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WHY MAINTENANCE MATTERS: DISORDER IN THE BUILT ENVIRONMENT AND PHYSICAL HEALTH

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ABSTRACT

Over the last decade there has been a renewed interest in identifying exactly how aspects of the residential built environment "get under the skin" and affect the health of not only those who dwell within, but reside and commute among, disorderly and deteriorating buildings.
In parallel, across the different disciplines that constitute the neighbourhood effects literature, there is a growing acknowledgement that unpacking the "black box" of the phenomenon will require a principled theoretical approach that proposes plausible causal pathways between the area-level neighbourhood context and individual-level health; that is a concerted effort to answer not only the "why?" (ultimate) question, but the "how?" (proximate) question, too.
Building on Wilson and O'Brien's explicitly evolutionary construct of Community Perception, we introduce Jos Brosschot's Generalised Unsafety Theory of Stress to propose and test a novel account of the causal pathway we believe residential maintenance plays between a place and its people.
We use C-reactive protein (CRP), a biomarker associated with infection and stress, alongside information relating to neighbourhood maintenance, demographic characteristics, and health behaviours, all drawn from the UK Household Longitudinal Study. Hierarchical multiple regression models estimate CRP for exposure to poor maintenance conditions, controlling for known predictors and confounders. Results indicate that poor maintenance is associated with elevated CRP.
Residential maintenance matters to people's physical health. Future work will look to further elucidate the proximate mechanisms that underlie this pathway, in the hope that it will lead to impactful evidence-based policy proposals.

Keywords: built environment, community perception, generalised unsafety theory of stress, physical health, neighbourhood effects

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INTRODUCTION

> It is not too much to say that an adequate solution of the housing question is the foundation of all social progress. Health, and housing, are indissolubly connected. If this country is to be the country which we desire, a great offensive must be taken against disease and crime, and the first point at which the attack must be delivered is the ugly, unhealthy, overcrowded house, in the mean street, which we all of us know too well.
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> — King George V, Speech to representatives of British Local Authorities, 1919.

It is now over a century since King George V (monarch of the United Kingdom; 1910-1936) made this observation regarding the centrality of housing in tackling the structural inequalities experienced by disadvantaged urban populations. His remarks, addressed to representatives of local authorities in the Britain of the day, resonated with emerging research, and practice, on both sides of the Atlantic (Park & Burgess, 1925; and the "Addison Act" – Housing and Town Planning [United Kingdom] Act, 1919). Housing continues to be recognised as one of the key determinants of an individual's life outcomes in the neighbourhood effects literature, a field that typically takes the residential neighbourhood as the principal ecological unit of analysis (Galster, 2012; Krieger & Higgins, 2002; Ribeiro, 2018; Sampson, 2012).

Established findings about the respiratory health consequences of living in damp conditions are perhaps the most obvious way in which poor housing functions as a vector of disease at the household-level (Shaw, 2004). However, recent work by Clair and Hughes (2019) has demonstrated how tenure type and housing typology also impact individual-level physical health outcomes for residents.

Over the last decade there has been a renewed interest in identifying exactly how physical aspects of residential housing in particular, and built environment more broadly, "get under the skin" and affect the health not only of those who dwell within, but reside and commute among, disorderly and deteriorating buildings (Corcoran et al., 2018; Galster, 2012; Keizer et al., 2008; Kruger et al., 2011; Sampson, 2012; Volker, 2017).

In parallel, across the different disciplines that constitute the neighbourhood effects literature (e.g., social epidemiology, public health, health geography, and medical sociology), there is a growing acknowledgement that unpacking the "black box" of neighbourhood effects will require a principled theoretical approach that proposes plausible causal pathways between the area-level neighbourhood context and individual-level health; that is a concerted effort to answer not only the "why?" (ultimate) question, but the "how?" (proximate) question, too (Glaster, 2012; Prior et al., 2018; Ribeiro, 2018; van Ham & Manley, 2012). As Prior and colleagues (2018) have asserted, this is best achieved by adopting a biosocial approach to the subject; one which recognises that chronic stress is most likely to play a key mediating role between the neighbourhood context and individual-level health outcomes.

Recent work in social science from an evolutionary perspective has identified a candidate cognitive mechanism that might account for the contribution the physical built environment plays in this process (Corcoran et al., 2018, Hill et al., 2014; Keizer et al., 2008; Nettle, 2015; O'Brien & Wilson, 2011). The term Community Perception was coined by David Sloan Wilson and Daniel O'Brien (2011) to define the psychological construct that they proposed to account for a particular socially oriented cognitive mechanism. They hypothesised that in an ultra-social group-living species, which must navigate not only their own but occasionally unfamiliar social environments, it would be adaptive to be able to quickly infer the kinds of social encounters that might occur there. In a series of studies conducted in the US city of Binghamton, which have gone on to inspire similar work in groups in the UK (the Prosocial Place Programme in Liverpool, Corcoran et al., 2018; and the Tyneside Neighbourhoods Project in Newcastle; Nettle, 2015), they found that participants were able to generate accurate assessments of the social quality of unfamiliar neighbourhoods using only photographs of the physical context of the built environment. Participants were less likely to cooperate in prisoner's dilemma games when paired with a person reported to be from a neighbourhood with low social quality, which O'Brien and Wilson interpreted as indicating an adaptive social response to a potentially threatening context (2011).

More recently, O'Brien and colleagues completed a meta-analysis of public health studies that have examined the association between physically disordered neighbourhoods and life-limiting health conditions (O'Brien et al., 2019). They identified three possible pathways from area-level urban disorder to negative individual-level health consequences, which are prevalent in this literature. O'Brien and colleagues characterise Pathway 1 as a direct effect route, where *cross-norm disinhibition*, which proponents claim results from individuals simply witnessing evidence of transgressive behaviour in the disorderly environment, leads not only to similar misdemeanours being perpetrated by residents and visitors alike, but other forms of risky, health endangering behaviours, too (Keizer et al., 2008; Rachele et al., 2016). Pathway 2 is characterised as an indirect effect route, where the disorderly environment leads residents to withdraw from the public realm, resulting in reduced physical exercise and the concomitant deterioration in both physical and mental health. Pathway 3, also characterised as an indirect effect route, is labelled the psycho-social pathway by O'Brien and colleagues, and it describes the process whereby the presence of disorder serves as an ever-present reminder of the threatening, and therefore stress-inducing, neighbourhood in which the resident lives. O'Brien and colleagues only found evidence supporting pathway 3, and even that came with methodological caveats and the qualification that there was no consistent evidence for disorder's impact on physical health (2019).

This psycho-social framing and finding is consistent with Jos Brosschot's Generalized Unsafety Theory of Stress (GUTS; Brosschot et al., 2018). GUTS is a recent development in the field of stress research, guided by evolutionarily informed theorising, that proposes a novel pathway from place to health, via chronic stress exposure (Brosschot et al., 2016, 2017, 2018). GUTS is predicated on the insight that the "stress response is a default response that is always 'on' but inhibited by the prefrontal cortex when safety is perceived" (Brosschot et al., 2018, p. 1).

According to Brosschot and colleagues (2018), hitherto, much of the stress literature has focused on acute exposure to stressors, usually characterised as potential threats to healthy functioning, and the resulting physiological consequences (Selye, 1976; Ursin, 1978), but has had little to say about the mechanisms of prolonged stress exposure, its determinants, and the body's physiological response.

Brosschot and colleagues (2017, 2018) assert that acute threat stressors typically cause stress reactions that are too transient to pose a harm to physical health when they occur. They argue that for a stressor to cause disease, the stress response to it must be prolonged. A protracted physiological response will eventually result in a pathogenic condition of bodily "wear and tear," also known as allostatic load, which will eventually lead to disease (McEwen, 1998; Juster et al., 2010; Prior, Manley & Jones, 2018). They argue that the fundamental challenge for stress science is to explain how protracted physiological stress-related activity occurs. They propose GUTS as a framework that addresses this challenge.

O'Brien and Wilson's community perception (2011), and much of the neighbourhood effects literature (e.g., Ross & Mirowsky, 2001; Sampson et al., 1997), when considering the consequences of disorder in the built environment, assume, following the logic of the standard stress literature criticised by Brosschot and colleagues (2018), that it is as a threat that these cues are either unconsciously or consciously perceived by residents and visitors alike. Brosschot and colleagues's reframing of the stress mechanism, from a situation where the presence of a threat/stressor triggers an acute physiological response (which somehow leads to chronic physiological dysregulation), to one where the chronic absence of unambiguous cues of safety triggers an ongoing physiological response, also reframes these cues informational value: Does disorder signal the absence of unambiguous cues of safety?

Encouragingly, given this paper's contention regarding the pathway the built environment might constitute in human health, in the paper in which they introduced the GUTS construct and mapped out their project's framework, Brosschot et al. (2018) identify the urban environment as "a territory of unknown others", and one of the domains in the category of a *compromised physical environment* (2018), which they propose functions as a cue of potential "unsafety" to a ultra-social species like ourselves.

Brosschot and colleagues (2018) speculate that, as the urban built environment is frequently the property of unknown others, meeting strangers and entering the territory of unknown others is both inevitable and likely to partially disinhibit the default stress response (a state of unsafety). Whilst not explicitly acknowledging that we are an ultra-social species, they do recognise that co-operation with, and consequently the necessity for social trust in, strangers is one of the foundations of our species' evolutionary success. Thus, in the absence of prior experience with a stranger, Brosschot and colleagues observe that humans in urban environments must rely on positive cues, such as the maintenance state of the built environment, to generate social trust and thus perceive social safety. Importantly, when an environment offers negative, limited, or ambiguous information about unknown residents, as is the situation in disorderly urban environment, this social trust, and thus a sense of social safety, cannot be generated, which, they speculate, may result in a partially maintained default stress response (a generalised state of unsafety), and hence a chronic stress exposure.

These frameworks together suggest a relationship between community perception and physical health. However, to date, the relationship between community perception and physical health has not been directly tested, nor has the construct been adopted as a guiding framework in health-related contexts previously; we think the construct is well placed, regarding the particular vector that the materiality of the residential built environment constitutes, to contribute to the project of finding a plausible process theory for the pathway between neighbourhood-level and household-level factors, and individual-level health.

Thus, the present study will integrate the constructs of community perception (O'Brien & Wilson, 2011) and GUTS (Brosschot et al., 2018) to address the following research question: How do levels of physical disorder (e.g., litter, property maintenance) in residential neighbourhoods affect residents' physical health outcomes, as indicated by the inflammation biomarker C-reactive protein? The study will control for known housing characteristics, socioeconomic factors, ethnicity, and health status to isolate the relationship between neighbourhood disorder and inflammation.

C-reactive protein (CRP), synthesized by the liver in response to inflammation, is a widely used marker of overall inflammatory response (Berger et al., 2019; Pepys & Baltz, 1983). Inflammation can be caused by infections, central-adipose tissue, tumour development, and most relevant to the present study, chronic stress activation (Black, 2002). Higher basal inflammation affects overall health and mortality. CRP is associated with atherosclerosis and coronary heart disease, playing a role in arterial plaque formation, and triggering cardiac or cerebrovascular events (Ridker, 2016). Elevated CRP levels are also linked to increased risk of certain cancers, such as lung and colorectal (Allin & Nordestgaard, 2011). Clearly, as a key indicator of inflammation, CRP provides valuable insights into various health conditions and risks. CRP has also been found to track very closely with measures of allostatic load, a composite index of multiple biomarkers, of which it is a key component (Castagné et al., 2018). Hence, we consider it a good measure for examining the hypothesised causal pathway from place to health (Prior et al., 2018).

METHODS

The UK Household Longitudinal Study (UKHLS) is an annual social survey covering about 40,000 UK households. It began in 2009, replacing the British Household Panel Survey (BHPS) and incorporating its sample in the second wave. The survey collects extensive information on individuals and households, with modules covering topics such as education, employment, money and finances, and housing situation. Biological data, including blood samples, were collected during a separate nurse visit between 2010 and 2012.

The nurse visits occurred within five months of the main survey interviews (Wave 2 sample 10,175; Wave 3 sample 3,342). Biomarker samples were collected from 90.8% of eligible participants. Of those eligible, 36.5% provided a blood sample, resulting in a final sample of 13,107 people with at least one biomarker, which determines the upper limit of our sample size. Further details regarding the nurse health assessment methodology and the collection and processing of the biomarkers are available in Benzeval et al. (2014). CRP levels above 3 mg/L are associated with chronic stress and cardiovascular disease, whilst levels above 10 mg/L are associated with the body's acute response to an infection (Benzeval et al., 2014; Pearson et al., 2003). As this study is investigating the health consequences of chronic exposures to disorder in the built environment and not acute disease, we excluded participants with CRP results above this acute category cut-off point (leaving us with a final analytical sample of n=10,783 unweighted, n=9,618 weighted). Those with CRP below the detectable limit of 0.2 mg/L were given a value of 0.1 mg/L. We then linked CRP, along with the individual-level and household-level control and predictor variables (see Measures), to the UKHLS's metadata on household-level and area-level factors regarding the built environment in which the participants reside (data collected on the Address Record Forms [ARF] by the NatCen [National Centre of Social Research] interviewers who were employed to conduct the in-person survey). The ARF was primarily designed to define non-response weights and predict response and attrition in subsequent waves. It included a few specific items about the residence and its immediate surroundings, all of which we leverage in the present study. All the observation questions were completed before interviewers made contact with the address, following UKHLS guidance that interviewers should simply record their initial observations and judgments. The present study combines these two waves of the UKHLS, treating them as a single cross-sectional sample for the purpose of this analysis. In cases where a variable required for our planned analysis was only collected at the wave prior to, or succeeding, the nurse visit, this study extrapolates across the two waves.

The necessary licence to conduct the research was granted by the UK Data Service (Project 118841).

Measures

The five items used in computing our Maintenance Index (MI) from the ARF were as follows:

- Item 1) "Does the address have an unkempt garden?" (0=*No* or 1=*Yes*);
- Item 2) "Are any of the following present or within sight or hearing of the address? Trash, litter or junk in the street/road?" (0=*No* or 1=*Yes*);
- Item 3) "Are any of the following present or within sight or hearing of the address? Boarded houses, abandoned buildings, or demolished houses?" (0=*No* or 1=*Yes*);
- Item 4) "Which of these best describes the condition of residential properties in the area?" (*Mainly good* = 1, *Mainly fair* = 2, *Mainly bad* = 3, *Mainly very bad* = 4);
- and Item 5) "How is the external condition of the address relative to other residential properties in the area?" (*Better* = 1, *About the same* = 2, *Worse* = 3).

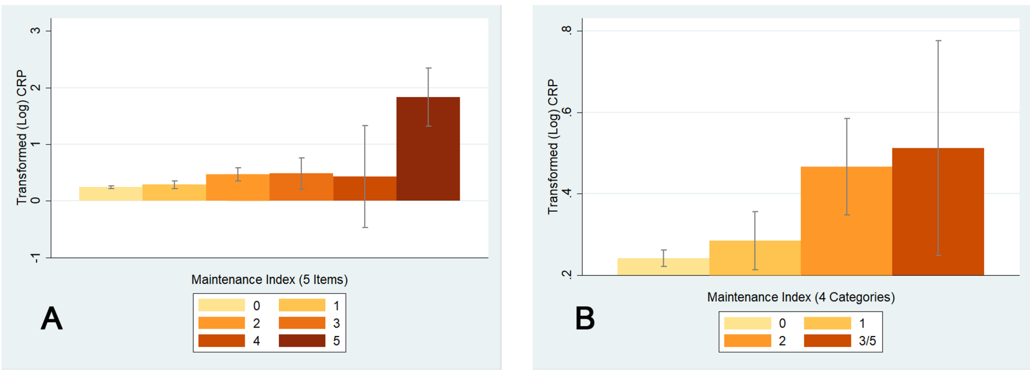
Initially, to examine the cumulative effect of exposure to poor standards of residential maintenance and physical disorder, the index was simply the sum of these five items from the ARF.

Since three of the selected variables had been coded so that 1 represented the presence of the negative characteristic, and 0 represented the alternative, with the remaining two variables coded 1-4 and 1-3 respectively, the initial iteration of the index simply dichotomized these remaining items to make a uniform scoring scale (with *mainly good/mainly fair* coded as 0 and *mainly bad/mainly very bad* coded as 1 for item 4, and *better* and *about the same* coded as 0 and *worse* coded as 1 for item 5). Thus, the MI was a measure of how many of the adverse characteristics the participant was exposed to (0-5).

One nuance to this method of computing the final score was the instance where the response to item 4 regarding the condition of residential properties in the area was coded 1 (*Mainly bad* or *Mainly very bad*), and item 5 was initially coded 2 (*About the same*) and would thus be coded 0 in the proposed scheme. In this case, as the condition of being "about the same" as properties in poor condition is clearly a negative state, a property with this combination of scores would receive an additional negative score to capture its relative condition.

Due to small cell sizes at the upper end of the scale, and overlapping confidence intervals across the range, for analytical purposes it was necessary to truncate the scale. After initial assessments of different numbers of categories determined by cell sizes (creating categories with at least 20 entries; see diagnostic graph B in Figure 1), it was decided that the scale should be dichotomised (see graph C in Figure 1).

It was not deemed substantively valid to collapse all MI categories into one; clearly, experiencing a single MI factor is more similar to not experiencing any, than to experiencing all five. On examining the diagnostic descriptive graphs (Figure 1), it was clear that the overlapping categories confidence intervals fall into two; so, we dichotomised the scale 0 and 1. Thus, a score of 0 or 1 maintenance issues results in an MI of 0 – the absence of issues regarding maintenance, and a score of 2 or more results in an MI of 1 – the presence of issues regarding maintenance (See Table 1 for descriptive statistics of the MI).



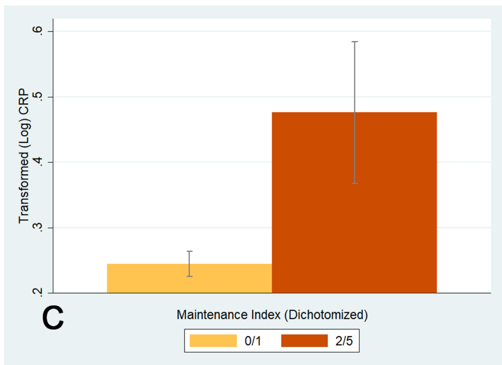


Figure 1
Descriptive Diagnostic Graphs for the Maintenance Index (MI). Maintenance Index (MI) computed from 5 metadata items recorded on the Address Record Forms by UKHLS interviewers prior to contact with household. Error bars show standard errors.

Table 1
Maintenance Index (MI) Descriptives (weighted)

	MI = 0		MI = 1	
	n	%	*n*	%
Litter				
Present	115	1.25	181	45.46
Absent	9093	98.75	218	54.54
Unkempt Garden				
Present	351	3.82	298	74.6
Absent	8856	96.18	101	25.4
Dilapidated Buildings				
Present	44	0.47	90	22.45
Absent	9164	99.53	309	77.55
Neighbourhood Built Env.				
Fair	9132	99.18	317	79.44
Poor	75	0.82	46	20.56
Relative Condition				
Better	878	9.54	17	4.16
About the Same	8156	88.57	139	34.91
Worse	174	1.89	243	60.93
n	9208	95.85	399	4.15
	Mean	SD	Mean	SD
C-reactive Protein (CRP) mgL	2.01	2.00	2.42	2.18
CRP log transformed	0.23	1.02	0.44	1.01
Age		SD (min/max)		SD (min/max)
	50.38	16.95 (20/95)	43.27	14.87 (20/94)

Note. Neighbourhood Built Env. = Neighbourhood Built Environment. N= 9,607 (weighted).

Control and Predictor variables

Clair and Hughes (2019) have found that living in the private rented sector or a home other than one that is detached is associated with higher CRP levels. We therefore include housing tenure and housing typology in the present study, along with a binary measure regarding whether the respondent would like to remain in their current home, as a block of predictor variables titled *Housing Characteristics*.

To measure socioeconomic position (SEP) we used two variables, highest educational qualification, and an indicator of income. Following the method adopted by Clair and Hughes (2019), for statistical analysis, the indicator of income was equivalised by age and divided into quartiles, where income reflected gross household income in the month before survey response, equivalised using the modified Organisation for Economic Co-operation and Development equivalence scale (OECD, n.d.), adjusted for inflation (inflation data from https://data.oecd.org/price/inflation-cpi.htm.).

Further, as the planned analysis echoed the approach adopted more generally by Clair and Hughes (2019), we also included those control variables they had selected in order to adjust for established associations with CRP; namely, age and sex (Benzeval et al., 2014); ethnicity and employment status; smoking status and BMI (categorised using standard WHO classifications, World Health Organisation, 2022); and a binary self-report indicator of longstanding illness. Descriptive statistics for these control and predictor variables appear in Table 2.

Table 2
Control Variables Descriptives (weighted)

	MI = 0		MI = 1		p-value*
	n	%	n	%	
Gender					.925
Female	5018	54.46	208	52.23	
Male	4193	45.54	191	47.77	
Employment Status					<.001
Employed	5624	61.08	216	54.15	
Unemployed	408	4.43	62	15.58	
Retired	2332	25.33	42	10.42	
Maternity/caring	561	6.1	44	10.95	
Long-term sick/disabled	282	3.06	35	8.89	
Ethnicity					<.001
White British	8097	87.93	307	77.04	
Other White	443	4.81	34	8.43	
Asian	388	4.21	36	9.05	
Other	280	3.04	22	5.48	
Highest Qualification					<.001
Degree	2225	24.16	64	16.05	
Other (higher education)	1152	12.51	46	11.74	
A-level and similar	1720	18.68	69	17.31	
GCSE and similar	1803	19.58	90	22.53	
Other qualification	1017	11.04	39	9.7	
No qualifications	1291	14.02	90	22.67	
Income Quartile (equiv.)					<.001
1	2397	26.03	214	53.55	
2	2342	25.44	88	22.14	
3	2252	24.46	52	13.09	
4	2217	24.07	45	11.22	
Long-standing illness					<.001
Yes	3245	35.24	170	42.6	
No	5963	64.76	229	57.4	
Smoking Status					<.001
Smoked or Smoker	5465	59.36	269	67.41	
Never smoked	3742	40.64	130	32.59	
BMI					<.001
18.5 to under 25	2854	31	118	29.49	
25 to below 30	3669	39.85	141	35.43	
30 to below 40	2432	26.41	120	30.14	
40 and above	253	2.75	20	4.94	
Dwelling type					<.001
Detached	2409	26.16	26	6.62	
Semidetached	3006	32.64	107	26.81	
Terrace	2580	28.02	176	44.13	
Flat	1214	13.18	89	22.44	
Tenure					<.001
Owned outright	3117	33.85	43	10.83	
Owned with mortage	3639	39.52	106	26.64	
Social rent	1331	14.46	154	38.55	
Private rent	1121	12.18	96	23.99	
Prefer to move home					<.001
Yes	3251	35.31	197	49.38	
No	5957	64.69	202	50.62	
Age	Mean	SD (min/max)	Mean	SD (min/max)	
	50.38	16.95 /20/95)	43.27	14.87 (20/94)	<.001

Note. *Student's *t*-tests for continuous variables and chi-square test for categorical; BMI = body mass index (categorised); GCSE = General Certificate of Secondary Education; equiv. = equivalised gross household income, standardised by age. *N*= 9,607 (weighted).

We excluded participants with any of the control or predictor variables missing, leaving an analytical sample of N = 9,606 (weighted; *N* = 10,775 unweighted). Weighting was applied using the combined Understanding Society (General Population Sample) and BHPS cross-sectional weights. All models apply inverse-probability weights to address differential sampling and response probabilities.

RESULTS

Within our sample the mean CRP was 2.03 (untransformed) with *SD* of 2.01, minimum 0.1 and maximum 10.0. Over a fifth of the analytical sample (22.17 percent, weighted) had raised CRP (above 3 mg/L). CRP was positively skewed and so was log transformed for the analysis.

Prior to proposing the series of hierarchical multiple regression models outlined here, an assessment of potential bias at the interviewer level was conducted. As the metadata of the ARF used to compute the maintenance index was harvested from the observations of interviewers (N = 677), it is plausible that some characteristic at this level of the data structure could introduce bias into our results (e.g., interviewer's perceptual appraisal of the built environment might be systematically biased by their developmental history). To examine if there was any significant effect of clustering at the level of the interviewer, we first ran an analysis using the interviewer ID as the absorbed categorical factor and compared it to the equivalent hierarchical multiple regression. The results were not substantively different, F (676, 10074) = 0.984, p = 0.607, ηp^2 = .062. Thus, we proceed with a single-level analysis strategy.

In model one of Table 3, we report the associations between the MI and our inflammatory marker. We introduce housing characteristics as an additional block of predictor variables, as they have been previously identified as significantly associated with the measure by Clair and Hughes (2019). We then introduce controls in blocks: demographic and socioeconomic (model 2), and health and health behaviours (model 3). Interactions between tenure, housing type, sex, and the MI were examined, but none were found to be significant (these are not reported here). All reported coefficients are unstandardized, as the complex survey data structure does not facilitate the computation of standardized results.

Table 3
Hierarchical Multiple Regression Models Predicting Log of C-reactive protein

	b SE 95% CI Model 1	*b* SE 95% CI Model 2	*b* SE 95% CI Model 3
Maintenance Index	0.157*	0.161*	0.130*
	(0.071)	(0.069)	(0.062)
	[0.018, 0.296]	[0.026, 0.296]	[0.008, 0.252]
Dwelling Type (ref: Detached)			
Semi-detached	0.105***	0.093**	0.064*
	(0.029)	(0.029)	(0.027)
	[0.048, 0.162]	[0.036, 0.15]	[0.011, 0.117]
Terrace	0.163***	0.159***	0.124***
	(0.033)	(0.034)	(0.031)
	[0.098, 0.0228]	[0.092, 0.226]	[0.063, 0.185]
Flat	0.107*	0.136**	0.149***
	(0.048)	(0.045)	(0.043)
	[0.013, 0.201]	[0.048, 0.224]	[0.065, 0.233]
Housing Tenure (ref: Owned outright)			
Owned with a mortage	-0.221***	0.028	-0.012
	(0.027)	(0.033)	(0.031)
	[-0.274, -0.168]	[-0.037, 0.093]	[-0.073, 0.049]
Social rent	0.093*	0.145**	0.057
	(0.043)	(0.046)	(0.043)
	[0.009, 0.177]	[0.055, 0.235]	[-0.027, 0.141]
Private rent	-0.123*	0.151**	0.112*
	(0.050)	(0.054)	(0.051)
	[-0.221, -0.025]	[0.045, 0.257]	[0.012, 0.212]
Prefer to stay	0.091**	0.030	0.045
	(0.028)	(0.027)	(0.025)
	[0.036, 0.146]	[-0.023, 0.083]	[-0.004, 0.094]
Demographic and SEP controls included	N	Y	Y
Health and health behaviour controls included	N	N	Y

Note. b = unstandardised regression coefficients; CI = confidence interval; N= 9,607 (weighted).
Demographic and socioeconomic position controls: Age, gender, ethnicity, employment status, highest educational qualification, and income quartile (age standardised). Health and health behaviour controls: Smoking status, body mass index (categorised), long-standing illness or disability.
*P<0.05; **P<0.01; ***P<0.001

Results of regression analysis indicate that, with housing characteristics, demographic and socioeconomic, and health and health behaviours adjusted for, participants resident in properties where the immediate built environment is in a poor state of maintenance, have significantly higher CRP than those whose households are resident in areas where maintenance is not considered an issue (B = .130, p = .035). Regarding the housing characteristics identified by Clair and Hughes (2019) as predicting levels of CRP, and therefore introduced here as an additional block of predicator variables, significantly, a substantively similar pattern of results were returned as in their original study (Table 3). This finding is evidence that the effect of maintenance on CRP is largely independent of these other household-level characteristics.

As outlined above, CRP levels are influenced by adiposity, age, and are higher in women compared with men (Benzeval et al., 2014; Khjera et al., 2009). Thus, another way to assess the importance of the MI is to compare it to one of these established predictors, all of which we use in the present study as controls (within the *Health and health behaviours* block). Both the MI (B = 0.130, p = .035) and Gender (B = 0.146, p < .001) are significantly associated with the outcome. Although Gender exhibited a marginally stronger association and higher statistical significance, the similarity in effect magnitudes underscores the comparable clinical importance of the Maintenance Index in predicting CRP levels.

DISCUSSION

This study's proxy for physical health, the inflammatory marker CRP, is significantly associated with the physical disorder (measured by the MI) of the immediate residential area participants live in, after adjusting for controls and predictors that are established individual-level and household-level factors (Benzeval et al., 2014; Clair & Hughes, 2019). This result, which is consistent with the growing series of studies examining the effect of the residential built environment on both physical and mental health from an evolutionary perspective (Brosschot et al., 2018; Corcoran et al., 2018; Kruger et al., 2011), highlights why residential maintenance should matter to public health agencies.

The present study represents the first attempt to integrate O'Brien and Wilson's work on community perception with Brosschot and colleagues GUTS construct, towards unpacking the black box of the causal pathways from the neighbourhood context to individual-level physical health; a project that is widely recognised as crucial in the neighbourhood effects literature (Glaster, 2012; Prior et al., 2018; Ribeiro, 2018; van Ham & Manley, 2012). Whilst most would agree with King George V, that the housing and health are "indissolubly connected", clearly, what is less settled is the nature of this relationship.

In Schulz and Northridge's (2004) ambitious attempt to identify the pathways through which social factors contribute to different environmental exposures and consequently health inequalities, they conceptualised the built environment as "all of the buildings, spaces, and products that are created or significantly modified by people" (p. 456). As such, the built environment is clearly an area of our lives which is both physically malleable and policy amenable, and therefore an area which, if studied, can be manipulated to improve outcomes. Furthermore, we agree with Ribeiro (2018) that, if variations in health outcomes depend on contextual factors, then "interventions toward residential, social, and physical environments become essential" (p. 1).

We propose that community perception, with a minor reframing from a construct where disorder in the built environment functions as an index of ambient threat, broadly defined, to one where disorder in the built environment functions both as a cue of threat and as an index of the availability of reliable social partners, provides a theoretical approach, once integrated with Brosschot's GUTS (2019) construct, to better understand the disease vector the disorderly built environment constitutes, and a toolkit to assist in the creation of therapeutic area-level interventions.

Inside the Black Box

As has been argued elsewhere by McAleavey (2023), Brosschot and colleagues' GUTS framework (2018) is a corollary of Coan and colleagues' (Beckes & Coan, 2011) social baseline theory (SBT). GUTS builds on SBT to recognise that the safety signalled by proximity to trustworthy conspecifics in and of itself is a critical cue, and is thus among the most salient information in the visual and auditory environment of our residential neighbourhoods. It is the absence of such unambiguous signals of safety that leads, if Brosschot and colleagues are correct, to the chronic stress exposures that are widely recognised as leading to negative health consequences across the life course (Brosschot et al., 2018; McEwen, 1998; Prior et al., 2018). To adopt a behavioural ecologist's approach suggested by this framework, the absence of the evidence of effort expended in the upkeep of a neighbourhood's built environment functions as a cue of the local bioenergetic burden residents find themselves under, and leads to the heuristic; people around here do not have the time, or the energy, to take care of even their own neck of the woods, let alone engage in prosocial behaviour with others.

Additionally, we speculate that the material evidence of such benign neglect itself, together with the ambient levels of malign denigration, may tax the already chronically stressed resident still further on account of the embodied "call to action" such a dilapidated environment presents to a territorial and ultra-social species (Taylor, 1988; Wilson, 2012).

This latter speculation is consistent with a stigmergic, or more precisely sematectonic, account of the potential impact the residential built environment, as a medium, has on humans; primed as we are to attend to the solicitations of affordances, both physical and social, in our environment (Heylighen, 2016; Rietveld & Kiverstein, 2014; Wilson, 1975, 2012).

Hence, with this minor reframing of community perception, to a construct where maintenance levels in the residential built environment functions both as a cue of threat and as an index of the availability of reliable social partners, we believe the theory has great potential utility to intervention-minded public bodies (see MacDonald et al., 2019 for experimental and quasi-experimental evidence, from the work of Michelle Kondo, Charles Branas, and their colleagues, of the potential of this approach).

Limitations

There are at least five potential limitations concerning the results of this study. Firstly, for pragmatic reasons we extrapolate a number of variables from one wave to the other on account of them only being recorded at one point – a reasonable process given the data assets available, but not one without its drawbacks. For instance, we assume a continuity of health behaviours such as smoking status across the two waves.

Secondly, although the present study leverages two waves of the UKHLS, it is a cross sectional design, and thus we only report the association between the maintenance index and CRP at a single point in time, and do not have evidence of a causal relationship. That said, given the experimental and quasi-experimental work of Kondo, Branas, and colleagues, it appears reasonable to assume that a causal relationship does exist between disorderly neighbourhoods and their residents' physical health (MacDonald et al., 2019).

Thirdly, the other factors commonly considered as contributing to the causal mechanisms of the neighbourhood effect (e.g., air pollution) are not included in our analysis (Galster, 2012) due to their absence from the UKHLS data asset.

Fourthly, CRP levels can vary significantly in the population due to multiple factors. As outlined above, age (with levels tending to increase with age), gender (women generally have higher CRP levels than men), and BMI (higher BMI is associated with higher CRP levels) are all recognised influences on basal inflammation. Given this variability, researchers often log-transform CRP values, as we did in the present study, to manage the skewed distribution in statistical analyses. We also adjusted for these factors, as well as others (smoking status and ethnicity), in all our statistical models. This variability in CRP levels underscores the importance of considering multiple factors when interpreting CRP data.

Finally, the relatively small sample size of our exposure group (n = 399, weighted) is also an artefact of the data assets available. Future work should search internationally for data assets that can address all, or some, of these shortcomings.

Conclusion

Residential maintenance matters to peoples' physical health. Different fields across the social sciences are looking to influence public policy by leveraging such findings to design interventions that promote better health outcomes in deprived neighbourhoods. Adopting a nuanced approach to community perception, one informed by generalised unsafety theory of stress (Brosschot et al., 2018; O'Brien & Wilson, 2011; O'Brien et al., 2019), we proposed a novel pathway to account for how a disordered and dilapidating built environment is associated with elevated CRP. Future work will look to further elucidate the proximate mechanisms that underlie this process, in the hope that it will lead to still more impactful evidence-based policy proposals.

DATA AVAILABILITY STATEMENT

Understanding Society data are available through the UK Data Service. Researchers who would like to use Understanding Society need to register with the UK Data Service before being allowed to apply for or download datasets.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

ETHICS APPROVAL STATEMENT

The necessary licence to conduct the research was granted by the UK Data Service (Project 118841).

TRANSPARENCY

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