

PEDIATRICS

Does initial length of stay impact 30-day readmission risk in pediatric asthma patients?

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Abstract

Objectives: Accountable care puts pressure on hospitals to manage care episodes. Initial length of stay (ILOS) and readmission risk are important elements of a care episode and measures of care quality. Understanding the association between these two measures can guide hospital efforts in managing care episodes. This study was designed to explore the association between ILOS and readmission risk in a cohort of pediatric asthma patients. **Materials and methods:** The sample cohort ($n = 4965$) consisted of all asthma patients discharged from Children's Hospitals and Clinics of Minnesota (CHC MN) from January 2008 through August 2012. Asthma discharges included cases with a principal diagnosis of asthma or certain respiratory cases with asthma listed as a secondary diagnosis. Multiple logistic regression was used to test associations, adjusting for covariates. **Results:** Adjusting for covariates, we found no significant association between ILOS and readmission (OR: 1.04 [95% CI: 0.98–1.10]). Analyzing ILOS categorically by length of stay, one-day stays did not have a significantly higher readmission risk (OR: 1.27 [95% CI: 0.87–1.85]) than two-day stays, which had the lowest observed readmission risk. Risk increased as ILOS exceeded two days but was not significantly different by day. We found no association when comparing the difference in actual versus expected ILOS and readmission risk (shorter than expected OR: 1.13 [95% CI: 0.74–1.71]; longer than expected OR: 0.97 [95% CI: 0.69–1.38]). **Conclusions:** Attempts to prolong ILOS would dramatically increase costs with little impact on readmissions. For example, increasing one-day visits to two-day visits would increase hospital patient days 38% (1870 d) in this cohort while decreasing total readmissions by 3.8% [95% CI: 3.6–4.0%]. Understanding the mechanisms that impact readmissions is essential in evaluating cost-effective approaches to improving patient outcomes and lowering the cost of care.

Keywords

Children's hospitals, early hospital discharge, episode of care, hospital readmissions, population health management

History

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Introduction

Preventable readmissions have been identified as a potential indicator of quality of care and patient health [1–4]. Some remain skeptical regarding the association between hospital care and readmission risk [5,6] as well as the number of pediatric and adult readmissions that are truly preventable [7,8]. Despite this, payers (including both government and commercial plans) are incorporating financial incentives designed to reduce readmissions into hospital contracts. Such incentives move away from traditional fee-for-service towards paying providers for successful outcomes associated with an episode of care [9,10].

While much research on the impact of readmissions on quality of care and cost has been conducted among the

general adult inpatient population, more research is needed to understand the nature and impact of readmissions on pediatric patients and hospitals [11]. The nature, treatment and ongoing care for childhood disease can differ substantially from the care and treatment of adults [12]. Recent research confirms that readmission risk is lower in children relative to adults. Only 20% of pediatric readmissions may be preventable across all conditions [8]. However, among asthma patients, effective disease control through primary care intervention and patient self-management has been shown to lower the risk of exacerbation and subsequent hospitalization [13–17].

Previous research into the primary causes of readmissions in the adult population point to several risk factors [18–22]. Patient demographics identified in previous studies include age, race, socio-economic status and hospital proximity. Disease characteristics include type and severity of disease, presence of mental health problems, substance abuse or other co-morbidities. Factors potentially related to care include length of time between initial admit and readmission, prior use

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of hospital resources, patient self-management, hospital admission rates, hospital capacity and the presence of a transition care plan. Among studies focused specifically on readmission risk in children, primary risk factors for readmission include the presence of complex chronic conditions, race and use of Medicaid [23–26]. These risk factors are consistent with studies of pediatric asthma patients [27–30].

Despite the existing research, estimating readmission risk remains a complex endeavor [31]. Yet understanding both the underlying clinical and economic implications of readmissions, as well as identifying the underlying mechanisms available to impact readmissions, are essential to ensuring quality improvement efforts are effective. One implicit assumption in efforts to reduce readmissions is that readmissions result from an overall misallocation by the provider of the hospital resources required to deliver quality care. Given this, we were interested in the association that might exist between hospital utilization as a measure of care quality and subsequent readmission risk for patients with asthma. Using length of stay as a surrogate for hospital utilization [32], we tested the hypothesis that an association exists between initial length of stay (ILOS) and readmission risk in pediatric asthma patients. We also examined the association between the difference in actual versus expected length of stay and readmission risk. Understanding the relationship between hospital utilization and the probability of readmission might assist pediatric hospitals in evaluating cost-effective approaches to reducing readmissions.

Methods

We used a retrospective cohort design to study patterns of readmission at a large, urban pediatric hospital. Children's Hospitals and Clinics of Minnesota (CHC MN) acts as a safety net hospital, serving the needs of urban and suburban children from multiple racial and ethnic backgrounds in the Twin Cities. We extracted data from the electronic medical records of all in-patient discharges occurring from 1 January 2008 to 31 August 2012. The final sample contained 80 820 discharges. To identify readmission cases, we linked our discharge population to subsequent admissions within 30 d. We defined as a readmission the *first* in-patient hospitalization initiated within 30 d of a discharge (i.e. each discharge could have only 1 readmission, and we did not consider readmission chains). Subsequent readmissions within 30 days after 31 August 2012, were not captured. This may under-report readmission counts but the estimated impact was small ($n = 4$ readmissions). We defined initial length of stay as the difference between the discharge date and the admit date measured as a whole number in days. Same-day admit/discharges were counted as one day. We included both inpatient and observation stay discharges [33]. An episode of care was defined as the initial hospital stay plus any subsequent readmission for a related condition within 30 d.

In an analysis of different classification systems for defining asthma cases, we determined that only 36% of cases with asthma in the first five International Classification of Diseases (ICD-9) diagnoses had asthma listed as the ICD-9 principal diagnosis and that only 26% of cases listing asthma among the first five ICD-9 diagnosis codes also had an

All-Patient Refined Diagnosis-Related Group (APR-DRG) code indicating asthma. Hospital conditions are generally coded sequentially beginning with the most serious condition. Working with a pulmonologist, we found through a separate validation study that when asthma was coded as a secondary condition, as either the second or third diagnosis for certain respiratory conditions, the underlying treatment was for asthma (0.89 [95% CI: 0.68–0.97]; 0.83 [95% CI: 0.60–0.93], respectively). Based upon these findings, we used the following criteria for identifying cases treated for asthma: (1) discharges coded with a principal diagnosis of asthma (ICD-9 493.x) ($n = 3342$); (2) discharges coded as respiratory failure or pneumonia (APR-DRG 133, 139) with asthma coded as a secondary condition (ICD-9 493.x) ($n = 1497$); (3) discharges coded as RSV/bronchiolitis (APR-DRG 138) where asthma was coded as secondary condition (ICD-9 493.x) and the patient's age was greater than 24 months ($n = 110$); and (4) all discharges for respiratory ventilation (APR-DRG 130) involving asthma (ICD-9 493.x) ($n = 16$). Applying these criteria to identify a more complete population of asthma cases increased the identification of probable asthma-related hospitalizations 48% ($n = 1623$ additional cases) from the use of the ICD-9 primary diagnosis alone. The use of the broader criteria increased the overall estimated detection accuracy from 52 to 83%.

We used logistic regression models to examine the association between ILOS and readmission risk. Categorical covariates were identified based upon known factors that can impact readmission including age, race, gender, language, hospital proximity ($< > 5$ miles), admit reason (asthma primary or secondary diagnosis), discharge disposition (home or health agency), admit season, procedure performed, severity of illness (using the APR-DRG classification scale 1–4, with 1 being minor and 4 being extreme), payer and admit year. Data regarding patient primary care utilization and medication compliance was not available for this study. To identify potential confounding or interaction variables, we used multivariate logistic and multiple linear regression with transformations (e.g. log) considered for covariates in the case of non-normal distribution to test the association between potential covariates and readmission risk and length of stay, respectively [34].

To test the hypothesis that differences in actual versus expected initial length of stay may impact readmission risk, we measured the difference between actual and expected initial length of stay (expected initial length of stay was defined as the median length of stay set by category of severity). We grouped discharges into three categories: (1) those with an actual ILOS that equalled the expected ILOS, (2) those with an ILOS that was less than expected, and (3) those with an ILOS that exceeded the expected value. We then applied univariate and multiple logistic regression to measure the association by category. We identified potentially significant covariates for further multivariate analysis and performed model testing, including goodness of fit, area under the curve (AUC) and variance inflation factor (VIF) testing as appropriate. All statistical analysis was performed using Stata (Version 10.0; StataCorp, College Station, Tx). IRB approval was obtained through CHC MN (IRB# 1207-067) and the University of Minnesota (IRB# 1209E20042).

Results

The study cohort included 4965 asthma patients discharged from CHC MN between January 2008 and August 2012. A description of the study population is noted in Table 1. We observed a readmission rate of 3.91% ($n = 194$ readmissions). The CHC asthma population ranged in age from birth to adult with the majority of patients between 1 and 4 years of age (mean age 4.72 years). Sixty-one percent of patients were male. Thirty-three percent were Black/African-American, including a relatively large population of recent African immigrants from Somalia (13.4% of the Black/African-American population declared Somali as their primary language). More than 90% of the patients had mild to moderate asthma severity. Two thirds of asthma patients were discharged with asthma as the primary diagnosis. Mean ILOS per asthma related admission was 2.21 d (median ILOS 2.0 d).

Using bivariate analysis, we identified case severity, age, procedure performed, season of the year and payer type as factors associated with ILOS and increased readmission risk. No significant collinearity was noted among risk factors. Univariate logistic regression analysis of ILOS (in days) indicated a 7% (OR: 1.07 [95% CI: 1.02–1.12]) increased risk of readmission with each additional day a patient stayed in the hospital. However, adjusting for severity, payer type, procedure status and age attenuated this risk estimate and the difference was no longer significant (OR: 1.04 [95% CI: 0.98–1.10]). Results of the multivariate analysis are summarized in Table 2.

Analyzing ILOS categorically by day, we found that one-day stays had an observed increased risk of readmission (OR: 1.27 [95% CI: 0.87–1.85]) over two-day stays, which had the lowest overall observed readmission rate as noted in Figure 1. Observed readmission rates increased as ILOS

Table 1. Demographic characteristics of patients with and without a readmission.

Characteristic	<i>n</i>	Overall (<i>n</i> = 4965)	No readmit (<i>n</i> = 4771)	With readmit (<i>n</i> = 194)	Readmit rate	OR (95% CI)
Age						
Overall (continuous)	4965	100.0%	100.0%	100.0%	3.9%	0.98 (0.95–1.02)
<1 year	339	6.8%	6.4%	16.5%	9.4%	2.80 (1.84–4.26)
1–4 years	2621	52.8%	53.0%	48.5%	3.6%	–
5–9 years	1301	26.2%	26.5%	18.0%	2.7%	0.74 (0.50–1.10)
10–14 years	525	10.6%	10.6%	9.3%	3.4%	0.95 (0.57–1.59)
15–17 years	150	3.0%	2.9%	6.7%	8.7%	2.55 (1.39–4.63)
18+ years	29	0.6%	0.6%	1.0%	6.9%	1.99 (0.47–8.49)
Race						
White/Caucasian	1864	37.5%	37.6%	35.1%	3.6%	–
Black/African-American	1641	33.1%	32.9%	35.6%	4.2%	1.16 (0.82–1.63)
Other	1460	29.4%	29.4%	29.4%	3.9%	1.07 (0.75–1.54)
Gender						
Male	1931	38.9%	38.7%	42.8%	4.3%	0.85 (0.63–1.13)
Female	3034	61.1%	61.3%	57.2%	3.7%	–
Admit reason						
Asthma primary	3342	67.3%	67.2%	69.1%	4.0%	1.09 (0.80–1.48)
Asthma secondary	1623	32.7%	32.8%	30.9%	3.7%	–
Patient admit type						
Observation	881	17.7%	17.9%	13.4%	3.0%	0.70 (0.47–1.08)
Inpatient	4084	82.3%	82.1%	86.6%	4.1%	–
Case severity						
Minor (with observation stays)	1740	35.0%	35.2%	30.9%	3.4%	–
Moderate	2757	55.5%	55.7%	52.1%	3.7%	1.06 (0.77–1.47)
Major	440	8.9%	8.6%	16.0%	7.0%	2.12 (1.35–3.32)
Extreme	28	0.6%	0.5%	1.0%	7.1%	2.15 (0.50–9.28)
Procedure						
Yes	117	2.4%	2.2%	5.7%	9.4%	2.64 (1.40–5.01)
No	4848	97.6%	97.8%	94.3%	3.8%	–
Actual to expected ILOS						
Actual < expected	857	17.3%	17.2%	19.1%	4.3%	1.21 (0.82–1.80)
Actual = expected	2396	48.3%	48.4%	44.3%	3.6%	–
Actual > expected	1712	34.5%	34.4%	36.6%	4.1%	1.16 (0.84–1.60)
Season						
Winter (Dec–Feb)	1075	21.7%	21.5%	25.3%	4.6%	2.06 (1.21–3.50)
Spring (Mar–May)	1391	28.0%	28.0%	27.8%	3.9%	1.74 (1.03–2.94)
Summer (Jun–Aug)	884	17.8%	18.1%	10.3%	2.3%	–
Fall (Sep–Nov)	1615	32.5%	32.4%	36.6%	4.4%	1.99 (1.20–3.29)
Payer						
Commercial	2176	43.8%	44.3%	33.0%	2.9%	–
Medicare/medicaid	2703	54.4%	54.0%	66.0%	4.7%	1.64 (1.20–2.23)
None	86	1.7%	1.8%	1.0%	2.3%	0.79 (0.19–3.26)

The odds ratio measures the difference in readmission rates by characteristic. Reference values for categorical variables are noted with a “–” in the OR (95% CI) column.

exceeded two days but resulting associations were not statistically significant as noted in Table 3. We then stratified our sample by category of severity in order to test for effect modification. The association of ILOS with odds of readmission was not affected by severity of asthma diagnosis at initial hospitalization: mild severity – (OR: 0.82 [95% CI: 0.55–1.21]), moderate severity – (OR: 1.00 [95% CI: 0.88–1.15]), major/extreme severity – (OR: 1.04 [95% CI: 0.98–1.12]).

Table 2. Results of final multivariate analysis.

Characteristic	Odds ratio	$p > z $	95% CI	
			LL	UL
ILOS	1.04	0.25	0.98	1.10
Severity (versus mild severity)				
Moderate	0.98	0.90	0.70	1.36
Major*	1.71	0.03	1.05	2.76
Extreme	0.66	0.64	0.12	3.74
Age group (versus age group 1–4)				
<1*	2.58	0.00	1.69	3.93
5–9	0.72	0.10	0.48	1.07
10–14	0.88	0.62	0.52	1.47
15–17*	2.52	0.00	1.37	4.64
18+	1.61	0.53	0.37	6.99
Payer (versus commercial payer)				
Medicare/medicaid*	1.59	0.00	1.17	2.18
None	0.92	0.92	0.22	3.87
Procedure	1.89	0.10	0.89	4.04

Reference values for categorical variables are noted in parenthesis.

*Significant values ($p < 0.05$)

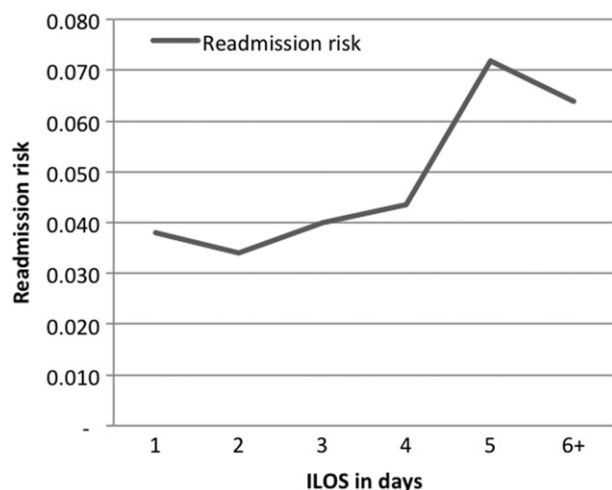


Figure 1. Observed readmission risk by initial length of stay (in days).

Table 3. Final multivariate results categorized by day.

Description	n	% Total population			Readmit rate	Adjusted OR 95% CI
		Overall	No readmit	With readmit		
Overall	4965	100.0%	100.0%	100.0%	3.9%	1.04 [0.98–1.10]
1 d	1870	37.7%	37.7%	36.6%	3.8%	1.27 [0.87–1.85]
2 d	1736	35.0%	35.1%	30.4%	3.4%	–
3 d	727	14.6%	14.6%	14.9%	4.0%	1.07 [0.68–1.70]
4 d	321	6.5%	6.4%	7.2%	4.4%	1.11 [0.60–2.04]
5 d	139	2.8%	2.7%	5.2%	7.2%	1.68 [0.82–3.46]
6+ d	172	3.5%	3.4%	5.7%	6.4%	1.11 [0.53–2.35]

The odds ratio measures the difference in readmission rates by day with the median ILOS of 2 d as the reference category.

To refine our measurement of possible early hospital discharge, we compared the actual to expected length of stay by readmission type, adjusting for severity. We found that patients who were discharged as expected (the difference in actual versus expected ILOS was zero) had the lowest observed readmission risk (3.6%). Patients who were released either earlier or later than expected had a higher readmission risk (OR: 1.21 [95% CI: 0.82–1.80]) and (OR: 1.16 [95% CI: 0.84–1.60]), respectively, than those released as expected as noted in Figure 2. Although the risk estimates for patients who were released either before or after expected were slightly elevated, these findings were not statistically significant. Though the observed value dropped for patients released later than expected, the lack of a statistical association remained upon further adjusting for known confounders (actual < expected – OR: 1.13 [95% CI: 0.74–1.71]; actual > expected – OR: 0.97 [95% CI: 0.69–1.38]).

Discussion

Our study objective was to determine if initial length of stay impacts readmission risk in pediatric asthma patients. To test this, we evaluated two measurements. The first measurement looked at ILOS more generally and by day. The second measurement categorized patients into three subgroups based upon whether their ILOS was shorter than, in line with or longer than the expected ILOS. Contrary to our initial expectations, after adjusting for known confounders, we found no significant association between ILOS and readmission risk (OR: 1.04 [95% CI: 0.98–1.10]). These findings are consistent with at least one study on the adult population that found that increasing LOS did not affect the likelihood of readmission across all conditions [35]. One study of readmission risk factors among inner-city children in the Bronx with asthma also found no association between ILOS and readmission risk (OR 1.08 [95% CI: 0.97–1.21]) [27].

The lack of association between ILOS and readmission risk could also be seen analyzing LOS categorically by day. The difference in risk for different values of LOS was not statistically different from the risk of readmission for the median LOS of two days. In categorically analyzing the association between the difference in actual versus expected length of stay, we found that the observed difference in readmission risk for patients was highest for those that had either a shorter or longer than expected ILOS, but the association was not significant. This lack of association remained after adjusting for confounders, indicating that patients who were released earlier than

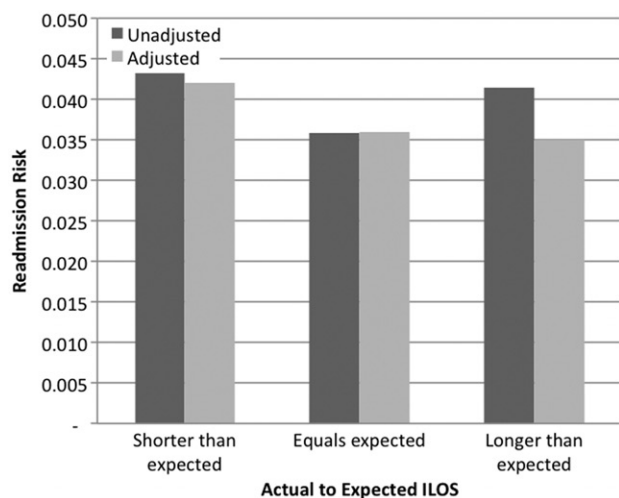


Figure 2. Observed readmission risk by the difference in actual versus expected ILOS.

anticipated did not have a significantly different risk of readmission.

These findings have several implications. First, use of the ICD-9 principal diagnosis code or the APR-DRG code for asthma detection understates the real burden of asthma within a hospital population. Early in the review of asthma cases, we found the use of the ICD-9 principal diagnosis introduced information bias into the results. Hospitals are incentivized through reimbursement guidelines to capture all conditions that the hospital treats during a patient's stay. However, to maximize payments, the principal diagnosis usually reflects the most resource-intensive treatment. Given that asthma may be less resource-intensive than respiratory failure or other conditions, this can lead to underreporting of asthma as the principal diagnosis despite clear evidence of asthma treatment and its major role in the illness. With a higher mean ILOS (2.85 d versus 1.90 days; $p < 0.001$) for asthma cases with a secondary ICD-9 diagnosis, capturing the more complete population of treated asthma cases increased the number of asthma patient days by 4625 or 73%.

Second, overall pediatric asthma readmission levels are relatively low when compared to the adult asthma population. The CHC MN readmission rate of 3.91% we measured over four years is generally consistent with national data that estimated pediatric asthma readmissions at 3.2% [36]. This is in contrast to adult asthma 30-day readmission levels that range from 11.8 to 17.3%, increasing with age [22,36]. This suggests that the opportunity to lower cost and improve outcomes through reducing readmissions is much lower in the pediatric population than in the adult population.

Third, the lack of association between ILOS and readmission risk suggests that days counted in an episode of care length of stay (ILOS + readmit LOS) are not exchangeable between the initial stay and the readmission. Efforts to reduce the average total length of stay for an episode of care (i.e. ILOS + readmit LOS) by increasing the ILOS will not necessarily lower overall hospital utilization. For example, based upon our findings, increasing all one-day visits in the study to two-day visits would increase hospital patient days by 38% in this cohort (1870 d)

while decreasing total readmissions by only 3.8% [95% CI: 3.6–4.0%]. This translates into 1870 additional days to eliminate 7 readmissions with a savings of 18–20 d of readmit length of stay, resulting in a net increase of 1850 d of hospitalization.

Finally, our findings support other empirical evidence that demonstrates that factors outside hospital care, such as the patient's background, medical history, home and family environment and primary care interventions, contribute to readmission risk and should be considered in setting incentives for improving patient outcomes and managing care episodes [37,38]. For example, researchers have demonstrated that continuous quality improvement programs upon discharge that increase coordination between the hospital, primary care organizations, community health workers and patient caregivers improve patient self-management and health outcomes and lower asthma hospitalizations [12,39–45].

This study was conducted within a single independent children's hospital system. Approximately 25% of children's hospitalizations in the US are at children's hospitals [46]. Children's hospitals have a set of potentially distinct characteristics from general hospitals including the setting, patient demographics, the nature and severity of conditions treated and any distinct asthma treatment protocols or clinical pathways in place. However, evidence suggests that median LOS may not vary significantly between children's hospitals and general hospitals though study results are mixed [46]. Patterns of care and readmission rates for asthma between children's hospitals and general hospitals in the NY/PA region, for example, were shown to be consistent after adjusting for certain covariates [47]. Even so, care should be taken in applying these results more generally across the pediatric population.

Length of stay may not represent a valid proxy for measuring hospital utilization, and by extension, quality of care, but may be measuring something else. For example, length of stay does not fully reflect the nature and intensity of treatments administered, the protocols deployed, and so forth, by the hospital care team. However, practically speaking, length of stay remains the most common industry measure of hospital utilization used today and an important component of hospital reimbursement. Understanding the lack of association between length of stay and readmission risk remains important for hospitals in balancing competing priorities regarding the quality and cost of care.

Readmission to a different hospital may introduce information bias into the study given that asthma patients readmitted to CHC MN self-select for readmission and may be lost to follow-up. This could lead to understating the true readmission rate related to hospital care in the population and remains a challenge in readmission studies. To estimate the potential impact of CHC MN discharges readmitted to a different hospital within 30 days, we conducted a preliminary analysis using data for 2011 ($n = 207$ readmits) from a local payer and determined that approximately 10% of cases readmitted for all causes were readmitted to a non-CHC MN hospital. Increasing the actual readmission volume by 10% did not statistically change the overall readmission rate of 3.91% [95% CI: 3.36–4.44%].

Conclusions and key findings

Understanding pediatric readmissions remains a complex endeavor. The primary contribution of this study is to demonstrate that initial length of stay as a measure of hospital utilization, and by extension quality of care, does not significantly alter the risk of readmission for pediatric asthma patients. More research is needed to further validate these results across multiple centers and diverse pediatric populations. Understanding the mechanisms that impact readmissions is essential in evaluating cost-effective approaches that improve patient outcomes and lower the cost of care.

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Declaration of interest

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