A pragmatic randomized controlled trial of a cardiac hospital-to-home transitional care program in a Singapore academic medical center

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Abstract

Background: This study reports on a pragmatic, randomized controlled trial of a standardized cardiac hospital-to-home transition care program (CareHub) at a major Asian academic center. CareHub, in Singapore's National University Hospital, merged an assortment of existing transitional care services to protocolize post-discharge patient encounters with the goal of improving patient monitoring and containing costs.

Methods: We evaluated CareHub using a pragmatic, randomized controlled trial. Study population: all eligible cardiac patients admitted between July 2016 to November 2016, during the pilot. Patients were followed for 6 months post-discharge. *Primary outcomes other than emergency department (ED) visits were all cardiac-related*: number of readmissions, specialist visits, ED visits, and total days readmitted. Secondary outcomes: variables related to quality of life and transitional care. Regression analyses were used to estimate the intent-to-treat effect of CareHub and explore treatment heterogeneity.

Results: CareHub reduced the mean number of unplanned readmissions by 0.23 (39% reduction relative to control mean of 0.60 unplanned readmissions, $p<0.05$), mean number of all readmissions by 0.20 (31% reduction relative to control mean of 0.63 readmissions, $p=0.10$), mean number of total unplanned days in hospital by 2.2 (56% reduction relative to control mean of 4.0 days, $p<0.05$), mean number of total days in hospital by 2.0 (42% reduction relative to control mean of 4.3 days, $p<0.10$). Treatment effects varied by pre-admission health and socio-economic status. We find evidence that CareHub improved patients' quality of life and achieved net cost savings.

Conclusion: A carefully designed protocolized cardiac hospital-to-home transition program can reduce resource utilization while improving quality of life.

Trial registration: ClinicalTrials.gov ID NCT03353155 (retrospectively registered)

Keywords: Transitional Care, Patient Discharge, Cardiac, Pragmatic Randomized Control Trial

Background

Rehospitalizations are common in healthcare. On average, almost 20% of Medicare beneficiaries discharged from a hospital were readmitted within 30 days from 2003 to 2004,[1] In Singapore, the 30-day readmission rate was approximately 11% in 2017.[2] They are costly for hospitals and patients and a substantial percentage are preventable,[3] partly because hospital-to-community transitions are often unmanaged or poorly managed.[4-6] To reduce unplanned readmissions and costs, hospitals worldwide (including those in the United States[7] and Singapore have implemented transitional care programs (TCPs).[8] However, TCP effectiveness can greatly vary,[9-18] due to implementation challenges. As more hospitals adopt TCPs, which are resource intensive, the need to measure program effectiveness becomes more important and understanding the sources of variation can facilitate improvement efforts.

In this study, we conducted a pragmatic randomized, controlled trial[19] to evaluate the effectiveness of a new nurse-practitioner-led TCP called CareHub, piloted in Singapore's National University Hospital (NUH). CareHub merged existing TCPs by offering a protocolized 'one-stop shop' for post-discharge patient follow-ups. We measured a comprehensive set of primary outcomes on healthcare services utilization, and an extensive list of secondary outcomes, including patients' quality of life and quality of transitional care.

Contribution

This study is among the few that utilized a randomized control trial of a post-discharge service to prospectively measure program effectiveness. Most program assessments are conducted after they are implemented, which may result in biased estimates. We built the program evaluation process into the service delivery model and show that an organization design focused on coordinating existing post-discharge program elements can have additional and dramatic (up to

50% reductions) effects on readmissions rates and lengths of stay, and strongly suggestive evidence of improvements in patients' quality of life. These outcomes were associated with significant cost avoidance. Organization theory explains why coordination increases the effectiveness of individual program features like phone calls to patients. In short, the costs of coordination are relatively low, compared to the costs of readmissions and extended lengths of stay.

Theory and Hypotheses

The literature has focused on the introduction of transitional care programs into settings without existing transitional care. Whether further gains can be made by attempts to improve existing programs (e.g. the Care Transitions Intervention[20]) remains understudied. In this study, we hypothesize that additional efficiencies can be extracted from the better coordination of service bundles across programs. Research has shown that organizational coordination can improve efficiencies by improving decision making transparency, closing knowledge gaps, identifying sources of inefficient resource use, and increasing governance accountability.[21] Hence, we hypothesize that hospitals with existing transitional care programs will experience improvements in efficiency and effectiveness because of additional integration and coordination across departments. We further posit that one-stop post-discharge programs like CareHub are natural extensions to the increasingly popular movement toward multidisciplinary chronic case management programs such as Medicare Health Support (MHS).[22, 23]

Research has also shown that the bridging of current gaps may lead to the formation of new ones.[24] Therefore, when new transitional care programs are introduced, for example for new sub-groups, such as the elderly, or disease conditions, new gaps may be created by the increased complexity of the transitional care landscape at the hospital. With increasing interest in TCPs,

different departments within a hospital may implement their own TCPs. Therefore, we hypothesize that program effectiveness overall will increase with the added coordination and integration across programs.

Methods

CareHub versus Usual Care

We summarise the differences between CareHub (intervention) and usual care (control) in Table 1. Usual care patients can be enrolled in one or more existing post-discharge services that operate independently of each other (e.g. care-coordination, home care, telemonitoring). CareHub patients deal with a single point of contact at the hospital whereas usual care patients might encounter several. CareHub oversees all post-discharge services offered to the patient, removes clinician discretion in enrolment, coordinates workflow across healthcare providers through systematic and regular multidisciplinary meetings, actively involves pharmacists and nurses in inpatient medication education, based on a comprehensive needs assessment, systematically monitors and resolves emerging medical issues during telephone follow-ups, and provides a call centre with access to doctor consults.

[Table 1 about here]

Study Population and Randomization

Patients were enrolled between July 2016 and November 2016, during a planned operational test-run of CareHub, and followed up for 6 months. The pilot included patients who (i) were admitted into the Cardiology wards through the Emergency Department (ED), (ii) qualified for government subsidies of more than 50% (ward-classes B and C), and (iii) recorded an ACE risk-score (derived from the LACE index) of nine or more, based on the number of existing co-morbidities and ED visits in the preceding six months [25, 26]. We excluded the 'L' (length-of-

stay) in the LACE because CareHub patients are enrolled at admission whereas 'L' is determined at discharge.

Non-residents and patients returning to institutionalized care after discharge were excluded. Non-residents such as tourists are a tiny proportion of NUH's patient population, and being transient, did not receive follow up. Patients returned to institutionalized care were not followed up by NUH. Since CareHub was provided for free as part of NUH's care plan, patients did not explicitly opt-out of the service, though they could reject any service component at any point.

As resources designated for the pilot program were insufficient for serving the entire target population, CareHub assignment followed a pragmatic randomization procedure. All patients that met the inclusion criteria were assigned to CareHub or usual care (control) during the study period. To balance day-to-day operational loads, NUH's IT system automatically generated an alphabetically-ordered list of newly eligible patients. Alternate patients on the list, starting with the first patient on each day's list, were then assigned to CareHub. In all, 270 patients were enrolled in the study with 150 in CareHub, and 120 controls. Assignment was not blinded, as providers had to know which patient was receiving case under CareHub while patients had to be briefed on the program if there were in CareHub.

Data sources

Our data comes from three sources: National University Hospital's (NUH) administrative data, National Healthcare Group's (NHG) administrative data (the regional network of community hospitals and outpatient clinics anchored by NUH), and patient surveys. NUH provided data on patient demographics and healthcare utilization six months before and after patients' index admission. We used these data to analyse patients' outcomes and compute CareHub's cost-effectiveness. NHG's data included information on patients' utilization of the community hospitals

in 2016. Due to restrictions, these data did not cover the full follow-up period, and could only be used for robustness checks. Finally, to complement the primary outcome measures in the administrative data, we conducted a patient survey, six months after enrolment ended. This survey collected data on quality of life and transitional care (see supplementary materials). The response rate was 28% (76 patients, 33 from CareHub).

Outcome Measures and Covariates

Our primary outcomes are observed in the six-month follow-up period, and focused on the utilization of services in NUH. They include the number of all/unplanned cardiac-related readmissions, total number of days spent in all/unplanned cardiac-related readmissions, number of cardiac-related specialist outpatient clinic (SOC) visits, and number of emergency department (ED) visits. These variables take the value 0 if patients were not readmitted or did not make any visits in the 6 months after the index admission (e.g. "total days spent in readmissions" includes patients who were not readmitted). Secondary outcomes include survey data on quality of life and transitional care. More details of the secondary outcome measures are provided in the supplementary materials.

Statistical Analyses

Main analyses. Randomization allowed an unbiased estimate of the intent-to-treat effect of CareHub. We recover only the intent-to-treat effect, not the average treatment effect, as patients can reject services by CareHub. We used ordinary least squares (OLS) regression with heteroskedasticity-robust standard errors to estimate the effect of CareHub on the primary outcomes. Full regression specifications are in the supplementary materials. The key treatment covariate is a binary variable "CareHub" that takes value 1 for CareHub patients. To control for small observed differences in a few baseline characteristics between patients in both arms (see

Results section and Table 2), we adopted a conservative approach and included our full set of baseline characteristics as covariates. These covariates are:

(i) demographics: gender, age, square of age, ethnicity, marital status, month of index admission, and ward-class, which contains information on socio-economic status as government subsidies are scaled by ward-class,

(ii) existing co-morbidities, and

(iii) baseline healthcare utilization at NUH, which contains information about patients' physical health and social needs that are captured by frequent readmissions due to the lack of caregivers or self-care at home. Covariates on baseline healthcare utilization include the number of inpatient visits, total number of days spent in inpatient stays, number of SOC visits, and number of ED visits in the six months preceding their index admission.

We performed sensitivity analyses that included different subsets of the covariates using OLS, and Cox proportional hazards regression, including a model free of covariates except the main treatment variable "CareHub". Our results are generally robust to the sensitivity checks. Details are reported in the supplementary materials.

To analyse the effect of CareHub on outcome variables related to quality of life and transitional care from the survey data, we used both ordered logistic regressions and t-tests. Results from both were similar. We did not include the control covariates previously mentioned when analysing these outcomes, due to the small sample size of the survey (details in supplementary materials).

Subgroup analyses. We hypothesized that CareHub would be most effective for patients with more health problems and/or social needs, given the interaction between social and health-related

factors. Hence, we conducted additional exploratory analyses of CareHub's impact on healthcare utilization across different patient subgroups.

To study whether effects vary by baseline health and social needs, we added the following interaction term into the main regression: "CareHub" × total number of inpatient days for each patient in the six months before index admission. Similarly, we examined differences in socio-economic status, gender, and age by interacting "CareHub" with "Ward C", "Female", and "Age". "Ward C" and "Female" are binary variables that take value 1 if the patient was admitted to a C-class (the most heavily subsidized) ward or female, respectively. As there was no theoretical rationale for interactions between the covariates, each heterogeneity analysis was conducted independently (i.e. only one interaction term was added to each regression). The values of interest are the coefficients of the interaction terms. A negative coefficient for implies that CareHub has a larger effect on patients with larger values of these variables. E.g., a negative coefficient for "CareHub" × Ward-C implies that CareHub may lead to greater reductions in utilization for C-class ward patients.

Results

Summary Statistics and Balance Checks

Balance tests show CareHub and control patients were similar in demographics, co-morbidities, and pre-index hospital utilization (Table 2). Differences between a few characteristics were statistically significant, but the absolute differences, standardized by variances, were small (less than 0.3). While these differences are small, we adopted a conservative approach and included observed baseline characteristics as covariates in our main analyses to control for these relatively small imbalances in a few baseline characteristics. Our results are generally robust to excluding these covariates (see supplementary materials).

[Table 2 about here]

Primary Outcomes

Table 3 reports the effect of CareHub on the primary outcomes in the model, which measured cardiac-related utilization (except the number of Emergency Department visits, which could not be classified). These estimates come from a regression that includes baseline covariates for demographics, co-morbidities, and pre-index-admission hospital utilization (see Technical Appendix for full regression results). In general, CareHub appears effective in reducing cardiac-related readmission outcomes in the six months after enrolment. This effect is strongest for unplanned, cardiac-related readmissions. All results are robust to sensitivity analyses with different sets of covariates, including one using only the CareHub variable as a covariate (see supplementary materials).

[Table 3 about here]

CareHub reduced unplanned, cardiac-related readmissions by 0.23 readmissions ($p<0.05$, 95% CI [-0.46, -0.0096]). In other words, compared to patients under usual care who experienced 0.60 unplanned readmissions on average, CareHub patients experienced 39% fewer unplanned, cardiac-related readmissions on average (Column 1, Table 3: -0.23 ÷ 0.60 = -39%). CareHub's effect on all (planned and unplanned) cardiac-related readmissions was very similar, which is a reduction of 0.20 readmissions ($p=0.10$, 95% CI [-0.43, 0.038] translating to 31% fewer readmissions than patients under usual care, who experienced 0.63 readmissions on average. The total number of unplanned, cardiac-related days spent in hospital were reduced by 2.2 days ($p<0.05$, 95% CI [-4.45, -0.034]; 56% lower than usual care), while the total number of all (planned and unplanned) cardiac-related days spent in hospital fell by 2.0 days ($p<0.10$, 95% CI [-4.35, 0.32]; 47% lower than usual care).

The fall in number of cardiac-related days spent in hospital can be attributed to three sources: fewer patients being readmitted, fewer readmissions amongst those readmitted at least once, and fall in length of stay per readmission. Our decomposition analysis shows that these three sources contributed about 29%, 46%, and 25% to the total effect, respectively (see Supplementary Materials).

Lastly, there is no evidence of any change in cardiac-related outpatient specialist visits (p=0.39, 95% CI [-0.43, 1.08) or emergency department visits (p=0.75, 95% CI [-0.50, 0.36]).

Heterogeneous Treatment Effects

NUH hypothesized that CareHub would be most effective for patients with more health problems and/or social needs, as they would probably benefit more from better planned care transitions. Consistent with that notion, our exploratory analyses show that CareHub's effects on cardiac-related readmission outcomes appear larger for patients who spent more days in the hospital prior to the index admission and patients who stayed in C-class wards. CareHub's effects did not vary by gender or age (Table 4).

Panels A and B report heterogeneous effects by the total number of days each patient spent in hospital prior to index admission and ward class, respectively. The coefficients of interest are negative across all the outcome variables, and statistically significant for the number of all cardiac-related admissions and unplanned cardiac-related readmissions. This suggests CareHub disproportionately reduced cardiac-related readmission utilization for those with greater pre-existing health/social needs and for those of lower socio-economic status. In other words, CareHub worked best for the population it intended to serve.

Panels C and D suggest that CareHub's impact did not vary by gender or age: the coefficients of interest are statistically insignificant, and inconsistent in sign across the outcomes studied.

[Table 4 about here]

Secondary Outcomes: Survey Results

The selected survey results in Table 5 suggest that CareHub improved quality of life and transitional care (see Supplementary Materials and Technical Appendix for full results and details). While our estimates are not sufficiently precise to achieve statistical significance for many survey outcome variables, the direction of the estimates consistently suggest that CareHub improved quality of life and transitional care. The strongest effects were in areas that CareHub was designed to address. CareHub patients reported lower anxiety/depression (odds ratio = 3.2, $p< 0.05$, 95% CI [1.28, 8.00]), were more likely to know who to contact for help at NUH (odds ratio = 2.6, $p<0.05$, 95% CI [1.07, 6.44]); were more satisfied with the hospital's follow-up care (odds ratio = 3.6, $p< 0.01$, 95% CI [1.37, 9.24]), and were less likely to run out of medication (odds ratio = 4.33, $p< 0.10$, 95% CI [0.80, 23.37]).

[Table 54 about here]

Discussion

Our study is subject to some limitations. Healthcare utilization data came only from NUH, which might bias our estimates if there was significant non-NUH utilization. Using 2016 data from the National Healthcare Group, which includes other public hospitals geographically closest to NUH, we find that the proportion of non-NUH utilization for CareHub and control patients were similar before index admission, while the proportion of non-NUH utilization fell for CareHub patients after admission to CareHub. This implies that our results (using NUH data) likely *under*estimated the true effect of the program. (Details and elaboration in supplementary materials.)

We did not account for deaths as a competing risk in our study due to data limitations. However, this is unlikely to affect our conclusion that CareHub reduced readmissions. This is because transitional care has the potential to reduce deaths.[10] If more deaths occur among usual care patients, hospital utilization among these patients would be underestimated to a greater extent as compared to the CareHub group. This implies that the magnitude of CareHub's effect we estimate is likely to be a lower bound (because we are comparing mean utilization in the CareHub group to a control group mean that is likely to be lower than it should have been).

Our survey results and heterogeneity analyses are only suggestive, due to the small sample (for surveys) and lack of *ex-ante* stratification (for heterogeneity). However, the consistency of the direction of the effects, coupled with the fact that the strongest improvements are in areas CareHub was designed to address, strongly suggests that CareHub's effects in these analyses are real (see Supplementary Materials and Table 4).

The number of outcome variables we measured, and heterogeneity analyses we perform may lead to concerns about multiple comparisons. To alleviate these concerns, we report all analyses we conducted, either in the main paper or supplementary materials. Our analyses *consistently* suggest that CareHub improved outcomes, with the strongest improvements among the patients CareHub was designed to address. Our reported improvements are thus unlikely to be statistical artefacts. Finally, our study was not blinded as it was not feasible in this pragmatic trial.

Our survey results, interviews with NUH healthcare staff, and a comparison of CareHub's features with those of other successful transitional care / care-coordination programs[16, 17, 27] suggest possible mechanisms that explain CareHub's effectiveness.

First, CareHub enrolled patients using a risk scoring tool, rather than clinician referrals. The more systematic recruitment process increased the odds that CareHub recruited patients that needed the program most.

Second, CareHub adopted protocols to improve communication among the relevant providers. CareHub's protocol mandated that the multidisciplinary team meet regularly (daily when the patient was in the hospital and weekly after discharge) to discuss each case. Before CareHub, providers only shared information whenever they felt it was necessary. The communication protocol reduced the risk of missed crucial information.

Third, post-discharge patient monitoring was protocolized, relative to usual care. CareHub's telephone follow-ups used structured checklists to check on patients' symptoms and medication compliance. A telephone line in the call center was dedicated to CareHub patients so they had a single number to call with questions or to report medical problems. Responses to patients' queries were also protocolized, so that patients' queries were directed to the correct personnel (e.g. doctors) for quick action. Interviews with CareHub staff and our survey results suggest that these practices improved medication compliance.

Implications

The extant literature has focused on the introduction of transitional care programs into settings without existing transitional care. Whether further gains can be made by attempts to improve existing programs (e.g. the Care Transitions Intervention [20]) remains understudied. Our results provide some answers to this question. First, hospitals with existing transitional care programs should continue to look for ways to increase efficiency and effectiveness by integrating and coordinating such programs, especially if they live in separate departments in the hospital. In fact, one-stop shop post-discharge programs like CareHub are a natural extension to the

increasingly popular movement toward multidisciplinary chronic case management programs such as Medicare Health Support (MHS) [22, 23]. Substantial improvements in patient outcomes may still be had by refining existing transitional care practices in the hospital.

A second insight from our study echoes Cook et. al.'s comment that bridging current gaps may lead to the formation of new gaps in care [24]. In our setting, the introduction of transitional care programs for different, but sometimes overlapping, groups of patients may have opened new gaps, as they increased the complexity of the transitional care landscape in the hospital. These gaps made coordination between programs difficult, so that patients often found themselves falling between the boundaries where such programs did not serve. The effectiveness of CareHub may partially be due to its ability to bridge these gaps (e.g., enrolment into these programs were all routed through the CareHub coordinator). With the increased interest in transitional care programs, different departments within a hospital may start to implement their own transitional care programs. Ensuring that they operate in a coordinated fashion is likely to improve patient outcomes and minimize waste.

Conclusions

CareHub was effective in reducing hospital utilization. Sub-group analyses suggest that it was most effective among patients with more complex health and social needs. This is consistent with past findings in the literature.[27-30] The net savings from reduced hospital utilization in the 6 months after index admission, after accounting for costs, was about US$146,000 (conversion rate as of Nov 2017) or US$973 per enrolled CareHub patient. (Total net savings were computed as follows: (total number of rehospitalization days saved due to CareHub × standard NUH costing norms for different ward classes) – (operational and start-up/fixed costs of CareHub)). Our agreement with NUH does not allow us to reveal the actual costing norms for each ward type. Per-

patient net savings were computed by taking the total net savings and dividing them by the 150 patients in CareHub.) This is likely to underestimates the true savings, as the computation of fixed operational costs included patients outside the study period, and as reduced readmissions among CareHub patients may continue beyond the six-month follow-up period. Our survey results also suggest that CareHub reduced anxiety/depression, improved transitional care quality, and reduced the likelihood of patients running out of medicine.

We note that these improvements occurred in a setting where TCPs already exist, suggesting that additional value can be extracted in healthcare systems with existing TCPs, through the continual identification and closure of service and process gaps. Our results also suggest that gains from program coordination are particularly important as post-discharge care programs become more popular. TCP proliferation may improve outcomes, but also increase care fragmentation, which can be bridged by improving care-coordination.

Abbreviations

NUH: National University Hospital

NHG: National Healthcare Group

Declarations

Ethics Approval and consent to participate

Singapore's National Healthcare Group's Domain-Specific Review Board approved our protocol (DSRB# 2016/00522). The trial was retrospectively registered in ClinicalTrails.gov (ID# NCT03353155). Consent for the use of administrative data was waived. Informed consent was sought for the survey, but not CareHub participation, as CareHub was part of a planned NUH quality improvement program.

Consent for publication

Not applicable

Availability of data and materials

The authors used restricted-access data for this study. Researchers wishing to replicate this study can approach the authors for contact details of the staff member at the National University Health System whom the authors liaised with for data access.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Yanying Chen, Yi Jin Tan, Jessica Sun, Phil Phan designed the study and measurement instruments, and wrote the first draft. Yanying Chen, Yi Jin Tan, and Jessica Sun managed the research process and conducted the data analysis. Cheng Zhan Chua and Shing Hei Wong managed the consent taking, survey interview, and data collection processes. Cheng Zhan Chua, Shing Hei Wong, Jeffrey Yoo, Helen Chen, and John Wong aided in the interpretation of the results and contributed to subsequent drafts. All authors approved the final draft for submission.

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