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A successful hospital-based disease management program to reduce admissions among patients with multiple chronic illnesses

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Abstract

Objectives: To examine the effect of a hospital-based disease management program in reducing monthly hospital admission rates among patients with multiple chronic illnesses.

Design: Interrupted time series analysis.

Setting: A public hospital system comprised of three campuses in suburban Melbourne, Australia.

Participants: 2,341 patients with three or more chronic illnesses enrolled in a hospital-based disease management program upon discharge.

Intervention: Prior to hospital discharge, an inpatient coordinator refers eligible patients to the disease management unit (DMU). A DMU care coordinator invites patients to enroll and immediately schedules a comprehensive hospital-based outpatient clinic visit. The clinic utilizes a patient-centered team approach including a physician trained in multi-specialty care, a pharmacist, and a DMU nurse. Additional clinic visits are scheduled as needed. Between clinic visits, patients receive continued intensive contact with the DMU team, home visits by a pharmacist if necessary and optional patient education classes. The DMU liaises with the patient's general practitioner throughout the program until the patient is stable.

Measurement: Admissions per 1,000 patients per month (PTPM), evaluated 50 months before and 50 months after enrollment in the DMU program.

Results: During the 50 month period pre-intervention period, admissions trended significantly upward at a rate of 2.43 admissions PTPM (95% confidence interval = 1.47, 3.38). Admissions PTPM during the 50-month period *after* enrollment trended significantly downward at a rate of 3.54 admissions PTPM (95% confidence interval = -4.71, -2.37).

Conclusion: A comprehensive hospital-based disease management program successfully reduced monthly admissions for complex chronically ill patients during the 50 months following enrollment in the program compared to the prior 50 months. Contrary to many recent disease management evaluations, these findings suggest that it is possible to design a program to effectively reduce admissions, the largest cost driver in a chronically ill population, but that a person-centered closed-loop system involving both inpatient and outpatient services is likely required.

Keywords

Comorbidities, disease management, hospitalization, interrupted time series analysis, patient-centered care

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Introduction

Developing an approach to managing patients with chronic illness that successfully reduces hospital admissions and costs has proven challenging. Commercial disease management (DM) programs remain the predominant

model, even though large-scale randomized controlled trials show little evidence of their effectiveness [1-4]. Perhaps the most obvious limitation is that as a third party they have limited ability to influence the healthcare delivery process [5].

An evolving model for the delivery of primary care, called the patient-centered medical home (PCMH), may offer the best approach to managing chronically ill patients and has been endorsed by most major primary care medical associations in the United States [6]. The American College of Physicians [7] describes the PCMH as “a team-based model of care led by a personal physician who provides continuous and coordinated care throughout a patient's lifetime to maximize health outcomes.” Several demonstration projects are currently underway, such as the Multi-payer Advanced Primary Care Practice (MAPCP) initiative funded by Medicare in the U.S. [8]. However, it is too early to ascertain whether the PCMH model can consistently reduce utilization and expenditures while improving the overall quality of care.

In this paper, we describe and evaluate a different approach to managing patients with multiple chronic illnesses, an innovative hospital-based program that coordinates care across delivery settings. Several aspects of the program distinguish it from the predominant commercial disease management model. First, it is explicitly designed to reduce avoidable hospitalizations, thereby targeting the highest cost medical service provided to chronically ill patients and the only pathway to substantially reduce overall medical costs in this population [9]. To accomplish this, the program intervenes at key points when risk of hospitalization is highest. For example, approximately 20% of Medicare patients are readmitted within 30 days of discharge from the hospital, mostly for chronic conditions and only about 50% of these patients have a documented physician visit in the interim [10]. The program therefore schedules a comprehensive hospital-based outpatient clinic visit immediately following discharge from the index admission.

Hospital-based programs are well situated to facilitate interventions in the complex chronically ill population because they can identify patients upon presentation to the emergency department or hospital, enabling immediate action (e.g. finding a more suitable lower level of care for non-acute exacerbations, etc.). The subsequent management of these patients can be further enhanced by including both inpatient and outpatient services within a closed-loop system. As these arguments remain largely untested, limiting our ability to design effective programs in the chronically ill population, we felt it would be valuable to both describe and evaluate a hospital-based program. The paper is organized as follows. We first provide general background information about the Alfred Health System and describe the hospital-based disease management program in detail. We then describe the data and analytic approach used to evaluate the effectiveness of the program in reducing admission rates over time. Next, we discuss the results of our analyses and reflect on our findings before presenting our concluding thoughts.

Setting

The Alfred Health System

The Alfred Health System is comprised of three public hospital campuses (The Alfred Hospital, Caulfield General Medical Centre and Sandringham Hospital) and is the main provider of health services to people living in the inner southeast suburbs of Melbourne, Australia. Services are provided in a full range of settings: inpatient, ambulatory, home and community-based. In 2010, there were 91,776 admissions at the three campuses totaling of 388,573 bed days. There were also 81,744 emergency department presentations and 293,075 outpatient contacts. In 2010, the hospital system employed 5,008 full time employees, including 155 medical specialists, 465 hospital medical officers, 120 sessional medical staff and 2,121 nurses.

The Alfred Health System provides undergraduate and postgraduate training for medical, nursing and allied health in association with Monash and LaTrobe Universities. It also is a partner in the Alfred Medical Research & Education Precinct and has research links with the Baker International Diabetes Institute, the Burnet Institute and Monash University.

The Disease Management Unit (DMU)

The Disease Management Unit (DMU) was established in 2000 by an initial grant from the Victorian Government and subsequently funded by block grants under the Government's Bed Management Strategy. The intent was to test strategies to reduce avoidable ED visits and hospitalizations in order to alleviate the shortage of hospital beds and reduce waiting times in emergency departments. The DMU is currently funded under the Hospital Admissions Risk Program, a Government program that funds initiatives across the state of Victoria that manage patients at risk of frequent hospital admission.

The DMU specifically targets people with multiple chronic diseases who are at high risk of acute exacerbation and hospital readmission. Typically, patients are elderly with 80% having at least three major co-morbid chronic illnesses, such as ischemic heart disease, congestive heart failure, chronic obstructive pulmonary disease, chronic kidney disease and diabetes. While general practitioners (GP) can refer eligible patients directly from the community setting, the majority of referrals come from an inpatient medical unit.

The enrollment process starts with an inpatient care coordinator or medical specialist identifying a patient who might be suitable for the program and then referring that patient to the DMU prior to their discharge from the hospital. A DMU nurse care coordinator then contacts the patient and invites them to participate in the program. A comprehensive assessment of the patient's medical and psycho-social needs is completed and the first DMU outpatient clinic consultation is scheduled (usually to occur

within one to two weeks depending on the patient's severity). Between discharge and the consultation, the DMU nurse care coordinator liaises with the patient's general practitioner.

The DMU outpatient clinic offers an innovative approach to managing patients across the health care continuum. DMU clinics rotate between the 3 hospital campuses as well as in 2 community health centers, offering patients the option of a clinic close to their home. Transportation needs are determined by the DMU nurse care coordinator to ensure that patients are able to make their appointments, thereby safeguarding against clinic visits being replaced with an emergency department visit or unplanned hospitalization. In the first part of the clinic visit (which lasts for approximately 30 minutes), the DMU nurse care coordinator records vital signs and any issues as well as discusses the patient's home environment and any needs for support. Next, a physician trained in multi-specialty care examines the patient. A pharmacist may also review a patient's drug list with respect to poly-pharmacy interactions, advising the physician if necessary as well as providing patient education. At the end of the clinic visit, a comprehensive report and treatment plan is created and it is sent immediately to the patient's GP. Follow-up clinic visits are scheduled in accordance with the patient's health needs, ranging from weekly to monthly visits.

After the clinic visit, the DMU nurse care coordinator makes any necessary referrals to community support services and follows up with diagnostic results and appointments. Patients and their GPs can also call the nurse coordinators in between visits with any issues that need addressing. The pharmacist may also follow up by conducting a medication review in a patient's home for those particularly at risk of adverse medication events. This is particularly helpful for patients who had their medication list revised many times during their hospitalization. The pharmacist provides education as well as reviews the medication supplies to ensure medication safety. The home reviews may also facilitate the identification of other issues such as home support needs which are passed on to the nurse care coordinator for follow-up.

Group Patient Education is provided on an opt-in basis and covers topics such as managing fatigue, depression and anxiety, energy conservation, talking to your GP, sleep issues and offers an opportunity to DMU patients to have lunch and discuss common issues. A DMU newsletter is also sent to all enrolled patients. Patients are discharged from the program if they are deemed stable, do not require ongoing review, or are fully managed by their GP. The DMU manages approximately 550 open cases at any one time.

Methods

Analytic Approach

To evaluate whether the DMU program successfully reduced hospital admissions, we relied on observational data provided by the Alfred Health System. We were unable to obtain hospitalization data for all discharged patients from all three affiliated hospitals for the 10 year period of observation to create a comparable control group. Therefore, we employed a single-group interrupted time series analysis (TSA). In time series analysis, the outcome variable is reported in equally-spaced intervals over a large period of time, capturing both pre- and post-intervention periods. The study design is generally referred to as an *interrupted time series* because the intervention is expected to "interrupt" the level and/or trend subsequent to its introduction [11-13]. This approach is considered a robust quasi-experimental study design, even in the absence of a comparison group, due primarily to its control over the effects of regression to the mean and the improbability that some factor other than the intervention would cause an "interruption" coinciding with the initiation of the intervention [11-13].

The single group TSA was performed using ordinary least squares (OLS) regression as described in Simonton (1977) [14], Matowe et al. (2003) [15] and Linden & Adams (2010) [16] with admissions per 1000 patients per month (PTPM) as the primary outcome under study. The possibility of serial correlation and heteroskedasticity was controlled for by computing robust standard errors as suggested by Newey & West (1987) [17]. As a robustness test, several population-averaged panel-data models were also estimated using generalized estimating equations (GEE) [18]. While the TSA estimates the treatment effect using aggregated monthly observations (accounting for serial correlation at the aggregate level), the GEE approach supports estimates of the treatment effect that account for further for within-patient serial correlation and allow for varying months of observation. The GEE approach uses patient level data and allows the researcher to specify a within-group (e.g. within patient) correlation structure. We manipulated both the distribution type (Gaussian and Poisson) as well as the link (identity and log) to determine if there were any substantial differences in effect estimates or t statistics. We then computed Akaike information criterion (AIC) statistics for each model to determine which approach best fit the data. We multiplied the coefficient by 1000 in the GEE Gaussian model to provide a comparison on the same scale as the coefficients in the TSA regression. All statistical analyses were performed using STATA version 11.2 (College Station, Texas).

Data

The DMU maintains a database which includes detailed information about the intervention provided to each

program participant. From this file we extracted the dates of enrollment and disenrollment or death for all participants between the period of January 2000 and December 2009.

Hospital discharge data were retrieved for each participant from the Alfred Health System for the period between January 2000 and December 2010. The additional year of hospital data (2010) beyond the end of the program observation period (2009) allowed us to capture any potential admission occurring at a minimum of 12 months beyond the last enrollment date. Data elements included: hospital identifier, admission and discharge date, date and country of birth, gender, primary language, type of admission (e.g. emergency, scheduled, etc.), ward and discharge diagnosis.

Next, each DMU participant's enrollment date was ordered temporally within the hospital data file. All hospitalizations prior to and after that enrollment date were categorized according to their month relative to that patient's start-date. For example, a hospitalization occurring 12 months prior to enrollment would be categorized as -12 and a hospitalization occurring 24 months after enrollment would be categorized as 24. Hospital data used in the analysis often spanned beyond participants' tenure in the program itself. In this regard, the study follows an intent-to-treat analytic approach.

In the next step, individual monthly admissions were aggregated across all participants and a monthly admission rate was determined by dividing that count of admissions in that month by the number of participants available in the data for that month. This value was then multiplied by 1000 to provide the final outcome measure – admissions PTPM.

The number of months with available hospitalization data for each participant followed a bell-shaped curve. We chose a 100 month period of observation (50 months in both pre- and post periods) as a reasonable cut-off for the analysis to ensure that (a) the denominator was sufficiently large (minimum N=2000 per month) and that (b) sufficient monthly observations were available to investigate the possibility of anomalies affecting the level or trend of the data, such as secular trends, seasonality, etc. [13].

Results

General DMU patient population characteristics

Table 1 presents the characteristics of the DMU population for the years 2000 through 2009. Cumulatively, 2,341 unique participants enrolled in the DMU over the study period. The mean age of participants at enrollment was 73.27 (SD = 12.13) and 1,117 (50.3%) were female. DMU participants came from diverse backgrounds, representing 79 different countries of birth. As expected, Australia (including external territories) was the primary location of

birth accounting for 47.6% of all participants. Similarly, 32 primary languages were represented, with English being the dominant language (for 83.3% of participants). DMU participants were enrolled in the program for an average of 16.2 months (SD = 18). Six-hundred and nineteen participants (26.4%) died while enrolled in the program at an average of 21.1 months following enrollment (SD = 21.7).

Table 1: Characteristics of study population (N=2,341)

Variable	Estimate	Percent (SD)
Age (mean)	73.3	(12.1)
Female	1,177	50.3%
Primary language		
English	1,949	83.3%
Russian	148	6.3%
Greek	118	5.0%
All others (29 languages)	126	5.4%
Country of Birth		
Australia	1,082	46.2%
Greece	187	8.0%
England	125	5.3%
Poland	113	4.8%
Russian Federation	111	4.7%
All others (74 countries)	723	30.9%
Months of program participation (mean)	16.2	(18.9)
Deaths	619	26.4%
Months from enrollment to death (mean)	21.1	(21.7)

Note: Continuous variables are reported as mean (standard deviation) and dichotomous variables are reported as n, %.

Sources and types of admissions (January 2000 – December 2010)

The 2,341 DMU participants experienced a total of 31,389 hospital admissions during the study period (2000 through 2010). This represents a very high number of admissions per patient per year (1.54) and is comparable to patients with end-stage renal disease [19].

Table 2 presents the characteristics of the 31,389 hospital admissions. 81.5% of the admissions occurred at The Alfred Hospital. There were 17 different types of admissions, more than half of which were emergency admissions (52.4%) followed by planned elective admissions (32.1%). Additionally, patients were admitted to 101 different wards (across the three hospitals) over the study period (data not shown).

Discharge diagnoses spanned the entire 23 major diagnostic categories (MDCs) associated with the Australian refined diagnostic related groups (AR-DRGs). As expected, the top three MDCs (circulatory, renal and pulmonary) accounted for the majority of discharge diagnoses (54.4%).

Table 2: Characteristics of hospitalizations (N=31,389)

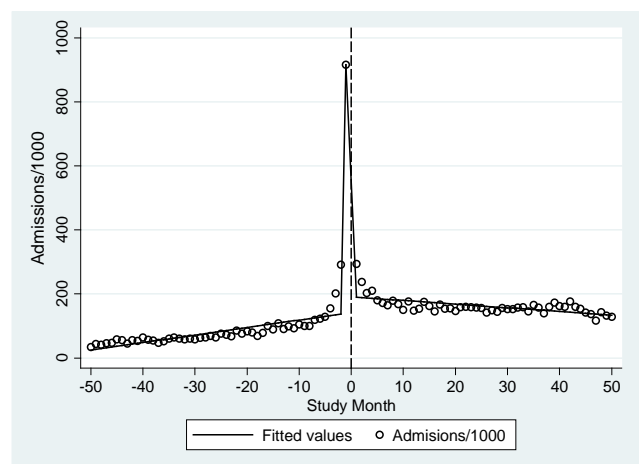
Variable	Frequency	Percent
Admitting Hospital		
The Alfred	25,570	81.5
Caulfield	3,923	12.5
Sandringham	1,896	6.0
Admission Type		
Emergency Admission	16,444	52.4
Elective Admission - Planned	10,081	32.1
Planned (Same Day/Overnight)	1,892	6.0
All others (14 types)	2,972	9.5
Discharge Diagnosis - Major Diagnostic Category (MDC)*		
Circulatory system (MDC 05)	6,296	20.1
Kidney and urinary tract (MDC 11)	5,856	18.7
Respiratory system (MDC 04)	4,899	15.6
Musculoskeletal system and connective tissue (MDC 08)	2,357	7.5
Factors influencing health status (MDC 23)	1,801	5.7
Digestive system (MDC 06)	1,774	5.7
Nervous system (MDC 01)	1,761	5.6
Skin, subcutaneous tissue and breast (MDC 09)	1,255	4
Neoplastic disorders (MDC 17)	1,069	3.4
Endocrine, nutritional and metabolic (MDC 10)	793	2.5
Injuries, poisonings and toxic effects of drugs (MDC 21)	709	2.3
Infectious and parasitic diseases (MDC 18)	550	1.8
Immunological disorders (MDC 16)	514	1.7
Ear, nose, mouth and throat (MDC 03)	484	1.5
Hepatobiliary system and pancreas (MDC 07)	430	1.4
All others (11 MDCs)	843	2.7

Note: Major diagnostic categories (MDCs) are 23 mutually exclusive categories into which all possible principal diagnoses fall and are part of the Australian refined diagnosis related groups (AR-DRGs) approach to coding:
<http://meteor.aihw.gov.au/content/index.phtml/itemId/269575>

Admissions per 1000 patients per month

Figure 1 illustrates the actual monthly admissions PTPM plotted against the predicted trend lines estimated from the OLS model over the 100 months under study. Several interesting findings are observed upon visual inspection and confirmed via statistical analysis. First, the pre-intervention slope trends statistically upward over the entire 50 month period at a rate of 2.43 admissions PTPM (95% confidence interval = 1.47, 3.38). Next, the month immediately prior to DMU enrollment reflects a sharp spike in admissions. This spike is not surprising given that the DMU identifies patients who meet program eligibility while they are hospitalized and enrolls them in the program immediately upon discharge. In the model we adjusted for this spike using a dummy variable coinciding with month - 1 (the parameter estimate for the spike was 775.06 admissions PTPM with a 95% confidence interval of 744.84 to 805.28). No adjustments were required for seasonality, as no patterns were identified either upon visual inspection of the autocorrelation function or by the Portmanteau (Q) statistic [20]. The final and perhaps most important finding is that the trend in admissions PTPM after enrollment trends significantly downward by 3.54 admissions PTPM (95% confidence interval = -4.71, -2.37).

Figure 1. Visual display of the interrupted time series results. The vertical line at 0 represents the each DMU participant's starting month of the program. Values to the left of 0 represent the pre-intervention and values to the right of 0 represent the intervention period.



The estimates derived from the patient level GEE model were comparable to those of the OLS approach, with a pre-intervention trend rising at 2.28 admits PTPM (95% confidence interval = 1.89, 2.66), and a post-enrollment downward trend in admissions PTPM of -3.18 admissions PTPM (95% confidence interval = -4.34, -2.03). The primary model (Gaussian distribution with an

identity link) had the lowest AIC statistic, suggesting that it is the best fitting GEE model for the current data.

Discussion

Using interrupted time series analysis, we found that the Alfred Health System's hospital-based disease management program was associated with a significant reduction in monthly admissions during the 50 months following patient enrollment. This is one of the few rigorous independent evaluations of a disease management intervention that demonstrates a reduction in admissions in a chronically ill population. Given that admission avoidance is key to realizing cost savings [9], these findings suggest that it is possible to design a program to achieve that goal. Clarifying the programmatic elements that enabled this program to be effective where others have failed is critical to both replicating these results in other settings as well as delivering on the promise of disease management as a viable strategy to curb the high healthcare costs in the chronically ill population [5].

These findings are perhaps not surprising when one considers the comprehensiveness of the program's innovative approach to patient-centered care for the chronically ill. First, there is organization-wide support for the program. Empirically this is evidenced by the fact that patients suitable for the program were referred from 101 different inpatient wards across the three hospitals. Second, the coordination between the inpatient care coordinator and DMU staff prior to the patient's discharge secures a smooth, supervised transition between settings - a point at which patients are typically the most vulnerable to readmission [10,21-23]. Third, the DMU nursing staff incorporates all the characteristics associated with successful intensive case-management (CM) interventions, including greater contact time, longer duration, face-to-face visits and integration with patients' usual care providers [24]. Fourth, the ongoing involvement of the pharmacy team to review and update the patient's medication profile may substantially reduce the likelihood of readmission triggered by drug-related problems (such as untreated indications, use of the medication without indication, improper drug selection, sub-therapeutic dosage, over-dosage, adverse reactions, interactions and failure to receive appropriate drugs) [25-27]. Finally, the dedicated DMU outpatient clinic utilizes a highly specialized team to ensure timely, comprehensive and continuous care. Taken together, this DM program differentiates itself from other models by employing a complete closed-loop system that includes all the important elements known to reduce the likelihood of hospital readmission.

The study design has two notable strengths, lending confidence to the results. First, the rationale for using interrupted time series analysis was that analyses of admission rates over a long time frame of 100 consecutive months can demonstrate patterns of response to the

intervention where the effects of confounding variables, including the variety of interactions between the individual and the environment, make determining causality extremely difficult. As a result, the time series design controls for most of the factors that otherwise could not be controlled for [11-13,28,29]. Second, we likely captured all hospitalizations that could have occurred in this cohort within the community because we were able to include data from all three hospitals' data for all admission types to every ward.

While our results are very promising, there are important limitations to consider. When faced with observational data, there is always a concern that threats to validity, such as selection bias, cloud the interpretation of the results. The study would have been strengthened with the inclusion of a comparable control group to address these concerns. Nonetheless, we are confident in the validity of the results for several reasons. First, given that this is a severely ill cohort of patients with multiple chronic conditions, we would intuitively expect to see an increase in admission rates over time due simply to disease progression. Indeed, in the 50 months prior to enrollment in the DMU intervention a consistent monthly increase in the monthly admission rate was observed.

Second, in the absence of an intervention, we would expect to see the admission rate continue to increase over time. This prospect is supported by the fact that over a quarter of the cohort died during their tenure in the program and there is sufficient literature that points to greater utilization in the last few months before death [30-33]. However the current data show that monthly admission rates decreased steadily in the 50 months after DMU enrollment. Additionally, a decrease in the average length of stay of -0.61 days (95% confidence interval = -1.16, -.072) was observed in the treatment period over the baseline period.

Third, and perhaps most importantly, the "interruption" in the time series is readily observed at month 1 of the program. In other words, there are no other points along the pre-intervention timeline where it appears that the monthly admission rate could show a similar behavior (i.e. a sustained decrease in admissions) to that witnessed at the true cut-off point. It would be difficult to explain how other factors outside the intervention could impact and sustain a decrease in admissions over a 50 month period, when the previous 50 months were steadily rising.

Several additional analyses could not be performed that could benefit our understanding of the population under study and the treatment effect. For example, it would be beneficial to investigate survival curves between treated and non-treated individuals. Without a comparable control group, however, we were limited to reporting the number of deaths and length of time to that death. Emergency department (ED) visit data would also contribute to a more complete picture of hospital utilization. However at The Alfred Hospital, ED data is collected in a different reporting system to which we did not have access.

Similarly, we had no access to other outpatient sources of data, such as GP office visits, ancillary services (rehabilitation, etc.) and community pharmacy.

Conclusion

The current study indicates that a comprehensive hospital-based disease management program can reduce monthly admissions for complex chronically ill patients. While many disease management interventions have attempted to design a program to reduce hospitalizations, the largest cost driver in health care, it has proven difficult. Therefore, it is likely that the unique features of the Alfred Health System DMU, a patient-centered closed-loop system involving both inpatient and outpatient services, are what enabled it to be successful. It is therefore important to test the model in other settings to confirm that results can be replicated as well as compare these results to those of alternative models, such as the Patient-centered Medical Home, in order to identify strategies to best manage complex chronically ill patients.

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