ORIGINAL ARTICLE

Medical injuries among hospitalized children

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Background: Inpatient medical injuries among children are common and result in a longer stay in hospital and increased hospital charges. However, previous studies have used screening criteria that focus on inpatient occurrences only rather than on injuries that also occur in ambulatory or community settings leading to hospital admission.

Objective: To describe the incidence and outcomes of medical injuries among children hospitalized in Wisconsin using the Wisconsin Medical Injury Prevention Program (WMIPP) screening criteria.

Methods: Cross sectional analysis of discharge records of 318 785 children from 134 hospitals in Wisconsin between 2000 and 2002.

Results: The WMIPP criteria identified 3.4% of discharges as having one or more medical injuries: 1.5% due to medications, 1.3% to procedures, and 0.9% to devices, implants and grafts. After adjusting for the All Patient Refined-Diagnosis Related Groups disease category, illness severity, mortality risk, and clustering within hospitals, the mean length of stay (LOS) was a half day (12%) longer for patients with medical injuries than for those without injuries. The similarly adjusted mean total hospital charges were \$1614 (26%) higher for the group with medical injuries. Excess LOS and charges were greatest for injuries due to genitourinary devices/implants, vascular devices, and infections/inflammation after procedures.

Conclusions: This study reinforces previous national findings up to 2000 using Wisconsin data to the end of 2002. The results suggest that hospitals and pediatricians should focus clinical improvement on medications, procedures, and devices frequently associated with medical injuries and use medical injury surveillance to track medical injury rates in children.

Safety indicators and chart review have been used to assess patient safety. One method for identifying adverse events is the Agency for Healthcare Research and Quality Patient Safety Indicators (AHRQ PSIs) which use hospital discharge data to report patient safety outcomes.¹ Research using these indicators suggests that adverse events during hospital admissions of adults and children lead to excess length of stay (LOS) and increased hospital charges and mortality.^{2–4} The safety indicators system focuses on assessing the quality of care during a given inpatient hospitalization. Accordingly, it attempts to exclude patient healthcare injuries that occurred before the index hospital admission, such as during outpatient care or a previous admission. It also focuses on a relatively limited number of indicators designed to reflect a high probability of poor quality care during that admission.

In contrast, major studies based on chart review have attempted to achieve a more comprehensive assessment of patient safety problems by including the full spectrum of adverse events and, specifically, those caused by medical care before as well as during the index hospital admission.⁵ An alternative assessment method uses the Wisconsin Medical Injury Prevention Program (WMIPP) screening criteria. The WMIPP screening criteria identify medical injuries in routinely collected hospital discharge data as part of a confidential preventive model of hospital patient safety.⁶ Compared with medical record review, the adjusted sensitivity of the screening criteria is 60% and the specificity is 97%.⁷ WMIPP criteria include some specific additional diagnosis codes not found in the AHRQ PSIs in the areas of infection during medical care, transfusion reaction, and anesthesia complications. The AHRQ PSIs focus on potential complications and adverse events to identify 20 types of inpatient medical injuries while our criteria include health care provided in inpatient, ambulatory, community, and home

settings that are associated with a medical injury identified during a subsequent or concomitant hospital admission. For example, an adolescent may ingest an overdose of acetaminophen at home with subsequent admission to hospital and a discharge diagnosis of acetaminophen poisoning. A hospital admission suggests the severity of the medical injury, while the occurrence at home suggests the need for community based prevention.

This study examined the incidence and outcomes of medical injuries among children admitted to hospital in Wisconsin using the WMIPP screening criteria. The primary research question was to determine the medical injury rates in four categories (medications; surgical and medical procedures; devices, implants and grafts; and radiation) and 40 subcategories. The secondary research question was to compare the length of stay and total hospital charges for children with and without medical injuries after adjusting for the All Patient Refined-Diagnosis Related Groups (APR-DRG) disease category, illness severity, mortality risk, and clustering within hospitals. We hypothesized that our findings would be consistent with previous published reports focused on inpatient errors and indicators, but would broaden the understanding of pediatric patient safety priorities in the context of a public health injury prevention model.

METHODS

Data source

The research design was a cross sectional review of hospital discharge records for children aged 0–17 years from the State

Abbreviations: AHRQ, Agency for Healthcare Research and Quality; APR-DRG, All Patient Refined-Diagnosis Related Groups; LOS, length of stay; PSI, patient safety indicator; WMIPP, Wisconsin Medical Injury Prevention Program

of Wisconsin Bureau of Health Information for the period from 1 January 2000 to 31 December 2002. The State mandates reporting from all general, acute care, non-federal hospitals in Wisconsin. Like many state agencies or hospital associations, the Bureau routinely collects, edits, and publicly disseminates summary data based on the Health Care Finance Administration uniform billing report form (UB-92) on all patients discharged from hospitals in Wisconsin. The UB-92 data include International Classification of Disease (ICD-9-CM) N-codes and, where relevant, E-codes. In cases of injury, E-codes attribute the injury to an external cause such as therapeutic misadventure, whereas N-codes describe the nature of the injury such as a complication particular to a specific surgical procedure, but do not attempt to attribute the cause of the injury. The Bureau cleans the data set so all records are complete and required data are reported and consistent.

WMIPP medical injury screening

Medical injuries were classified into four broad categories: medications; surgical and medical procedures; devices, implants and grafts; and radiation. These categories were further divided into 40 subcategories that indicate more precisely the cause of the injury. For example, subgroups of *medication injuries* include complications due to poisoning, accidental poisoning, and adverse reaction with proper administration. Similarly, the subgroups of *device, implant or graft injuries* include infection, inflammation, mechanical and other complications. The classification scheme and the ICD-9-CM criteria for each category and subcategory are listed in the online Appendix available at <http://www.qshc.com/supplemental>.

Hospital characteristics were obtained from the 2001 Wisconsin Bureau of Health Information Annual Survey of Hospitals. The Medical College of Wisconsin institutional review board approved this study involving human subject records.

Data analysis

Rates of medical injuries were calculated as the number of children discharged with the particular type of medical injury divided by the total number of discharges of children admitted to hospital in Wisconsin during the study period.

Table 1 Characteristics of Wisconsin hospitals, 2000–2

	No (%) of hospitals*
Ownership	
Non-profit	86 (69%)
Religious	35 (28%)
County	2 (2%)
For profit	4 (3%)
Residencies	
None	95 (76%)
1–2	21 (17%)
3+	9 (7%)
Self-designated trauma level	
None	67 (54%)
Rural center	20 (16%)
Community center	34 (27%)
Regional resource	4 (3%)
Pediatric proportion of all discharges (mean (SD) %)	16 (15)
Total	125 (100%)

*Although discharge records from 134 hospitals were analyzed, nine of these hospitals did not have survey information about characteristics due to the hospital closing before the 2001 survey (n = 2) or opening subsequent to the survey (n = 7).

Table 2 Characteristics of pediatric patients in Wisconsin hospitals, 2000–2

	No (%) pediatric patients
Age	
<8 days	205584 (64%)
8–365 days	22953 (7%)
1–4 years	25446 (8%)
5–12 years	27134 (9%)
13–17 years	37668 (12%)
Sex	
Male	162850 (51%)
Female	155935 (49%)
Primary payer	
Private	227578 (71%)
Public	81805 (26%)
Self-pay	9402 (3%)
Condition on admission	
Normal term newborns	189096 (59%)
Sick or premature newborns	6536 (2%)
Extramural birth	3759 (1%)
Urgent	67987 (21%)
Emergency	30446 (10%)
Elective	20961 (7%)
APR-DRG severity class	
1 (lowest)	236523 (74%)
2	58351 (18%)
3	18037 (6%)
4 (highest)	4901 (2%)
APR-DRG mortality risk	
1 (lowest)	297807 (94%)
2	13242 (4%)
3	4990 (2%)
4 (highest)	1773 (1%)
Medical or Surgical APR-DRG	
Medical	292536 (92%)
Surgical	26249 (8%)
Discharge status*	
Routine discharge	302068 (95%)
Home under care	7747 (2%)
Transfer to other hospital or facility	7657 (2%)
Expired	1042 (<1%)
Left against medical advice	237 (<1%)
Hospice care	34 (<1%)
Overall mean (SD) LOS (days)	4.3 (7.1)
Total	318785

APR-DRG, All Patient Refined-Diagnosis Related Groups; LOS, length of stay

*One hospital incorrectly reported discharge status during 2000–1. While this error cannot be corrected, we estimate that only routine discharge and home under care categories were affected sufficiently to alter their distribution. Their true proportions are estimated to be 94% and 3%, respectively.

Statistical analysis was performed using Stata software release 8.0 (StataCorp, College Station, TX, 2003).

We calculated the impact of medical injury on LOS and total hospital charges using linear regression on log transformations of the LOS and charge data for patient discharges with and without medical injury. For analytical purposes we added 1 to the routinely reported LOS so that the reported LOS measure indicated the number of days on which the patient was hospitalized. As a result, patients admitted and discharged on the same day would be considered to have an LOS of 1 day. We determined mean excess LOS and percentage increase in LOS compared with discharges without the specified medical injury using a log transformation of LOS to normalize the variable and after adjusting for the All Patient Refined-Diagnosis Related Groups (APR-DRG) disease classification version 15.0 (3M Health Information Systems, 1998) and indices for risk of mortality and severity of illness calculated by the APR-DRG system. Because the indices for risk of mortality and severity of illness were intended to adjust for the severity of the underlying illness in patients with and without a medical

Table 3 Medical injuries and related outcomes for pediatric patients in Wisconsin hospitals, 2000–2

Categories (and subcategories) of WMIPP screening criteria	No of cases	Rate per 10 000 discharges	Adjusted mean excess LOS (days)‡	Adjusted % change in LOS (days)‡	Adjusted mean excess hospital charges (\$)‡
Complications due to medications	4918	154.8	0.0	1.1	1437**
Antibiotics	530	16.7	0.9**	22.1**	2019**
Hormones	279	8.8	0.6**	13.8**	2255**
Systemic agents	879	27.7	0.2	5.2	1249**
Agents affecting blood constituents	40	1.3	0.1	1.3	1945**
Blood products	150	4.7	0.5	12.6	1386**
Non-narcotic analgesics, antipyretics, anti-rheumatics	1184	37.3	−0.5**	−12.7**	1844**
Narcotic analgesics	438	13.8	0.5**	12.0**	1796**
Anticonvulsants, anti-Parkinson drugs	269	8.5	−0.3	−7.3	553
Sedatives, hypnotics	320	10.1	−0.1	−2.4	1230**
Other psychotropics	613	19.3	−1.0**	−24.0**	68
Autonomic nervous system	192	6.0	−0.3	−5.9	1237**
Cardiovascular drugs	104	3.3	−0.8*	−18.4*	−404
Gastrointestinal, smooth muscle, and respiratory drugs	121	3.8	−0.9**	−20.9**	−112
Water, mineral, and uric acid drugs	85	2.7	1.4**	33.8**	4064**
Anesthesia	77	2.4	−0.3	−6.5	553
CNS stimulants, topical drugs, vaccines, other miscellaneous drugs	216	6.8	−0.9**	−20.6**	−118
Specific reaction to unknown drug	418	13.2	1.0**	22.4**	1497**
Miscellaneous complications due to unspecified drugs	476	15.0	−0.5**	−12.8**	1050**
Surgical and medical procedures	4194	132.0	0.9**	21.8**	1333**
Complication of amputation or other removed organ	105	3.3	0.8**	18.7**	628
Tracheostomy	159	5.0	0.9**	20.5**	1920*
Formation of a stoma	466	14.7	1.0**	24.1**	2007**
Gastrointestinal complication	503	15.8	1.3**	29.7**	1311**
Cardiac complication	262	8.2	0.8**	19.2**	1119**
Vascular complication	193	6.1	1.0**	22.9**	1597**
Respiratory complication	722	22.7	0.4**	10.5**	466*
Nervous system complication	151	4.8	1.5**	34.0**	1355**
Genitourinary complication	117	3.7	1.0**	22.2**	764*
Infection, inflammation	503	15.8	2.0**	47.1**	2398**
Hematoma, hemorrhage	517	16.3	0.2	5.8	416
Non-healing wound	218	6.9	1.7**	40.7**	1895**
Miscellaneous complications to specific procedures	41	1.3	1.0*	23.7*	1610
Misadventure	256	8.1	0.8**	18.8**	1280**
Complications not classified elsewhere	1168	36.8	0.8**	17.7**	1403**
Devices, implants and grafts	2880	90.6	1.1**	26.8**	2508**
Cardiac	88	2.8	0.6**	14.0**	3051**
Vascular	946	29.8	2.1**	49.5**	4465**
Orthopedic	190	6.0	0.6**	13.0**	1429**
Genitourinary	70	2.2	2.4**	56.1**	3803**
Transplanted organ or body part	463	14.6	1.3**	29.2**	3726**
Other complications	1468	46.2	0.5**	12.1**	1118**
Radiation	46	1.5	−0.1	−1.6	1032*
All radiation related injuries	46	1.5	−0.1	−1.6	1032*
Total	10850†	3.41	0.51**	11.9**	1614**

WMIPP, Wisconsin Medical Injury Prevention Program; LOS, length of stay.

* $p < 0.05$, ** $p < 0.01$

†The number of injured patients in each category adds to more than the total number of injured patients because some patients had a medical injury in more than one category. 10 850 patients had a total of 12 038 medical injuries.

‡Excess length of stay (LOS), percentage change in LOS, and total hospital charges were adjusted for APR-DRG disease category, illness severity, mortality risk, and clustering within hospitals.

injury, they were calculated after excluding all medical injury related diagnostic codes. To account for within hospital similarities or clustering we used the Huber/White/sandwich estimator of variance in the regression model.

We could not assign a severity of underlying illness score to 970 patient records (0.3%), primarily because, after exclusion of the medical injury codes, no codes valid as a principal diagnosis remained. Patients who could not be assigned a severity of illness score were excluded from the analyses of LOS. Patients who could not be assigned a severity of illness score, who had a principal diagnosis of “V650” (healthy person accompanying sick person), or who had no hospital charges were excluded from the analyses of hospital charge data.

RESULTS

We studied 318 785 discharge records from 134 general, acute care, non-federal hospitals serving children in Wisconsin from January 2000 through December 2002 (table 1). The proportion of all discharges that were children at these hospitals varied widely; range 0.5–99%, mean (SD) 16 (15)%. In four hospitals over 50% of all the discharges were children. Most of the hospitals were non-profit organizations without residency training programs or trauma centers, while 24% had residency programs and 27% were community trauma centers.

Sixty four percent of the pediatric patients were normal full term newborns discharged within 7 days of age; 12% were

Table 4 Adjusted LOS and hospital charges for Wisconsin pediatric patients with and without medical injuries, 2000–2

	Adjusted mean LOS (days)	Adjusted mean total hospital charges (\$)
Patients with medical injury	4.78 (n = 10 850)	7774 (n = 10 850)
Patients without medical injury	4.27 (n = 306 962)	6160 (n = 306 894)*
Absolute difference	0.51	1614
Percentage difference (95% CI)	11.9% (6.9 to 17.1)	26.2% (22.1 to 30.5)

LOS, length of stay; CI, confidence interval.

Mean LOS and total hospital charges adjusted for APR-DRG disease category, illness severity, mortality risk, and clustering within hospitals.

*68 records were excluded because they had missing charge data. 58 of these cases were expired newborns, four were instances of a healthy person accompanying a sick person, and three were stays over 100 days for which charge data are not required. It is unknown why the remaining two cases had no charges.

adolescents (table 2). Slightly more than 50% were male. Most were privately insured, 25% were enrolled in Medicaid or the State Child Health Insurance Program, and 3% were uninsured; 74% had the lowest severity of illness classification and 94% had the lowest mortality risk; 92% were medical patients; 95% had routine discharges to home. The overall mean LOS was 4 days but 4% had stays of 10 days or longer.

The WMIPP screening criteria identified 10 850 pediatric discharges (3.4% of all discharges) with 12 038 medical injuries (table 3). Medical injuries were attributed to medications in 41%; surgical and medical procedures in 35%; devices, implants and grafts in 24%; and radiation in <1%. The rate of medical injury among all pediatric discharges was 1.5% for medications, 1.3% for surgical and medical procedures, 0.9% for devices, implants, and grafts, and 0.01% for radiation. The highest rates were found with non-specific device complications, non-narcotic analgesic/antipyretic/anti-rheumatic drugs (such as acetaminophen overdoses), unclassified procedure complications, vascular devices, systemic drugs, respiratory complications of procedures, other psychotropic medications, antibiotic complications, and hematomas/hemorrhage or infections/inflammation after a procedure.

The mean LOS adjusted for APR-DRG disease category, illness severity, mortality risk and clustering within hospitals was 4.8 days for patients with medical injuries and 4.3 days for patients without medical injuries (table 4). This half day difference represents a statistically significant 12% excess

mean LOS associated with medical injuries. The regression model results for LOS and hospital charges are listed in table 5.

The similarly adjusted mean total hospital charges were \$7774 for patients with medical injuries and \$6160 for patients without medical injuries. This difference of \$1614 represents a 26% increase in the mean charge associated with medical injuries, which is statistically significant. The adjusted mean excess LOS and percentage change associated with medical injuries was highest with genitourinary devices/implants, vascular devices, infections/inflammation and non-healing wounds after procedures, water/mineral/uric acid drugs, gastrointestinal complications due to a procedure, specific reactions to unknown drugs, and antibiotic complications (table 3). Medical injuries with adjusted mean excess hospital charges exceeding \$2000 were associated with vascular devices (mean increased charge \$4465), water/mineral/uric acid drugs, genitourinary devices/implants, transplanted organs/body parts, infections/inflammation after procedures, hormone medications, antibiotic complications, and stoma formation after procedures. Although medical injuries associated with a few selected medication subcategories (such as other psychotropics, gastrointestinal/smooth muscle/respiratory, and central nervous system stimulants/topicals/vaccines/miscellaneous) had statistically significant decreased adjusted mean LOS, the decrease in adjusted mean hospital charges was not significant and less than \$120. By contrast, radiation injuries were associated with no significant change in adjusted mean LOS but a statistically significant increase in adjusted mean charges in excess of \$1000.

DISCUSSION

This is the first report of medical injury rates among children in Wisconsin hospitals and of hospital safety outcomes analyzed through 2002 for a large population of children. The study uses the new WMIPP screening criteria as a comprehensive surveillance tool to assess hospital measures of child health and safety. The criteria identify medical injuries that may occur in inpatient, ambulatory, home, or other community settings and are diagnosed in hospital settings. Our focus on medical injuries requires both a clinical and a public health approach to preventing these adverse events. Healthcare professionals can use medical injury surveillance to guide clinical quality improvement initiatives. Public health leaders can use this information to prioritize areas for outpatient or community interventions—for example, healthcare professionals, community representatives, government officials, and family members might combine to develop preventive strategies to reduce hospital admissions for acetaminophen overdoses among adolescents.

Our results generally are consistent with AHRQ PSI findings published by Miller *et al.*³ In their analysis of 3.8 million pediatric discharge records from 22 states in 1997, AHRQ PSI events were associated with 2–6-fold longer LOS and 2–20-fold higher total charges. In our study specific medical injuries had up to 56% excess adjusted mean LOS and \$4465 excess mean adjusted hospital charges. Multivariate analyses by Miller *et al.* showed that all AHRQ PSI events except birth trauma were directly associated with factors related to greater illness severity—that is, PSI events occurred more frequently in those with more severe illness.³ In a second AHRQ PSI analysis of 7.45 million hospital discharges of patients of all ages from 28 states in 2000, postoperative sepsis and wound dehiscence were the most serious events in terms of extra LOS and excess hospital charges.² In our study extra LOS and excess hospital charges were greater for injuries due to genitourinary devices/implants, vascular devices, and infections/inflammation after

Table 5 Regression model results for length of stay and hospital charges

Adjusted covariates in regression models	Increased LOS % (95% CI)	Increased hospital charges % (95% CI)
Medical injury	11.9 (6.9 to 17.1)*	26.2 (22.1 to 30.5)*
Severity level		
1 (lowest)	Reference group	Reference group
2	20.8 (18.5 to 23.1)*	47.4 (42.0 to 53.0)*
3	62.0 (56.6 to 67.5)*	247.9 (229.1 to 268.2)*
4	325.5 (272.1 to 389.5)*	612.8 (458.9 to 818.2)*
Risk of mortality level		
1 (lowest)	Reference group	Reference group
2	5.1 (1.6 to 8.8)*	8.6 (2.2 to 15.5)*
3	3.7 (–8.6 to 17.5)	18.3 (1.5 to 37.9)*
4	–25.3 (–49.6 to 10.7)	–2.0 (–41.6 to 64.6)

*p<0.05.

APR-DRG was also a covariate in the two models but the categories are too numerous to list.

procedures. In a third AHRQ PSI analysis of 5.7 million pediatric discharge records from 27 states in 2000, AHRQ PSI events occurred more frequently in the very young and those enrolled in Medicaid.⁴ WMIPP criteria do not capture any of the AHRQ PSI birth trauma codes. We did not analyze medical injuries by age, payer, or other patient characteristics because this study focused on hospital outcomes rather than patient demographic characteristics. Furthermore, the State of Wisconsin does not report racial/ethnic background of patients in publicly available hospital records. Accordingly, we cannot interpret our findings along these parameters.

The AHRQ PSIs focus exclusively on hospital inpatient safety problems. As a result of their focus on inpatient quality of care, the AHRQ PSIs are more appropriate tools to evaluate the quality of care in hospitals. However, our approach provides a more accurate estimate of the full scope of patient safety problems as it includes medical injuries identified or treated in a hospital even if injury took place in the outpatient, community, or home setting, or during a previous hospital admission. In addition, this approach can target certain patient safety problems such as drug reactions and device failures which frequently occur in an outpatient setting.

Our study and the work of others show that medication related injuries are an important and common problem in pediatrics. In our study, medical injuries due to medications were diagnosed in 1.5% of hospitalized children and were associated with an excess mean hospital charge of \$1437. In a cohort study of hospitalized non-newborn pediatric patients in the US in 1988, 1991, 1994, and 1997, the rate of hospital reported medical errors ranged from 1.8% to 3.0%. Children with special needs or dependence on medical technology experienced significantly higher rates of medical errors.⁸ In a prospective study of 1197 pediatric admissions at one center, adverse drug events occurred in 6% and potential events in 8% of hospitalized children, especially in those with a greater disease burden and medication exposure.⁹ Use of computerized physician order entry with clinical decision support systems, ward based clinical pharmacists, and improved communication among physicians, nurses, and pharmacists might substantially reduce medication error rates and prevent potential adverse drug events in pediatric inpatients.^{10–13} The magnitude of benefits may be even greater in pediatric than in adult medicine because of the need for weight based dosing.

This approach to patient safety monitoring has limitations. It is based on hospital discharge data collected for administrative purposes and shares the limitations of all studies using administrative data.¹⁴ Because they are collected primarily for administrative purposes, hospital discharge data cannot include deep clinical detail. Due to privacy concerns, these data also do not have patient identifiers, so multiple admissions for the same person cannot be linked. The Wisconsin public use data set also lacks important information about patient race/ethnicity. In this study medical injuries cannot be attributed to a hospital or to inpatient care due to inter-hospital transfers and injuries occurring in outpatient and non-medical settings. At the same time, administrative data have advantages of being readily available, inexpensive, computer readable, and covering large populations.¹⁵ They are therefore useful for medical injury surveillance but efforts need to be made to overcome selected limitations.

The use of administrative indicators as useful valid outcome measures has limitations including problems with variations in coding accuracy and practice, challenges to appropriate risk adjustment, and difficulty with correct attribution of the timing of events.^{16–19} The sensitivity of the WMIPP screening criteria is approximately 60%. Given the

relatively low statistical prevalence of medical injuries, a positive screening has a predictive value of 50–60%. The descriptive epidemiology of injuries described by our WMIPP method therefore only has a 50–60% chance of being accurate. This may not be reassuring even if, on average, those with positive screens have higher costs and LOS for some categories and overall. The same criticism can be made of the AHRQ PSIs but it has not slowed their adoption.

While the WMIPP method provides a more public health oriented approach to medical injury than PSI, it is consistent with other administrative data based tools in that it does not separate the injuries into pre-hospital or in-hospital phases, nor does it indicate which are injuries as a result of ambulatory care or even intentional poisoning such as during a suicide attempt. Although the finding that the most significant injuries relate to devices and procedures—most likely inpatient related—makes this distinction less relevant, it also lowers the relative value of using the WMIPP measures compared with the PSI.

These limitations serve as a caution to public reporting for accountability, but do not preclude the use of medical injury screening of administrative data for improving patient care. The WMIPP criteria reflect the public health impact of medical injuries better than systems focused on inpatient events only. Medical injuries that are challenging to prevent with current knowledge and technology may be preventable with future greater knowledge and new technology, medications and devices.

Our approach is also limited by the variability among states in external cause of injury coding in hospital discharge data.²⁰ In Wisconsin, external cause of injury coding is very complete.²¹ In this pediatric dataset, E-coding is 80% complete. Although our approach uses N-codes as well as E-codes, WMIPP screening criteria would be of greatest use in this and other states with high levels of E-coding. Despite these limitations, the face validity of the diagnostic codes comprising the criteria, the agreement of the criteria with medical record review,⁷ and the adverse effect on LOS and charges experienced by individuals fulfilling the criteria all indicate that the WMIPP criteria are useful in identifying injuries from healthcare interventions that have an appreciable impact on patient health.

We think that actual specific medical injuries are under-reported by Wisconsin hospitals. Patients may under-report symptoms and physicians may under-report specific diagnoses associated with medical injuries—for example, therapeutic misadventures and complications associated with childbirth. Moreover, non-specific and unspecified codes, as defined in the ICD-9-CM manual, may be over-represented as

Key messages

- Inpatient medical injuries are common and result in excess length of stay and increased hospital charges.
- This study applied new screening criteria that included healthcare injuries occurring before rather than just during a hospital admission.
- The results reinforce previous national findings to the end of 2000 using Wisconsin data to the end of 2002.
- They suggest that hospitals and pediatricians should use more specific diagnostic coding, focus clinical improvement on medication, procedures and devices frequently associated with medical injuries, and use medical injury surveillance to track medical injury rates in children.

they account for 10.8% and 12.3% of all codes reported in this dataset. Individual hospitals had an average of 10.1% non-specific codes (range 0–50%) and 14.7% unspecified codes (range 3.3–50%).

Medical injuries may occur with or without an error in medical practice. The issue of whether medical injuries are caused by errors is complicated by variations in definitions of errors and lack of reproducibility in error determination. Cook and Woods²² have identified multiple reasons for the limitations of focusing safety efforts on error including ease of identifying a human proximal to a failure as a sole cause, the difficulty in identifying the “causal chain that led to the system failure”, the usual success of human performance in the same flawed and complex systems and, lastly, hindsight bias. Additionally, focusing on error leads to attributions of blame²³ which does little to advance injury prevention.

Our approach and the results of this study have important generalizable implications for the practice of pediatrics, healthcare improvements, and the betterment of child and adolescent health.²⁴ The application of the WMIPP screening criteria to large population based databases permits public health surveillance of patient safety.

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The classification scheme and ICD-9-CM criteria for each category and subcategory are listed in the online Appendix available at <http://www.qshc.com/supplemental>.

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