Fever and hypothermia do not affect the all-cause 30-day hospital readmission

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ABSTRACT

Background: One of the goals of the Affordable Care Act is to decrease hospital readmissions. While widely adhered to, there is no published research to support the practice of delaying discharge if patients exhibit fever or hypothermia in the preceding 24 h, which is the focus of our study.

Methods: Retrospective analysis of the minimal (Tmin) and maximal (Tmax) body temperatures collected during the last 24 h before discharge of 19,038 inpatients. Fever was defined as Tmax >99.5F (+1SD from the mean Tmax) or >100.2F (+2SDs), and hypothermia as Tmin <97.1F (-1SD from the mean Tmin) or <96.7F (-2SDs).

Results: The overall readmission rate was 10.2% (highest for General Medicine and Pediatrics). The rate of readmission was not different between normothermic patients and those with abnormal body temperature, except for higher readmission rate (12.2%) for patients with fever at 1SD from Tmax compared with normothermic patients (9.96%). Neither fever nor hypothermia was associated with shorter time to readmission, except for fever at 2 SDs from Tmax (10.6 days) compared with normothermic patients (12.6 days). Surprisingly, univariate analysis revealed that higher Tmax and older age were associated with lower readmission probability. Both uni- and multivariate analysis showed that the presence of fever is associated with lower readmission probability. Evaluating 200 individual cases, the most common explanation for body temperature abnormality was infection and 90% of the preventable readmissions were due to infection.

Conclusions: Abnormal body temperature 24 h prior to discharge was not useful for predicting the probability of readmission.

Key Indexing Terms: Fever; Hyperthermia; Hypothermia; Body temperature; Hospital discharge; Readmission. **[Am J Med Sci 2022;364(6):714–723.]**

INTRODUCTION

Every year, hospitals are evaluated and compared to one another along a variety of metrics in order to improve the health care delivered to patients and to optimize the use of limited resources.[1,2] One of the most important metrics is hospitals' 30-day readmission rate. According to the Affordable Care Act, if a given hospital's readmission rate is higher than the expected risk-stratified readmission rate, then the hospital is fined.[3-5] Also, re-hospitalization had been associated with worse patient outcomes and higher financial costs.[6,7] Therefore, it is paramount to understand which variables affect the readmission rate. Previously published research revealed that comorbidities such as heart disease, liver and renal disease as well as active malignancy play a role in readmission.[8] However, a literature review pooling data from 34 studies on readmission following treatment for heart failure concluded that "[n]o single patient characteristic stands out as a key contributor [to readmission] across multiple studies...".[9] Among lung transplant patients, a "post-transplant complication" was found to be the greatest risk factor for readmission,[10] whereas "preoperative medical comorbidities" were likewise the major risk following pancreaticoduodenectomy.[11] These findings, ranging from nonspecific to intuitively obvious, underscore the need to further examine factors influencing hospital readmission. Of those, the "too early to discharge" factor is of particular interest as it is usually guided by a judgement call by the primary hospital team. In our experience, and as illustrated in the literature, it is a common practice to postpone the discharge if the patient has had a period of fever or hypothermia during the last 24 h.[12-14] However, body temperature is a difficult concept to interpret as it depends on a multitude of factors such as age, measurement site, time of the day, and many others.[15,16] The range of normothermia itself had been debated[17] and appears to be shifting over time towards lower temperatures.[18] Perhaps most importantly, there are no peer-reviewed data to support the practice of ensuring 24 h of normothermia before hospital discharge. To the best of our knowledge, there is no published research to suggest a correlation between fever/hypothermia and readmission rates. The research data we present here spans 12 months of hospitalizations at a tertiary care medical center. It features a quantification of the relationships between abnormal body temperature (fever or hypothermia) during the 24 h prior to hospital discharge and readmission. We evaluated different age groups and all major service departments, including Medicine, General Surgery, Orthopedic Surgery, Neurology, Urology, and Pediatrics. We evaluated 200 cases in more detail with regards to their specific diagnoses and possible readmission prevention. The results of our project are expected to aid clinicians' decision making for patient discharges from the hospital.

METHODS

This research project was reviewed and granted exemption by the Institutional Review Board (IRB) at the institution where the research took place – State University of New York Upstate Medical University, with IRB exception number 1566638-1. All data were collected retrospectively from the electronic medical record (EMR) of our tertiary medical center. At our institution, new data from our Epic EMR is extracted daily into a Clarity database with Oracle encryption. The data for our project was extracted from the Clarity database using a proprietary SQL code. We extracted data for patients that had an inpatient status from December 1, 2018 to November 30, 2019. We only excluded patients who have died during the index admission. All patient data was deidentified. The data collected were patients' age (where patients of 90 years or older were reported as 90 year-old, in compliance with our IRB protocol), sex, the primary service caring for the patient, the maximal (Tmax) and minimal (Tmin) temperatures measured during the last 24 h before discharge, the location of measurement of these temperature readings (oral, axillary, bladder, core, esophageal, rectal, tympanic), whether the patient was readmitted within 30 days of discharge, the number of days elapsed from discharge to readmission (1-30), and the primary service to which the patient was readmitted (Table 1). Microsoft Excel (Microsoft Corporation, Redmond, Wash, USA) and SPSS Version 25.0 (IBM, Chicago, IL, USA) were used for all analyses of the effect of body temperature before discharge on the readmission. We purposefully chose to evaluate the data using two different cutoffs for abnormal body temperature – at 1 and 2 standard deviations from the mean Tmax and Tmin for fever and hypothermia, respectively. This was done because as of yet it remains unclear what the proper cutoffs are that define abnormal body temperature[15] and therefore providing information for both cutoffs might be useful for clinical decision making. Fever was defined as Tmax >99.5F (1SD (standard deviation) above the mean) or >100.2F (2SDs above the mean), while hypothermia was defined as Tmin <97.1F (1SD below the mean) or <96.7F (2SDs below the mean). T-testing was used to compare the body temperature means according to measurement site. We used the Kruskal-Wallis test to evaluate the effect of fever and hypothermia on the number of days to readmission, and to compare the number of days to readmission between specialty services (Neurology, Orthopedics, Surgery, Pediatrics, and General Medicine). This allowed us to account for the non-normal distribution of the data. The Chi-square test was used to quantify the effect of body temperature on the readmission rate. For all statistical analyses, the results were considered significant if $p \leq 0.05$. Finally, we selected randomly and manually reviewed 200 individual cases: 50 each for patients with fever without readmission, patients with fever and readmission, patients with hypothermia without readmission, and patients with hypothermia and readmission. We noted the discharge diagnoses from the index admissions and their readmission diagnoses, and the number of days until readmissions, if readmitted. We separated the discharge diagnoses into two main groups: those that could explain the fever or hypothermia and those that could not (Table 5). We defined "avoidable readmission" criteria–a readmission is avoidable if the readmission diagnosis could have been inferred from the discharge diagnosis where the abnormal body temperature could be regarded as a "red flag" and if the readmission occurred no more than 7 days after the discharge, as summarized in Table 6.

RESULTS

Patient population descriptive statistics

From the 19,038 inpatients in our study (Table 1), 48% were female and the mean age was 46.3 +/- 27.2 years. The distribution of patients' ages in Fig. 1A shows a slight predominance of the age groups 0 to 10 years and 50 to 70 years. The top 5 most populous primary services were General Medicine with 8,018 patients, Pediatrics with 3,557 patients, General Surgery with 1,989 patients, Orthopedics with 1,848 patients, and Neurology with 1,140 patients. The rest of the primary services comprised less than 5% of the total number of patients in this study and are listed in Table 1. A total of 1936 patients (10.2%) were readmitted within 30 days of discharge, with an average of 12.5 +/- 8.2 days to readmission. The majority of the temperatures were oral (80.4%); the second most common was axillary (18.9%). Therefore, oral and axillary temperatures

TABLE 1. Descriptive statistics of the patient population.

Total # of patients studied	19038
% female	48.30%
Ages (mean +/- SD)	46.3+/-27.2
# readmitted (and % of total) within 30 days	1936 (10.2%)
# days between discharge and readmission (mean +/- SD)	12.5+/-8.2
Tmax (mean+/SD)	98.7+/-0.74
Tmax indicating fever at 1 SD above the mean Tmax	99.5
Tmax indicating fever at 2 SD above the mean Tmax	100.2
Total # with fever using 1 SD (and % of total) above the mean Tmax	1762 (9.2%)
Total # with fever using 2 SD (and % of total) above the mean Tmax	651 (3.4%)
Tmin (mean+/-SD)	97.6+/-0.49
Tmin indicating hypothermia at 1 SD below the mean Tmin	97.1
Tmin indicating hypothermia at 2 SD below the mean Tmin	96.7
Total # with hypothermia using 1 SD (and % of total) below the mean Tmin	1435 (7.5%)
Total # with hypothermia using 2 SD (and % of total) below the mean Tmin	244 (1.3%)
Number patients per primary service (% of total)	
General Medicine	8018 (42.1%)
Pediatrics	3557 (18.7%)
Surgery	1989 (10.4%)
Orthopedics	1848 (9.7%)
Neurology	1140 (6.0%)
HematologyOncology	469 (2.5%)
Trauma	466 (2.4%)
Neurosurgery	429 (2.2%)
Urology	250 (1.3%)
Cardiology	248 (1.3%)
Cardiopulmonary	156 (0.8%)
Transplant	114 (0.6%)
Burn	105 (0.6%)
Otolaryngology/ENT	103 (0.5%)
Gynecology	42 (0.2%)
Psychiatry	35 (0.2%)
Proportion of abnormal body temperature per primary service	
Fever at 1 SD	
Medicine	788 (9.8%)
Pediatrics	439 (12.3%)
Surgery	197 (9.9%)
Orthopedics	251 (13.6%)
Neurology	71 (6.2%)
Fever at 2 SDs	
Medicine	173 (2.2%)
Pediatrics	253 (7.1%)
Surgery	60 (3.0%)
Orthopedics	77 (4.2%)
Neurology	19 (1.7%)
Hypothermia at 1 SD	
Medicine	396 (4.9%)
Pediatrics	609 (17.1%)
Surgery	131 (6.6%)
Orthopedics	52 (2.8%)
Neurology	64 (5.6%)
Hypothermia at 2 SDs	
Medicine	133 (1.7%)
Pediatrics	59 (1.7%)
Surgery	13 (0.6%)
Orthopedics	6 (0.3%)
Neurology	8 (0.7%)

(continued)

Abbreviations: SD: standard deviation.

together comprised 99.3% of all measured temperatures during the 24 h before hospital discharge. We used a 2-tailed t-test to compare the means of the oral and axillary temperatures which did show a statistically significant difference ($p<0.001$), yet a small numeric difference (97.7F vs 97.4F for Tmin oral and axillary, respectively; 98.7F vs 98.8F for Tmax oral and axillary, respectively), rendering it of little clinical significance. This is in accordance with a previously published observation of ours[19] about the comparison of oral and axillary temperature readings among hospitalized patients. Therefore, in the remaining analyses we have combined data from all measurement sites.

Within 24 h of discharge, and using all patients in our dataset, there were 1762 (9.2%) patients with fever at 1SD from the mean Tmax and 651 (3.4%) at 2SDs; there were 1435 (7.5%) patients with hypothermia at 1SD from the mean Tmin and 244 (1.3%) at 2SDs. When looking at the most populous specialties, it became apparent that Orthopedics and Pediatrics were most likely to discharge patients with fever in the last 24 h, while Neurology was least likely. With regards to hypothermia, Pediatrics again featured the highest proportion of hypothermic patients while Orthopedics featured the lowest. Fig. 1B features the readmission rate according to age groups, with the highest rate for patients from 60-70 years (12%) and lowest among patients between 70 and 90+ years (8%). Fig. 1C-D demonstrate a slight decline in body temperatures (Tmax and Tmin) with age.

Differences in readmission among the primary services

The patient distribution among all primary services is featured in Fig. 1E, while the readmission rate for the top 5 most populous primary services is illustrated in Fig. 1F. The highest readmission rate was in Pediatrics, followed closely by General Medicine; the lowest was among patients admitted to the Orthopedics service. All primary services except for Pediatrics featured a lower readmission rate compared with General Medicine. With regards to the mean number of days to readmission (Table 2), when comparing the five most populous primary services using the Kruskal-Wallis test, there was no significant difference ($p=0.058$).

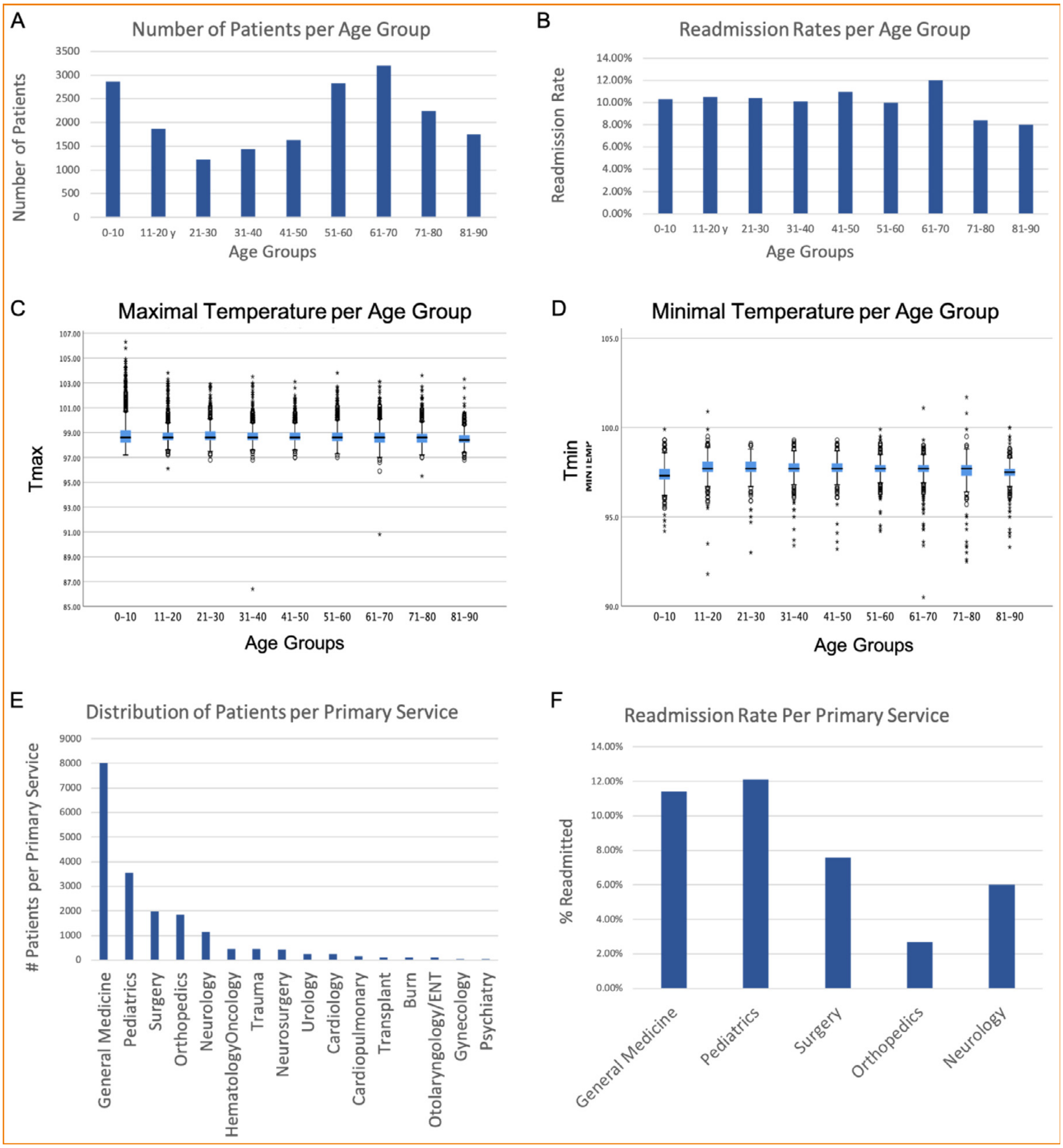

FIGURE 1. Description of patient population based on age, body temperatures, primary service, and the readmission rates. (A) Bar plot of the distribution of patients per age group in 10-years' increments; (B) Bar plot of the readmission rate per age group; (C) Boxplot of the Tmax and Tmin (D) per age group; on each box, the central mark indicates the median, the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively, the whiskers extend to the most extreme data points not considered outliers, and the outliers are plotted individually using the '+' symbol; (E) Bar plot of the distribution of patients per primary service; (F) Bar plot of the readmission rate per primary service.

Neither fever nor hypothermia consistently associate with readmission

Kruskal-Wallis analysis (Table 2) showed that the average number of days to readmission was not different between those with normal body temperature before discharge and those with fever or hypothermia, except for patients with temperature >100.2F (10.61+/-8.61 days to readmission) compared with those with normal temperature (12.56+/-8.13 days to readmission), with p=0.042. Table 2 also features a Chi-square analysis, which revealed that the rate of readmission was statistically higher for patients with body temperature over 99.5F (1SD from the mean Tmax) compared with normothermic patients—12.2 % vs 9.96%, respectively. However, the rest of the analysis failed to demonstrated any difference between the normothermic patients and those with fever or hypothermia. Notably, patients with body temperature over 100.2F (2 SDs above the mean Tmax) did not have

TABLE 2. The effect of abnormal body temperature on the time-to-readmission and the readmission rate.

	Kruskal Wallis Test for the effect of body temperature on the # days to readmission				*Chi-Square for the effect of body temperature on the readmission rate*		
	# readmitted	**# days to readmission +/-SD**	**Mean Rank**	**p-value for # days to readmission**	**# total patients**	**rate of readmission**	**p-value for rate of readmission**
Tmax at 1 SD (> 99.5F)	215	11.87+/-8.57	913.50	0.129	1762	12.20%	**0.003**
Normal Tmax	1721	12.58+/-8.10	974.81		17276	9.96%	
Tmax at 2SDs (>100.2F)	57	10.61+/-8.61	819.77	**0.042**	651	8.76%	0.226
Normal Tmax	1879	12.56+/-8.13	972.50		18387	10.22%	
Tmin at 1SD (<97.1F)	163	11.85+/-8.01	971.99	0.300	1435	11.36%	0.120
Normal Tmin	1773	12.56+/-8.16	924.60		17603	10.07%	
Tmin at 2SDs (<96.7F)	24	12.08+/-8.63	968.45	0.749	244	9.84%	0.865
Normal Tmin	1912	12.51+/-8.15	931.77		18794	10.17%	

Primary service comparison with Kruskal Wallis Test

Primary service	**# readmitted**	**# days to readmission +/-SD**	**Mean Rank**	**p-value for # days to readmission**
Neurology	68	12.57+/-8.07	817.93	0.058
Orhtopedics	49	11.31+/-6.94	760.71	
Surgery	151	10.95+/-8.00	719.75	
Pediatrics	431	12.24+/-8.03	795.41	
General Medicine	916	12.88+/-8.36	829.37	

TABLE 3. Univariate analysis of abnormal body temperature and other factors affecting the readmission rate.

Univariate Analysis of the Readmission Rate			
	OR	**p value**	**CI**
T max	0.936	**0.049**	[0.877-1.000]
T min	1.052	0.321	[0.952-1.163]
Presence of fever at 1 SD	0.888	0.117	[0.765-1.030]
Presence of fever at 2SDs	0.683	**0.006**	[0.520-0.898]
Presence of hypothermia at 1 SD	0.941	0.484	[0.794-1.115]
Presence of hypothermia at 2 SDs	1.134	0.56	[0.743-1.730]
Sex (male as reference)	1.068	0.172	[0.972-1.173]
Age	0.998	**0.046**	[0.997-1.000]
Primary service, compared against General Medicine			
Neurology	0.492	**<0.001**	[0.381-0.634]
Orthopedics	0.211	**<0.001**	[0.158-0.283]
Surgery	0.637	**<0.001**	[0.532-0.762]
Pediatrics	1.069	0.284	[0.946-1.208]

Abbreviations: C.I.: confidence interval, OR: odds ratio, SD: standard deviation; **Bolded:** statistically significant p-value.

higher readmission rate compared with normothermic patients.

The results of our regression analyses that aimed to model readmission are featured in Table 3 and Table 4. We quantified the effect of several variables on the readmission rate: Tmax and Tmin (as continuous variables), the presence of fever at 1 or 2 SDs from the mean Tmax; and the presence of hypothermia at 1 or 2 SDs from the mean Tmin (as dichotomous variables), as well as patient's sex, and age. Also, we compared the readmission rates among the different services, with General Medicine serving as reference.

Univariate analysis (Table 3) surprisingly revealed that higher Tmax and age are associated with lower readmission probability. Further, both uni- and multivariate analysis (Tables 3 and 4) showed that the presence of fever at 2 SDs from the mean Tmax is associated with lower readmission probability and that compared with General Medicine, the other major primary services, except for Pediatrics, have significantly lower readmission probability, when correcting for all the other listed variables.

TABLE 4. Multivariate analysis of abnormal body temperature and other factors affecting the readmission rate.

Multivariate Analysis of the Readmission Rate at 1 SD from the mean Tmax and Tmin			
	adjusted OR	**adjusted p value**	**95% C.I.**
T max	0.976	0.648	[0.878-1.084]
T min	1.243	**0.003**	[1.076-1.436]
Presence of fever at 1 SD	0.93	0.551	[0.732-1.182]
Presence of hypothermia at 1 SD	0.828	0.097	[0.663-1.034]
Sex (male as reference)	1.076	0.168	[0.970-1.194]
Age	0.999	0.436	[0.996-1.002]
Primary service, compared against General Medicine			
Neurology	0.485	**<0.001**	[0.376-0.626]
Orthopedics	0.208	**<0.001**	[0.155-0.280]
Surgery	0.627	**<0.001**	[0.521-0.754]
Pediatrics	1.017	0.864	[0.836-1.237]
Multivariate Analysis of the Readmission Rate at 2 SDs from the mean Tmax and Tmin			
	adjusted OR	**adjusted p value**	**95% C.I.**
T max	1.044	0.409	[0.943-1.155]
T min	1.141	0.052	[0.999-1.304]
Presence of fever at 2SDs	0.625	**0.018**	[0.424-0.923]
Presence of hypothermia at 2 SDs	0.985	0.952	[0.603-1.609]
Sex (male as reference)	1.075	0.172	[0.969-1.193]
Age	0.999	0.384	[0.996-1.002]
Primary service, compared against General Medicine			
Neurology	0.486	**<0.001**	[0.377-0.628]
Orthopedics	0.206	**<0.001**	[0.154-0.277]
Surgery	0.623	**<0.001**	[0.518-0.750]
Pediatrics	1.029	0.772	[0.846-1.252]

Abbreviations: C.I.: confidence interval, OR: odds ratio, SD: standard deviation; **Bolded:** statistically significant p-value.

TABLE 5. Analysis of a 200-patient sample with regards to their discharge diagnoses.

	Diagnoses that can account for abnormal body temperature										*Other diagnoses*			
	Infection	**CNS**	**Cancer/ chemotherapy**	**Trauma**	**GI**	**Cardiovascular**	**Endocrine**	**Dehydration/ FTT**	**Hematologic**	**Autoimmune**	**Alcohol**	**Respiratory without infection**	**Nephrologic**	**Idiopathic/ unknown**
Fever, not readmitted	16	5	0	9	4	2	2	2	1	1	1	6	1	0
Fever, readmitted	17	5	9	1	6	0	1	2	2	0	0	5	2	0
Hypothermia, not readmitted	12	6	4	4	5	6	5	1	0	0	0	3	2	2
Hypothermia, readmitted	15	10	8	3	2	2	1	1	1	0	0	4	3	0
# cases per diagnosis category	60	26	21	17	17	10	9	6	4	1	1	18	8	2
% of total cases	30%	13%	11%	9%	9%	5%	5%	3%	2%	1%	1%	9%	4%	1%

Abbreviations: CNS: central nervous system, GI: gastroenterology, FTT: failure to thrive.

Infection as the predominant reason for preventable readmissions among people with fever or hypothermia at discharge

Using the information from the 200 manually reviewed cases, we found that the most likely diagnosis among patients with fever or hypothermia that could explain their body temperature abnormality was infection, followed by CNS injury, followed by cancer/chemotherapy, trauma, then others, as detailed in Table 5. With regards to preventable readmissions (Table 6), where the abnormal body temperature could have served as a "red flag", we found that from the 10 preventable readmission cases of patients with fever, 9 were due to infection; from the 8 preventable readmission cases of patients with hypothermia, 7 were due to infection.

DISCUSSION

Understanding the various variables that determine the readmission rate is paramount for preventing readmission while optimizing the care provided during hospitalization. Our data revealed a variety of useful statistical findings, most of which have never been previously reported in the literature.

In our large study population of 19,038, the percentage of patients with fever within 24hrs of hospital discharge (9.2% at 1SD (Tmax >99.5F) and 3.4% at 2SDs (Tmax >100.2F)), as shown in Table 1, were lower compared with the previously reported 15% by Barone et al,[20] who used Tmax >100F as the cutoff for fever. The patient population in the cited study was limited to Surgery and Gynecology patients, whose fevers may have been handled differently than non-surgical patients, and indeed we also found a similarly higher tolerance to fever among our Orthopedics patient subgroup (13.6% at 1SD and 4.2% at 2SDs from the mean Tmax). Unfortunately, we cannot comment on our Gynecology subgroup as it contained very few patients. We suspect that the reason behind the higher fever tolerance in Orthopedics is the knowledge that fever and leukocytosis are expected following surgical procedures and are often benign in nature as they are the result of post-surgical inflammatory response rather than true infection.[21] Further, we observed a high tolerance to fever in the Pediatrics subgroup. This is partially due to the fact that average body temperature is higher in children and decreases with age.[15,19] Also, children are known to be less efficient at dissipating heat,[22] thus making their fevers correlate less with disease severity.[23] With regards to hypothermia, again we found a high level of tolerance in the Pediatrics subgroup, of whom 17.1% were discharged with temperatures at 1SD below the mean Tmin (<97.1F), while Orthopedics patients were least likely (2.8%) to be discharged while hypothermic. To the best of our knowledge, there had been no published literature about the relationship between hypothermia and hospital readmission rates.

TABLE 6. Analysis of a 200-patient sample with regards to preventable readmissions.

Patients with Fever on Discharge			
Case #	**Diagnosis at index admission**	**Diagnosis at readmission**	**# days to readmission**
1	Non-infectious gastroenteritis	Non-infectious gastroenteritis	1
2	Pneumonia	Sepsis	7
3	Parkinson's	Urinary tract infection	3
4	Acute bronchiolitis due to respiratory syncytial virus	Coronavirus infection	4
5	Eye discharge	Congenital HSV 2 infection	2
6	Surgical site infection	Surgical site infection	7
7	Pneumonia	Pneumonia	1
8	Hydronephrosis	Bacteremia	2
9	Pneumonia	CLABSI	3
10	CLABSI	CLABSI	3
Patients with Hypothermia on Discharge			
Case #	**Diagnosis at index admission**	**Diagnosis at readmission**	**# days to readmission**
1	Lobar pneumonia	Lobar pneumonia	1
2	Intracranial hypertension	Intracranial hypertension	1
3	Open fracture of left tibia	Osteomyelitis of left tibia	6
4	Chemotherapy encounter	Neutropenic fever	6
5	Lyme meningitis	Lyme disease	1
6	Gram negative bacteremia	Gram negative bacteremia	1
7	Pneumonia	Pneumonia	2
8	Sepsis	Sepsis	1

Abbreviations: SD: HSV: herpes simplex virus, CLABSI: central line associated blood stream infection.

The overall readmission rate of 10.2% measured in our study was lower compared with the rate of 14% reported for all-cause readmission for all US patients in the period of 2010-2016, using the Nationwide Readmissions Database,[24] a difference that is likely multifactorial in origin and beyond the scope of this paper. Interestingly, we measured the highest readmission rate to be for patients in the 60-70 years age group (12%) and the lowest among patients between 70 and 90+ years (8%). This may appear contradictory as one would expect the older patients to have more co-morbidities and to be on average sicker than younger patients. However, a likely bias here is the fact that some among the elderly may have transitioned to hospice or have do-not-readmit orders in place. Similar results were obtained on the national level, where the highest readmission rate in 2016 was at 21.2% from young-to-middle-aged Medicare beneficiaries aged 21-64.[24]

With regards to comparing the various hospital services, there is sparsity of data in the literature. In our hospital, we found highest readmission rates among Pediatrics (12.1%) and General Medicine (11.4%), with the rest of the most populous specialties General Surgery, Orthopedics, and Neurology being significantly lower at 7.6%, 2.7%, and 6.0%, respectively. Our rates are lower compared with the Hollis et al. study,[25] where the 30-day readmission rate for their 64,724 Orthopedics patients was 6.3%, for their 24,963 General Surgery inpatients was at 13.6%, and for their 10,399 Vascular Surgery inpatients at 16.4%. Similarly, the 300 surgical and Gynecology inpatients from the Barone et al study[20] featured higher readmission rate of 12.7% compared with our surgical specialties subgroup.

Interestingly, our analyses revealed only inconsistent dependence of readmission on abnormal body temperature 24 h before discharge. The number of days to readmission was the same in those with normothermia and those without. The only exception here was the group of patients with temperature 2SDs above the mean Tmax. Also, while the overall rate of readmission was statistically higher for temperatures over 99.5F (1SD above the mean Tmax) compared with normothermic patients, there was no difference between normothermic patients and those with fever >100.2F (2SDs above the mean Tmax), nor was there any statistically significant difference when compared with any of the hypothermia categories. Lastly, our logistic regression analyses, where we controlled for patient demographics and the service to which patients were admitted, did not demonstrate strong correlations between abnormal body temperature and readmission rates except for the finding that Tmin at 1SD below the mean correlated with higher readmission probability and the controversial statistically significant finding that the presence of fever at 2 SDs above the mean Tmax is associated with lower readmission probability—a trend that emerged after controlling for the rest of the variables. We need to add a word of caution when evaluating these results because when having a large study size one can more easily reach statistical significance but the findings may still lack clinical significance. For instance, the fact that the number of days to readmission is 12.6 in normothermic patients and 10.6 for patients with fever at 2 SDs, where the standard deviation is over 8 days, is likely of no clinical significance. The only other published studies in the literature featured similar findings. Barone et al[20] did not find any difference in readmission rates between normothermic surgery and gynecology inpatients and those with fever before discharge. Walid et al[14] did not find a correlation between the delay in the discharge of inpatients with fever after spine surgery until normothermia is achieved with the readmission rate for infections. However, the latter study did identify a significant increase in the hospital length of stay and overall hospitalization cost for patients whose discharge was delayed due to fever. While both of these publications are limited in the scope of their patient populations and only investigate the effect of fever, our study represents a comprehensive analysis of the relationship between the readmission rate and both fever and hypothermia and shows that neither temperature deviation from normothermia can be used as a reliable predictor for 30-day readmission, that this finding is independent of demographics such as age and sex, and that it holds true for the primary services General Medicine, General Surgery, Orthopedics, Pediatrics, and Neurology.

Another distinguishing feature of our paper is the readmission prevention analysis which allowed us to demonstrate that about 90% of the avoidable readmissions, where abnormal body temperature could have been used as readmission predictor, were due to infections (Table 6). This is important in the face of the fact that although infections are indeed the most common diagnosis to account for fever or hypothermia, they account for only 30% of the diagnoses (Table 5) while they constitute 90% of the avoidable readmissions. Therefore, one of the most important conclusions we could derive from our study is that when planning the discharge of patients with abnormal body temperature closer attention should be paid to those patients in whom the abnormal temperature is explained by infection as these patients are much more likely to result in an avoidable readmission.

We need to point out important caveats in our study. First, in the city where our study took place, there are 4 main hospitals and therefore, it is possible that if a patient is discharged from our hospital, which is by far the hospital with the largest bed capacity, then the patient could be readmitted to one of the other three hospitals. We reasoned that this confounding bias would be counteracted by our large study population of 19,038 inpatients and the fact that almost certainly patients with abnormal body temperature and patients with normal body temperature on discharge are equally likely to be readmitted to the other three hospitals instead to our hospital. Second, given the fact that our study was performed at a single tertiary center, it remains possible that the discharge practices may be unique to our hospital and therefore our results may not be extrapolated to other hospitals. However, we would like to point out that at our institution there are no specific policies that regulate discharge planning with regards to body temperature and that for each of the specialties included in our analyses there are 50+ provides who are involved in discharge planning, thus making provider preferences likely to cancel out in our ensemble analyses. Third, the patient population with abnormal temperatures was much smaller, especially when using the 2SDs cut offs, compared with the normothermic patients. This raises the question as to whether there had been a selection bias for which patients had been discharged with abnormal body temperatures and which patients were deemed sick enough to be kept for observation longer until their body temperature was normal for 24 h. This likely bias is of particular significance as it emphasizes the importance of clinical judgement, which often overrules numeric measurements such body temperature. Finally, a major confounding factor is our incomplete knowledge of patient's diagnoses. Even though the data is available, there is no reliable way of extracting it in a form that could be automatically placed into the convenient categories that we defined for the manually sorted admission diagnoses featured in Table 5. Additional details, such as the use of specific antibiotics, the presence of positive blood cultures, urine cultures, sputum cultures, etc., could greatly increase the prediction power of our readmission model. Therefore, a big goal of our group moving forward is to develop automated routines for data extraction, aiming to improve our readmission model and subsequently decrease readmissions.

CONCLUSIONS

Our study demonstrated that abnormal body temperature measured within 24 h before discharge was not a reliable predictor of all-cause 30-day hospital readmission. However, in the case where an infectious process is present or suspected, consideration of abnormal body temperature may aid clinicians in preventing readmissions.

FOOTNOTE

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AUTHOR CONTRIBUTIONS

IG conceived of the project and prepared the manuscript drafts and the final manuscript for submission; CL designed and implemented the data analysis; AW contributed to the discussion section and performed manuscript text editing.

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