


# Codesign of health technology interventions to support best-practice perioperative care and surgical waitlist management

Sarah Joy Aitken <sup>1,2</sup>, Sophie James,<sup>3,4</sup> Amy Lawrence,<sup>5</sup> Anthony Glover,<sup>3,6</sup> Henry Pleass,<sup>3,7</sup> Janani Thillianadesan,<sup>3,8</sup> Sue Monaro,<sup>9,10</sup> Kerry Hitos,<sup>3,11</sup> Vasi Naganathan,<sup>3,10</sup> SHP Perioperative CAG collaborators

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For numbered affiliations see end of article.

## Correspondence to

Professor Sarah Joy Aitken;  
sarah.aitken@sydney.edu.au

## ABSTRACT

**Objectives** This project aimed to determine where health technology can support best-practice perioperative care for patients waiting for surgery.

**Methods** An exploratory codesign process used personas and journey mapping in three interprofessional workshops to identify key challenges in perioperative care across four health districts in Sydney, Australia. Through participatory methodology, the research inquiry directly involved perioperative clinicians. In three facilitated workshops, clinician and patient participants codesigned potential digital interventions to support perioperative pathways. Workshop output was coded and thematically analysed, using design principles.

**Results** Codesign workshops, involving 51 participants, were conducted October to November 2022. Participants designed seven patient personas, with consumer representatives confirming acceptability and diversity. Interprofessional team members and consumers mapped key clinical moments, feelings and barriers for each persona during a hypothetical perioperative journey. Six key themes were identified: 'preventative care', 'personalised care', 'integrated communication', 'shared decision-making', 'care transitions' and 'partnership'. Twenty potential solutions were proposed, with top priorities a digital dashboard and virtual care coordination.

**Discussion** Our findings emphasise the importance of interprofessional collaboration, patient and family engagement and supporting health technology infrastructure. Through user-based codesign, participants identified potential opportunities where health technology could improve system efficiencies and enhance care quality for patients waiting for surgical procedures. The codesign approach embedded users in the development of locally-driven, contextually oriented policies to address current perioperative service challenges, such as prolonged waiting times and care fragmentation.

**Conclusion** Health technology innovation provides opportunities to improve perioperative care and integrate clinical information. Future research will prototype priority solutions for further implementation and evaluation.

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Significant progress has been made in redesigning perioperative services, emphasising the importance of early risk assessment, improved communication and multidisciplinary care. However, it is unknown how health technology can effectively support surgical waitlist management and optimal models of perioperative care.

## WHAT THIS STUDY ADDS

⇒ This study identified perioperative system challenges and potential opportunities where the user-based design of health technology can support the implementation of person-centric perioperative care pathways.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study provides a user-based foundation for future prototyping and innovation of digital tools and interfaces for perioperative care, supporting the need for integrated health technology solutions that address both clinical and administrative requirements.

## INTRODUCTION

Perioperative surgical services are facing a global crisis characterised by long waiting lists, high rates of low-value surgery and increased health system costs.<sup>1</sup> Surgical services, already stretched servicing an ageing population with finite resources, were further strained by the COVID-19 pandemic.<sup>2-3</sup> The demand for surgery, coupled with resource and bed capacity limitations, has led to extensive waiting times for patients requiring surgical interventions.<sup>4</sup> Prolonged surgical waiting times are associated with serious complications, poor quality of life and higher risk of death, representing an important performance indicator for the quality of surgical services.<sup>5-7</sup> Operating theatres represent one of the most costly healthcare

commodities,<sup>8 9</sup> and efficient use requires avoiding futile or low-value procedures and unplanned cancellations.<sup>10–12</sup> These resource limitations and service challenges underscore the urgent need for innovative strategies to transform perioperative surgical services towards a more efficient, patient-centred and proactive models of care.<sup>6 13</sup>

Considerable progress has been made to define perioperative care as ‘the multidisciplinary, individualised, integrated care of patients’ from initial consideration of surgery to completing postoperative recovery.<sup>14</sup> New models of perioperative care, such as geriatric co-management,<sup>15</sup> Enhanced Recovery After Surgery<sup>16</sup> and prehabilitation,<sup>17</sup> are promising approaches to optimise patient outcomes. However, an ongoing unmet need is how healthcare systems can effectively identify patients on surgical waitlists who would benefit most from enhanced perioperative care models.<sup>18</sup>

Health technology solutions (such as electronic medical records, telehealth, digital applications and wearable technologies) are currently used by health services to improve perioperative patient safety, enhance data collection and monitoring, streamline management and share information between multiple care providers.<sup>19–21</sup> Health technology has the potential to improve how clinicians evaluate, communicate and plan the care of patients in the period between the initial decision for surgery and admission to the hospital. We, therefore, conducted a participatory research project to determine where health technology can support perioperative care for patients prior to hospital admission for surgery.

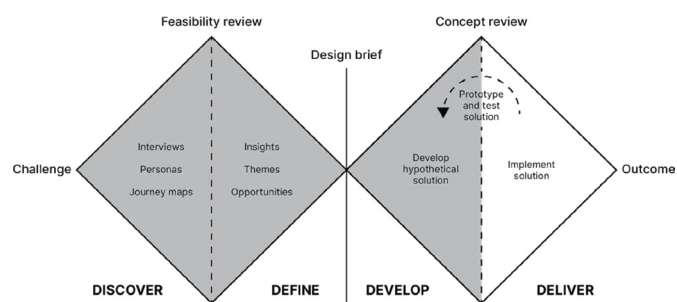
## METHODS

### Setting

Australia has universal government-funded healthcare in public hospitals, managed through local health districts (LHDs). The COVID-19 pandemic has exacerbated the challenge of providing timely surgery with finite resources, leading to increased waiting times for surgical procedures in Australian public hospitals.<sup>22</sup> This project was conducted in New South Wales, Australia, where median elective public surgical wait-times increased 28% between 2019–2020 and 2021–2022.<sup>23</sup> Funding and health policy can vary between LHDs, according to measures of clinical activity and nationally mandated priorities. Different electronic medical record platforms and systems hinder record integration between LHDs.<sup>24</sup> Participating LHDs were actively exploring strategies to enhance the efficiency and effectiveness of perioperative assessment and improve patient flow. This research is conducted by Sydney Health Partners Perioperative and Surgery Clinical Academic Group (CAG), a translational research centre including interprofessional members from four Sydney LHDs, funded by the National Health and Medical Research Council.<sup>25</sup>

### Study design

This participatory research project used codesign to gain a deeper understanding of how clinicians deliver perioperative



**Figure 1** ‘The double diamond of design’\*: applied methodology for the codesign processes \*modified from UK Design Council.<sup>16</sup>

care and identify gaps, inefficiencies and opportunities for improvement in healthcare systems.<sup>26–28</sup> Participatory research uses a process of systematic inquiry in collaboration with the people or ‘users’ who are most impacted by the issue being studied.<sup>28</sup> In this study, the users are the perioperative clinicians who, along with patients, are using the existing or future health technology interventions. The codesign steps in figure 1 are modified from the ‘Double Diamond’ design process of the UK Design Council.<sup>29</sup> In the first Discover phase, participants begin with an open, divergent approach to identify a set of opportunities and service gaps. These insights help support and guide the Define process, refining ideas into a nuanced ‘design brief’ that consolidates initial ideas into robust concepts for generating potential technology solutions in the Develop phase. In this paper, we describe the implementation and findings of the Discover, Define and Develop phases. The final Deliver stage, where proposed priority solutions are prototyped, delivered and implemented into practice, is planned for future research.

The codesign workshops were conducted over a 3-month period between October and December 2022. The need for change and project scope was established through one-on-one interviews with key members of the research team and senior perioperative clinician stakeholders. Three rounds of participatory codesign workshops involving interprofessional clinicians were conducted that aimed to identify current system needs and key opportunities for change, focusing the design direction toward potential technology solutions to support perioperative service delivery.

We employed personas (workshops 1 and 2) and journey maps (workshop 3) as interactive tools to take participants through a process of contextual inquiry and solution ideation. Personas are research-based characters that participants create to represent the diversity of different patient profiles and allow stakeholders to empathise with user needs, concerns and preferences throughout the perioperative journey.<sup>30 31</sup> Coupled with personas, journey maps provided a visual representation of user experiences, highlighting the various touchpoints and interactions with the healthcare system. From these workshops, hypothetical solutions were generated for future prototyping and testing.

## Participants

For the purpose of this research, users were defined as the clinicians and healthcare staff who frequently use the clinical systems supporting perioperative assessment pathways (including resident doctors, anaesthetists, intensive care specialists, internal medicine specialists, surgeons, nurses and allied health clinicians) and healthcare managers.<sup>28</sup>

Participants were recruited via an email invitation extended to perioperative CAG members, and clinicians in perioperative and surgical services at participating LHDs. Purposeful sampling was used to ensure a broad representation of relevant stakeholders. Consumer representatives were directly approached and invited to attend as co-creators, to provide their perspectives on patient experiences and relevance.

All 51 participants provided informed consent. Clinician participants volunteered their time; however, consumer representatives were remunerated according to guidelines from Health Consumers NSW.<sup>32</sup> The workshops were facilitated by an external, paid codesign consultant (RD).

## Data collection

All clinician participants completed an electronic pre-workshop questionnaire on their current perioperative practices and methods of risk assessment, with de-identified results collated to guide the workshop discussions. Pre-workshop contextual inquiry also involved interviewing key CAG representatives. Field notes from pre-workshop interviews and questionnaires were collated to inform the scope for the subsequent codesign activities.

Three participatory codesign workshops were conducted—two via video conferencing and one face-to-face. Data collected included pre-workshop surveys, field notes on discussion points and workshop documents (persona templates, participant notes, journey map posters, mind-maps and other output from interactive activities). Workshop outputs were photographed for data analysis and record retention.

## Data analysis

The principal investigator (SJA) and codesign consultant (RD) independently and systematically coded the output from the codesign workshops using an iterative constant comparative method. The preliminary report was provided to the full research team and workshop participants for comments and validation. Themes were then collated and revised, guided by the principles of human-centred design.

## Reflexivity statement

The researchers involved in the project have different perspectives and lived experiences, as both clinicians and consumers within the healthcare system. The research group has a range of career stages, and clinical and academic specialties, many with concurrent clinical, governance and administrative roles. The principal investigator (SJA) is a

**Table 1** Distribution of primary professional roles of participants in the codesign workshops

	Virtual workshops 1 and 2 'Persona Development'	Face-to-face workshop 3 'Journey-mapping'	
	Total, n=22		Total, n=29
Surgeon	5	Surgeon	3
Anaesthetist	4	Anaesthetist	4
Physician (geriatric medicine)	2	Physician (geriatric medicine)	1
Emergency medicine	1	Nursing	6
Nursing	3	Primary care physician	1
Primary care physician	2	Allied health	2
Resident doctor	4	Administrator	2
Consumer	1	Intensive care specialist	3
		Resident doctor	3
		Consumers	3
		Other	1

vascular surgeon interested in patient-focused healthcare systems, with personal experiences of disability and surgery. The consumer representatives involved in the project, and many of the clinician participants, were encouraged to ask questions about each other and share their own lived experiences of surgery or as carers for people having surgery with differing degrees of health sector engagement. These experiences helped develop collective knowledge and insights that shaped and guided the codesign discussions for subsequent analysis.


## Ethics approval

Approval was obtained from the Sydney Local Health District Concord Human Research Ethics Committee and informed consent was obtained from all participants (HREC 2022/ETH01436).

## RESULTS

Across the three workshops, 51 clinicians from multiple professions and three consumer representatives participated in the codesign process (table 1). After the initial contextual inquiry, the project scope was limited to where health technology can support perioperative care occurring between the initial decision for surgery and admission to the hospital. Improving clinical decisions and practices within this time frame were considered the most important to providing high-quality care to patients waiting for surgery.

Workshop 1 and 2 participants worked as a group to iteratively develop seven patient-modelled user personas across a range of perioperative risk profiles.<sup>27</sup> Persona descriptions were sufficiently detailed to adequately support clinical decision-making, including personal characteristics (name,

 <b>GINA</b>	<b>Age:</b> 59 <b>Sex at Birth:</b> Female <b>Gender identity:</b> Female <b>Suburb:</b> Canterbury <b>Family Status:</b> Divorced, no kids <b>Living Status:</b> Alone <b>Language spoken:</b> English, Italian <b>Employment:</b> Fulltime <b>Role:</b> Teacher	<b>BIOPHYSICAL</b> BMI: 30 BP: 124/80 Pulse: 72 Respiratory: 12	<b>PATHOLOGY</b> HbA1c 6.0 eGFR >90	<b>MEDICATIONS</b> Meloxicam Jardimet (empagliflozin/metformin hydrochloride) Amitriptyline Prn codeine/paracetamol							
	<b>MEDICAL HISTORY</b> <table border="1"> <tr> <td> None CARDIAC</td> <td> None CEREBROVASCULAR</td> </tr> <tr> <td> None RESPIRATORY</td> <td> None CANCER</td> </tr> <tr> <td> Type 2 DM. DIABETES</td> <td> None MENTAL HEALTH</td> </tr> <tr> <td> None RENAL</td> <td> Chronic Back Pain Recent COVID-19 OTHER</td> </tr> </table>		None CARDIAC	None CEREBROVASCULAR	None RESPIRATORY	None CANCER	Type 2 DM. DIABETES	None MENTAL HEALTH	None RENAL	Chronic Back Pain Recent COVID-19 OTHER	<b>NUTRITION</b> No issues
None CARDIAC	None CEREBROVASCULAR										
None RESPIRATORY	None CANCER										
Type 2 DM. DIABETES	None MENTAL HEALTH										
None RENAL	Chronic Back Pain Recent COVID-19 OTHER										
<b>SURGICAL HISTORY</b> PRIOR SURGERY? YES      ANAESTHETIC ISSUES? NO Hysterectomy		<b>ALLERGIES</b> Kiwifruit	<b>COGNITION</b> No deficits	<b>Any Other Information</b> Primary carer for elderly mother who lives nearby.							
		<b>TAD</b> Smoking: Nil Alcohol: 1-2 standard drinks daily Drugs: Nil									

**Figure 2** Example of a patient persona. BMI, body mass index. Example of a patient persona. ASA, American Society of Anesthesiologists Score. BMI, body mass index. BP, blood pressure. DASI, Duke Activity Status Index. eGFR, estimated glomerular filtration rate; HbA1c, haemoglobin A1c; TAD, tobacco, alcohol and drugs.

photo, gender, social situation and supports, financial status, personal needs and treatment goals), clinical context (contact with healthcare systems, symptoms, pain scores, function, medications, comorbid illnesses) and baseline investigations (blood tests, relevant imaging or investigations). Researchers and participants ensured that the personal and social attributes of the personas were representative of the populations serviced by the participating LHDs. Figure 2 shows an example of persona. Summaries of the persona development exercise were further refined based on consensus feedback from the wider research group. Online supplemental table S1 summarises each persona's characteristics.

In the final workshop, participants mapped anticipated perioperative experiences for elective anterior resection for colon cancer or hip arthroplasty, according to each persona. During the initial inquiry and scoping process, these two surgical procedures were chosen as representing different levels of procedural magnitude, clinical urgency and perioperative risk associated with elective surgical procedures. In this workshop, participants worked in small interprofessional groups of five to six people to generate a visual depiction of the perioperative journey for their allocated patient persona, shown in online supplemental figure S1. Journey mapping included reference to key perioperative decisions, person-centred care elements,<sup>33</sup> emotions (both patient and clinician), location and access to required clinical information and potential system pitfalls. After reflecting on the journey maps and group summaries, an interactive exercise had participants propose and rank potential solutions where health technology could address identified needs and opportunities (table 2). In this exercise, participants each allocated

a limited sum of hypothetical money to their preferred solutions.

Thematic analysis of the project output identified six key design challenges, which were reframed as opportunities to improve current perioperative health systems.

### Proactive and preventative perioperative care requires a shift in care processes towards earlier assessment

Currently, most perioperative planning occurs towards the end of the preoperative period, often within weeks of the anticipated surgery date. This gives limited opportunity to implement preventative treatments such as rehabilitation or nutritional therapy.

We currently have a highly labour-intensive process and system. Tasks are often done at the last minute. It's not optimised.

Improving digital health record integration could provide critical clinical information required for triage and risk assessment at the time of surgical listing and facilitate streamlined preparation, monitoring of clinical status while on the waitlist and planning for hospital services such as intensive care beds.

### Clinical records need to support clinicians to make evidence-based yet individualised care decisions

Clinician participants desired autonomy to individualise treatment plans to patient needs and priorities. While participants valued clinical risk scores and algorithms, they wanted flexibility to tailor their preferred tools and avoid over-protocolisation. Some participants

**Table 2** Proposed solutions to perioperative challenges, ranked according to participant preferences

Ranking	Proposed solution	Key opportunities addressed	Hypothetical monetary sum assigned*
1	Develop a digital perioperative dashboard that has the ability to send alerts and notifications and links the various information and data created by different actors involved in the care, coordination and treatment decisions for the patient. Provide a high-level overview with visual design to show different specialties involved, what they are currently doing for that patient, and the ability to drill down and then link to other systems with detailed information. Map the patient's progress through the pathway. Make available to the care team, general practice and patients.	1, 2, 3, 4, 5, 6	\$A920
2	Digitise the request for admission surgical booking and patient survey forms.	2, 3, 4, 6	\$A570
3	Integrate care coordination and virtual MDT for rural/remote or isolated patients to provide support with systems navigation, compliance with preoperative indications and recommendations and coordination of diverse perioperative activities and consultations, as well as leveraging requirements for in-person consultation.	1, 2, 3, 4, 5, 6	\$A440
4	Virtual care coordinator support for patients with complex care to assist with system navigation, collate and disseminate information, streamline processes for pre-admission clinics, patient liaison and coordination of early referrals to other services and maintain continuity of care. Follow-up on existing NSW Health trials outcomes around care coordinators for complex care patients.	1, 2, 3, 4, 5, 6	\$A370
5	Establishment of surgical MDT virtual mega clinical available for complex patients and not just for cancer patients.	1, 3, 4, 5	\$A230
6	Standardisation and digitisation of Health Questionnaires, making them available in other languages and accessible to general practitioners and patients. Ensure data quality and completion prior to the booking date.	2, 3, 6	\$A220
7	Implement automated electronic medical record system alerts for pre-admission clinical patients when they require insulin/time-sensitive medications for high-risk medicines reconciliation, early identification and inclusion on patients' charts.	1, 2, 6	\$A120
8	Virtual MDT/case coordination, focused on information sharing, streamlining transitions and earlier assessment.	1, 3, 5, 6	\$A100
9	Decrease last-minute pre-admission clinics' requests to general practices for patient information/test results by automating electronic medical record sharing, triggering 'data missing/request' eMR workflow activities days in advance and consolidating information with existing electronic medical health records. Decrease and avoid duplication of investigations by integrating imaging and pathology activities/requests into the patient pathway dashboard with real-time progress (eg, done, booked, to be scheduled) and system alerts of pending/next steps stages.	1, 2, 3, 4	\$A40
10	Develop and integrate into eMR a tool for risk score and fitness for life-saving surgery in the emergency department and emergency surgery, with the ability to liaise with MDT for advice and recommendations on the futility.	1, 2, 5	\$A40
11	Automated high-risk patient identification at the point of procedure booking by incorporating validated scoring onto e-health systems.	1, 2	\$A20
12	Integrated coordination of care for patients with multiple interventions through real-time digital patient pathway tracker available to patients and carers.	1, 3, 4	
13	Perioperative process information booklet, pathway and wait times transparency through a real-time digital tracker available to patients and carers.	3	

Continued

**Table 2** Continued

Ranking	Proposed solution	Key opportunities addressed	Hypothetical monetary sum assigned*
14	Increase and improve communications regarding patient needs and status between parties involved in the perioperative journey (health providers, urban/rural hospital, community health services, patient and carer).	3, 4	
15	Set advanced care planning and subsidising confirmation, where community services are required for disability or aged care, from the early stages of the pathway.	1, 2, 3, 6	
16	Increase awareness and education around 'It's ok to say No to surgery', including realistic and achievable management plans and surgery vs no-surgery outcomes.	1, 4, 5	
17	Cost-benefit analysis and opportunities around burden and expenses of receiving non-hospitalised clinical services such as allied health at prehabilitation or rehabilitation.	2, 3	
18	Comprehensive support for and early identification of the non-compliant patient and how to address patients not following preoperative instructions.	1, 3, 4	
19	For non-surgical patients (eg, highly complex aged care or disability) who are referred for surgical consult/specialist referral/opinion, integrate systems and existing electronic patient data from care facilities and electronic health records to inform risk assessment and outcomes onto patient dashboard. Share this with care teams for transparency and integration of care.	2, 3, 5	
20	Increase awareness and education of senior policymakers and non-hospital advisories on real-life operationalisation and patients' struggles, promoting empathy and understanding how to help them, so these learning can be considered when policymaking for real-life impacts.	3, 4, 6	

\*Participants were allocated fictional money counters equating to \$A100 per participant, to distribute to their preferred solutions as part of an interactive ranking exercise: 'Put your money on your solution'.

were apprehensive about policymakers promoting specific risk scores in clinical algorithms, replacing the role of experienced clinicians in decision-making. All clinicians advocated that better visualisation of clinical parameters in electronic health records could improve decision-making.

A dashboard is an opportunity to get away from manual time-consuming paper-based processes. This gives us an opportunity to identify and triage patients more effectively.

Opportunities for health technology solutions included summarising key perioperative clinical and social variables into visually appealing ways, that provided sufficient data for clinicians to calculate their preferred risk scores.

### Communication can be integrated by improving access to clinical information across different healthcare settings

Participants were frustrated by difficulties locating clinical information in electronic medical records, spending considerable time obtaining documentation from private facilities and primary care providers. Different healthcare staff prioritised different aspects of the clinical record, and current processes duplicate information gathering.

Data is buried; different clinical groups use the system in different ways, and there are opportunities for assessments to be done in an interdisciplinary way.

Primary care clinicians wanted access to electronic hospital records to advise patients of waitlist times, and support preventative care and monitoring. Participants also proposed that patients should have input into their perioperative records and information-sharing. There are opportunities to improve access to digital clinical records across different healthcare jurisdictions, between hospital and community and between different members of the perioperative team.

### Key transitions in clinical care need to be more streamlined to help with patient and clinician experiences

Transitions in care to different providers and services in the perioperative journey represented potential care fragmentation and uncertainty.

We need better flow systems for how patients come to the surgery and how we optimise and prepare them for that operation.

Participants proposed that the experience of patients and clinicians could be significantly improved through

virtual care coordination, especially for high-risk or vulnerable patients or those with additional barriers to care such as rural and remote residence or limited English-language proficiency.

### **Perioperative organisational structures need to provide an opportunity for shared decision-making and options to pursue non-operative management**

Participants reported limited opportunities to redirect patients towards non-operative pathways if surgery is deemed to be of limited benefit, or if treatment goals change. The current demand for complex decision-making support is unknown and proactive referrals are ad hoc. Digital health summaries present opportunities to monitor and stratify subgroups of patients on the surgical waitlist with different perioperative needs and plan health services based on projected requirements.

### **Partnerships between administrative and clinical staff are required for safe and timely perioperative care**

Current systems separate waitlist administration and demand management from clinical services. Participants desired greater partnership between clinicians and administrative staff to manage the waitlist and align clinical needs with efficiency indicators. Participants saw an opportunity to integrate administrative and electronic health records, with the aim of supporting perioperative review and operating theatre demand management and reducing unplanned cancellations.

Twenty digital solutions were suggested, shown in [table 2](#). The highest ranked were a digital clinical support dashboard, virtual care coordination and digitisation of core clinical documents. These three potential solutions also address all six of the key opportunities to improve care.

## **DISCUSSION**

We have shown how health technology-based solutions can be used to improve the perioperative phase of care occurring between the initial decision for surgery until hospital admission. By engaging diverse stakeholders, including clinicians and patients, in a participatory design process, we identified key design challenges and locally relevant solutions for further evaluation. Interprofessional teamwork, perioperative health system transformation and health technology infrastructure investment are required to address these design challenges. By co-creating this research with clinician end-users and other key stakeholders, the opportunities and interventions proposed have the potential to create meaningful solutions to real-world problems. This collaborative approach has been shown to foster a shared sense of ownership and responsibility for creating meaningful changes.<sup>27 28 30 34</sup> Our findings emphasise the surgical waitlist period is an opportunistic time to implement preventative care that promotes proactive and patient-centred perioperative management. Digitisation of key documents and improved integration of clinical information across healthcare jurisdictions were seen as solutions to overcome existing communication barriers and streamline

patient progress through transitional phases of care. Participants strongly supported integrating digital tools into existing clinical services, to monitor service provision and support patient pathways.

The identified knowledge gaps and perioperative service needs are not unique to our local context. Similar health system strains are reported globally, indicating the need for a comprehensive redesign of perioperative pathways.<sup>1 13</sup> Building health system capacity to support patient self-management before and after surgery is essential to improving system efficiencies and supporting patient-centred care. Our study reinforces the value of the recently published Australian and New Zealand College of Anaesthetists (ANZCA) Perioperative Framework, which emphasises the importance of non-operative care and early perioperative optimisation.<sup>14</sup> This includes ensuring that all patients who need surgery receive high-quality care, with their health managed to ensure optimal surgical outcomes. For patients in whom surgery may have minimal value, the perioperative pathway should include options for non-surgical care that aligns with their treatment goals and preferences. The ANZCA perioperative model, along with our findings, advocates for moments in the perioperative journey where the surgical team and patient can review perioperative risks and benefits, deciding collaboratively whether to pursue surgical intervention.<sup>14</sup> We, along with others, identified that informed and collaborative discussions on surgical risk are often delayed until anaesthetic review immediately before surgery, with delays in obtaining sufficient clinical information, reducing the time for contemplation and decision support.<sup>4 6 7 35 36</sup> Digital support tools, such as a perioperative dashboard that summarises and presents pertinent clinical information, are potential mechanisms to improve the quality of shared decision-making and proactive care coordination.<sup>13</sup>

The quality and ease of access to clinical data are important mechanisms to inform perioperative health system design, improve patient safety and support decision-making. Patient portals, perioperative dashboards and virtual coordination were some solutions raised during the codesign process to improve information sharing, build partnerships between stakeholders and engage patients in their perioperative care. Improving the visual comprehensibility of complex clinical data can improve communication between patients and clinicians.<sup>37</sup> An example of innovative health technology supporting perioperative care is the UK National Health Service 'perioperative digital playbook', which has improved communication between health services and patients.<sup>38</sup> This intervention supports in-depth clinical decision-making, preoperative assessment and waitlist coordination and provides patient education about surgery.<sup>39</sup> Similar programmes in the USA focus on reducing last-minute surgery cancellations through computerised modelling of key predictors in electronic health records,<sup>40 41</sup> using machine-learning algorithms to streamline perioperative services<sup>42</sup> and improving patient access to information through personal health record portals.<sup>(42)</sup> Participants in our study also saw opportunities for clinical information to link with administrative and waitlist management, improving system

efficiencies by ensuring all patients scheduled for surgery are fit to proceed. The solutions our participants ranked highest were also those that addressed all of the key opportunities identified in our thematic analysis, and solutions that addressed only one or two opportunities had less support. This suggests that clinicians prioritise whole-system solutions over more targeted interventions focused on efficiency.

Our study is strengthened by the participatory design process, which included multiple clinician and administrative stakeholders from various career stages and specialties, minimising selection bias through comprehensive representation. The involvement of consumer representatives in the codesign process lends weight to our findings. However, as the focus of this research was on how clinicians interact with perioperative systems, this bias towards clinical professions may under-represent the perspectives of non-clinicians and consumers. While many of the findings are comparable to experiences of the wider perioperative care community, the project focused on perioperative services in Sydney, Australia and there are generalisability limitations. Despite trying to balance the need for both specificity and generality in the personas and journey maps, it was not possible to fully represent the nuances of perioperative care for individual diseases or surgical procedures. Differences in electronic health record systems and local practices meant that detailed prototyping and location-specific solutions were not feasible during these workshops, and future work on the delivery design phase will address these implementation challenges.

## CONCLUSION

This research provides valuable insights for future policy and practice by identifying key challenges in perioperative care and generating potential solutions through codesign. The findings highlight the need for a comprehensive redesign of perioperative care and the integration of health technologies to support information sharing, care coordination and decision-making. There is potential to transform perioperative systems, improve patient outcomes and enhance the experiences of both patients and healthcare providers through effective implementation of well-designed, user-oriented health technology solutions. Clinician support for system change was higher when their priorities were addressed with multifaceted interventions, compared with targeted, specific cost-saving measures. Future research should focus on the implementation and evaluation of proposed solutions to ensure their effectiveness and maximise value to perioperative care.

## Strengths and limitations

- ▶ Strengthened by the participatory study design with broad interprofessional representation to support the validity of study findings and reduce selection bias.
- ▶ Relevance to person-centred care is strengthened by consumer participation at all stages of the project.
- ▶ Codesigned resources (personas and journey maps) can be reused in future projects, strengthening sustainability and reach of the research.

- ▶ Generalisability has some limitations due to regional variations in e-health platforms and local policies.
- ▶ Findings are limited to general principles of perioperative care, not specific surgical procedures or diseases.

## Author affiliations

<sup>1</sup>Sydney Medical School, The University of Sydney Faculty of Medicine and Health, Camperdown, New South Wales, Australia

<sup>2</sup>Concord Institute of Academic Surgery, Sydney Local Health District, Concord West, New South Wales, Australia

<sup>3</sup>The University of Sydney Faculty of Medicine and Health, Sydney, New South Wales, Australia

<sup>4</sup>Concord Institute of Academic Surgery, Concord Repatriation General Hospital, Concord, New South Wales, Australia

<sup>5</sup>Anaesthetics, Concord Repatriation General Hospital, Concord, New South Wales, Australia

<sup>6</sup>Department of Surgery and Endocrinology, Royal North Shore Hospital, St Leonards, New South Wales, Australia

<sup>7</sup>Department of Surgery, Westmead Hospital, Westmead, New South Wales, Australia

<sup>8</sup>Geriatrics, Concord Repatriation General Hospital, Concord, New South Wales, Australia

<sup>9</sup>Clinical Excellence Commission, Sydney South, New South Wales, Australia

<sup>10</sup>Concord Repatriation General Hospital, Concord, New South Wales, Australia

<sup>11</sup>Westmead Hospital, Westmead, New South Wales, Australia

**Twitter** Sarah Joy Aitken @drsarahaitken

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#### ORCID iD

Sarah Joy Aitken <http://orcid.org/0000-0002-6701-6213>

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**Supplementary Table S1:** Summary of key demographic and clinical characteristics of personas developed during codesign process.

Persona	Name, Age, Gender	Ethnicity, preferred language	Social characteristics	Medical History	Biophysical parameters	Cognition	Pathology/Imaging	Medications	Function	Prior surgery	TAD
1	Harold, 42yo, Male	First Nations, English	Office manager, lives with female partner, two children	Nil	BMI 29 BP 135/90 Pulse 88 Resp 16	No impairment	Fasting Glucose 5.7	Glucosamine Fish oil	Independent Active sports player	ACL repair	Non-smoker, No alcohol, No drug use
2	Gina, 59yo, Female	Italian, English	Teacher, lives alone (divorced), no children, carer for mother	T2DM Chronic backpain Recent COVID-19	BMI 30 BP 124/80 Pulse 72 Resp 12	No impairment	HbA1c 6% eGFR >90	Meloxicam Empagliflozin + Metformin Amitriptyline	Independent Frailty Score 3 DASS 18.95	Hysterectomy	Non-smoker, 1-2 standard drinks/day
3	Sam, 55yo, Male	Arabic, limited English	Tradie, married, 4 kids, lives with extended family	IHD Bowel cancer Iron deficiency anaemia	BMI 30 BP 140/80 Pulse 80 Resp 16	No impairment	Hb 102 Iron deficiency anaemia - low ferritin and iron Albumin 30	Aspirin Clopidogrel Fish oil Ramipril	Independent	Nil	Smoker, 30 pack years, 20/day 5-6 standard drinks/week
4	Tim, 58yo, Male (transgender)	Korean, English	Chef, single, lives alone, no family in Australia	T2DM	BMI 27 BP 120/70 Pulse 70 Resp 14	No impairment	HbA1c 9.5%	Metformin Dapagliflozin	Independent	Hernia repair	Non-smoker, 5-6 standard drinks/week
5	Margaret, 80yo, Female	English	Retired, widow, no children, lives alone with niece close by	Atrial fibrillation T2DM Mild renal impairment Urinary incontinence	BMI 19 BP 110-909 Pulse 90 Resp 15	No impairment Prior post-op delirium	CrCl 50 mL/min HbA1c 0% Mild anaemia	Apixaban Furosemide Metformin Empagliflozin Insulin Metoprolol Oxybutynin	Independent, assistance with shopping Frailty Score 4	Hysterectomy THR Cataracts	Ex-smoker, independent

6	Mei, 85yo Female	Mandarin, no English	From nursing home, son and daughter in-law support care	Atrial fibrillation PPM CCF Hypertension T2DM Diabetic foot ulcer Early vascular dementia MCA stroke without deficit	Weight 46 kg BP 145/90 Pulse 80 Resp 20	Vascular dementia (RUDAS 18/30) Son is medical decision- maker	Hb 98 Cr 120 / eGFR 28	Apixaban Metformin Sitagliptin Digoxin Simvastatin Telmisartan Furosemide Citalopram Vitamin D Denosumab injection Paracetamol	Dependent ADLs Mobilises with walking frame Frailty Score 7	Carotid endarterectomy NOF repair	Non-smoker, no alcohol
7	Carl, 64yo, Male	English	IT consultant, single, lives alone, rural resident	IHD LHF EF 35% T2DM TIA TURP for cancer Major depression	BMI 36.5 BP 145/88 Pulse 60 Resp 14	No impairment	Cr 188 / eGFR 30 HbA1c 8%	Insulin Metformin Aspirin Clopidogrel Escitalopram Amlodipine Ramipril Tamsulosin Atorvastatin Esomeprazole PRN GTN Fluticasone propionate + Salmeterol inhaler	Independent Frailty Score 4	TURP Coronary stent Cataracts	Smoker, 20/day, 6 standard drinks/day

TAD: Tobacco Alcohol and Disability; BMI: Body Mass Index; BP: Blood Pressure; ACL: Anterior Cruciate Ligament; T2DM: Type 2 Diabetes Mellitus; Hb: Haemoglobin; HbA1c: Glycated Haemoglobin; eGFR: estimated Glomerular Filtration Rate; DAS: Depression Anxiety Stress Scale; IHD: Ischaemic Heart Disease; CrCl: Creatinine Clearance; THR: Total Hip Replacement; PPM: Permanent Pacemaker; CCF: Congestive Cardiac Failure; MCA: Mid Cerebral Artery; RUDAS: Rowland Universal Dementia Assessment Scale; ADLs: Activities of Daily Living; NOF: Neck of Femur; LHF EF: Left Heart Failure Ejection Fraction; TIA: Transient Ischaemic Attack; TURP: Transurethral Resection of the Prostate; PRN GTN: Glyceryl Trinitrate 'as needed'.

DESCRIPTION	Tim meets with Orthopaedic Specialist team	Tim is sent to have an ECG, Stress Test, Endocrine R/V and full bloods to assess and ensure suitability for surgery, or if any action to minimise risks prior to surgery.	Further assessment is requested from: • Endocrine - T2Dm and Transgender/ • Cardiologist • Physio	Paperwork completed Surgical booking made Education material provided to the patient	Pre habilitation is actioned during waiting time for surgery to improve exercise tolerance and reduce surgical risks	Pre admission clinic Anaesthetic consult Ortho surgery CNC R/V ?further bloods/ECg Pharmacy medication R/V	Tim presents to day surgery admission clinic and meets with all team members and is admitted for his surgery
WHO	<ul style="list-style-type: none"> <li>Tim Orthopaedic</li> <li>Surgeon Registrar</li> <li></li> </ul>	<ul style="list-style-type: none"> <li>Tim Pathology lab</li> <li>Endocrinologist (book apt)</li> <li>Cardiologist (to book apt)</li> <li></li> </ul>	<ul style="list-style-type: none"> <li>Tim Endocrinology practice, Cardiology</li> <li>clinic Physiotherapist</li> <li>Ortho surgeon</li> <li></li> </ul>	<ul style="list-style-type: none"> <li>Tim Secretary (Admin)</li> <li>Surgeon/Specialist / Registrar</li> <li></li> </ul>	Tim Physiotherapist	<ul style="list-style-type: none"> <li>Tim Ortho JMO?</li> <li>Anaesthetic team</li> <li>JMO Pharmacy</li> <li>Radiology (ECG)</li> <li>PAC Nurse PAC</li> <li>admin</li> <li></li> <li></li> </ul>	<ul style="list-style-type: none"> <li>Tim Ortho Surgical</li> <li>team Nurse Theatre</li> <li>team Ward clerk</li> <li>Anaesthetist DOSAC</li> <li>staff</li> <li></li> <li></li> </ul>
QUESTIONS	<p>Tim asks</p> <ul style="list-style-type: none"> <li>How much will this cost?</li> <li>What are the risks of serious complications?</li> <li>Hospital Length of Stay</li> <li>When can I return to work</li> <li>Driving when? Need for a length of rehab Pain</li> <li>management Wait time</li> <li>Anaesthetic</li> <li></li> <li>Continuity of Meds</li> <li>Who does the actual surgery? Specialist or Registrar?</li> <li>What are the risks of serious complications?</li> </ul> <p>Specialist</p> <ul style="list-style-type: none"> <li>Do we proceed with Surgery? What type of surgery should be performed? Financial agreement Is this a public or private patient?</li> <li>Acceptance of benefits versus risk by the patient in order to proceed</li> </ul>	<p>Tim</p> <ul style="list-style-type: none"> <li>How much will this cost?</li> <li>Will it Hurt? How long will it take? Do I need time off work? Can I get it done all at once or at the same place? Where do I go to get it done?</li> <li></li> </ul>	<p>Tim</p> <ul style="list-style-type: none"> <li>Why do I have to see all these people its only my hip?</li> <li>What are the results?</li> <li>Can I have the surgery?</li> <li>Are there long-term consequences of this diagnosis? How much will each of these visits cost?</li> <li>Will this delay my surgery or ability to go on the wait list?</li> </ul>	<p>Tim</p> <ul style="list-style-type: none"> <li>What is the wait time?</li> <li>What do I do next?</li> <li>Who do I call to chase up?</li> </ul> <p>Specialist</p> <ul style="list-style-type: none"> <li>Is this an acceptable wait time?</li> <li>Are they public or Private?</li> <li>Insurance issues</li> </ul>	<p>Physiotherapist</p> <ul style="list-style-type: none"> <li>What is the baseline</li> <li>What are the best exercises to improve mobility and manage pain while awaiting surgery? Also, prepare and strengthen the body to improve recovery time.</li> </ul>	<p>Tim</p> <ul style="list-style-type: none"> <li>Are we going ahead? Where and when do I go? What do I bring to hospital? What meds do I take or stop, and how will this affect me? How long will I be in the hospital?</li> </ul> <p>PAC team</p> <ul style="list-style-type: none"> <li>Medications to stop pre-surgery and risks - e.g insulin</li> </ul>	<p>Tim</p> <ul style="list-style-type: none"> <li>When do I go? Can I go home today, Can I take my meds? How long (delays)</li> </ul>
DECISIONS	Public or private patient Category decision - what category are they for surgery Endocrine referral and cardiology referrals	Does the patient need further assessment?	Have any further assessment identified any issues that make patient unfit for surgery? Are any further investigations or assessments required?			<ul style="list-style-type: none"> <li>Male or female bed</li> <li>Where on surgical priority list</li> </ul>	
CHALLENGES	MONEY Wait time to see the specialist Support (lack of) Language barrier	Coordinating all these extra things means more time off work, knowing where to go to get various tests and follow-up activities requested.	Chasing documents, Ensuring everyone knows what information has been captured to date and is also sharing information with others. Systems that don't share information. Time off work for patient = \$\$\$	Wait time Communication Paperwork / insurance	Communication Time off work for Tim as a Chef, shift worker.	Language Health literacy	Theatre time cancellations Fasted and Diabetic
FEELINGS -Patient							
FEELINGS Clinicians							
Pickers 8 Principles	<ul style="list-style-type: none"> <li>Clear communication</li> <li>Fast Access</li> </ul>	<ul style="list-style-type: none"> <li>Effective care</li> <li>Fast Access</li> </ul>	<ul style="list-style-type: none"> <li>Continuity of care</li> <li>Empathy</li> </ul>	<ul style="list-style-type: none"> <li>Continuity of care</li> <li>Patient involved</li> </ul>		<ul style="list-style-type: none"> <li>Empathy</li> <li>Clear communication</li> </ul>	<ul style="list-style-type: none"> <li>Empathy</li> </ul>

**Supplementary Table S3:** Complete list of authors and contributors (in alphabetical order by surname)

Author	Position	Email	Institutions	Contribution
Sarah Aitken	Surgeon, Vascular	Sarah.aitken@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; Concord Institute of Academic Surgery, Concord Repatriation General Hospital, Sydney Local Health District	Chief Investigator, Project Design, Evaluation, Manuscript writing and editing.
Hector Blamey	Consumer	SLHD-ConcordIAS@health.nsw.gov.au		Project conception and Design, Evaluation.
Carina Cutmore	Resident Doctor, Surgery	Carina.cutmore@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; Concord Institute of Academic Surgery, Concord Repatriation General Hospital, Sydney Local Health District	Project Design, Evaluation, Manuscript writing, and editing.
Anthony Glover	Surgeon, endocrine	Anthony.glover@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; Royal North Shore Hospital, Northern Sydney Local Health District	Project conception and Design, Manuscript editing.
Lilijana Gorringer	Primary Care Physician	lilijana.gorringer@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney;	Project conception and Design, Manuscript editing.
Kerry Hitos	Epidemiologist	Kerry.hitos@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; Westmead Hospital, Western Sydney Local Health District	Project conception and Design, Manuscript editing.
Sophie James	Resident Doctor, Surgery	Sophie.james@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; Concord Institute of Academic Surgery, Concord Repatriation General Hospital, Sydney Local Health District	Project Design, Evaluation, Manuscript writing, and editing.
Amy Lawrence	Anaesthetist	Amy.lawrence@health.nsw.gov.au	Concord Institute of Academic Surgery, Concord Repatriation General Hospital, Sydney Local Health District	Project conception and Design, Manuscript editing.
Cherry Leslie	Consumer	SLHD-ConcordIAS@health.nsw.gov.au		Project conception and Design, Evaluation.
Andrew Marks	Anaesthetist	andrew.w.marks@gmail.com	Royal North Shore Hospital, Northern Sydney Local Health District	Project conception and Design, Manuscript editing.
Kate McBride	Healthcare Manager	Kate.mcbride@health.nsw.gov.au	RPA Institute of Academic Surgery, Royal Prince Alfred Hospital, Sydney Local Health District	Project conception and Design.
Sue Monaro	Nurse, Vascular	Sue.monaro@health.nsw.gov.au	Faculty of Medicine and Health, The University of Sydney; Concord Institute of Academic Surgery, Concord Repatriation General Hospital, Sydney Local Health District; Centre for Clinical Excellence, NSW Health	Project conception and Design, Manuscript editing.

Vasi Naganathan	Geriatrician	Vasi.naganathan@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; Concord Institute of Academic Surgery, Concord Repatriation General Hospital, Sydney Local Health District	Project conception and Design, Manuscript editing.
Nicole Phillips	Anaesthetist	Nicole.phillips1@health.nsw.gov.au	Faculty of Medicine and Health, The University of Sydney; Royal Prince Alfred Hospital, Sydney Local Health District	Project conception and Design, Manuscript editing.
Henry Pleass	Surgeon, transplant	Henry.pleass@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; Westmead Hospital, Western Sydney Local Health District	Project conception and Design, Manuscript editing.
Angus Richie	Nephrologist, Chief Information Officer	Angus.richie@health.nsw.gov.au	Faculty of Medicine and Health, The University of Sydney; Concord Institute of Academic Surgery, Concord Repatriation General Hospital, Sydney Local Health District	Project conception and Design, Manuscript editing.
Robert Sanders	Anaesthetist	Robert.sanders@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; Royal Prince Alfred Hospital, Sydney Local Health District	Project conception and Design, Manuscript editing.
Danielle Slater	Consumer	SLHD-ConcordIAS@health.nsw.gov.au		Project conception and Design, Evaluation.
Michael Solomon	Surgeon, Colorectal	Professor.solomon@sydney.edu.au	Faculty of Medicine and Health, The University of Sydney; RPA Institute of Academic Surgery, Royal Prince Alfred Hospital, Sydney Local Health District	Project conception and Design, Manuscript editing.
Janani Thillianadesan	Geriatrician	Janani.thillianadesan@health.nsw.gov.au	Faculty of Medicine and Health, The University of Sydney; Concord Repatriation General Hospital, Sydney Local Health District	Project conception and Design, Manuscript editing.