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# The potential impacts of a digital preoperative assessment service on appointments, travel-related carbon dioxide emissions, and user experience: a case study

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## Abstract

**Background:** The National Health Service (NHS) cannot keep up with the demand for operations and procedures. To improve efficiency and reduce wait times for operations, preoperative assessments could be conducted online. MyPreOp is a cloud-based platform where patients can complete their preoperative questionnaires. These are reviewed by a nurse, who determines if they need a subsequent face-to-face appointment.

**Objectives:** The primary objective was to describe the potential impact of MyPreOp® (Ultramed Ltd, Penryn, UK) on the number of face-to-face appointments. Secondary objectives examined time spent on preoperative assessments completed using MyPreOp in NHS Trusts and user ratings of usability and acceptability.

**Methods:** The study design is a case study service evaluation. Data was collected by the MyPreOp system from two NHS Trusts (Guy's and St Thomas' (GSTT) and Royal United Hospitals Bath RUHB)) and the private BMI Bath Clinic during the four-month period of September to December 2020. Participants were adults of any age and health status at the participating hospitals who used MyPreOp to complete a preoperative assessment before a scheduled surgery. The primary outcome was the number of face-to-face appointments avoided by patients who used MyPreOp. Secondary outcomes investigated included the length of time spent by nurses completing preoperative assessments, associated travel-related CO2 emissions compared with standard care, and quantitative user feedback. User feedback was assessed at all three sites, but the other outcomes could only be examined in the RUHB sample due to data limitations.

**Results:** Data from 2,500 participants was included. Half of the patients assessed did not need a further face-to-face appointment and required a median of only 5.3 minutes of nurses' time. The reduction in appointments was associated with a small saving of CO2e emissions (9.05 tonnes). Patient feedback was generally positive: 80% of respondents rated MyPreOp as easy or very easy to use and 85% thought the overall experience was good or very good.

**Conclusions:** This evaluation demonstrated potential benefits of MyPreOp. However, further research using rigorous scientific methodology and a larger sample of NHS Trusts and users is needed to provide strong evidence of MyPreOp's efficacy, usability, and cost-effectiveness.

## Key Points

**Question:** Can the use of a cloud-based service reduce the number of appointments and time needed to conduct preoperative assessments?

**Findings:** In a case study including data from 2,500 MyPreOp submissions, half of patients who used MyPreOp did not require a subsequent face-to-face appointment. However, this benefit was concentrated in younger and healthier patients.

**Meaning:** A cloud-based system that enables patients to complete preoperative assessments on their own has the potential to reduce the number of necessary face-to-face appointments and clinical time needed to assess them. However, further research is needed to quantify actual time and cost-benefits for clinicians.

## Introduction

### Background and rationale

The United Kingdom's National Health Service (NHS) is unable to keep up with the demand for operations and procedures; it has failed to meet its 18-week waiting time goal since 2016 [1–3]. Preoperative assessments are essential to mitigate patient risk during surgery and to support their recovery [4–7]. However, across the NHS, these assessments are predominantly administered using non-standard, paper-based questionnaires [8–10]. With over 10 million operations and procedures occurring each year [11,12], conducting these assessments to a high-standard is time-intensive. The Royal College of Anaesthetists (RCoA) recommends 30-45 minute appointments, but preoperative assessments can take up to 2 hours [6,8,13–15]. Healthcare staff often then need to manually transfer the data collected into hospital IT systems, which introduces another opportunity for error and hinders rapid screening of patients [16]. The Digital by Default report determined that preoperative assessments could be conducted remotely in 40% of cases, eliminating 1.2M appointments and saving up to £48M [17]. Therefore, reducing the need for nurses and healthcare assistants to collect patient's health records would be significantly valuable, in terms of saving both time and cost.

### Solution overview

Ultramed's MyPreOp is a cloud-based platform that empowers patients to complete preoperative assessments online, improving data quality, streamlining admission procedures, and ultimately saving time and costs [18]. Patients can complete the questionnaire in their own time and choose to share their data with their healthcare provider (retaining ownership). MyPreOp uses decision-support algorithms to determine what questions to ask depending on patients' previous responses, reducing the number of questions they have to complete, and to analyze the data to determine patients' American Society of Anesthesiologists (ASA) grade [19] and to recommend National Institute for Health and Care Excellence (NICE)-guided preoperative tests [20]. The data and analysis are currently reviewed by a registered nurse in the Clinician Portal and the patient is moved along the appropriate care pathway.

MyPreOp is hosted on Google Cloud [21] and is compliant with FHIR (Fast Health Interoperability Resources) HL7 standards of interoperability [22–24], so the preoperative assessment report can be easily incorporated into patients' electronic health records (EHR). MyPreOp automatically codes data using SNOMED Clinical Terms [25,26] and generates the ICD10 codes for comorbidities [27,28], providing a standardized clinical summary.

### Potential benefits of solution

MyPreOp has the potential to provide several key benefits for patients, clinicians, and health systems [29]. It provides patients with control over their personal health record and improves patient experience by increasing convenience, minimizing hospital visits, and decreasing the need to discuss sensitive topics. MyPreOp also includes built-in links to provide patients with easy access to accurate information about their procedure. Clinical

benefits could include reducing the time clinicians spend conducting assessments and analyzing data, allowing them to spend more time on high-value care activities.

The use of digital preoperative assessments could also have a significant economic benefit for health systems. According to RCoA requirements, conducting 12,000 preoperative assessments currently requires 7.2 whole time equivalent (wte) nurses and 3.6 wte healthcare assistants [6]. In comparison, a preoperative assessment service using MyPreOp requires about 3.7 wte nurses and 1.1 wte healthcare assistants. After including costs for MyPreOp [30], this represents a potential 38% reduction in service cost. By enabling home-completion of preoperative assessments, MyPreOp is also likely to reduce travel costs for the patient (and carers) and environmental costs from that travel.

## Aims and objectives

This study aimed to evaluate the potential for Ultramed's MyPreOp to provide clinical and economic benefits when replacing the current standard of care. Specifically, the aim was to investigate the impact of Ultramed's MyPreOp system on the time and environmental costs associated with preoperative assessments in one clinical site where it has been adopted and to examine ratings of its usability and acceptability in three clinical sites. The objectives of this case study were to:

1. Measure the time saved through the use of MyPreOp by assessing the number of face-to-face appointments avoided and the time spent by nurses completing the MyPreOp process at RUHB NHS Trust;
2. Estimate the reduction in travel and CO2 emissions due to the reduction in face-to-face appointments at RUHB NHS Trust;
3. Examine quantitative feedback about MyPreOp from users in three clinical sites (RUHB NHS Trust, GSTT NHS Trust, and BMI Bath Clinic);
4. Compare patient responses to questions about the usability of MyPreOp to a previous service evaluation.

## Methods

### Study design

This investigation used a case study design (summarized in Table 1) to perform a formative service evaluation of data collected during the use of MyPreOp at two NHS Trusts and a private hospital. A case study framework [31] was used to structure the process of the evaluation. A formative service evaluation [32] was conducted to assess how well MyPreOp is achieving its main aim of streamlining the preoperative assessment process in its early implementation [33]. This will provide preliminary evidence to inform future clinical investigations and cost analyses of the MyPreOp system. As the data used was collected and anonymized by a second party with informed consent, formal ethical approval for this evaluation was unnecessary.

Table 1. Case study framework (based on [31,34,35])

Number	Stage	Outcome
1	Plan	Description of problem, case, and research questions.
2	Design	Construction of case study design and linkage of research questions and available data.
3	Prepare	Selection of NHS Trusts with appropriate data and sufficient sample sizes.
4	Collect	Collection of MyPreOp use and patient feedback data from the MyPreOp analytics dashboards and from the MyPreOp System
5	Analyze	Descriptive analysis and validation of data.
6	Create	Drafting of case study (this paper).
7	Share	Submission of the case study for publication in a peer-reviewed journal (this paper).

## Context and Participants

This study will evaluate version 2 of MyPreOp. Versions 1 and 2 are similar from a patient perspective; however, version 2 is Fast Healthcare Interoperability Resources (FHIR)- and cloud-based and includes a clinician portal. Two NHS Trusts using version 2 were included in this study: Royal United Hospitals Bath (RUHB) [36] and Guy’s and St Thomas’ (GSTT) [37]. Data from the private BMI Bath Clinic was also included in the analysis of user feedback [38]. These hospitals were selected because they had used the MyPreOp system with the largest number of patients and had the most data available to analyze per site and because they had the specific customizations and collaborations needed to collect the relevant data. These included the system being set up to ask relevant user feedback questions, statuses within the system that facilitated user feedback, statistics about face-to-face appointments, and an understanding of how the clinical sites’ processes aligned with the statuses being entered into the system (so that the face-to-face appointment data could be verified). The other hospitals that were live with MyPreOp version 2 were excluded due to low numbers of submissions ( $n < 300$ ) and/or a high degree of customization meaning the relevant data could not be collected. The majority of the analysis is conducted on data from RUHB, because they have been using MyPreOp version 2 for a longer period of time than the other sites, and therefore have the largest body of service data.

All available patient submissions on MyPreOp during the study period were included in the analysis, regardless of age, health status, or type of surgery, so that the analysis would reflect typical patient use. However, the number of submissions included for each specific analysis varied depending on certain factors, such as whether the nurse had marked the submission as complete or whether the patient had answered a specific question.

## Data collection

Anonymized operational data was collected from and processed by the MyPreOp system at each of the clinical sites for a four-month period covering 1 September 2020 to 31 December 2020. One of the authors (JL) created datasets from the raw JSON data using BigQuery SQL and manually examined a small subset of data to check that it was being processed correctly.

Raw data is automatically collected and compiled by the MyPreOp system. Clinicians use their MyPreOp portal to set patients' status as they move through the process (e.g. as requiring a face-to-face appointment with a nurse or anesthetist). The number of face-to-face appointments avoided was assumed to be the number of patients who progressed through the entire process without having their status set to requiring a face-to-face appointment. The system also tracks the length of time from the start of nurses' processing of a patient on MyPreOp to the assessment being uploaded into the patient's record.

The amount of carbon emissions saved by using MyPreOp was calculated from patient-reported data about their distance from the hospital (in miles) and which mode of transit they usually use to travel to the hospital (car, motorcycle, bus, train, bicycle, or walking), although this data was only available for RUHB as the other sites chose to ask their patients different questions. Patients who did not need face-to-face appointments were assumed to have avoided one return trip to the hospital. The website carbonfootprint.org was used to calculate the approximate carbon dioxide equivalent (CO<sub>2</sub>e) of the travel avoided by using MyPreOp [39].

User feedback data was collected from patient feedback questions presented at the end of the MyPreOp questionnaire and stored in the MyPreOp system.

## Data analysis

A descriptive analysis was conducted by one of the authors (JL) to summarize the data collected. The same author created visualizations of the data in datastudio. No statistical analyses were conducted, due to the limitations of the study design and data collected. The service evaluation at RUHB identified the percentage of patients who were not listed as requiring face-to-face follow-up appointments, the mean and median of nurse time spent on assessments, and an estimate of CO<sub>2</sub> emissions avoided by reducing the number of patients seen for face-to-face appointments. Usability data collected from the three clinical sites examined in this study were summarized and compared with a previous service evaluation of MyPreOp in different NHS Trusts [40].

## Results

During the four-month period of data collection (1 September 2020 until 31 December 2020), there were 1,777 MyPreOp submissions from patients at RUHB, 406 from GSTT, and 317 from BMI Bath, for a total of 2,500 submissions. The total number of patients assessed for each outcome measure is reported for the individual analyses as it does not always equal the total number of submissions. This is because patients were not required to

answer all questions and not all submissions had progressed through the whole system to completion at the time of data collection.

### Face-to-face appointments avoided

Of the patients who used the MyPreOp assessment at the RUHB during the four-month period, half (813/1630) did not require any further face-to-face follow-up. The total sample for this analysis includes patients who completed the assessment and those who have been flagged on the system as requiring a face-to-face assessment but had not yet had the appointment. It excludes patients whose preoperative assessments had not yet been processed. The number of patients requiring face-to-face appointments varied by age and ASA grade (Figure 1). Totals differ slightly because a small minority of patients who did not have their age and/or ASA grade correctly entered into the system were excluded from the analysis. There was a greater number of patients under the age of 60 who did not require a face-to-face appointment ( $n = 663$ ) than those who did ( $n = 388$ ), although this was more pronounced at younger ages. A similar trend was observed for ASA grade, with more patients with lower ASA grades (1 and 2) avoiding face-to-face appointments than those with higher grades. Data on face-to-face appointments avoided for GSTT and BMI Bath could not be included in this analysis because the process of nurses flagging the patients who required a face-to-face assessment on the system could not be fully validated throughout the entire trial period, unlike with RUHB.

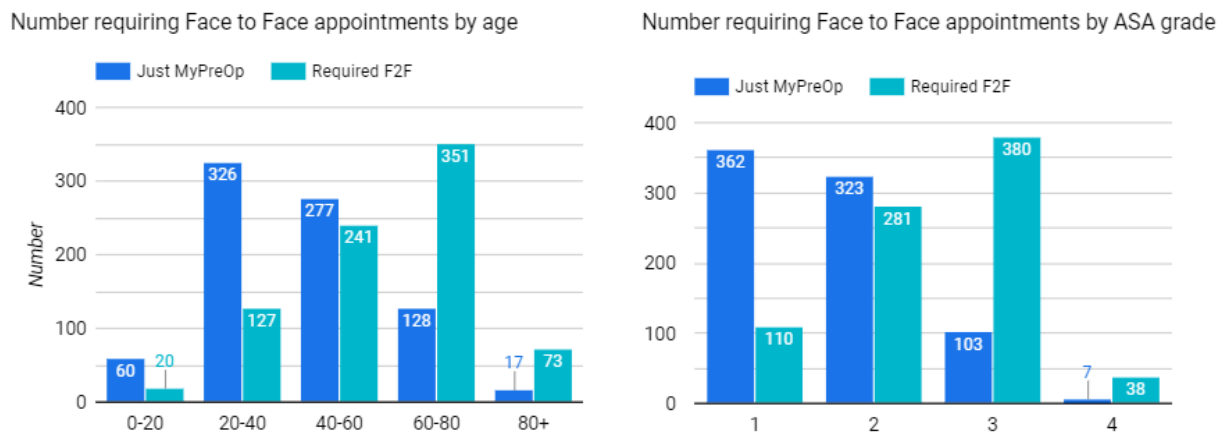


Figure 1. Proportions of patients needing face-to-face appointments by age and ASA grade (data from RUHB).

### Nursing time spent completing MyPreOp

The median amount of time that nurses at RUHB spent completing MyPreOp assessments for patients who did not require a face-to-face appointment was 5.3 minutes (Figure 2). This is significantly shorter than the mean time (49.9 minutes), because the distribution of the data is skewed heavily to the right. The time from start to completion was longer than an hour for 11% of patients (94/860). However, as time spent on the assessment is measured by the difference between when it began and when it was marked as complete, the cause of these delays cannot be accounted for in this analysis.



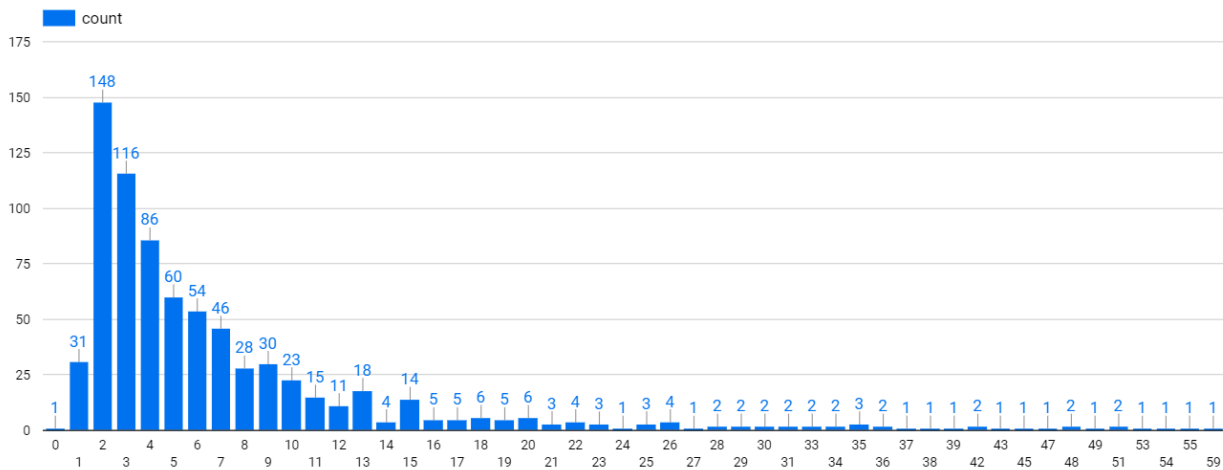


Figure 2. Time from the nurse start of assessment to completion of assessment for patients who do not need a face-to-face appointment (data from RUHB). Note: 11% of the data points have been excluded as they were longer than an hour.

### CO2 reduction

The vast majority of RUHB patients (90%, 1583/1757) used a car as their usual mode of transit to the hospital. Half of the respondents (50%, 771/1541) lived between 5 to 15 miles away from the hospital, about a third (34%, 517/1541) lived further than 15 miles away from the hospital, and the remaining 16% (253/1541) lived within 5 miles of the hospital. The information about patients’ usual mode of transit was combined with their distance from the hospital (Table 2) and the data about the number of appointments avoided to estimate potential carbon savings. Over the four-month period, the reduction in face-to-face appointments at RUHB is estimated to have resulted in a total carbon savings of 9.05 tonnes of CO<sub>2</sub>e.

Table 2. Distance that patients need to travel to get to RUHB hospitals stratified by mode of transit

Mode of Transport	Distance from Hospital (miles)			Total
	(0-5)	(5-15)	(15+)	
Car	177	732	493	1402
Bus	17	27	12	56
Train	1	4	11	16
Motorcycle	1	1	0	2
Bicycle	5	3	0	8
Walk	52	4	1	57
<b>Total</b>	<b>253</b>	<b>771</b>	<b>517</b>	<b>1541</b>

## User Feedback

User feedback was examined using data from both NHS Trusts (RUHB and GSTT) and the private BMI Bath Clinic. Across the three sites, 88% (2,195/2,496) of patients reported completing MyPreOp on their own. Of the patients who reported having assistance completing MyPreOp, only 4% (10/266) were helped by a member of staff; the remaining patients were assisted by relatives, friends or neighbours, or parents or guardians. To facilitate evaluation and improvement of MyPreOp, patients are also asked if they consent to having their anonymized data used for research. Of those who responded (from GSTT, RUHB, and BMI Bath), 82% (1741/2126) said that they were happy for their anonymized data to be used.

As the clinical sites did not all use the same user feedback questions, the remaining analyses were conducted separately for each site dataset. BMI Bath assessed the length of time patients required to complete MyPreOp.. Nearly half the patients completed MyPreOp in 30 minutes or less (44%, 131/301), and less than a quarter of patients needed longer than 45 minutes (22%, 65/301).

At GSTT, a total of 403 patients completed MyPreOp assessments over the four-month period. Most of these patients responded to the patient feedback questions provided at the end of the MyPreOp questionnaire; however, they were not mandatory, so the number of respondents varies per question. MyPreOp was generally rated highly on user feedback: 80% (317/397) rated MyPreOp as easy or very easy to use, and 85% (340/399) thought the overall experience was good or very good (Figure 3). At RUHB, patients were asked if they had any concerns with MyPreOp; 88% (1548/1757) reported having none.

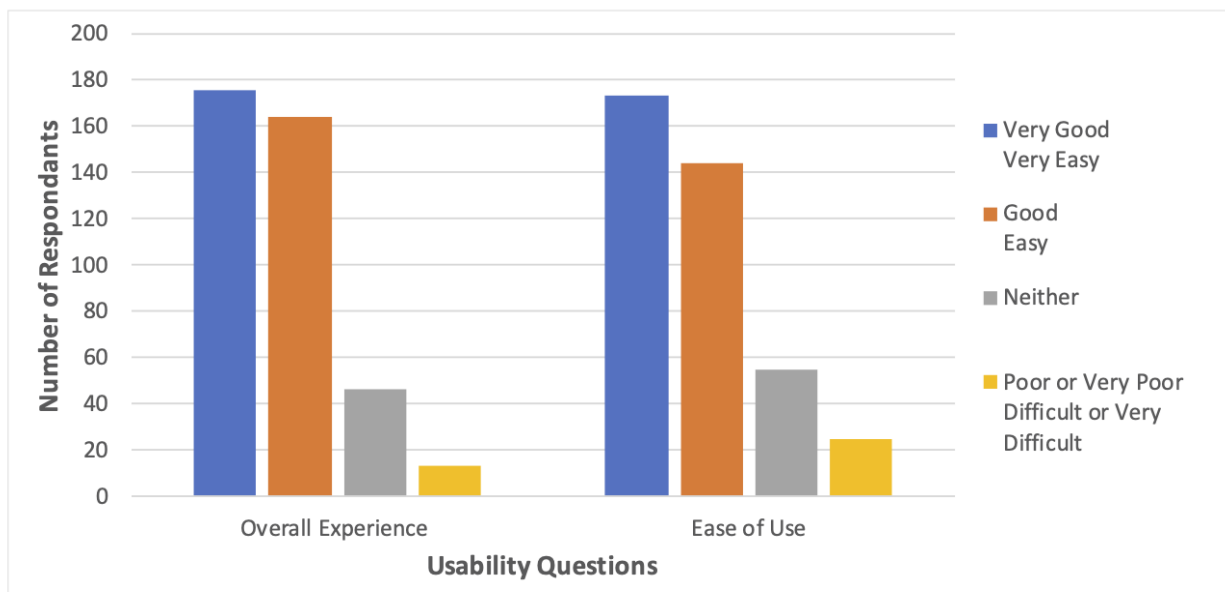


Figure 3. Guy's and St Thomas' NHS Trust patient responses to MyPreOp user feedback questions

Users at GSTT were also asked for feedback on the additional supporting information provided by the system. 83% (320/386) of patients thought that the information about what to expect next in their perioperative pathway after completion of MyPreOp was somewhat or

very easy to understand and 81% (312/387) of patients rated the additional health information provided as quite or very useful.

## Discussion

### Principal findings

The data from the RUHB NHS Trust demonstrated that half of the patients who used the MyPreOp service for their preoperative assessment did not require a face-to-face appointment. This is higher than the Digital by Default's 2012 estimate that 40% of secondary care preoperative appointments could be avoided by using remote screening [17], but will need to be confirmed in larger, more diverse samples. The reduction in appointments was most prominent in users who were younger and healthier (as indicated by a low ASA score). Therefore, the impact of the service could be limited, as younger and healthier patients might be more likely to have more straightforward and rapid preoperative assessments.

A reduction in preoperative assessment appointments has the potential to save nurses' time. The RCoA recommends that preoperative assessments be scheduled to last 30 minutes (for day patients) to 45 minutes (for inpatients) [6]. According to the time logs from the MyPreOp data, nurses at RUHB spent a median of about 5 minutes on patients who did not need a face-to-face appointment. During the period of data collection, half (813) of the 1,630 patients at RUHB avoided an appointment. If the time spent on an average patient is 33 minutes (the RCoA assumes a ratio of 80% day patients and 20% inpatients [6]), and the median time spent on patients who avoided an appointment is 5 minutes, an estimate of the average time saved for each of those 813 patients is 28 minutes. In this sample, that would represent approximately 379 hours saved. While this estimation is based on a relatively small sample, it illustrates MyPreOp's potential to reduce the time nurses spend on preoperative assessments. However, over half of users reported needing at least 30 minutes to complete their assessment, so potential time savings for patients appears to be more limited. These findings should be further examined in a clinical trial to establish further evidence of the impact of MyPreOp on time spent on preoperative assessments.

A reduction in face-to-face appointments also has the potential to reduce travel, which could save time for patients and contribute to reducing carbon emissions. The amount of carbon savings identified in this study (9.05 tonnes) is small compared to the UK's net CO<sub>2</sub> emission (351.5 million tonnes in 2019) [41]. However, transport is the biggest contributor to UK CO<sub>2</sub> emissions (34% in 2019) [41,42], with road transport (particularly passenger cars) accounting for the largest proportion of emissions in that sector [43,44]. Therefore, reducing car use is one of several key strategies to reducing transport-related carbon emissions [45,46]. Although any preoperative assessment-related travel reductions associated with remote preoperative assessments will not be a large proportion of road transport, it is aligned with the NHS's Net Zero Carbon goal [47].

Overall, the majority of patients at GSTT rated MyPreOp fairly positively on the user feedback questions. These results are similar to a previous service evaluation of MyPreOp

version 1 (unpublished data), which found high ratings of overall experience (82% (974/1193) rated it as good or excellent) and ease of use (94% (1119/1193) thought it was very easy or easy enough to use) [40]. The data assessed from GSTT in this service evaluation found a slightly lower rating for ease of use (80% (317/397) rated MyPreOp as easy or very easy to use). The wording of the usability questions varied slightly between the two evaluations (very easy or 'easy' in this assessment, compared to very easy or 'easy enough' in the previous one), which could have affected ratings. However, the variation seems to come from fewer people rating MyPreOp as 'very easy' in this assessment (44%) compared to the previous one (58%); ratings for 'easy' (36%) and 'easy enough' (35%) were similar. It is possible that sample demographics influenced the ratings, and research in larger and more diverse samples will be necessary to explore potential demographic differences in acceptability and usability further, to evaluate any potential impact of MyPreOp on health inequalities.

### Limitations of the study

A major limitation on the interpretability of the study is that it was a service evaluation without a rigorous, pre-established methodology or statistical analysis. It cannot provide strong evidence of any positive or negative impacts of MyPreOp on the outcomes examined and only demonstrates the feasibility of the solution and its potential impacts. A controlled clinical trial is necessary to provide evidence of the efficacy of MyPreOp at reducing the time, economic, and environmental costs of preoperative assessments.

The data was provided to the academic team in a processed form, due to difficulties and concerns about accessing the Ultramed system. One author (JL) used SQL queries to extract JSON data into tables. This introduces a potential for bias, and conflict of interest, as the quality of the data depends on the accuracy of those queries, which were not validated by a second author.

The measure of face-to-face appointments avoided is limited because it uses the patient statuses set by nurses in MyPreOp as an indicator of whether the patient had a face-to-face appointment. There was no external validation of the accuracy of these statuses and whether or not the patient actually avoided a face-to-face appointment.

Another limitation is that the data was only available for individual NHS Trusts for most of the outcomes measured. A compilation of data from each of the Trusts would have provided larger samples from more diverse populations. For example, many of the patient feedback questions included at the end of MyPreOp questionnaires vary depending on the Trust and could not be collated. This raises another limitation: the user feedback questions displayed at the end of MyPreOp were selected by the individual Trusts and based on what they perceived to be most useful to them, not a usability theory or framework. The lack of theoretical framework and validated measure, as well as the difference in wording between trusts, introduces potential bias in the evaluation of usability and acceptability.

### Future directions

Further research is needed to examine the cost- and time-benefits of MyPreOp on a larger scale. This should be conducted as a proper academic study and include a full health

economic assessment (including environmental costs), instead of a service evaluation, as a pre-established methodology will increase the credibility of the results. A comparison of the time and costs of using MyPreOp compared to current standards of care would also provide a more compelling argument for the use of digital preoperative assessment services in general, and MyPreOp in particular [48,49].

More research into patient usability would also be beneficial [50]. Future studies should include a theory-based qualitative examination of patient feedback about the acceptability and usability. This will likely be particularly important for older users, as there is an increasing number of older adults undergoing surgery [51] and there tends to be greater digital exclusion of older people [52,53]. Evaluating the usability of digital health solutions in older adults - and other groups who might struggle to access digital services - is important to ensure that MyPreOp and other digital solutions do not worsen existing health inequalities.

## Conclusion

The aim of this evaluation was to describe the data being collected by MyPreOp and to provide an assessment of the potential benefits of its implementation. From the data included in this study, a reduction of the number of face-to-face appointments was observed, but this appeared to vary depending on age and ASA grade. A potential reduction in time spent on preoperative assessments that did not require a face-to-face appointment was observed for nurses, but not for patients. The reduction of face-to-face appointments was demonstrated to have a potential impact on travel-related CO<sub>2</sub>e emissions. The study also found generally positive ratings of MyPreOp. However, the quantity and quality of the evidence, as well as the methodology of this service evaluation, are not sufficient to provide strong support for the efficacy and usability of MyPreOp. Further studies should be conducted using rigorous scientific methods and including more clinical sites to evaluate a greater range of outcomes, including cost-effectiveness compared to the current standard of care and qualitative user feedback.

## Author Contributions

MMI drafted the case study in collaboration with JL, who provided the processed data and feedback on the analyses. JL and IM revised the paper, with final revisions from AC and EM.

## Acknowledgments

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## Funding

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## Conflicts of Interest

JL is an employee of Ultramed LTD. This author was responsible for retrieving the raw data from the Ultramed system and processing it using BigQuery (SQL) and datastudio to produce the analyzed data and graphs. JL was also involved in the drafting and revision of the case study.

EM is the Editor-in-Chief of JMIRx Med.

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## Appendices

### Appendix 1. Standards for Reporting Qualitative Research (SRQR) Checklist [54]

<b>Title and abstract</b>		<b>Page no(s).</b>
	Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Title page
	Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	1
<b>Introduction</b>		
	Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	2
	Purpose or research question - Purpose of the study and specific objectives or questions	3
<b>Methods</b>		
	Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale <sup>a</sup>	3-4 (Table 1)
	Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	4, 11
	Context - Setting/site and salient contextual factors; rationale <sup>a</sup>	4

	Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale <sup>a</sup>	4
	Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	3
	Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale <sup>a</sup>	4-5
	Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	2, 4-5
	Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	5
	Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	4
	Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale <sup>a</sup>	5
	Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale <sup>a</sup>	4
<b>Results/findings</b>		
	Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	5-8

	Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	5-8
<b>Discussion</b>		
	Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	8-9
	Limitations - Trustworthiness and limitations of findings	9-10
	Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	11
	Funding - Sources of funding and other support; role of funders in data collection, interpretation, and reporting	11

<sup>a</sup>The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together [54].