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Original Study

A Multidisciplinary, Community-Based Program to Reduce Unplanned Hospital Admissions

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A B S T R A C T

Objectives: To evaluate the effect of Hospital Admission Risk Program (HARP) on unplanned hospitalization, bed days, and mortality of enrolled individuals and to evaluate the cost-effectiveness of HARP.
Design: A retrospective longitudinal analysis of hospital administrative data.
Intervention: Individuals at risk of hospitalization were provided with multidisciplinary, community-based care support managed by care coordinators including integrated care planning, education, monitoring, service linkages, and general practitioner liaison over 6-9 months.
Setting and Participants: Individuals who were enrolled into 1 of 8 HARP chronic disease management programs between July 1, 2017, and June 30, 2018, at the Royal Melbourne Hospital, Australia.
Methods: Hospital admissions between 18 months before and 18 months after HARP enrollment were analyzed. Total hospital costs were compared between 18 months before and 12 months after HARP enrollment.
Results: A total of 1553 individuals with a median age of 71 years (interquartile range 60-81), 63.4% males, were admitted to HARP. Both unplanned hospitalizations and bed days were reduced during the HARP intervention compared to within 3 months before enrollment in each of the HARP management programs. After the HARP intervention, cardiac coach, cardiac heart failure, chronic respiratory, diabetes comanagement, and medication management programs had higher hospitalizations and bed days than individuals' baseline of at least 3 months before HARP enrollment. Individuals in cardiac heart failure and chronic respiratory management programs had a higher mortality rate than other HARP chronic disease management programs. Individuals in cardiac coach, diabetes comanagement, and medication management programs had lower hospital costs during the HARP intervention compared to within 3 months before HARP enrollment.
Conclusions and Implications: HARP reduced unplanned hospitalization and bed days but did not return individuals' hospital use to baseline before the intervention. The variations in mortality between HARP chronic disease management programs implies that condition-specific goals between programs is preferable.

Over the last decade, the incidence of rehospitalization has been steadily increasing in developed countries[1] because of an increasing life expectancy and number of chronic conditions.[2] In England, almost half the annual National Health Service financial expenditure has been put toward acute hospital care.[3] In Australia, more than 60% of the hospital-based health care budget is dedicated to chronic conditions related inpatient services.[4,5] Approximately 45% of all potentially preventable hospitalizations are related to chronic conditions,[6] which significantly impacts the quality of life of the affected patients. Therefore, reducing avoidable hospitalization associated with chronic conditions has become one of the major priorities of policy makers in order to relieve hospital burden.[7]

Integrated care improves chronic disease self-management, quality of life, and subsequently reduces hospital readmissions and

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mortality because of the core principle of care coordination between the hospital and primary health care providers, and facilitates timely and effective continuity of care for individuals.[8,9] Most programs are disease specific and involve 1 or a combination of interventions such as patient education, case management, medication reconciliation, home visits, and telephone follow-up.[10–12] Programs with multiple interventions, individualized care delivery, and those that support patient capacity for self-care are key features of an effective program for reducing the risk of all-cause or unplanned readmissions and mortality.[10] A recent umbrella review showed that chronic care models with multiple components and the involvement of a condition-specific multidisciplinary team reduced admission rates.[2]

In Australia, the Victorian State Government invested $150 million to develop the Hospital Admission Risk Program (HARP) to provide chronic disease management programs to target specific chronic diseases.[11] HARP provides intensive care coordination and multidisciplinary disease-specific input to patients with chronic, complex conditions and intensive complex care coordination needs aiming to prevent hospital admissions and improve patient self-management and independence in the community.[13] HARP reduces emergency department presentations, inpatient admissions, and bed days of individuals with chronic obstructive pulmonary disease and chronic heart failure.[14] However, the longitudinal analysis of hospitalization of other HARP chronic disease management programs, mortality, and cost has not yet been performed.

The aim of the study was to determine the rate of hospitalization, bed days, and mortality in individuals admitted to HARP, and to evaluate the cost-effectiveness of the multidisciplinary, community-based service.

Methods

Study Intervention

HARP is a partnership between the Royal Melbourne Hospital in metropolitan Melbourne and community health services to provide assessment, integrated care planning and coordination, specialist medical care, multidisciplinary services, education and monitoring, service linkages, and general practitioner (GP) liaison. The multidisciplinary team includes physicians, nurses, social workers, physiotherapists, pharmacists, occupational therapists, dietitians, and care coordinators.

Individuals enter HARP via a discharge planning staff member or community referrers who undertake HARP screening for eligibility into the program by reviewing the patient's hospital admissions in the past year to determine if they were potentially avoidable (defined as admissions that could have been avoided by timely and adequate community interventions that prevent deterioration or exacerbation that lead to hospital admission), and if patients are at imminent risk of admitting (due to deterioration or exacerbation of their condition where community supports were either not available or not used effectively). Individuals with complex medical or psychosocial needs such as depression and anxiety, mental health issues not eligible for specialist mental health service, medication management issues, social isolation, fragile support system, and high carer stress, and with 1 or more avoidable emergency presentation or hospital admission to the Royal Melbourne Hospital in the past 12 months or at imminent risk of hospitalization where community services cannot meet their needs, are eligible for HARP. Individuals are eligible when their hospitalizations become more frequent. Individuals with acute psychiatric needs, palliative care needs, aged below 18 years, or adequately managed by community services are not eligible for HARP.

Once admitted to the HARP, the care coordinator (nurse or allied health background) contacts individuals within 3 working days, first face-to-face contact within 10 working days, followed by regular contact [average 2 (range 1-3) contacts per week] to support the individual to reach their goals as defined in their individualized care plan, which was tailored to each individual based on their needs.

The aim of the HARP program was to reduce individual's admissions to hospital by linking tertiary care to community supports and their GP for ongoing management. The care plan involved the HARP care coordinator working directly with the individual and GP, other health care professionals, and support services in the community, acting as a central point to arrange, refer, and coordinate services to build their self-management and independence to live at home and manage their condition(s) independently. The individual's condition(s) and needs would determine which HARP care coordinator they were managed by and which other multidisciplinary HARP staff were involved.

Common features of the management program included hospital and GP liaison, community service referral, and overarching care coordination to become better connected to their GP and community resources to improve their independence at home.[13] Additionally, each of the 8 HARP chronic disease management programs (cardiac coach, chronic heart failure, chronic respiratory, diabetic foot management, HIV, diabetes comanagement, medication management, and service facilitation) provided a tailored disease-specific service as summarized in Supplementary Table 1. Services were generally delivered in the home, yet individuals were also able to attend outpatient or community centers where required for wound management, medical review, or specialist support. Services delivered included personal care, home care (showering, dressing, meal preparation, cleaning), nursing care, medication management, rehabilitation support from physiotherapists or occupational therapists, social support, and medical reviews.

Individuals were discharged from HARP if their individualized goals of the care plan were met, including self-managing their medications, or services were in place to support their independence in the community, including nursing and allied health, or home and personal care, and food shopping or meal preparation. The length of inclusion in the program varied from several months up to 1 year.[13]

Participants

Individuals enrolled in at least 1 of the 8 HARP chronic disease management programs between July 1, 2017, and June 30, 2018, were included in the present analysis. If individuals were enrolled in several HARP chronic disease management programs, their primary chronic disease program allocation was defined based on disease severity in the following order: cardiac coach, cardiac heart failure, chronic respiratory, diabetes foot management, HIV, diabetes comanagement, medication management, and service facilitation.

Data Collection

Hospitalization, bed days and mortality were extracted from the patient administration system from January 1, 2016, to December 31, 2019 (equivalent to 18 months before and 18 months after HARP enrollment). Total hospital cost was defined as the summation of hospital services costs in each inpatient episode and HARP staff costs in each HARP chronic disease management programs to provide relevant services. Hospital costs were available until July 1, 2019, from the hospital administration system.

The number of unplanned hospitalizations (defined as hospitalization excluding elective admissions for follow-up surgical or medical treatments), bed days, and total hospital costs before and after HARP enrollment were compared between 4 time frames stratified by HARP chronic disease management programs and number of chronic disease programs enrolled: (1) 18-4 months before HARP enrollment—individual's baseline; (2) 3 months to HARP enrollment:

establishment phase of frequent hospital presentations and becoming HARP eligible; (3) HARP enrollment to the median duration of HARP chronic disease management programs intervention—HARP intervention; (4) median duration of HARP chronic disease programs intervention to 18 months after HARP enrollment—post HARP intervention phase. Age, sex, Australian born, nonindigenous, interpreter use, and being married were extracted from The Care Manager (TCM) and i.Patient Manager (iPM).

Statistical Analysis

Descriptive characteristics were presented as mean and standard deviation for normally distributed data or as median and interquartile range for data that were not normally distributed. Categorical variables were presented as a numeric value (n) with percentages (%). To compare the change of unplanned hospitalizations and bed days in the 4 time frames, univariable linear regression analyses were performed to determine beta coefficients and standard errors (SEs). Beta-beta analyses were used to examine group differences in hospitalization rates and bed days between time frames stratified by HARP chronic disease management programs. Nonparametric Wilcoxon matched-pairs signed rank test was used to compare differences in total hospital costs between time frames. Log rank test in Kaplan-Meier survival analysis and Cox regression adjusting for age and gender were used to detect differences in mortality patterns between HARP chronic disease management programs and number of chronic disease programs enrolled.[15,16] In Cox regression analyses, the cardiac coach and individuals enrolled in 1 chronic disease management program were the reference group for comparison with all other HARP chronic disease programs and number of chronic disease programs (expressed as hazard ratio and 95% confidence interval). Statistical analyses were conducted using the Statistical Package for Social Sciences (IBM SPSS for Windows, version 25.0; IBM Corp, Armonk, NY).

Results

Patient Characteristics

Table 1 shows demographics of 1553 individuals enrolled into HARP. Individuals had a median age of 71 years (interquartile range: 60-81) (63.4% male) and were enrolled in the cardiac coach (27.2%), cardiac heart failure (14.6%), chronic respiratory (15.2%), diabetes foot management (17.4%), HIV (3.5%), diabetes comanagement (11.8%), medication management (7.5%), and service facilitation (2.8%) chronic disease management programs. Twenty-five percent of individuals were admitted to more than 1 HARP chronic disease program. The median duration of HARP enrollment was 272 days (interquartile range: 119-525). Individuals in cardiac coach and HIV programs were more likely to be enrolled in only 1 chronic disease program and were younger than individuals in other chronic disease programs.

Hospitalization and Bed Days

Figure 1 illustrates the cumulative number of unplanned hospitalizations, total bed days, and bed days per individual before and after HARP enrollment, stratified by HARP chronic disease management programs and number of chronic disease programs enrolled. Similar cumulative trends in hospitalizations and bed days were observed for all chronic disease programs. Table 2 presents results of comparing unplanned hospitalizations and bed days between the 4 time frames. Individuals in all HARP chronic disease programs had higher number of unplanned hospitalizations and number of bed days within 3 months before HARP enrollment compared to other time frames ($P < .001$). During the HARP intervention, the number of unplanned hospitalization rates and number of bed days reduced significantly compared to 3 months before HARP enrollment ($P < .001$), regardless of the numbers of chronic disease programs enrolled ($P < .001$). Unplanned hospitalization rates were higher after the HARP intervention compared with baseline in all HARP chronic disease programs ($P < .001$). The number of bed days was higher post HARP intervention compared to baseline except of the diabetes foot management ($P = .150$), HIV ($P = .841$), and service facilitation ($P = .403$) programs. Individuals enrolled in more HARP chronic disease programs had a higher number of bed days compared with individuals enrolled in 1 chronic disease program.

Mortality

Figure 2 illustrates Kaplan-Meier survival curves for individuals stratified by HARP chronic disease management programs (Figure 1A) and number of chronic disease programs enrolled (Figure 1B). The overall 18-month survival rate was 88.5%, but it differed significantly between HARP chronic disease programs (Supplementary Table 2; log rank test $P < .001$). After adjusting for age and gender, individuals in the cardiac heart failure (hazard ratio 5.96, 95% confidence interval 2.90-12.24; Supplementary Table 2) and chronic respiratory (hazard ratio 5.15, 95% confidence interval 2.53-10.50) programs had higher mortality rates compared to the cardiac coach programs as the referent group. No difference in survival rates between the number of chronic disease programs enrolled was found ($P = .222$).

Table 1
Demographics of Individuals at HARP Enrollment Stratified by Chronic Disease Management Programs

Variable	Cardiac Coach (n = 423)	Cardiac Heart Failure (n = 227)	Chronic Respiratory (n = 236)	Diabetes Foot Management (n = 270)	HIV (n = 55)	Diabetes Comanagement (n = 183)	Medication Management (n = 116)	Service Facilitation (n = 43)	Total (n = 1553)
Age, y, median (IQR)	63 (55, 70)	84 (79, 88)	75 (64, 82)	67 (58, 77)	43 (35, 52)	72 (61, 81)	80 (69, 85)	79 (69, 84)	71 (60, 81)
Male	324 (76.6)	122 (53.7)	136 (57.6)	193 (71.5)	39 (70.9)	98 (53.6)	59 (50.9)	13 (30.2)	984 (63.4)
Australian born	281 (66.4)	52 (22.9)	123 (52.1)	160 (59.3)	26 (47.3)	76 (41.5)	38 (32.8)	22 (51.2)	778 (50.1)
Non-Indigenous	409 (96.7)	227 (100)	234 (99.2)	265 (98.1)	52 (94.5)	183 (100)	115 (99.1)	43 (100)	1528 (98.4)
Interpreter, yes	14 (3.3)	115 (50.7)	46 (19.5)	49 (18.1)	12 (21.8)	57 (31.1)	47 (40.5)	15 (34.9)	355 (22.9)
Married, de facto	261 (61.7)	105 (46.3)	109 (46.2)	149 (55.2)	10 (18.2)	92 (50.3)	53 (45.7)	8 (18.6)	787 (50.7)
Management programs, n									
1	388 (91.7)	100 (44.1)	163 (69.1)	189 (70.0)	53 (96.4)	141 (77.0)	87 (75.0)	43 (100.0)	1164 (75.0)
2	23 (5.4)	84 (37.0)	63 (26.7)	65 (24.1)	2 (3.6)	37 (20.2)	29 (25.0)	—	303 (19.5)
3 or more	12 (2.8)	43 (19.0)	10 (4.2)	16 (5.9)	—	5 (2.7)	—	—	86 (5.5)
Intervention, d, median (IQR)	195 (121, 327)	385 (216, 536)	362 (190, 524)	396 (198, 540)	413 (365, 542)	252 (121, 524)	52 (22, 96)	66 (17, 185)	272 (119, 525)

IQR, interquartile range.
Unless otherwise noted, variables are presented as number (percentage).

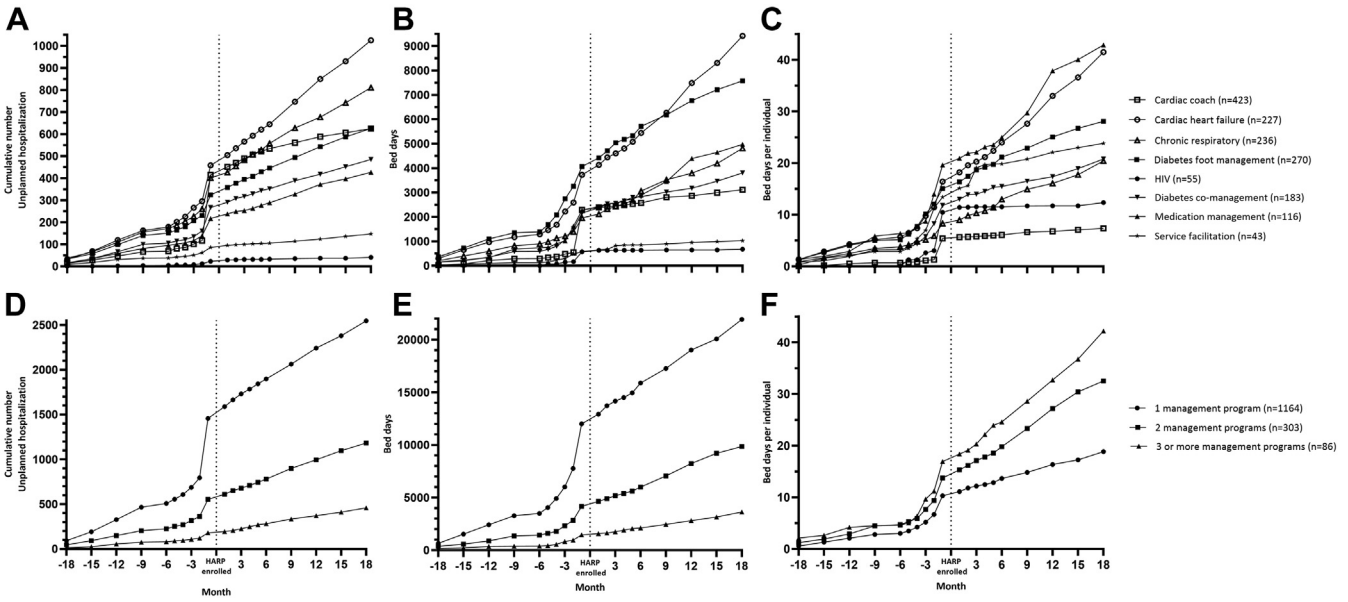

Fig. 1. (A, D) Cumulative number of unplanned hospitalizations, (B, E) total bed days, and (C, F) bed days per individual before and after HARP enrollment, stratified by (A-C) HARP chronic disease management programs and (D-F) number of chronic disease programs enrolled.

Table 2
Comparison of Unplanned Hospitalizations and Bed Days for the 4 Time Frames Stratified by HARP Chronic Disease Management Programs and Number of Chronic Disease Programs Enrolled

Variable	Time Frames				*P* Value		
	Baseline, B (SE)	3 mo Prior Enrollment, B (SE)	HARP Intervention, B (SE)	Post HARP Intervention, B (SE)	Between All Time Frames	Between 3 mo Prior Enrollment and HARP Intervention	Between Baseline and Post HARP Intervention
Hospitalizations by chronic disease management programs							
Cardiac coach (n = 423)	5.06 (0.31)	157.00 (81.41)	16.80 (0.74)	7.00 (0.48)	<.001	<.001	<.001
Cardiac heart failure (n = 227)	13.27 (0.68)	96.00 (38.11)	29.69 (0.68)	29.17 (1.44)	<.001	<.001	<.001
Chronic respiratory (n = 236)	11.83 (0.56)	87.00 (31.18)	25.07 (0.46)	22.33 (0.39)	<.001	<.001	<.001
Diabetes foot management (n = 270)	10.41 (0.58)	58.00 (20.21)	16.98 (0.29)	13.83 (0.48)	<.001	<.001	.004
HIV (n = 55)	0.48 (0.04)	7.50 (2.02)	0.70 (0.09)	0.67 (0.39)	<.001	<.001	<.001
Diabetes comanagement (n = 183)	7.66 (0.55)	66.00 (23.09)	12.00 (0.32)	11.17 (0.10)	<.001	<.001	.002
Medication (n = 116)	6.63 (0.24)	50.50 (15.88)	7.50 (2.02)	11.91 (0.44)	<.001	<.001	<.001
Service facilitation (n = 43)	2.50 (0.26)	17.50 (3.75)	2.50 (0.29)	3.26 (0.15)	<.001	<.001	<.001
Hospitalizations by number of chronic disease management programs enrolled							
1 (n = 1164)	36.20 (1.85)	385.00 (160.50)	61.06 (1.90)	52.87 (1.81)	<.001	<.001	<.001
2 (n = 303)	15.72 (0.69)	118.50 (41.86)	35.46 (0.98)	31.17 (1.64)	<.001	<.001	<.001
3 or more (n = 86)	5.92 (0.47)	36.00 (13.28)	17.95 (0.57)	14.50 (0.87)	<.001	<.001	<.001
Bed days by chronic disease management programs							
Cardiac coach (n = 423)	24.29 (2.44)	903.44 (484.41)	36.84 (1.95)	34.66 (3.57)	<.001	<.001	<.001
Cardiac heart failure (n = 227)	88.31 (6.60)	751.94 (220.20)	265.06 (10.79)	321.91 (28.08)	<.001	<.001	<.001
Chronic respiratory (n = 236)	61.61 (3.38)	374.11 (112.30)	176.33 (12.22)	171.06 (22.43)	<.001	<.001	<.001
Diabetes foot management (n = 270)	104.35 (12.23)	661.33 (85.45)	218.79 (13.37)	135.66 (8.06)	<.001	<.001	.15
HIV (n = 55)	4.51 (2.00)	215.69 (110.42)	1.69 (0.27)	5.81 (3.35)	<.001	<.001	.84
Diabetes comanagement (n = 183)	45.41 (4.27)	549.98 (53.13)	78.89 (6.45)	104.31 (5.37)	<.001	<.001	<.001
Medication (n = 116)	53.89 (5.48)	630.68 (12.89)	69.16 (25.58)	179.83 (13.81)	<.001	<.001	<.001
Service facilitation (n = 43)	11.79 (2.21)	138.57 (27.53)	85.07 (36.96)	13.49 (0.67)	<.001	<.001	.40
Bed days by number of chronic disease management programs enrolled							
1 (n = 1164)	0.23 (0.02)	2.57 (0.62)	0.46 (0.04)	0.43 (0.03)	<.001	<.001	<.001
2 (n = 303)	0.33 (0.02)	3.04 (0.76)	0.99 (0.05)	0.89 (0.11)	<.001	<.001	<.001
3 or more (n = 86)	0.26 (0.04)	3.63 (1.21)	1.33 (0.06)	1.58 (0.14)	<.001	<.001	<.001

B, unstandardized beta coefficient; SE, standard error.
Baseline: 18-4 months before HARP enrollment; 3 months prior enrollment: 3 months before HARP enrollment to HARP enrollment; HARP intervention: during the HARP intervention; post HARP intervention: after HARP intervention.

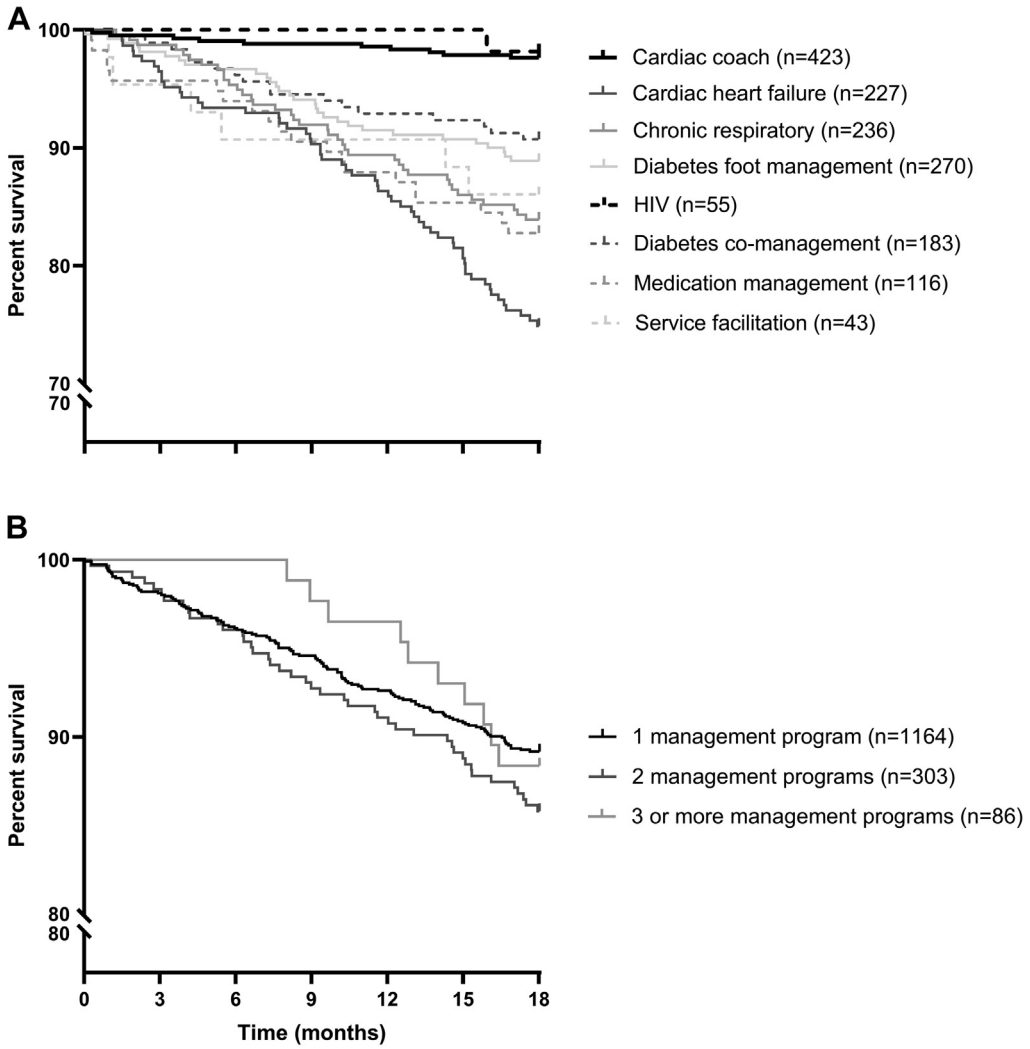

Fig. 2. Kaplan-Meier survival curves for individuals after HARP enrollment, stratified by (A) HARP chronic disease management programs and (B) number of chronic disease programs enrolled.

Hospital Costs

Table 3 shows monthly total hospital costs before and after HARP enrollment stratified by HARP chronic disease management programs and number of chronic disease programs enrolled. The monthly total hospital costs during the HARP intervention was lower compared to within 3 months before HARP enrollment ($P < .001$), irrespective of the number of programs enrolled ($P = .001$). Individuals in cardiac coach ($P < .001$), cardiac heart failure ($P < .001$), diabetes comanagement ($P = .001$), and medication management ($P < .001$) programs had lower monthly total hospital costs during the HARP intervention compared to within 3 months before HARP enrollment. The monthly total hospital costs post HARP intervention was higher compared with baseline ($P < .001$). Individuals enrolled in cardiac coach ($P < .001$), diabetes comanagement ($P = .042$), and medication management programs ($P = .004$) and individuals in 1 HARP chronic disease program ($P < .001$) had higher monthly total hospital costs post HARP intervention compared with their baseline.

Discussion

Individuals in all HARP chronic disease management programs had the highest number of unplanned hospitalization rates, bed days, and total hospital costs 3 months before HARP enrollment, and these were lower during the HARP intervention. Hospitalization rates, bed days, and total hospital costs were higher post HARP intervention compared to baseline. Individuals enrolled in the chronic heart failure and chronic respiratory programs had the least survival rate.

A reduction in unplanned hospitalization rates and bed days during the HARP intervention compared to the 3 months before HARP enrollment time frame illustrates the effectiveness of the HARP program reducing potentially avoidable unplanned readmissions. Increased unplanned hospitalization and bed days 3 months before HARP enrollment show the integrated and intensive care needs of the individuals.[4] After HARP enrollment, unplanned hospitalizations and bed days were reduced. This result concurs with previous literature that the HARP program reduced emergency department presentations, inpatient admissions, and bed days of HARP individuals with chronic obstructive pulmonary disease and chronic heart failure compared to hospital use before HARP enrollment.[4,11,14,17] Programs with multidisciplinary clinical management, care coordination and community-based interventions are effective in reducing readmissions and bed days.[18,19]

Unplanned hospitalization, bed days, and total hospital costs of individuals were higher post HARP intervention compared to their baseline. The included individuals were relatively old, experienced

Table 3
Monthly Hospital Costs per Individual in Australian Dollars Before and After HARP Enrollment, Stratified by HARP Chronic Disease Management Programs and Number of Chronic Disease Management Programs Enrolled

Variable	Time Frames		*P* Value*	Time Frames		*P* Value*
	3 mo Prior Enrollment, Median (IQR)	HARP Intervention, Median (IQR)		Baseline, Median (IQR)	Post HARP Intervention, Median (IQR)	
By HARP chronic disease management programs						
Cardiac coach (n = 423)	2641 (16, 4685)	431 (411, 448)	<.001	37 (0, 64)	68 (0, 727)	<.001
Cardiac heart failure (n = 227)	2055 (546, 5129)	762 (421, 1618)	<.001	44 (0, 782)	—	—
Chronic respiratory (n = 236)	1079 (70, 2414)	833 (525, 2209)	.77	32 (0, 355)	—	—
Diabetes foot management (n = 270)	836 (151, 3749)	662 (406, 1460)	.22	50 (0, 438)	—	—
HIV (n = 55)	471 (230, 1132)	662 (311, 1301)	.10	22 (0, 502)	—	—
Diabetes comanagement (n = 183)	1524 (398, 4578)	670 (625, 1500)	.001	41 (0, 144)	92 (0, 347)	.042
Medication (n = 116)	2712 (268, 9557)	435 (269, 1735)	<.001	46 (0, 536)	74 (0, 1146)	.004
Service facilitation (n = 43)	962 (148, 3743)	1466 (531, 2299)	.54	50 (0, 412)	70 (0, 335)	.80
By number of chronic disease management programs enrolled						
1 (n = 1164)	1237 (89, 4235)	554 (411, 1171)	<.001	29 (0, 149)	68 (0, 301)	<.001
2 (n = 303)	1688 (395, 4828)	1036 (625, 1902)	<.001	59 (0, 489)	70 (0, 877)	.53
3 or more (n = 86)	2080 (271, 6194)	937 (429, 2250)	.001	73 (0, 741)	92 (0, 1180)	.14
Total (n = 1553)	1384 (99, 4419)	625 (411, 1454)	<.001	38 (0, 171)	74 (0, 351)	<.001

IQR, interquartile range.
Baseline: 18-4 months before HARP enrollment; 3 months prior enrollment: 3 months before HARP enrollment to HARP enrollment; HARP intervention: during the HARP intervention; post HARP intervention: after HARP intervention.
*Wilcoxon matched-pairs signed rank test.

complex comorbidities, and had a history of frequent admissions; therewith, the likely progressive nature of the patient's conditions has to be acknowledged. HARP aims to return patients to their baseline function and health; however, this is often impossible in the context of disease progression. Therewith, higher costs compared to baseline were expected. This result is inconsistent with previous literature, possibly because of the use of different research methodologies and definitions. A systematic review on randomized controlled trials found that transitional care interventions were effective in both reducing intermediate (31-180 days) and long-term (180-365 days) readmissions for adults with chronic diseases compared to individuals without transitional care.[19] Transitional care interventions such as Hospital in the Home or community transition care programs admit individuals for a predominantly short period of time to facilitate their needs after hospitalization. In contrast, the HARP program follows individuals for a longer time and operates in conjunction with transitional care programs. Two studies found that chronic disease management programs had reduced readmissions and hospital expenditure by comparing readmissions and costs before and after interventions, but they did not rule out the period when intensive inpatient care was necessary and did not take program cost into consideration.[20,21]

A progressive reduction in survival probability of HARP enrolled individuals implies that they might barely return to their baseline of at least 3 months before HARP enrollment due to the progression of complex health conditions, which requires more costly hospital-based acute inpatient care at the end of life.[22] Palliative care provision to individuals with advanced diseases not only improves patients' and their families' satisfaction with care but also reduces hospital costs on intensive care.[23] The involvement of palliative care consultation within 3 days of admission with patients and their families on symptom management, communication, and patient autonomy reduces direct hospital costs.[24] Given that it is unknown whether the unplanned hospitalizations after HARP intervention are preventable or not, further research is required to disentangle reasons for these hospitalizations after HARP intervention to provide insights into improving HARP and when palliative care needs to be implemented.

This study further revealed that chronic disease management programs performed differently in bed days, mortality and cost utilization, which might be due to the differences in patients' disease severity and health care needs. For instance, individuals in the cardiac heart failure and chronic respiratory management programs were older and were more likely to be enrolled in multiple management programs, illustrating more complex health conditions and subsequently higher mortality risk. A patient-centered, proactive, interdisciplinary, and health condition–specific approach is essential to satisfy individuals' complex health care needs, improve quality of life,[14] and improve the utilization of hospital resources.[21,25,26] The differences in demographics and survival rates between HARP chronic disease management programs suggest the need for condition-specific goal setting. As the current HARP program enrolled older adults with cardiac heart failure or chronic respiratory when their health was already compromised, it might be worthwhile for care coordinators to assess the need for palliative care rather than focusing on reducing readmission risks.

Strengths and Limitations

To our knowledge, this is the first study to evaluate HARP, a multidisciplinary, community-based service, by investigating unplanned hospitalization rates, bed days, mortality, and total costs. As no matched control group was available to evaluate HARP services, hospital administrative data, mortality, and total hospital costs were compared between after HARP intervention and baseline. In studies aimed to evaluate the effectiveness of programs that targeted individuals with high health care utilization without a control group, it could be a potential pitfall to observe a reduction in hospital utilization due to regression to the mean. Yet, a consistent trend of reduced hospital admissions during and after the intervention indicates the effectiveness of the program. Furthermore, total hospital costs were only available between 18 months before and 12 months after HARP, and there was no information on emergency department presentations.

Conclusions and Implications

The HARP service model reduced unplanned hospitalization rates, bed days, and total hospital costs during the HARP intervention

compared to the time frame when intensive acute care was needed within 3 months before HARP enrollment. However, HARP was ineffective in reducing unplanned hospitalizations, bed days, and total hospital costs back to baseline. Further research is warranted to explore the reasons for hospitalizations after HARP intervention in various HARP chronic disease management programs to determine whether they could potentially be avoided.

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Supplementary Table 1
Hospital Admission Risk Program, Chronic Disease Management Programs Overview

Chronic Disease Management Program	Eligibility Criteria	Exclusion Criteria	Services Provided
Cardiac coach (including chest pain)	Atypical chest pain, nonischemic chest pain, angina pectoris, angiogram confirmed ischemic heart disease (IHD), post invasive IHD intervention	Unable to participate in phone conversation	Education to support management, postdischarge phone-based coaching
Cardiac heart failure	Exacerbation of condition		Education to support management, clinic review
Chronic respiratory	Exacerbation of chronic obstructive pulmonary disease, asthma, pulmonary of interstitial lung disease, pulmonary hypertension		Education to support management, advice on physical exercise, medication review and support, respiratory physician review
Diabetes foot management	Diabetes mellitus with current foot wound(s) or active diabetic complication(s)		Wound management, vascular intervention, antibiotic management
HIV	HIV diagnosis with management needs		Education to support management, clinic and outreach support
Diabetes comanagement	Poorly regulated diabetes mellitus due to poor self-management	Gestational diabetes	Education to support management, support on insulin use, support for diabetes complication management
Medication management	Polypharmacy, adaptation to medication changes, adherence concerns, medication reconciliation	Individuals in residential aged care	Comprehensive home medication assessment, education and referrals as needed
Service facilitation	Individuals with complex comorbidities and high-level care coordination support	Acute medical requirements	Intensive care coordination, assessment and advocacy, connection with housing, employment, mental health, and other specialist services

Supplementary Table 2
Survival Analysis Using Kaplan-Meier Survival Curve Analysis and Cox Regression

Variable	χ^2	*P* Value of χ^2	Hazard Ratio (95% CI)
By HARP chronic disease management programs			
Log rank (Mantel-Cox) test in Kaplan-Meier analysis	90.5	<.001*	—
Cox regression by HARP chronic disease management programs			
Cardiac coach	126.4	<.001*	Reference
Cardiac heart failure	126.4	<.001*	5.96 (2.90, 12.24)*
Chronic respiratory	126.4	<.001*	5.15 (2.53, 10.50)*
Diabetes foot management	126.4	<.001*	4.17 (2.03, 8.56)*
HIV	126.4	<.001*	1.48 (0.19, 11.71)
Diabetes comanagement	126.4	<.001*	3.20 (1.45, 7.07)*
Medication management	126.4	<.001*	4.84 (2.20, 10.62)*
Service facilitation	126.4	<.001*	4.07 (1.44, 11.51)*
By number of chronic disease management programs			
Log Rank (Mantel-Cox) test in Kaplan-Meier analysis	5.7	.222	
Cox regression by number of chronic disease management programs enrolled:			
1 chronic disease programs	95.8	<.001*	Reference
2 chronic disease programs	95.8	<.001*	0.99 (0.70, 1.40)
3 or more chronic disease programs	95.8	<.001*	1.06 (0.56, 2.02)

CI, confidence interval.