00	[-0.02, -0.00]	*	-0.01	0.00	[-0.02, -0.00]	*	-0.01	0.00	[-0.02, -0.00]	*	-0.01	0.00	[-0.02, -0.00]	*
life stressors	0.07	0.04	[0.00, 0.14]	*	0.05	0.04	[-0.02, 0.12]		0.04	0.04	[-0.03, 0.12]		0.05	0.04	[-0.03, 0.12]	
acculturative stress					0.11	0.04	[0.03, 0.20]	*	0.10	0.05	[0.01, 0.19]	*	0.10	0.05	[0.01, 0.20]	*
baseline RMSSD									0.00	0.00	[-0.01, 0.00]		0.00	0.00	[-0.01, 0.00]	
recall task Δ RMSSD									0.02	0.01	[0.01, 0.03]	***	0.02	0.01	[0.01, 0.03]	**
sad film Δ RMSSD									0.01	0.01	[-0.00, 0.02]		0.01	0.01	[-0.00, 0.02]	
acculturative stress X recall task Δ RMSSD													0.00	0.01	[-0.02, 0.01]	
acculturative stress X sad film Δ RMSSD													0.01	0.01	[-0.00, 0.02]	
<i>N</i>	224				224				201				201			
R ²	0.13				0.16				0.23				0.24			
adjusted R ²	0.11				0.14				0.19				0.19			
Δ R ²					0.03				*				0.01			

Note. GHQ = 12-item General Health Questionnaire (psychological distress), SSS = MacArthur Scale of Subjective Social Status, RMSSD = root mean square

of successive differences, CI = confidence intervals. * $p < .05$. ** $p < .01$. *** $p < .001$

Table 4.3

Multiple linear regression of Psychological Distress on Control Variables (Step 1), Acculturative Stress (Step 2), HF-HRV during the 1st Neutral Stimulus and Change (Δ) in HF-HRV between each Neutral Stimulus and the Next Stressful Stimulus (Step 3), and Interaction of Acculturative Stress and HF-HRV (Step 4).

variable	Step 1: control variables				Step 2: + acculturative stress				Step 3: + HF-HRV				Step 4: + Interaction			
	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>
intercept	2.10	0.07	[1.96, 2.23]	***	2.10	0.07	[1.97, 2.23]	***	2.09	0.07	[1.95, 2.23]	***	2.08	0.07	[1.94, 2.23]	***
age	-0.01	0.01	[-0.02, 0.00]		-0.01	0.01	[-0.02, 0.00]		0.00	0.01	[-0.02, 0.01]		0.00	0.01	[-0.02, 0.01]	
female	0.22	0.09	[0.04, 0.39]	*	0.21	0.09	[0.04, 0.38]	*	0.23	0.09	[0.04, 0.41]	*	0.22	0.09	[0.04, 0.41]	*
SSS	-0.07	0.02	[-0.12, -0.03]	**	-0.07	0.02	[-0.11, -0.02]	**	-0.06	0.02	[-0.11, -0.02]	**	-0.06	0.02	[-0.11, -0.02]	**
exercise (hours/week)	-0.01	0.00	[-0.02, -0.00]	*	-0.01	0.00	[-0.02, -0.00]	*	-0.01	0.00	[-0.02, -0.00]	*	-0.01	0.00	[-0.02, -0.00]	*
life stressors	0.07	0.04	[0.00, 0.14]	*	0.05	0.04	[-0.02, 0.12]		0.04	0.04	[-0.03, 0.12]		0.04	0.04	[-0.03, 0.12]	
acculturative stress					0.11	0.04	[0.03, 0.20]	*	0.10	0.05	[0.01, 0.20]	*	0.11	0.05	[0.01, 0.20]	*
baseline HF-HRV									0.02	0.05	[-0.07, 0.11]		0.03	0.05	[-0.06, 0.12]	
recall task Δ HF-HRV									0.19	0.10	[-0.01, 0.39]		0.24	0.11	[0.03, 0.46]	*
sad film Δ HF-HRV									0.14	0.10	[-0.06, 0.33]		0.16	0.10	[-0.04, 0.36]	
acculturative stress X recall task Δ HF-HRV													0.16	0.11	[-0.06, 0.37]	
acculturative stress X sad film Δ HF-HRV													0.04	0.10	[-0.15, 0.23]	
<i>N</i>	224				224				201				201			
R ²	0.13				0.16				0.18				0.19			
adjusted R ²	0.11				0.14				0.14				0.15			
Δ R ²					0.03				*				0.01			

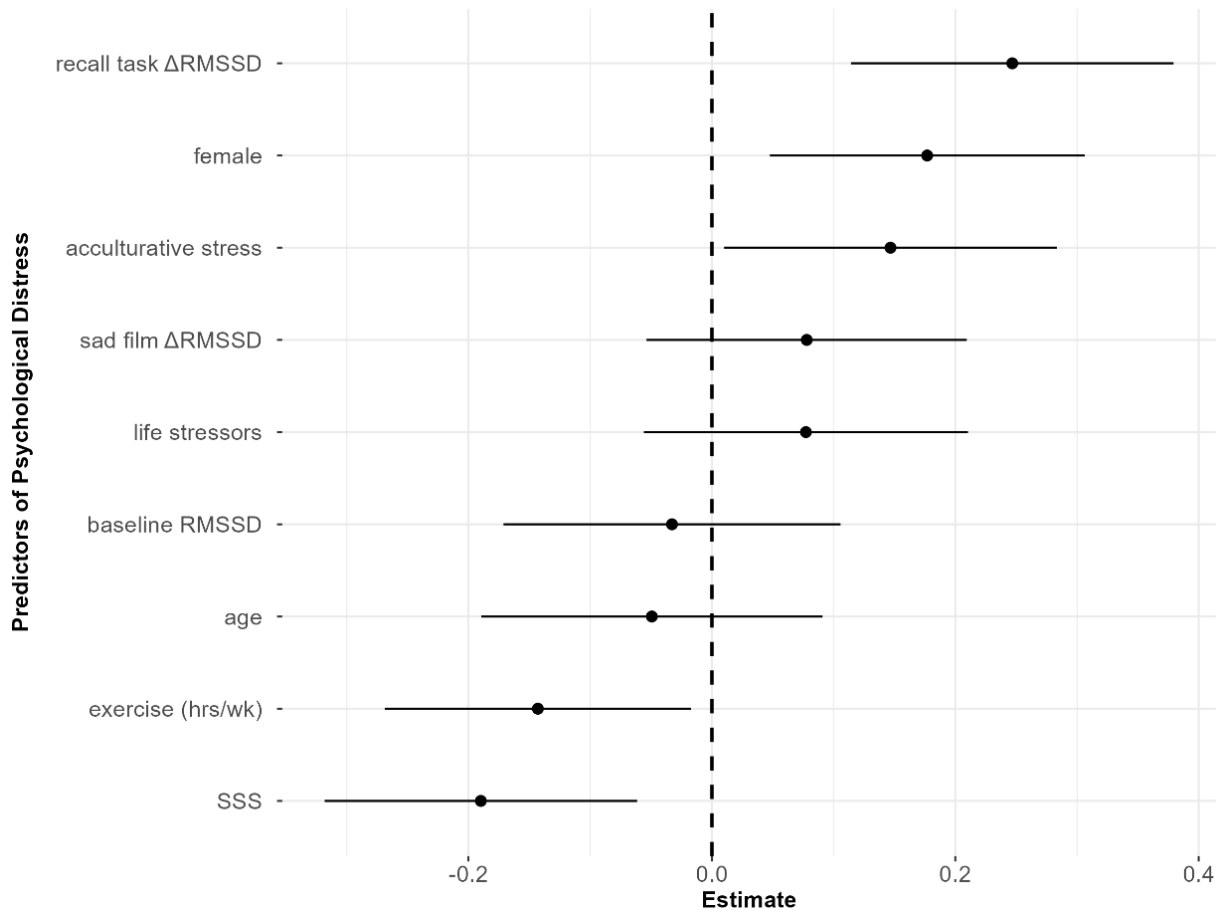
Note. GHQ = 12-item General Health Questionnaire (psychological distress), SSS = MacArthur Scale of Subjective Social Status, HF-HRV = high-frequency

heart rate variability, CI = confidence intervals.

* $p < .05$. ** $p < .01$. *** $p < .001$

Figure 4.2

Standardised Coefficients and 95% Confidence Intervals for Predictors of Psychological Distress in Step 3 Regression Model including RMSSD variables.



Note. SSS = MacArthur Scale of Subjective Social Status, Δ = change, RMSSD = root mean square of successive differences, hrs/wk = hours per week.

Disjunction Hypothesis Testing. Multiple tests were used to address each hypothesis related to vmHRV (hypotheses 2, 3, 5, and 6), so a family-wise alpha correction was applied to account for the four separate tests, which comprised of two types of vmHRV measures and the two stressor tasks (García-Pérez, 2023; Rubin, 2021). We used Dunn–Šidák correction for which the adjusted alpha used in each test is equal to “ $1-(1-\alpha)^{1/k}$ ”, where k is equal to the number of tests used for each hypothesis (Rubin, 2021; Šidák, 1967). So, the vmHRV related

hypotheses were tested against an adjusted p -value $< .013$ in the final step that significantly improved the variance explained by the model. In Step 3, the recall task Δ RMSSD surpassed this threshold, which supports Hypothesis 2 that vmHRV reactivity would positively predict psychological distress. However, no tests of the interaction between acculturative stress and RMSSD reactivity in their prediction of psychological distress surpassed that adjusted threshold, or even the $p < .05$ threshold, so Hypothesis 3 was not supported. Hypothesis 1 proposed that acculturative stress would positively predict psychological distress. It was tested once within each of the two sets of vmHRV analyses, which relates to an adjusted threshold of $p < .025$. In Step 2, the final step that significantly improved explained variance in the HF-HRV model, the significance of relationship between acculturative stress and psychological distress surpassed that $p < .025$ threshold in support of Hypothesis 1.

Longitudinal Multiple Regression Analysis

The four steps of the cross-sectional analysis for each vmHRV measure were then repeated with the outcome, psychological distress (GHQ-12), measured in the follow-up survey (see Table 4.4). None of the potential confounder variables predicted psychological distress at follow-up in any of the steps of the models. As in the cross-sectional analysis, psychological distress at follow-up was not significantly predicted by either of the baseline vmHRV measures or for the sad film Δ vmHRV reactivity measures. Psychological distress at follow up was significantly predicted by recall task Δ RMSSD, but not by recall task Δ HF-HRV. For each longitudinal analysis, the interaction terms that were added in Step 4 were not significant and they made negligible difference to the other coefficients. For brevity, Step 4 of each analysis was not presented in Table 4.4. In both longitudinal models, neither Step 3 nor 4 significantly improved the proportion of GHQ-12 variance explained by the model. So, neither Hypothesis 5 nor Hypothesis 6 were supported.

However, in Step 2, which was the final step that improved explained variance, acculturative stress significantly predicted psychological distress and surpassed the $p < .025$ adjusted threshold. This supports Hypothesis 4, which stated that acculturative stress would prospectively positively predict psychological distress. However, these prospective predictions do not account for the stability of psychological distress from the day of the laboratory session to the day participants completed the follow-up survey. The inclusion of baseline psychological distress reduced the predictive association between acculturative stress at baseline and psychological distress at follow-up by three-quarters and the relationship became non-significant (see Table 4.4 Step 3c). Baseline psychological distress significantly positively predicted later psychological distress, but no other predictors were significant.

Table 4.4

Multiple linear regression of Psychological Distress at Follow-Up on Baseline Control Variables (Step 1), Acculturative Stress (Step 2), and vmHRV during the 1st Neutral Stimulus and Change (Δ) in vmHRV between each Neutral Stimulus and the Subsequent Stressful Stimulus (vmHRV measured as RMSSD in Step 3a and as HF-HRV in Step 3b), or Baseline Psychological Distress (Step 3c).

variable	Step 1: control variables				Step 2: + acculturative stress				Step 3a: + RMSSD				Step 3b: + HF-HRV				Step 3c: + baseline GHQ											
	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>								
intercept	2.06	0.08	[1.90, 2.22]	***	2.06	0.08	[1.90, 2.21]	***	2.09	0.08	[1.93, 2.26]	***	2.11	0.09	[1.94, 2.28]	***	2.14	0.07	[2.00, 2.27]	***								
age	0.00	0.01	[-0.01, 0.01]		0.00	0.01	[-0.01, 0.01]		0.00	0.01	[-0.01, 0.02]		0.00	0.01	[-0.01, 0.02]		0.00	0.01	[-0.01, 0.01]									
female	0.19	0.10	[-0.02, 0.39]		0.18	0.10	[-0.02, 0.38]		0.19	0.11	[-0.02, 0.40]		0.16	0.11	[-0.06, 0.38]		0.05	0.09	[-0.12, 0.22]									
SSS	-0.03	0.03	[-0.08, 0.02]		-0.02	0.03	[-0.08, 0.03]		-0.02	0.03	[-0.08, 0.03]		-0.02	0.03	[-0.08, 0.03]		0.01	0.02	[-0.04, 0.05]									
exercise (hrs/wk)	0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.00, 0.01]									
life stressors	0.03	0.04	[-0.05, 0.11]		0.01	0.04	[-0.07, 0.09]		0.00	0.04	[-0.09, 0.09]		-0.01	0.04	[-0.10, 0.08]		-0.02	0.04	[-0.09, 0.04]									
acculturative stress					0.12	0.05	[0.02, 0.22]	*	0.11	0.06	[-0.00, 0.22]		0.12	0.06	[0.01, 0.23]	*	0.04	0.04	[-0.04, 0.13]									
baseline RMSSD									0.00	0.00	[-0.01, 0.01]		0.00	0.05	[-0.11, 0.11]													
recall task Δ RMSSD									0.02	0.01	[0.00, 0.03]	*																
sad film Δ RMSSD									0.01	0.01	[-0.01, 0.02]																	
recall task Δ HF-HRV													-0.03	0.12	[-0.27, 0.20]													
sad film Δ HF-HRV													0.21	0.11	[-0.02, 0.43]													
GHQ																	0.56	0.07	[0.43, 0.70]	***								
<i>N</i>	182				182				162				162				182											
R ²	0.04				0.07				0.11				*				0.09				0.33				***			
adjusted R ²	0.01				0.03				0.06				0.04				0.31											
Δ R ²					0.03				*				0.04				0.02				0.26				***			

Note. GHQ = 12-item General Health Questionnaire (psychological distress), SSS = MacArthur Scale of Subjective Social Status, RMSSD = -root mean square

of successive differences, HF-HRV = High-frequency Heart Rate Variability CI = confidence intervals.

p* < .05. *p* < .01. ****p* < .001

Discussion

Summary

Acculturative stress significantly positively predicted concurrent psychological distress, which supports Hypothesis 1. Individuals with worse acculturative stress were significantly more likely to experience greater psychological distress. Hypothesis 2 was also supported because psychological distress was significantly lower during the laboratory session for participants with a more negative vmHRV reactivity, as measured by change in RMSSD between a neutral stimulus and the acculturative stress recall task. However, neither HF-HRV measure nor the RMSSD measure of vmHRV reactivity into the sad film clip significantly predict psychological distress.

Contrary to Hypothesis 3, vmHRV reactivity did not moderate the relationship between acculturative stress and concurrent psychological distress. These results indicate that a greater reduction in vmHRV may be a more adaptive response to the acculturative stress recall task independent of the severity of acculturative stress that is experienced.

The longitudinal associations from both acculturative stress and vmHRV reactivity to later psychological distress were also analysed (Hypotheses 4–6). Only Hypothesis 4 was supported because acculturative stress was the only significant predictor of later psychological distress. However, when the baseline measure of psychological distress was included as a predictor, acculturative stress was no longer significant. The inclusion of baseline psychological distress accounts for the stability of that variable over time and changes the interpretation of the other coefficients in the model from being predictors of later psychological distress to being predictors of change in psychological distress (Adachi & Willoughby, 2015). The strength of the association between acculturative stress and follow-up psychological distress, dropped by two-thirds and became non-significant when that stability effect was accounted for. This might indicate that the time between surveys was too

short to capture sufficient changes in psychological distress. However, the correlations between measures of vmHRV and follow-up psychological distress were not significant, so the stability effects do not explain those non-significant longitudinal relationships. Instead, the lack of a longitudinal association may indicate that vmHRV reactivity is a symptom of poor psychological distress rather than a precursor to worsening psychological distress.

The significant positive cross-sectional association that we found between acculturative stress and psychological distress provides further support to previous studies that found associations between measures of cultural stress and psychological health (Merced et al., 2022; Miller, Yang, et al., 2011; Wypych & Bilewicz, 2024). However, other operationalisations of cultural stress have previously been found to longitudinally predict psychological health even after adjusting for baseline measures of psychological health (Cano et al., 2015; McCord et al., 2019), which was not replicated in the present study. Another study found that only a subset of cultural stress domains prospectively predicted depression symptoms measured two years later (Lorenzo-Blanco & Unger, 2015). They found significant associations for measures of everyday discrimination and family conflict, but not for a measure that represented bicultural stress.

The present study found that only RMSSD reactivity and not HF-HRV reactivity cross-sectionally predicted psychological distress at our Dunn–Šidák corrected significance threshold and that association was only found for reactivity in response to the acculturative stress recall task and not in response to the sad film clip. Both RMSSD reactivity and HF-HRV reactivity have previously been found to significantly predict measures of psychological distress, but reviews have found mixed results for the strength and direction of those associations (Beauchaine et al., 2019; Hamilton & Alloy, 2016; Schiweck et al., 2019). Higher psychological distress being associated with more negative RMSSD reactivity in response to our acculturative stress recall task indicates that emotional sensitivity and active

coping would be adaptative responses to the task rather than emotional regulation and passive coping. This contrasts with the results from Gouin et al. (2014) who found that later psychological distress was worse for participants who experienced less negative vmHRV reactivity in response to a task where they were asked to worry about their future. Despite their task and our acculturative stress recall task both asking participants to make a mental representation of a stressful event and neither task putting participants under any real threat, the adaptive physiological response differed between the two tasks. Greater ventral vagal withdrawal was the more adaptive response to our task, which is also an adaptive response to real threats. Whereas in Gouin et al.'s (2014) study the adaptive response to considering future possible events was a blunted physiological response, which does not match the strategy that would be adaptive if the event actually occurred. The participants in that study should have been able to perceive safety in the threat being purely hypothetical. However, some participants, who could not perceive safety, might have instead experienced generalised unsafety and a reduction in vmHRV (Brosschot et al., 2017).

There could be several reasons why vmHRV reactivity to the acculturative stress recall task predicted psychological distress but vmHRV reactivity to the sad film clip did not. If physiological stress responses are context specific, then participants whose physiological and psychological health have been impacted by chronic acculturative stress may respond differently to the acculturative stress recall task compared to participants who have not experienced adverse effects of acculturative stress. Whereas responses to the sad film clip would be less likely to be influenced by participants experiences of acculturative stress. However, previous studies have found that physiological stress responses may not be context specific (Sattler et al., 2021). The present study used a sad film clip from the film *The Champ* (Zeffirelli, 1979), which has been used in many previous studies. Most studies found that more negative vmHRV reactivity in response to that clip was associated with less

psychological distress (Brush et al., 2020; Panaite et al., 2016; Rottenberg et al., 2005; Stange et al., 2017). However, other studies found that less negative vmHRV reactivity in response to that clip predicted less psychological distress (Pang & Beauchaine, 2013), and others found no main effect (Yaroslavsky, Rottenberg, et al., 2013). This may indicate that the adaptive physiological response to seeing that clip may depend on the sample. In our sample participants may have been less cognitively or emotionally engaged with the sad film clip than the acculturative stress recall task so their psychological state may have had less bearing on their physiological activity during that sad film clip. Most studies only included one stressor task in their analysis models, whereas ours included two. If our novel task shares a mechanism with the sad film clip, then the shared variance will not be captured by our model, which could explain why vmHRV reactivity in response to sad film clip did not predict psychological distress in our analyses. However, we repeated the analysis separately for each stressor task and the results were not substantively different. Schiweck et al. (2022) offered an alternative explanation that might explain why psychological distress was only associated with vmHRV reactivity for the second stressor task. In their study, which also included two stressor tasks, they argued that participants with depression were exhausted by the first stressor so could not recover enough to appropriately physiologically respond to the second stressor. As part of their Vagal Tank Theory, Laborde et al. (2018) argued that vmHRV recovery has a unique role in physiological regulation alongside the roles of resting vmHRV and vmHRV reactivity which have already been discussed. Recovery relates to how efficiently an individual's physiological state can return to resting following a stressor. Individuals who can recover from one stressor before they experience their next stressor have the capacity to self-regulate and respond to that new stressor appropriately. In our study, most participants may have been able to appropriately respond to the sad film clip. However, those with worse psychological distress may have not then been able to recover sufficiently during

the following neutral stimuli, which inhibited their ability to adaptively respond to the acculturative stress recall task.

However, the expected reduction in RMSSD between neutral tasks and stressor tasks only occurred for 40.47% of participants in response to the sad film clip and only 49.51% in response to the recall task. Volpe et al. (2025) had a similar finding when they recently reanalysed data from an earlier study that included a racial discrimination vignette (Volpe et al., 2019). They found that only 6.78% of their participants experienced a significant reduction in HRV at any stage of their experiment. In future, it may be beneficial to reanalyse our data using Volpe et al.'s (2025) Hidden Markov model approach to further understand how and when participants' vmHRV changed in response to our tasks.

Acculturative stress and vmHRV reactivity were not found to interact in their prediction of psychological distress. That result contrasts with previous studies, which found that at higher levels of stress there were stronger associations between vmHRV reactivity and psychological distress (Gouin et al., 2014; Stange et al., 2017). However, in agreement with our results, Daches et al. (2019) also did not find a two-way interaction in their sample of adolescents. Instead, they found a three-way interaction where the number of life stressors only predicted psychological distress for participants who both had more negative vmHRV reactivity and a family history of depression. For all other participant groups their number of life stressors did not predict their level of psychological distress and neither did their vmHRV reactivity. That indicates that the lack of an interaction in our study could be because participants' history of depression, their family's history of depression, or potentially other traumatic events during their development, may have determined whether their vmHRV reactivity and acculturative stress impacted their current psychological distress. The theory of biological sensitivity to context, would have also predicted an interaction between acculturative stress and vmHRV reactivity in their prediction of psychological distress

(Boyce & Ellis, 2005). That theory would indicate that compared to less negative vmHRV reactivity, more negative vmHRV reactivity should be related to lower psychological distress at low levels of acculturative stress, but with higher levels of psychological distress at higher levels of acculturative stress. However, we found no interaction and participants with more negative vmHRV reactivity were more likely to have lower psychological distress. That may be because too few of the participants were experiencing high enough levels of acculturative stress for low vmHRV reactivity to be found to be adaptive. The mean of acculturative stress in the sample was 2.92 ($SD = 1.00$) on a 7-point Likert scale between *strongly disagree* (1) and *strongly agree* (7) in response to statements such as “I feel that my particular cultural/ethnic practices have caused conflict in my relationships”. Thus, a large majority of our sample at least somewhat disagreed that they were experiencing acculturative stress, which indicates that greater biological sensitivity may have been more adaptive for most participants.

Strengths & Limitations

A large sample of first-generation migrants living in the UK participated in this study, which collected measures of physiological activity as well as survey data. Eighty-two percent of participants also completed the follow-up survey which enabled us to assess longitudinal relationships between physiological and psychological measures. This study provides unique insights into the associations between acculturative stress, vmHRV reactivity and psychological distress which, to the best of the authors’ knowledge, have not been simultaneously assessed in any previous study or dataset. Additionally, a novel acculturative stress recall task was created for this study based on previous tasks that related to discrimination (Doucerain et al., 2022).

The sample size was identified using power calculations based on a medium effect size. This was likely sufficient power to detect cross-sectional associations, however a recent

review of cross-lagged effects (i.e., longitudinal analyses that adjusted for baseline values of the outcome variable) found that their effect sizes are often much smaller than cross-sectional effects (Orth et al., 2024). They recommended that .03 should be considered a small effect size and .07 should be considered a medium effect size. As such, the longitudinal analyses presented in this paper may be underpowered. Another review argued that qualifying longitudinal effect sizes as “small” or “medium” using consistent thresholds is not helpful, because the importance of a particular longitudinal effect will depend on the size of the cross-sectional baseline association and the size of the autoregressive effect (Adachi & Willoughby, 2015).

The ECG and respiration data collected for this data suffered from a relatively large amount of noise to the extent that the respiration data was unusable. This meant that we could not verify that the participants all had respiration rates within the normal range (0.12–0.4 Hz) throughout all stimuli. The transfer function between vagal activity and HF-HRV varies across respiration rates and HF-HRV is a weaker measure of vagal activity outside of that normal breathing range. As such, if participants’ respiration rate was outside that range or if there were substantial changes in respiration within- or between- stimuli, then the HF-HRV measure may not be a reliable measure of vagal control. However, RMSSD is not substantially influenced by respiration frequency so it can still be considered a reliable marker of vmHRV when respiration frequencies cannot be verified. Still, RMSSD is somewhat affected by other influences on heart rate, such as SNS activity. Despite RMSSD and HF-HRV each having different sources of interference, we found partial support for both measures of vmHRV reactivity predicting concurrent psychological health. For vmHRV reactivity between the second neutral stimulus and the acculturative stress recall task, the HF-HRV measure was significant of psychological distress at the conventional $p < .05$ threshold and the RMSSD measure was significant at the Dunn–Šidák adjusted threshold of $p < .013$

(Rubin, 2021; Šidák, 1967). As ventral vagal activity is a common influence on both measures, these findings provide tentative converging evidence that a greater ventral vagal withdrawal in response to an acculturative stressor could be beneficial for psychological outcomes. Beauchaine et al. (2019) argued that even when the construct validity of vmHRV measures as indicators ventral vagal activity is threatened by physiological confounders, they can still have predictive validity as physiological predictors of psychological distress.

Both stressor tasks used in the present study were expected to produce negative emotional responses and the neutral stimuli were expected to enable physiological and emotional recovery. However, participants were not asked to declare which emotions they were feeling after each stimulus so we cannot be certain that each stimulus had the intended impact on participants' emotional state. After the acculturative stress recall task, in which participants had spent five minutes thinking about their experiences of acculturative stress, they were asked to write down everything they had been thinking about during those five minutes. Almost all participants wrote about their experiences of acculturative stress, which may indicate that they were cognitively and emotionally engaged in the acculturative stress recall task.

The second measure of vmHRV reactivity was calculated as the difference between vmHRV during the acculturative stress recall task and vmHRV during the preceding neutral stimulus. However, that neutral stimulus took place immediately after a stressor task which means that that period would have included both the participants' physiological recovery from that stressor as well as a period of rest. As such, that measure of vmHRV reactivity conflated the distinct processes of vmHRV recovery and vmHRV reactivity, which were outlined in the Vagal Tank Theory (Laborde et al., 2018). This could have either attenuated or inflated the estimated association between that variable and psychological distress. Future

studies that include two stressor tasks should include distinct recovery and rest periods, so that the processes of rest, reactivity and recovery can be independently evaluated.

Most participants in the sample had at least started an undergraduate degree (92.98%) and were in education (60.96%). Current education may provide protective factors, such as student support services and student societies (G. Hughes & Spanner, 2019; Tabor et al., 2021). As such, this sample may not be representative of the full range of and severity of acculturative stresses that are experienced by 1st generation migrants in the UK. Acculturative stress may have a more substantial impact psychological distress when experiences of acculturative stress are particularly severe and when individuals do not have the practical or psychological resources to manage their stress. If that is the case, then the strength of the association between acculturative stress and psychological distress in this study may be repressed compared to the true size of the association among 1st generation migrants in the UK. Additionally, a sample that included participants with higher levels of acculturative stress, may have found an interaction between acculturative stress and vmHRV reactivity. However, international students can still experience a wide range of acculturative stressors. For example, taught students will have been more likely to experience separation from family, after the introduction of legislation in 2024 that prevented dependents from joining taught students in the UK (Sumption et al., 2025).

The present study focusses on ventral vagal activity within the parasympathetic nervous system (PNS). However, stress responses are also determined by sympathetic nervous systems (SNS) activity as the two systems usually have a reciprocal relationship that enables individuals to adaptively respond to their environment (Berntson et al., 2016; Wagner & Abaied, 2015). In response to stressors used in this study, negative vmHRV reactivity (i.e., PNS withdrawal) coupled with SNS activation is likely to be the most adaptive response (J. W. Choi et al., 2021). However, individuals can also experience less adaptive responses such

as coactivation or inhibition of both systems (Berntson et al., 2016; Wagner & Abaied, 2015). The interaction between these two systems may explain why some studies found blunted vmHRV to be an adaptive stress response, whereas others have found more negative vmHRV reactivity to be associated with lower psychological distress (J. W. Choi et al., 2021).

The present study found that acculturative stress and vmHRV reactivity were both independently associated with psychological distress. This indicates that HRV biofeedback interventions could reduce overall psychological distress for people experiencing acculturative stress. HRV biofeedback interventions involve training participants to breathe at their *resonant frequency*, which refers to the respiratory frequency that maximises HRV within each respiratory cycle, usually around six breaths per minute (Lalanza et al., 2023). HRV biofeedback interventions have been found to increase resting vmHRV and reduce psychological distress (Castro Ribeiro et al., 2023; Fernández-Alvarez et al., 2022).

Conclusion

Preliminary evidence was found for the cross-sectional association between psychological distress and vmHRV reactivity in response to an acculturative stress recall task, but no longitudinal associations were detected. vmHRV reactivity did not moderate the association between acculturative stress and psychological distress, which indicates that across all levels of acculturative stress a greater reduction (i.e., a more negative change) in vmHRV in response to an acculturative stressor is a more adaptive physiological response.

5. Discussion

Overview

The many forms of acculturative stress that migrants and racialised minorities can experience have repeatedly been associated with psychological distress and worse well-being (Gonzalez-Guarda et al., 2021; Nandi et al., 2020; Soufi Amlashi et al., 2024; Viruell-Fuentes et al., 2012). This thesis investigated features of neighbourhood and social context that may influence exposure to both the acculturative stressors and protective factors that influence psychological health. Cultural isolation refers to the acculturative stress of feeling that no one around you shares your cultural attitudes, beliefs or history (Benet-Martínez & Haritatos, 2005; Miller, Kim, et al., 2011). A sense of cultural isolation can be triggered by exposure to structural discrimination, racism or other forms of interpersonal acculturative stressors if someone feels that no one around them can relate to their experiences. Lower levels of ethnic density, a measure of how many people in a geographic area share an individual's ethnicity, may represent a context where cultural isolation may be more likely to be experienced. Several studies have found that ethnic density is positively associated with psychological and physical health outcomes (Bécares et al., 2018). However, these findings have been inconsistent across studies and between the groups and contexts that those studies investigate. Chapter 2 and Chapter 3 of this thesis assessed the role of ethnic density in prospectively predicting psychological well-being and psychological distress respectively. Chapter 2 focussed on the mediation pathways between ethnic density and psychological well-being in older adults in the US. Chapter 3 focussed on the direct effect of ethnic density and change in ethnic density on psychological distress in a broad age range of adults in England who identified with minority ethnic groups.

Chapter 2 used data from the Health and Retirement Study (HRS), which is a nationally representative longitudinal survey of people over the age of fifty in the US

(Sonnegga et al., 2014). The first wave of HRS began in 1992 for a cohort born between 1931 and 1941 and a cohort born before 1924 were added the following year (HRS Staff, 2011). In 1998, two more cohorts were included so that the sample then represented all age brackets of adults over the age of 50. Those respondents were then interviewed every two years with a new cohort of adults who had aged into the sample added every six years. Many of the measures assessed in Chapter 2; including linked census data, biomarkers, and psychosocial measures; were first comprehensively measured in 2006/2008 and were measured consistently until 2014/2016 (Ailshire et al., 2020; Crimmins et al., 2020; J. Smith et al., 2023). As such, Chapter 2 focussed on the waves between 2006 and 2016. For both the collection of blood-based biomarkers and the Psychosocial and Lifestyle Questionnaire, the HRS sample was split into two. One half was invited to complete those measures in 2006, 2010, and 2014, and the other half was invited to complete them in 2008, 2012, and 2016. For the analyses in Chapter 2, these six waves were merged into three pooled waves so that each pooled wave could include the full sample. In each of these pooled waves ethnic density was measured using American Community Survey and US Decennial Census data which were summarised at the level of census tracts and linked to the census tract of each HRS respondent. These datasets provided the proportion of every census tract population who identified with each of five ethnic groups: non-Hispanic White, non-Hispanic Black, non-Hispanic Asian and Pacific Islander, non-Hispanic Other, and Hispanic (Ailshire et al., 2020). Of those groups, there was not a substantial enough sample of non-Hispanic Asian and Pacific Islander people in HRS. Additionally, the non-Hispanic Other category was weakly defined and heterogenous, which would have made it very difficult to interpret any possible ethnic density effects. Consequently, only non-Hispanic White, non-Hispanic Black, and Hispanic respondents were included in the sample analysed in Chapter 2.

Chapter 3 used a subsample from Understanding Society, the UK Household Longitudinal Study (UKHLS). These respondents were interviewed annually following their first interview in 2009–2011. Respondents answered a core set of questions annually, but to avoid participation fatigue some questions were only included every few years. For Chapter 3, waves 1 to 9 (2009–2019) were split into three periods of 2–3 waves. The predictor variable (ethnic density) and potential confounders were measured at the start of each period, potential mediators were measured during or at the end of each period, and the outcome variable (psychological distress) was measured in the last wave of each period. Ethnic density was calculated using decennial Census population data that had been summarised for each ethnic group using small geographic areas, called Lower Layer Super Output Areas (LSOA). As this data was only available every ten years, the values for waves in inter-census years were linearly imputed. Compared to the US, in England and Wales, a slightly broader range of ethnic groups are included in these census summaries. For Chapter 3, respondents who identified with the following ethnicities were included in the analysis: Indian, Pakistani, Bangladeshi, Black African, Black Caribbean, and White Other. Unlike in Chapter 2, the dominant ethnic group, White British, were not analysed because the distribution of ethnic densities is much higher for White British people than for any other ethnic group. Whereas, in the US, ethnic minority groups constitute a larger proportion of the population and neighbourhoods tend to be more racially segregated (Iceland et al., 2011; National Centre for Education Statistics, 2024; Office for National Statistics, 2011, 2021). Consequently, ethnic density distributions are more comparable between non-Hispanic White, non-Hispanic Black, and Hispanic respondents, than between the dominant and minority ethnic groups in the UK.

In Chapter 4, a broader measure of acculturative stress, which included items on perceived cultural isolation, was analysed and like Chapter 3 the outcome variable was psychological distress. Physiological stress responses to an acculturative stress recall task

were also collected and analysed as part of a novel primary data collection study. A sample of 1st generation migrants living in the East of England participated in this study between May and December 2024. Vagally-mediated Heart Rate Variability (vmHRV) was recorded whilst participants completed two stressor tasks, which were each preceded by neutral tasks so that change in vmHRV between each neutral task and stressor task could be calculated to measure participant's physiological stress responses. The first stressor task was a sad film clip, which has been used in many previous studies (Gross & Levenson, 1995; Yaroslavsky, Bylsma, et al., 2013; Zeffirelli, 1979), and the second stressor task was an acculturative stress recall task that was designed for this study. In the latter task, participants were asked to spend five minutes thinking about their experiences of acculturative stressors since they first moved to the UK.

Ethnic Density Effects for Psychological Distress and Well-being in Chapters 2 & 3

Ethnic density effects were compared across ethnic groups and (migrant) generations using multi-group Structural Equation Modelling (SEM, Chapter 2) or moderated multilevel modelling (Chapter 3).

In Chapter 2, SEM that specified a multiple group structure did not have substantially better fit than models that assumed all effects to be equal across ethnic groups or migrant generations. As such that analysis did not find sufficient evidence that ethnic group effects differed between non-Hispanic White, non-Hispanic Black, and Hispanic respondents, or between 1st generation migrant and US born respondents. The analysis also did not support the hypothesised indirect effect of ethnic density on psychological well-being through mediators of social cohesion, social support and allostatic load. However, a sensitivity analysis found that the direct effect of ethnic density significantly positively predicted later psychological well-being.

Chapter 3 focused on the direct effect of ethnic density as well on how change in ethnic density predicted psychological distress measured at the end of that change period. The direct effect was referred to as *lagged ethnic density* in Chapter 3, which was only found to predict psychological distress for White Other respondents. Change in ethnic density significantly negatively predicted psychological distress among UK born and 1st generation Black Caribbean and UK born Black African respondents with some support also found for a negative association for UK born Pakistani respondents. There were also significant interactions between change in ethnic density and ethnic group for Black Caribbean respondents and between change in ethnic density, ethnic group and generation for Black African respondents. The reference groups for these interactions were Indian and 1st generation migrant respondents, which indicates that the association between change in ethnic density and psychological distress was significantly more negative for Black Caribbean respondents compared to Indian respondents, and significantly more negative for UK born Black African respondents than for 1st generation Indian respondents. Neither the average marginal effects nor the interactions were significant for any other groups.

Ethnic Density Effects in the US

The mixed findings of the association between ethnic density and psychological well-being and distress across those two chapters is consistent with the findings of a previous systematic review and meta-analysis (Bécares et al., 2018). Most of the studies included in that review used samples that were collected in the US. Like Chapter 2, most of those US based studies tested ethnic density effects for Hispanic or non-Hispanic Black ethnic groups. Others studied the effects for non-Hispanic White and non-Hispanic Asian Americans. Additionally, almost all those studies were cross-sectional, unlike Chapter 2 which longitudinally analysed data spanning 2006 to 2016. Approximately half of the studies found no significant association between ethnic density and outcomes of depression or common

mental disorders for both non-Hispanic Black samples (e.g., Aneshensel et al., 2007; Wight et al., 2009, 2011) and Hispanic samples (e.g., Alegría et al., 2014; Aneshensel et al., 2007; Vogt Yuan, 2007; Wight et al., 2009, 2011). One study found that ethnic density positively predicted a well-being measure and negatively predicted depression symptoms for non-Hispanic Black respondents, but neither association was significant for Hispanic respondents (Vogt Yuan, 2007). However, ethnic density was found to negatively predict depression symptoms for Hispanic respondents in other studies (Ostir et al., 2003; Shell et al., 2013). A couple of studies found that ethnic density was negatively associated with depression symptoms for Hispanic men but not women (Arévalo et al., 2015; C. F. Mair et al., 2010). One of those studies also found that ethnic density was positively associated with depression symptoms for non-Hispanic Black men but not women (C. F. Mair et al., 2010) and another study ran sub-group analyses that found that a negative association between ethnic density and depression symptoms was significant for African American women but not men (Bécares et al., 2014). Neither Chapter 2 nor Chapter 3 tested whether the ethnic density effects were moderated by gender, which could have altered the associations that were reported in each chapter. Very few of the studies included in Bécares et al.'s (2018) review had tested whether ethnic density effects were moderated by generation. One study that did test that interaction for Hispanic respondents, found that the positive association between ethnic density and anxiety symptoms was stronger for 1st generation migrants than for US born respondents (Alegría et al., 2014). However, their measure of ethnic density was a combination of the proportion of Hispanic people and the proportion of 1st generation migrants in each census tract, so the stronger association for 1st generation migrants should be expected in that context. As compared to US born Hispanic people, 1st generation migrants may share their cultural and life experiences with a higher proportion of the people included in that ethnic density score. Three of the previously mentioned studies that were included in Bécares et al.'s

(2018) review used early waves from two HRS age cohorts. Two of these used cross-sectional data, from 1993 and 1994 respectively, and both found non-significant associations between ethnic density and depression symptoms for both non-Hispanic Black and Hispanic respondents (Aneshensel et al., 2007; Wight et al., 2011). The third study used longitudinal data between 1993 and 1998 and also found non-significant associations for both ethnic groups (Wight et al., 2009).

Compared to the number of studies that have assessed the association between ethnic density and depression or common mental disorders in the US, few studies have considered ethnic density effects for life satisfaction, which was assessed in Chapter 2. One study that did consider life satisfaction as an outcome for a sample of US born non-Hispanic Black adults in New York found that ethnic density interacted with neighbourhood income in predicting life satisfaction (Roy et al., 2012). They found that ethnic density was protective at higher levels of neighbourhood income, but detrimental at lower levels of neighbourhood income. In that study ethnic density was measured at the census block level, which is a smaller unit than census tract. That finding may indicate that in both Chapter 2 and Chapter 3, it could have been more appropriate to interact ethnic density by neighbourhood deprivation rather than just controlling for neighbourhood deprivation. However, that study was only conducted in a single city and they used a dichotomous measure of ethnic density. As their target population was US born non-Hispanic Black people in New York, they recruited their low ethnic density respondents from neighbourhoods where both between 10–30% of the population were non-Hispanic Black and that percentage was at least 10% higher than the percentage of foreign-born residents. High ethnic density respondents were instead recruited from neighbourhoods where at least 45% of residents were non-Hispanic Black and either the proportion of foreign-born residents was at least 40% lower than that or the percentage of non-Hispanic Black residents was above 70% (D. L. Hughes & Shweder, 2002). Only

including this subset of neighbourhoods may have induced interactions that would not have occurred in studies that sampled wider geographic areas and used continuous measures of ethnic density.

Ethnic Density Effects in the UK

The results of Chapter 3 differ somewhat from the findings of previous studies in the UK. One other study in the UK has previously tested the three-way interaction between ethnic density, ethnic group, and generation in the prediction of psychological distress using the UKHLS dataset (Y. Yan et al., 2019). Their cross-sectional analysis of wave 2 of UKHLS, found that ethnic density positively predicted psychological distress for 1st generation Pakistani, Bangladeshi, and Indian respondents, but that relationship was non-significant for 1st generation Black Caribbean and Black African respondents. They found that ethnic density significantly interacted with generation for each South Asian ethnic group, such that the ethnic density effect was negatively trending for 2nd generation migrants in each of those groups. For Black African and Black Caribbean respondents, the interaction was not significant. Those findings broadly contradict the results of Chapter 3, where interactions were instead significant for Black Caribbean and Black African respondents and all the significant estimates of ethnic density had protective associations with psychological distress rather than the detrimental associations found by Y. Yan et al. (2019). However, the significant interactions in Chapter 3 were for change in ethnic density, whereas Y. Yan et al.'s (2019) cross-sectional variable would be more comparable with the lagged ethnic density variable used in Chapter 3 for which no interactions were significant. The differences in the results between our two studies, which used the same core sample, show how longitudinal data analyses can reveal different and sometimes contradictory findings to analyses that only assess cross-sectional associations.

Several other studies have also examined ethnic density effects in the UK, but no others interacted ethnic density with both ethnic group and generation. For example, in a pooled cross-sectional analysis of waves 1, 3, and 5 of UKHLS, one study found that ethnic density significantly negatively predicted psychological distress across a sample of that included a broader range of ethnic groups while still excluding White British respondents (Nandi et al., 2020). They did not interact ethnic density with ethnic group, but they did find that the interaction between ethnic density and generation was not significant. Like Chapter 3, they also measured ethnic density using LSOA. The differences between our findings may indicate that, although ethnic density may be cross-sectionally related to psychological distress, ethnic density may not causally influence psychological distress for most ethnic groups in the UK. Another cross-sectional analysis of UKHLS' third wave, which interacted ethnic density and generation, found that ethnic density did not predict psychological distress for ethnic minority respondents in any generation (Dorsett et al., 2019). However, that study modelled ethnic density using larger units (LAS-NUTS3 regions) ranging between 100,000 and 1,100,000 people (Office for National Statistics, 2025). In comparison, LSOA units are more granular and each include between 983 and 8,300 people (Office for National Statistics, 2011). The statistics obtained from larger units make it less likely to be a proxy for individual's experiences of cultural isolation or cultural affirmation and belonging. The only other study that used a UK sample to interact ethnic density at the LSOA level with both generation and ethnic group to predict a psychological outcome, life satisfaction, also found mixed results for their analysis of wave 1 of UKHLS (Knies et al., 2016). However, they included White British respondents in their sample, which meant that they had to operationalise ethnic density slightly different to avoid their ethnic density measure being dominated by the higher values for White British respondents. For all respondents they measured and analysed the proportion of their neighbourhood who identified with each of

White Other, Chinese, South Asian; including Bangladeshi, Pakistani, and Indian; and Black; including Black Caribbean and Black African. In their analyses they interacted detailed ethnic groups (i.e., Bangladeshi, Pakistani, and Indian) with the relevant ethnic density (e.g., South Asian). For instance, they found that the portion of South Asian people was more positively related to life satisfaction for UK born Pakistani respondents compared to non-South Asian respondents. However, that interaction was only marginally significant and negative for 1st generation Pakistani respondents, marginally positively significant for UK born Indian respondents, and not significant for either generation of Bangladeshi respondents or 1st generation Indian respondents. In the equivalent interactions for Black respondents, they found that the proportion of Black people in an area was only significantly more positively related to life satisfaction for 1st generation, but not UK born, Black African respondents compared to non-Black respondents and that interaction was not significant for either generation of Black Caribbean respondents. For each interaction the simple effect for respondents not in the relevant ethnic groups was non-significant. These results confirm that ingroup ethnic density can be more important for psychological well-being than the proportion of other ethnic groups in that area for some ethnic groups in the UK but even ingroup ethnic density may be unrelated to psychological well-being for other groups. A different set of ethnic groups were found to have significant in-group ethnic density effect in that study, than in the main analysis (Model 1) of Chapter 3. However, Model 1 controlled for lagged psychological distress, which meant that the estimates could be interpreted as predictors of change in psychological distress, rather than prospective psychological distress. As such, the analysis without adjusting for lagged psychological distress (Model 1.4) may be a more appropriate comparison. In that model, lagged ethnic density positively predicted psychological distress for UK born Black African respondents, which is in agreement with

the findings of Knies et al. (2016), but the pattern of significant findings remained different between our studies for other groups.

Other studies that used UK datasets interacted ethnic density with ethnic group, but not generation, in their prediction of psychological health outcomes. In a cross-sectional nationally representative sample of England in 2000, which measured ethnic density at the broader Middle Layer Super Output Area (MSOA) level, Das-Munshi et al. (2010) found negative associations between ethnic density and common mental disorders for Indian, Bangladeshi, and Black Caribbean respondents. Of those groups, the equivalent association in Chapter 3 was only negatively significant for Black Caribbean respondents and that was only for change in ethnic density and not for lagged ethnic density. In another cross-sectional sample of ethnic minorities in England in 2004 that also used the MSOA level, ethnic density only significant predicted psychological distress negatively for Indian respondents and positively for Bangladeshi respondents. Whereas neither of those relationships were supported in Chapter 3. The differences between the results of Chapter 3 and those two studies could be a consequence of many different factors. The differences may have arisen because ethnic density was measured at a different level of geography, or because the other studies were cross-sectional and they did not interact with generation. However, both of those other studies share all these features so the differences may be a consequence the samples being collected at a different point in time, which may indicate that ethnic density effects are unstable over time in the UK.

Non-linear Ethnic Density Effects

In both Chapters 2 and 3, only the linear associations between ethnic density and life satisfaction or psychological distress were assessed. However, previous studies have found mixed support for possible non-linear effects of ethnic density for psychological health outcomes. One study that analysed a cross-sectional sample of African Americans who were

recruited between 2001 and 2003 found a quadratic association between ethnic density and depression symptoms (Bécares et al., 2014). Their quadratic association showed that at lower levels of ethnic density there was a negative association between ethnic density and depression symptoms. However, that negative association weakened at higher levels of ethnic density and above 85% ethnic density the association became positive. However, in that study their statistical comparison between linear and quadratic models found that the quadratic model was only marginally better ($p = .051$) than the linear model. They also found that the strength of both the detrimental association above that 85% threshold and the protective association below that threshold were reduced when neighbourhood deprivation was controlled for. However, the detrimental effects above that threshold were reduced to a greater extent. In sub-group analyses, they found that across measures of household income and individual education levels, the protective ethnic density effects below the threshold tended to only be significant for respondents with lower levels of education or income, and the detrimental effects above the threshold tended to only be significant for respondents with higher levels of education or income. Interestingly they also found that below the 85% threshold, ethnic density was detrimental for respondents with the highest income quintile. Those sub-group findings indicate that ethnic density may not be protective for people with higher economic affluence or education, who may experience socioeconomic isolation and fewer opportunities in neighbourhoods where their relative income or education is particularly high (Bécares et al., 2014).

Another study considered potential non-linear ethnic density effects for mental health for multiple ethnic groups in the UK using UKHLS (Shankley & Laurence, 2022). They pooled all data across waves 1–9 of UKHLS and analysed the data cross-sectionally except for the inclusion of a lagged value of mental health from the previous wave as a predictor. They used values from the 2010 Census to calculate ethnic density for all responses in all

nine waves, and they measured mental health using the mental health component of the Short-Form 12 Health Survey where higher values indicate better health. They found no evidence of the ethnic density having a quadratic effect. When their linear measure was calculated using LSOA level population data, they found that ethnic density was negatively associated with mental health for White Other respondents and positively associated for Black African respondents. The association was not found to be significant for any of the other ethnic groups that were analysed in Chapter 3. These findings indicated that it was appropriate to treat ethnic density as linear in Chapter 3. However, the previously mentioned finding in Bécaries et al. (2014) suggests that it may have been informative to examine the quadratic effects of ethnic density in the US context of Chapter 2. The findings of Bécaries et al. (2014) additionally indicate that it could have been useful to test whether individual affluence and education would have interacted with ethnic density or neighbourhood deprivation in the longitudinal analyses that were performed for Chapters 2 and 3.

When Are Ethnic Density Effects Meaningful?

Ethnic density effects may be more pronounced when ethnicity is defined in a way that groups individuals with other people who share their cultural heritage or racialised identities. Bhui (2009) argued that ethnic groupings may never be meaningful for everyone in that group and that cultural identity or religiosity, rather than ethnic group, would be more important in determining patterns of behaviour such as consumption, employment opportunities for social support. Consequently, measures of the percentage of people in a neighbourhood who share a cultural identity or a religion may be stronger predictors of psychological distress and well-being than ethnic density. Interpreting ethnic group differences may be particularly difficult or nonsensical if the groupings aggregate together people who identify with many different cultures or who have heterogeneous experiences of socioeconomic disadvantage or discrimination. For instance in the UK in the 1990s, Indian,

Pakistani and Bangladeshi people were often grouped together as a single South Asian group for analyses of health outcomes (Bhopal, 2009; Bhopal et al., 1999). However, in the UK, Indian people tend to have higher educational and occupational attainment than Bangladeshi and Pakistani people (Dorsett et al., 2019; Nandi et al., 2016). Within nation-based ethnic groups, there may still be high heterogeneity in experiences of racism in the UK based on individual's religious identity. For example, when groups were disaggregated by both ethnicity and religion, Indian-Sikhs were found to have higher psychological distress than Indian-Hindus (Nandi et al., 2020).

In the US census, South and East Asian people are still grouped together and Arabs are grouped within the White ethnic group despite being excluded from many of the benefits of *Whiteness* in US society (Abdulrahim et al., 2012; Awad et al., 2021; Naber, 2000; Viruell-Fuentes et al., 2012). As such, the non-Hispanic White group utilised in Chapter 2 may represent people with many different cultural identities and experiences of discrimination across which ethnic density may differently relate to psychological distress. Similarly in the Chapter 3, the White Other category includes people that were born in a broad range of different countries. In the 2011 Census of England and Wales there were 24 countries, including 16 European Union member states, which were the birthplace of at least 1% of the 1st generation White Other population of England and Wales, but Poland (25%) and Italy (5%) were the only countries that accounted for at least than 5% of those births (Office for National Statistics, 2014). First generation White Other migrants from Poland and other countries that joined the EU in the 21st Century, have been subject to greater prejudice and xenophobic rhetoric in the UK than other White Other people so they may experience stronger benefits from increases in ethnic density (Harris et al., 2022; Rzepnikowska, 2019). Additionally, as 25% of 1st generation White Other people in the England and Wales in 2011 were born in Poland, when ethnic density is defined using the percentage of White Other

people in an area, it is much more likely to capture the true variation in cultural or linguistic ingroup members for Polish people than it is for any other sub-population of White Other people. As such, the possible sociocultural benefits of ethnic density, such as cultural affirmation and culturally relevant community resources, may be more pronounced for 1st generation Polish people than other 1st generation White Other people in England and Wales.

Previous studies have also shown that ethnic density effects vary depending on the specificity of the ethnic groupings. One study compared samples of Black Caribbean people in England and the US and mutually adjusted for both Black ethnic density and Caribbean ethnic density in their cross-sectional analysis (Bécares, Nazroo, Jackson, et al., 2012). Both measures of ethnic density were calculated at the census tract level for the US sample and MSOA for the English sample. For the US sample, the Caribbean ethnic density measure was based on the proportion of a neighbourhood population who were born in the Caribbean. Whereas it was based on the proportion who identified as Black Caribbean in the English sample regardless of where they were born. In the US, they found that higher Caribbean ethnic density was associated with better self-rated health, but Black ethnic density was associated with worse self-rated health. However, the detrimental relationship for Black ethnic density was only significant when Caribbean ethnic density was also included in the model. In the UK, they found no significant associations with self-reported health. However, they did find that when both (Black and Caribbean) ethnic density measures were included in the model, respondents with higher Black ethnic density were less likely to be refused a job due to discriminatory recruiting practices and respondents with higher Caribbean ethnic density were more likely to be refused a job. The former relationship was also found in the US, but the latter was not. However, in both countries, neither measure of ethnic density significantly predicted whether respondents had been insulted in the last 12 months, which was component of the discrimination measure used in Chapter 3. The authors argued that the

different associations found in each country were due to Black Caribbean people experiencing more prejudice and being stereotyped as “lazy” in the UK, whereas Black Caribbean people in the US have been stereotyped as “hard workers” and have tended to experience greater economic prosperity than other Black groups in the US (Bécares, Nazroo, Jackson, et al., 2012). However, the differences between Black ethnic density and Caribbean ethnic density in the US may be due to Caribbean ethnic density being a better proxy for respondent’s ingroup cultural identity than Black ethnic density. Only 37% of the respondents in the US sample were US born, so they may be more likely to identify with other immigrants from the Caribbean, as measured by Caribbean ethnic density, than with other Black Americans. This is supported by a study that found that a sample of 1st generation Jamaican immigrants in the US were more acculturated towards Jamaican culture than to African American or European American cultures (Ferguson et al., 2014). However, it should be noted that in that study most respondents were positively culturally oriented towards with either all three of those cultural groups or to Jamaican and one of the American groups.

Another study found that ethnic density effects varied for across groups of Hispanic and Latino people in the US and across definitions of co-ethnic density (Bécares, 2014). Their sample included US born and 1st generation migrants who identified as Cuban, Puerto Rican, or Mexican. When ethnic density was measured using each of those three identities, it was only significantly positively associated with psychological distress for 1st generation Mexican respondents. When ethnic density was instead measured using the percentage of Hispanic residents, there was a significant negative relationship with psychological distress for US born Puerto Ricans and a significant positive relationship for 1st generation Mexican respondents. However, when ethnic density was measured as the proportion of residents who were immigrants from Latin American, it had a negative association with psychological distress for US born Cubans, and both US born and 1st generation Puerto Ricans, but a

positive relationship for 1st generation Mexicans. The author argued that Puerto Ricans have faced more discrimination in the US and are more likely to have poorer health than other Latino groups, which may mean that they can benefit most from the possible benefits of higher ethnic density. However, the authors could not explain why the 1st generation migrants from Mexico, who face the most hostile migration laws, did not also benefit from higher ethnic density.

Mediation Mechanisms of the Ethnic Density Effect in Chapters 2 & 3

In Chapters 2 and 3, in addition to testing ethnic density effects across ethnic groups and generations in the US and England, potential mediation pathways that could connect ethnic density to psychological well-being and distress were also considered. Chapter 2 assessed a serial mediation pathway from ethnic density to psychological well-being through social cohesion, social support, and allostatic load. However, ethnic density was only found to longitudinally predict social cohesion and psychological distress. Ethnic density also indirectly predicted social support through social cohesion, but the total effect of the relationship between ethnic density and social cohesion was not significant. In Chapter 3 the associations between lagged or change in ethnic density and psychological distress were not substantively altered when either social cohesion, social support, or discrimination were adjusted for in multilevel models. As such, across the two chapters there was limited support for the potential mediating role of social cohesion, but no support for any of the other potential mediators that were considered.

Previous studies in both the US and the UK have found mixed results for the mediating roles of social cohesion, social support and discrimination. However, no previous studies appear to have examined the potential mediating role of allostatic load. One cross-sectional study found that for a Latino sample in the US, ethnic density negatively predicted self-rated mental health but with a positive indirect effect through social cohesion (Hong et

al., 2014). Ethnic density positively predicted social cohesion which in turn positively predicted self-rated mental health. In other studies, ethnic density was found to cross-sectionally positively predict self-rated health (Yang et al., 2018), and longitudinally negatively predict depression symptoms (Flores et al., 2022) for Hispanic respondents, but the indirect effect through social cohesion was not significant in either study. However, one of those studies found marginal evidence that social cohesion mediated the ethnic density effect for non-Hispanic Black respondents (Yang et al., 2018). The other study assessed the indirect effect of social support and found it to be non-significant (Flores et al., 2022).

A study that used a cross-sectional sample of non-Hispanic Black respondents found that the significant relationships between ethnic density and both depression symptoms and well-being became non-significant when measures of social support and social cohesion were included in the analysis (Vogt Yuan, 2007). Both social cohesion and social support significantly positively predicted well-being and negatively predicted depression symptoms, which indicates that either or both measures may have mediated the ethnic density effect. Another cross-sectional study found that ethnic density negatively predicted depression symptoms for Hispanic respondents before but not after each of social support, perceived stress, and discrimination were separately included in their analyses, which indicates that social support, perceived stress, and discrimination may have each mediated that relationship (Shell et al., 2013).

A previously discussed study that assessed the effects of multiple definitions of ethnic density for Puerto Ricans, Mexicans, and Cubans in the US also tested the mediating roles of social cohesion and racist discrimination (Bécares, 2014). They found that no associations were significant for the Cuban respondents. For Puerto Rican respondents, ethnic density negatively predicted psychological distress and racist discrimination and positively predicted social cohesion. However, those estimates were only significant when ethnic density was

measured using either the proportion of Latin American immigrant or Hispanic residents in their census tract, and not when ethnic density was measured as the proportion of Puerto Ricans in their census tract. That study found that racist discrimination, but not social cohesion, significantly predicted psychological distress for Puerto Rican respondent. The combined indirect effect through both alternative mediation paths was marginally significant (i.e., $.050 < p < .10$), and the total effect was more negative than the direct effect of ethnic density, which may indicate that racist discrimination, but not social cohesion, partially mediated ethnic density effect for Puerto Ricans. For Mexican respondents' discrimination partially mediated the ethnic density effects with the direct effects of ethnic density being more positively associated with psychological distress than were the total effects for all three operationalisations of ethnic density.

In the UK context, one cross-sectional study found that ethnic density predicted social capital, which in turn predicted psychological distress (Bécares & Nazroo, 2013). Their measure of social cohesion combined typical measures of social cohesion with measures of neighbourhood graffiti and whether teenagers were hanging around on the streets. They found the association between ethnic density and social capital to be positive for Indian and Pakistani respondent, but negative for Bangladeshi and Black Caribbean respondents and non-significant for Black African respondents. For all those groups, they found a negative association between social capital and psychological distress. However, the associations they found between ethnic density and psychological distress did not substantively change when social capital was controlled for, which indicated that it did not act as a mediator.

Another study, which also used a cross-sectional sample collected in England, found that neither discrimination nor social support mediated associations between ethnic density and common mental disorders (Das-Munshi et al., 2010). They found that ethnic density was negatively associated with discrimination and common mental disorders and positively

associated with practical social support for Bangladeshi respondents but not for Black Caribbean, Indian, or Pakistani respondents. However, when minority ethnic groups were assessed together, they also found that ethnic density was associated with practical social support and common mental disorders.

One of the important contributions of Chapters 2 was the use of longitudinal analyses to assess potential mediation mechanisms between ethnic density and psychological well-being, whereas most of the previous studies that have been discussed in this section only explored those relationships using cross-sectional analyses.

Acculturative Stress and Psychological Distress in Chapters 3 & 4

In Chapters 3 and 4, several domains of acculturative stress were assessed as potential predictors of psychological distress. Chapter 3 considered how acculturative stressors and acculturative stress may mediate or confound the relationship between ethnic density and psychological distress. Whereas Chapter 4 focused on a measure of acculturative stress that addressed several potential domains of acculturative stress: cultural isolation, intercultural relations, discrimination, language skills, and work.

Several previous studies have considered proxies for acculturation, such as length of time spent living in the settlement country, as predictors of either health behaviours, or physiological and psychological health. For example, Kaestner et al. (2009) found that on arrival in the US, middle-aged Mexicans had lower levels of physiological dysregulation than US born Mexican-Americans. However, this health advantage diminished as immigrants spent more years living in the US. Researchers have previously proposed that that health deterioration may result from maladaptive US smoking and eating behaviours and experiences of acculturative stress (Geronimus et al., 2020; Kaestner et al., 2009; Luthra et al., 2020). Chapters 3 and 4 focused on measures of acculturative stressors and stress rather than of acculturation because it is through acculturative stress that low levels of acculturation

may negatively impact psychological distress. As such, exploring measures of acculturative stress may provide more insight into the processes that influence psychological distress.

However, as described in the previous section, both Chapter 2 and 3 tested whether generation (i.e., whether respondents were being born in the settlement country of the USA or UK) moderated the associations between ethnic density and psychological distress.

Generation is typically considered a proxy of acculturation but it may also be considered a proxy for historical differences in experience of structural racism (Viruell-Fuentes et al., 2012), such as historic exclusion from housing markets or employment opportunities for racialised minorities and migrants (Geronimus, 2023; Rothstein, 2017).

Only one domain of acculturative stress, namely negative context of reception, was directly measured in the dataset used for Chapter 3, UKHLS, but several of the other items that were measured could be considered as proxies for different domains of either acculturative stressors or acculturative stress. For example, most of the explanations of the benefits of ethnic density are grounded in higher ethnic density providing the context for individuals to experience cultural affirmation and to not experience cultural isolation. The ability to easily visit family members could also help to prevent cultural isolation. So, ethnic density may only help to prevent cultural isolation and reduce psychological distress if individuals are not already psychologically benefitting from being able to see their family and vice versa. An analysis included in Appendix B Supplementary Analysis found that ease of visiting family significantly negatively predicted later psychological distress. However, the interaction between the two terms was not significant. To test that interaction, the interactions between the ethnic density variables, ethnic group, and generation were omitted, which resulted in a non-significant association between psychological distress, and both lagged- and change in ethnic density across the whole sample. A much larger sample would be required to assess whether the interaction between ethnic density and ease of visiting family would be

significant for any specific generation of any ethnic group, but a future analysis using this dataset could potentially consider the interaction for either specific ethnic groups or specific generations.

In the acculturative stress scale that was used in Chapter 4, the Riverside Acculturative Stress Inventory (Benet-Martínez, 2003; Benet-Martínez & Haritatos, 2005), the intercultural relations stress items were focused on close relations and referred to disagreements with “friends or family” and “conflict in my relationships”. As such, the negative social support questions in UKHLS may act as proxies for intercultural relations. Those questions asked respondents how much their partners, family, and friends criticised them, let them down, or got on their nerves. As has already been discussed, both a summary measure of those items and of positive social support were included in the analyses of Chapter 3 as potential mediators. They did not mediate the associations between ethnic density and psychological distress, but as expected, negative social support positively predicted psychological distress and positive social support negatively predicted psychological distress. These significant associations between the measures of social support and psychological distress support the finding of many previous studies (Chen & Feeley, 2014; Lerman Ginzburg et al., 2021; Mulvaney-Day et al., 2007; Siedlecki et al., 2014; Stephens & Bakhshandeh Bavarsad, 2025; B. Yan et al., 2016).

The discrimination domain of acculturative stress can be effectively captured by the discrimination questions that were included in UKHLS. Respondents were asked if they had avoided, felt unsafe, been insulted or attacked in any place in the last 12 months. If they had had any of those experiences, they were asked to provide a reason why. To create a measure of discrimination that related specifically to acculturative stress only the following reasons were used in the variable that was derived for Chapter 3: ethnicity, nationality, religion, language or accent, dress or appearance. As discussed previously, discrimination was not

found to mediate the relationship between ethnic density and psychological distress in Chapter 3. However, discrimination was found to positively predict later psychological distress, which supports the results of previous studies (Hudson et al., 2016; McCord et al., 2019; Nandi et al., 2020; Salas-Wright et al., 2024; Wallace et al., 2016).

Another domain of acculturative stress is language skills, or rather language difficulties, which refers to whether an individual finds it difficult to perform well at school, work, or in daily situations due to their level of language competency. In UKHLS, respondents who did not speak English as a first language were asked if they had any difficulty speaking English during daily activities or difficulty reading formal documents that were written in English. For Chapter 3, those two types of English language difficulty were merged to form a single binary variable. As neither question explicitly asked respondents how stressed their language difficulties made them feel, this measure can be seen as a measure of the language stressor rather than the resulting stress. Most respondents were only asked those questions once, in wave 1 or 5, so the measure derived from each respondent's first answer was treated as if it were time-invariant. It was included in the Chapter 3 analyses as a potential confounder in the relationship between ethnic density and psychological distress because people with limited English language proficiency may be more likely to live in areas where more people speak other languages that they are fluent in, which may also be areas with higher ethnic density for some migrant groups. However, that measure of English language difficulty did not significantly predict later psychological distress. Previous studies have found mixed findings for the link between language competency and psychological outcomes (Park et al., 2020; Schachter et al., 2012; Zlotnick et al., 2020). In Chapter 3, the non-significant relationship may have resulted from the binary measure of language difficulty not appropriately capturing the full variation across of levels of language difficulty. Alternatively, the threshold between the binary outcomes might not have been the most

appropriate choice. For example, if the threshold related to whether respondents had extreme difficulty speaking or reading English, rather than contrasting any language difficulty with no language difficulty, then that may have been a better predictor of psychological distress. The measure was also derived from self-report items, whereas an English language examination may have been a more accurate measure of ability. However, respondents' self-perception of having language difficulties may be a more important predictor of psychological distress than their objective ability, so using a self-report measure may not in itself have been a reason for the lack of association. A more likely reason may be that respondents' levels of English language proficiency could have substantially improved between when the language difficulties were measured in wave 1 and when psychological distress was measured in waves 3, 6, or 9. If that improvement occurred then respondents' earlier levels of language ability may have little relation to their current level of psychological distress.

The final domain of acculturative stress that was included in the Riverside Acculturative Stress Inventory used in Chapter 4 was *work challenges* (Benet-Martínez & Haritatos, 2005). Two of the work challenges items in that measure asked respondents whether they felt that they must work harder than other people because of their "ethnic/cultural status", and whether they felt that their "cultural/ethnic status" was a limitation when looking for a job. Both of those items could be considered measures of negative context of reception, which is another form of acculturative stress that has been assessed by previous studies and as a component of Cultural Stress Theory (Meca & Schwartz, 2024). Measures of both work challenges and negative context of reception have previously been found to be positively associated with depression and anxiety symptoms (Miller, Kim, et al., 2011; Schwartz et al., 2014, 2018). In wave 7 of UKHLS, 1st generation migrant respondents were asked two questions that related to negative context of reception. The first of those items asked if "the UK is a hospitable or welcoming country for people from your

country of birth” and the second asked whether “people from your country of birth can get ahead in the UK if they work hard”. These items were answered using a 5-point Likert scale and they only had a correlation of $r = .41$, so they were separately included in the analyses. However, unexpectedly, neither item significantly predicted psychological distress. That result may be due to previous levels of psychological distress also be controlled for in the analysis, which meant that the results could be considered as estimates of change in psychological distress. When 1st generation migrants first perceived a negative context of reception they might experience a deterioration in their psychological distress, but their level of psychological distress could then become stable or recover. If that was the case, then analyses may be predominantly capturing the stable period of psychological distress after respondents have already reacted to any negative context of reception. Additionally, the items were only measured in wave 7, which is after the first two outcome measurements of psychological distress. So, some respondents may have had different perceptions of their context of reception during the first six waves of UKHLS, which would have added substantial noise to the analysis.

In Chapter 4, acculturative stress was measured using an inventory that included the previously discussed domains of cultural isolation, intercultural relations, discrimination, language skills, and work stress. Greater acculturative stress predicted psychological distress when it was measured concurrently and when it was measured approximately one month after the measurement of acculturative stress. However, the latter association became non-significant when the former measurement of psychological distress was controlled for. The significant findings are in keeping with findings from previous studies (Corona et al., 2017; Doucerain et al., 2025; Merced et al., 2022; Miller, Kim, et al., 2011).

Physiological Dysregulation, Psychological Distress and Well-being in Chapters 2 & 4

Chapters 2 and 4 assessed how measures of physiological dysregulation related to psychological well-being and distress. Chapter 2 assessed allostatic load as a composite index of eight markers of dysregulation across multiple physiological systems. Allostatic load was conceived as a measure of the cumulative impact of an individual's lifetime exposure to stress (McCrory et al., 2023; McEwen, 1998). Over the last three decades of research into allostatic load, there has been no consensus on which physiological markers should be used, or how they should be combined, to create allostatic load (McCrory et al., 2023). However, because HRS only collected a few biomarkers from each respondent, there has been more consensus across studies that have analysed HRS data (Ding et al., 2019; Pak & Kim, 2021; Stephan et al., 2016; Suh et al., 2019). In Chapter 2, allostatic load was found to prospectively negatively predict psychological well-being, which was measured as life satisfaction. Additionally, in a cross-lagged panel model analysis, both allostatic load and psychological well-being were found to prospectively predict each other. Measures of psychological health and well-being have repeatedly been found to predict later allostatic load (Boehm et al., 2016; Boylan & Ryff, 2015; Rouch et al., 2014), but the reverse direction found in Chapter 2 has rarely been explored (Prior et al., 2018). However, allostatic load was not found to mediate the association between social support and psychological well-being as part of a biopsychosocial pathway.

In Chapter 4, physiological dysregulation was measured as vagally-mediated Heart Rate Variability (vmHRV). At rest, greater vmHRV indicates stronger physiological regulation or specifically indicates that vagal nerve activity is having a stronger inhibitory influence on an individual's heart rate during the exhalation phase of their respiratory cycle. For Chapter 4, resting vmHRV was calculated using electrocardiograph (ECG) data that was collected whilst participants watched a neutral film clip. Unlike previous studies, resting

vmHRV was neither found to predict concurrent nor prospective psychological distress (Beauchaine, 2015; Koch et al., 2019; Muhtadie et al., 2015).

In addition to measuring resting vmHRV, change in vmHRV between a period of rest and a stressor task (vmHRV reactivity) was also measured in Chapter 4. vmHRV reactivity measures how much the vagal control of an individual's heart rate changes in response to their environment. For Chapter 4, participants were presented two different stressor stimuli which each followed a neutral film clip that acted as their baseline in the calculation of vmHRV reactivity. vmHRV reactivity in response to the first stressor stimulus, a sad film clip, did not significantly predict concurrent or prospective psychological distress. Previous studies have found mixed results when assessing the association between vmHRV reactivity in response to that sad film clip and psychological outcomes (Rottenberg et al., 2005; Stange et al., 2017; Yaroslavsky, Bylsma, et al., 2013). However, vmHRV reactivity in response to the second stressor stimulus, a novel acculturative stress recall task, did significantly negatively predict concurrent psychological distress.

Previous studies have found that the strength of the relationship between vmHRV and psychological health was stronger for individuals who were experiencing greater life stress (Gouin et al., 2014; Stange et al., 2017). So, the interaction between acculturative stress and the vmHRV reactivity measures were also assessed, but the interactions terms were not significant.

Implications

Chapters 2 and 3 assessed the longitudinal relationships between ethnic density and psychological well-being and distress and assessed potential biopsychosocial mediation pathways between ethnic density and those psychological outcomes. Most previous studies that have assessed ethnic density effects for psychological outcomes have used cross-sectional data (Bécares et al., 2018), which restricts their capacity to appropriately control for

confounding variables and prevents them from investigating how changes in ethnic density may predict changes in psychological outcomes. Additionally, both Chapters 2 and 3 investigated how ethnic density effects vary between ethnic groups and across generations. Of the previous studies that have separately assessed ethnic density effects for different ethnic groups, many did not formally test whether the estimates for each group were substantively different from one another (Das-Munshi et al., 2010; Hong et al., 2014; Shankley & Laurence, 2022; Yang et al., 2018). In this thesis, those differences were tested by comparing model fit statistics in Chapter 2 and with interaction terms in Chapter 3. Using these longitudinal methods, which were more robust than cross-sectional methods that are prevalent in the literature, Chapter 2 found evidence that ethnic density positively predicted psychological well-being for older adults in the US, and Chapter 3 found that ethnic density negatively predicted psychological distress for some generations of some minority ethnic groups in England. However, neither chapter found strong evidence for the mediating roles of social cohesion, social support, discrimination, or allostatic load, which indicates that other mechanisms may need to be explored in future studies to further understand the protective effects of ethnic density.

Chapter 2 also found that allostatic load and psychological well-being had a bi-directional longitudinal relationship. Most previous studies considered poor psychological health or well-being as a precursor of increasing allostatic load and did not assess whether allostatic load would influence later psychological distress (Boehm et al., 2016; Boylan & Ryff, 2015; Rouch et al., 2014).

Chapter 4 measured vmHRV reactivity in response to a novel acculturative stress recall task. A few studies have assessed vmHRV reactivity in responses to tasks that elicit specific domains of acculturative stress such as discrimination (Doucerain et al., 2022; Volpe et al., 2019), but none to the author's knowledge have assessed vmHRV reactivity in

response to participants being asked to recall their experiences of other domains of acculturative stress. That measure of vmHRV reactivity positively predicted psychological distress, which indicated that a stronger reduction in vmHRV in response to recalling acculturative stress may be more adaptive than smaller reductions, or increases, in vmHRV.

Limitations

Chapters 2 and 3 each only tested one measure of neighbourhood ethnic group composition (i.e., ethnic density) at one level of geography. Chapter 2 used census tracts in the US and Chapter 3 used LSOA in the UK. However, the effects of neighbourhood ethnic group composition may vary depending on the measure used and the scales at which those measures are used. For example, studies often find that higher ethnic density has a protective effect for psychological health, but measures of segregation have detrimental effects (Shankley & Laurence, 2022). Measures of segregation assess how much the ethnic composition of smaller geographic units (e.g., Output Areas) vary across a larger unit (e.g., LSOA). For example, a measure of ethnic density at the LSOA level might find that half the residents identify with one ethnicity and the other half identify with another ethnicity, so residents of each group would have an ethnic density of 50%. If a segregation measure was then used to summarise the ethnic density of the Output Areas within that LSOA, it might find that every output area also had an ethnic density of 50%, which would indicate that the two ethnic groups are residentially integrated. On the other end of the spectrum, that measure could find that 100% of one ethnic group live in one half of the Output Areas and 100% of the other ethnic group live in the other half of the Output Areas, which would show complete residential segregation. This extreme example also shows that when ethnic density is measured at different levels, such as between Output Area and LSOA, the same individual may appear to be exposed to very different levels of ethnic density and as such the estimated relationships between ethnic density and psychological outcomes may also substantially

differ. One study cross-sectionally pooled waves 1-9 of UKHLS and tested measurements of ethnic density and segregation at different geographic scales (Shankley & Laurence, 2022). From smallest to largest geographic area, they used LSOA, Middle Layer Super Output Areas, and Local Authorities. For their measurements of ethnic segregation, they used each of those areas as the “larger unit”, and Output Area as the “smaller unit”. They found mixed support for protective effects of ethnic density across ethnic groups and levels of measurement, but they found more consistent support for negative impacts of segregation, and they found that the effect sizes for segregation tended to be strongest at the MSOA level. Additionally, they found that segregation, but not ethnic density, had quadratic effects in the prediction of common mental disorder symptoms. They also found that segregation confounded the effects of ethnic density, with effect sizes of ethnic density tending to increase when segregation was controlled for. As such, the estimates of ethnic density in Chapters 2 and 3 could have been confounded by unmeasured differences in neighbourhood segregation across respondents, across ethnic groups, or across generations.

Due to differences in the availability of data between the US and the UK, Chapters 2 and 3 controlled for neighbourhood deprivation in different ways, which may have meant that they were more or less effective at adjusting for the detrimental impacts of structural racism on neighbourhood conditions (Das-Munshi et al., 2010). For example, Chapter 3 used a measure of deprivation that included crime rate, but it was not possible to adjust for crime in Chapter 2 due to that data only being available on a larger geographic scale in the US and because that US crime data had much more missing data than the other neighbourhood variables. Crime and incarceration rates may have an important detrimental impact on individual health in some neighbourhoods in the US (Larrabee Sonderlund et al., 2022), which may have confounded the estimates of ethnic density effects in Chapter 2.

The associations between ethnic density and psychological well-being or distress were found to differ between the US (Chapter 2) and UK (Chapter 3) contexts and between ethnic groups and migrant generations in the UK, which could be a consequence of those groups differing on untested moderating variables. For example, several previous studies have found that ethnic density interacts with some of the variables that were included as confounders or mediators in those chapters. Studies have found evidence that discrimination may interact with ethnic density in prediction of psychological outcomes (Nandi et al., 2020; Syed & Juan, 2012) and one study additionally found a three-way interaction between ethnic density, social cohesion, and discrimination (Syed & Juan, 2012). If the average values of social cohesion and discrimination differed between ethnic groups or migrant generations, that could explain the different estimated relationships between ethnic density and psychological distress for each group included in Chapter 3.

The strength of the relationship between ethnic density and psychological distress could also depend on whether individuals are living in a neighbourhood out of choice or due to external structural or social influences. Those influences could include rent affordability, access to employment, or family obligations, which could each clash with an individual's acculturation preferences, such as their desire to have separation from a cultural ingroup. One study of immigrant students in Canada measured their preference for engaging with their heritage culture (known as heritage acculturation) alongside their perception of how many people from their ethnic group lived in their neighbourhood (known as perceived ethnic density) and their depression symptoms (Jurcik et al., 2013). They found that for individuals with higher perceived ethnic density, higher heritage acculturation was associated with a lower severity of depression symptoms. Whereas heritage acculturation was not significantly associated with depression symptoms in low perceived ethnic density neighbourhoods and depression symptoms tended to be worse for individuals with low heritage acculturation in

high perceived ethnic density neighbourhoods (Jurcik et al., 2013). However, in a second study that considered psychological distress they found that those relations only held for participants who had lived in their neighbourhood for fewer than two years (Jurcik et al., 2015). For participants who had lived in their neighbourhood for more than two years, those with low perceived ethnic density and low heritage acculturation had the highest levels of psychological distress with psychological distress being low for those who had higher values for either or both of perceived ethnic density and heritage acculturation. Those studies show that poor person-ecology fit could influence the associations between ethnic density and psychological distress, which could lead to group level differences in those estimates if the groups differed on any untested moderating factor.

In Chapter 4 the only physiological measures that were included as predictors of psychological distress were derived from vmHRV, which is intended as a measure of parasympathetic nervous activity. As such, unmeasured activity in the other branch of the autonomic nervous system, the sympathetic nervous system, could confound or moderate the results of Chapter 4. Typically more adaptive physiological response to stressors involve reciprocal changes in parasympathetic and sympathetic activity, rather than simultaneous co-inhibition or coactivation across both systems (Berntson et al., 2016; J. W. Choi et al., 2021; Wagner & Abaied, 2015). Consequently, the strength of the relationship between vmHRV reactivity and psychological distress may differ across the participants depending on their level of sympathetic nervous system activation.

Chapter 4 was recruited using convenience sampling and was not representative of the local or national 1st generation migrant population, whereas both Chapter 2 and 3 were collected using clustered and stratified sampling techniques that produced much more representative samples of the target populations. Additionally, the analyses in Chapter 3 were weighted to adjust for unequal sampling probability and unequal attrition rates across the

population and robust standard errors were calculated to account for the clustered sample design. Consequently, the findings of the Chapters 2 and 3 are more likely to represent the relationships that would be found across the target populations. In contrast, the relationships estimated in Chapter 4 may be biased to reflect the experiences of people who share characteristics with the study's participants. Those participants were predominantly 1st generation migrants with short-term student visas and high levels of education.

Directions for Future Research

Future research on ethnic density effects should assess the longitudinal roles of ethnic segregation in combination with ethnic density for different ethnic groups and generations. However, larger samples would be required to assess these complex interactions.

More work should be done to assess the political and socioeconomic conditions that may influence whether residents benefit from higher levels of ethnic density effects.

Additionally, other mediation mechanisms need to be investigated as the mechanisms that have been assessed to date are often not empirically supported. Alternative mechanisms that are rarely considered included health behaviours; such as diet, smoking, and alcohol consumption (Luthra et al., 2020; Yang et al., 2018); or acculturation (Jurcik et al., 2019).

Many more longitudinal analyses are required across national contexts and between ethnic groups and generations. That will enable future meta-analyses to then be able to synthesise the findings of longitudinal studies rather than relying on cross-sectional research.

Existing nationally representative longitudinal datasets should be more used more frequently in future cross-cultural and acculturation studies. Several studies have used those datasets to consider proxies for acculturation (Knies et al., 2016; Scholaske et al., 2021), but few have previously considered acculturative stress. The proxy variables of acculturative stressors and acculturative stress identified in Chapter 3, show promise for how acculturative stress could be operationalised in future analyses of these datasets.

Future studies on acculturative stress, or cultural stress, should utilise the acculturative stress recall task that was devised for this study, or the previously created discrimination recall task (Doucerain et al., 2022), to further explore how physiological responses to acculturative stress may influence psychological distress in other samples and how those physiological responses may influence other outcomes related to acculturative experiences such as sociocultural adaptation, health behaviours, or academic performance. As was discussed in Chapter 4, there is still considerable uncertainty over whether it is more adaptive to respond to negatively valenced stressor tasks with blunted physiological responses or greater reductions in vmHRV. Additionally, it is unclear whether different responses may be more adaptive depending on the level of chronic stress that people are experiencing (Boyce & Ellis, 2005; Gouin et al., 2014; Stange et al., 2017). Studies that measure physiological functioning should additionally measure both parasympathetic nervous system and sympathetic nervous system activity to explore how their reciprocal activation, co-inhibition, or co-activation may influence those outcomes.

Final Conclusions

This thesis assessed how measures of acculturative stress and neighbourhood sociocultural context relate to psychological distress and well-being. Chapters 2 and 3 focussed on ethnic density, which is the proportion of people in an area who share an individual's ethnic identity. For migrants populations and racialised ethnic minorities, low levels of ethnic density may stimulate feelings of cultural isolation and may make experiences of other domains of acculturative stress more likely such as intercultural relations stress and discrimination. In contrast, higher levels of ethnic density may make positive interactions with their cultural in-group more common which could provide cultural identity affirmation and provide opportunities to develop neighbourhood social cohesion and social support systems.

In Chapter 2, ethnic density was found to prospectively positively predict psychological well-being across a sample of Hispanic, non-Hispanic Black, and non-Hispanic White older adult respondents in the US. Then in Chapter 3, ethnic density prospectively negatively predicted psychological distress for UK born and 1st generation migrant Black Caribbean, UK born Black African, and UK born Pakistani respondents in England, but the association was not significant for 1st generation migrant Black African and 1st generation migrant Pakistani respondents or for either UK born or 1st generation migrant Indian, Bangladeshi or White Other respondents.

Both Chapters 2 and 3 also assessed potential mediators of the association between ethnic density and psychological well-being or distress. Chapter 2 found no support for a hypothesised biopsychosocial serial mediation pathway that included neighbourhood social cohesion, social support, and allostatic load. However, ethnic density did prospectively positively predict neighbourhood social cohesion, which in turn predicted psychological well-being. The results presented in Chapter 3 also showed no support for the mediating role of neighbourhood social cohesion, social support, and discrimination.

In Chapters 2 and 4, the role of physiological dysregulation was assessed. Chapter 2 assessed physiological dysregulation across multiple physiological systems using a measure of allostatic load. A cross-lagged model showed that ethnic density and allostatic load did not prospectively predict each other, but that allostatic load and psychological well-being did. Chapter 4 then assessed how physiological stress responses were related to psychological distress. In response a novel task where 1st generation migrant participants were asked to think about their past experiences of acculturative stress, a greater reduction in vagally-mediated Heart Rate Variability was found to predict concurrent psychological distress.

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Appendices

Appendix A. Chapter 2

Descriptive Statistics

To enable descriptive comparisons between respondents living in high and low ethnic density neighbourhoods, each column of Table 2.1 was split using the total sample median ethnic density (81.4%). The descriptive statistics for the resulting groups are shown in Table A.1.

Compared to the total sample median ethnic density, 56.11% of non-Hispanic White respondents lived in high ethnic density neighbourhoods, compared to 32.04% of non-Hispanic Black respondents and 30.20% of Hispanic respondents.

More than 90% of non-Hispanic respondents living in both low and high ethnic density neighbourhoods were US born. Whereas the percentage of Hispanic respondents who were US born was much lower for those living in high ethnic density neighbourhoods (36.84%) than in low ethnic density neighbourhoods (48.24%).

Hispanic respondents in high ethnic density neighbourhoods had the lowest mean years of education (6.93 years) which was more than 2 years less than Hispanic respondents who lived in low ethnic density neighbourhoods, almost 4 years less than non-Hispanic Black respondents, and over 5 years less than non-Hispanic White respondents.

Mean census tract neighbourhood income was highest for non-Hispanic White respondents and lowest for non-Hispanic Black and Hispanic respondents that lived in high ethnic density neighbourhoods.

Mean census tract neighbourhood levels of education were lowest for Hispanic respondents in high ethnic density neighbourhoods. Hispanic respondents in low ethnic density neighbourhoods had similar neighbourhood education means to non-Hispanic Black

respondents in both low and high ethnic density neighbourhoods. Non-Hispanic White respondents in both high and low ethnic density neighbourhoods had the highest means of neighbourhood education.

In all waves, neighbourhood unemployment was highest for non-Hispanic Black respondents in high ethnic density neighbourhoods and lowest for non-Hispanic White respondents in high ethnic density neighbourhoods.

The percentage of people living in poverty was on average two to three times higher for non-Hispanic Black and Hispanic respondents in high ethnic density neighbourhoods than for non-Hispanic White respondents in high ethnic density neighbourhoods in each wave. Whereas in low ethnic density neighbourhoods the groups had much more similar average levels of poverty.

Table A.1

Descriptive Statistics Grouped by Ethnic Density.

variable /wave	stat.	Non-Hispanic White		Non-Hispanic Black		Hispanic	
		Low Ethnic Density (<i>N</i> = 9,754)	High Ethnic Density (<i>N</i> = 12,470)	Low Ethnic Density (<i>N</i> = 3,004)	High Ethnic Density (<i>N</i> = 1,416)	Low Ethnic Density (<i>N</i> = 1,932)	High Ethnic Density (<i>N</i> = 836)
US born	%	94.58	96.03	94.31	95.97	48.24	36.84
female	%	55.93	55.60	60.52	60.52	57.25	57.18
birth year	<i>M</i> (<i>SD</i>)	1932 (13)	1933 (13)	1935 (13)	1933 (13)	1939 (12)	1934 (14)
education	<i>M</i> (<i>SD</i>)	12.52 (2.99)	12.55 (2.80)	10.72 (3.78)	10.98 (3.46)	9.35 (4.66)	6.93 (4.52)
ethnic density							
01	<i>M</i> (<i>SD</i>)	58.23 (19.97)	91.53 (5.05)	38.99 (24.38)	92.61 (5.02)	40.95 (25.34)	91.83 (4.93)
02	<i>M</i> (<i>SD</i>)	57.10 (21.52)	88.64 (8.86)	39.55 (25.43)	88.25 (13.71)	43.24 (26.86)	91.09 (11.32)
03	<i>M</i> (<i>SD</i>)	55.92 (21.83)	86.90 (10.40)	38.85 (25.42)	85.89 (16.64)	44.20 (26.77)	90.32 (13.56)
social cohesion							
01	<i>M</i> (<i>SD</i>)	5.48 (1.12)	5.69 (1.04)	5.13 (1.30)	4.96 (1.25)	5.18 (1.31)	5.02 (1.48)
	<i>N</i>	4,478	6,381	1,203	540	900	331
02	<i>M</i> (<i>SD</i>)	5.54 (1.15)	5.71 (1.07)	5.09 (1.35)	4.63 (1.30)	5.18 (1.37)	4.96 (1.46)
	<i>N</i>	3,554	5,186	927	405	749	237
03	<i>M</i> (<i>SD</i>)	5.51 (1.15)	5.64 (1.12)	4.95 (1.43)	4.53 (1.38)	5.07 (1.45)	4.76 (1.49)
	<i>N</i>	2,650	4,006	738	325	608	218
social support							
01	<i>M</i> (<i>SD</i>)	3.05 (0.63)	3.05 (0.63)	3.08 (0.63)	3.17 (0.60)	2.95 (0.68)	2.94 (0.67)
	<i>N</i>	4,214	6,044	1,123	513	810	280
02	<i>M</i> (<i>SD</i>)	3.05 (0.65)	3.05 (0.64)	3.10 (0.62)	3.16 (0.59)	2.96 (0.68)	2.94 (0.67)
	<i>N</i>	3,330	4,898	865	374	666	204
03	<i>M</i> (<i>SD</i>)	3.04 (0.63)	3.04 (0.63)	3.08 (0.62)	3.08 (0.60)	2.94 (0.65)	2.85 (0.72)
	<i>N</i>	2,413	3,754	658	290	535	183

variable /wave	stat.	Non-Hispanic White		Non-Hispanic Black		Hispanic	
		Low Ethnic Density (<i>N</i> = 9,754)	High Ethnic Density (<i>N</i> = 12,470)	Low Ethnic Density (<i>N</i> = 3,004)	High Ethnic Density (<i>N</i> = 1,416)	Low Ethnic Density (<i>N</i> = 1,932)	High Ethnic Density (<i>N</i> = 836)
allostatic load							
01	<i>M (SD)</i>	-0.04 (0.49)	-0.03 (0.50)	0.14 (0.57)	0.14 (0.57)	0.05 (0.51)	0.10 (0.48)
	<i>N</i>	4,444	6,290	1,302	586	972	376
02	<i>M (SD)</i>	-0.04 (0.49)	-0.02 (0.47)	0.14 (0.53)	0.15 (0.53)	0.02 (0.47)	0.11 (0.47)
	<i>N</i>	3,579	5,126	1,120	491	850	312
03	<i>M (SD)</i>	-0.05 (0.45)	-0.03 (0.46)	0.12 (0.53)	0.12 (0.49)	0.02 (0.46)	0.06 (0.52)
	<i>N</i>	2,788	4,123	922	391	726	302
life satisfaction							
01	<i>M (SD)</i>	5.03 (1.32)	5.07 (1.29)	4.67 (1.35)	4.70 (1.30)	4.97 (1.34)	4.86 (1.43)
	<i>N</i>	4,517	6,456	1,236	555	924	344
02	<i>M (SD)</i>	4.89 (1.36)	5.00 (1.33)	4.54 (1.38)	4.60 (1.27)	4.86 (1.41)	4.86 (1.38)
	<i>M (SD)</i>	3,599	5,232	939	411	772	244
03	<i>M (SD)</i>	5.06 (1.32)	5.18 (1.27)	4.77 (1.32)	4.69 (1.28)	5.07 (1.38)	4.98 (1.42)
	<i>N</i>	2,673	4,042	752	331	632	225
neighbourhood sociodemographic							
income							
01	<i>M (SD)</i>	6.62 (2.97)	7.47 (3.14)	5.39 (2.60)	4.02 (1.77)	6.20 (2.86)	3.87 (1.35)
02	<i>M (SD)</i>	6.36 (3.08)	7.03 (2.98)	5.15 (2.58)	3.82 (1.79)	5.91 (2.80)	3.79 (1.48)
03	<i>M (SD)</i>	6.56 (3.17)	7.24 (3.06)	5.24 (2.59)	3.81 (1.76)	6.03 (2.81)	4.13 (1.47)
education							
01	<i>M (SD)</i>	1.09 (0.25)	1.17 (0.22)	0.99 (0.24)	0.89 (0.16)	0.97 (0.26)	0.65 (0.18)
02	<i>M (SD)</i>	1.11 (0.25)	1.19 (0.22)	1.02 (0.25)	0.94 (0.16)	1.00 (0.26)	0.71 (0.20)
03	<i>M (SD)</i>	1.15 (0.25)	1.22 (0.21)	1.05 (0.24)	0.98 (0.16)	1.03 (0.26)	0.75 (0.20)
% unemployed							
01	<i>M (SD)</i>	7.83 (4.23)	6.30 (3.30)	10.34 (6.00)	16.81 (7.97)	8.68 (4.88)	9.55 (4.08)
02	<i>M (SD)</i>	10.59 (5.35)	8.58 (4.36)	13.14 (6.73)	21.13 (8.85)	12.22 (5.97)	12.62 (4.67)

variable /wave	stat.	Non-Hispanic White		Non-Hispanic Black		Hispanic	
		Low Ethnic Density (N = 9,754)	High Ethnic Density (N = 12,470)	Low Ethnic Density (N = 3,004)	High Ethnic Density (N = 1,416)	Low Ethnic Density (N = 1,932)	High Ethnic Density (N = 836)
03	<i>M (SD)</i>	7.17 (4.24)	5.53 (3.08)	9.42 (5.29)	15.78 (7.37)	8.49 (4.52)	8.09 (3.58)
% poverty							
01	<i>M (SD)</i>	15.28 (10.59)	9.22 (6.16)	21.51 (13.24)	30.05 (15.20)	18.30 (12.34)	32.14 (13.41)
02	<i>M (SD)</i>	17.22 (11.46)	11.07 (7.28)	23.56 (13.38)	31.66 (14.84)	20.52 (12.76)	32.71 (12.41)
03	<i>M (SD)</i>	16.29 (10.68)	10.73 (7.13)	22.70 (12.76)	30.02 (14.50)	19.83 (12.21)	28.92 (10.62)
% female headed households							
01	<i>M (SD)</i>	8.29 (5.26)	5.04 (3.03)	11.29 (6.72)	18.50 (8.58)	9.52 (6.18)	12.13 (5.91)
02	<i>M (SD)</i>	8.06 (5.34)	5.13 (3.27)	11.09 (6.63)	16.44 (7.33)	9.69 (6.55)	12.10 (5.33)
03	<i>M (SD)</i>	7.23 (4.78)	4.81 (3.22)	9.87 (6.07)	15.25 (7.98)	8.83 (5.66)	11.37 (5.02)

Notes. stat. = descriptive statistics. Neighbourhood ethnic density, unemployment, poverty, and female-headed households are reported in this table as

percentages. However, their equivalent decimal fractions were used in the analyses because those units are closer in scale to the other in those analyses.

Model Comparisons

To assess whether our proposed serial mediation models were appropriate, we compared fit statistics across a series of confirmatory factor analysis and SEM models. Each model can be identified by its model number and fit statistics in Table A.2. For all model comparisons, the more complex model was considered more appropriate if it had a Robust Comparative Fit Index (CFI) of less than 0.01 worse than the less complex model (Cernat & Sakshaug, 2021; Cheung & Rensvold, 2002; Little & Card, 2013).

First, we tested the fit of the three simple mediations for the variables included in Hypotheses 1.c, 1.e, and 1.g (see Table A.2 Models 1–10). Although these models have structural differences, the measurement models overlapped substantially, as only social cohesion, social support, and life satisfaction were measured as latent factors. The first two simple mediation models have a measurement model consisting of social cohesion and social support latent variables. The third simple mediation model has a measurement model consisting of social support and life satisfaction latent variables.

In scalar models, item intercepts and latent factor loadings are fixed to be constant across waves, whereas in configural models they are all allowed to vary across waves. The configural measurement model including only social cohesion and social support (see Table A.2 Model 1.1) had a Robust CFI of less than .01 better than the scalar measurement model for those variables (see Model 2). This means that the item intercepts and factor loadings did not substantially vary over time, which indicates that the measurement model had longitudinal scalar invariance. Longitudinal scalar invariance means that the latent factors represent the same constructs over time, and it is thus appropriate to compare measurements of those factors at different timepoints. Longitudinal scalar invariance was also supported for the measurement models that only included social support and life satisfaction because the

configural model (Model 3) had a Robust CFI of less than .01 higher than the scalar model (Model 4).

After confirming that the measurement models had longitudinal scalar invariance, the fit of those scalar models was compared to the fit of the full SEM for each simple mediation (including the structural and measurement components). The fit of all three simple mediation models (see Table A.2 Models 5, 7, & 9) was worse than the fit of the scalar measurement models (Models 2 & 4), but that was expected because they each introduced a third construct (ethnic density or allostatic load) as well as a series of time-invariant controls (gender, age, generation, ethnicity, and education). The inclusion of these extra variables changes the covariance structure, which makes the models less directly comparable (Mulder & Hamaker, 2021). However, these simple mediation models still had marginal fit (Robust CFI > .90), so they were next compared to more restricted models.

The fit statistics of those three simple mediation SEM models (Models 5, 7, & 9) were compared to alternative models where all structural paths that were included in a model twice (e.g., control variables that predict the key variables of interest in both the second and third pooled waves) were constrained to be equal for both instances. For all three simple mediations, the models with structural path loadings constrained to be equal across waves (Models 6, 8, and 10) had Robust CFI values of less than .01 worse than the less constrained models that allowed the structural paths to vary between waves (Models 5, 7, and 9). This indicates that the longitudinal relationships between the latent factors are consistent over the waves of data.

Next, the three latent factors were included in a single measurement model which had similar fit to the previous measurement models for both configural (see Model 11) and scalar invariance (Model 12). The fit statistics for the full serial mediation SEM with time invariant controls were then assessed. When structural path loadings were constrained to be equal

across waves (Model 14) the Robust CFI was less than .01 worse than when those paths were not constrained (Model 13). This supports the assumption that the relationships were consistent over time. Thus, a partially longitudinal serial mediation model (see Figure 2.2) was suitable for testing the theoretical fully longitudinal mediation (see Figure 2.1).

Of the simple mediation SEM models with equal loadings across waves, the model including ethnic density, social cohesion, and social support had the best model fit (Robust CFI = .952). That fit is .11 better than the equivalent serial mediation Robust CFI fit. As that model fit is better than the serial mediation model fit, we compared the structural paths between the simple mediation models and the serial mediation model and found that there were no notable differences between them. Consequently, the serial mediation (Model 14) was deemed suitable to compare with more complex models in the remainder of this section.

We then ran a model that included the five measures of neighbourhood socioeconomic characteristics (see Table A.2 Model 16). Many respondents were missing those variables, which meant that the inclusion of those variables reduced the size of our sample. So, we also ran a model with that reduced sample, but without including the neighbourhood variables (Model 15). That allowed us to separate the effect of reducing the sample size from the effect of including neighbourhood controls. Both models had similar fit to the serial mediation model that did not include neighbourhood controls (Model 14). As the more complex models including neighbourhood variables did not perform substantially worse than the simpler serial mediation model, we have only presented the structural paths for Model 16 in the Chapter 2 Results section.

We next tested cross-lagged panel model (CLPM) that included all the variables in the serial biopsychosocial pathway, but with paths specified between each variable and every variable in the next wave (i.e., all paths have a time lag of one pooled wave). The CLPM with

and without neighbourhood controls (Model 17–19) all had similar fit to the serial mediation model (Model 16).

So far, we have used the difference in robust CFI between models to assess their relative fit. However, the robust CFI values also indicated that all the models presented in Table A.2 had at least marginal fit ($>.90$). In Table A.2, we have also included chi-square statistics, robust root-mean-square error (RMSEA), standardised root-mean-squared residual (SRMR), and Bayesian Information Criterion (BIC). Chi-square statistics are presented here for completeness, but as would be expected given our large sample sizes they all have p -values $< .001$, indicating poor fit. All RMSEA values indicate that all models had good fit ($<.05$) and all SRMR values indicated at least marginal fit ($<.08$; Mackinnon et al., 2022)

Next, we tested whether the pathways in the serial mediation model were moderated by ethnic group (Hypothesis 2) or generation (Hypothesis 3). We found that the models that specified either ethnic group (see Table A.2 models 20–24) or US born (Models 25–29) as grouping variables were not substantially better or worse than the previously described models that included no grouping variables (Models 11–16), except when neighbourhood controls were included when the model was grouped by ethnic group. In that model, the Robust CFI fit of the model without moderation (Model 16) was $>.01$ higher than the fit for the model that moderated by ethnic group (Model 24). As grouping the models did not include the model fit statistics, we did not find support for Hypotheses 2 or 3. Consequently, it is more appropriate to interpret the results of the serial mediation model without groups, which were reported in the main results section, than it would be to interpret the results of the moderated models.

Table A.2*Fit Statistics for Simple and Serial Mediation Models.*

#	model	χ^2 (df)	CFI	RMSEA	SRMR	BIC
simple mediation measurement invariance						
1	social cohesion and social support: configural measurement invariance	1031 (167)	.992	.024	.025	760771
2	social cohesion and social support: scalar measurement invariance	1114 (187)	.991	.023	.025	760659
3	social support and life satisfaction: configural measurement invariance	4130 (229)	.974	.041	.031	915265
4	social support and life satisfaction: scalar measurement invariance	4310 (253)	.973	.040	.031	915183
simple mediation models						
5	ethnic density to social support: unequal loadings across waves	9933 (356)	.954	.046	.063	677851
6	ethnic density to social support: equal loadings across waves	10270 (385)	.952	.045	.070	677984
7	social cohesion to allostatic load: unequal loadings across waves	6194 (356)	.948	.043	.058	842621
8	social cohesion to allostatic load: equal loadings across waves	6414 (385)	.947	.042	.062	842606
9	social support to life satisfaction: unequal loadings across waves	9952 (449)	.940	.047	.054	1004834
10	social support to life satisfaction: equal loadings across waves	10182 (478)	.939	.046	.059	1004817
serial mediation						
11	configural measurement invariance	5659 (546)	.976	.031	.031	1435206
12	scalar measurement invariance	5883 (582)	.975	.030	.031	1435077
13	unequal loadings across waves	18415 (990)	.942	.040	.063	1447371
14	equal loadings across waves	19099 (1049)	.940	.040	.072	1447571
neighbourhood sample						
15	equal loadings across waves with neighbourhood sample	15516 (1049)	.944	.038	.066	1145898
16	equal loadings across waves and groups with neighbourhood controls	17739 (1444)	.940	.034	.067	1145890
cross-lagged panel model						
17	equal loadings across waves	18789 (1036)	.942	.039	.065	1447373
18	equal loadings across waves with neighbourhood sample	15266 (1036)	.945	.038	.058	1145763
19	equal loadings across waves and groups with neighbourhood controls	17507 (1431)	.941	.033	.062	1145774
grouped by ethnic group						
20	configural measurement invariance	7434 (1662)	.974	.031	.035	1424162

# model	χ^2 (df)	CFI	RMSEA	SRMR	BIC
21 scalar measurement invariance	9412 (1806)	.967	.034	.038	1424993
22 equal loadings across waves and unequal loadings across groups	18803 (2985)	.942	.039	.069	1427821
23 equal loadings across waves and across groups	19588 (3069)	.940	.039	.072	1427788
24 equal loadings across waves and groups with neighbourhood controls	38454 (4304)	.916	.040	.080	1131886
grouped by generation					
25 configural measurement invariance	6680 (1104)	.975	.031	.032	1511922
26 scalar measurement invariance	7324 (1194)	.973	.031	.033	1511735
27 equal loadings across waves and unequal loadings across groups	20880 (2054)	.939	.040	.075	1446366
28 equal loadings across waves and groups	21208 (2101)	.938	.040	.076	1446208
29 equal loadings across waves and groups with neighbourhood controls	21632 (2916)	.937	.034	.071	1145048

Notes. # = Model Number, CFI = Robust Comparative Fit Index, RMSEA = Robust Root Mean Square Error, SRMR = Standardised Root Mean Squared Residual, BIC = Bayesian Information Criterion. $p < .001$ for all χ^2 .

Weighted Descriptive Statistics

The main analyses did not employ survey sample weights, so the descriptive statistics presented in the Results section (Table 2.1) also did not include sample weights. Table A.3 is presented to compare a sample weighted to represent the US population over 50-years-old and the unweighted sample that was used in the analyses. Non-Hispanic Black and Hispanic respondents were overrepresented in the unweighted analysis sample (non-Hispanic White: 75.56%; non-Hispanic Black: 15.03%; Hispanic: 9.41%), compared to the population weighted sample (non-Hispanic White: 83.94%; non-Hispanic Black: 9.25%; Hispanic: 7.82%).

Across ethnic groups, in the unweighted sample a slightly lower percentage of respondents were US born compared to the weighted sample (unweighted: 90.55%; weighted: 92.32%). Similarly, female respondents were slightly overrepresented in the unweighted sample (unweighted: 56.60%; weighted: 54.12%). Older respondents were over-represented (unweighted mean date of birth: 1933; weighted: 1940), but the unweighted sample on average only had one fewer year of education than the weighted sample. In the weighted sample ethnic density was slightly higher for non-Hispanic White respondents and slightly lower for non-Hispanic Black and Hispanic respondents, but for each group the difference was only 2-4 percentage points. The mean scores of allostatic load varied between the unweighted and weighted samples for each ethnic group, but those differences were fairly small compared to their respective standard deviation. The other key variables in the serial mediation analyses (i.e., social cohesion, social support, allostatic load and life satisfaction) did not notably vary between the unweighted and weighted samples. Compared to the weighted sample, in the unweighted sample mean neighbourhood income was higher, and unemployment, poverty and prevalence of female-headed households were lower. Neighbourhood education varied little between the two samples.

Table A.3

Weighted Descriptive Statistics.

variable /wave	stat.	Non-Hispanic White			Non-Hispanic Black			Hispanic			Total (N = 74,517)
		Ethnic Density		Total (N = 61,801)	Ethnic Density		Total (N = 6,891)	Ethnic Density		Total (N = 5,825)	
		Low (N = 23,934)	High (N = 37,867)		Low (N = 4,863)	High (N = 2,028)		Low (N = 4,307)	High (N = 1,518)		
US born	%	95.39	96.81	96.26	94.29	96.29	94.88	50.36	39.19	47.45	92.32
female	%	54.03	53.16	53.50	57.52	62.47	58.98	54.99	55.03	55.00	54.12
birth year	<i>M</i>	1940	1940	1940	1942	1941	1942	1943	1942	1943	1940
	(<i>SD</i>)	(10)	(10)	(10)	(10)	(10)	(10)	(9)	(10)	(9)	(10)
education	<i>M</i>	13.40	13.30	13.34	11.82	12.10	11.90	10.21	7.79	9.58	12.91
	(<i>SD</i>)	(2.57)	(2.52)	(2.54)	(3.29)	(2.95)	(3.20)	(4.48)	(4.29)	(4.55)	(3.00)
ethnic density											
01	<i>M</i>	60.42	91.71	79.59	36.43	93.24	53.15	40.47	91.85	53.86	75.13
	(<i>SD</i>)	(18.49)	(5.02)	(19.50)	(24.03)	(5.08)	(32.95)	(25.74)	(5.38)	(31.72)	(24.31)
02	<i>M</i>	60.76	88.57	77.80	37.67	85.66	51.79	42.85	89.12	54.90	73.61
	(<i>SD</i>)	(20.29)	(9.62)	(19.99)	(25.43)	(20.17)	(32.47)	(27.07)	(15.61)	(31.90)	(24.38)
03	<i>M</i>	59.78	86.73	76.29	37.84	82.77	51.08	43.97	87.34	55.27	72.32
	(<i>SD</i>)	(20.77)	(11.38)	(20.47)	(25.33)	(22.44)	(31.95)	(26.78)	(19.49)	(31.49)	(24.42)
social cohesion											
01	<i>M</i>	5.46	5.67	5.59	5.10	4.79	5.01	5.26	4.82	5.15	5.51
	(<i>SD</i>)	(1.10)	(1.03)	(1.06)	(1.30)	(1.29)	(1.30)	(1.25)	(1.51)	(1.33)	(1.12)
	<i>N</i>	21,254	34,005	55,259	3,787	1,526	5,314	3,359	1,159	4,518	65,090
02	<i>M</i>	5.54	5.69	5.63	5.11	4.56	4.95	5.17	4.83	5.09	5.54
	(<i>SD</i>)	(1.14)	(1.06)	(1.10)	(1.29)	(1.26)	(1.31)	(1.32)	(1.46)	(1.36)	(1.16)
	<i>N</i>	16,994	27,695	44,689	2,993	1,210	4,203	2,733	825	3,558	52,451
03	<i>M</i>	5.52	5.64	5.60	5.02	4.37	4.83	5.02	4.86	4.98	5.49

variable /wave	Non-Hispanic White			Non-Hispanic Black			Hispanic			Total (N = 74,517)	
	Ethnic Density			Ethnic Density			Ethnic Density				
	Low <i>stat.</i> (N = 23,934)	High (N = 37,867)	Total (N = 61,801)	Low (N = 4,863)	High (N = 2,028)	Total (N = 6,891)	Low (N = 4,307)	High (N = 1,518)	Total (N = 5,825)		
	(SD)	(1.13)	(1.10)	(1.11)	(1.38)	(1.39)	(1.41)	(1.42)	(1.38)	(1.41)	(1.19)
	N	13,403	22,397	35,801	2,292	955	3,247	2,207	759	2,967	42,015
social support											
01	M	3.07	3.05	3.06	3.08	3.20	3.12	2.93	3.00	2.94	3.06
	(SD)	(0.63)	(0.62)	(0.63)	(0.63)	(0.60)	(0.62)	(0.68)	(0.63)	(0.67)	(0.63)
	N	20,264	32,234	52,498	3,550	1,379	4,929	2,961	972	3,933	61,360
02	M	3.06	3.04	3.05	3.15	3.15	3.15	2.95	2.85	2.93	3.05
	(SD)	(0.64)	(0.64)	(0.64)	(0.58)	(0.61)	(0.59)	(0.68)	(0.72)	(0.69)	(0.64)
	N	15,853	26,092	41,945	2,663	1,086	3,748	2,454	704	3,158	48,851
03	M	3.04	3.03	3.03	3.09	3.02	3.07	2.90	2.77	2.87	3.02
	(SD)	(0.64)	(0.63)	(0.63)	(0.63)	(0.59)	(0.62)	(0.66)	(0.77)	(0.69)	(0.64)
	N	12,225	20,927	33,152	2,041	840	2,881	1,930	712	2,642	38,674
allostatic load											
01	M	-0.03	-0.03	-0.03	0.15	0.17	0.16	0.08	0.14	0.09	0.00
	(SD)	(0.46)	(0.45)	(0.46)	(0.48)	(0.51)	(0.49)	(0.49)	(0.45)	(0.48)	(0.47)
	N	23,393	37,064	60,457	4,704	1,958	6,661	4,137	1,462	5,598	72,717
02	M	-0.03	-0.02	-0.03	0.19	0.18	0.18	0.04	0.21	0.08	0.00
	(SD)	(0.47)	(0.45)	(0.46)	(0.51)	(0.51)	(0.51)	(0.46)	(0.53)	(0.48)	(0.47)
	N	18,062	29,219	47,281	3,730	1,518	5,248	3,244	1,020	4,264	56,793
03	M	-0.03	-0.03	-0.03	0.15	0.10	0.14	0.04	0.09	0.06	-0.01
	(SD)	(0.44)	(0.44)	(0.44)	(0.50)	(0.50)	(0.50)	(0.46)	(0.54)	(0.48)	(0.45)
	N	14,324	23,745	38,069	2,956	1,170	4,126	2,696	977	3,673	45,868
life satisfaction											
01	M	5.01	5.05	5.04	4.56	4.43	4.52	4.89	4.77	4.86	4.98
	(SD)	(1.34)	(1.29)	(1.31)	(1.38)	(1.41)	(1.39)	(1.33)	(1.48)	(1.37)	(1.33)

variable /wave	Non-Hispanic White			Non-Hispanic Black			Hispanic			Total (N = 74,517)	
	Ethnic Density			Ethnic Density			Ethnic Density				
	Low <i>stat.</i> (N = 23,934)	High (N = 37,867)	Total (N = 61,801)	Low (N = 4,863)	High (N = 2,028)	Total (N = 6,891)	Low (N = 4,307)	High (N = 1,518)	Total (N = 5,825)		
02	<i>N</i>	21,408	34,310	55,718	3,857	1,563	5,420	3,417	1,193	4,610	65,748
	<i>M</i>	4.86	5.00	4.95	4.42	4.44	4.43	4.82	4.79	4.82	4.90
	(<i>SD</i>)	(1.37)	(1.33)	(1.35)	(1.41)	(1.33)	(1.39)	(1.39)	(1.44)	(1.40)	(1.36)
03	<i>N</i>	17,198	27,896	45,094	2,991	1,216	4,207	2,790	841	3,631	52,932
	<i>M</i>	5.08	5.21	5.16	4.70	4.62	4.68	5.02	4.93	5.00	5.11
	(<i>SD</i>)	(1.33)	(1.28)	(1.30)	(1.35)	(1.28)	(1.33)	(1.39)	(1.55)	(1.43)	(1.32)
	<i>N</i>	13,547	22,563	36,111	2,328	963	3,292	2,272	782	3,054	42,456
neighbourhood sociodemographic											
income											
01	<i>M</i>	6.97	7.56	7.33	5.60	4.08	5.15	6.43	4.00	5.80	7.01
	(<i>SD</i>)	(3.10)	(3.05)	(3.09)	(2.80)	(1.76)	(2.63)	(3.23)	(1.31)	(3.05)	(3.13)
02	<i>M</i>	6.84	7.11	7.01	5.31	3.85	4.88	6.01	3.94	5.47	6.69
	(<i>SD</i>)	(3.36)	(2.90)	(3.09)	(2.76)	(1.72)	(2.59)	(3.11)	(1.58)	(2.93)	(3.12)
03	<i>M</i>	6.96	7.33	7.19	5.40	3.88	4.95	6.08	4.23	5.60	6.86
	(<i>SD</i>)	(3.31)	(3.02)	(3.14)	(2.70)	(1.63)	(2.53)	(2.88)	(1.55)	(2.72)	(3.15)
education											
01	<i>M</i>	1.11	1.17	1.15	0.99	0.91	0.97	0.99	0.63	0.90	1.11
	(<i>SD</i>)	(0.25)	(0.21)	(0.23)	(0.25)	(0.15)	(0.23)	(0.27)	(0.18)	(0.29)	(0.25)
02	<i>M</i>	1.15	1.19	1.17	1.02	0.96	1.00	1.00	0.70	0.93	1.14
	(<i>SD</i>)	(0.25)	(0.21)	(0.23)	(0.25)	(0.17)	(0.23)	(0.28)	(0.21)	(0.29)	(0.25)
03	<i>M</i>	1.17	1.23	1.21	1.06	0.99	1.04	1.03	0.75	0.96	1.17
	(<i>SD</i>)	(0.25)	(0.21)	(0.23)	(0.24)	(0.16)	(0.22)	(0.27)	(0.21)	(0.28)	(0.24)
% unemployed											
01	<i>M</i>	7.68	6.28	6.82	10.20	17.31	12.29	8.64	9.50	8.87	7.49
	(<i>SD</i>)	(4.15)	(3.22)	(3.68)	(5.93)	(7.98)	(7.35)	(4.92)	(3.85)	(4.68)	(4.53)

variable /wave	Non-Hispanic White			Non-Hispanic Black			Hispanic			Total (N = 74,517)	
	Ethnic Density			Ethnic Density			Ethnic Density				
	Low <i>stat.</i> (N = 23,934)	High (N = 37,867)	Total (N = 61,801)	Low (N = 4,863)	High (N = 2,028)	Total (N = 6,891)	Low (N = 4,307)	High (N = 1,518)	Total (N = 5,825)		
02	<i>M</i>	10.10	8.43	9.08	13.10	19.98	15.12	12.24	13.15	12.47	9.90
	(<i>SD</i>)	(5.02)	(4.39)	(4.72)	(6.96)	(8.85)	(8.19)	(6.08)	(4.48)	(5.72)	(5.55)
03	<i>M</i>	6.71	5.50	5.97	9.21	14.82	10.86	8.49	8.37	8.46	6.62
	(<i>SD</i>)	(3.84)	(3.11)	(3.46)	(5.50)	(7.49)	(6.66)	(4.54)	(3.56)	(4.30)	(4.21)
% poverty											
01	<i>M</i>	14.13	9.05	11.01	20.94	29.69	23.51	17.69	31.61	21.32	12.98
	(<i>SD</i>)	(9.78)	(6.17)	(8.16)	(13.45)	(14.63)	(14.37)	(12.19)	(12.10)	(13.61)	(10.37)
02	<i>M</i>	15.58	10.94	12.74	23.01	30.96	25.35	20.56	32.86	23.77	14.77
	(<i>SD</i>)	(10.59)	(7.36)	(9.04)	(13.47)	(13.85)	(14.06)	(13.32)	(12.91)	(14.27)	(11.05)
03	<i>M</i>	14.76	10.57	12.19	22.03	29.16	24.13	19.96	29.03	22.33	14.09
	(<i>SD</i>)	(9.92)	(7.22)	(8.62)	(13.06)	(13.44)	(13.57)	(13.10)	(10.96)	(13.18)	(10.48)
% female headed households											
01	<i>M</i>	7.92	5.10	6.20	10.98	18.04	13.06	9.49	11.40	9.99	7.13
	(<i>SD</i>)	(4.84)	(3.04)	(4.08)	(6.56)	(8.43)	(7.85)	(6.23)	(5.34)	(6.07)	(5.19)
02	<i>M</i>	7.41	5.08	5.99	10.86	15.96	12.36	9.54	11.69	10.10	6.90
	(<i>SD</i>)	(4.93)	(3.30)	(4.17)	(6.41)	(7.10)	(7.02)	(6.21)	(5.09)	(6.01)	(5.10)
03	<i>M</i>	6.77	4.77	5.54	9.99	14.42	11.30	8.91	11.65	9.63	6.39
	(<i>SD</i>)	(4.42)	(3.26)	(3.88)	(6.14)	(7.60)	(6.90)	(5.65)	(5.10)	(5.64)	(4.79)

Notes. stat. = descriptive statistics. N = weighted population estimate / 1000. For year of birth, 01/01/1960 is represented as 0.

Alternative Models Without Neighbourhood Sample Confounders or Restrictions

To allow the analyses to control for neighbourhood sociodemographic variables, the sample had to be restricted because those variables were not available for all respondents. To assess how this impacted the sample, the unrestricted sample is presented in Table A.4 and a weighted version is in Table A.5. Table A.4 and Table A.5 also have additional columns that show the proportion of the sample with missing ethnic density data in the first pooled wave.

The restricted sample had a higher proportion of non-Hispanic White respondents (restricted: 75.56%; unrestricted: 67.64%), and lower proportions of non-Hispanic Black (restricted: 15.03%; unrestricted: 19.05%) and Hispanic (restricted: 9.41%; unrestricted: 13.31%) respondents.

The percentage of non-Hispanic respondents who were US born was very similar across samples, but for Hispanic respondents a larger percentage of respondents were US born in the restricted sample than the unrestricted sample (restricted: 44.80%; unrestricted: 39.67%)

The two samples were similar in their proportions of female respondents, but the restricted sample had a lower mean birth year (1933) than the unrestricted sample (1940). Additionally, average years of education were lower among both non-Hispanic Black and Hispanic respondents in the restricted sample than in the unrestricted sample.

However, there was only minor variation in the mean scores of our key serial mediation variables between the restricted and unrestricted samples.

Table A.4

Descriptive Statistics without Neighbourhood Variables.

variable /wave	stat.	Non-Hispanic White				Non-Hispanic Black				Hispanic				Total
		Ethnic Density			Total	Ethnic Density			Total	Ethnic Density			Total	
		Low	High	NA		Low	High	NA		Low	High	NA		
		(N = 9,758)	(N=12,470)	(N=4,711)	(N=26,939)	(N=3,008)	(N=1,416)	(N=3,163)	(N=7,587)	(N=1,932)	(N=836)	(N=2,533)	(N=5,301)	(N=39,827)
US born	%	94.58	96.03	95.58	95.43	94.32	95.97	91.97	93.65	48.24	36.84	34.07	39.67	87.67
female	%	55.92	55.60	52.86	55.24	60.47	60.52	57.60	59.29	57.25	57.18	55.31	56.31	56.15
birth year	<i>M</i>	1932	1933	1959	1937	1935	1933	1959	1944	1939	1934	1959	1948	1940
	(<i>SD</i>)	(13)	(13)	(6)	(16)	(13)	(13)	(6)	(16)	(12)	(14)	(7)	(15)	(16)
education	<i>M</i>	12.51	12.55	13.75	12.75	10.72	10.98	12.96	11.70	9.35	6.93	10.56	9.55	12.12
	(<i>SD</i>)	(2.99)	(2.80)	(2.60)	(2.88)	(3.77)	(3.46)	(2.50)	(3.41)	(4.66)	(4.52)	(4.28)	(4.63)	(3.44)
ethnic density														
01	<i>M</i>	58.22	91.53	NA	76.91	39.01	92.61	NA	56.17	40.95	91.83	NA	56.32	71.85
	(<i>SD</i>)	(19.98)	(5.05)		(21.52)	(24.39)	(5.02)		(32.21)	(25.34)	(4.93)		(31.65)	(26.06)
	<i>N</i>	9,758	12,470		22,228	3,008	1,416		4,424	1,932	836		2,768	29,420
02	<i>M</i>	57.09	88.64	68.47	74.11	39.57	88.25	52.98	54.50	43.24	91.09	55.86	57.05	68.57
	(<i>SD</i>)	(21.53)	(8.86)	(24.54)	(22.54)	(25.43)	(13.71)	(29.51)	(31.19)	(26.86)	(11.32)	(29.90)	(31.30)	(26.84)
	<i>N</i>	9,758	12,470	2,686	24,914	3,008	1,416	1,908	6,332	1,932	836	1,495	4,263	35,509
03	<i>M</i>	55.91	86.90	65.67	71.98	38.87	85.89	49.48	52.08	44.20	90.32	53.38	55.87	66.05
	(<i>SD</i>)	(21.84)	(10.40)	(23.96)	(22.95)	(25.42)	(16.64)	(29.08)	(30.76)	(26.77)	(13.56)	(28.48)	(30.30)	(27.07)
	<i>N</i>	9,753	12,470	4,653	26,876	3,008	1,416	3,136	7,560	1,932	836	2,507	5,275	39,711
social cohesion														
01	<i>M</i>	5.47	5.68	NA	5.59	5.13	4.96	NA	5.08	5.19	5.02	NA	5.14	5.49
	(<i>SD</i>)	(1.12)	(1.05)		(1.08)	(1.31)	(1.25)		(1.29)	(1.32)	(1.48)		(1.36)	(1.15)
	<i>N</i>	4,481	6,381		10,862	1,203	540		1,743	900	331		1,231	13,836
	(<i>SD</i>)	5.53	5.69	5.42	5.59	5.09	4.65	4.63	4.82	5.17	4.97	4.71	4.95	5.40

variable /wave	Non-Hispanic White				Non-Hispanic Black				Hispanic				Total (N=39,827)	
	Ethnic Density			Total (N=26,939)	Ethnic Density			Total (N=7,587)	Ethnic Density			Total (N=5,301)		
	Low <i>stat.</i> (N = 9,758)	High (N=12,470)	NA (N=4,711)		Low (N=3,008)	High (N=1,416)	NA (N=3,163)		Low (N=1,932)	High (N=836)	NA (N=2,533)			
02	<i>M</i>	(1.15)	(1.07)	(1.06)	(1.10)	(1.35)	(1.29)	(1.30)	(1.34)	(1.37)	(1.46)	(1.38)	(1.40)	(1.22)
	(<i>SD</i>)	3,554	5,186	1,763	10,503	927	405	972	2,304	749	237	703	1,689	14,496
	<i>N</i>	5.50	5.62	5.37	5.53	4.95	4.55	4.57	4.69	5.05	4.76	4.62	4.79	5.28
03	<i>M</i>	(1.14)	(1.11)	(1.06)	(1.11)	(1.41)	(1.37)	(1.30)	(1.36)	(1.43)	(1.47)	(1.39)	(1.43)	(1.26)
	(<i>SD</i>)	2,650	4,006	2,135	8,791	738	325	1,176	2,239	608	218	916	1,742	12,772
	<i>N</i>	5.47	5.68	NA	5.59	5.13	4.96	NA	5.08	5.19	5.02	NA	5.14	5.49
social support														
01	<i>M</i>	3.04	3.05	NA	3.05	3.08	3.16	NA	3.11	2.95	2.94	NA	2.94	3.04
	(<i>SD</i>)	(0.63)	(0.63)		(0.63)	(0.63)	(0.60)		(0.62)	(0.68)	(0.67)		(0.68)	(0.63)
	<i>N</i>	4,217	6,044		10,261	1,123	513		1,636	810	280		1,090	12,987
02	<i>M</i>	3.04	3.05	3.13	3.06	3.10	3.15	3.15	3.13	2.96	2.94	3.00	2.98	3.06
	(<i>SD</i>)	(0.65)	(0.64)	(0.64)	(0.64)	(0.62)	(0.60)	(0.63)	(0.62)	(0.68)	(0.67)	(0.68)	(0.68)	(0.64)
	<i>N</i>	3,330	4,898	1,637	9,865	865	374	863	2,102	666	204	613	1,483	13,450
03	<i>M</i>	3.03	3.04	3.14	3.06	3.07	3.09	3.11	3.09	2.93	2.86	2.98	2.95	3.05
	(<i>SD</i>)	(0.64)	(0.63)	(0.63)	(0.64)	(0.62)	(0.61)	(0.64)	(0.63)	(0.66)	(0.73)	(0.65)	(0.66)	(0.64)
	<i>N</i>	2,413	3,754	1,955	8,122	658	290	1,034	1,982	535	183	791	1,509	11,613
allostatic load														
01	<i>M</i>	-0.04	-0.03	NA	-0.04	0.14	0.14	NA	0.14	0.05	0.10	NA	0.06	0.00
	(<i>SD</i>)	(0.49)	(0.50)		(0.50)	(0.57)	(0.57)		(0.57)	(0.51)	(0.48)		(0.50)	(0.51)
	<i>N</i>	4,447	6,290		10,737	1,302	586		1,888	972	376		1,348	13,973
02	<i>M</i>	-0.04	-0.02	-0.11	-0.05	0.14	0.15	0.13	0.14	0.02	0.11	0.00	0.02	0.00
	(<i>SD</i>)	(0.49)	(0.47)	(0.55)	(0.49)	(0.53)	(0.53)	(0.61)	(0.57)	(0.47)	(0.47)	(0.56)	(0.52)	(0.52)
	<i>N</i>	3,579	5,126	2,201	10,906	1,120	491	1,596	3,207	850	312	1,205	2,367	16,480
03	<i>M</i>	-0.05	-0.03	-0.06	-0.04	0.12	0.12	0.12	0.12	0.02	0.06	0.00	0.01	0.00
	(<i>SD</i>)	(0.45)	(0.46)	(0.49)	(0.47)	(0.53)	(0.49)	(0.57)	(0.55)	(0.46)	(0.52)	(0.53)	(0.51)	(0.50)

variable /wave	Non-Hispanic White				Non-Hispanic Black				Hispanic				Total (N=39,827)	
	Ethnic Density			Total (N=26,939)	Ethnic Density			Total (N=7,587)	Ethnic Density			Total (N=5,301)		
	Low stat. (N = 9,758)	High (N=12,470)	NA (N=4,711)		Low (N=3,008)	High (N=1,416)	NA (N=3,163)		Low (N=1,932)	High (N=836)	NA (N=2,533)			
<i>N</i>	2,788	4,123	2,729	9,640	922	391	1,850	3,163	726	302	1,486	2,514	15,317	
life satisfaction														
01	<i>M</i>	5.01	5.06	NA	5.04	4.66	4.69	NA	4.67	4.96	4.85	NA	4.93	4.98
	(<i>SD</i>)	1.32	1.29		1.30	1.35	1.31		1.34	1.34	1.44		1.37	1.32
	<i>N</i>	4,520	6,456		10,976	1,236	555		1,791	924	344		1,268	14,035
02	<i>M</i>	4.90	4.95	4.68	4.89	4.60	4.55	4.21	4.43	4.92	4.84	4.73	4.83	4.81
	(<i>SD</i>)	1.36	1.34	1.46	1.37	1.40	1.30	1.43	1.41	1.42	1.38	1.49	1.45	1.40
	<i>N</i>	3,599	5,232	1,757	10,588	939	411	983	2,333	772	244	708	1,724	14,645
03	<i>M</i>	5.09	5.13	4.87	5.05	4.85	4.60	4.48	4.62	5.15	4.93	5.10	5.09	4.98
	(<i>SD</i>)	1.34	1.28	1.42	1.34	1.36	1.30	1.38	1.37	1.40	1.45	1.35	1.38	1.36
	<i>N</i>	2,673	4,042	2,143	8,858	752	331	1,194	2,277	632	225	931	1,788	12,923

Notes. stat. = descriptive statistics. For year of birth, 01/01/1960 is represented as 0.

Table A.5

Weighted Descriptive Statistics without Neighbourhood Variables.

variable /wave		Non-Hispanic White				Non-Hispanic Black				Hispanic				Total
		Ethnic Density			Total	Ethnic Density			Total	Ethnic Density			Total	
		Low	High	NA		Low	High	NA		Low	High	NA		
	<i>stat.</i>	(N=23,952)	(N=37,867)	(N=16,594)	(N=78,414)	(N=4,863)	(N=2,028)	(N=4,019)	(N=10,910)	(N=4,307)	(N=1,518)	(N=3,894)	(N=9,719)	(N=99,043)
US born	%	95.39	96.81	96.82	96.38	94.29	96.29	92.64	94.05	50.36	39.19	38.71	43.95	90.98
female	%	54.01	53.16	46.88	52.09	57.52	62.47	51.58	56.25	54.99	55.03	48.83	52.53	52.59
birth year	<i>M</i>	1940	1940	1956	1943	1942	1941	1954	1947	1943	1942	1954	1947	1944
	<i>(SD)</i>	(10)	(10)	(4)	(11)	(10)	(10)	(4)	(10)	(9)	(10)	(4)	(9)	(11)
education	<i>M</i>	13.39	13.30	14.01	13.48	11.82	12.10	12.93	12.28	10.21	7.79	9.99	9.75	12.98
	<i>(SD)</i>	(2.57)	(2.52)	(2.30)	(2.50)	(3.29)	(2.95)	(2.34)	(2.95)	(4.48)	(4.29)	(4.43)	(4.51)	(3.03)
ethnic density														
01	<i>M</i>	60.40	91.71	NA	79.58	36.43	93.24	NA	53.15	40.47	91.85	NA	53.86	75.13
	<i>(SD)</i>	(18.50)	(5.02)		(19.51)	(24.03)	(5.08)		(32.95)	(25.74)	(5.38)		(31.72)	(24.31)
	<i>N</i>	23,952	37,867		61,820	4,863	2,028		6,891	4,307	1,518		5,825	74,536
02	<i>M</i>	60.76	88.57	73.35	76.87	37.67	85.66	52.98	52.23	42.85	89.12	60.32	57.07	72.21
	<i>(SD)</i>	(20.29)	(9.62)	(22.68)	(20.66)	(25.43)	(20.17)	(30.25)	(31.68)	(27.07)	(15.61)	(31.56)	(31.87)	(25.14)
	<i>N</i>	23,952	37,867	16,413	78,233	4,863	2,028	3,975	10,866	4,307	1,518	3,894	9,719	98,818
03	<i>M</i>	59.78	86.73	72.44	75.48	37.84	82.77	49.77	50.60	43.97	87.34	60.92	57.53	70.98
	<i>(SD)</i>	(20.77)	(11.38)	(22.95)	(21.07)	(25.33)	(22.44)	(30.06)	(31.26)	(26.78)	(19.49)	(30.76)	(31.31)	(25.20)
	<i>N</i>	23,952	37,867	16,594	78,414	4,863	2,028	4,019	10,910	4,307	1,518	3,894	9,719	99,043
social cohesion														
01	<i>M</i>	5.45	5.66	NA	5.58	5.10	4.79	NA	5.01	5.27	4.82	NA	5.15	5.50
	<i>(SD)</i>	(1.11)	(1.03)		(1.06)	(1.30)	(1.29)		(1.30)	(1.25)	(1.51)		(1.34)	(1.12)
	<i>N</i>	21,272	34,005		55,277	3,787	1,526		5,314	3,359	1,159		4,518	65,109
	<i>(SD)</i>	5.53	5.67	5.50	5.59	5.11	4.58	4.63	4.84	5.16	4.83	4.82	4.98	5.47

variable /wave	Non-Hispanic White				Non-Hispanic Black				Hispanic				Total	
	Ethnic Density				Ethnic Density				Ethnic Density					
	Low	High	NA	Total	Low	High	NA	Total	Low	High	NA	Total		
<i>stat.</i>	(<i>N</i> =23,952)	(<i>N</i> =37,867)	(<i>N</i> =16,594)	(<i>N</i> =78,414)	(<i>N</i> =4,863)	(<i>N</i> =2,028)	(<i>N</i> =4,019)	(<i>N</i> =10,910)	(<i>N</i> =4,307)	(<i>N</i> =1,518)	(<i>N</i> =3,894)	(<i>N</i> =9,719)	(<i>N</i> =99,043)	
02	<i>M</i>	(1.14)	(1.06)	(1.02)	(1.08)	(1.29)	(1.26)	(1.34)	(1.32)	(1.31)	(1.45)	(1.35)	(1.36)	(1.16)
	(<i>SD</i>)	16,994	27,695	12,303	56,992	2,993	1,210	2,306	6,510	2,733	825	2,237	5,795	69,297
	<i>N</i>	5.51	5.62	5.48	5.56	5.02	4.39	4.48	4.69	5.01	4.87	4.68	4.85	5.41
03	<i>M</i>	(1.12)	(1.09)	(1.01)	(1.08)	(1.37)	(1.38)	(1.29)	(1.37)	(1.40)	(1.36)	(1.39)	(1.40)	(1.18)
	(<i>SD</i>)	13,403	22,397	11,124	46,925	2,292	955	2,182	5,429	2,207	759	2,085	5,051	57,406
	<i>N</i>	5.45	5.66	NA	5.58	5.10	4.79	NA	5.01	5.27	4.82	NA	5.15	5.50
social support														
01	<i>M</i>	3.06	3.05	NA	3.06	3.08	3.19	NA	3.11	2.92	3.00	NA	2.94	3.05
	(<i>SD</i>)	(0.63)	(0.62)		(0.63)	(0.63)	(0.60)		(0.62)	(0.68)	(0.63)		(0.67)	(0.63)
	<i>N</i>	20,282	32,234		52,516	3,550	1,379		4,929	2,961	972		3,933	61,379
02	<i>M</i>	3.06	3.04	3.14	3.07	3.15	3.14	3.13	3.14	2.95	2.86	2.98	2.95	3.07
	(<i>SD</i>)	(0.64)	(0.64)	(0.63)	(0.64)	(0.58)	(0.61)	(0.63)	(0.60)	(0.68)	(0.72)	(0.65)	(0.68)	(0.64)
	<i>N</i>	15,853	26,092	11,509	53,454	2,663	1,086	2,040	5,789	2,454	704	1,973	5,131	64,373
03	<i>M</i>	3.03	3.03	3.13	3.06	3.07	3.04	3.10	3.08	2.89	2.78	2.90	2.88	3.04
	(<i>SD</i>)	(0.64)	(0.64)	(0.62)	(0.63)	(0.63)	(0.59)	(0.66)	(0.63)	(0.66)	(0.77)	(0.68)	(0.69)	(0.64)
	<i>N</i>	12,225	20,927	10,410	43,562	2,041	840	1,913	4,794	1,930	712	1,870	4,511	52,867
allostatic load														
01	<i>M</i>	-0.03	-0.03	NA	-0.03	0.15	0.17	NA	0.16	0.08	0.14	NA	0.09	0.00
	(<i>SD</i>)	(0.46)	(0.45)		(0.46)	(0.48)	(0.51)		(0.49)	(0.49)	(0.45)		(0.48)	(0.47)
	<i>N</i>	23,412	37,064		60,476	4,704	1,958		6,661	4,137	1,462		5,598	72,735
02	<i>M</i>	-0.03	-0.02	-0.13	-0.05	0.19	0.18	0.11	0.15	0.04	0.21	0.02	0.05	-0.02
	(<i>SD</i>)	(0.47)	(0.45)	(0.45)	(0.46)	(0.51)	(0.51)	(0.49)	(0.50)	(0.46)	(0.53)	(0.47)	(0.48)	(0.47)
	<i>N</i>	18,062	29,219	16,187	63,468	3,730	1,518	3,934	9,182	3,244	1,020	3,812	8,076	80,727
03	<i>M</i>	-0.03	-0.03	-0.09	-0.05	0.15	0.10	0.13	0.13	0.04	0.09	0.04	0.05	-0.02
	(<i>SD</i>)	(0.44)	(0.44)	(0.47)	(0.45)	(0.50)	(0.50)	(0.52)	(0.51)	(0.46)	(0.54)	(0.47)	(0.47)	(0.46)

variable /wave	Non-Hispanic White				Non-Hispanic Black				Hispanic				Total	
	Ethnic Density			Total	Ethnic Density			Total	Ethnic Density			Total		
	Low	High	NA		Low	High	NA		Low	High	NA			
<i>stat.</i>	(<i>N</i> =23,952)	(<i>N</i> =37,867)	(<i>N</i> =16,594)	(<i>N</i> =78,414)	(<i>N</i> =4,863)	(<i>N</i> =2,028)	(<i>N</i> =4,019)	(<i>N</i> =10,910)	(<i>N</i> =4,307)	(<i>N</i> =1,518)	(<i>N</i> =3,894)	(<i>N</i> =9,719)	(<i>N</i> =99,043)	
<i>N</i>	14,324	23,745	13,099	51,168	2,956	1,170	3,135	7,261	2,696	977	3,092	6,765	65,194	
life satisfaction														
01	<i>M</i>	5.00	5.04	NA	5.02	4.55	4.42	NA	4.52	4.88	4.76	NA	4.85	4.97
	(<i>SD</i>)	(1.34)	(1.29)		(1.31)	(1.38)	(1.41)		(1.39)	(1.34)	(1.49)		(1.38)	(1.33)
	<i>N</i>	21,427	34,310		55,737	3,857	1,563		5,420	3,417	1,193		4,610	65,767
02	<i>M</i>	4.87	4.95	4.63	4.86	4.48	4.36	4.10	4.32	4.88	4.74	4.72	4.80	4.80
	(<i>SD</i>)	(1.38)	(1.34)	(1.48)	(1.39)	(1.43)	(1.39)	(1.43)	(1.43)	(1.41)	(1.43)	(1.49)	(1.45)	(1.41)
	<i>N</i>	17,198	27,896	12,287	57,382	2,991	1,216	2,333	6,540	2,790	841	2,266	5,897	69,819
03	<i>M</i>	5.10	5.15	4.90	5.08	4.80	4.48	4.51	4.62	5.10	4.86	5.16	5.09	5.04
	(<i>SD</i>)	(1.35)	(1.30)	(1.39)	(1.34)	(1.38)	(1.32)	(1.35)	(1.36)	(1.41)	(1.60)	(1.31)	(1.40)	(1.35)
	<i>N</i>	13,547	22,563	11,167	47,278	2,328	963	2,223	5,515	2,272	782	2,125	5,179	57,972

Notes. *stat.* = descriptive statistics. *N* = weighted population estimate / 1000. For year of birth, 01/01/1960 is represented as 0.

To further assess the impact of restricting the sample to only include respondents who had neighbourhood data, we inspected the structural paths for two of the alternative models that we presented the fit statistics for in Table A.2. In the first of these models, the sample does not have the neighbourhood sample restrictions, and those variables are not included (see Table A.6 for structural paths and see Table A.2 model 14 for fit statistics). In the second model, the sample has the neighbourhood sample restrictions, but those variables are still not adjusted for in the model (see Table A.7 for structural paths and see Table A.2 model 23 for fit statistics). Comparing these two models to the model that we presented in the Results section (see Table 2.2), makes it possible to separately inspect the impact of restricting the sample and controlling for the neighbourhood sociodemographic variables.

In both models that did not control for the measures of neighbourhood deprivation (i.e., Table A.6 and Table A.7), social cohesion significantly negatively predicted allostatic load measured two pooled waves later and the total effect of that relationship including its mediation through social support was also negative and significant, whereas both estimates were not significant in the main analysis model (Table 2.2). As those estimates were different for the main analysis model but the same for the other two models, that indicates that the difference was due to controlling for the neighbourhood deprivation measures rather than the reduction in sample size. However, there were no other differences in significance or notable discrepancies in standardised estimates for the biopsychosocial paths between the three models. That indicates that most results were robust to both controlling for neighbourhood deprivation measures and to the reduction in sample size.

Table A.6*Serial Mediation Analysis Without Neighbourhood Sample Restrictions.*

variable	ethnic density			social cohesion			social support			allostatic load			life satisfaction		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
Direct Effects															
ethnic density (lag 1)	.925	.002	***	.041	.032	***	—	—	—	—	—	—	—	—	—
ethnic density (lag 2)	—	—	—	—	—	—	.008	.025	—	—	—	—	—	—	—
social cohesion (lag 1)	—	—	—	.434	.011	***	.044	.005	***	—	—	—	—	—	—
social cohesion (lag 2)	—	—	—	—	—	—	—	—	—	-.004	.007	**	—	—	—
social support (lag 1)	—	—	—	—	—	—	.574	.009	***	-.002	.005	—	—	—	—
social support (lag 2)	—	—	—	—	—	—	—	—	—	—	—	—	.046	.023	***
allostatic load (lag 1)	—	—	—	—	—	—	—	—	—	.561	.009	***	-.005	.018	***
life satisfaction (lag 1)	—	—	—	—	—	—	—	—	—	—	—	—	.555	.009	***
Indirect Effects															
ethnic density (via social cohesion)	—	—	—	—	—	—	.002	.001	***	—	—	—	—	—	—
social cohesion (via social support)	—	—	—	—	—	—	—	—	—	.000	—	—	—	—	—
social support (via allostatic load)	—	—	—	—	—	—	—	—	—	—	—	—	.000	.001	—
full serial mediation	—	—	—	—	—	—	—	—	—	—	—	—	.000	.000	—
Total Effects															
ethnic density (via social cohesion)	—	—	—	—	—	—	.010	.025	—	—	—	—	—	—	—
social cohesion (via social support)	—	—	—	—	—	—	—	—	—	-.002	.007	**	—	—	—
social support (via allostatic load)	—	—	—	—	—	—	—	—	—	—	—	—	.046	.023	***
Time Invariant Confounders															
Non-Hispanic Black	-.030	.001	***	-.139	.023	***	.011	.011	—	.072	.007	***	-.005	.021	***

variable	ethnic density			social cohesion			social support			allostatic load			life satisfaction		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
Hispanic	.000	.002		-.063	.030	***	-.025	.015	***	.0	.008	***	.0	.029	
US born	.002	.001		.033	.030	***	-.006	.015		.0	.009	***	-.0	.029	***
female	.000	.001		.014	.014	**	.121	.008	***	-.0	.005	***	-.0	.015	
birth year	-.006	.000	***	-.085	.001	***	.075	.000	***	-.0	.000	***	-.0	.001	***
years in education	-.014	.000	***	.094	.003	***	.036	.001	***	-.0	.001	***	.0	.003	***

Notes. lag 1 = predictor was measured one pooled wave before the outcome was measured,

lag 2 = predictor was measured two pooled waves before the outcome was measured, _ =

path not included in SEM. * $p < .05$; ** $p < .01$; *** $p < .001$

Table A.7*Serial Mediation Analysis with Neighbourhood Variables Only Used to Restrict Sample.*

variable	ethnic density			social cohesion			social support			allostatic load			life satisfaction		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p	β	SE	p
Direct Effects															
ethnic density (lag 1)	.940	.002	***	.048	.039	***	—	—	—	—	—	—	—	—	—
ethnic density (lag 2)	—	—	—	—	—	—	.016	.030	—	—	—	—	—	—	—
social cohesion (lag 1)	—	—	—	.435	.012	***	.041	.005	***	—	—	—	—	—	—
social cohesion (lag 2)	—	—	—	—	—	—	—	—	—	-.023	.004	*	—	—	—
social support (lag 1)	—	—	—	—	—	—	.593	.010	***	-.004	.005	—	—	—	—
social support (lag 2)	—	—	—	—	—	—	—	—	—	—	—	—	.034	.024	**
allostatic load (lag 1)	—	—	—	—	—	—	—	—	—	.541	.010	***	-.048	.019	***
life satisfaction (lag 1)	—	—	—	—	—	—	—	—	—	—	—	—	.565	.009	***
Indirect Effects															
ethnic density (via social cohesion)	—	—	—	—	—	—	.002	.001	***	—	—	—	—	—	—
social cohesion (via social support)	—	—	—	—	—	—	—	—	—	.000	.000	—	—	—	—
social support (via allostatic load)	—	—	—	—	—	—	—	—	—	—	—	—	.000	.001	—
full serial mediation	—	—	—	—	—	—	—	—	—	—	—	—	.000	.000	—
Total Effects															
ethnic density (via social cohesion)	—	—	—	—	—	—	.018	.030	—	—	—	—	—	—	—
social cohesion (via social support)	—	—	—	—	—	—	—	—	—	-.023	.004	*	—	—	—
social support (via allostatic load)	—	—	—	—	—	—	—	—	—	—	—	—	.034	.024	**
Time Invariant Confounders															
Non-Hispanic Black	-.011	.001	***	-.109	.031	***	.019	.014	*	.049	.009	***	-.034	.027	***
Hispanic	.012	.002	***	-.032	.039	***	-.008	.020	—	.009	.011	—	.013	.036	—
US born	.002	.001	—	.031	.038	***	.011	.019	—	.017	.011	*	-.012	.036	—
female	-.001	.001	—	.022	.017	***	.109	.009	***	-.044	.006	***	-.010	.017	—
birth year	.011	.000	***	-.033	.001	***	.041	.000	***	.000	.000	—	.018	.001	*
years in education	-.009	.000	***	.089	.003	***	.032	.002	***	-.055	.001	***	.065	.003	***

Notes. lag 1 = predictor was measured one pooled wave before the outcome was measured,

lag 2 = predictor was measured two pooled waves before the outcome was measured, _ =

path not included in SEM, * $p < .05$; ** $p < .01$; *** $p < .001$

Appendix B. Chapter 3

Understanding Society Sample Design

Understanding Society, the UK Household Longitudinal Survey (UKHLS), includes multiple samples that were recruited at different times and for different purposes. However, the present study only includes data from two of these samples: the General Population Sample and the Ethnic Minority Boost Sample, which were the only two samples to be included in wave 1 of UKHLS. Here we describe the design of these two samples as their design influenced our use of weights and computation of standard errors.

To recruit the General Population Sample of Understanding Society, the population of Great Britain was stratified into regions, based on Government Office Regions (for details on the recruitment of the General Population Sample in Northern Ireland see Lynn, 2009)). The regions of Great Britain were next stratified according to the proportions of each postal sector that had particular sociodemographic characteristics (occupational class, population density, ethnic minority density; Lynn, 2009). Within those strata, systematic random sampling was used to identify postcode sectors to include in the sample, which became the primary sampling units. Systematic random sampling was then used within each primary sampling unit to select 18 residential addresses. At these addresses up to three dwelling units were selected and within each dwelling unit up to three households were selected (although in most addresses there is one dwelling unit and within that one household). These households were invited to participate in the sample (Lynn, 2009).

To recruit the Ethnic Minority Boost Sample, a selection of 3,145 postal sectors was identified, which included over 80% of each of the five target ethnic groups. These were then stratified based on the expected number of households that could be identified and interviewed within each postal sector. All postal sectors where at least three households were expected to be identified were retained in the sample as primary sampling units. Whereas only a sub-

sample of postal sectors were retained from the postal sectors that were anticipated to recruit fewer than three households. This avoided too many primary sampling units including only one or two household. Of the postal sectors chosen, 758 were in England, and only 7 were in Wales and 6 in Scotland. The addresses within each primary sampling unit were then sampled at differing rates that were established to maximise the likelihood that the target sample size would be achieved for each of the target ethnic groups (Lynn, 2009).

Preliminary Models

To understand how the estimates for lagged and change in ethnic density may be influenced by the other variables that were included in the Main Analysis Model (Model 1), series of four preliminary models were tested. The first of those models (Model 1.1) only included outcome wave, lagged- and change in ethnic density as predictors and then in each successive model more variables or interactions were included. The results for these four preliminary models are presented across Table B.1, Table B.2, and Table B.3.

In Model 1.1, lagged- and change in ethnic density and an indicator of the outcome wave were included as predictors of psychological distress, but none of these were statistically significant. In Model 1.2, lagged IMD was included in the model as a confounder. The coefficient for lagged IMD was positive and statistically significant, but both measures of ethnic density and the wave indicator remained non-significantly significant. This shows that respondents in neighbourhoods with higher deprivation were more likely to report higher psychological distress, an expected finding, but it does not indicate that the exclusion of IMD in Model 1.1 was confounding the association between ethnic density and psychological distress.

To test whether the relationships between ethnic density and psychological distress may vary across generations and between ethnic groups, three-way interactions were introduced in Model 1.3 between ethnic group, generation, and either lagged- or change in

ethnic density. For the variables included in these interactions the reference groups were Indian, 1st generation, and mean lagged- or change scores respectively. The AME of the change in ethnic density and lagged ethnic density were only significant predictors for UK Black African respondents (see Table B.3). The estimated coefficient of generation, otherwise known as the simple effect of generation, was significant. Simple effects are calculated using the reference groups of the other variables included in interactions, so the significant and positive simple effect of generation indicated that UK born Indian respondents were more likely to have higher psychological distress than 1st generation Indian migrants. The only significant interaction was the three-way interaction including change in ethnic density for Black African respondents, which indicates that UK born Black African respondents had a stronger negative association between change in ethnic density and psychological distress than the 1st generation Indian reference group. This stronger negative association for UK born Black African respondents is also evident in the previously described AME as they were the only group with a significant AME for the association between change in ethnic density and psychological distress. The lack of other significant interactions combined with the significant simple effect of generation, indicates that UK born respondents across ethnic groups tended to have higher psychological distress than 1st generation migrant respondents. As in Model 1.2, IMD remained significant in Model 1.3.

Model 1.4 included lagged- and change in social cohesion, which, as expected, both significantly negatively predicted psychological distress, However, IMD no longer significantly predicted psychological distress. The partial effect estimate of generation was also no longer significant. The AME of lagged- and change in ethnic density for UK born Black African respondents remained statistically significant after inclusion of the social cohesion variables, and additionally AME of change in ethnic density was statistically significant for UK born Black Caribbean respondents.

Table B.1

Fixed Effects Coefficients for Change (Δ) and Lagged Ethnic Density, Generation, Ethnic Group, and their Interaction Terms for Models 1.1-1.4.

#	variable	reference group†			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other					
		<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>			
.1	Δ ethnic density	-0.02	0.03	.489																		
	lagged ethnic density	0.01	0.01	.254																		
.2	Δ ethnic density	-0.02	0.02	.508																		
	lagged ethnic density	0.00	0.01	.819																		
.3	Δ ethnic density	0.00	0.04	.956																		
	lagged ethnic density	0.02	0.02	.377																		
	UK born	2.26	0.84	.007	**																	
	ethnic group					2.21	1.16	.057	1.74	0.97	.074	2.18	1.35	.106	0.03	0.87	.969	1.03	0.64	.111		
	Δ ethnic density X UK born	0.02	0.06	.782																		
	lagged ethnic density X UK born	-0.06	0.03	.090																		
	Δ ethnic density X ethnic group					-0.02	0.06	.687	0.00	0.06	.989	-0.27	0.38	.485	0.02	0.06	.717	0.10	0.07	.147		
	lagged ethnic density X ethnic group					-0.04	0.03	.204	-0.03	0.03	.430	-0.12	0.12	.312	-0.05	0.06	.406	-0.01	0.04	.862		
	UK born X ethnic group					-3.01	1.49	.043	*	-1.56	1.89	.408	-2.53	1.60	.114	1.84	1.68	.274	-2.75	1.42	.052	
	Δ ethnic density X UK born X ethnic group					-0.09	0.10	.378	0.20	0.30	.510	-0.14	0.40	.728	-0.23	0.09	.015	*	-0.15	0.33	.655	
	lagged ethnic density X UK born X ethnic group					0.11	0.05	.030	*	0.05	0.06	.410	0.19	0.14	.155	-0.09	0.11	.403	0.26	0.10	.010	*
.4	Δ ethnic density	0.00	0.04	.919																		
	lagged ethnic density	0.02	0.02	.236																		
	UK born	1.86	0.85	.028	*																	
	ethnic group					2.30	1.15	.045	*	1.93	0.99	.051	2.21	1.33	.097	-0.17	0.83	.841	0.87	0.62	.160	
	Δ ethnic density X UK born	0.02	0.07	.740																		
	lagged ethnic density X UK born	-0.05	0.03	.106																		
	Δ ethnic density X ethnic group					-0.01	0.06	.806	0.01	0.06	.888	-0.23	0.35	.523	0.03	0.07	.662	0.07	0.07	.315		
	lagged ethnic density X ethnic group					-0.04	0.03	.197	-0.02	0.03	.480	-0.13	0.12	.277	-0.06	0.05	.293	-0.03	0.04	.519		
	UK born X ethnic group					-2.83	1.48	.056	-1.41	1.91	.461	-2.51	1.59	.116	1.84	1.64	.261	-2.53	1.40	.071		
	Δ ethnic density X UK born X ethnic group					-0.10	0.10	.349	0.11	0.32	.721	-0.17	0.38	.654	-0.25	0.10	.009	**	-0.06	0.34	.847	
	lagged ethnic density X UK born X ethnic group					0.10	0.05	.034	*	0.05	0.06	.435	0.20	0.14	.141	-0.09	0.11	.386	0.31	0.11	.004	**

Note. # = preliminary model number. † Reference group: 1st generation Indian with mean lagged and change in ethnic density. Δ = change between lagged wave and outcome wave. * $p < .05$; ** $p < .01$; *** $p < .001$

Table B.2

Fixed Effects Coefficients for Wave, Index of Multiple Deprivation (IMD), and Change (Δ) and Lagged Social Cohesion for Models 1.1-1.4.

variable	Model 1.1			Model 1.2			Model 1.3			Model 1.4		
	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>
intercept	11.12	0.22	<.001 ***	10.49	0.30	<.001 ***	9.31	0.60	<.001 ***	13.88	1.05	<.001 ***
wave 6	-0.22	0.21	.287	-0.21	0.21	.307	-0.19	0.21	.357	-0.08	0.20	.713
wave 9	0.03	0.25	.906	0.06	0.25	.812	0.04	0.25	.877	0.12	0.25	.622
lagged IMD				0.03	0.01	.005 **	0.03	0.01	.022 *	0.02	0.01	.072
lagged social cohesion										-1.26	0.23	<.001 ***
Δ social cohesion										-1.37	0.18	<.001 ***
Marginal R ²	.00			.01			.04			.06		

Note. Reference categories: wave 3. IMD = English Index of Multiple Deprivation score excluding health domain, GHQ-12 = psychological distress.

* $p < .05$; ** $p < .01$; *** $p < .001$

Table B.3

Average Marginal Effects of change (Δ) and lagged ethnic density on psychological distress for Models 3-4.

model	variable	gen.	Indian			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
			AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p
3	Δ ethnic density	1 st gen.	0.00	0.04	.956	-0.02	0.05	.648	0.00	0.05	.954	-0.27	0.38	.486	0.02	0.05	.641	0.10	0.06	.084
	lagged ethnic density	1 st gen.	0.02	0.02	.377	-0.02	0.02	.363	-0.01	0.02	.805	-0.10	0.12	.389	-0.03	0.05	.599	0.01	0.04	.728
	Δ ethnic density	UK born	0.02	0.05	.712	-0.09	0.06	.135	0.22	0.29	.454	-0.39	0.11	<.001***	-0.19	0.05	<.001***	-0.03	0.32	.929
	lagged ethnic density	UK born	-0.04	0.03	.141	0.03	0.03	.284	-0.02	0.04	.694	0.03	0.06	.554	-0.18	0.09	.046*	0.22	0.09	.018*
4	Δ ethnic density	1 st gen.	0.00	0.04	.919	-0.01	0.05	.814	0.01	0.05	.789	-0.22	0.35	.527	0.03	0.05	.542	0.08	0.06	.208
	lagged ethnic density	1 st gen.	0.02	0.02	.236	-0.02	0.02	.498	0.00	0.03	.973	-0.10	0.12	.372	-0.03	0.05	.519	0.00	0.03	.968
	Δ ethnic density	UK born	0.03	0.05	.642	-0.08	0.06	.172	0.15	0.31	.632	-0.37	0.11	.001**	-0.19	0.05	<.001***	0.03	0.32	.916
	lagged ethnic density	UK born	-0.03	0.03	.274	0.03	0.03	.191	-0.01	0.04	.852	0.04	0.06	.481	-0.18	0.09	.042*	0.25	0.10	.010*

Note. gen. = generation, AME = average marginal effect. Δ = change between lagged wave and outcome wave.

* $p < .05$; ** $p < .01$; *** $p < .001$

Additional and Interim Analyses

In addition to the Main Analyses a series of additional models were analysed to examine the potential confounding or mediating roles of several potential proxies for acculturative stressors or acculturative stress. Each of those additional models included extra variables, which reduced the possible size of the analysis sample. So, to disentangle whether differences between the main analyses and the additional models were due to changes in the sample size or the inclusion of additional variables, interim models were specified using the variable specification of the main analysis, but the smaller samples of the additional analyses.

1st Generation Migrants

In the first additional analysis, the main analysis was repeated solely for 1st generation migrants to assess the confounding role of proxies for acculturative stressors and acculturative stress that were specific to 1st generation migrants (the 1st Generation Model: Model 2). An interim model (Model 2.1) was also tested to facilitate the comparison between the Main Analysis Model (Model 1) and Model 2. For that interim model, the Main Analysis Model (Model 1) specification was repeated for only 1st generation migrant respondents who had valid responses for four additional variables that related to their experience of migrating to the UK: whether they migrated for family reasons, perceived negative reception, perceived unfair context, and English language communication difficulties. As only 1st generation migrants were included in this sample, the interaction terms involving generation were omitted from the model (see Model 2.1, Table B.5). The descriptive statistics for that sample are presented in Table B.4.

Table B.4*Descriptive Statistics: Sample Restricted to Exclude Missing Data for Migration Variables.*

variable	<i>stat.</i>	Indian	Pakistani	Bangladeshi	Black Caribbean	Black African	White Other	Total
unweighted	N_{rw}	435	195	109	218	293	602	1,852
	N_r	202	97	59	104	145	247	854
weighted	N_{rw}	458	168	89	163	313	674	1,864
outcome wave								
3	%	34.83	33.44	35.52	33.32	31.79	38.96	35.59
6	%	34.90	35.32	35.99	39.02	35.26	35.53	35.64
9	%	30.27	31.24	28.49	27.67	32.96	25.51	28.78
GHQ-12								
lagged	M	10.51	12.14	11.67	12.26	9.25	10.66	10.71
	SD	5.65	6.14	4.61	7.02	5.51	4.65	5.49
outcome	M	10.48	11.64	11.50	11.84	9.37	10.72	10.65
	SD	5.52	6.40	4.69	6.53	5.07	4.46	5.28
ethnic density								
lagged	M	16.57	21.52	16.72	7.66	9.72	8.51	12.18
	SD	14.96	22.14	18.56	5.47	8.98	6.76	13.01
Δ	M	-0.56	-0.55	-1.43	-0.54	0.30	0.22	-0.17
	SD	5.67	7.94	7.66	1.21	4.28	3.54	4.93
Mediator								
social cohesion								
lagged	M	3.67	3.70	3.70	3.61	3.42	3.44	3.54
	SD	0.59	0.59	0.69	0.59	0.73	0.65	0.65
Δ	M	0.00	-0.02	0.06	0.03	-0.03	0.01	0.00
	SD	0.65	0.65	0.74	0.61	0.75	0.67	0.68
moved neighbourhood	%	19.40	14.77	19.64	8.58	22.08	27.15	21.30
Confounder – 1st Generation migrant stressor								
migrated for family	%	64.05	84.15	77.65	78.76	56.85	43.03	58.99
negative context of reception								
negative reception	M	2.05	1.62	2.18	2.19	2.02	2.03	2.02
	SD	0.71	0.71	1.09	1.02	0.93	0.83	0.85
unfair context	M	1.93	1.69	2.02	2.11	1.83	1.82	1.87
	SD	0.62	0.68	1.06	0.92	0.78	0.75	0.76
English difficulty	%	9.10	21.14	26.98	0.00	3.14	15.67	11.62

variable	<i>stat.</i>	Indian	Pakistani	Bangladeshi	Black Caribbean	Black African	White Other	Total
Confounder – individual and neighbourhood sociodemographic								
lagged IMD	<i>M</i>	20.95	32.27	29.62	26.05	29.66	18.45	23.39
	<i>SD</i>	11.52	13.11	13.84	12.64	12.87	12.16	13.36
lagged equivalized household income (/£10,000)	<i>M</i>	0.14	0.09	0.10	0.12	0.10	0.16	0.13
	<i>SD</i>	0.10	0.06	0.10	0.08	0.08	0.14	0.11
female	%	42.18	40.53	46.56	60.81	59.25	57.03	52.10
lagged age	<i>M</i>	45.14	39.89	36.07	55.56	39.33	40.83	42.61
	<i>SD</i>	13.70	12.16	10.59	14.70	14.26	13.99	14.49
lagged married/ partner	%	85.31	84.69	79.84	45.65	54.92	67.55	70.02
lagged employed	%	66.20	55.70	65.97	57.29	61.88	76.82	67.58
lagged education								
degree	%	39.41	44.63	42.85	14.46	41.63	41.21	38.89
advanced	%	28.60	18.88	24.52	33.32	40.03	26.72	29.18
≤ secondary	%	31.98	36.49	32.63	52.22	18.34	32.07	31.93
lagged health condition	%	33.73	32.38	31.46	61.69	24.63	18.93	29.07

Note. N_{rw} = number of responses across waves, N_r = number of unique respondents, Δ =

change between lagged wave and outcome wave. IMD = Index of Multiple Deprivation.

In Model 2.1, none of the Average Marginal Effects (AME), partial effects or interaction terms that related to the measures of ethnic density were significant. As described in the Chapter 3 Additional Analyses, almost all those associations were also non-significant in the 1st Generation Model (Model 2). Consequently, the differences between the 1st Generation Model and the Main Analysis Model can be attributed to restricting the sample to only respondents who answered the migration specific questions, rather than to adjusting for migration specific variables in the model.

Table B.5

Average Marginal Effects of Lagged- and Change in Ethnic Density (Panel A) and Fixed Effects Coefficients for Interactions (Panel B) for Respondents with Valid Data for Acculturative Stressors and Reasons for Migration (Model 2.1) and After Controlling for Those Variables as Potential Confounders (Model 2).

Panel A		Indian			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
model	variable	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p
7.1	Δ ethnic density	-.007	.026	.793	.028	.039	.475	-.012	.036	.735	-.651	.409	.112	.085	.044	.054	.084	.071	.237
	lagged ethnic density	.016	.017	.337	.003	.017	.849	.016	.017	.367	-.086	.089	.333	.017	.030	.586	.039	.030	.198
7	Δ ethnic density	-0.01	0.03	.742	0.03	0.04	.500	-0.01	0.04	.805	-0.66	0.40	.102	0.09	0.04	.049*	0.08	0.07	.227
	lagged ethnic density	.017	.017	.332	.003	.017	.848	.016	.018	.350	-.082	.087	.348	.017	.031	.584	.040	.030	.181
Panel B		reference group†			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
model	variable	b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p
7.1	intercept	7.12	0.89	<.001***															
	Δ ethnic density	-0.01	0.03	.793															
	lagged ethnic density	0.02	0.02	.337															
	ethnic group				0.80	0.74	.279	0.68	0.68	.317	1.18	1.10	.286	-0.84	0.55	.129	0.01	0.46	.985
	Δ ethnic density X ethnic group				0.03	0.05	.451	-0.01	0.04	.901	-0.64	0.41	.116	0.09	0.05	.071	0.09	0.08	.236
	lagged ethnic density X ethnic group				-0.01	0.02	.596	0.00	0.02	.983	-0.10	0.09	.258	0.00	0.03	.989	0.02	0.04	.514
7	intercept	7.54	1.27	<.001***															
	Δ ethnic density	-0.01	0.03	.742															
	lagged ethnic density	0.02	0.02	.332															
	ethnic group				0.86	0.74	.251	0.68	0.71	.340	1.13	1.09	.301	-0.80	0.56	.154	0.03	0.47	.947
	Δ ethnic density X ethnic group				0.04	0.05	.449	0.00	0.04	.989	-0.65	0.40	.107	0.10	0.05	.060	0.09	0.08	.220
	lagged ethnic density X ethnic group				-0.01	0.02	.588	0.00	0.02	.994	-0.10	0.09	.268	0.00	0.03	.986	0.02	0.04	.503
	migrated for family	0.01	0.23	.971															
	negative reception	-0.03	0.16	.869															
	unfair context	0.21	0.17	.230															
	English language difficulty	0.04	0.39	.918															

Note. Δ = change between lagged wave and outcome wave, AME = average marginal effect. † Reference group: 1st generation Indian with mean lagged and change in ethnic density. Reference categories: wave 3, migrated for reasons other than family, and no difficulty communicating in English. This model also included all confounders that were included in Model 1. * $p < .05$; ** $p < .01$; *** $p < .001$

Positive and Negative Social Support

For the Social Support Model (Model 3), responses were only included if their outcome wave was wave 3 or 6 and if they had valid data for the social support measures in waves 2 and 5 respectively. The descriptive statistics for that sample are presented in Table B.6. An interim model (Model 3.1) was also tested using the variables included in the Main Analysis Model (Model 1) and the smaller sample of the Social Support Model (Model 3) to determine whether differences in their results were due to changes in the sample or the mediating role of social support.

In Model 3.1, neither the partial effect of generation nor any of the interactions were significant (see Table B.7, and Table B.8). The only significant partial effect of ethnic group was for 1st generation Pakistani respondents who were more likely to have higher psychological distress than the reference group (i.e., 1st generation Indian respondents). Like the Main Analysis Model, change in ethnic density significantly predicted psychological distress for UK born Black Caribbean respondents. But unlike the Main Analysis Model, that association was neither significant for 1st generation Black Caribbean respondents, nor for UK born Black African and Pakistani respondents.

The Social Support Model (Model 3) did not substantively differ from Model 3.1, but both positive and negative social support significantly predicted psychological distress. As the estimated effects of ethnic density differed between the Main Analysis Model and Model 3.1, but not between Model 3.1 and the Social Support Model, the differences between the models can be attributed to the restrictions that were made to the sample.

Table B.6

Descriptive Statistics: Sample Restricted to Exclude Missing Data for Social Support Variables.

variable	Indian ($N_{rw} = 711$)		Pakistani ($N_{rw} = 385$)		Bangladeshi ($N_{rw} = 187$)		Black Caribbean ($N_{rw} = 494$)		Black African ($N_{rw} = 417$)		White Other ($N_{rw} = 785$)			
	stat.	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	Total	
generation														
unweighted	N_{rw}	439	288	225	265	117	99	230	435	359	82	613	84	3,236
	N_r	298	187	159	185	85	76	161	283	258	54	385	50	2,181
weighted	N_{rw}	431	280	166	219	83	104	161	333	350	67	703	82	2,979
outcome wave														
3	%	57.57	55.38	57.15	56.19	56.60	59.22	57.12	51.98	59.73	52.53	60.18	59.65	57.43
6	%	42.43	44.62	42.85	43.81	43.40	40.78	42.88	48.02	40.27	47.47	39.82	40.35	42.57
GHQ-12														
lagged	M	10.14	11.40	11.63	12.50	11.34	12.50	11.57	11.90	9.88	11.93	10.86	11.31	11.12
	SD	5.54	6.09	5.99	6.87	4.90	6.38	6.25	5.76	5.62	5.46	4.82	5.16	5.70
outcome	M	10.13	11.50	12.26	12.70	11.45	12.48	11.55	11.88	9.62	12.53	10.73	11.68	11.14
	SD	5.31	5.99	6.83	6.53	3.98	7.64	6.43	6.27	5.72	6.09	4.69	5.84	5.82
ethnic density														
lagged	M	18.32	16.26	20.00	28.71	20.71	10.89	7.47	8.06	10.71	7.16	8.67	6.63	13.31
	SD	16.04	15.86	21.01	24.70	20.74	16.57	5.35	6.89	8.79	6.89	7.27	6.09	14.85
Δ	M	-1.16	0.02	0.15	-0.60	-1.56	0.35	-0.28	-0.19	0.00	0.63	0.09	0.17	-0.23
	SD	6.00	4.82	6.56	8.47	7.72	1.83	1.52	1.84	4.20	2.68	3.43	1.99	4.76
Mediator														
social cohesion														
lagged	M	3.69	3.46	3.82	3.65	3.75	3.53	3.58	3.33	3.43	3.17	3.41	3.58	3.51
	SD	0.59	0.71	0.64	0.78	0.71	0.56	0.64	0.67	0.75	0.66	0.67	0.79	0.70
Δ	M	-0.06	-0.06	-0.12	-0.12	0.05	0.06	-0.01	0.03	-0.11	-0.07	0.00	0.00	-0.04
	SD	0.67	0.59	0.62	0.66	0.75	0.69	0.63	0.72	0.74	0.71	0.69	0.58	0.68

variable		Indian ($N_{rw} = 711$)	Pakistani ($N_{rw} = 385$)	Bangladeshi ($N_{rw} = 187$)	Black Caribbean ($N_{rw} = 494$)	Black African ($N_{rw} = 417$)	White Other ($N_{rw} = 785$)							
generation	<i>stat.</i>	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	1st gen. UK born	Total
social support†														
positive	<i>M</i>	3.23	3.14	3.18	3.23	3.20	2.92	3.10	3.09	3.22	2.96	3.23	3.15	3.18
	<i>SD</i>	0.54	0.52	0.54	0.56	0.56	0.65	0.63	0.61	0.57	0.61	0.53	0.48	0.56
negative	<i>M</i>	1.93	1.94	1.84	2.09	1.97	1.96	1.85	1.99	2.08	1.99	1.86	1.82	1.94
	<i>SD</i>	0.60	0.50	0.58	0.64	0.61	0.51	0.60	0.59	0.55	0.56	0.46	0.47	0.55
moved neighbourhood	%	23.77	11.25	14.11	14.72	18.80	9.74	6.93	14.40	22.17	13.03	26.74	21.06	19.00
Confounder – individual and neighbourhood sociodemographic														
lagged IMD	<i>M</i>	21.67	23.30	31.55	32.37	31.59	27.98	26.29	26.34	29.90	26.14	18.19	14.47	24.47
	<i>SD</i>	11.17	13.51	13.19	14.95	13.65	15.10	11.98	12.63	11.93	15.69	11.76	10.93	13.58
lagged equivalized household income (/£10,000)	<i>M</i>	0.12	0.13	0.08	0.09	0.09	0.14	0.09	0.11	0.09	0.11	0.16	0.18	0.12
	<i>SD</i>	0.10	0.09	0.06	0.07	0.07	0.09	0.21	0.08	0.06	0.08	0.17	0.22	0.13
female	%	41.39	43.28	44.15	54.49	38.20	52.98	57.83	59.94	54.37	70.43	55.44	44.11	51.53
lagged age	<i>M</i>	43.38	30.47	40.56	27.54	35.16	33.76	52.88	34.18	35.53	36.28	38.94	40.95	37.57
	<i>SD</i>	14.06	9.25	13.21	8.31	10.46	17.32	15.51	12.15	13.02	10.99	13.88	13.71	14.16
lagged married/ partner	%	82.16	44.65	78.47	46.42	78.59	43.94	48.98	33.34	49.99	23.39	64.75	68.43	57.53
lagged employed	%	64.85	65.57	50.78	44.31	60.99	61.82	58.56	57.89	58.92	69.30	75.96	68.35	63.42
lagged education														
degree	%	44.67	36.22	41.73	33.58	33.88	10.41	17.13	17.80	33.64	34.34	43.63	55.34	35.43
advanced	%	26.41	37.85	19.70	25.61	22.08	34.03	26.65	38.04	40.72	47.75	26.03	31.07	30.71
≤ secondary	%	28.91	25.93	38.57	40.81	44.04	55.56	56.22	44.17	25.64	17.91	30.34	13.58	33.86
lagged health condition	%	30.72	20.02	35.92	17.39	32.10	17.83	52.70	31.65	18.55	19.61	17.05	44.00	25.37

Note. gen. = generation, lag = value in the analytical wave prior (wave 1, 3, or 6) to the outcome wave (wave 3, 6, 9), Δ = change between lagged wave and outcome wave, IMD = Index of Multiple Deprivation.

Table B.7

Average Marginal Effects of Change (Δ) and Lagged Ethnic Density on Psychological Distress. Comparing Model 3.1 (Using Model 1 Variables but Only for Responses with Outcomes in Waves 3 and 6 and Valid Social Support Measures) and Model 3 (Model 3.1 after Adjusting for Social Support).

model	variable	gen.	Indian			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
			AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p
8.1	Δ ethnic density	1 st gen.	-.01	.03	.846	-.05	.052	.371	-.02	.03	.475	-.55	.29	.060	.01	.07	.943	.12	.07	.064
	lagged ethnic density	1 st gen.	0.01	0.01	.659	-0.01	0.02	.669	0.02	0.02	.255	-0.10	0.09	.262	0.00	0.04	.993	0.02	0.03	.523
	Δ ethnic density	UK born	.04	.08	.576	-.062	.04	.158	.17	.28	.542	-.33	.13	.008**	.03	.12	.804	.07	.50	.881
	lagged ethnic density	UK born	-0.01	0.02	.837	0.02	0.02	.240	0.01	0.04	.853	0.02	0.04	.721	-0.14	0.11	.207	0.16	0.09	.068
8	Δ ethnic density	1 st gen.	-0.02	0.04	.603	-0.05	0.05	.345	0.00	0.03	.963	-0.54	0.29	.067	-0.01	0.07	.865	0.13	0.06	.053
	lagged ethnic density	1 st gen.	0.00	0.01	.725	-0.01	0.02	.468	0.02	0.02	.293	-0.09	0.08	.264	0.00	0.04	.940	0.01	0.03	.707
	Δ ethnic density	UK born	0.04	0.08	.612	-0.06	0.05	.160	0.17	0.27	.524	-0.33	0.14	.014 *	-0.01	0.11	.892	0.02	0.47	.965
	lagged ethnic density	UK born	-0.01	0.02	.817	0.03	0.02	.138	0.01	0.04	.764	0.01	0.04	.801	-0.11	0.11	.296	0.14	0.09	.111

Note. N_{rw} = number of responses across waves, N_r = number of unique respondents, Δ = change between lagged wave and outcome wave, gen. = generation, AME = average marginal effect. * $p < .05$; ** $p < .01$; *** $p < .001$

Table B.8

Fixed Effects Coefficients for Interaction Terms. Comparing Model 3.1 (Using Model 1 Variables but Only for Responses with Outcomes in Waves 3 and 6 and Valid Social Support Measures) and Model 3 (Model 3.1 After Adjusting for Social Support).

model	variable	reference group†			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other			
		<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	
8.1	intercept	7.20	0.95	<.001 ***																
	Δ ethnic density	-0.01	0.03	.846																
	lagged ethnic density	0.01	0.01	.659																
	UK born	0.87	0.60	.150																
	ethnic group				1.67	0.84	.046 *	0.74	0.61	.220	0.93	0.98	.340	-0.80	0.63	.203	0.14	0.43	.747	
	Δ ethnic density X UK born	0.05	0.08	.541																
	lagged ethnic density X UK born	-0.01	0.03	.678																
	Δ ethnic density X ethnic group				-0.04	0.06	.516	-0.02	0.05	.734	-0.54	0.29	.065	0.01	0.07	.879	0.13	0.07	.084	
	lagged ethnic density X ethnic group				-0.01	0.02	.541	0.01	0.02	.553	-0.10	0.09	.239	-0.01	0.04	.868	0.01	0.03	.727	
	UK born X ethnic group				-1.69	1.16	.143	-0.23	1.39	.866	-1.45	1.17	.215	1.81	1.18	.124	-1.04	1.07	.332	
	Δ ethnic density X UK born X ethnic group				-0.06	0.11	.550	0.14	0.29	.623	0.17	0.33	.617	-0.02	0.16	.879	-0.10	0.51	.850	
	lagged ethnic density X UK born X ethnic group				0.04	0.04	.264	0.00	0.05	.979	0.12	0.10	.213	-0.13	0.12	.286	0.16	0.10	.097	
8	intercept	7.34	1.31	<.001 ***																
	Δ ethnic density	-0.02	0.04	.603																
	lagged ethnic density	0.00	0.01	.725																
	UK born	0.90	0.59	.131																
	ethnic group				1.92	0.84	.022 *	0.76	0.63	.229	0.97	0.94	.301	-0.88	0.61	.149	0.34	0.42	.421	
	Δ ethnic density X UK born	0.06	0.09	.491																
	lagged ethnic density X UK born	-0.01	0.03	.700																
	Δ ethnic density X ethnic group				-0.03	0.06	.616	0.02	0.05	.715	-0.52	0.30	.079	0.01	0.08	.931	0.14	0.07	.051	
	lagged ethnic density X ethnic group				-0.02	0.02	.423	0.02	0.02	.517	-0.10	0.08	.246	-0.01	0.04	.847	0.01	0.03	.864	
	UK born X ethnic group				-2.10	1.12	.061	-0.45	1.40	.748	-1.50	1.15	.193	1.53	1.08	.156	-1.02	1.04	.328	
	Δ ethnic density X UK born X ethnic group				-0.08	0.12	.516	0.11	0.29	.692	0.15	0.34	.668	-0.06	0.16	.683	-0.17	0.48	.733	
	lagged ethnic density X UK born X ethnic group				0.05	0.04	.176	0.00	0.05	.965	0.11	0.10	.241	-0.10	0.12	.397	0.14	0.09	.140	

Note. Δ = change between lagged wave and outcome wave. † Reference group: 1st generation Indian with mean lagged and change in ethnic density.

* $p < .05$; ** $p < .01$; *** $p < .001$

Discrimination

An interim Model (Model 4.1, Table B.10 and Table B.11), was analysed to examine why the results of the Main Analysis Model (Model 1) differed from the Discrimination Model (Model 4). Model 4.1 used the same specific of variables as the Main Analysis Model but only included the reduced sample of responses that were included in the Discrimination Model. The descriptive statistics for that sample are presented in Table B.9. None of the results in Model 4.1 were notably different from those of the Discrimination Model. Thus, the differences between the Main Analysis Model and the Discrimination model could be attributed to some of the responses in the Main Analysis Model sample being omitted from the Discrimination sample.

Table B.9

Descriptive Statistics: Sample Restricted to Exclude Missing Data for Discrimination

Variables.

variable	stat	Indian ($N_{rw} = 697$)		Pakistani ($N_{rw} = 391$)		Bangladeshi ($N_{rw} = 178$)		Black Caribbean ($N_{rw} = 536$)		Black African ($N_{rw} = 456$)		Total
		1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	
unweighted	N_{rw}	417	216	212	226	119	91	217	425	331	79	2,333
	N_r	247	119	126	146	74	63	127	220	211	43	1,376
weighted	N_{rw}	459	238	176	215	84	94	167	369	371	85	2,258
outcome wave												
3	%	40.41	38.79	39.94	42.77	38.93	41.43	41.05	38.22	42.51	32.14	40.14
6	%	29.42	30.06	30.20	31.40	30.81	29.93	29.34	34.57	29.72	28.33	30.65
9	%	30.17	31.15	29.86	25.83	30.26	28.64	29.61	27.22	27.76	39.53	29.21
GHQ-12												
lagged	M	10.13	11.77	12.20	12.34	11.39	12.16	12.68	11.82	9.69	12.88	11.30
	SD	5.20	5.64	6.21	6.25	4.93	7.77	6.91	5.61	5.64	5.65	5.93
outcome	M	10.17	12.14	12.10	12.37	11.79	11.67	11.89	12.33	9.68	13.15	11.37
	SD	5.43	5.67	6.68	6.62	4.85	7.43	6.54	6.63	5.35	7.00	6.18
ethnic density												
lagged	M	17.40	16.19	23.20	29.98	22.91	14.82	8.17	7.98	10.08	8.10	15.25

variable	stat	Indian ($N_{rw} = 697$)		Pakistani ($N_{rw} = 391$)		Bangladeshi ($N_{rw} = 178$)		Black Caribbean ($N_{rw} = 536$)		Black African ($N_{rw} = 456$)		Total
		1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	
	<i>SD</i>	15.63	15.66	22.39	24.76	20.72	18.61	5.76	7.04	8.90	8.15	16.61
Δ	<i>M</i>	-0.62	0.33	-0.44	-0.41	-1.40	0.61	-0.52	-0.41	0.16	1.01	-0.23
	<i>SD</i>	5.49	6.06	7.27	7.96	7.87	1.94	1.16	1.71	4.24	3.71	5.18
Mediator												
social cohesion												
lagged	<i>M</i>	3.68	3.43	3.78	3.61	3.76	3.56	3.57	3.40	3.43	3.15	3.54
	<i>SD</i>	0.59	0.68	0.66	0.80	0.72	0.58	0.64	0.69	0.74	0.58	0.69
Δ	<i>M</i>	0.00	-0.07	-0.05	-0.06	0.09	-0.07	0.01	-0.02	-0.04	-0.08	-0.03
	<i>SD</i>	0.62	0.55	0.65	0.71	0.80	0.64	0.61	0.71	0.73	0.68	0.67
discrimination	%	20.46	25.68	25.04	34.53	21.21	27.17	10.81	14.55	26.10	22.62	22.34
moved neighbourhood	%	22.15	10.67	11.67	13.72	17.87	4.18	8.20	14.72	23.92	13.00	16.12
Confounder – individual and neighbourhood sociodemographic												
lagged IMD	<i>M</i>	21.11	24.72	32.42	33.24	32.49	26.25	27.54	25.97	30.07	26.36	27.11
	<i>SD</i>	10.97	13.68	13.18	14.59	11.94	14.63	12.99	12.30	12.50	16.00	13.44
equivalized household income	<i>M</i>	0.14	0.14	0.09	0.09	0.09	0.14	0.10	0.12	0.10	0.10	0.11
(/£10,000 lag)	<i>SD</i>	0.11	0.08	0.05	0.07	0.09	0.10	0.21	0.12	0.07	0.06	0.11
female	%	39.65	45.37	43.57	54.24	45.05	60.64	61.04	62.09	54.03	80.70	52.18
lagged age	<i>M</i>	44.91	31.22	42.12	28.08	37.63	33.42	54.11	35.60	36.93	39.28	38.53
	<i>SD</i>	14.04	9.28	12.86	9.17	9.47	16.85	15.05	12.60	14.46	10.72	14.57
lagged married/ partner	%	86.12	44.38	87.01	42.36	82.61	53.88	42.81	33.78	47.50	21.03	55.60
lagged employed	%	65.93	69.46	54.87	42.33	68.26	61.20	61.69	62.80	58.13	75.34	61.33
lagged education												
degree	%	42.19	44.23	39.12	33.31	39.37	13.47	15.91	17.54	37.91	33.83	33.03
advanced	%	27.65	29.68	20.08	28.21	18.93	37.58	25.53	40.10	42.46	52.78	32.67
≤ secondary	%	30.16	26.10	40.80	38.47	41.70	48.95	58.56	42.36	19.63	13.39	34.29
lagged health condition	%	34.38	20.63	41.25	17.29	39.51	17.50	62.95	29.89	22.71	31.10	30.67

Note. N_{rw} = number of responses across waves, N_r = number of unique respondents, gen. =

generation, Δ = change between lagged wave and outcome wave. IMD = Index of Multiple

Deprivation.

Table B.10

Average Marginal Effects of Change (Δ) and Lagged Ethnic Density on Psychological Distress. Comparing Model 4.1 (Using Model 1 Variables but Only for Responses with Valid Discrimination Measures and Without White Other Respondents) and Model 4 (Model 4.1 After Adjusting for Discrimination).

model	variable	gen.	Indian			Pakistani			Bangladeshi			Black Caribbean			Black African				
			AME	SE	<i>p</i>	AME	SE	<i>p</i>	AME	SE	<i>p</i>	AME	SE	<i>p</i>	AME	SE	<i>p</i>		
9.1	Δ ethnic density	1 st gen.	-0.09	0.04	.797	-0.02	0.05	.657	-0.02	0.03	.663	-0.75	0.43	.082	0.06	0.06	.340		
	lagged ethnic density	1 st gen.	0.01	0.02	.491	-0.02	0.02	.293	0.02	0.02	.317	-0.11	0.09	.226	0.00	0.03	.989		
	Δ ethnic density	UK born	0.05	0.08	.567	-0.06	0.03	.064	0.17	0.25	.503	-0.56	0.15	<.001	***	-0.25	0.07	.001	**
	lagged ethnic density	UK born	-0.02	0.03	.570	0.02	0.02	.279	0.02	0.04	.671	0.00	0.06	.946	-0.12	0.08	.124		
9	Δ ethnic density	1 st gen.	-0.01	0.04	.747	-0.02	0.05	.709	-0.01	0.04	.689	-0.77	0.43	.076	0.06	0.06	.346		
	lagged ethnic density	1 st gen.	0.01	0.02	.397	-0.02	0.02	.292	0.02	0.02	.271	-0.10	0.08	.238	0.02	0.03	.497		
	Δ ethnic density	UK born	0.05	0.08	.553	-0.05	0.04	.183	0.12	0.23	.617	-0.55	0.16	<.001	***	-0.24	0.07	.001	**
	lagged ethnic density	UK born	-0.01	0.03	.666	0.03	0.02	.187	0.02	0.04	.633	0.00	0.06	.982	-0.09	0.08	.222		

Note. Δ = change between lagged wave and outcome wave, gen. = generation, AME = average marginal effect.

* $p < .05$; ** $p < .01$; *** $p < .001$

Table B.11

Fixed Effects Coefficients for Interaction Terms. Comparing Model 4.1 (Using Model 1 Variables but Only for Responses with Valid Discrimination Measures and Without White Other Respondents) and Model 4 (Model 4.1 After Adjusting for Discrimination).

model	variable	reference group†			Pakistani			Bangladeshi			Black Caribbean			Black African					
		<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>			
9.1	intercept	7.12	0.89	<.001	***														
	Δ ethnic density	-0.01	0.04	.797															
	lagged ethnic density	0.01	0.02	.491															
	UK born	1.42	0.65	.028	*														
	ethnic group					1.78	0.88	.044	*	1.02	0.85	.231	0.64	1.15	.581	-0.71	0.59	.230	
	Δ ethnic density X UK born	0.05	0.08	.511															
	lagged ethnic density X UK born	-0.03	0.03	.353															
	Δ ethnic density X ethnic group					-0.01	0.06	.829		-0.01	0.05	.907	-0.74	0.43	.087	0.06	0.07	.343	
	lagged ethnic density X ethnic group					-0.03	0.03	.216		0.01	0.02	.779	-0.12	0.09	.188	-0.01	0.03	.746	
	UK born X ethnic group					-2.75	1.18	.019	*	-2.21	1.76	.209	-1.52	1.35	.260	1.24	1.23	.315	
	Δ ethnic density X UK born X ethnic group					-0.09	0.10	.382		0.13	0.27	.631	0.13	0.46	.772	-0.35	0.13	.005	**
	lagged ethnic density X UK born X ethnic group					0.07	0.04	.082		0.03	0.05	.612	0.13	0.11	.234	-0.09	0.09	.294	
9	intercept	7.04	1.25	<.001	***														
	Δ ethnic density	-0.01	0.04	.747															
	lagged ethnic density	0.01	0.02	.397															
	UK born	1.40	0.64	.030	*														
	ethnic group					1.82	0.88	.039	*	1.12	0.88	.201	0.79	1.10	.473	-0.87	0.59	.139	
	Δ ethnic density X UK born	0.06	0.08	.480															
	lagged ethnic density X UK born	-0.03	0.03	.363															
	Δ ethnic density X ethnic group					-0.01	0.06	.916		0.00	0.05	.970	-0.76	0.44	.082	0.07	0.07	.332	
	lagged ethnic density X ethnic group					-0.03	0.02	.178		0.01	0.02	.784	-0.11	0.09	.188	0.01	0.03	.842	
	UK born X ethnic group					-2.87	1.17	.014	*	-2.26	1.67	.177	-1.45	1.31	.266	1.29	1.19	.279	
	Δ ethnic density X UK born X ethnic group					-0.09	0.10	.398		0.07	0.25	.776	0.16	0.46	.738	-0.36	0.13	.005	**
	lagged ethnic density X UK born X ethnic group					0.07	0.04	.062		0.02	0.05	.644	0.12	0.11	.249	-0.09	0.09	.303	
	discrimination	1.53	0.32	<.001	***														

Note. Δ = change between lag wave and outcome wave. † Reference group: 1st generation Indian with mean lagged and change in ethnic density.

* $p < .05$; ** $p < .01$; *** $p < .001$

Supplementary Analysis

Neighbourhood Racism

Introduction. The discrimination items in UKHLS were only asked to a subset of respondents, which substantially reduced the sample size of the analysis that included discrimination. However, UKHLS did repeatedly ask all adult respondents about how frequently racist attacks occurred in their neighbourhood. Those attacks may be directed at people who do not share a respondent's ethnicity, but the occurrence of racism against any ethnic minority group is likely to make all residents feel less safe. If discrimination is less common in higher ethnic density neighbourhoods, then reports of racist attacks in neighbourhoods (i.e., neighbourhood racism) may also be less frequent in higher ethnic density neighbourhoods, which could in turn negatively predict psychological distress.

Measure. In waves 3, 6, and 9, respondents were asked how common racist attacks were in their neighbourhood from 1 (*very common*) to 4 (*not at all common*). This variable was reverse coded so that higher variables related to more frequent racist attacks.

Analysis Plan. *Main Analysis Model + neighbourhood racism.*

Neighbourhood racism was included as a potential mediator and was measured in all outcome waves. Only 88 responses in the main analysis sample had invalid or missing values for neighbourhood racism.

Descriptive Statistics. Neighbourhood racism, a measure of the perceived prevalence of racist attacks in respondents' neighbourhoods, varied slightly between ethnic groups with the highest average found for Pakistani respondents ($M = 1.65$, $SD = 0.70$) and lowest for White Other respondents ($M = 1.28$, $SD = 0.50$). However, the prevalence does not appear to vary much by generation (1st generation: $M = 1.43$, $SD = 0.62$; UK born: $M = 1.49$, $SD = 0.64$). Full descriptive statistics for this sample are presented in Appendix B Table B.12.

Analysis. The results of this analysis were not substantively different from those of the main analysis model except that the AME for change in ethnic density for UK born Pakistani respondents transitioned from being slightly lower than the $p < .05$ threshold to being slightly above that threshold (see Table B.13). Neighbourhood racism significantly positively predicted psychological distress. As there was little substantive difference between the main analysis model and this supplementary model, there was no need to conduct an interim model to separate the influence of the reduced sample size from the influence of including neighbourhood racism in the model. So, as was the case for discrimination, the coefficients for lagged and change in ethnic density were robust to the inclusion of the potential mediating variable of neighbourhood racism.

Table B.12

Descriptive Statistics: Sample Restricted to Exclude Responses Missing Neighbourhood Racism.

variable	stat.	Indian ($N_{rw} = 923$)		Pakistani ($N_{rw} = 493$)		Bangladeshi ($N_{rw} = 240$)		Black Caribbean ($N_{rw} = 664$)		Black African ($N_{rw} = 554$)		White Other ($N_{rw} = 964$)		Total
		1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	
unweighted	N_{rw}	538	354	263	316	141	113	281	535	422	106	759	107	3,935
	N_r	300	187	162	186	87	75	160	283	264	54	381	50	2,189
weighted	N_{rw}	560	363	216	277	108	132	208	456	449	105	864	100	3,838
outcome wave														
3	%	44.87	42.49	45.24	44.68	44.61	43.60	43.18	38.09	47.31	33.63	48.54	49.13	44.62
6	%	31.19	34.59	31.25	34.61	33.22	31.57	33.00	34.33	30.77	29.13	31.64	31.40	32.30
9	%	23.94	22.92	23.51	20.71	22.17	24.83	23.81	27.58	21.92	37.24	19.82	19.47	23.08
GHQ-12														
lagged	M	10.25	11.28	11.71	12.32	11.44	11.93	11.95	11.88	9.65	12.70	10.81	11.62	11.11
	SD	5.47	5.87	6.04	6.52	4.75	7.09	6.58	5.99	5.58	5.65	4.76	5.85	5.73
outcome	M	10.28	11.56	11.66	12.56	11.60	12.18	11.43	12.35	9.73	12.95	10.84	11.57	11.22
	SD	5.45	5.84	6.67	6.72	4.73	7.31	6.19	6.56	5.61	6.69	4.58	5.62	5.85
ethnic density														
lagged	M	17.20	15.81	21.02	27.32	19.50	11.39	7.72	8.02	10.30	7.47	8.57	6.52	12.98
	SD	15.37	15.07	21.81	24.07	19.83	16.46	5.44	6.86	8.89	7.82	7.08	6.04	14.47
Δ	M	-0.84	0.11	-0.27	-0.22	-1.18	0.39	-0.37	-0.32	0.30	0.80	0.17	0.19	-0.12
	SD	5.77	5.74	7.32	8.00	7.09	1.70	1.45	2.03	4.12	3.44	3.30	2.04	4.77
Mediator														
social cohesion														
lagged	M	3.68	3.45	3.79	3.62	3.75	3.58	3.56	3.38	3.42	3.14	3.43	3.61	3.51
	SD	0.59	0.68	0.64	0.77	0.70	0.60	0.64	0.70	0.75	0.59	0.67	0.74	0.69

variable	stat.	Indian ($N_{rw} = 923$)		Pakistani ($N_{rw} = 493$)		Bangladeshi ($N_{rw} = 240$)		Black Caribbean ($N_{rw} = 664$)		Black African ($N_{rw} = 554$)		White Other ($N_{rw} = 964$)		Total
		1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	1 st gen.	UK born	
Δ	<i>M</i>	-0.02	-0.07	-0.07	-0.07	0.04	-0.06	0.00	0.00	-0.06	-0.07	-0.02	-0.05	-0.04
	<i>SD</i>	0.66	0.62	0.64	0.74	0.76	0.78	0.61	0.72	0.75	0.69	0.68	0.65	0.69
neighbourhood racism	<i>M</i>	1.47	1.45	1.64	1.66	1.66	1.48	1.39	1.46	1.52	1.56	1.29	1.19	1.45
	<i>SD</i>	0.67	0.59	0.69	0.71	0.81	0.76	0.55	0.58	0.64	0.67	0.50	0.51	0.63
moved neighbourhood	%	22.37	11.60	14.22	14.65	19.26	8.42	8.14	16.84	22.12	16.89	26.67	17.44	19.00
Confounder – individual and neighbourhood sociodemographic														
lagged IMD	<i>M</i>	21.40	23.57	32.03	32.01	30.95	27.60	26.51	25.90	29.65	25.40	18.01	14.38	24.39
	<i>SD</i>	11.32	13.79	13.31	14.67	13.61	14.95	12.52	12.38	12.52	15.91	11.83	10.48	13.67
lagged equivalized household income (/£10,000)	<i>M</i>	0.13	0.14	0.09	0.09	0.10	0.14	0.10	0.12	0.10	0.11	0.16	0.18	0.13
	<i>SD</i>	0.10	0.09	0.05	0.07	0.09	0.09	0.19	0.11	0.07	0.07	0.16	0.20	0.12
female	%	41.02	42.62	42.77	52.09	40.98	56.76	61.35	59.32	53.70	74.48	54.72	43.46	51.42
lagged age	<i>M</i>	44.47	31.14	40.50	28.58	36.20	34.44	54.48	34.90	36.93	37.75	40.11	42.46	38.56
	<i>SD</i>	14.05	9.28	12.81	8.82	10.29	17.22	15.35	12.12	13.83	11.33	14.16	13.42	14.33
lagged married/ partner	%	83.74	45.16	81.18	48.79	80.55	42.53	44.42	35.14	51.36	21.08	67.12	71.37	58.46
lagged employed	%	66.05	69.48	55.92	47.01	64.83	61.93	59.02	63.84	59.79	75.31	75.97	70.46	65.48
lagged education degree	%	43.29	40.95	41.81	34.14	38.97	11.53	14.76	19.64	37.15	35.86	43.31	55.65	36.17
advanced	%	26.31	33.58	18.83	26.43	20.87	36.72	28.44	38.30	39.81	50.46	25.77	29.34	30.52
≤ secondary	%	30.40	25.47	39.36	39.43	40.16	51.75	56.80	42.06	23.04	13.67	30.93	15.01	33.31
lagged health condition	%	33.73	21.02	36.64	18.01	34.93	26.02	57.85	33.90	20.62	27.96	18.38	42.58	27.73

Note. N_{rw} = number of responses across waves, N_r = number of unique respondents, gen. = generation, Δ = change between lagged wave and outcome wave, IMD = Index of Multiple Deprivation.

Table B.13

Average Marginal Effects of Lagged- and Change in Ethnic Density (Panel A) and Regression Coefficients (Panel B) After Adjusting for Neighbourhood Racism (Model 5).

variable	Gen.	Indian			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
		AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p
Δ ethnic density	1st gen.	0.01	0.03	.685	-0.02	0.04	.690	-0.03	0.03	.286	-0.53	0.23	.018 *	0.04	0.06	.542	0.13	0.07	.056
lagged ethnic density	1st gen.	.011	.015	.480	-.010	.016	.547	.009	.017	.590	-.050	.084	.555	-.001	.031	.972	.024	.024	.321
Δ ethnic density	UK born	0.02	0.06	.718	-0.07	0.04	.067	0.15	0.29	.599	-0.33	0.10	.001 **	-0.29	0.06	<.001 ***	0.03	0.35	.933
lagged ethnic density	UK born	-.011	.023	.622	.024	.019	.196	-.004	.035	.904	-.004	.050	.932	-.146	.069	.034 *	.158	.078	.043 *
		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>		<i>N_{rw}</i>	<i>N_r</i>	
	1st gen.	538	300		263	162		141	87		281	160		422	264		759	381	
	UK born	354	187		316	186		113	75		535	283		106	54		107	50	
variable	reference group †	Pakistani			Bangladeshi			Black Caribbean			Black African			White Other					
		<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>	<i>b</i>	<i>SE</i>	<i>p</i>			
intercept		6.39	0.97	<.001 ***															
Δ ethnic density		0.01	0.03	.685															
lagged ethnic density		0.01	0.02	.480															
UK born		1.00	0.58	.084															
ethnic group					1.10	0.73	.133	0.83	0.70	.234	0.37	0.96	.705	-0.65	0.56	.244	0.20	0.42	.640
Δ ethnic density X UK born		0.01	0.06	.887															
lagged ethnic density X UK born		-.022	.025	.387															
Δ ethnic density X ethnic group					-0.03	0.05	.574	-0.05	0.04	.296	-0.54	0.23	.017 *	0.02	0.07	.726	0.11	0.07	.120
lagged ethnic density X ethnic group					-0.02	0.02	.355	0.00	0.02	.947	-0.06	0.09	.481	-0.01	0.03	.734	0.01	0.03	.639
UK born X ethnic group					-1.52	1.03	.138	-0.68	1.39	.625	-0.57	1.16	.624	1.78	1.05	.088	-1.38	0.96	.153
Δ ethnic density X UK born X ethnic group					-0.06	0.09	.462	0.18	0.30	.555	0.19	0.25	.444	-0.33	0.11	.002 **	-0.11	0.36	.769
lagged ethnic density X UK born X ethnic group					0.06	0.04	.116	0.01	0.04	.849	0.07	0.10	.505	-0.12	0.08	.124	0.16	0.08	.064
neighbourhood racism		0.46	0.17	.008 **															

Note. Marginal $R^2 = .27$. N_{rw} = number of responses across waves, N_r = number of unique respondents, AME = average marginal effect. † Reference group: 1st generation Indian with mean lagged and change in ethnic density. Δ = change between lagged wave and outcome wave. This model also included all confounders that were included in Model 1. * $p < .05$; ** $p < .01$; *** $p < .001$

Ease of visiting family

Introduction. If ethnic density is related to worse psychological distress because low ethnic density is a stressor that can lead to cultural isolation, then other determinants of cultural isolation could moderate the relationship between ethnic density and psychological distress. For example, individuals may also be more likely to experience cultural isolation if they cannot easily visit their family members. As both ethnic density and ease of visiting family may help to prevent cultural isolation stress, the presence of either may be sufficient to prevent that stress and consequently facilitate low psychological distress. The previously observed differences between samples and sub-populations could result from some groups tending to live closer to their families than other groups do. To test that possibility, we tested the moderating role of how easily respondents could visit their family.

We hypothesised that respondents with high values for either or both of ethnic density and ease of visiting family will have lower psychological distress compared to respondents who have low values for both ethnic density and ease of visiting family.

Measure. In wave 3, respondents were asked how easy they would find it to visit family when they need to. This was asked on a scale from 1 (*very difficult*) to 5 (*very easy*). Ease of visiting family was only measured once, so for the purposes of this study it was treated as being time invariant.

Analysis Plan. *Main Analysis Model + ease of visiting family X lagged ethnic density, ease of visiting family X change in ethnic density, with ethnic group and generation included as confounders and not moderators.*

Ethnic group and generation are included as confounders instead of moderators because the cell sizes in the potential 4-way interactions would be too small. As ease of visiting family was only measured in wave 3, it was an appropriate moderator for outcomes in waves 6 and 9 because ease of visiting family is measured at or before the measurement of

the predictor variable, ethnic density. However, the temporal order of the moderator and predictor may be reversed for 293 respondents who moved neighbourhood between waves 1 and 3. Of the 4,023 responses included in the main analysis sample, 4,015 responses had valid measures of ease of visiting family. The eight responses with non-valid data were from only 6 different respondents.

Descriptive Statistics. As the sample for this analysis included only eight fewer responses than the main analysis, the descriptive statistics for both analysis are very similar (for main analysis see Chapter 3 Table 3.3; for sample including ease of visiting family see Table B.15). As could be expected, respondents born in the UK reported that it was easier to visit family ($M = 3.59$, $SD = 1.12$) than did 1st generation migrant respondents ($M = 2.76$, $SD = 1.35$).

Analysis. The fixed effects for this model are presented in Table B.14. In this model, the partial effect estimate for generation was significant, but the only significant partial effect of ethnic group was for Black African respondents being more likely to have lower psychological distress than Indian respondents (the reference group). Ease of visiting family significantly negative predicted psychological distress, but the interaction terms were not significant.

The non-significant interaction terms indicate that the ease with which individuals can visit their family does not alter whether they benefit from the potentially protective features of higher ethnic density. However, in this model, ethnic group and generation were not included in interaction terms, so it is possible that ease of visiting family may have had a moderating role for some groups but not others.

Table B.14

Fixed Effects Coefficients for a Model Including Interactions Between Ease of Visiting Family and Both Lagged- and Change in Ethnic Density (Model 6).

variable	<i>b</i>	<i>SE</i>	<i>p</i>
intercept	7.69	0.88	<.001***
Δ ethnic density	0.03	0.04	.468
lagged ethnic density	0.00	0.02	.931
UK born	0.80	0.23	.001**
Pakistani	0.67	0.36	.064
Bangladeshi	0.57	0.54	.295
Black Caribbean	0.10	0.32	.759
Black African	-0.67	0.33	.041*
White Other	0.12	0.25	.640
ease of visiting family	-0.25	0.10	.011*
Δ ethnic density X ease of visiting family	-0.01	0.01	.231
lagged ethnic density X ease of visiting family	0.00	0.00	.770
N_{rw}	4,015		
Marginal R ²	.27		

Note. Δ = change between lagged wave and outcome wave. N_{rw} = # responses across waves.

Reference categories: 1st generation migrant, Indian, wave 3. This model also included all confounders that were included in Model 1.

* $p < .05$; ** $p < .01$; *** $p < .001$

Table B.15

Descriptive Statistics: Sample Restricted to Exclude Responses Missing Ease of Visiting Family Data.

variable	stat.	Indian ($N_{rw} = 941$)		Pakistani ($N_{rw} = 503$)		Bangladeshi ($N_{rw} = 248$)		Black Caribbean ($N_{rw} = 678$)		Black African ($N_{rw} = 563$)		White Other ($N_{rw} = 983$)		Total
		1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born			
unweighted	N_{rw}	550	356	271	323	142	118	287	545	428	108	777	110	4,015
	N_r	301	186	161	188	87	77	162	284	263	54	385	50	2,198
weighted	N_{rw}	574	367	218	286	110	138	214	464	457	106	880	103	3,915
outcome wave														
3	%	43.78	42.10	45.24	43.78	44.00	44.56	43.63	37.69	46.33	33.21	48.25	47.98	44.13
6	%	32.09	34.25	30.62	33.54	32.77	30.68	33.29	34.63	31.11	30.01	31.66	32.46	32.39
9	%	24.12	23.66	24.15	22.68	23.23	24.76	23.08	27.68	22.56	36.77	20.09	19.56	23.47
GHQ-12														
lagged	M	10.27	11.31	11.96	12.37	11.40	11.76	11.99	11.88	9.64	12.66	10.78	11.71	11.13
	SD	5.48	5.85	6.11	6.51	4.72	6.99	6.63	5.98	5.55	5.63	4.79	5.88	5.74
outcome	M	10.24	11.60	11.89	12.52	11.61	11.88	11.51	12.33	9.71	12.97	10.81	11.62	11.21
	SD	5.46	5.84	6.64	6.67	4.70	7.26	6.26	6.57	5.57	6.75	4.61	5.62	5.85
ethnic density														
lagged	M	17.29	15.67	21.36	27.74	19.34	11.25	7.68	8.04	10.32	7.58	8.65	6.55	13.05
	SD	15.48	14.93	21.80	24.29	19.74	16.37	5.43	6.87	8.90	7.84	7.07	5.99	14.54
Δ	M	-0.79	0.11	-0.41	-0.13	-1.15	0.40	-0.38	-0.32	0.29	0.96	0.18	0.15	-0.11
	SD	5.72	5.72	7.25	7.90	7.04	1.67	1.44	2.03	4.10	3.77	3.27	2.05	4.74
Moderator														
ease of family visits	M	2.89	3.71	2.91	3.60	2.80	3.63	3.12	3.69	2.73	2.85	2.56	3.45	3.07
	SD	1.42	0.96	1.40	1.09	1.50	1.17	1.20	1.07	1.41	1.33	1.24	1.31	1.33

variable	stat.	Indian	Pakistani	Bangladeshi	Black Caribbean	Black African	White Other	Total						
		($N_{rw} = 941$)	($N_{rw} = 503$)	($N_{rw} = 248$)	($N_{rw} = 678$)	($N_{rw} = 563$)	($N_{rw} = 983$)							
		1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born	1 st gen. UK born							
Mediator														
social cohesion														
lagged	<i>M</i>	3.68	3.44	3.76	3.63	3.74	3.57	3.57	3.39	3.43	3.14	3.43	3.60	3.51
	<i>SD</i>	0.59	0.67	0.64	0.76	0.70	0.59	0.64	0.70	0.75	0.59	0.66	0.75	0.69
Δ	<i>M</i>	-0.02	-0.07	-0.07	-0.07	0.05	-0.05	-0.01	0.00	-0.06	-0.07	-0.03	-0.05	-0.04
	<i>SD</i>	0.66	0.62	0.64	0.73	0.76	0.77	0.61	0.73	0.74	0.69	0.69	0.65	0.69
moved neighbourhood	%	22.09	11.48	12.50	14.72	18.99	8.03	7.89	16.70	21.84	17.58	26.74	18.07	18.82
Confounder – individual and neighbourhood sociodemographic														
lagged IMD	<i>M</i>	21.35	23.56	31.93	32.15	30.89	27.35	26.40	25.99	29.63	25.42	18.15	14.46	24.41
	<i>SD</i>	11.29	13.70	13.38	14.79	13.53	14.90	12.51	12.43	12.44	15.82	11.80	10.41	13.64
lagged equivalized household income	<i>M</i>	0.13	0.14	0.09	0.09	0.10	0.14	0.10	0.12	0.10	0.11	0.16	0.18	0.13
(/£10,000)	<i>SD</i>	0.10	0.09	0.05	0.08	0.09	0.09	0.19	0.11	0.07	0.07	0.16	0.20	0.12
female	%	41.11	43.37	44.52	52.31	41.78	56.06	60.28	59.86	54.00	74.80	55.59	44.24	51.90
lagged age lag	<i>M</i>	44.49	31.14	40.66	28.90	35.97	34.58	54.28	35.02	37.05	37.76	39.94	42.49	38.59
	<i>SD</i>	14.16	9.23	12.75	9.06	10.41	17.08	15.21	12.10	13.89	11.29	14.08	13.58	14.31
lagged married/ partner	%	83.54	45.67	83.34	49.89	79.45	44.20	44.37	35.05	50.98	21.71	67.04	71.00	58.63
lagged employed	%	65.24	69.37	54.33	46.29	65.31	62.78	59.85	63.89	59.80	75.62	75.98	70.11	65.29
lagged education														
degree	%	42.53	41.52	40.89	33.61	38.44	12.00	15.57	19.73	37.06	36.31	43.45	55.10	36.06
advanced	%	27.27	33.15	19.34	26.06	21.95	35.44	27.57	38.44	39.85	50.19	26.03	29.69	30.64
≤ secondary	%	30.20	25.33	39.77	40.33	39.61	52.56	56.86	41.83	23.10	13.50	30.52	15.21	33.30
lagged health condition	%	33.52	21.11	37.14	18.03	34.45	24.83	58.02	33.70	20.90	27.60	18.14	43.92	27.69

Note. N_{rw} = number of responses across waves, N_r = number of unique respondents, Δ = change between lagged wave and outcome wave, IMD = Index of

Multiple Deprivation.

Non-Movers

Introduction. The main analysis sample included some responses from respondents who moved neighbourhood between their predictor wave (i.e., when lagged ethnic density was measured) and outcome wave (i.e., when psychological distress was measured). These respondents may experience a much larger difference in ethnic density between the predictor and outcome wave than someone who remains in the same neighbourhood. As such, the results for the full sample may be unduly influenced by these respondents. So, we reran the main analysis model specification, but with only responses where the respondent did not move between their predictor and outcome wave.

Measure. A dummy variable was created to identify responses where the respondent moved LSOA between their predictor wave and their outcome wave (e.g., between waves 1 and 3). Responses that included a change in LSOA were assigned a value of “1” and non-movers were assigned a value of “0”.

Analysis Plan. *Main Analysis Model excluding responses who moved neighbourhood between their predictor and outcome waves.*

The main analysis sample was split between responses in which the respondents moved neighbourhood ($N = 582$) and responses where they did not ($N = 3,530$). The main analysis model could only be reassessed using the latter group because the sample size of the former group would result in very small cell sizes for some combinations of ethnic group and generation ($10 \leq \text{cell } N \leq 151$).

Descriptive Statistics. Respondents who moved tended to move to areas with lower ethnic density ($M = -2.32$, $SD = 10.39$) whereas the neighbourhoods that the non-movers lived in tended to slightly increase in ethnic density over time ($M = 0.42$, $SD = 1.07$). Unsurprisingly, the variation in change in ethnic density was much higher for respondents

who moved than among those who did not. The full descriptive statistics for the sample of the non-movers are presented in Table B.16.

Analysis. In this model, lagged- and change in ethnic density were not significant predictors for any ethnic group in either generation (see Table B.17). The only significant coefficient for any of the variables included in the interactions was the three-way interaction term between lagged ethnic density, generation, and ethnic group for Black African respondents. That would indicate that the association between lagged ethnic density and psychological distress was significantly more negative for UK born Black African respondents than for the reference group, 1st generation Indian respondents. However, as previously indicated, the AME for the association between lagged ethnic density and psychological distress was still not significant for UK born Black African respondents.

These results indicate that the significant association between change in ethnic density and psychological distress, which were found in the Main Analysis Model, may have reflected the benefits of moving to a neighbourhood with higher ethnic density rather than the benefits of ethnic density increasing within a neighbourhood. However, it is also possible that the difference in the results was due to the reduction in sample size, rather than due to the change in the sample's composition.

Table B.16*Descriptive Statistics: Sample Restricted to Responses who did not move Neighbourhoods.*

variable	stat.	Indian ($N_{rw} = 774$)		Pakistani ($N_{rw} = 434$)		Bangladeshi ($N_{rw} = 216$)		Black Caribbean ($N_{rw} = 584$)		Black African ($N_{rw} = 444$)		White Other ($N_{rw} = 733$)		Total
		1 st	UK	1 st	UK	1 st	UK	1 st	UK	1 st	UK	1 st	UK	
		gen.	born	gen.	born	gen.	born	gen.	born	gen.	born	gen.	born	
unweighted	N_{rw}	457	319	239	287	121	108	273	485	348	88	629	96	3,450
	N_r	269	177	153	175	80	71	159	273	226	50	346	47	2,026
weighted	N_{rw}	448	326	190	244	89	127	197	387	357	87	649	84	3,185
outcome wave														
3	%	44.01	42.98	46.79	42.62	45.71	45.08	44.16	40.64	44.06	34.48	49.21	48.74	44.58
6	%	30.27	33.14	30.04	34.83	31.55	28.77	33.70	33.78	33.21	32.24	30.69	28.77	31.94
9	%	25.72	23.88	23.17	22.55	22.75	26.16	22.14	25.58	22.73	33.28	20.09	22.50	23.47
GHQ-12														
lagged	M	10.69	11.21	11.94	12.35	11.04	11.60	11.68	11.77	10.06	13.14	10.73	11.89	11.22
	SD	5.75	5.60	6.14	6.50	4.70	7.02	6.39	5.87	5.56	5.55	4.82	5.79	5.74
outcome	M	10.62	11.62	12.05	12.61	11.28	12.29	11.27	12.18	10.08	13.53	10.84	11.76	11.37
	SD	5.65	5.85	6.73	6.80	4.87	7.19	6.24	6.60	5.66	6.82	4.64	5.39	5.94
ethnic density														
lagged	M	17.57	15.68	20.24	28.75	19.85	11.82	7.85	8.56	10.99	8.10	8.08	6.48	13.31
	SD	15.78	15.05	20.60	23.69	19.46	16.72	5.46	6.90	8.77	8.28	6.88	6.19	14.65
Δ	M	0.34	0.25	0.97	0.94	0.59	0.42	-0.29	-0.18	0.43	0.46	0.69	0.50	0.41
	SD	1.15	1.10	1.41	1.29	1.25	1.14	0.61	0.83	0.86	0.74	0.82	0.58	1.06
Mediator														
social cohesion														
lagged	M	3.71	3.49	3.81	3.68	3.87	3.58	3.60	3.43	3.49	3.18	3.52	3.69	3.57
	SD	0.59	0.64	0.60	0.77	0.61	0.59	0.62	0.69	0.72	0.57	0.65	0.73	0.67
Δ	M	-0.04	-0.11	-0.11	-0.09	0.10	-0.08	0.00	-0.04	-0.11	-0.13	-0.03	-0.05	-0.06
	SD	0.64	0.57	0.62	0.73	0.73	0.69	0.58	0.65	0.70	0.60	0.65	0.59	0.65
Confounder – individual and neighbourhood sociodemographic														
lagged IMD	M	21.45	23.52	31.42	32.53	31.80	27.84	26.80	26.27	30.41	25.66	18.11	14.28	24.82
	SD	11.31	13.77	13.53	14.71	13.74	15.26	12.75	12.16	12.74	16.19	12.18	10.82	13.87
lagged equivalized household income (£10,000)	M	0.13	0.14	0.09	0.09	0.10	0.14	0.10	0.12	0.10	0.11	0.16	0.19	0.13
	SD	0.10	0.08	0.06	0.07	0.10	0.09	0.20	0.11	0.07	0.07	0.17	0.21	0.12
female	%	43.60	43.56	45.69	53.62	42.61	54.07	59.20	59.59	54.75	75.01	56.78	49.27	52.73
lagged age	M	46.45	31.52	40.95	28.92	37.50	34.41	55.75	36.02	38.69	38.44	42.37	44.92	39.87
	SD	14.27	9.36	13.20	9.57	10.70	17.08	14.33	12.32	14.44	10.88	14.76	12.74	14.80

variable	stat.	Indian ($N_{rw} = 774$)		Pakistani ($N_{rw} = 434$)		Bangladeshi ($N_{rw} = 216$)		Black Caribbean ($N_{rw} = 584$)		Black African ($N_{rw} = 444$)		White Other ($N_{rw} = 733$)		Total
		1 st	UK	1 st	UK	1 st	UK	1 st	UK	1 st	UK	1 st	UK	
		gen.	born	gen.	born	gen.	born	gen.	born	gen.	born	gen.	born	
lagged married/ partner	%	85.42	46.68	82.00	49.08	84.53	42.24	46.16	34.30	51.03	22.36	66.86	72.45	58.37
lagged employed	%	61.28	69.40	53.02	46.90	62.62	64.03	56.95	63.91	60.68	75.31	73.22	72.70	63.77
lagged education degree	%	36.68	39.23	38.54	27.52	34.42	9.86	16.57	18.44	35.84	33.69	45.60	56.14	33.91
advanced	%	29.82	34.23	20.66	28.73	20.30	36.63	23.70	40.11	39.80	51.63	23.75	26.61	30.91
≤ secondary	%	33.50	26.54	40.79	43.75	45.28	53.52	59.73	41.45	24.37	14.68	30.65	17.25	35.17
health condition (lag)	%	37.37	20.60	37.74	18.37	32.77	24.02	60.06	33.89	24.97	26.41	20.15	45.99	29.57

Note. N_{rw} = number of responses across waves, N_r = number of unique respondents,

Δ = change between lagged wave and outcome wave. IMD = Index of Multiple Deprivation.

Table B.17

Average Marginal Effects of lagged- and change in ethnic density (Panel A) and Coefficients (Panel B) for Respondents who did not Move (Model 7).

Panel A		Indian			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
variable	Gen.	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p	AME	SE	p
Δ ethnic density	1st gen.	0.01	0.23	.981	-0.51	0.33	.126	-0.62	0.55	.262	-0.88	1.24	.478	-0.11	0.40	.779	0.04	0.28	.891
lagged ethnic density	1st gen.	0.00	0.01	.871	0.00	0.02	.936	0.00	0.02	.828	-0.14	0.09	.128	-0.02	0.03	.434	0.03	0.03	.289
Δ ethnic density	UK born	0.16	0.31	.611	-0.20	0.31	.521	0.15	0.41	.714	-0.36	0.40	.363	0.05	0.97	.963	1.16	1.11	.293
lagged ethnic density	UK born	-0.02	0.02	.257	0.01	0.02	.648	0.00	0.03	.908	-0.01	0.05	.804	-0.16	0.09	.062	0.15	0.08	.058
		N_{rw}	N_r		N_{rw}	N_r		N_{rw}	N_r		N_{rw}	N_r		N_{rw}	N_r		N_{rw}	N_r	
N_{rw}	1st gen.	457	269		239	153		121	80		273	159		348	226		629	346	
N_{rw}	UK born	319	177		287	175		108	71		485	273		88	50		96	47	
Panel B		reference group†			Pakistani			Bangladeshi			Black Caribbean			Black African			White Other		
		b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p	b	SE	p
intercept		7.09	1.07	<.001	***														
Δ ethnic density		-0.06	0.23	.807															
lagged ethnic density		0.00	0.01	.824															
UK born		0.84	0.60	.164															
ethnic group					1.29	0.85	.128	1.25	0.77	.102	0.84	1.01	.407	-0.56	0.70	.424	0.05	0.47	.908
Δ ethnic density X UK born		0.23	0.47	.630															
lagged ethnic density X UK born		-0.02	0.02	.489															
Δ ethnic density X ethnic group					-0.35	0.43	.417	-0.51	0.52	.330	-0.78	1.32	.554	0.07	0.45	.875	0.12	0.35	.730
lagged ethnic density X ethnic group					0.00	0.02	.833	0.00	0.02	.898	-0.14	0.09	.139	-0.01	0.04	.854	0.03	0.03	.425
UK born X ethnic group					-1.31	1.15	.253	-0.60	1.40	.669	-0.99	1.23	.419	1.95	1.20	.103	-1.76	1.17	.133
Δ ethnic density X UK born X ethnic group					-0.08	0.67	.910	0.51	0.78	.509	0.12	1.41	.935	0.80	1.25	.520	0.83	1.26	.511
lagged ethnic density X UK born X ethnic group					0.04	0.04	.265	0.00	0.05	.990	0.13	0.11	.228	-0.17	0.08	.042*	0.14	0.09	.123

Note. Marginal $R^2 = .27$. N_{rw} = number of responses across waves, N_r = number of unique respondents, AME = average marginal effect. † Reference group: 1st generation Indian with mean lagged and change in ethnic density. Δ = change between lagged wave and outcome wave. This model also included all confounders that were included in Model 1. * $p < .05$; ** $p < .01$; *** $p < .001$

Appendix C. Chapter 4

Testing Assumptions and Outliers

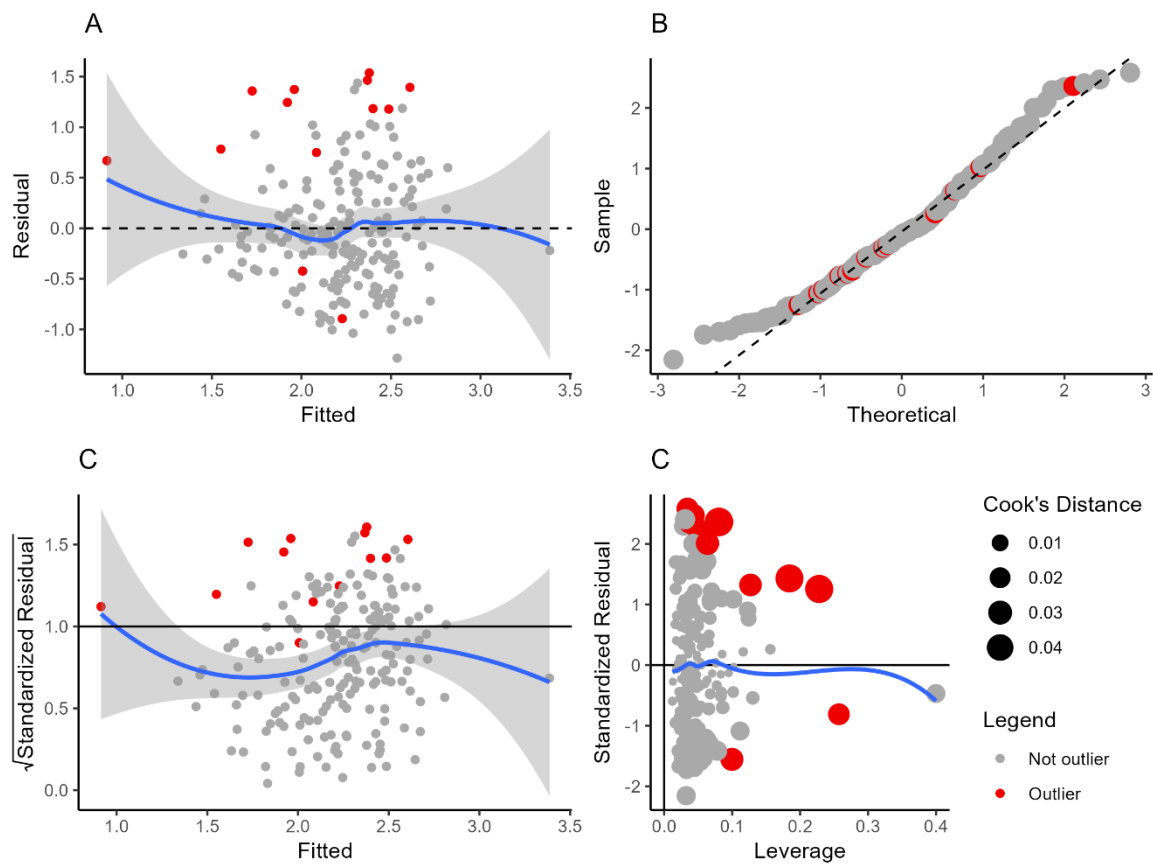
To assess whether the analyses met the assumptions of linear regression analysis, the residual error and fitted values of GHQ-12 from were plotted for Step 3 of the cross-sectional model that included RMSSD (see Figure C.1). Fitted GHQ scores were plotted against their residual, which was the difference between participant's fitted scores and their actual scores (see Figure C.1 Panel A). This supports the assumption that residuals should be relatively consistent across levels of the outcome. The sample distribution of GHQ-12 scores was also close to the theoretical normal distribution (see Q-Q plot in Figure C.1 Panel B). There was a small degree of heteroscedasticity (see Figure C.1 Panel C), however the studentized Breusch-Pagan test found that this did not significantly deviate from the assumption on homoscedasticity ($BP=14.05$, $df=9$, $p=.124$).

In most real datasets, some participants have a greater influence on estimated regression coefficients than others. The most influential participants, known as outliers, are those with the highest residuals and the highest leverage. Leverage is the extent to which a participant's predictor variable values differ from the rest of the sample. For all participants, leverage was plotted against their standardised residuals (see Figure C.1 Panel D). Cook's distance is a measure that combines leverage and standardised residual values to identify outliers. Participants with a higher Cook's distance have greater influence on regression coefficients. Various thresholds have previously been used to identify outliers. A common threshold is 1, whereas other researchers use a threshold of $4/(N-k-1)$, where N is the sample size and k is the number of predictors (Fox, 2016). For Step 3 of the cross-sectional model including RMSSD measures, our analytical sample was 201 participants, and we used 9 predictors, which resulted in a Cook's distance threshold of 0.02. This threshold classed 13

participants as outliers, whereas no participants had a Cook's distance greater than 1. Outliers were identified with red dots in Figure C.1.

Figure C.1

Graphical tests of Analysis Assumptions.



To further assess how these 12 potential outlier participants differ from others, we plotted each predictor against GHQ. Those scatter plots are not presented here because they may enable reidentification of participants, but the most notable features of those plots were as follows. Of the outliers, five had GHQ values higher than 3.5, whereas fewer than five non-outliers had a GHQ above 3.5. Notably, all participant with a value above 3.5 were female. Most outliers also appeared to have had higher GHQ than other participants with similar levels of subjective social status (SSS). In the sample, acculturative stress was positively correlated with GHQ (see Table 4.1). However, most of the outliers had higher

than average GHQ and lower than average acculturative stress. To assess the impact of these outliers, we ran a sensitivity analysis with the outliers removed (see Table C.1). Without outliers, acculturative stress and recall task Δ RMSSD both significantly predicted psychological distress.

Table C.1

Multiple linear regression of Psychological Distress on control variables (step 1), acculturative stress (step 2), RMSSD during the 1st neutral stimulus and the change in RMSSD between each neutral stimulus and the subsequent stressful stimulus (step 3), and the interaction between acculturative stress and RMSSD (step 4). Participants who were identified as potential Cook's distance outliers, were excluded from these analyses.

variable	Step 1: control variables				Step 2: + acculturative stress				Step 3: + RMSSD				Step 4: + Interaction			
	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>
intercept	2.01	0.06	[1.89, 2.14]	***	2.02	0.06	[1.90, 2.15]	***	2.02	0.06	[1.90, 2.14]	***	2.03	0.06	[1.90, 2.15]	***
age	-0.02	0.01	[-0.03, -0.01]	**	-0.02	0.01	[-0.03, -0.00]	**	-0.01	0.01	[-0.03, -0.00]	*	-0.01	0.01	[-0.03, -0.00]	*
female	0.22	0.08	[0.06, 0.39]	**	0.21	0.08	[0.05, 0.38]	*	0.22	0.08	[0.06, 0.38]	**	0.21	0.08	[0.05, 0.37]	*
SSS	-0.10	0.02	[-0.14, -0.06]	***	-0.09	0.02	[-0.13, -0.05]	***	-0.09	0.02	[-0.13, -0.04]	***	-0.09	0.02	[-0.13, -0.04]	***
exercise (hours/week)	-0.01	0.00	[-0.02, -0.00]	**	-0.01	0.00	[-0.02, -0.00]	*	-0.01	0.00	[-0.02, -0.00]	**	-0.01	0.00	[-0.02, -0.00]	**
life stressors	0.04	0.04	[-0.03, 0.11]		0.02	0.04	[-0.05, 0.09]		0.02	0.04	[-0.04, 0.09]		0.02	0.04	[-0.05, 0.09]	
acculturative stress					0.12	0.04	[0.04, 0.21]	**	0.12	0.04	[0.04, 0.21]	**	0.13	0.04	[0.04, 0.21]	**
baseline RMSSD									0.00	0.00	[-0.00, 0.00]		0.00	0.00	[-0.00, 0.00]	
recall task Δ RMSSD									0.02	0.00	[0.01, 0.03]	***	0.02	0.01	[0.01, 0.03]	***
sad film Δ RMSSD									0.01	0.01	[-0.00, 0.02]		0.01	0.01	[-0.00, 0.02]	
acculturative stress X recall task Δ RMSSD													0.00	0.01	[-0.01, 0.02]	
acculturative stress X sad film Δ RMSSD													0.01	0.01	[-0.01, 0.02]	
<i>N</i>	188				188				188				188			
R ²	.21				.24				.30				.30			
adjusted R ²	.19				.22				.27				.26			
Δ R ²					.03				.06				.00			

Note. GHQ = 12-item General Health Questionnaire (psychological distress), SSS = MacArthur Scale of Subjective Social Status, CI = confidence intervals.

p* < .05. *p* < .01. ****p* < .001

Correlation between HRV measures

Two measures of HRV were derived for the present study. RSA was derived as a frequency-domain measure and RMSSD is a time-domain measure. The two measures were highly correlated both within and across stimuli ($.73 \leq r \leq .93$, see Table 4.2). For change scores between stimuli, the correlations were consistently lower, but they were still large. Each set of change scores negatively correlated as expected with the neutral stimuli that they were derived from. Both RMSSD and RSA measures of the sad film clip (i.e., sad film RMSSD and sad film RSA) were positively correlated with sad film Δ RMSSD, and recall task Δ RSA, but not sad film Δ RSA. Additionally, only sad film RMSSD, and not sad film RSA, was correlated with recall task Δ RMSSD. Unexpectedly, neither recall task Δ RMSSD or recall task Δ RSA were correlated with either measure of the acculturative stress recall task (i.e., recall task RMSSD and recall task RSA).

Preregistered Analyses

A set of hypotheses and an analysis plan were pre-registered for this study before data collection began (see <https://doi.org/10.17605/OSF.IO/7QFJE>). We made the following changes to that analyses plan. Cross-sectional data was analyses in the first three hypotheses with the longitudinal associations instead assessed in hypotheses 4-6. The pre-registered analysis plan adjusted for perceived social support. However, perceived social support was removed from the final analysis plan because it is likely that perceived social support acts as a mediator in the relationship between acculturative stress and psychological health as individuals who experience tension with heritage or settlement contacts will likely report worse social support and worse psychological health (Abu-Kaf & Khalaf, 2020; Franco et al., 2019; Katsiaficas et al., 2013). The measure of life stressors used in this study was modified from a binary variable to a count variable because almost all participants reported at least one

life stressor. Compared to the pre-registration, the number of items included in that count were reduced to exclude any items that had conceptual overlap with acculturative stress (e.g., bullying, issues at work, problems in a close relationship) or psychological health (e.g., personal health problems). In the final analysis plan, an additional step was added to include acculturative stress before the measures of vmHRV were included. This was done to show how the inclusion of vmHRV measures may mediate the effects of acculturative stress. In the pre-registered analysis plan, the final step adjusted for respiration. However, a valid measure of respiration could not be estimated from the data, so that step was omitted. After the analyses were conducted based on the final analysis plan, the full pre-registered analysis plan was also tested, except for the final step, for both RMSSD (Table C.3) and HF-HRV (Table C.4) measures. In those analyses life stressors was dichotomised between participants who had experienced two or less or three or more life stressors in the last year because too few participants only reported one or no life stressors. Social support was calculated as the average of each participant's responses to three questions that were asked about four potential sources of social support: partners, family, friends living in the same neighbourhood, and friends living in other neighbourhoods. Participants responded on a 4-point Likert scale from 1 (*Not at all*) to 4 (*A lot*) in response to items adapted from measures previously used in the Health and Retirement Study (J. Smith et al., 2023) and the UK Household Longitudinal Survey (Institute for Social and Economic Research, 2021). In these analyses, RMSSD reactivity in response to the acculturative stress recall task significantly predicted follow-up psychological distress, but no other associations were significant in either the RMSSD or HF-HRV analyses (see Table C.3 and Table C.4).

Table C.2

Bi-variate Correlations and Descriptive Statistics for Two Measures of vagally-mediated Heart Rate Variability: RMSSD and HF-HRV.

variable	<i>N</i>	<i>M</i> (<i>SD</i>)	2	3	4	5	6	7	8	9	10	11	12
1. baseline RMSSD	211	36.46 (20.08)	.83 ***	.92 ***	.77 ***	.92 ***	.80 ***	.91 ***	.74 ***	-.18 **	-.21 **	-.22 **	-.20 **
2. baseline RSA	211	4.79 (1.14)		.77 ***	.91 ***	.75 ***	.93 ***	.76 ***	.89 ***	-.13	-.31 ***	-.13	-.18 **
3. sad film RMSSD	210	37.40 (20.30)			.82 ***	.93 ***	.80 ***	.89 ***	.73 ***	.22 **	.04	-.27 ***	-.22 **
4. sad film RSA	210	4.79 (1.09)				.75 ***	.92 ***	.76 ***	.89 ***	.14 *	.11	-.13	-.15 *
5. 2 nd neutral clip RMSSD	208	37.02 (21.15)					.82 ***	.91 ***	.74 ***	.04	-.07	-.4 ***	-.29 ***
6. 2 nd neutral clip RSA	208	4.81 (1.12)						.80 ***	.92 ***	.01	-.12	-.23 **	-.28 ***
7. recall task RMSSD	208	36.62 (19.41)							.81 ***	-.01	-.07	.01	-.03
8. recall task RSA	208	4.83 (1.08)								-.01	-.09	.03	.12
9. sad film Δ RMSSD	210	0.90 (8.09)										.63 ***	-.12
10. sad film Δ RSA	210	0.00 (0.47)											.02
11. recall task Δ RMSSD	206	-0.48 (8.65)											
12. recall task Δ RSA	206	0.01 (0.45)											.64 ***

Note. baseline RMSSD and baseline RSA refer to vmHRV during the first neutral film clip.

* $p < .05$. ** $p < .01$. *** $p < .001$

Table C.3

Multiple linear regression of Psychological Distress at follow-up on control variables (step 1), acculturative stress, RMSSD during the 1st neutral stimulus, and the change in RMSSD between each neutral stimulus and the subsequent stressful stimulus (RMSSD reactivity) (step 2), and the interaction between acculturative stress and RMSSD (step 3).

variable	Step 1: control variables				Step 2: + acculturative stress & RMSSD				Step 3: + Interaction			
	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>
intercept	1.93	0.10	[1.72, 2.13]	***	1.94	0.11	[1.72, 2.16]	***	1.94	0.11	[1.72, 2.16]	***
age	0.00	0.01	[-0.01, 0.01]		0.00	0.01	[-0.01, 0.02]		0.00	0.01	[-0.01, 0.02]	
female	0.19	0.10	[-0.01, 0.39]		0.20	0.11	[-0.01, 0.41]		0.20	0.11	[-0.01, 0.41]	
SSS	-0.02	0.03	[-0.08, 0.03]		-0.02	0.03	[-0.07, 0.04]		-0.02	0.03	[-0.07, 0.04]	
exercise (hours/week)	0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.01, 0.01]	
life stressors	0.20	0.11	[-0.01, 0.41]		0.23	0.12	[-0.00, 0.46]		0.23	0.12	[-0.00, 0.46]	
social support	-0.11	0.10	[-0.30, 0.08]		-0.02	0.10	[-0.23, 0.18]		-0.01	0.11	[-0.22, 0.20]	
acculturative stress					0.08	0.06	[-0.03, 0.19]		0.08	0.06	[-0.03, 0.19]	
baseline RMSSD					0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.01, 0.01]	
recall task Δ RMSSD					0.02	0.01	[0.00, 0.03]	*	0.02	0.01	[0.00, 0.03]	*
sad film Δ RMSSD					0.01	0.01	[-0.01, 0.02]		0.01	0.01	[-0.01, 0.02]	
acculturative stress X recall task Δ RMSSD									0.00	0.01	[-0.01, 0.02]	
acculturative stress X sad film Δ RMSSD									0.00	0.01	[-0.01, 0.01]	
<i>N</i>	180				160				160			
<i>R</i> ²	0.07			*	0.14			**	0.14			*
adjusted <i>R</i> ²	0.04				0.09				0.07			
Δ <i>R</i> ²					0.05			*	0.00			

Note. GHQ = 12-item General Health Questionnaire (psychological distress), SSS = MacArthur Scale of Subjective Social Status, RMSSD = -root mean square of successive differences, CI = confidence intervals.

p* < .05. *p* < .01. ****p* < .001

Table C.4

Multiple linear regression of Psychological Distress at follow-up on control variables (step 1), acculturative stress, HF-HRV during the 1st neutral stimulus, and the change in HF-HRV between each neutral stimulus and the subsequent stressful stimulus (HF-HRV reactivity) (step 2), and the interaction between acculturative stress and HF-HRV (step 3).

variable	Step 1: control variables				Step 3: + HF-HRV				Step 3: + Interaction			
	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>	<i>b</i>	<i>SE</i>	95% CI	<i>p</i>
intercept	1.93	0.10	[1.72, 2.13]	***	1.98	0.11	[1.75, 2.20]	***	1.96	0.12	[1.73, 2.19]	***
age	0.00	0.01	[-0.01, 0.01]		0.00	0.01	[-0.01, 0.02]		0.00	0.01	[-0.01, 0.02]	
female	0.19	0.10	[-0.01, 0.39]		0.18	0.11	[-0.04, 0.39]		0.19	0.11	[-0.04, 0.41]	
SSS	-0.02	0.03	[-0.08, 0.03]		-0.02	0.03	[-0.07, 0.04]		-0.02	0.03	[-0.07, 0.04]	
exercise (hours/week)	0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.01, 0.01]		0.00	0.00	[-0.01, 0.01]	
life stressors	0.20	0.11	[-0.01, 0.41]		0.19	0.12	[-0.05, 0.42]		0.20	0.12	[-0.04, 0.44]	
social support	-0.11	0.10	[-0.30, 0.08]		-0.04	0.11	[-0.25, 0.17]		-0.03	0.11	[-0.25, 0.18]	
acculturative stress					0.09	0.06	[-0.02, 0.20]		0.09	0.06	[-0.03, 0.20]	
baseline HF-HRV					-0.01	0.05	[-0.11, 0.10]		-0.01	0.05	[-0.12, 0.10]	
recall task ΔHF-HRV					-0.02	0.12	[-0.26, 0.21]		-0.01	0.13	[-0.26, 0.24]	
sad film ΔHF-HRV					0.18	0.11	[-0.04, 0.41]		0.17	0.12	[-0.06, 0.40]	
acculturative stress X recall task ΔHF-HRV									0.06	0.12	[-0.18, 0.31]	
acculturative stress X sad film ΔHF-HRV									-0.08	0.11	[-0.30, 0.14]	
<i>N</i>	180				160				160			
R ²	0.07				*				0.12			
adjusted R ²	0.04								0.04			
ΔR ²					0.02				0.01			

Note. GHQ = 12-item General Health Questionnaire (psychological distress), SSS = MacArthur Scale of Subjective Social Status, HF-HRV = root mean square of successive differences, CI = confidence intervals. * $p < .05$. ** $p < .01$. *** $p < .001$.

Acculturative Stress Recall Task

Before starting the task, participants were provided the following instructions and examples of acculturative stress:

“For the next part of this study you will be asked to reflect on any stressful or uncomfortable experiences you have had as a consequence of moving to the UK and interacting with multiple cultural groups.

Some stressful experiences are common when you first move to a new country. For example, you may experience language barriers, find it difficult to cope with cultural differences, or you might not have family or friends to support you in the UK.

However, other stressful situations can occur many years after moving. These can include experiences of harassment or discrimination on the basis of your ethnicity, language or heritage. You may also experience tension or have arguments with family members over how traditionally you or they should behave.

You may have experienced some of these situations or had other uncomfortable interactions with people as a result of real or perceived cultural differences between you.

Please click on the arrow below to start this task.”

When a participant had finished reading that description, they could use their mouse to click on an arrow to start the task. During the task another message was presented on their screen to help them to focus and to provide prompts to help them start thinking about their acculturative experiences. That message read:

“Please now spend the next five minutes thinking about stressful or uncomfortable experiences you have had as a consequence of moving to the UK and interacting with multiple cultural groups.

This could include issues with language barriers, cultural differences, feelings of isolation, experiencing discrimination or cultural conflict within your family.

Please think about how you responded in those situations and whether you would respond differently now. These can be recent memories, or if you have lived in the UK for many years you could also think about the first years after you moved to the UK.

During these five minutes, if you find your mind wondering to other topics please try to return to thinking about those stressful experiences.

You **should not** write during this task.

The task will be complete when the timer below reaches 0m 0s.”

After they completed the task, they were given five minutes to write down everything that they had been thinking about during the task. This helped to check whether participants understood the task and whether they were engaged with the task. That writing exercise was introduced on participants’ computer monitor with the following message:

“Thank you for completing that task.

For the next five minutes, please use the paper and pen that are provided on your table to write down everything that you were thinking about during that task.

Please provide as much detail as you are comfortable providing. These responses will be held confidentially by the research team and once data collection has concluded, any data links to your personal details will be removed, which will mean that your comments will be anonymous.

Please write down everything you were thinking about even if it was not related to the task. This is important so that we can check that our sensors are well calibrated.

The task will be complete when the timer below reaches 0m 0s.”

Participants were provided a pen and paper which included the following instructions:

“For the next five minutes, please use the box below to write down everything that you were thinking about during the previous part of this task. There is a second piece of paper if you need it, and you may use both sides.

Please write down everything you were thinking about even if it was not related to the task. This is important so that we can check that our sensors are well calibrated.

If you finish writing every thought you had during the last task, please remain sat still for the remainder of the task and continue to think about any stressful experiences you have had since moving to the UK.”