

Implementing Evidence to Inform Recovery After Cardiac Surgery via Median Sternotomy Is Feasible and Effective Using a Research Translation Framework

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Background

After cardiac surgery including median sternotomy, patients are often advised to restrict upper limb activity, lifting, and weight bearing to reduce the risk of wound dehiscence and sternal instability. “Keep Your Move in the Tube” (KMIT) is an evidence-based strategy developed for patients after a sternotomy for cardiac surgery that promotes early resumption of functional activities using biomechanical principles. To date, there is inconsistency of KMIT implementation to improve patient recovery and outcomes. The application of a knowledge translation approach may facilitate the transformation in practice required. The aims of this study were to conduct a review of current practice, with a focus on exercise for patients after median sternotomy in public acute surgical and cardiac rehabilitation programs in Australia and assess the implementation of KMIT using the Knowledge to Action framework.

Method

This prospective, longitudinal, observational study used a RE-AIM framework for assessment. The project was undertaken in four main phases; i) a survey to assess cardiac rehabilitation practice, ii) development and codesign of an implementation strategy to standardise education and exercise training, iii) implementation, and iv) assessment of the implementation strategy between December 2021 and June 2024.

Results

The survey found lifting and weight bearing advice and exercise provided to patients after a sternotomy for cardiac surgery was inconsistent across the included cardiac rehabilitation programs. The results of the education delivered by 12 local change champions and attended by 390 clinicians demonstrated an improvement in KMIT familiarity from 11% to 76%. A total of 82% reported integrating KMIT principles into usual clinical practice, an increase from 23% at baseline. At follow-up, 82% of respondents reported that KMIT was embedded as clinical practice. Despite a comprehensive education and training strategy, a systematic implementation using a structured framework and high levels of adoption, uncertainty remained about load and time restrictions after a sternotomy, highlighting a need for strategies which focus on the key principles of KMIT and their implications for functional tasks and exercise.

Conclusions

Using a structured process to codesign, develop, and implement a bespoke education and training intervention, KMIT was successfully adopted across cardiac rehabilitation programs within a large health service. This study has also identified opportunities for future improvements and strategies to promote consistency translation and sustainability.

Keywords

Cardiac rehabilitation • Median sternotomy • Exercise • Research translation

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© 2025 Australian and New Zealand Society of Cardiac and Thoracic Surgeons (ANZSCTS) and the Cardiac Society of Australia and New Zealand (CSANZ). Published by Elsevier B.V. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

Introduction

Performance of upper limb exercise after median sternotomy surgery has been reported to be safe and improves cognitive, physical, and functional outcomes in these patients [1–3]. However, patients are often advised to adhere to “sternal precautions,” which limit upper limb movement, lifting, and weight bearing to reduce the risk of wound dehiscence and sternal instability [1,2,4]. Evidence supports an active participatory model of cardiac rehabilitation (CR) after surgery that engages patients in early active and resisted exercise to reduce pain, facilitate activities of daily living, and optimise recovery and suggests that sternal precautions may be overly restrictive [3]. In fact, routine daily activities such as opening fridges and carrying shopping items generate significantly greater forces across the sternum than lifting a 5 kg weight [1,3,5]. The disconnect between restrictive sternal precautions and emerging evidence poses a challenge for exercise professionals to deliver evidence-based CR [2,6].

“Keep Your Move in the Tube” (KMIT) is an evidence-based strategy developed for patients after median sternotomy surgery [7]. It imposes no load or time restrictions but instead prompts patients to perform everyday functional tasks by keeping the upper limbs close to the body in an imaginary tube. Using these biomechanical principles, activities are undertaken within the limits of pain, thus promoting an early return to functional activities. The KMIT protocol has been reported to promote improved quality of life, function, and health cost efficiencies without an increase in adverse events [1,2,8] compared with historical restrictive sternal precautions [1,2,9,10]. When the four core elements of CR are applied (assessment, information, individualised program, and continuing support with follow-up) in tandem with an assessment of sternal instability, individualised exercise prescription can safely occur, incorporating the key principles of KMIT [11,12].

In the state of Queensland, Australia, median sternotomy surgery is conducted at four acute public facilities with approximately 2,500 patients each year [13]. Outpatient CR is delivered by 35 public services to 56 sites across the state via face to face, telehealth, and digital models of care. Despite KMIT being first described more than 8 years ago [7], health professionals share challenges translating this into practice in a timely and sustainable way, leading to variations in practice across this large health service. To implement the principles of KMIT at these public acute sites and outpatient CR programs across the state, a knowledge translation approach was used. We used the Knowledge to Action framework (KTA) to provide a systematic approach for bridging the gap between research and implementation via the identification of key activities such as adaptation to local context and assessment of barriers and enablers [14,15].

The aims of this study were to conduct a review of public CR programs, with a focus on exercise and functional recovery, for patients after median sternotomy surgery and assess the implementation of KMIT using the KTA framework.

Methods

Study Design and Participants

This prospective, longitudinal, observational study was undertaken across four public acute cardiac surgery services and 35 outpatient CR programs within the state of Queensland, Australia. The study was supported by a CR program adviser, a content expert, and a statewide working group consisting of 14 clinicians (11 physiotherapists and three exercise physiologists) who were representatives of four acute and six outpatient CR programs. In addition, four members (S.P., D.E., J.A., and A.M.) constituted a research project team within the working group.

As depicted in Figure 1, the project was undertaken in four main phases which aligned with the KTA framework and included i) a survey to review practice related to exercise and functional recovery in participating settings ii) development and codesign of an implementation strategy to implement KMIT across these services for patients post median sternotomy, iii) implementation, and iv) assessment of the implementation strategy. The project was undertaken between December 2021 and June 2024, with the implementation strategy sequentially rolled out across inpatient surgical sites before expansion to the CR programs associated with the major referring site. The project was deemed exempt from full ethical review by the Metro North Human Research Ethics Committee (EX/2022/QRBW/87534), Queensland, Australia and reported according to the Strengthening the Reporting of Observational studies in Epidemiology checklist (Supplementary Material 1) [16].

Phase 1: Review of CR Practice

To assess CR clinical practice related to exercise interventions and resumption of functional activities, the research team developed a purpose-built web survey. Physiotherapists from each of the four acute cardiac surgery sites and a senior clinician (physiotherapist, exercise physiologist, or nurse) from the 35 CR services were invited to complete the survey between December 2021 and February 2022, with one response sought from each service.

The survey was divided into inpatient management and outpatient CR practice. Questions explored knowledge of, and clinical experience with KMIT, postoperative physiotherapy interventions (secretion clearance techniques, walking aid prescription, sternal binders), use of sternal precaution protocols, exercise prescription principles (including resumption of resistance training), and barriers and enablers to integrating KMIT into clinical practice, as relevant to the time of intervention. To ensure ease of comprehension, the survey was initially piloted by seven clinicians and subsequently modified after feedback. The clinician responses to their use of sternal precaution protocols, exercise prescription principles, and barriers and enablers to KMIT implementation informed the subsequent project design to support the standardisation of KMIT into practice.

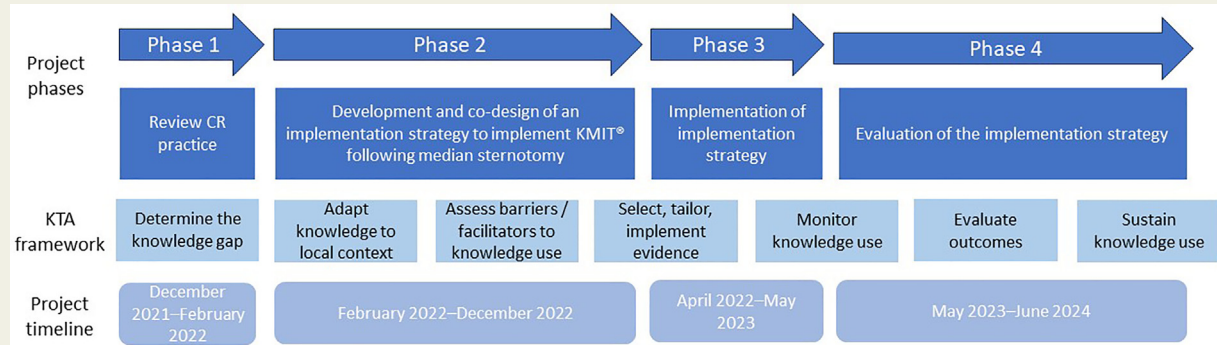


Figure 1 KMIT project plan.

Abbreviation: KMIT, Keep Your Move in the Tube.

Phase 2: Designing the Implementation Strategy

During the development and codesign phase, the working group met six times via Microsoft Teams to understand the contexts, barriers, and enablers to implementation of KMIT in the acute and outpatient settings. Barriers and enablers were collated via a variety of methods including clinician interviews, web-based surveys, working group meetings, and opportunistic conversations. Results for each of these were summarised using quantitative (web-based surveys) and qualitative (interviews with clinicians, working group meetings, and opportunistic conversations) methods. Triangulation of this data by the project lead (SP) then enabled common barriers and enablers to be identified; the results of which were discussed with the project team to ensure consensus. These were then reviewed against the COM-B behaviour change model [17], which identified priority areas (capability, opportunity, and motivation) to enable sustainable change. The statewide working group reviewed the data and used the behaviour change wheel [17] to identify potential strategies to overcome these barriers (Table 1).

The final KMIT implementation strategy included:

1. Acquisition and distribution of KMIT teaching resources to all participating services;
2. Codesign, development, and delivery of an education and training strategy;
3. Centralised project management by the CR program adviser (S.P.) to operationalise the implementation strategy and facilitate support for change champions to assist with motivation and problem solving; and
4. Facilitation of local service adoption and change management by change champions.

KMIT teaching resources

KMIT resources, available from Baylor Health Services, include two digital images and a patient script. These resources require a copyright user agreement between the Licensor and the user. The Queensland CR program adviser facilitated this process between the Department of Health, Queensland, and Baylor Health Services legal teams. Once

attained, a further sublicense was negotiated between the Department of Health, Queensland, and each of the 14 public health services delivering CR programs. This process required negotiations between the individual health service contracts teams and Department of Health, Queensland with regular reminders by the Queensland CR program adviser.

Codesign, development, and delivery of an education and training strategy

The education and training strategy aimed to improve clinician familiarity, knowledge and understanding, and confidence in applying KMIT in the clinical setting. This strategy was multimodal in approach to accommodate the different audiences at each site and preferred learning styles. The working group codesigned these methods with the intent that they could be adapted for local implementation depending upon context. The education and training instruments included a PowerPoint presentation outlining the evidence, principles, and practical application of KMIT; a recorded webinar by the content expert describing key evidence and reasons for change; a reference list of key evidence supporting KMIT; a standardised competency test for lead exercise specialists to support “hands-on” training; and a best practice guideline for management after median sternotomy. The content expert and Queensland CR program adviser also engaged with the Queensland Cardiac Surgeon Committee to ensure support and advocacy for the proposed strategy.

To support implementation, change champions were identified within each health service by the CR program adviser. These champions were key personnel with an interest and expertise in exercise delivery in CR. In the absence of a suitable exercise specialist, the program adviser collaborated with the local CR nurse to facilitate the training by the main referring hospital physiotherapy staff or by the program adviser.

Phase 3: Implementing the Implementation Strategy

To ensure success, project implementation was underpinned by change management principles, as demonstrated in Figure 2. These eight steps initially described by Kotter [18]

Table 1 Barriers and potential implementation strategies identified by the working group.

Behaviour change theory	Barrier	Stakeholder group	Agreed Strategy
Capability	• Lack of knowledge about, understanding and awareness of evidence-based practice. • Lack of familiarity and confidence to deliver evidence-based practice. • Access to resources and guidelines.	Medical and CR clinicians, clients, researchers	Education and training package Access to KMIT resources
Opportunity	• Need for a CUA to use KMIT resources. • Lack of change champion.	Qld CR program advisor, CR clinicians, Department of Health, Qld Hospital and Health Services and licence holder	Access to KMIT resources Support change management
Motivation	• Risk of adverse events with new practice.	Clients, medical and CR clinicians, Qld CR program advisor	Education and training package

Abbreviations: CR, cardiac rehabilitation; CUA, Copyright User Agreement; KMIT, Keep Your Move in the Tube; Qld, Queensland.

have previously been used to assist with KMIT translation [1]. Change management is important because it increases stakeholder engagement in and satisfaction with the implementation process, ultimately improving the success of practice change. The detailed implementation timeline describing the facilitation and support provided by the statewide role and the local service adoption activities led by the change champions is reported in [Supplementary Figure 1](#).

Phase 4: Assessing the Implementation Strategy

Assessment of this project was informed by the RE-AIM framework using a mixed-method design, synthesising qualitative and quantitative data. All staff with a clinical role associated with managing patients post median sternotomy surgery were invited to complete three web-based purpose-built surveys throughout the project, all of which were distributed by the change champions at each site. These surveys were also available via paper in case the staff were unable to use the electronic survey.

Clinician familiarity, knowledge, and understanding of KMIT was assessed using an education and training survey, completed at baseline ([Supplementary Material 2](#)) and 12 weeks ([Supplementary Material 3](#)) after the education interventions. These surveys were completed between May and November 2023 and targeted all clinicians who attended the education and training sessions. A third survey ([Supplementary Material 4](#)) was used to assess adoption and acceptability of KMIT into local practice and undertaken 16–18 weeks after the education. This survey was adapted from the Normalisation Measure Development Questionnaire protocol [19,20], which maps processes that affect the embedding of sustainable practice based on normalisation

process theory and targeted those clinicians who permanently work within the acute and outpatient CR settings. The working group connected on a further four occasions via email to monitor the assessment strategy progress.

Reach was assessed according to the number of clinicians who were trained in KMIT, captured by the change champion at each site, for all education and training sessions delivered during the study period.

Effectiveness was measured by comparing clinician familiarity, knowledge, and understanding of KMIT between baseline and 12-week follow-up, using the education and training surveys. Clinician familiarity was measured using a nine-point Likert scale (question 6, [Supplementary Material 2](#); question 10, [Supplementary Material 3](#)) and knowledge and understanding were measured using a yes, no, and unsure response to a variety of clinical scenarios (questions 12–15, [Supplementary Material 2](#); questions 12–15, [Supplementary Material 3](#)).

Adoption was measured according to the proportion of clinicians who reported integrating KMIT into clinical practice. Two questions were used to assess this. The question “Do you integrate principles of KMIT into your current practice?” was asked in the baseline and follow-up education and training survey, using a yes, no, and unsure response. The question “To what degree do you feel that KMIT is currently a normal part of your work?” was included in all surveys and used a nine-point Likert scale.

Implementation was measured according to clinician perceptions about the acceptability of implementing KMIT into work practices (questions 9, 12, 13, 19, and 20, [Supplementary Material 4](#)). The four domains of normalisation process theory were measured by four questions within each domain using a 5-point Likert scale.

Maintenance was measured by assessing clinician perceptions about maintenance of KMIT. Five questions in the

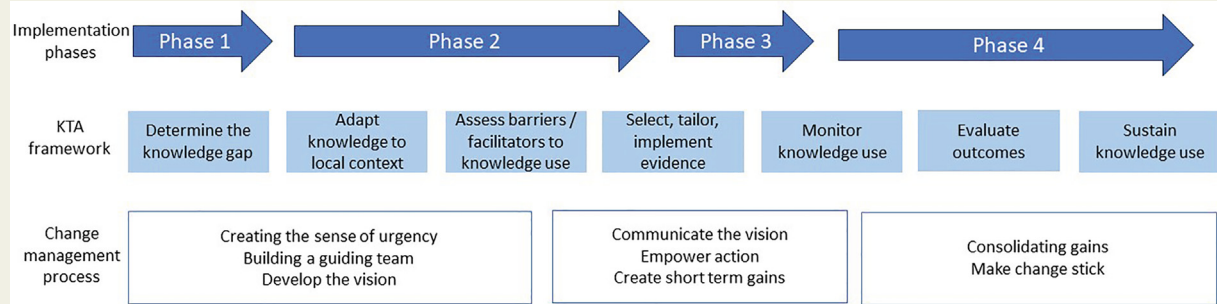


Figure 2 KMIT project aligning KTA framework with implementation phases and change management principles. Abbreviations: KMIT, Keep Your Move in the Tube; KTA, Knowledge to Action framework.

adoption and acceptability survey were used to capture this response, using a 5-point Likert scale (questions 7, 12, 13, 16, and 17, [Supplementary Material 4](#)).

Clinical outcomes

Data for sternal wound infection (deep and superficial), hospital length of stay, discharge destination, and readmission within 30 days were obtained for all patients in Queensland public facilities who underwent median sternotomy surgery between September 2020 and June 2021 (pre-KMIT implementation) and between September 2023 and June 2024 (post-KMIT implementation). These data were used with permission from the cardiac surgery statewide data registry.

Data Analysis

Standard descriptive statistics were used to summarise results for the RE-AIM assessment. The 9- and 5-point Likert scales were grouped into three classifications and reported as “agree,” “neutral,” and “disagree.” Comparing clinical outcomes pre- and post-intervention was not the primary intent of this study, and, for this reason, no statistical analysis was conducted. Results were, therefore, reported descriptively.

Results

The scoping survey, which explored clinical practice at baseline, was completed by participants at all four acute hospitals and 19 of the 25 CR programs in operation at the time. Because of COVID-19 redeployments, 10 CR programs were not staffed between December 2021 and February 2022. The baseline education and training survey was completed by 390 clinicians, 58% of whom worked in the acute setting. The follow-up education and training survey was completed by 148 clinicians, 54% working in the acute setting. The adoption and acceptability survey was completed by 44 clinicians directly included in delivering CR, of whom 54% worked in the outpatient setting.

Review of CR Practice

Before implementation, all respondents within the acute hospital sites reported being aware of the KMIT concept,

with 75% of clinicians reporting that they integrated some principles into practice. Acute physiotherapy management, including postoperative secretion clearance techniques and mobility aid prescription, was found to be consistent across the four hospitals; however, advice pertaining to the use of the upper limbs during functional activities was inconsistent. Similarly, advice about upper limb time and load restrictions also varied between sites.

For outpatient CR programs, 58% of clinicians reported being aware of KMIT, of whom 91% reported integrating some of the KMIT principles into their practice. In this setting, four respondents reported adhering to a post-sternotomy exercise protocol, with two based on time and load restrictions only and two combined traditional time and load restrictions with some KMIT principles. There was no consensus on upper limb load and time restrictions for commonly prescribed exercises in the outpatient CR setting.

Reach

A total of 39 education and training sessions were delivered by change champions: nine in the acute hospital setting and 30 in outpatient CR services, reaching a total of 390 clinicians. Of these, 305 clinicians attended the 34 education sessions delivered in regional and rural settings. As demonstrated in [Table 2](#), attendees were predominantly exercise specialists (46%) and nurses (36%).

Effectiveness

After the intervention, familiarity with KMIT improved from 11% to 76%. Knowledge and understanding about weight-bearing, load, and time restrictions associated with the clinical application of KMIT also improved. Clinician agreement about permitted weight-bearing activities within and outside the tube improved from 50% to 99% and 24% to 69%, respectively, while an improvement from 20% to 76% and from 12% to 57% was observed for load and time restrictions, respectively. However, some uncertainty remained post-education, with 25% of clinicians incorrectly responding that KMIT provided time restrictions on loaded upper limb activities and 16% of clinicians incorrectly responding that KMIT provided load limits to upper limb activities. A total of

Table 2 Characteristics of clinicians who attended education and training sessions.

Respondent characteristic	n (%)
Physiotherapists	161 (41)
Exercise physiologists	19 (5)
Nurses	141 (36)
Doctors	7 (2)
Allied health assistants	12 (3)
Occupational therapists	9 (2)
Other allied health professionals	9 (2)
Students	8 (2)
Other	24 (6)

31% of clinicians demonstrated uncertainty or responded incorrectly to the question about whether KMIT allowed unloaded activities outside the tube. Although this represents a 45% improvement from baseline, a small increase in the proportion of clinicians who responded incorrectly to these questions was also observed.

Adoption

Of the 44 participants who responded to the adoption survey (16–18 weeks post-intervention), 82% reported integrating KMIT principles into their clinical practice, an increase from 23% at baseline and 66% from 12 weeks after education and training.

Implementation

Acceptability of implementing KMIT into clinical practice according to patient and clinician value and normalisation of work processes was reported by clinicians to be very high (100%). However, 2% of respondents reported neutrality about supporting sustainable implementation and KMIT being an effective intervention.

Maintenance

Based on survey questions relevant to sustainability, respondents reported consistently high agreement that KMIT would be maintained as usual practice for patients after median sternotomy. A total of 82% of respondents reported that KMIT was a normal part of work, with 100% agreeing that it will become so. Almost all clinicians (98%) reported they would provide continuing support to maintain KMIT as practice, with 89% identifying that there was key stakeholder support to sustain practice. A total of 84% of clinicians responded that there were sufficient resources and training available for supporting continuing knowledge and understanding of KMIT.

Clinical Outcomes

Data for clinical outcomes were available for 2,124 patients who underwent median sternotomy surgery in 2020–2021

and 1,980 patients for the same 9-month period in 2023–2024. Of these, 2,239 (55%) patients were aged 65 years or older. As demonstrated in Table 3, the results were similar pre- and post-intervention for all measures, with no observable increase in adverse events associated with this change in practice. Similar results were observed when data were confined to those aged 65 years and over.

Discussion

This study identified that exercise prescription targeting the upper limb and guidelines on lifting and weight bearing provided to patients after a sternotomy for cardiac surgery varied across the included CR programs. This is consistent with previous studies that implemented surveys to review clinical practice after cardiac surgery [8,21]. Clinicians reported awareness of the evidence supporting KMIT but had not translated this into practice because of several barriers within their respective CR settings. These findings align with earlier research which reported significant variation in practice on exercise prescription and progression and sternal instability assessment, and recommendations for resistance training were not routinely included in CR guidelines or position statements [6,21].

This study used the KTA framework supported by project implementation guidelines and change management principles to assist with the development and implementation of an appropriately tailored implementation strategy. Broad reach of an education and training strategy to acute surgical and CR clinicians in metropolitan, regional, and rural centres resulted. Respondents demonstrated improved familiarity and knowledge of KMIT application, high levels of adoption in clinical practice, and consensus that KMIT would become part of their usual work. Hospital length of stay, discharge to home or to inpatient rehabilitation, and prevalence of superficial and deep wound infections were similar between baseline and post-intervention periods.

The findings of our assessment indicate that the application of the multifaceted strategy to implement KMIT in CR programs was successful; however, results also highlight opportunities for improvement. Despite a comprehensive education and training intervention and 82% of clinicians reporting that they integrated KMIT principles into practice, 25% responded incorrectly to questions related to time restrictions and 16% responded incorrectly about load limits with loaded upper limb activities. These results perhaps suggest that the principles and practice of KMIT are not fully understood, thus highlighting a need for clear messaging, continuing clinician support, and strategies which accommodate the high turnover of staff within health services. Based on our findings, the project team has since developed a short educational video, in collaboration with international colleagues, which describes the principles of KMIT, demonstrates active performance of common functional tasks and activities of daily living by a consumer, and specifically deals with time and load restrictions. This video is intended to act

Table 3 Characteristics of patients who received a median sternotomy.

Characteristic	Baseline			Post-intervention		
	<65 years n=1,004	≥65 years n=1,120	Total n=2,124	<65 years n=861	≥65 years n=1,119	Total n=1,980
Mean age, years (SD)	53 (10)	73 (5)	64 (13)	53 (10)	73 (6)	65 (13)
Deep sternal wound infection, n (%)	5 (1)	6 (1)	11 (0.5)	3 (<1)	5 (<1)	8 (0.4)
Superficial sternal infection, n (%)	26 (3)	27 (2)	53 (2.5)	11 (1)	20 (2)	31 (1.6)
Discharge destination, n (%)						
Home	899 (90)	945 (84)	1844 (87)	750 (87)	944 (84)	1694 (86)
HITH, local hospital, or another surgical ward	65 (6)	87 (8)	152 (7)	75 (9)	108 (10)	183 (9)
Inpatient rehab	30 (3)	53 (5)	83 (4)	19 (2)	39 (4)	58 (3)
Died	10 (1)	35 (3)	45 (2)	17 (2)	28 (3)	45 (2)
Readmitted within 30 days, n (%)	141 (14)	128 (12)	269 (13)	102 (12)	119 (11)	221 (11)
Readmitted due to sternal infection n (%)	2 (1)	3 (2)	5 (1.9)	1 (1)	5 (4)	6 (2.7)
Mean LOS, days, (SD)	14 (18)	14 (15)	13.97 (16)	16 (19)	14 (16)	14.39 (17)

Abbreviations: HITH, Hospital in the home; LOS, length of stay; SD, standard deviation.

as a patient and clinician education instrument to support continuing sustainability of KMIT practice. Other strategies to promote sustainability may include the inclusion of KMIT education into higher education programs at university, regular in-service programs and orientation training for new staff, a multipurpose educational resource using consistent language across the state, and continuing support for local change champions through a statewide clinician network. The release of updated guidelines supporting exercise assessment and prescription is another strategic resource to support clinician practice in delivering contemporary CR practice [12].

A key strength of this study was the leadership provided by a statewide CR program adviser role, which has a dedicated function to support CR programs in delivering evidence-based services and support quality and service improvement initiatives. This role assumed the project management role and facilitated the use of a structured framework with dedicated time for planning, ensuring translation of KMIT into practice in a systematic and coordinated manner. This was facilitated by the codesign of the intervention and dissemination of training by the local and passionate change champions.

Despite these strengths, there are several limitations which should be noted. The study took place over a 2-year period. Staff and service changes during the time, and the nature of busy clinical settings meant that we were unable to confirm the number of eligible clinicians and, thus, accurately calculate response rates. As such, the findings are limited to those who responded to each survey and may represent a sample of convenience. Survey data were grouped into three classifications from the original nine-point Likert scales, potentially influencing interpretation of results. Numerous factors contribute to clinical outcomes which we did not measure; therefore, inferences about the association between

implementation of KMIT and the selected clinical outcomes cannot be made. Future work should target assessment of the sustainability of implementing KMIT at scale and the influence of this transformative practice change on patients, clinicians, and the utilisation of the health services.

Conclusions

Using the KTA framework provided a structured process to codesign, develop, and implement a tailored intervention to facilitate the implementation of KMIT across four acute surgical and 35 outpatient CR programs. Planning assessment and monitoring strategies early in the process and consideration of local context, as well as barriers and facilitators to implementation, promoted adoption into practice, improvements in clinician familiarity, and confidence in KMIT and optimised sustainability. Although a research translation framework was appropriate for the design of the implementation strategy, strong project and change management principles underpinned successful implementation.

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Declaration of Competing Interests

There are no conflicts of interest to disclose.

Author Contributions

S.P. provided the project administration, funding acquisition and gathering of data. S.P. and J.A. analysed and interpreted the data. S.P., J.A., A.M., and D.E. conceptualised the project and contributed to the writing and editing of the manuscript. All authors read and approved the final manuscript.

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Availability of Data and Materials

The data sets used and/or analysed during this study are available from the corresponding author on reasonable request.

Appendices

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.hlc.2025.06.008>

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