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RESEARCH ARTICLE

# IMPROVING THE QUALITY AND SUSTAINABILITY OF HOME-BASED ACUTE CARE MODELS USING VIRTUAL CARE TECHNOLOGY

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## ABSTRACT

### IMPORTANCE

COVID-19 has facilitated the rise of a new service model that combines Hospital in the Home (HITH) service provision with technology to create 'virtual hospitals', but evidence on the impact of this new model in terms of cost and clinical outcomes, compared to usual (HITH) care, is currently lacking.

### OBJECTIVE

To assess the clinical and financial impacts of virtual care technology on HITH models of care.

### DESIGN

Quasi-experimental study comparing outcomes of a control group receiving 'usual' home-based acute care and a virtual care cohort using remote monitoring technology while also receiving usual HITH care.

### SETTING AND PARTICIPANTS

Adult (aged 18+ years) and paediatric (aged 0-17 years) patients admitted to the Mackay Hospital in the Home (MHITH) program between 1 August 2020 and 30 June 2021.

### INTERVENTION

Virtual care technology.

### MAIN OUTCOMES AND MEASURES

Readmissions within 28 days, unplanned emergency department (ED) presentations, transfers-in to facility-based hospital beds, and average length of stay.

## RESULTS

During the study period, 151 adult and 26 paediatric patients utilised virtual care technology for the majority, or all, of their home-based acute care. Use of such technology was associated with a statistically significant reduction in risk of hospital readmission within 28 days—from 43% to 21%. The risk of hospital readmission within 28 days for the same diagnosis-related group (DRG) dropped from 18% to 4%, and the length of stay for the top three DRGs by volume decreased from a mean of 7.2 days to 4.0 days, saving an average of $3,698 per admission. Use of technology was also associated with reduced rates of unplanned ED presentations and transfers-in to traditional hospital beds compared to usual care for adults.

## CONCLUSIONS

Our findings confirm there are clinical, economic and consumer benefits associated with embedding virtual care technology in HITH service models that warrant consideration in health systems facing capacity constraints and rising costs.



## KEYWORDS

hospital in the home, virtual care, remote patient monitoring, virtual hospital, emergency department presentations, hospital readmission, length of stay


## INTRODUCTION

Despite evidence that hospital in the home (HITH) is a safe, satisfying, and cost-effective alternative to in-hospital care for suitable patients, [1,2] uptake of the model in Australia has historically been limited. Between 2011 and 2017, HITH care comprised, on-average, just 3.7% of all hospital admissions in Australia [3]. However, as the COVID-19 pandemic continues to place unprecedented strain on healthcare systems worldwide, Australian hospitals have been forced to rapidly scale bed-alternate models such as HITH to meet skyrocketing demand for acute care and avoid system collapse [4,5]. In Queensland, public patients who are admitted to HITH programs receive care and treatment comparable to the services offered in a traditional hospital setting [6]. Regular monitoring of vital signs and other clinical observations is an essential component of caring for patients who are admitted with acute conditions in order to assess treatment effects, detect complications, and identify early signs of clinical deterioration [7]. In a traditional inpatient setting, clinical observations are recorded by nurses as part of an admission assessment; these are recorded at the commencement of each shift and at a frequency determined by the patient's clinical status, with four hourly observations considered 'routine' [8,9,10]. However, the current face-to-face service delivery approach for HITH, which involves visiting a patient at home once or twice daily, inherently constrains the collection of routine clinical observation data to once every 12 to 24 hours and creates an insurmountable barrier to the HITH objective of providing care equivalence.

Standard 8 of the National Safety and Quality Standards in Healthcare states that:
"measurement of physiological observations plays a significant role in detecting clinical deterioration. Abnormal observations may occur at any time during a patient's admission. Multiple studies and adverse events have shown that patients in acute care settings often go for prolonged periods without having appropriate physiological observations measured. When this occurs it can mean that clinical deterioration may not be recognised, and treatment may be delayed" [7 p.7].

Infrequent and delayed collection of clinical observation data has been identified as a potential contributing factor to increased average length of stay for HITH patients because of late identification of deterioration and/or delayed recognition of stabilisation to support discharge [11]. Historically, there has been no practical solution to this problem; however, recent advances in remote patient monitoring technology provide renewed hope that a panacea does in fact exist.

Trials and research into remote patient monitoring (RPM) programs, both nationally and internationally, have delivered results that indicate positive outcomes for patients and the health care system more broadly. These benefits include lower mortality rates [12,13,14] reduced

average length of stay [15], reduced hospital admission and re-admission rates, reduced emergency department utilization [16,17] improved symptom recognition and control, improved patient satisfaction [18], and cost savings [19]. Despite evidence suggesting that HITH is an optimal use case for RPM, the technology has not been routinely deployed in HITH programs throughout Australia. However, the onset of the global pandemic appears to have ignited clinical interest in remote patient monitoring technology [20]. It has also facilitated the rise of a new service model that combines HITH service provision with RPM and secure videoconferencing technology to create a new care delivery paradigm known as the 'virtual hospital'. Although the 'virtual hospital' concept has become popularised in healthcare transformation and thought leadership circles [21], studies that examine the impact of technology on HITH costs, clinical outcomes, and patient experience are limited [22]. Our aim was to assess the clinical impacts and potential financial benefits of virtual care technology on home-based acute care models in Mackay Hospital and Health Service, which provides adult and paediatric HITH services to a population of around 180,000 people in a range of regional, community, and rural settings in Queensland.

## METHODS

In this quasi-experimental study, adult (18+ years) and paediatric patients (0-17 years) referred to the Mackay Base Hospital HITH program from 1 August 2020 to 31 June 2021 were approached for recruitment to the virtual care technology intervention at the point of admission, either in the hospital or during the initial home visit. Members of the HITH clinical team screened for suitability against pre-defined criteria (Table 1). They discussed the potential risks and benefits of using technology as an adjunct to usual HITH care before asking patients to sign a hard copy consent form and an equipment loan agreement. Patients who did not meet the inclusion criteria or who did not consent to participate were allocated to the control group (total n= 142, consisting of 134 adults and 8 paediatric patients) and reasons for non-enrolment were documented by the clinical team (Tables 2 and 3).

Two different deployment models were implemented to allocate and manage the 'loan pool' of hardware needed to remotely monitor the group of patients who consented to participate. Patients who did not own a suitable mobile device were provided with a complete monitoring kit consisting of an Android phone, pre-loaded with the Telstra Health MyCareManager remote patient monitoring mobile app, and three Therapeutic Goods Administration (TGA)-approved Bluetooth-connected medical devices: a thermometer, a blood pressure monitor, and a pulse oximeter. Patients who owned a suitable mobile device, and who were willing to use it, were supported at the point of enrolment to download the MyCareManager app from the AppStore or Google Playstore and pair the TGA-approved medical devices to their own mobile phone or tablet. Additional Bluetooth-enabled medical devices, such as glucometers and weight scales, were added to the kit based on clinical need and paired to the patient's mobile device. At the time of the trial there were no TGA-approved, Bluetooth-enabled pulse oximeters availablefor paediatric patients in Australia. Instead, these patients were loaned paediatric-specific, non-Bluetooth, TGA-approved medical devices, and their carers received instruction on how to manually enter data into the MyCareManager App.

Following set-up, the HITH team provided a brief induction on correct use of the software and devices, followed by a technical competency assessment of the patient and/or carer. After completion of these processes the patient was considered 'enrolled' in the technology and remote monitoring commenced. Both the control group receiving 'usual HITH care' and the intervention group using virtual care technology received once daily home visits, plus phone calls as required. In addition to this, patients allocated to the virtual care technology group were assigned daily tasks to complete in the app, including health surveys and assessments customised to their diagnosis, taking vital sign readings using medical devices, and participating in video consultations and coaching sessions with the HITH clinical team.

Data transmitted via the app was automatically triaged according to rule-based algorithms, and alerts were generated in the clinician portal to trigger proactive investigation and intervention by the HITH clinical team for any 'missed tasks' as well as any results returned outside of the reference ranges set by the HITH clinical team. At the end of the monitoring period, a patient experience survey was sent to all patients/carers who were officially enrolled in the program. In total, 151 adult and 26 paediatric patients were enrolled in the technology intervention over the study period. Further detail on patient numbers and baseline characteristics for both groups are outlined in Table 4. Clinician experience of virtual care delivery was

also assessed at completion of the study via a clinician survey as well as stakeholder interviews.

Existing admitted and non-admitted hospital data collections were linked, de-identified, and retrospectively analysed to identify differences between groups with regards to case mix as well as all-cause and same-diagnosis related grouping (DRG) readmission rates within 28 days. Differences in emergency department (ED) presentations during HITH admissions, transfers-in to a traditional hospital bed during the HITH episode of care, and avoidable readmissions (in accordance with Australian Commission on Safety and Quality in Health Care definitions of 'Avoidable Hospital Readmissions') [23] were also analysed. Validated methodologies were used to determine the cumulative incidence of events between groups and quantify relative differences in risk [24]. In addition to hospital statistical collections, HITH clinical teams recorded data in close-to-real time on events that were avoided through the use of technology, including home visits, ED presentations, and ambulance callouts. These avoided events were added to the total count of observed differences in hospital events reported in hospital data collections.

For the economic analysis, we calculated the theoretical savings associated with differences in the rate of events between groups that are known to contribute to healthcare costs, including readmissions within 28 days, ED presentations, transfers-in, and average length of stay (ALOS). Bed-day savings associated with ALOS differences were derived by calculating the variance in LOS between the intervention and comparator cohorts, multiplied by the number of separations in the intervention cohort. Each avoided hospitalisation event was assigned an average cost using 2020–2021 cost data supplied to the Independent Health and Aged Care Pricing Authority [25], with specific adjustments to reflect evidence suggesting that HITH separations are, on-average, 22% cheaper than facility-based separations for the same DRG [26]. Cost savings were then calculated based on differences in the incidence of events reported in hospital data collections between the two groups. Savings associated with avoided transfers-in to a traditional hospital bed were costed at 22% of the average cost of a hospital admission across all DRGs in the intervention group. A similar method was used to derive the average cost of an ED presentation using urgency related grouping cost and activity data. However, without the 22% cost adjustment given, there is no evidence to suggest that HITH patients who present to ED during an admission result in lower ED presentation costs. To correct for differences in admission profiles between groups, ALOS changes were analysed across the combined three highest volume DRGs common to both groups. Avoided ambulance callouts were costed using actual cost data supplied by the Department of Health and were calculated using an average of costs between basic transfers and paramedic transfers, as detailed in Table 5. Cost savings associated with avoided home visits were derived using the formula outlined in Table 6. Statistical significance in outcomes between groups were calculated using unpaired confidence intervals.

## RESULTS

During the study period, there were a total of 319 separations from the Mackay Base Hospital HITH program. Of these separations, 285 (89%) were for adult patients, and the remaining 34 (11%) were for paediatric patients. In total, 53% (n=151) of all adult separations and 76% (n=26) of all paediatric separations utilised virtual care technology during the trial period. Adult patients who used technology were more likely to be younger (average age 55 years compared to 67 years in the 'usual care' group) and require treatment for higher complexity conditions (37% of admissions coded as major complexity DRGs vs. 31% in the usual care group), as detailed in Table 4.

While small sample size combined with the positively skewed uptake of technology in the paediatric group resulted in inadequate statistical power to reliably detect any effects of the intervention, trends were positive for paediatric patients using virtual care technology. An 8% reduction in all-cause readmission risk within 28 days [95% CI 5%-13%, n=34] was reported for the paediatric virtual care technology group compared to those receiving usual HITH care and a 69% reduction in the risk of readmission for same-DRG within 28 days (Table 7).

The results for adults were more definitive, with a statistically significant reduction of 22% [95% CI 21%-23%] in all-cause readmission risk within 28 days for adult virtual care admissions compared to usual HITH care as well as a statistically significant reduction of 13.9% [95% CI 13.5%-14.4%] in same-DRG readmission risk within 28 days. In addition to this, there was a statistically significant reduction in average HITH LOS for the top three DRGs by volume (average HITH LOS reduced by 3.20 days from 7.20 to 4.00 days [95% CI 1.05 - 5.35, n=74]) for patients using

virtual care technology, compared to those receiving usual HITH care.

The benefits associated with avoided readmissions, avoided ambulance callouts, avoided home visits, and avoided ED presentations, in combination with LOS reductions, were identified for the group using virtual care technology. The results showed an estimated savings value of $548,879 over the study period, which equates to an average cost savings of $3,101 per admission. As a result, HITH episodes that utilised virtual care technology were determined to be, on-average, 23% less expensive than usual HITH care, with the majority of savings attributable to reductions in costs associated with readmissions and LOS.

Other non-financial benefits were also identified via patient experience surveys which were sent to all patients and/or their carers within 24 hours of discharge. The survey consisted of twenty-four questions covering the broad themes of: satisfaction with the virtual hospital service, adequacy of support to self-manage recovery at home, reliability and user friendliness of remote patient monitoring technology, future preference for home monitoring, financial impacts of remote patient monitoring technology, workforce participation during admission, and caregiver support during home-based hospitalisation. Results are summarised in Table 8.

In total, 133 out of the 177 (75%) patients onboarded to the virtual monitoring intervention responded to the patient experience survey. Patient and carer satisfaction with the 'virtual hospital' model was exceptionally high, with 97% of respondents indicating they were 'happy' or 'very happy' with the care provided by Mackay Hospital in the Home Virtual Care Service. Furthermore, 96% of participants reported being 'very comfortable' or 'comfortable' with the remote monitoring of their health observations and 97% identified that they felt 'very confident' or 'fairly confident' to self-manage their condition at home using the MyCareManager mobile application.

This high level of comfort and empowerment appears largely attributable to the comprehensive training and support offered by the Mackay HITH team. Patients and/or their caregivers in the intervention groups underwent in-person training and competency assessments on the mobile application and connected Bluetooth devices before going home. Furthermore, HITH staff offered both on-demand and scheduled telephone and video support, as needed, during their admission. This approach proved highly effective in bolstering self-efficacy, as evidenced by the fact that 99% of patients and/or their carers reported feeling adequately supported to self-manage their medical condition at home.

In terms of usability, 94% of participants reported that the MyCareManager application was 'easy' or 'very easy' to use, while an equal proportion rated the Bluetooth equipment as user-friendly. Most patients (83%) reported no difficulties in using the Bluetooth equipment, however, a small fraction occasionally encountered Bluetooth connectivity disruptions (9%). Similarly, 85% reported no internet connectivity issues, with occasional issues reported by 12% of participants. The videoconferencing experience garnered positive feedback, with 91% rating it as 'excellent' or 'good'. These findings provide important evidence regarding the feasibility and acceptability of deploying virtual monitoring technology, even in rural and regional areas of Australia where mobile connectivity is reduced or compromised compared with the capital cities [27].

Qualitative feedback from parents of paediatric patients who lived in rural or remote areas indicated particularly high satisfaction with the model of care. Its primary benefits included allowing patients and their caregivers to return home much earlier than with conventional hospital stays and the familiarity and comfort of home care alleviated much of the typical stress and anxiety associated with hospitalisation, as evidenced by the following comments:

- "Cannot rate this service high enough. My child was so much happier being treated at home it made a massive difference in his recovery. Nurses were lovely."
- "The service was fantastic. It allowed our son to come home whilst still being on IV antibiotics when he otherwise would have had another 3 days in hospital."
- "A really great service and peace of mind as we live on cattle property not close to hospital."

The survey data yielded new insights concerning the perceived impacts and benefits of home-based admission on workforce participation. 45% of survey respondents reported having a designated caregiver while admitted to the virtual hospital. Among these caregivers, 30% reported needing to take time off from their own work responsibilities to attend to care for their friend or relative while they recovered at home. Specifically, 18% of caregivers took 1-10 hours off, another 18% took 10-20 hours off, and 64% took more than 20 hours off from their employment. While these figures may seem alarming, it is worth noting that 52% of

caregivers reported that they would have taken the same amount of time off if the patient had been admitted to a traditional hospital bed and a further 7% indicated they would have needed more time off if the patient had been admitted to a hospital bed as opposed to receiving treatment at home.

Survey respondents highlighted other financial advantages linked to the virtual hospital model. Approximately seven percent of patients and/or carers reported that they were able to continue to actively participate in paid employment whilst recovering at home. Among these, 30% reported engaging in work for 1-10 hours, while an equal percentage worked for between 10-20 hours and 40% were able to engage in more than 20 hours of paid employment during their HITH admission.

Finally, 99% of survey respondents reported that they did not encounter any unexpected out-of-pocket expenses related to the use of remote patient monitoring technology, such as additional data purchases. Only one patient reported incurring unexpected costs but these were relatively minor, with an estimated range between $0-30.

The study also captured clinician feedback on the virtual care model through a 22-question survey (Table 9). This survey focused on key areas including: the significance of remote patient monitoring data in clinical practice, confidence in the virtual hospital model, usability and perceived value of remote patient monitoring technology, safety considerations, and the influence of remote patient monitoring technology on their clinical approach and decision-making.

Overall clinician satisfaction with remote patient monitoring technology was high, with 77% of respondents reporting being 'mostly' or 'very satisfied' with their overall experience. 92% of clinical end-users who responded to the survey agreed that remote patient monitoring technology and telehealth consultations had demonstrably improved the management of HITH patients. More specifically, 77% reported that having frequent access to biometric and health survey data was important or very important for overall management of remotely monitored patients.

Clinicians were also asked to quantify the impacts of remote patient technology on operational efficiency. 85% of clinicians reported finding it 'easy' to onboard new patients to remote patient monitoring technology and 50% believed that there had been no unexpected time costs associated with the use the remote monitoring technology on their clinical practice. However, 17% expressed uncertainty about the impact, while 33% identified the technology as having a negative time-cost. This mix of positive and negative effects is consistent with findings from similar studies examining the impact of new technologies, such as electronic medical records, on clinician workload [28]. These studies have pinpointed the initial learning curve as a significant, yet typically transient, challenge affecting both patient care and workflow for some clinicians. Although not explicitly measured in this study, it's plausible to deduce that the workforce disruptions caused by the frequent furloughing and substitution of hospital staff during the peak of the pandemic [29] when our clinician survey was conducted might have impacted their familiarity with the technology. This, in turn, may have influenced perceptions regarding impacts on operational efficiency.

Crucially, clinical end-users did not report any incidents or cases of patient harm associated with the use of remote patient monitoring technology in HITH cohorts. This feedback is consistent with data obtained from the hospital incident management system, which was cross-referenced for completeness and found to contain no reports of clinical incidents associated with remote patient monitoring technology. Together these datasets provide important evidence for the safe integration of remote patient monitoring technology into HITH care models at Mackay Hospital and Health Service.

One of the most surprising findings from the clinician survey related to the perceived impact of the introduction remote patient monitoring on the behaviour of referring clinicians. Half of survey respondents reported that, following an awareness campaign to promote the introduction of remote patient monitoring technology in the HITH service, they had noticed a positive change in the likelihood of other hospital-based clinicians to refer a patient to the HITH service.

A recent study on clinician perceptions of patient safety in home healthcare by Shahrestanaki et al sheds light on why this change may have occurred [30]. Their research revealed that many clinicians view the home environment as considerably more dangerous and less predictable compared to traditional hospital settings, offering fewer opportunities for monitoring and managing the risk of deterioration. Furthermore, they identified that if clinicians perceive that processes for safe care of a patient at home

are not implemented properly, it can cause collective loss for all those involved including: patients and caregivers (preventable injuries/complications, stress, anxiety and out-of-pocket expenses), clinicians (stress, anxiety, complaints) and home care providers (lawsuits and increased cost of care). However, the presence of strategies to proactively monitor patients and identify and mitigate risks were seen as key to maintaining perceptions of a safe model of care. Although not able to be verified, it is possible that the introduction of remote patient monitoring technology, with its inherent capability to monitor symptoms and vital signs of patients at home, may have improved referring practitioner perceptions of the overall safety of the Hospital in the Home service model.

## DISCUSSION

Although a small pilot, this study demonstrates potentially large financial and non-financial benefits that could arise from embedding virtual care technology in HITH service models at scale. It also provides further evidence that technology-enabled 'virtual hospital' models appear to outperform usual HITH care in terms of reducing re-admissions, emergency department visits, and length of stay. The role that virtual care technology plays in delivering cost savings from the prevention of high-cost health events appears to be unique because of its dual influence on both patient and provider-related causes of preventable readmissions and ED presentations.

Providing HITH clinicians with more frequent access to quantitative observational data and qualitative symptom data appears to improve clinical decision-making in response to underlying trends and, in doing so, tackles the leading causes of provider-related preventable readmissions in the literature: poor resolution of the main problem during the index admission and unstable therapy at discharge [31]. By design, virtual care technologies incorporate a range of features that natively address patient-related factors in preventable readmissions and ED presentations, such as sub-optimal care plan adherence, poor health literacy, and self-management capability [32,33], through targeted nudging and real-time, continuous facilitation of feedback loops with established links to behaviour change [34].

Beyond empowering and educating patients, virtual hospital models appear to generate wider societal and health benefits stemming from increased workforce participation for both patients and their carers. Research indicates that participating in the labor force not only leads to economic benefits but also promotes higher levels of social inclusion. This, in turn, has been associated with lower mortality and morbidity, along with an enhanced quality of life [35]. These effects have important implications, not only for recovery and re-admission in the context of acute illness for HITH patients, but in the development of strategies to reduce caregiver strain associated with hospitalisation in traditional settings.

## CONCLUSIONS

Our findings suggest that there are clinical, economic and consumer benefits that arise from embedding virtual care technology in HITH service models that warrant consideration in health systems facing capacity constraints and rising costs. However, larger studies are needed to confirm whether these benefits are repeatable, particularly in paediatric populations receiving home-based acute care.

### AUTHOR CONTRIBUTIONS:

Brown, Cavanagh, Dorricott, Irving and LaRiviere had full access to all the data in the study and take joint responsibility for the integrity of the data and the accuracy of the data analysis.

### CONFLICT OF INTEREST DISCLOSURES:

Mackay Hospital and Health Service has a licensing agreement with Telstra Health to utilise MyCareManager Virtual Health Monitoring technology. James Brown, Brian Dorricott, and Vickie Irving are employed by Telstra Health. Cathie LaRiviere and Judi Cavanagh are employed by Mackay Hospital and Health Service and have no disclosures.

### ETHICS REVIEW:

Central Queensland Hospital and Health Service Human Research Committee (HREC) evaluated this quality initiatives (Project ID: 92467 17.01.2023) and determined that the proposal did not necessitate a comprehensive HREC review. The decision was based on the project's classification as non-research, involving existing data that exclusively comprises non-identifiable information about human subjects. Central Queensland Hospital and Health Service HREC noted the intent to publish.

**FUNDING/SUPPORT:**

Telstra Health was contracted by Queensland Health to supply remote patient monitoring software, hardware and related project implementation fees over the nine-month period of the pilot program. Telstra Health did not fund any costs associated with this research, outside of editorial and article processing fees.

**ROLE OF THE FUNDER/SPONSOR:**

Telstra Health-affiliated authors (Brown, Dorricott and Irving) were involved in the development of the program logic framework for evaluation, data synthesis, and data/statistical significance analysis in this study, however, none of the Telstra Health-affiliated authors played a direct role in any aspect of pilot implementation. Additionally, all three Telstra Health authors were unaware of any processes related to patient selection/consent, data collection/extraction, service model design, and clinical/technical project management. Cathie LaRiviere and Judi Cavanagh are employed by Mackay Hospital and Health Service and were responsible for various aspects of this study, including service model design, ethics approval, project management, patient and clinician experience survey development, data collection/extraction/deidentification, and clinical consultation-liaison. Neither of these authors have received any compensation or funding from Telstra Health to participate in this study.

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## FIGURES AND TABLES

**TABLE 1 – ELIGIBILITY & PATIENT EXCLUSION CRITERIA**

| Eligibility |
|---|
| All HITH patients meeting the following criteria were offered participation in virtual care technology:<br>• Has provided written consent to participate in the program.<br>• Is admitted to the HITH Service and resides within the designated geographic catchment (40km/40 min drive from Mackay Base Hospital).<br>• Is physically able to apply and use virtual care equipment or has a carer who is physically able and consenting.<br>• Is deemed competent (by the Virtual Health Program Officer) in the use of the virtual care mobile application.<br>• Acknowledges (via written consent) that the clinician triage dashboard is only actively monitored at set intervals during business hours (0800-1630hrs), and after-hours ad-hoc vital signs will not be reviewed/acted upon, unless the patient contacts the Mackay HITH Coordinator with clinical concerns.<br><br>**Exclusion Criteria**<br>• Non-English-speaking patient who does not have an English-speaking family member/carer in residence to assist with using virtual care technology.<br>• Patient assessed as not competent to use virtual care software application and/or connected medical devices.<br>• Patient with cognitive impairment(s) and who does not have a competent/willing carer.<br>• Patient with visual impairment and who does not have a competent/willing carer.<br>• Patient who does not have access to the internet in their usual place of residence or whose access is unreliable. |

HITH = Hospital In The Home.

Of the 354 patients admitted to the HITH program during the study period, 58.2% (n=206) were enrolled in virtual care technology. The 148 that were not enrolled were deemed to be not appropriate due to a range of factors, including patient confidence/competence/willingness to utilise technology, suitability, feasibility (brief admission), health service resourcing constraints, technology availability, or other factors, as outlined in Table 3.

**TABLE 2 – UPTAKE OF VIRTUAL CARE TECHNOLOGY**

| *Measure* | *Total* |
|---|---|
| Accepted to HITH | **354** |
| Onboarded to virtual care technology | **206** |
| % of patients using virtual care technology | **58.2** |
| No. of adult patients onboarded to virtual care technology | **177** |
| No. of adult patients suspended but recommenced virtual care technology | **6** |
| No. of paediatric patients onboarded to virtual care technology | **26** |
| No. of paediatric patients suspended but recommenced virtual care technology | **8** |
| No. of virtual care technology admissions excluded from analysis* | **26** |

HITH = hospital in the home.

**TABLE 3 – REASONS FOR NON-ENROLMENT IN VIRTUAL CARE TECHNOLOGY**

| Reason for non-enrolment | Proportion (of those not onboarded) |
|---|---|
| Logistical factors (administrative) | 28% |
| Excluded – no suitable device | 14% |
| No clinical indication for virtual care technology | 12% |
| Patient did not consent | 11% |
| Excluded – patient not comfortable with technology | 10% |
| Excluded – patient impairment/disability | 9% |
| Other | 8% |
| Excluded – home situation | 3% |
| Excluded – internet reception | 3% |

*A further reduction of the cohort size was performed because

(a) there were a number of admissions that were identified as having commenced the program *after* the cut-off period of 30 June 2021.

(b) two HITH admissions were for dialysis and were subsequently excluded.

(c) 15 virtual care technology admissions were excluded from the analysis after clinical review of the 'withdrawal' list with Mackay Hospital staff as it was identified that they had withdrawn consent to participate after being onboarded or did not actually use the technology during the HITH admission after being onboarded.

**TABLE 4 – PATIENT POPULATION AND CHARACTERISTICS**

| Key statistics | Virtual care technology HITH admissions | HITH 'usual care' admissions |
|---|---|---|
| **Total admissions** | 177 (55%) | 142 (45%) |
| Adult | 151 | 134 |
| Paediatric | 26 | 8 |
| **Gender (count)** | | |
| Male | 93 (53%) | 90 (63%) |
| Female | 84 (47%) | 52 (37%) |
| **Average age (years)** | | |
| Adult | 55 | 67 |
| Paediatric | 6 | 6 |
| **Case mix** | | |
| DRG types | 88 | 76 |
| Major complexity DRGs | 37.1% | 30.6% |
| Intermediate complexity DRGs | 49.7% | 51.5% |
| Minor complexity DRGs | 11.3% | 16.4% |
| z-code DRGs | 2.0% | 1.5% |

DRG = diagnosis-related group; HITH = hospital in the home

**TABLE 5 – AVOIDED AMBULANCE CALLOUT COSTS**

| Cost data | Cost ($) |
|---|---|
| Avg cost per callout – *basic transfer (no paramedic)* ^ | $130 |
| Avg cost per callout – *paramedic transfer* ^ | $830 |
| Average cost per callout | $480 |

^Source: BROLGA. Data supplied by Healthcare Improvement Unit, Queensland Health June 2020.

**TABLE 6 – AVOIDED HOME VISIT COSTS**

Where a home visit is avoided, the clinician will not only experience a time saving/efficiency benefit for the consultation but also for the time taken to travel to and from the patient's home. The methodology for calculating travel time savings is presented below.

**A) Clinician travel time savings**

| Clinician travel time savings methodology |
|---|
| Travel time savings = average travel time x number of trips (avoided/substituted) x value of time |
| Average travel time = (average distance from hospital x 2) / average travel speed = 50 minutes |
| Average travel speed = 60km/hr (urban roads/motorways) |
| Average distance from hospital = 15 km (30 km return) - Based on 1 week sample data collected by HITH clinical team |
| RN Level 6 Qld 2020 hourly wage rate $46.88 |
| Value of clinician travel time = 50 mins = 0.83 x RN level 6 hourly wage = $38.90 |

**B) Vehicle operating cost savings**

Vehicle operating cost savings are another benefit associated with avoided home visits. Where a patient's incident is resolved through an alternative response that does not require travel by either the clinician or the patient, the costs associated with operating a vehicle such as fuel, oil, tyres, and repairs and maintenance are reduced compared to the baseline.

| Vehicle operating cost savings methodology |
|---|
| • Total vehicle operating cost savings = average travel distance x avoided trips x VOC per km<br>• VOC = $0.42 per km (assuming an average travel speed of 60 km per hour) based on ATAP Guidelines PV2 Road Parameter Values (2016), inflated to 2020 prices.<br>• Average distance = 16 km (32 km return)<br>• Average VOC per home visit = $13.44<br>• **Total home visit cost** = value of clinician travel time + average VOC per home visit **= $38.90 + $13.44 = $52.79** |

VOC = vehicle operating cost.

**TABLE 7 – INCIDENCE OF ADULT AND PAEDIATRIC HOSPITAL EVENTS**

| Key statistics from pilot | MCM pilot participants | HITH 'usual care' patients |
|---|---|---|
| **Adult admissions** | | |
| HITH all cause readmissions | 31 (21%) | 57 (43%) |
| HITH same-DRG readmissions (subtotal) | 6 (4%) | 24 (18%) |
| % Reduction in all-cause risk of readmission within 28 days | 51.7% | - |
| % Reduction in same-DRG risk of readmission within 28 days | 77.8% | - |
| # of avoided readmits associated with reduction in all-cause risk of readmission | 33 | - |

| Key statistics from pilot | MCM pilot participants | HITH 'usual care' patients |
|---|---|---|
| **Paediatric admissions** | | |
| HITH all cause readmissions | 3 (12%) | 1 (13%) |
| HITH same-DRG readmissions (subtotal) | 1 (4%) | 1 (13%) |
| % Reduction in all-cause risk of readmission within 28 days | 7.7% | - |
| % Reduction in same-DRG risk of readmission within 28 days | 69.2% | - |
| # of avoided readmits within 28 days | <1 | - |
| **All admissions** | | |
| Avoidable readmissions – ACSQHC defined* | 0 | 0 |
| **Emergency department presentations** | | |
| % reduction in risk of transfer-in from home ward to inpatient ward compared to usual HITH care | 11.3% | |
| # of avoided transfers-in from home to inpatient ward | <1 | |
| # ED presentations during HITH admission | 5 out of 151 (3.3%) | 5 out of 134 (3.7%) |
| % reduction in ED presentations during HITH admission | 11.3 % | |
| # of avoided ED presentations during HITH admission | <1 | |

DRG = diagnosis-related group; ED = emergency department; HITH = hospital in the home.

**TABLE 8 – PATIENT EXPERIENCE DATA**

| Key patient experience findings | | | | | |
|---|---|---|---|---|---|
| Overall, how satisfied were you with the care from the Mackay Base Hospital in the Home Virtual Care Service | very satisfied (91%) | mostly satisfied (6%) | neutral (0%) | not very satisfied (1%) | very unsatisfied (2%) |
| How did you find the MyCareManager (MCM) application to use? | very easy (61%) | easy (33%) | neutral (4%) | difficult (1%) | very difficult (1%) |
| Overall, how did you find the equipment to use? | very easy (66%) | easy (28%) | neutral (4%) | difficult (2%) | very difficult (0%) |
| **Other patient experience findings** | | | | | |
| Comfort having observations remotely monitored: 96% very comfortable or comfortable | | | | | |
| Confidence to self-manage condition at home using MCM: 97% very confident or fairly confident | | | | | |
| Any difficulties using equipment: 83% no difficulties | | | | | |
| Support to self-manage condition at home using MCM: 99% very supported or fairly supported | | | | | |
| Preference to be monitored at home in future: 80% definitely or probably would; 12% do not have a particular preference | | | | | |
| Videoconferencing experience: 91% excellent or good | | | | | |
| Bluetooth connectivity: 70% of patients had no issues with Bluetooth; 9% sometimes or occasionally had connectivity issues; 12% did not use Bluetooth equipment | | | | | |
| Internet connectivity: 85% of patients had no issues with connectivity; 12% sometimes or occasionally had connectivity issues | | | | | |
| Workforce participation during HITH RPM: 7% patients participated in the paid workforce during HITH admission while using the remote patient monitoring technology | | | | | |

| Key patient experience findings |
|---|
| • 30% of these patients worked 1-10 hours during their HITH admission<br>• 30% of these patients worked 10-20 hours during their HITH admission<br>• 40% of these patients worked more than 20 hours during their HITH admission<br>Financial Impacts of HITH RPM: 99% patients did not experience unexpected out-of-pocket costs associated with using the remote patient monitoring (e.g. purchasing extra data).<br>• 1 patient reported experiencing unexpected costs associated with RPM ranging between $0-30<br>HITH impacts on Caregiving:<br>• 45% RPM patients reported having a carer during HITH admission<br>• 30% of carers had to take time off work to care for the patient during HITH admission<br>• 18% carers took 1-10 hours off work<br>• 18% carers took 10-20 hours off work<br>• 64% carers took more than 20 hours off work<br>• 52% carers would have taken the same amount of time off if the patient had been admitted to traditional hospital bed<br>• 18% would have taken less time off if the patient had been admitted to hospital<br>• 7% would have taken more time off if the patient had been admitted to hospital |

MCM = MyCareManager.

There was a 75% response rate (n=133/177) to the patient experience survey.

**TABLE 9 – CLINICIAN EXPERIENCE DATA**

| Key clinical experience findings | | | | |
|---|---|---|---|---|
| 'Please rate the impact that having access to ____ had on the interaction you had with HITH patients during home visits'. | | | | |
| Quantitative (biometric) data | 77% very positive impact | 15% somewhat of a positive impact | 0% Somewhat negative, very negative, & no impact | 8% N/A – I did not do any home visits |
| Qualitative (health survey / symptom) data | 62% very positive impact | 31% somewhat of a positive impact | 0% Somewhat negative, very negative, & no impact | 8% N/A – I did not do any home visits |
| **Other clinician experience findings** | | | | |
| • **92%** believed that MyCareManager and Telehealth consultations has **enabled improvement in** the management of HITH patients.<br>• **85%** of those that onboarded patients, found it '**easy' to onboard new patients** onto the platform<br>• **77%** found it moderately or very **important to have access to data** (both frequent biometric and health survey) for the overall management of HITH patients<br>• **77%** were mostly or very **satisfied with the overall experience** using the care model<br>• **50%** observed a positive change in the likelihood of clinicians to refer a patient to the HITH service. The remainder were unsure or observed no change.<br>• **50%** believed there have been no unexpected time costs to use the remote monitoring technology (17% unsure) | | | | |

HITH = hospital in the home; MCM = MyCareManager.

Survey included 22 questions covering broad themes: importance and impact of data, confidence in model of care, level of ease, value of MCM, incident management & behavioural change. Responses (n=14) to clinician surveys from 11 nurses, 1 allied health practitioner, and 2 medical officers.