

Optimizing Patient Care Pathways: Impact Analysis of an AI-Assisted Smart Referral System for Musculoskeletal Services

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Abstract—The UK’s National Health Service (NHS) confronts critical challenges in patient referrals amidst rapidly growing musculoskeletal (MSK) care demands. Current systems contribute to extended waiting times, incomplete referrals, fragmented care, and access disparities. To address this, we proposed an AI-assisted Smart Referral System (SRS) that enhances accuracy, efficiency, and equity. The SRS integrates a patient web portal, AI triage for real-time recommendations, and a digital pathway for seamless data handling. The system aims to streamline, utilizing AI for data analysis and specialist recommendations, potentially reducing waits and administrative burdens. In this study, we examined data spanning from August 2022 to July 2023, covering a period of 12 months, to assess the influence of the SRS platform on service delivery, cost-effectiveness, and time efficiency. The results showed a significant reduction in missing information, coupled with substantial time and cost savings both at the administrative and clinical levels.

Index Terms—AI, Healthcare, Musculoskeletal, Recommendation Engine

I. INTRODUCTION

The National Health Service (NHS) in the UK is facing several challenges when it comes to patient referrals [1]. One of the health conditions such as musculoskeletal (MSK) care demand is rising and significantly impacting individuals, employers, the NHS, and the economy [2]. MSK condition results in the loss of over 30 million working days annually in the UK, constituting up to 30% of GP consultations [3]. With an ageing population, the demand for MSK services is expected to rise, posing challenges, especially in socioeconomically disadvantaged areas and certain ethnic groups [4]. To manage huge demand, NHS referrals involve directing patients to specialists, which comes with several challenges. Some of the main problems include waiting times: patients may have to wait several weeks or months to see a specialist, which can lead to delays in diagnosis and treatment [5]. There are several reasons behind this unwanted delay: a) Inappropriate referrals [6]: sometimes, patients are referred to specialists who are not the best fit for their specific condition or needs, leading to further delays or ineffective treatment. b) Fragmented care [7]: Patients may be referred to multiple specialists or services,

which can lead to a lack of coordination and communication between healthcare providers, and may result in gaps in care. c) Disparities in access [8]: Patients from certain demographics or geographic areas may face barriers in accessing specialist services, resulting in inequitable healthcare outcomes. d) Administrative burden [9]: Referral processes can be time-consuming and complex, placing an administrative burden on healthcare providers and potentially delaying patient care. An AI-assisted referral system could help address some of these challenges by improving the accuracy and efficiency of referrals, ensuring that patients are referred to appropriate specialists and services, and reducing administrative burdens on healthcare providers.

Around 100 million appointments in England alone were dedicated to an MSK complaint – all of which could be freed up if patients were given the choice of a physiotherapist as their first point of contact [10]. There is a specific operational and clinical need based on data that revealed it took over three months for a patient to access treatment, mainly because a GP referral form went straight to the central processing unit and contained minimal information [2]. Exploring issues in-house, our clinicians reported a challenge that various formats of referral forms are being used to refer patients from a variety of sources, from different GP surgeries. This lack of consistency often creates backwards and forwards between the central processing unit and the person referring to get the information needed surrounding the injury, and then to determine the urgency of the triage. Due to this tedious process, each patient takes approximately 2-3 hours to triage. Because the waiting list was so long, some patients had often self-healed before the appointment but were still taking up a place in the system. Moreover, clinicians discovered that the referral forms frequently lacked comprehensive details regarding the onset of the problem or injury. As a result, they were often required to dedicate significant portions of the initial appointment to piecing together background information from the patient, even months after the incident occurred. The demand for a more streamlined system for physio services came from clinicians themselves, whose main drivers were a redefined referral pathway, an improved patient experience and increased staff efficiency. An AI-assisted referral system could help streamline this process and improve the efficiency and accuracy of referrals [11]. By analyzing patient data, such as medical records and test results, and applying machine learning algorithms, the system could identify patterns and

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make recommendations for the most appropriate specialist or service to refer the patient to. This could potentially reduce waiting times for patients, improve patient outcomes, and reduce the burden on healthcare providers. Additionally, an AI-assisted referral system could also help address disparities in healthcare access and outcomes by ensuring that patients are referred to appropriate services regardless of their location, ethnicity, or socioeconomic status. It could also provide a standardized and transparent process for making referrals, which could help improve trust and confidence in the NHS among patients and healthcare providers alike.

In addressing the aforementioned challenges, we propose an AI-assisted Smart Referral System (SRS). The SRS comprises essential components: i) a patient web portal for self-referral, ii) an AI-assisted triage application offering real-time recommendations to patients and the clinical team based on data-driven insights, and iii) a digital pathway for data collection and referral triage. The SRS system is deployed within the MSK service of Provide Community, a Community Interest Company (social enterprise) delivering healthcare services for NHS across East Anglia, Dorset and northern England. This study examines data spanning from August 2022 to July 2023, covering a period of 12 months, to assess the influence of the SRS platform on service delivery, cost-effectiveness, and time efficiency.

This paper is organized as follows: Section II presents the proposed AI-assisted Smart Referral System (SRS). Section III contains the result and impact, which includes all the experimental results and a comparison with the traditional system. Section IV contains discussions and conclusions regarding the experiment.

II. PROPOSED SYSTEM

A. Problem Statement

The high volume of referrals within the MSK service causes pressure on the existing workflow. This resulted in several challenges for healthcare organisations such as i) data inconsistency: incomplete and inconsistent data from diverse referral sources led to delayed triage times, non-standardized decision-making, and lower overall service delivery quality; ii) varied referral sources: referrals received from different resources, complicating the coordination and consolidation of information; iii) data collection challenges: care navigators are compelled to chase referrers and patients for data collection, consuming additional time and resources. iv) triage time burden: clinicians spend extensive time on triage due to the need to gather and review collated data. v) extended waiting times: patients experience prolonged waiting times for referral triage outcomes, impacting overall service efficiency.

B. Developed Solution and Analysis Methodology

We have designed and developed an AI-assisted Smart Referral System (SRS) - a digital platform to tackle the challenges mentioned in Section II-A. Fig. 1 illustrates system architecture components for the SRS platform. The key components of the digital platform consist of a web portal

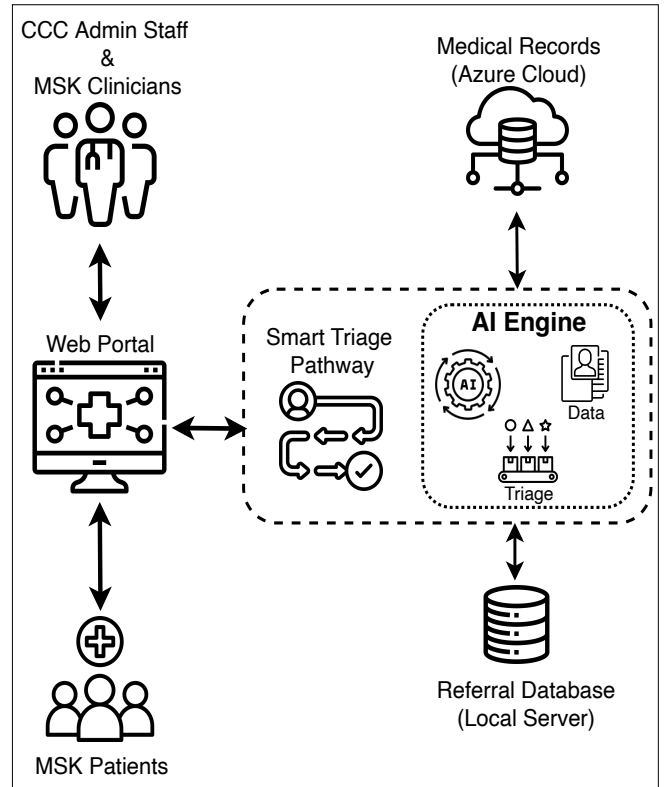


Fig. 1: System architecture diagram of the developed: AI-assisted Smart Referral System (SRS) pathway for the Musculoskeletal Services (MSK).

for patients to complete a self-referral, an AI-assisted triage application to provide real-time inputs/recommendations to the patients and clinical team by using data-driven insights from various sources of data, and a digital pathway for data collection and referral triage. The AI engine underwent training using electronic health records sourced from both the local server and medical records stored in the cloud. More precisely, we employed collaborative filtering with k-nearest Neighbors and content-based filtering algorithms [12]. This training aimed to equip the AI engine with the capability to provide recommendations to both care navigators and MSK clinicians.

The SRS digital platform has been deployed within the MSK service of a healthcare organisation delivery service for NHS England in the Mid and South Essex region. We gathered data related to service delivery, cost-effectiveness, and time efficiency covering a period of 12 months (between August 2022 to July 2023) to evaluate the impact of the SRS digital platform. During this time period, the MSK service received a total of 9149 referrals from various sources (i.e., via email, Electronic Health Records, and the SRS platform). Out of these, 2671 referrals (approx. 29% of the total) were received through the SRS platform. In further sections of the manuscript, we called these referrals: *SRS referrals* and the new AI system-driven process: *SRS pathway*. Similarly, the

rest of the referrals (i.e., 6478) are collectively called: *non-SRS referrals* and the old process: *non-SRS pathway*.

To evaluate the impact created by the SRS pathway, we focused on the time and cost savings generated and performed four steps of analysis. Firstly, we considered several key impact factors (KIFs) that are relevant to the time-saving comparison between the two pathways and among the two stakeholders (i.e., Care Navigator staff and MSK clinician staff). Secondly, we estimated the percentage(%) and actual number of referrals for each KIF. Here, we estimated the numbers by considering only the SRS referrals to show the impact generated by the current uptake of the pathway. Table I provided the list of selected KIFs for the study, the percentage(%) of referrals associated with these KIFs, and their actual numbers considering the total 2671 SRS referrals. Thirdly, we estimated the time spent (on a single referral and overall) by each stakeholder for the relevant KIFs. Lastly, we use the time spent in minutes and cost in GBP per unit [13] to estimate the overall time savings for both stakeholders against the KIFs. Furthermore, the cost savings are estimated for different uptake percentages (30%, 50%, 70%, 100%) to showcase the possible impact created in future.

III. RESULTS AND IMPACT

To assess the impact of the SRS pathway on current service delivery, we have conducted an evaluation based on the 2671 SRS referrals, reflecting the current utilization of the SRS pathway. Table II provides comprehensive data on cost and time savings for care navigator staff, encompassing three Key Impact Factors (KIF-01, KIF-02, and KIF-03). The aggregated annual time and cost savings across all three KIFs for care navigator staff amount to 24,580 minutes and £14,010.60, respectively. Additionally, Table III outlines the cost and time-saving metrics for MSK clinician staff, covering four KIFs (KIF-03, KIF-04, KIF-05, and KIF-06). The total annual time and cost savings across all four KIFs for care navigator staff are 126,681 minutes and £105,145.23, respectively.

The comparative analysis in Fig. 2 and 3 reveals distinct trends in the relationship between key variables. Fig. 2, depicting "Care Navigator Time" and "MSK Clinician Time" against "% uptake of SRS pathway". Additionally, Fig. 3 illustrates "Care Navigator Cost" and "MSK Clinician Cost" against "% uptake of SRS pathway", where we observed a clear correlation between cost and future savings for both the Care Navigator and MSK Clinician, which elucidates a different dynamic. As future savings increase, there is a corresponding upward trend in costs incurred by both entities. The plot illustrates that as future savings rise, the time invested by both the Care Navigator and MSK Clinician follows distinct trajectories. Analyzing these figures side by side provides a comprehensive understanding of how future savings impact both cost and time, offering valuable insights into the efficiency dynamics of the Care Navigator and MSK Clinician Staff processes.

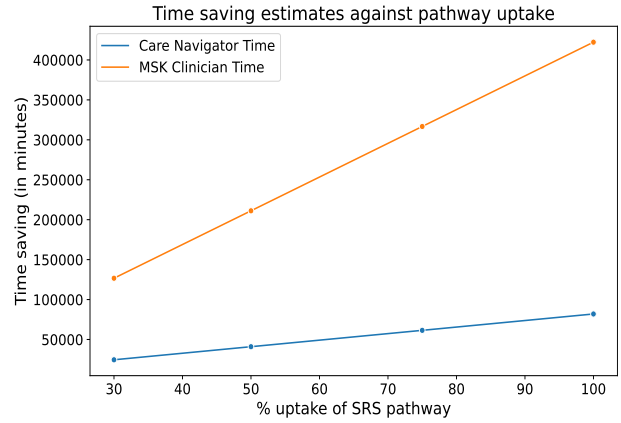


Fig. 2: Possible future time savings with 50%, 75% and 100% uptake of SRS pathway.

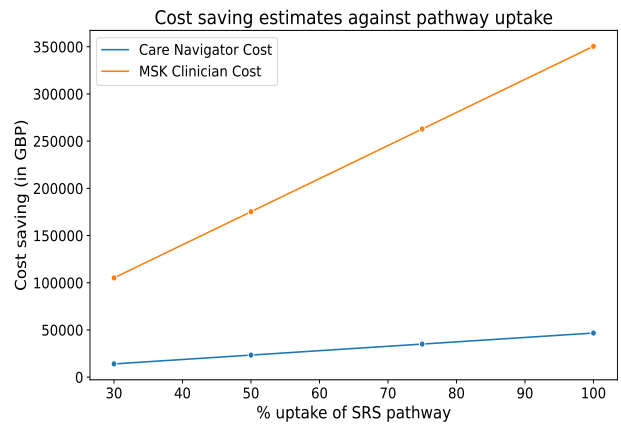


Fig. 3: Possible future cost savings in GBP with 50%, 75% and 100% uptake of SRS pathway.

IV. DISCUSSION

Current healthcare systems are under huge pressure with increasing demand and limited resources. AI-driven clinical pathways can play a huge role in supporting healthcare providers by creating value and efficiency. This study showed significantly high efficiencies can be created in terms of staff time and cost. Moreover, the new pathway also delivered several other positive impacts i.e., the Self-referral algorithm allowed patients to refer to the service directly and effectively signposted based on their condition in real-time thus reducing the need for GP appointment. This itself leads to huge savings for the NHS in terms of freeing the GP time, travel and time cost for patients to attend GP appointments, and to their over well-being and time of recovery. The data showed that the MSK-HQ score (a key determinant of health recovery outcome) [14] for SRS pathway patients increased by 18.7 points as compared to 16.9 points for non-SRS pathway patients thus delivering better health recovery outcomes.

The feedback collected from patients for the new pathway

TABLE I: Key factors selected for the impact analysis of SRS pathway

KIF ID	Key Impact Factors (KIFs)	% of referrals considered
KIF-01	Lack of Keele STaRT Questionnaire Score in non-SRS pathway	36%
KIF-02	Lack of Musculoskeletal Health Questionnaire (MSK-HQ) Score in non-SRS pathway	100%
KIF-03	Lack of any other critical information required for the triage process in non-SRS pathway	12%
KIF-04	Processing of referrals meeting exclusion criterion for service delivery	9.4%
KIF-05	Additional processing time spent by the MSK clinicians for the non-SRS referrals compared to the SRS referrals with complete information	100%
KIF-06	Additional appointment time spent by the MSK clinicians for the non-SRS pathway patients as compared to the SRS pathway patients	100%

TABLE II: Time and cost savings for Care-navigators

KIF ID	# referrals	Time saved (mins) for each referrals	Total time saved (mins)	Staff cost per min. (£)	Total Cost savings (£)
KIF-01	962	10	9620	0.57	5,483.40
KIF-02	2671	5	13,355	0.57	7,612.35
KIF-03	321	5	1,605	0.57	914.85
Total	-	-	24,580	-	14,010.60

TABLE III: Time and cost savings for MSK clinicians.

KIF ID	# referrals	Time saved (mins) for each referrals	Total time saved (mins)	Staff cost per min. (£)	Total Cost savings (£)
KIF-03	321	2	642	0.83	532.86
KIF-04	251	2	502	0.83	416.66
KIF-05	2671	2	5,342	0.83	4,433.86
KIF-06	2671	45	120,195	0.83	99,761.85
Total	-	-	126,681	-	105,145.23

serves as a testament to their contentment with the expeditious service delivery facilitated by the AI-assisted SRS platform. Notably, the system has demonstrated a significant advancement in operational efficiency, exemplified by a remarkable reduction in administrative processing time. Physiotherapists have reported substantial time savings, with a notable reduction of one patient appointment for each referral. This efficiency gain is attributed to the immediate availability of comprehensive background information during the initial patient appointment. The system's ability to provide a swift review of patient history empowers physiotherapists to conduct more expeditious assessments, contributing to an overall enhancement in the efficiency and effectiveness of patient care.

The dual perspective collected from both patient feedback and professional insights underscores the multifaceted positive impact of the implemented system. Patients experience quicker and more transparent service delivery, while healthcare professionals benefit from streamlined workflows, leading to substantial value generation. The future projections with higher uptake of the AI-driven pathway show a massive impact in terms of staff cost and time and additional benefits for all key stakeholders i.e. patients, clinicians and care-provider organisations will create a significant impact.

V. CONCLUSION

In conclusion, the SRS platform, comprising a patient web portal, an AI-assisted triage application, and a digital path-

way, proves to be instrumental in addressing key challenges identified in the MSK service referral process. The significant reduction in missing information, coupled with the potential for substantial time and cost savings, positions the SRS as a transformative solution in healthcare service delivery. As the system continues to evolve, ongoing research and continuous evaluation will play a pivotal role in refining its functionalities and ensuring its seamless integration into the broader healthcare landscape. In conclusion, the AI-assisted Smart Referral System stands as a beacon for optimized and patient-centric MSK referral pathways.

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