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Reducing hospital inpatient complications: A four-year experience

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ABSTRACT

This study described the use of administrative data and a computer software algorithm, Potentially Preventable Complications, to support reduction of inpatient hospital complications. The study was carried out between 2008 and 2012 in St. Joseph's Hospital Health Center in Syracuse, New York. The hospital generates approximately 23,000 inpatient discharges annually. The study employed summary tables for individual inpatient complications and patient specific spreadsheets to evaluate and follow adverse outcomes. The spreadsheets were employed by hospital staff to determine whether patient medical records confirm each complication identified by the software. This process resulted in improvement of the accuracy of administrative data describing inpatient complications. The administrative data and the software were also used in conjunction with medical records to identify patients who received program interventions and still experienced inpatient complications. This process enabled hospital staff to ensure that interventions were being provided and evaluate their effectiveness. The study demonstrated that, at the aggregate level, the inpatient complication rate per 1000 discharges declined by 33.4 percent, from 56.11 to 37.37 between 2008 and 2011. The principal drivers of this decline were high volume complications such as pneumonia, where the rate declined by 45.7 percent and urinary tract infection where the rate declined by 23.7 percent. The project provided a means of communicating and managing outcomes data that could be implemented and understood by a wide range of health care providers.

Keywords: Hospital Outcomes; Hospital Complications; Quality of Care

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1. INTRODUCTION

In recent years, increased attention has developed concerning improvement of hospital and health care outcomes in the United States. This development has resulted from a combination of factors related to inpatient complications, hospital readmissions, and other indicators.

A major cause of this development has been research that demonstrates the relationship between adverse health care outcomes and higher costs to providers and payers. Studies have demonstrated that patients with inpatient complications such as pneumonia, urinary tract infection, and clostridium difficile colitis have much longer hospital stays and related labor and pharmaceutical costs than those who do not [1-3].

Related to these costs is a new urgency to reduce health care expenses in society. In the United States, all major health care payers, including Medicare, Medicaid, and private insurance, are under a large amount of pressure to reduce spending. This situation strongly suggests that current increases in these expenditure can no longer be sustained [4,5]. The potential to control these costs through financial penalties for adverse outcomes holds the potential to reduce health care spending while improving patient care [6].

In addition to these factors, efforts to improve health care outcomes are benefiting from the development of electronic software for analysis of patient specific data. Tools such as the Potentially Preventable Complications system developed by 3M Health Information Systems can analyze large amounts of administrative data at the aggregate and patient specific levels. The information produced by these tools can guide clinical management initiatives [7,8].

This study described the use of administrative data and one of these algorithms to support reduction of inpatient complications in a large urban hospital in Syracuse, New York during a four year period. It demonstrated the use of this software to identify and address adverse outcomes at the aggregate and specific levels.

2. POPULATION AND METHODS

This study involved the use of administrative data to identify and manage inpatient complications in St. Joseph's Hospital Health Center, in Syracuse, New York during a four year period. This hospital has the largest inpatient volume (23,832 inpatient discharges excluding well newborns in 2011) of the acute care facilities in Syracuse. Other hospitals in Syracuse that participated in the program included Crouse Hospital (20,540 discharges) and Upstate University Hospital at Community General (6959 discharges) (Hospital Executive Council, Unpublished data, 2012).

The program involved the staffs of St. Joseph's Hospital Health Center and the Hospital Executive Council, the cooperative planning organization for the Syracuse Hospitals. Historically, the Syracuse Hospitals have worked through the Council to improve health care efficiency and outcomes in Central New York [9].

3. DATA DEVELOPMENT

The study was developed as part of a demonstration program including the Hospital Executive Council, St. Joseph's Hospital Health Center, and 3M Health Information Systems. This program involved the use of the 3M Potentially Preventable Complications software and hospital administrative data to identify and manage inpatient complications.

The Potentially Preventable Complications software includes extensive logic for identifying inpatient hospital complications in administrative data. At the summary level, it identifies complications at the patient specific level based on specific secondary diagnoses. These diagnoses, which are identified by the reporting indicator as Not Present on Admission, are assumed to be candidates for inpatient complications. The software then screens these diagnoses with specific exclusion criteria such as logical sequelae of principal diagnoses and services such as trauma and neonatal care for which inpatient complications have not been clearly identified.

In the demonstration program with 3M Health Information Systems, the Hospital Executive Council generated Potentially Preventable Complications data for St. Joseph's Hospital Health Center each month beginning in 2009. These data included patient specific spreadsheets and summary tables for PPCs that were the subject of clinical interventions at the Hospital.

In response to this information, the Hospital staff identified whether patient records confirmed that each patient experienced the complication(s) identified by the software and whether they received the clinical intervenetions designed to avoid these adverse outcomes. This information was used to monitor development of the program by the Hospital Executive Council and for internal follow up by the hospital.

4. HOSPITAL INTERVENTIONS

The charts of patients that were identified as having a particular potentially preventable complication were reviewed in detail to identify commonalities. The first intervention was to determine whether the documenttation supported the diagnosis that resulted in the PPC. Coding errors had to be eliminated before clinical interventions could be put in place. This gave the hospital a more accurate picture of the scope of the problem. This was accomplished by reviewing each clinical record and by comparing them to coding summaries and coding definitions [10].

The charts fell into two distinct categories: The first were records where the documentation did not support the coding. The other category included charts where the clinical information did not support the diagnosis. By educating coders about errors and common mistakes, coding errors were systematically eliminated. By educating providers about how diagnosis of pneumonia and urinary tract infections were coded, their documentation regarding these complications became clearer.

With administrative "slack" taken out of the system the true clinical situations could be identified and mitigated. Over 100 chart reviews were conducted to define what specific outcome issues there was at the hospital. The staff wanted to be as specific as possible for the patient populations so that they could effectively deploy resources to reduce the complications of interest. The hospital focused on four complications: Pneumonia, Urinary Tract Infection, Clostridium Difficile Colitis, and Decubitus Ulcers.

5. PNEUMONIA

Charts were examined to identify if patients were receiving the basic care documented in the literature to prevent hospital acquired pneumonia [11]. Specifically, nursing charting was reviewed to determine if the patients with the complication received mouth care, had the use of incentive spirometry documented, were out of bed ambulating, and if they had the head of their bed elevated [12,13]. It was clear from chart reviews that incentive spirometry and mouth care were opportunities to improve care. Units and services with the highest numbers of cases were selected for education regarding incentive spirometry use and documentation. Daily rounding was instituted to ensure that nurses were reminding patients to use their incentive spirometers and that they documented its use.

6. URINARY TRACT INFECTION

The data from each source were imported into a Micro-

soft Access database and compared using medical record number, account number and admission date. Records for review were then sorted by comparing them with valid culture results to arrive at the study group. Chart reviews were conducted to determine what care was documented. These reviews included the collection of the infection indicators of white blood cell count and temperature associated with culture collection. The reviews determined for each case if there was a urinary catheter placed during the patients admission, how many days it was in place, and the number of times care was charted in association with it. For those infections where a urinary catheter was in place, the number of catheter days was compared with the number of times catheter care was charted to approximate a rate of care episodes per catheter day.

The key intervention in reducing hospital acquired urinary tract infection was to reduce the overall usage of urinary catheters. To do this, the problem was addressed by a number of approaches. First, using the CDC's guidelines for reducing catheter associated urinary tract infections, standard indications for catheter insertion were implemented [14]. Three interventions were effective in reducing the number of catheter days per patient (the in process measure). Firstly, an RN driven foley removal protocol for inpatients was instituted. Essentially, if the indications no longer existed, the catheter was removed automatically by the nurse. Secondly, for surgical patients, an education program for physician assistants, residents and nurse practitioners about the correct indications for indwelling catheters was instituted. Finally, it was determined that the majority of urinary catheters were inserted in the emergency department. As a result, an education program for the both the nurse and providers in the emergency department about the indications, and effects of indwelling catheters for patients during the entire hospitalization was carried out. All of these interventions resulted in approximately a 20 percent reduction of catheter days per patients and a precipitous decline in hospital acquired urinary tract infections.

7. CLOSTRIDIUM DIFFICILE COLITIS

Cases identified by the 3M Potentially Preventable Complication (PPC) software were compared with those reported to the National Health Safety Network (NHSN) at the Centers for Disease Control and Prevention (CDC) [15-17]. They were also cross referenced with clostridium difficile colitis cases identified by Care fusion/Med mined Virtual Surveillance Indicators. After cases were identified and cross referenced, a total of 124 unique records identified as hospital onset were reviewed in detail using data found in the clinical documentation system, the orders system and the pharmacy system. Finally, patient room assignments were reviewed.

The initial review was carried out using the pharmacy system, Horizon Meds Management (HMM). The reviewer reviewed notations made by pharmacist regarding antibiotic prescribing and indications. This documentation is not part of the patient's clinical record. The reviewer attempted to identify the patient's original infection and the antibiotics used to treat it. When this was not documented in HMM, the clinical record was reviewed.

The findings of infection requiring antibiotic treatment are listed in **Table 1**.

Next the antibiotics used to treat these infections were review and counted. Vancomycin and Flagyl were excluded from this count. The results are listed in **Table 2**.

It is worthwhile to know that 84 percent of patients received at least one of the antibiotics listed in **Table 2** and 45 percent of patients received at least two. These findings are consistent with the findings noted by Pepin *et al.* in their study "Emergence of Fluotoquinolones as the predominant risk factor for Clostridium Difficile-Associated Diarrhea: A cohort study during an epidemic in Quebec" [18].

8. DECUBITUS ULCERS

It was clear from an extensive review of patient records and careful comparisons of other data sets that a previously identified quality improvement opportunity in the care of the decubitus ulcer PPC was far more theoretical

Table 1. St. Joseph's Hospital Health Center, infections treated with antibiotics in patients with C. Diff.

Infection	Count
Pneumonia or rule out pneumonia	42
Urinary tract infections or urosepsis	22
Other infections including sepsis, preop, prophylaxis, cellulitis, and wound infections	60

Table 2. St. Joseph's Hospital Health Center, antibiotics commonly prescribed to patients who later developed C. Diff infections.

Antibiotic	Number of C. Diff cases presecribed
Zosyn	47
Ciprofloxacin	46
Cephalosporins	34
Ampicillin/Amoxicillin	10
Moxifloxacin	8
Clindamycin	4
Zyvox	3
Azactam	2

than practical. Coding errors, careful nursing documentation, poor initial patient condition and co-morbidities and additional PPCs have conspired to negate any real financial gain to be had from further improvements to decubitus care alone.

9. DATA ANALYSIS

Analysis of the data involved the impact of interventions for individual inpatient complications, as well as the development of summary tables including numbers of complications, at risk populations, and rates per 1000 discharges for St. Joseph's Hospital Health Center. In order to define the full and most recent impacts of the program, one analysis included data for January-December 2008-2011, while the other included data for January-March 2008-2012. In both analyses, data for individual and aggregate complications were identified.

10. RESULTS

The first component of the results involved the individual complications addressed by the project. Data concerning all individual complications are summarized in **Tables 3** and **4** which follow.

With respect to pneumonia, increased incentive spirometry use and documentation resulted in the direct reduction of hospital acquired pneumonia. Changes in complication rates for pneumonia are identified in **Tables 3** and **4** which follow.

With respect to urinary tract infection, the association between urinary catheters and urinary tract infections was examined. The review looked at all of these infections, as well as their relationship to indwelling urinary catheters. It found that 78% (n-76) of St. Joseph's hospital acquired urinary tract infections were in patients who had been catheterized during their admission. On average, a patient who developed a urinary tract infection had an indwelling catheter for 12 days. St. Joseph's standard for catheter care is that it be performed and documented once daily. The review found that only 25 percent (n-19) of patients with positive urine cultures received this care correctly. In 34 percent of the cases the patient received less than what was required (n-23) and curiously, 45 percent (n-34) of the patients received too much care, that is to say they had more episodes of care then recommended. Changes in complication rates for urinary tract infection are identified in **Tables 3** and **4** which follow.

With respect to clostridium difficile colitis, another factor examined was the timeliness of isolation precautions associated with the onset of symptoms. To determine this all of the nursing orders for "enteric" and "contact precautions C. difficile" were compared with orders for "Stool for C. difficile". The basic presumption of this comparison was that for a "Stool for C. difficile" to be ordered there was reason to believe that the patient is in some way symptomatic of the disease. As such, if there was a reasonable expectation that a patient is symptommatic, they were placed isolation in accordance with the hospitals isolation manual and the CDC's current best practice guidelines. The examination included all inpatients who were placed on isolation and all of those who had an order for stool for C. diff. This produced 607 unique order combinations for inpatients that were admitted for at least 48 hours. On average, patients who were placed on isolation in greater than one hour waited five hours for the isolation order to be entered.

Finally, an examination of positive clostridium difficile colitis results was made, irrespective of the onset to determine if any other environmental factors could be identified. This review specifically looked at the rooms patients with positive results stayed in. It found that 15 patient rooms (7 percent of rooms) accounted for 54 (20 percent) of positive results. This was significant in that environmental contamination with C. Diff spores is a major contributing factor in developing the disease in patients with other risk factors. Changes in complication rates for clostridium difficile colitis are identified in **Tables 3** and **4** which follow.

With respect to decubitus ulcers, prolonged length of stay seemed to contribute to the development of the complication. In other words, the ulcer resulted from the extended stay, rather than the long stay resulting from the ulcer. Changes in complication rates for decubitus ulcer are identified in **Tables 3** and **4** which follow.

The second component of the results involved Potentially Preventable Complications at the aggregate and diagnosis specific levels for January-December 2008-2011. Relevant data are summarized in **Table 3**.

This information demonstrates that, at the aggregate level, the PPC rate per 1000 discharges at the hospital declined by 33.4 percent, from 56.11 to 37.37 during this period. This occurred as the number of PPCs declined by 13.4 percent from 1035 to 896, while the at risk population increased by 30.0 percent, from 18,446 to 23,975. It was notable that the hospital was able to reduce complications at a time when its inpatient population was increasing substantially.

At the PPC specific level, the principal drivers of the decline were high volume diagnoses that were addressed by specific interventions. For pneumonia (PPC 04) the rate declined by 45.7 percent from 14.07 to 7.64 per 1000 discharges between 2008 and 2011. Most of this reduction occurred between 2009 and 2011. For urinary tract infection (PPC 16), the rate declined by 23.7 percent from 8.37 to 6.39 between 2008 and 2011. As a result of an increase between 2008 and 2009, all of the decline occurred during the last three years.

Table 3. Potentially preventable complications, St. Joseph's Hospital Health Center, January-December 2008-2011.

		Patients w PPC				At Risk Population				Major PPC Rate/1000 Discharges			
	Major PPC Category	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
01	Stroke & Intracranial Hemorrhage	37	49	49	47	17,866	17,121	19,783	21,189	2.07	2.86	2.48	2.22
02	Extreme CNS Complications	7	7	16	18	16,898	16,166	18,831	20,079	0.41	0.43	0.85	0.90
03	Pulm Ed/Rsp Fail w/Vent	116	94	49	32	16,558	15,495	17,997	19,235	7.01	6.07	2.72	1.66
04	Pneum & Other Lung Infect	200	175	168	128	14,219	13,295	15,484	16,743	14.07	13.16	10.85	7.64
05	Aspiration Pneumonia	44	76	64	49	16,915	16,147	18,639	20,271	2.60	4.71	3.43	2.42
06	Pulmonary Embolism	19	20	22	25	17,925	17,101	19,736	21,160	1.06	1.17	1.11	1.18
07	Shock	81	80	101	79	17,691	16,855	19,593	20,982	4.58	4.75	5.15	3.77
08	Congestive Heart Failure	75	84	72	82	15,195	14,609	17,517	18,122	4.94	5.75	4.11	4.52
09	Acute Myocardial Infarct	74	55	67	74	17,154	16,336	18,903	20,165	4.31	3.37	3.54	3.67
10	Ventricular Fibrillation/Cardiac Arrest	80	73	80	65	18,113	17,311	19,961	21,382	4.42	4.22	4.01	3.04
11	Peripheral Vascular Comp Except Venous Thrombosis	8	15	20	13	18,026	17,209	19,865	21,286	0.44	0.87	1.01	0.61
12	Venous Thrombosis	38	50	41	49	17,910	17,095	19,745	21,143	2.12	2.92	2.08	2.32
13	Major Gastrointestinal Comp w Transfus or Sign Bleed	8	12	0	0	17,211	16,522	18,998	20,428	0.46	0.73	0.00	0.00
14	Major Liver Complications	10	21	17	12	17,938	17,125	19,743	21,084	0.56	1.23	0.86	0.57
15	Clostridium Difficile Colitis	29	38	74	85	18,113	17,311	19,961	21,382	1.60	2.20	3.71	3.98
16	Urinary Tract Infection	141	145	162	127	16,854	16,055	18,456	19,884	8.37	9.03	8.78	6.39
17	Renal Failure with Dialysis	15	16	0	0	16,433	15,332	17,981	18,992	0.91	1.04	0.00	0.00
18	Post-Hemorrh & Oth Acute Anemia w Transfusion	91	27	0	0	14,448	13,929	16,208	17,494	6.30	1.94	0.00	0.00
19	Decubitus Ulcer	53	42	49	43	17,538	16,581	19,232	21,033	3.02	2.53	2.55	2.04
20	Septicemia & Severe Infections	121	102	103	73	17,614	16,768	19,479	20,874	6.87	6.08	5.29	3.50
21	Post-Op Wound Inf & Deep Wound Disruption w Proc	4	3	0	0	7,779	7,055	3,799	4,125	0.51	0.43	0.00	0.00
22	Reopening Surgical Site	13	18	0	0	7,724	7,041	3,765	4,102	1.68	2.56	0.00	0.00
23	Post-Op Hemorrhage & Hematoma w Hem Cntrl Procedure or I&D Procedure	26	22	5	5	7,968	7,237	3,919	4,257	3.26	3.04	1.28	1.17
24	Accidental Puncture/Laceration During Invasive Proc	95	78	88	58	9,252	8,551	5,068	5,590	10.27	9.12	17.36	10.38
25	Post-Procedure Foreign Bodies	1	1	1	2	7,976	7,243	3,921	11,292	0.13	0.14	0.26	0.18
26	Encephalopathy	28	26	37	28	17,093	16,321	18,953	19,052	1.64	1.59	1.95	1.47
27	Iatrogenic Pneumothrax	14	22	35	25	14,994	14,394	17,034	18,344	0.93	1.53	2.05	1.36
28	Mechanical Complication of Device, Implant & Graft	26	24	19	23	17,645	16,822	19,359	20,796	1.47	1.43	0.98	1.11
29	Inflamm & Other Complication of Devices, Implants or Grafts Except Vascular Infection	42	36	96	43	17,645	16,822	19,416	20,796	2.38	2.14	4.94	2.07
30	Infections Due to Central Venous Catheters	20	14	17	7	18,017	17,175	19,764	21,404	1.11	0.82	0.86	0.33
31	Obstetrical Hemorrhage w Transfusion	7	7	6	5	1,925	1,892	1,888	1,898	3.64	3.70	3.18	2.63
32	Obstetrical Lacerations & Oth Trauma w/o Instrumentation	19	31	38	23	1,924	1,888	1,894	1,902	9.88	16.42	20.06	12.09
33	Obstetrical Lacerations & Oth Trauma with Instrumentation	4	3	1	0	963	27	11	18	4.15	111.11	90.91	0.00
34	Major Puerperal Infection and Other Major Obstetrical Complications	4	5	2	3	1,946	1,916	1,906	1,920	2.06	2.61	1.05	1.56
35	Post-Op Resp Failure w Tracheostomy	18	10	0	0	6,093	5,459	1,962	2,256	2.95	1.83	0.00	0.00
	Discharges w/One or More PPCs	1,035	993	1,026	896	18,446	17,635	21,700	23,975	56.11	56.31	47.28	37.37

Hospital Executive Council—3M Health Information Systems PPC demonstration program.

Table 4. Potentially preventable complications, St. Joseph's Hospital Health Center, January-March 2008-2012.

Major PPC Category		Patients w PPC					At Risk Population					Major PPC Rate/1000 Dchgs				
		2008	2009	2010	2011	2012	2008	2009	2010	2011	2012	2008	2009	2010	2011	2012
01	Stroke & Intracranial Hemorrhage	13	11	9	13	9	4,655	4,384	4,642	5,171	5,462	2.79	2.51	1.94	2.51	1.65
02	Extreme CNS Complications	2	1	4	7	5	4,418	4,135	4,413	4,900	5,161	0.45	0.24	0.91	1.43	0.97
03	Pulm Ed/Rsp Fail w/Vent	40	31	12	10	9	4,359	3,962	4,194	4,730	4,882	9.18	7.82	2.86	2.11	1.84
04	Pneum & Other Lung Infect	52	42	50	27	30	3,597	3,404	3,577	4,065	4,292	14.46	12.34	13.98	6.64	6.99
05	Aspiration Pneumonia	13	13	21	16	14	4,415	4,130	4,384	4,900	5,360	2.94	3.15	4.79	3.27	2.61
06	Pulmonary Embolism	10	3	9	4	3	4,668	4,384	4,631	5,152	5,479	2.14	0.68	1.94	0.78	0.55
07	Shock	24	20	25	22	15	4,630	4,321	4,587	5,131	5,421	5.18	4.63	5.45	4.29	2.77
08	Congestive Heart Failure	16	28	16	28	15	3,915	3,755	4,498	4,404	4,619	4.09	7.46	3.56	6.36	3.25
09	Acute Myocardial Infarct	24	8	18	27	11	4,486	4,194	4,452	4,975	5,084	5.35	1.91	4.04	5.43	2.16
10	Ventricular Fibrillation/Cardiac Arrest	24	9	12	17	19	4,720	4,432	4,690	5,223	5,521	5.08	2.03	2.56	3.25	3.44
11	Peripheral Vascular Comp Except Venous Thrombosis	3	4	8	2	1	4,694	4,410	4,666	5,192	5,489	0.64	0.91	1.71	0.39	0.18
12	Venous Thrombosis	13	10	5	13	12	4,669	4,380	4,634	5,153	5,460	2.78	2.28	1.08	2.52	2.20
13	Major Gastrointestinal Comp w Transfusion or Sign Bleed	2	6	0	0	0	4,486	4,239	4,454	4,961	5,261	0.45	1.42	0.00	0.00	0.00
14	Major Liver Complications	1	4	5	4	3	4,683	4,383	4,647	5,159	5,437	0.21	0.91	1.08	0.78	0.55
15	Clostridium Difficile Colitis	8	9	13	19	18	4,720	4,432	4,690	5,223	5,521	1.69	2.03	2.77	3.64	3.26
16	Urinary Tract Infection	34	37	41	28	34	4,405	4,117	4,329	4,851	5,140	7.72	8.99	9.47	5.77	6.61
17	Renal Failure with Dialysis	0	3	0	0	0	4,281	3,886	4,173	4,732	4,495	0.00	0.77	0.00	0.00	0.00
18	Post-Hemorrh & Oth Acute Anemia w Transfusion	22	11	0	0	0	3,760	3,619	3,810	4,285	4,589	5.85	3.04	0.00	0.00	0.00
19	Decubitus Ulcer	12	9	14	11	8	4,574	4,255	4,490	5,034	5,603	2.62	2.12	3.12	2.19	1.43
20	Septicemia & Severe Infections	34	25	22	22	11	4,619	4,303	4,556	5,109	5,382	7.36	5.81	4.83	4.31	2.04
21	Post-Op Wound Inf & Deep Wound Disruption w Procedure	0	1	0	0	0	2,047	1,751	907	979	1,158	0.00	0.57	0.00	0.00	0.00
22	Reopening Surgical Site	5	3	0	0	0	2,034	1,749	896	966	1,141	2.46	1.72	0.00	0.00	0.00
23	Post-Op Hemorrhage & Hematoma w Hem Cntrl Proc or I&D Proc	9	7	1	4	1	2,096	1,804	925	1,018	1,199	4.29	3.88	1.08	3.93	0.83
24	Accidental Puncture/Laceration During Invasive Procedure	24	19	12	24	13	2,418	2,135	1,200	1,376	1,485	9.93	8.90	10.00	17.44	8.75
25	Post-Procedure Foreign Bodies	1	1	0	0	0	2,097	1,805	926	1,014	6,649	0.48	0.55	0.00	0.00	0.00
26	Encephalopathy	9	3	9	11	4	4,466	4,172	4,448	4,943	4,171	2.02	0.72	2.02	2.23	0.96
27	Iatrogenic Pneumothrax	5	4	8	6	6	3,864	3,731	3,995	4,492	4,716	1.29	1.07	2.00	1.34	1.27
28	Mechanical Complication of Device, Implant & Graft	6	9	4	3	5	4,599	4,322	4,548	5,077	5,381	1.30	2.08	0.88	0.59	0.93
29	Inflamm & Other Complication of Devices, Implants or Grafts Ex Vascular Infection	13	10	10	10	4	4,599	4,322	4,548	5,077	5,381	2.83	2.31	2.20	1.97	0.74
30	Infections Due to Central Venous Catheters	7	6	5	0	3	4,712	4,412	4,646	5,162	5,657	1.49	1.36	1.08	0.00	0.53
31	Obstetrical Hemorrhage w Transfusion	2	3	1	1	2	447	468	440	436	431	4.47	6.41	2.27	2.29	4.64

Continued

32	Obstetrical Lacerations & Oth Trauma w/o Instrumentation	4	8	11	3	4	457	465	441	435	427	8.75	17.20	24.94	6.90	9.37
33	Obstetrical Lacerations & Oth Trauma with Instrumentation	1	1	0	0	1	457	8	3	3	4	2.19	125.00	0.00	0.00	250.00
34	Major Puerperal Infection and Other Major Obstetrical Complications	1	1	0	2	1	457	474	445	438	431	2.19	2.11	0.00	4.57	2.32
35	Post-Op Resp Failure w Tracheostomy	4	2	0	0	0	1,620	1,365	453	553	647	2.47	1.47	0.00	0.00	0.00
	Discharges w/One or More PPCs	282	239	245	237	202	4,820	4,510	5,389	5,527	6,649	58.51	52.99	45.46	42.88	30.38

Hospital Executive Council—3M Health Information Systems PPC demonstration program.

The lower volume complications that were addressed by specific interventions contributed less to the overall PPC decline. The rate for clostridium difficile colitis increased from 1.60 to 3.98 between 2008 and 2011. The rate for decubitus ulcer declined from 3.02 to 2.04.

In addition to pneumonia and urinary tract infection, PPCs that were not addressed by specific interventions also contributed to declines in the overall rate. These included pulmonary embolism (PPC 03), ventricular fibrillation (PPC 10), and septicemia (PPC 20).

In order to provide more updated information concerning Potentially Preventable Complications at St. Joseph's Hospital Health Center, the third component of the study included information for January-March 2008-2012. These data are summarized in **Table 4**.

This information demonstrated that between January-March 2008 and 2012, the aggregate PPC rate at the hospital declined by 48.1 percent, from 58.51 to 30.38 per 1000 discharges. This decline progressed throughout the five year period. Between the two most recent periods, January-March 2011 and 2012, the reduction was 29.2 percent, from 42.88 to 30.38 per 1000 discharges.

As in the annual data, high volume PPCs that were addressed by interventions were major drivers of the aggregate reduction. These included pneumonia (PPC 04), where the rate declined by 51.7 percent, from 14.46 to 6.99 per 1000 discharges and urinary tract infection (PPC 16) where the rate declined by 14.4 percent, from 7.72 to 6.61 per 1000 discharges, during the five year period. It was notable that the rates for both of these complications increased between January-March 2011 and 2012.

As in the annual data, smaller volume PPCs did not contribute greatly to the overall decline for this time period. The rate for clostridium difficile colitis (PPC 15) increased, while the rate for decubitus ulcer declined.

As in the annual data, additional PPCs that were not addressed by specific interventions also contributed to declines in the overall rates. These included pulmonary edema and respiratory failure (PPC 03), an 80.0 percent reduction; septicemia (PPC 20), a 72.3 percent reduction, and postoperative hemorrhage (PPC 23), an 80.7 percent reduction.

11. DISCUSSION

This study described the use of administrative data and computer software to support the reduction of inpatient complications in a large urban hospital during a four year period. It demonstrated how these resources could be employed to identify and improve these outcomes for a wide range of diagnoses.

The interventions to reduce complications implemented by St. Joseph's Hospital Health Center were derived from research literature and local experience. Based on recommendations from published research, they were adapted to the needs and resources of the hospital. The results of the study demonstrated that the identification and use of these interventions were largely successful.

The experience of St. Joseph's Hospital Health Center demonstrated how aggregate complications data could be used to identify address specific diagnoses for intervenetions. Using the Potentially Preventable Complications software, the hospital staff was able to select complications with relatively high volumes, such as pneumonia and urinary tract infections, that would have the largest impact on aggregate outcomes and related costs. The staff was also able to identify complications with lower volumes, such as clostridium difficile colitis and decubitus ulcer that were of interest.

The administrative data and computer software were useful in identifying patient specific issues with respect to documentation. The spreadsheets that were developed from these resources contributed to improvements in the coding of administrative data that clarified the actual numbers of complications that occurred. This process improved evaluation of hospital quality assurance efforts to address these outcomes, as well as the accuracy of administrative data being used by reporting agencies in the public area.

The administrative data and computer software also made it possible to identify patients who received the program inventions, but also experienced the complications. From this perspective, it provided information for evaluation of the impact of interventions over time on a patient specific basis.

Through these applications, the staff of St. Joseph's Hospital Health Center was able to use these resources at both the patient specific and aggregate levels to improve care and reduce related costs. The aggregate data provided perspectives concerning this information across a wide range of individual complications and through total frequencies and rates.

In summary, this approach to improving patient outcomes was simple and direct. It provided a means of communicating and managing outcomes data that could be understood and used by a wide variety of health care providers.

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