BMJ Open

Impact of time from discharge to readmission on outcomes: an observational study from the US National Readmission Database

Jean-Sebastien Rachoin ,[1] Krystal Hunter,[2,3] Jennifer Varallo,[3] Elizabeth Cerceo[1]

To cite: Rachoin J-S, Hunter K, Varallo J, *et al*. Impact of time from discharge to readmission on outcomes: an observational study from the US National Readmission Database. *BMJ Open* 2024;**14**:e085466. doi:10.1136/bmjopen-2024-085466

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (https://doi.org/10.1136/bmjopen-2024-085466).

Received 16 February 2024
Accepted 13 August 2024

[1]Medicine, Cooper Medical School of Rowan University, Camden, New Jersey, USA
[2]Cooper Medical School of Rowan University, Camden, New Jersey, USA
[3]Cooper Research Institute, Cooper University Health Care, Camden, New Jersey, USA

Correspondence to
Dr Jean-Sebastien Rachoin; Rachoin-jean@cooperhealth.edu

ABSTRACT

Background The Hospital Readmission Reduction Programme (HRRP) was created to decrease the number of hospital readmissions for acute myocardial infarction (AMI), chronic obstructive pulmonary disease (COPD), heart failure (HF), pneumonia (PNA), coronary artery bypass graft (CABG), elective total hip arthroplasty (THA) and total knee arthroplasty.

Objectives To analyse the impact of the HRRP on readmission rates from 2010 to 2019 and how time to readmission impacted outcomes.

Design Population-based retrospective study.

Setting All patients included in the US National Readmission database from 2010 to 2019.

Patients We recorded demographic and clinical variables.

Measurements Using linear regression models, we analysed the association between readmission status and timing with death and length of stay (LOS) outcomes. We transformed LOS and charges into log-LOS and log-charges to normalise the data.

Results There were 31 553 363 records included in the study. Of those, 4 593 228 (14.55%) were readmitted within 30 days. From 2010 to 2019, readmission rates for COPD (20.8%–19.8%), HF (24.9%–21.9%), PNA (16.4%–15.1%), AMI (15.6%–12.9%) and TKR (4.1%–3.4%) decreased whereas CABG (10.2%–10.6%) and THA (4.2%–5.8%) increased. Readmitted patients were at higher risk of mortality (6% vs 2.8%) and had higher LOS (3 (2–5) vs 4 (3–7)). Patients readmitted within 10 days had a mortality 6.4% higher than those readmitted in 11–20 days (5.4%) and 21–30 days (4.6%). Increased time from discharge to readmission was associated with a lower likelihood of mortality, like LOS.

Conclusion Over the last 10 years, readmission rates decreased for most conditions included in the HRRP except CABG and THA. Patients readmitted shortly after discharge were at higher risk of death.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Observations from a very large database represent a broad swath of the US population.
⇒ However, because this study is conducted at the database level, granular details that may permit a richer perspective of the patient experience are not available.
⇒ The impact of the Hospital Readmission Reduction Programme on readmission is unclear since rates started to decline before its institution.
⇒ The observational nature of the study does not permit causal associations to be determined.

INTRODUCTION

Medicare covers 64 million Americans, accounting for 21% of the gross national product.[1 2] Hospital readmissions result in high economic, societal and health costs. In the previous fee-for-service model of the Centers for Medicare and Medicaid, health systems had no incentive to minimise readmissions. In 2007, the Medicare Payment Advisory Commission assembled specialist political appointees who advised Congress that the high rates of readmissions (13.3% of Medicare beneficiaries) may be a target for health spending remediation.[3]

US policy-makers targeted the metric of 30-day risk-standardised readmission rates (RSRRs) to reduce healthcare costs. The Patient Protection and Affordable Care Act of 2010 enacted the Hospital Readmissions Reduction Programme (HRRP), an approach to reduce readmissions by financially penalising hospitals with higher than average 30-day RSRR. To improve transparency and promote informed patient choice in health systems, public reporting of RSRRs began in June 2009. HRRP readmission penalties went into effect starting fiscal year 2013.[4 5]

Initially targeting heart failure (HF), acute myocardial infarction (AMI) and pneumonia (PNA), HRRP penalties could be up to 3% of a hospital's Medicare reimbursements, thus affecting all payments and not just those related to the target conditions, providing a strong incentive to decrease readmissions.[6] Not only was there no reward for achieving targets, but there was also a moving baseline due to changes in national trends of readmission rates. Thus, a hospital could face penalties even with improved readmission rates if their improvement was less than others.[7 8]

At its announcement, many health systems and analysts expressed concerns about unintended consequences, especially for the most vulnerable patients, less resourced systems and safety net health organisations. There was also concern about impacts on the quality of care delivered, including premature discharge of patients in a system prioritising readmissions over survival.[9] 'Gaming' of the system from increasing observation stays, delaying readmissions beyond discharge day 30th and inappropriate triage strategies in emergency departments to achieve lower readmission rates may have avoided penalties but adversely impacted public health. A series of independent reports have now suggested that implementation of the HRRP was associated with an increase in 30-day, 90-day and 1-year risk-adjusted HF mortality in the USA with a reversal in the decade-long trend of declining HF mortality.[7]

Investigations into the impacts of the policy decision have shown variable results but essentially minimal improvement in publicly reported readmission trends. Reviews of the data from 2006 to 2012 showed no measurable change in 30-day readmissions for PNA, HF and MI.[10] Even beyond, the policy had limited success in achieving its primary objective of reducing readmissions as the achieved reduction in HF readmissions was much smaller (~9%) than anticipated (~25%) with some of the decreases in RSRRs attributable to the artefact of administrative upcoding post-HRRP rather than an actual decline in readmissions. Initially, there was a decrease in reported readmissions (23.5% in 2008 to 21.4% in 2014), but systems could have quickly identified broken processes or target populations and implemented more successful strategies.[11] There could have also been an artifactual component with increased use of observation status for those patients presenting after an index hospitalisation, eliminating tracking of readmissions.[12] Some of the variability in readmission rates across health systems could also suggest areas for improvement in the discharge and postdischarge care process.[13 14] These could include discharge care plans, coordination with primary care physicians, discharge instructions and reduction of inpatient complications.[13 14]

OBJECTIVES

To analyse the impact of the HRRP on readmission rates from 2010 to 2019 and how time to readmission impacted the outcomes: mortality, hospital charges and length of stay (LOS).

METHODS

Study design

We performed a retrospective study of inpatient records included in the National Readmission Database (NRD) from 2010 to 2019.[15]

Setting

The NRD includes encounters with patients admitted to a hospital. The initial hospitalisation is considered the index hospitalisation. Subsequent hospitalisations are linked to the index hospitalisation and permit assessment of readmissions. A unique record identifier is assigned annually and cannot be used to track an individual over time but refers only to the index hospitalisation.

Eligibility criteria

The NRD records 30-day readmissions, and the data are collected every year. Therefore, patients admitted in December month and readmitted in January of the following year would not be recorded as a readmission. Consequently, we decided to exclude admissions that occur in December and focus on the remaining months for the index hospitalisation.

Data sources

The NRD is the largest publicly available inpatient readmission database in the USA.[15 16] The NRD includes all payers and allows weighted analysis. Databases from 2010 to 2015 (included) were coded using the International Classification of Diseases (ICD), Ninth Revision and Clinical Modification/Procedure Coding System. Databases from 2016 to 2019 were coded using the ICD, 10th Revision and Clinical Modification/Procedure Coding System. The index and following readmissions are linked by identifiers by year with each year within the NRD considered as a separate sample. Thus, the unique record identifier cannot be used to track a person over time but permits assessment linked to the index hospitalisation.

Patient and public involvement

None.

Statistical methods

For each encounter, the NRD records the discharge diagnosis. We collected information regarding the following discharge diagnoses: AMI, acute exacerbation of chronic obstructive pulmonary disease (COPD), acute HF, acute PNA, coronary artery bypass graft surgery (CABG), total knee arthroplasty (TKA) and total hip arthroplasty (THA). The specific ICD codes used for our study are presented in online supplemental file 1.

We recorded the following variables: age, gender, admission year, hospital size (large, medium and small), hospital academic status (teaching vs non-teaching, urban category (large metropolitan, small metropolitan, micropolitan and not metro/micro), insurance status (Medicare, Medicaid, private, self-pay, no charge and other) and time from index hospital admission to readmission. We then recorded the following outcomes: death, charges and hospital LOS. Definitions are listed on the Healthcare Cost and Utilisation Project website (hcup-us.ahrq.gov). In the univariate analysis, we looked at three categories of hospitals: metro non-teaching, metro teaching and non-metro. In the multivariate analysis, we created a variable for teaching only and compared it to all non-teaching hospitals (metro and non-metro). We used a logistic regression for mortality and a linear regression for LOS.

We ran linear regression models to examine factors contributing to the LOS and total charges for each admission. We transformed LOS and charges into log-LOS and log-charges to normalise the data. We also ran logistic regressions to examine factors that had the most significant relationship to readmissions and mortality.

We used the Strengthening the Reporting of Observational Studies in Epidemiology cross-sectional checklist when writing our report.[17]

RESULTS

Patients and readmission trends over time

There were 31 541 431 records included in the study; of those, 4 590 883 (14.55%) were readmitted within 30 days. From 2010 to 2019, readmission rates for COPD (20.8%–19.8%), HF (24.8%–21.9%), PNA (16.4%–15.1%) AMI (15.6%–12.9%) and TKA (4.1%–3.4%) decreased whereas CABG (10.2%–10.6%) and THA (4.2%–5.8%) increased over time (table 1 and figure 1). Table 1 is descriptive of readmission rates over the years. Table 2 is a descriptive report of ORs based on a univariate regression analysis. Table 3 is a multivariate regression analysis. Table 4 describes the readmissions based on time increments.

Differences and outcomes in readmitted patients

There were significant differences between readmitted and non-readmitted patients. Readmitted patients were more likely to be males, have a higher age, be at a non-teaching institution, be admitted for a non-elective reason, have a lower income and be more likely to have Medicaid as a payor (table 2). Readmitted patients had a higher likelihood of dying (5.7% vs 2.8%) and had a higher LOS (3 (2–5) vs 4 (3–7) but lower charges (35 769 vs 29 586) (table 2).

Multivariable analysis

Factors associated with increased readmission risk included increased age, non-elective admission, male gender, large metro area and large hospital size. Metropolitan regions and large hospital sizes were also associated with increased LOS and charges. For the payer variable, there were some inconsistent findings between the outcomes. Patients with higher income (fourth quartile) experienced lower readmission rates, LOS and charges. There was an inconsistent association with mortality. Longer time to readmission was found to be significantly associated with lower mortality, similar LOS and lower charges (table 3).

Subgroups by time to readmission

We then divided our sample into four subgroups based on their time to readmission for further stratification: 1–10 days, 11–20 days, 21–30 days and either not readmitted or readmitted after 30 days. We compared the outcomes by quartile. We found that patients readmitted within 10 days had a mortality of 6.4% higher than those readmitted in 11–20 days (5.4%) and 21–30 days (4.6%). LOS was higher in patients readmitted 1–30 days, and charges were consistently lower (table 4).

DISCUSSION

Transitions of care, especially discharges, can be a vulnerable time for patients. Despite sizeable efforts to decrease readmissions across the USA, analysis of a large database demonstrated inconsistent findings with readmissions actually increasing for CABG and THA. Patient factors played a significant role as well with non-modifiable traits such as male gender and increased age increasing the risk for readmission. Other factors such as non-elective admissions could be explained by the fact that these individuals are likely sicker than those patients who can be scheduled for elective procedures. Readmitted patients as compared with those who were not readmitted were generally of a lower socioeconomic status, as demonstrated by lower income and a higher per cent enrolment in Medicaid. Healthcare disparities are not novel and it is not surprising that vulnerable patients with less social equity had an association with higher rates of readmissions and more complications. As an observational study, causation cannot be determined but directionality points to these as risk factors in readmissions.

Clinicians have not routinely been reliable judges of discharge readiness, with historical readmission rates of almost 20% for Medicare patients.[18 19] Readmissions can be traumatic for patients and exact a significant cost on the healthcare finances, with the cost of readmissions in 2020 being 12.4% higher than the index admission (US$16 300 vs US$14,500)[20] Addressing preventable hospital readmissions has been a national priority for years with large datasets, multiple interventions and toolkits developed.[16 21] Single-component interventions are less successful at reducing readmissions significantly, and even multitiered interventions for patients discharged to postacute care facilities, such as enhanced communication, medication safety, advanced care planning and enhanced training to manage medical conditions, have had variable success. Those discharged to home may benefit from more robust home-care services, mental healthcare, caregiver support, community partnerships, telehealth and additional transitional care personnel focusing on ensuring continuity of care during transitions. Still, there has been no silver bullet to decrease readmissions.[22]

Despite these overarching strategies and years of research on readmissions, the association of increased readmission rates among patients receiving CABG or THA call into question the overall success of the HRRP. CABG patients are known to be a high-risk patient population, and predictive risk factors for readmission have been identified, including age, prior HF or MI, total albumin before surgery and history of diabetes.[23] Patients undergoing THA have an association with an even greater increase in readmission rate. While differences in

Table 1 Readmissions and rates over the years

	COPD	CHF	Pneumonia	AMI	CABG	Total knee arthroplasty	Total hip arthroplasty
2010 30-day readmission, n (%)	143 881 (20.8)	121 673 (24.9)	137 827 (16.4)	78 390 (15.6)	2648 (10.2)	13 563 (4.1)	4205 (4.2)
Total	690 363	489 379	842 276	504 108	25 876	332 665	100 435
2011 30-day readmission, n (%)	149,48 (21.1)	130 127 (24.8)	138 627 (16.1)	75 861 (15.3)	2569 (10.3)	12 779 (3.9)	4261 (4.1)
Total	710 027	525 346	860 942	496 431	24 890	326 363	104 171
2012 30-day readmission, n (%)	137 372 (20.5)	131 571 (23.9)	130 762 (16.2)	73 386 (14.4)	2169 (9.8)	13 837 (4.0)	4628 (3.9)
Total	671 023	550 101	805 520	508 956	22 117	346 979	117 992
2013 30-day readmission, n (%)	130 592 (19.8)	137 875 (23.1)	124 375 (15.6)	71 252 (13.9)	2129 (10.1)	14 317 (3.6)	5042 (3.9)
Total	659 643	597 617	797 902	513 790	21 112	396 370	129 550
2014 30-day readmission, n (%)	122 305 (20.0)	144 685 (22.7)	114 225 (15.6)	68 238 (13.4)	2093 (8.9)	15 843 (3.6)	5630 (3.9)
Total	610 614	637 758	733 316	507 929	23 434	435 973	145 555
2015 30-day readmission, n (%)	123 627 (20.1)	163 411 (22.8)	113 721 (15.5)	72 213 (13.4)	9560 (10.8)	17 311 (3.6)	8529 (4.3)
Total	614 371	715 994	733 949	538 238	88 406	486 340	198 190
2016 30-day readmission, n (%)	113 099 (20.1)	155 390 (22.6)	107 551 (15.3)	73 133 (13.2)	9389 (10.8)	18 859 (3.5)	20 008 (5.1)
Total	563 256	687 680	702 004	555 003	87 079	535 207	395 203
2017 30-day readmission, n (%)	139 720 (19.6)	36 049 (22.0)	84 055 (14.4)	75 431 (13.2)	10 001 (10.9)	18 417 (3.4)	20 046 (5.0)
Total	711 916	164 192	585 681	573 347	91 936	544 558	402 531
2018 30-day readmission, n (%)	101 798 (19.6)	23 712 (22.0)	112 857 (14.8)	74 307 (13.0)	15 145 (10.8)	21 474 (3.5)	31 642 (5.9)
Total	519 572	107 698	763 548	571 866	140 040	612 230	537 358
2019 30-day readmission, n (%)	91 964 (19.8)	18 759 (21.9)	103 634 (15.1)	74 507 (12.9)	15 281 (10.6)	18 290 (3.4)	32 116 (5.8)
Total	465 540	85 795	688 105	578 980	144 366	538 760	557 900

AMI, acute myocardial infarction; CABG, coronary artery bypass graft; CHF, chronic heart failure; COPD, chronic obstructive pulmonary disease.

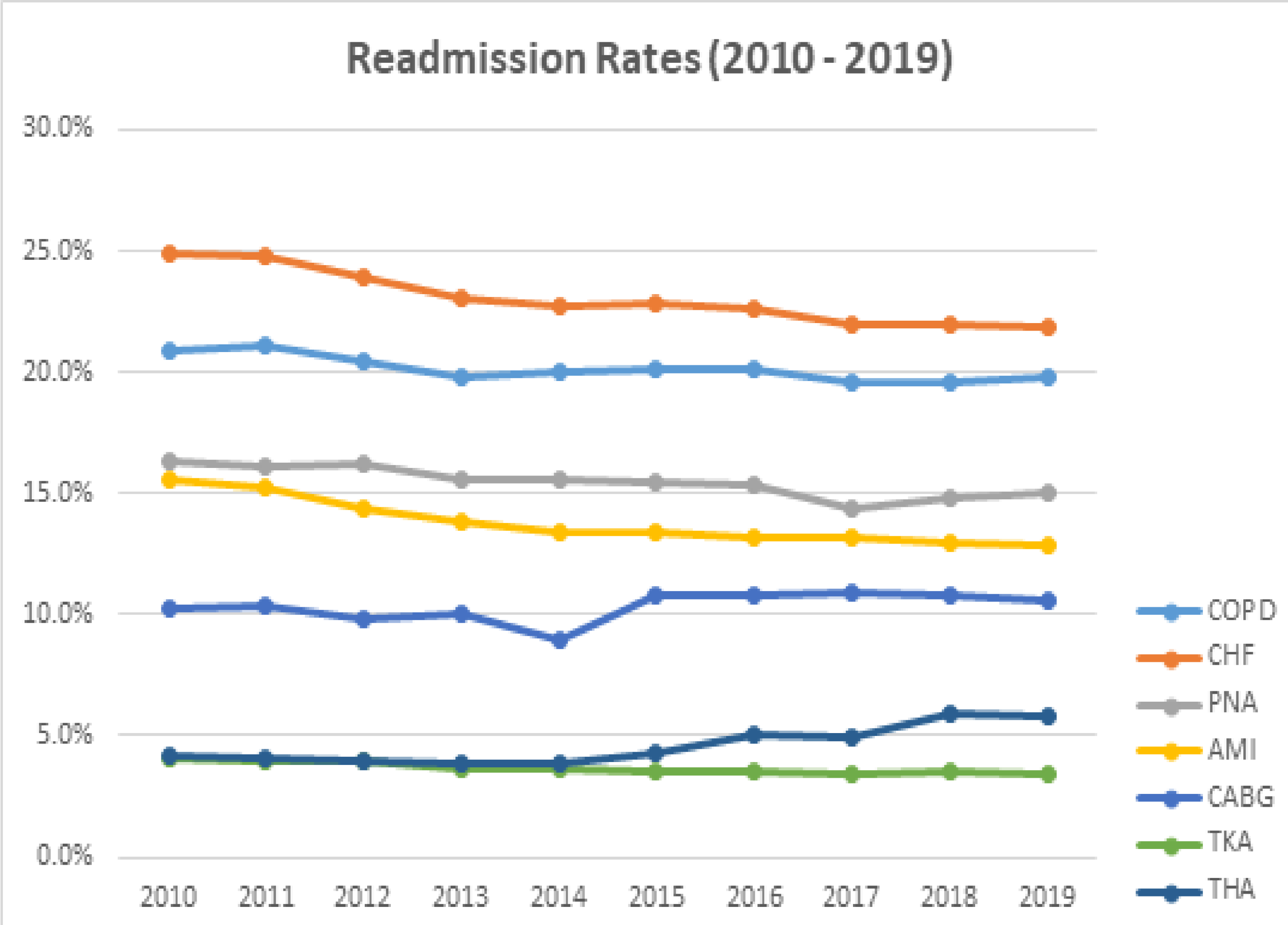

Figure 1 Readmission rates from 2010 to 2019 by conditions. AMI, acute myocardial infarction; CABG, coronary artery bypass graft; CHF, chronic heart failure; COPD, chronic obstructive pulmonary disease; PNA, pneumonia; THA, total hip arthroplasty; TKA, total knee arthroplasty.

surgical techniques and underlying patient comorbidities may account for some readmissions, as THA resulted in higher readmission rates compared with open reduction internal fixation, this is certainly not the only factor in a complex equation.[24] Prior studies suggest that risk factors for these populations correlate with health disparities such as non-private insurance (Medicare or Medicaid), identifying as black or living in a low-income area.[20 25 26]

Hospital readmission rates and reasons vary depending on disease and patient-specific characteristics.[27] Infection and falls are among the top reasons for readmission after THA[28] while infection, HF and arrhythmia were the most common after CABG.[29] For those readmissions attributable to postoperative complications, the health system is penalised twice: once for the readmission and again through pay-for-performance programmes centred on postoperative complications such as surgical site infections.[30] Another concerning trend is associated with readmission factors beyond the hospital's control, such as ileus, falls and readmissions unrelated to the initial admission.[30] These critical outliers, CABG and THA, suggest that evidence-based risk factor identification and tailored approaches for individual conditions may be effective strategies to optimise patient outcomes. Still, a penalty system likely has unintended but negative consequences on the health system and downstream patient care and little effect on meaningful readmission reduction.

Demographic differences predicting increased rates of readmission include being older and male. Older age is an explicable risk factor, likely associated with increased comorbidity, frailty and possibly more significant social needs. However, the association of male sex with increased readmission has not been shown in meta-analyses and other studies.[29 31 32] Socioeconomic considerations were also significantly predictive of readmission. Those with a lower reported income or on Medicaid were at higher risk.[26 31] Such risk factors are not modifiable and could lead hospitals to preferentially screen patients for surgery based on these characteristics, ultimately harming patients and contributing to health inequities.

Care at teaching institutions was also a risk factor for readmission, like many other extensive studies.[28] There are many unique aspects of teaching hospitals that may contribute beyond care from trainees that could affect

Table 2 Differences between readmitted and non-readmitted patients

	Non-readmitted	Readmitted	Total	OR
Total patients	26 950 548	4 590 883	31 541 431	
Age (years)	68.11 (±13.8)	69.46 (±13.9)	68.3 (±13.8)	
Male gender	12 886 654 (47.8%)	2 278 176 (49.6%)	15 164 830	1.08 (1.07–1.08)
Elective admission	7 644 944 (28.4%)	351 670 (7.7%)	7 996 614	0.21 (0.21–0.21)
Teaching hospital	14 344 638 (53.2%)	2 388 031 (52%)	16 732 669	0.95 (0.94–0.95)
Urban category				
Large metro	13 120 662 (48.7%)	2 362 521 (51.4%)	15 594 569	Ref.
Small metro	10 002 892 (37.1%)	1 576 769 (34.3%)	11 579 661	0.88 (0.87–0.88)
Micropolitan	2 648 711 (9.8%)	455 446 (9.9%)	3 104 157	0.96 (0.95–0.96)
Not metro/micro	1 187 870 (4.4%)	198 492 (4.3%)	1 386 362	0.93 (0.92–0.93)
Hospital bed size				
Large	14 662 793 (54.4%)	2 616 040 (57%)	17 278 833	Ref.
Medium	7 135 176 (26.5%)	1 210 476 (26.4%)	8 345 652	0.95 (0.95–0.95)
Small	5 162 167 (19.1%)	766 712 (16.7%)	5 928 879	0.83 (0.83–0.84)
Payer				
Medicare	17 424 741 (64.8%)	3 348 313 (73%)	20 773 054	Ref.
Medicaid	2 143 030 (8.0%)	525 697 (11.5%)	2 668 727	1.28 (1.27–1.28)
Private	5 773 712 (21.5%)	513 413 (11.2%)	6 287 125	0.46 (0.46–0.46)
Self-pay	755 054 (2.8%)	85 960 (1.9%)	841 014	0.59 (0.59–0.60)
No charge	93 599 (0.3%)	11 994 (0.3%)	105 593	0.67 (0.65–0.68)
Other	719 559 (2.7%)	99 712 (2.2%)	819 271	0.72 (0.72–0.73)
Income				
First quartile	8 101 600 (30.5%)	1 596 138 (35.2%)	9 697 738	1.33 (1.32–1.33)
Second quartile	7 217 378 (27.2%)	1 208 670 (26.7%)	8 426 048	1.13 (1.12–1.13)
Third quartile	6 323 130 (23.8%)	992 909 (21.9%)	7 316 039	1.06 (1.05–1.06)
Fourth quartile	4 919 796 (18.5%)	730 432 (16.1%)	5 650 228	Ref
Mortality	749 858 (2.8%)	259 564 (5.7%)	1 009 422	2.09 (2.08–2.10)
Length of stay (days)	3.00 (2–5)	4.00 (3–7)	3.10 (2–7)	1.04 (1.039–1.040)
Charges (US$)	35 769 (18 661–63 304)	29 586 (16 059–57 750)	34 869 (18 282–62 496)	

this. Teaching institutions are also frequently safety net hospitals and essential institutions in communities. Teaching hospitals also have a great deal to lose with readmissions. Revenue gains from an avoided readmission were 10%–15% greater for significant teaching hospitals than non-teaching hospitals. Thus, without the HRRP, systems would have a financial reason to minimise readmissions.[33] This is not a universally consistent finding, however, with some studies reporting no association with procedure volume, hospital size, hospital quality and teaching status.[32]

Although this database study could not assess the severity of illness, the implication that readmitted patients are a sicker population may be inferred as these patients incurred a longer LOS. Readmitted patients' mortality risk was similarly elevated, but the timing of readmission determined the degree of mortality risk. Those readmitted very soon after discharge (within 10 days) had the highest mortality. These individuals may have had very severe conditions that rapidly developed or could have had incomplete recovery from the primary admission. While there may be modifiable opportunities in quality patient care management, an outcome of mortality may have many additional causes leading to adverse outcomes beyond premature discharge.

General population differences among the readmitted and non-readmitted groups may inform some of these tailored interventions among all groups. Many studies have sought to identify predictors of readmission that may be amenable to intercessions, although most readmission risk prediction models performed poorly.[34] Newer models using mobile data streams[35] and machine learning[36] may have improved prediction capabilities over traditional systems such as LACE. Patient-centred models of care for hospital discharge centred on these risk factors may be more effective at moderating change.[37]

Table 3 OR and beta-coefficient for regression analysis

	30-day readmission risk	Mortality	Log-LOS (beta coefficient)	Log-charges (beta coefficient)
Time to readmission	N/A	0.98 (0.98–0.98)	0‡	–0.02
Age in years	0.99 (0.99–0.99)	1.04 (1.04–1.04)	0.06	–0.03
Male gender	1.15 (1.14–1.16)	1.15 (1.14–1.16)	–0.04	0.02
Elective admission	0.40 (0.4–0.4)	0.72 (0.71–0.74)	–0.02	0.07
Teaching hospital	1.02 (1.02–1.02)	1.04 (1.03–1.05)	0.04	–0.04
Urban category				
Large metro	Ref.	Ref.	Ref.	Ref
Small metro	0.90 (0.90–0.90)	1.09 (1.08–1.10)	–0.02	–0.08
Micropolitan	0.87 (0.87–0.88)	1.12 (1.10–1.14)	–0.04	–0.14
Not metro/micro	0.86 (0.85–0.86)	1.17 (1.15–1.20)	–0.03	–0.12
Hospital bed size				
Large	Ref	Ref	Ref.	Ref.
Medium	0.95 (0.95–0.95)	0.95 (0.94–0.96)	–0.07	–0.10
Small	0.98 (0.98–0.98)	0.94 (0.93–0.95)	–0.05	–0.06
Payer				
Medicare	Ref.	Ref.	Ref.	Ref.
Medicaid	1.08 (1.08–1.08)	1.09 (1.08–1.10)	0.01	–0.02
Private	0.60 (0.60–0.61)	0.98 (0.97–0.98)	–0.09	–0.04
Self-pay	0.49 (0.49–0.49)	0.99 (0.97–1.01)*	–0.11	–0.12
No charge	0.54 (0.53–0.55)	0.57 (0.54–0.61)	–0.11	–0.09
Other	0.78 (0.78–0.79)	1.58 (1.56–1.60)	–0.02	0.01
Income				
First quartile	1.19 (1.18–1.19)	1.01 (1.00–1.02)	0.05	0.05
Second quartile	1.10 (1.10–1.10)	1.00 (0.99–1.01)†	0.04	0.03
Third quartile	1.05 (1.05–1.05)	0.97 (0.97–0.98)	0.01	0.01
Fourth quartile	Ref	Ref	Ref	Ref.

*p=0.249.
†p=0.931.
‡p=0.34.
LOS, length of stay; N/A, not applicable.

Aspects of the policy may be considered successful. The decrease in readmission rates for five of the seven conditions could be seen as a success, but none achieved readmission rates under 1%. This non-zero readmission rate is likely contingent on factors beyond the hospital's control, not least of which may be the diminishing social support structures and family proximity and availability. Patients need assistance with daily personal and medical care, transportation, and support navigating the health system after discharge. Patients without solid social support after

Table 4 Outcomes by time to readmission subgroups

	No readmission or greater than 30 days	1–10 days	11–20 days	21–30 days	Total
Number of patients	26 960 135	2 109 160	1 430 160	1 053 822	31 553 278
Mortality	749 858 (2.8%)	134 405 (6.4%)	76 661 (5.4%)	48 470 (4.6%)	1 009 394 (3.2%)
LOS	3 (2–5)	4 (3–7)	4 (3–7)	4 (3–7)	3.1 (2–7)
Charges ((US$))	35 769 (18 661–63 304)	30 095 (16 159)	29 453 (16 101–57 139)	28 816 (15 812–55 078)	34 869 (18 282–62 496)

LOS, length of stay.

discharge have experienced increased hospital readmissions.[38] Additionally, trends in reduced readmission rates were shown to be similar in Canada despite no penalties assessed on their hospitals.[39]

Given the discrepant results, the policy should be reviewed for its utility in the current healthcare landscape. Nine in 10 general acute care hospitals have been penalised at least once in the past decade, and those hospitals with more low-income beneficiaries and teaching hospitals have experienced a disproportionate share of the penalties.[6] Average HRRP penalties have not declined despite improved readmission rates since the programme's inception. Thus, the HRRP has saved the government billions of dollars, but impacts on patients with various conditions have been less specific.[40] The high rate of hospital closures may further exacerbate quality care delivery.[41] Priority alignment should be recalibrated given that the HRRP-exacted readmission penalties are 15 times higher than penalties for 30-day mortality. While readmission is undoubtedly an outcome patients would relish, focusing on mortality outcomes may be more beneficial. Creating a system of financial incentives rather than penalties, which is not linked to the performance of other hospitals, may generate sustainable and positive patient outcomes.

Limitations

One limitation of the study is inherent in the design of any study using an extensive database, namely that nuanced assessments at the patient level are not possible, and specific conclusions about readmission cannot be ascertained. Additionally, scheduled hospitalisations were not distinguished from unanticipated admissions. The contribution of scheduled hospitalisations would not be anticipated to be large and would likely have been equally distributed over the various index hospitalisations but definitive conclusions cannot be drawn. Further investigations should be conducted into readmission reasons and characteristics of those at highest risk, especially those receiving CABG or THA. While a large database study cannot answer questions related to specific factors involved in readmissions, it does suggest that a once-size-fits approach is not proportional to meeting the needs of all patient populations. More tailored interventions may be required for subpopulations, informed by further studies into the reasons behind the readmission for these two conditions.

While a zero-readmission rate may not be attainable with our current medical model, many intrinsic and extrinsic considerations to health systems may mitigate readmission risk factors. A medical system emphasising preventative and primary care would create a healthier community, putting less stress on the hospital system. Our current health system prioritises tertiary care, allocating most resources to individuals who have already become severely ill rather than advocating for systems and policies that emphasise healthier populations. This would include increasing physical activity and active transportation, promoting plant-based diets, decreasing exposure to environmental pollution, prioritising mental health and providing resources for those with substance use disorders. Health systems must address the ecological and social determinants of health for local populations, including difficulties accessing transportation, food and housing.[42]

Even though these foundational issues must be addressed, health systems can leverage existing data to identify especially vulnerable patients. They are providing more carrots than sticks, which would support health systems already struggling postpandemic with administrative burdens and declining reimbursement. Advocating for patient-centred policies should be the focus of next-generation healthcare legislation.

CONCLUSION

Over the last 10 years, readmission rates decreased for most conditions included in the HRRP except CABG and THA. The impact of the HRRP is unclear since rates started to decline before its institution. Patients readmitted shortly after discharge were at higher risk of death and had higher hospital charges compared with those readmitted later.

Contributors EC and J-SR conceived the project. KH gathered the data and performed the analysis. EC, JV, KH and J-SR wrote and revised the manuscript. J-SR is responsible for the overall content as the guarantor.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The approval was waived because the data were publicly available and contained no patient identifiers.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. Data are publicly available in the National Readmission database: Agency for Healthcare Research and Quality, Data From NRD Database Documentation. Healthcare Cost and Utilisation Project (HCUP). Rockville, MD. 2024.THE HCUP NATIONWIDE READMISSIONS DATABASE (NRD), 2020 (ahrq.gov).

ORCID iD

Jean-Sebastien Rachoin http://orcid.org/0000-0002-6322-092X

REFERENCES

1 Services CfMaM. CMS Releases Latest Enrollment Figures for Medicare, Medicaid, and Children's Health Insurance Program, 2021. Available: https://www.cms.gov/newsroom/news-alert/cms-releases-latest-enrollment-figures-medicare-medicaid-and-childrens-health-insurance-program-chip [Accessed 17 Oct 2023].
2 Services CfMaM. National Health Expenditure Fact Sheet, 2021. Available: https://www.cms.gov/data-research/statistics-trends-and-reports/national-health-expenditure-data/nhe-fact-sheet [Accessed 17 Oct 2023].
3 MedPac. Medicare Payment Advisory Commission Report to the Congress: Promoting Greater Efficiency in Medicare, 2007. Available: http://www.medpac.gov/docs/default-source/reports/Jun07_Ch05.pdf?sfvrsn=0 [Accessed 9 Jul 2023].
4 James J. Health policy brief: Medicare hospital readmissions reduction program. *Health Aff* 2013;12:1–5.
5 Zuckerman RB, Sheingold SH, Orav EJ, *et al*. Readmissions, observation, and the hospital readmissions reduction program. *N Engl J Med* 2016;374:1543–51.
6 KFF. 10 Years of Hospital Readmissions Penalties, 2021. Available: https://www.kff.org/health-reform/slide/10-years-of-hospital-readmissions-penalties/ [Accessed 17 Oct 2023].
7 Gupta A, Fonarow GC. The hospital readmissions reduction program-learning from failure of a healthcare policy. *Eur J Heart Fail* 2018;20:1169–74.
8 McIlvennan CK, Eapen ZJ, Allen LA. Hospital readmissions reduction program. *Circulation* 2015;131:1796–803.
9 Woolhandler S, Himmelstein DU. The hospital readmissions reduction program. *N Engl J Med* 2016;375:493.
10 DeVore AD, Hammill BG, Hardy NC, *et al*. Has public reporting of hospital readmission rates affected patient outcomes?: analysis of medicare claims data. *J Am Coll Cardiol* 2016;67:963–72.
11 Dharmarajan K, Wang Y, Lin Z, *et al*. Association of changing hospital readmission rates with mortality rates after hospital discharge. *JAMA* 2017;318:270.
12 Joynt KE, Figueroa JE, Oray J, *et al*. Opinions on the hospital readmission reduction program: results of a national survey of hospital leaders. *Am J Manag Care* 2016;22:e287–94.
13 Jack BW, Chetty VK, Anthony D, *et al*. A reengineered hospital discharge program to decrease rehospitalization: a randomized trial. *Ann Intern Med* 2009;150:178–87.
14 Silow-Carroll S. Reducing hospital readmissions: lessons from top-performing hospitals. *Comm Fund* 2011;1–20.
15 Agency for Healthcare Research and Quality, Data From: NRD Database Documentation. Healthcare Cost and Utilization Project (HCUP). Rockville, MD, 2024. Available: www.hcup-us.ahrq.gov/db/nation/nrd/nrddbdocumentation.jsp
16 Quality AfHR. Healthcare Cost & Utilization Project, 2019. Available: https://hcup-us.ahrq.gov/db/nation/nrd/nrddbdocumentation.jsp [Accessed 17 Oct 2023].
17 Altman DG, Egger M, *et al*. The Strengthening The Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Epidemiol (Sunnyvale)* 2007;18:800–4.
18 Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the medicare fee-for-service program. *N Engl J Med* 2009;360:1418–28.
19 Lau D, Padwal RS, Majumdar SR, *et al*. Patient-reported discharge readiness and 30-day risk of readmission or death: aprospective cohort study. *Am J Med* 2016;129:89–95.
20 Agency for Healthcare Research and Quality. Characteristics of 30-Day All Cause Hospital Readmissions 2016-2020.2023:1–15.Available: https://hcup-us.ahrq.gov/reports/statbriefs/sb304-readmissions-2016-2020.pdf304
21 Hospital Readmissions: Agency for Healthcare Research and Quality, 2023. Available: https://www.ahrq.gov/topics/hospital-readmissions.html [Accessed 17 Oct 2023].
22 Becker C, Zumbrunn S, Beck K, *et al*. Interventions to improve communication at hospital discharge and rates of readmission: a systematic review and meta-analysis. *JAMA Netw Open* 2021;4:e2119346.
23 Benuzillo J, Caine W, Evans RS, *et al*. Predicting readmission risk shortly after admission for CABG surgery. *J Card Surg* 2018;33:163–70.
24 Upfill-Brown A, Shi B, Maturana C, *et al*. Higher rates of readmission after acute total hip arthroplasty versus open reduction internal fixation for elderly acetabular fractures, a national study from 2010 to 2019. *J Orthop Trauma* 2023;37:334–40.
25 Epstein AM, Jha AK, Orav EJ. The relationship between hospital admission rates and rehospitalizations. *N Engl J Med* 2011;365:2287–95.
26 White RS, Sastow DL, Gaber-Baylis LK, *et al*. Readmission rates and diagnoses following total hip replacement in relation to insurance payer status, race and ethnicity, and income status. *J Racial Ethn Health Disparities* 2018;5:1202–14.
27 Wang S, Zhu X. Nationwide hospital admission data statistics and disease-specific 30-day readmission prediction. *Health Inf Sci Syst* 2022;10:25.
28 Phruetthiphat O-A, Otero JE, Zampogna B, *et al*. Predictors for readmission following primary total hip and total knee arthroplasty. *J Orthop Surg (Hong Kong)* 2020;28:2309499020959160.
29 Shah RM, Zhang Q, Chatterjee S, *et al*. Incidence, cost, and risk factors for readmission after coronary artery bypass grafting. *Ann Thorac Surg* 2019;107:1782–9.
30 Merkow RP, Ju MH, Chung JW, *et al*. Underlying reasons associated with hospital readmission following surgery in the United States. *JAMA* 2015;313:483–95.
31 Feng TR, White RS, Gaber-Baylis LK, *et al*. Coronary artery bypass graft readmission rates and risk factors - a retrospective cohort study. *Int J Surg* 2018;54:7–17.
32 Shawon MSR, Odutola M, Falster MO, *et al*. Patient and hospital factors associated with 30-day readmissions after coronary artery bypass graft (CABG) surgery: a systematic review and meta-analysis. *J Cardiothorac Surg* 2021;16:172.
33 Hoffman GJ, Tilson S, Yakusheva O. The financial impact of an avoided readmission for teaching and safety-net hospitals under medicare's hospital readmission reduction program. *Med Care Res Rev* 2020;77:324–33.
34 Kansagara D, Englander H, Salanitro A, *et al*. Risk prediction models for hospital readmission: a systematic review. *JAMA* 2011;306:1688–98.
35 Qian C, Leelaprachakul P, Landers M, *et al*. Prediction of hospital readmission from longitudinal mobile data streams. *Sensors (Basel)* 2021;21:7510.
36 Le Lay J, Alfonso-Lizarazo E, Augusto V, *et al*. Prediction of hospital readmission of multimorbid patients using machine learning models. *PLoS One* 2022;17:e0279433.
37 Anthony MK, Hudson-Barr D. A patient-centered model of care for hospital discharge. *Clin Nurs Res* 2004;13:117–36.
38 Schultz BE, Corbett CF, Hughes RG, *et al*. Scoping review: social support impacts hospital readmission rates. *J Clin Nurs* 2022;31:2691–705.
39 Samsky MD, Ambrosy AP, Youngson E, *et al*. Trends in readmissions and length of stay for patients hospitalized with heart failure in Canada and the United States. *JAMA Cardiol* 2019;4:444–53.
40 KFF. Look up your hospital: Is it being pnealized by Medicare?, 2023. Available: https://kffhealthnews.org/news/hospital-penalties/readmissions/ [Accessed 17 Oct 2023].
41 Why are 600+ rural hospitals at risk of closing?, 2023. Available: https://www.advisory.com/daily-briefing/2023/03/22/rural-hospitals#:~:text=According%20to%20CHQPR%2C%20these%20hospitals,and%20very%20low%20financial%20reserves.&text=%22Costs%20have%20been%20increasing%20significantly,president%20and%20CEO%20of%20CHQPR [Accessed 17 Oct 2023].
42 Warchol SJ, Monestime JP, Mayer RW, *et al*. Strategies to reduce hospital readmission rates in a non-medicaid-expansion state. *Perspect Health Inf Manag* 2019;16:1a.

Supplemental Materials

<u>ICD9 Acute myocardial infarction</u>

410, 410.01, 410.02, 410.1, 410.11, 410.12, 4410.2, 410.21, 410.22, 410.3, 410.31, 410.32, 410.4, 410.41, 410.42, 410.5, 410.51, 410.52, 410.6, 410.61, 410.62, 410.7, 410.71, 410.72, 410.8, 410.81, 410.82, 410.9, 410.91, 410.92

<u>ICD10 Acute myocardial infarction</u>

I21.02, I21.09, I21.1, I21.11,I21.19, I21.2, I21.21 , I21.29, I21.3, I21.4,I21.9, I21.A, I21.A1, I21.A9, I22, I22.0, I22.1, I22.2, I22.8, I22.9

<u>ICD9 CABG</u>

36.1, 36.12, 36.13, 36.14, 36.15, 36.16, 36.17, 36.19, 36.91, 36.99

<u>ICD 10 – PCS/CPT codes CABG</u>

0210083	0211083	0212083	0213083	02100Z3
0210088	0211088	0212088	0213088	02100Z8
0210089	0211089	0212089	0213089	02100Z9
021008C	021108C	021208C	021308C	02100ZC
021008F	021108F	021208F	021308F	02100ZF
021008W	021108W	021208W	021308W	02110Z3
0210093	0211093	0212093	0213093	02110Z8
0210098	0211098	0212098	0213098	02110Z9
0210099	0211099	0212099	0213099	02110ZC
021009C	021109C	021209C	021309C	02110ZF
021009F	021109F	021209F	021309F	02120Z3
021009W	021109W	021209W	021309W	02120Z8
02100A3	02110A3	02120A3	02130A3	02120Z9
02100A8	02110A8	02120A8	02130A8	02120ZC
02100A9	02110A9	02120A9	02130A9	02120ZF
02100Ac	02110Ac	02120Ac	02130Ac	02120Z3
02100AF	02110AF	02120AF	02130AF	02120Z8
02100AW	02110AW	02120AW	02130AW	02130Z3
02100J3	02110J3	02120J3	02130J3	02130Z8
02100J8	02110J8	02120J8	02130J8	02130Z9
02100J9	02110J9	02120J9	02130J9	02130ZC
02100JC	02110JC	02120JC	02130JC	02130ZF
02100Jf	02110Jf	02120Jf	02130Jf	
02100JW	02110JW	02120JW	02130JW	
02100K3	02110K3	02120K3	02130K3	
02100K8	02110K8	02120K8	02130K8	
02100K9	02110K9	02120K9	02130K9	
02100KC	02110KC	02120KC	02130KC	
02100KF	02110KF	02120KF	02130KF	
02100KW	02110KW	02120KW	02130KW	

ICD9- pneumonia

003.22, 073.0, 052.1, 021.2, 083.0, 083.9, 022.1, 011.6, 078.5, 039.1, 112.4, 114.0, 130.4, 136.3, 136.9, 480.0, 480.1, 480.2, 480.3,480.31, 480.8, 480.9, 481, 482, 482.1, 482.2, 482.2, 482.3, 482.31, 482.32, 482.39,482.4, 482.41, 482.42, 482.49, 482.81, 482.82, 482.83, 482.89,482.9, 483, 483.1, 483.8, 484.1, 484.3, 484.5, 484.6, 484.7, 484.8, 485,486,487.0,488.01, 488.11, 488.81, 770.18,516.8,516.36, 513, 770.18, 510

ICD 10- Pneumonia

J12.0, J12.1, J12.2, J12.3, J12.8, J12.81, J12.82, J12.89.J12.9, J15.0, J15.1, J15.2, J15.21, J15.211, J15.212, J15.29, J15.3, J15.4, J15.6, J15.7, J15.8, J15.9, J16.0, J 16.8, J16.9, J17, J18, J18.1, J18.2, J18.8, J18.9

ICD 9 – Acute CHF

428.21, 428.23, 428.31, 428.33, 428.41, 428.43

ICD 10 Acute CHF

I50.21, I50.23, I50.31, I50.33, I50.41

ICD 9- Acute COPD exacerbation

491.21, 491.22, 493.22

ICD10- Acute COPD exacerbation

J44.0, J44.1, J45.21 ,J45.22 ,J45.3,J45.31,J45.32

ICD9- Primary total hip arthroplasty

81.51

ICD10- Primary total hip arthroplasty

0SRB019, 0SR9019, 0SRB01A ,0SR901A ,0SRB029, 0SR9029 ,0SRB02A, 0SR902A ,0SRB039, 0SR9039, 0SRB03A ,0SR903A, 0SRB049 ,0SR9049, 0SRB04A , 0SR904A , 0SUB0BZ , 0SU90BZ

ICD9-Primary Total Knee Arthroplasty

81.54

ICD10 Primary Total Knee Arthroplasty

0SRD0J9, 0SRC0J9, 0SRC0JA,0SRD0JA