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Research

Factors affecting management of children's low-risk distal radius fractures in the emergency department: a population-based retrospective cohort study

Tara Baxter MD MSc, Teresa To PhD, Maria Chiu PhD, Mark Camp MD, Andrew Howard MD MSc

Abstract

Background: Ten randomized controlled trials over the last 2 decades support treating low-risk pediatric distal radius fractures with removable immobilization and without physician follow-up. We aimed to determine the proportion of these fractures being treated without physician follow-up and to determine whether different hospital and physician types are treating these injuries differently.

Methods: We conducted a retrospective population-based cohort study using ICES data. We included children aged 2–14 years (2–12 yr for girls and 2–14 yr for boys) with distal radius fractures having had no reduction or operation within a 6-week period, and who received treatment in Ontario emergency departments from 2003 to 2015. Proportions of patients receiving orthopedic, primary care and no follow-up were determined. Multivariable log-binomial regression was used to quantify associations between hospital and physician type and management.

Results: We analyzed 70 801 fractures. A total of 20.8% (*n* = 14 742) fractures were treated without physician follow-up, with the proportion of physician follow-up consistent across all years of the study. Treatment in a small hospital emergency department (risk ratio [RR] 1.86, 95% confidence interval [CI] 1.72–2.01), treatment by a pediatrician (RR 1.22, 95% CI 1.11–1.34) or treatment by a subspecialty pediatric emergency medicine–trained physician (RR 1.73, 95% CI 1.56–1.92) were most likely to result in no follow-up.

Interpretation: While small hospital emergency departments, pediatricians and pediatric emergency medicine specialists were most likely to manage low-risk distal radius fractures without follow-up, the majority of these fractures in Ontario were not managed according to the latest research evidence. Canadian guidelines are required to improve care of these fractures and to reduce the substantial overutilization of physician resources we observed.

Distal radius fractures are the most common pediatric orthopedic injury, with an estimated 10 000 fractures yearly in Ontario.[1] Many of these fractures are minimally displaced (initial angulation < 15° in the sagittal plane and < 5 mm translation on the frontal plane), are at low risk for complications and yield excellent clinical results.[2,3] One very common subtype of these fractures, buckle fractures, are stable injuries in which pediatric bone deforms without completely breaking.[4] Historically these fractures have been seen for follow-up in hospital fracture clinics exclusively by orthopedic surgeons. However, a large body of evidence accumulated over the last 2 decades has shown that this is unnecessary and results in increased costs and more complications.[5–15] Rather, these fractures can be treated more simply, with a single diagnostic radiograph, removable immobilization that is taken off at home and no physician follow-up, with equivalent outcomes. This simplified treatment is supported in multiple systematic reviews, randomized controlled trials, cohort studies and literature reviews.[2–4,11–37] Many hospitals have also developed their own internal guidelines pertaining to this injury. One formal guideline advising on management of these injuries, Choosing Wisely UK, cites plaster casting and scheduled follow-up for distal radius buckle fractures in its list of treatments and procedures that are of little or no benefit to patients.[38] We are unaware of any formal Canadian or American guidelines providing guidance on managing this fracture type.

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Correspondence to: Tara Baxter, tara.baxter@medportal.ca

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Despite the evidence, large numbers of referrals to orthopedic surgeons have persisted for this fracture type.[39–41] Application of best evidence is linked to hospital infrastructure and resources, physician education and training, and research affiliation, but these relations have not been well studied for these fractures.[32,39–53] The aim of this study was to examine how low-risk pediatric distal radius fractures are being managed in Ontario, and to determine whether different hospital and physician types are making different choices regarding care.

Methods

Design and setting

We conducted a retrospective population-based cohort study in Ontario involving children with low-risk pediatric distal radius fractures, using administrative data.

Participants

We included all children aged 2–12 years for girls and 2–14 years for boys presenting to an Ontario emergency department with a closed fracture of the distal radius, identified in the National Ambulatory Care Reporting System database between Oct. 1, 2003, and Feb. 17, 2015. The upper age limit is the approximate age of skeletal maturity, which differs between sexes and after which low-risk-type fractures are no longer seen.[1] The lower age limit corresponds to the age at which children are reliably walking, a requisite to have a fall onto outstretched hands with enough force to cause a fracture. It is rare to see a wrist fracture in a child who cannot yet walk, and such a fracture is concerning for nonaccidental injury, which has a remarkably different course of follow-up.

Patients were excluded if they had a discharge disposition other than "home," if they did not reside in Ontario, if the fracture was manipulated or operated on within 6 weeks, if there were other fracture diagnoses within 6 months or if there were comorbidities necessitating increased fracture surveillance. These factors would preclude the ability to isolate care related to the fracture of interest. We also excluded patients with the following characteristics that would make determination of exposure or outcome status unreliable: no valid Ontario Health Insurance Plan (OHIP) number and admission to hospital for any reason during the 6-week observation period.

Data sources

Data were obtained by linking multiple administrative databases housed at ICES (formerly the Institute for Clinical Evaluative Sciences) in Toronto. Databases that were accessed and linked include the National Ambulatory Care Reporting System, OHIP, Registered Persons Database, ICES Physician Database, Ontario Health Care Institution Database, Census (Ontario Ministry of Health and Long-Term Care: IntelliHEALTH ONTARIO), Canadian Institute for Health Information Discharge Abstract Database and Ontario Cancer Registry (Table 1; Appendix 1, available at www.cmajopen.ca/content/9/2/E659/suppl/DC1). Linkage across these databases proceeds using the ICES key number, which is an anonymized code that identifies individual patient records.

Reporting of National Ambulatory Care Reporting System data is mandatory for all Ontario emergency departments, with accuracy at the level of granularity required for this study reported at 88.8% and 93.5% for main problem and intervention coding, respectively.[54] These percentages are likely higher for common injuries such as low-risk pediatric distal radius fractures. There are no data-quality studies regarding OHIP coding of fracture follow-up. Intuitively, OHIP coding represents a highly specific indication of patient interaction with a physician, given that nearly all Ontario physicians must submit billing codes to receive compensation. Even physicians functioning exclusively under salaried models are typically required to shadow bill. Only 4.2% of emergency department visits that appear in the National Ambulatory Care Reporting System database lack either a compatible OHIP claim submitted or explanation for the lack of claim (such as leaving without being seen).[55] Of these visits with no submission to insurance, more than three-quarters were from facilities using alternative funding models.[55]

Exposures

The primary exposure of interest was hospital type, obtained from the Ontario Health Care Institution Database, having 4 categories: pediatric hospital, academic hospital (nonpediatric Council of Academic Hospitals of Ontario members), small hospital (single community provider, annual weighted case load < 2700)[56] and community hospital (other hospitals). These definitions were originally established by the Joint Policy and Planning Committee,[56] with the addition of pediatric hospital type made by ICES.

The secondary exposure of interest was type of physician providing treatment in the emergency department, obtained from the ICES Physician Database, having 6 categories: emergency medicine residency training, general or family medicine with emergency medicine certification, family or general practitioner, pediatrician, subspecialty pediatric emergency medicine and orthopedic surgery.

Other covariates collected were year of service, patient age, patient sex, rural patient residence, patient deprivation quintile and physician year of medical graduation.

Primary outcome

The primary outcome of interest was whether a follow-up visit occurred within 6 weeks of presentation, operationalized as a binary, yes/no, variable. A clinician visit was considered a follow-up for low-risk pediatric distal radius fracture only if both the OHIP billing code and associated diagnostic code were compatible with this.[57] Where a compatible follow-up visit was identified, the type of follow-up provider was noted. Patients who had visits to a provider for reasons unrelated to the fracture met the definition of no follow-up.

Statistical analysis

Baseline descriptive characteristics were calculated and reported for all variables of interest. The total proportion of children receiving no follow-up was calculated for each year of the study.

Table 1: ICES databases and data elements accessed		
Database	Description	Data obtained
National Ambulatory Care Reporting System	Outpatient data: Same-day surgery, emergency department and clinic visits in hospital and community settings in Ontario	• Main diagnosis code • Intervention codes • Visit disposition • Date of service
Ontario Health Insurance Plan	Billing data: Records of all claims for insured services made to the health plan	• Fee codes • Diagnosis codes • Date of service
ICES Physician Database	Physician data: Demographic characteristics, training, practice location, and specialty.	• Physician type/specialty • Year of medical graduation
Ontario Health Care Institution Database	Hospital data	• Hospital type
Registered Persons Database	Identification data: Demographic characteristics, ability to link other data and ongoing eligibility to receive insurance coverage	• Patient age • Patient sex • Rurality of residence • Insurance eligibility
Census	General data: Demographic characteristics, ethnicity, income, housing conditions, family structure and spoken languages from households across Canada	• Deprivation quintile
Canadian Institute for Health Information Discharge Abstract Database	Inpatient data: Admissions, diagnoses and interventions	• Intervention codes • Comorbidities • Hospital admission
Ontario Cancer Registry	Cancer data: Cancer diagnoses in Ontario residents	• Comorbidities

A multivariable log-binomial regression model was used to assess the association between hospital and physician type and no follow-up. The multivariable model was chosen a priori based on physician judgment of the potential clinical relevance of available covariates and consisted of the outcome variable; best-evidence treatment; variables of interest: hospital and physician type; and covariates: age, sex, deprivation quintile, rural residence and fiscal year. Collinearity of variables was assessed using the variance inflation factor with a threshold of greater than 2.5. Individuals with missing data were excluded, as this typically meant the entire visit record was blank.

Statistical analysis was conducted using SAS version 9.4.

Ethics approval

This study was approved by the Hospital for Sick Children Research Ethics Board (#1000055743) and the University of Toronto Research Ethics Board (#34118).

Results

A total of 78 252 eligible fractures were isolated. Of these, 508 fractures had an incompatible practitioner type providing care (e.g., psychiatry and pathology), and 6943 were missing data on relevant predictors. Where values were missing for 1 predictor, typically all predictor values were missing, and therefore these fractures were excluded. After exclusions, 70 801 fractures remained for analysis (Figure 1).

Proportion with no follow-up

Table 2 shows the results of the descriptive analysis. Overall, 20.8% (*n* = 14 742) of patients with a low-risk pediatric distal radius fracture received no follow-up visit after their initial emergency department visit. The remaining 79.2% (*n* = 56 059) received follow-up with either an orthopedic surgeon (48 703/70 801, 68.8%) or a primary care practitioner (7356/70 801, 10.4%). This trend was consistent throughout all years of the study (Figure 2).

Multivariable log-binomial regression

Results of the multivariable analysis are shown in Table 3. No variables reached the threshold of greater than 2.5 for collinearity, and therefore all variables from the a priori model were included in the final model.

Hospital type

Small hospital type had the largest positive association with no follow-up (risk ratio [RR] 1.86, 95% confidence interval [CI] 1.72–2.01) when compared with teaching hospitals as a reference category. Pediatric hospital (RR 1.16, 95% CI 1.07–1.26) and community hospital (RR 1.13, 95% CI 1.06–1.20) types were also significant predictors of having no follow-up.

Physician type

The risk ratios for pediatric emergency medicine subspecialty training (RR 1.73, 95% CI 1.56–1.92), pediatricians (RR 1.22, 95% CI 1.11–1.34), family or general practitioners (RR 1.09,

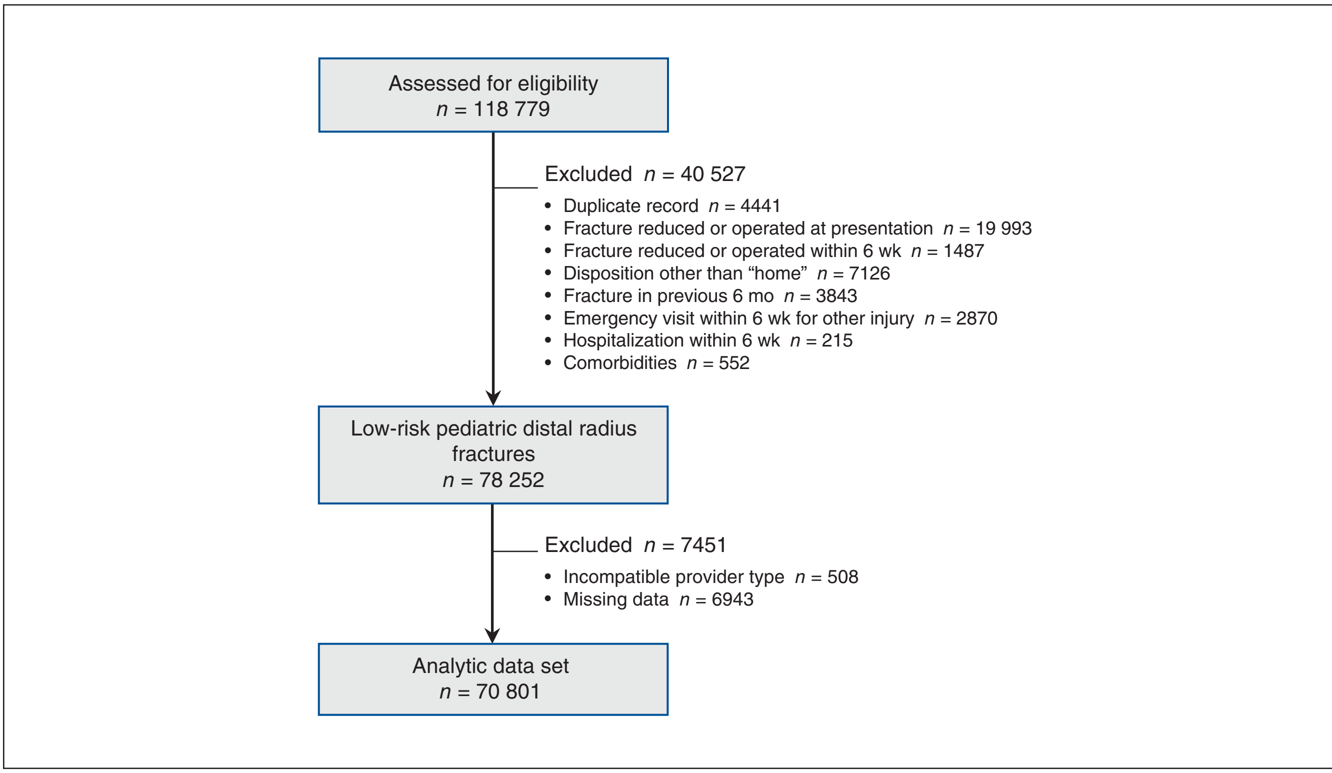

Figure 1: Exclusion flow diagram.

95% CI 1.02–1.16), and orthopedic surgeons (RR 0.77, 95% CI 0.64–0.92) were significant when compared with emergency medicine residency training as a reference category. Family medicine plus emergency medicine certification was not a significant predictor (RR 1.00, 95% CI 0.94–1.06).

Other covariates

Rural patient residence showed a large significant association with no follow-up after adjustment (RR 1.44, 95% CI 1.38–1.50). Female patient sex had a small but significant association (RR 1.08, 95% CI 1.05–1.11). One patient deprivation quintile reached significance (fourth quintile, RR 1.06, 95% CI 1.01–1.10), with no trend shown among the quintiles. Patient age was not a significant predictor (RR 1.00, 95% CI 0.99–1.01).

Interpretation

We have shown that while small hospital emergency departments, pediatricians and pediatric emergency medicine specialists were most likely to manage low-risk distal radius fractures without follow-up, most of these fractures in Ontario were not managed according to the latest research evidence. A substantial body of evidence exists to support simplified treatment for low-risk pediatric distal radius fractures, with most of the literature having been published since 2002. Until now, little was known about management patterns and contributing factors. Most surprising is the finding that follow-up care has not changed over time. With only 21% of patients receiving care in line with current research evidence, we are left to wonder where the disconnect exists between evidence generation and application for this injury. Hospital and physician type emerged as important determinants of treatment received; pediatric and small hospitals, and pediatric emergency medicine subspecialists were most associated with no follow-up.

Limited resources in the small hospital or rural settings may be an asset; emergency department physicians working in these settings may have developed excellent resource stewardship skills out of necessity. Furthermore, fracture clinics and orthopedic surgeons may not be as readily available, as they are in large or urban centres or may be located far from the patient's residence. Another possible explanation for our results is that patients are pursuing the care they desire, regardless of follow-up recommendations.

The finding that pediatric hospitals and pediatric emergency medicine subspecialists were most associated with follow-up care in line with current best evidence is not surprising; Canadian research on best practices for low-risk pediatric distal radius fractures was largely conducted in pediatric hospitals through collaboration with pediatric emergency medicine subspecialists and research groups. Standardized treatment protocols may also exist in these emergency departments, with their rollout championed by the same groups.

As expected for a low-risk, nonoperative fracture, orthopedic surgeons were the primary treating provider in the emergency department for only 1.1% of these injuries and had the least association with no follow-up. This may represent a tendency for orthopedic surgeons to want to follow patients they

Table 2: Description of low-risk pediatric distal radius fracture cohort, stratified by outcome of interest, no follow-up

Predictor of interest	No. (%)* No follow-up *n* = 14 742 (20.8%)	Other treatment *n* = 56 059 (79.2%)	Total *n* = 70 801 (100.0%)
Patient sex			
Male	8775 (20.2)	34 713 (79.8)	43 488 (61.4)
Female	5967 (21.8)	21 346 (78.2)	27 313 (38.6)
Patient age at diagnosis, mean ± SD	9.22 ± 3.2	9.25 ± 3.2	9.24 ± 3.2
Patient deprivation quintile			
1 (least marginalized)	3733 (19.5)	15 408 (80.5)	19 141 (27.0)
2	3162 (20.5)	12 228 (79.5)	15 390 (21.7)
3	2856 (21.8)	10 258 (78.2)	13 114 (18.5)
4	2578 (22.3)	8974 (77.7)	11 552 (16.3)
5 (most marginalized)	2413 (20.8)	9191 (79.2)	11 604 (16.4)
Rural patient residence			
Yes	2689 (34.4)	5135 (65.6)	7824 (11.1)
No	12 053 (19.1)	50 924 (80.9)	62 977 (88.9)
Rural emergency department			
Yes	2135 (38.2)	3458 (61.8)	5593 (7.9)
No	12 607 (19.3)	52 601 (80.7)	65 208 (92.1)
Hospital type			
Pediatric	1362 (24.1)	4298 (75.9)	5660 (8.0)
Teaching	1274 (17.8)	5880 (82.2)	7154 (10.1)
Community	10 394 (19.3)	43 495 (80.7)	53 889 (76.1)
Small	1712 (41.8)	2386 (58.2)	4098 (5.8)
Physician year of medical graduation			
Before 2002	12 012 (21.2)	44 637 (78.8)	56 649 (80.0)
After 2002	2730 (19.3)	11 422 (80.7)	14 152 (20.0)
Physician specialty			
Emergency medicine residency trained	1103 (18.0)	5022 (82.0)	6125 (8.7)
Family medicine + emergency medicine certification	5894 (18.9)	25 276 (81.1)	31 170 (44.0)
Family or general practitioner	6130 (23.1)	20 450 (76.9)	26 580 (37.5)
Pediatrician	984 (21.7)	3559 (78.3)	4543 (6.4)
Pediatric emergency medicine subspecialty	522 (32.4)	1090 (67.6)	1612 (2.3)
Orthopedic surgery	109 (14.1)	662 (85.9)	771 (1.1)
Fiscal year			
2003	429 (18.1)	1939 (81.9)	2368 (3.3)
2004	1187 (18.9)	5089 (81.1)	6276 (8.9)
2005	1174 (19.5)	4854 (80.5)	6028 (8.5)
2006	1222 (21.2)	4552 (78.8)	5774 (8.2)
2007	1167 (20.4)	4561 (79.6)	5728 (8.1)
2008	1136 (20.4)	4439 (79.6)	5575 (7.9)
2009	1160 (20.6)	4464 (79.4)	5624 (7.9)
2010	1208 (21.7)	4352 (78.3)	5560 (7.9)
2011	1263 (22.2)	4414 (77.8)	5677 (8.0)
2012	1238 (23.0)	4152 (77.0)	5390 (7.6)
2013	1262 (22.2)	4412 (77.8)	5674 (8.0)
2014	1261 (21.8)	4522 (78.2)	5783 (8.2)
2015	1035 (19.4)	4309 (80.6)	5344 (7.5)

Note: SD = standard deviation.
*Unless stated otherwise.

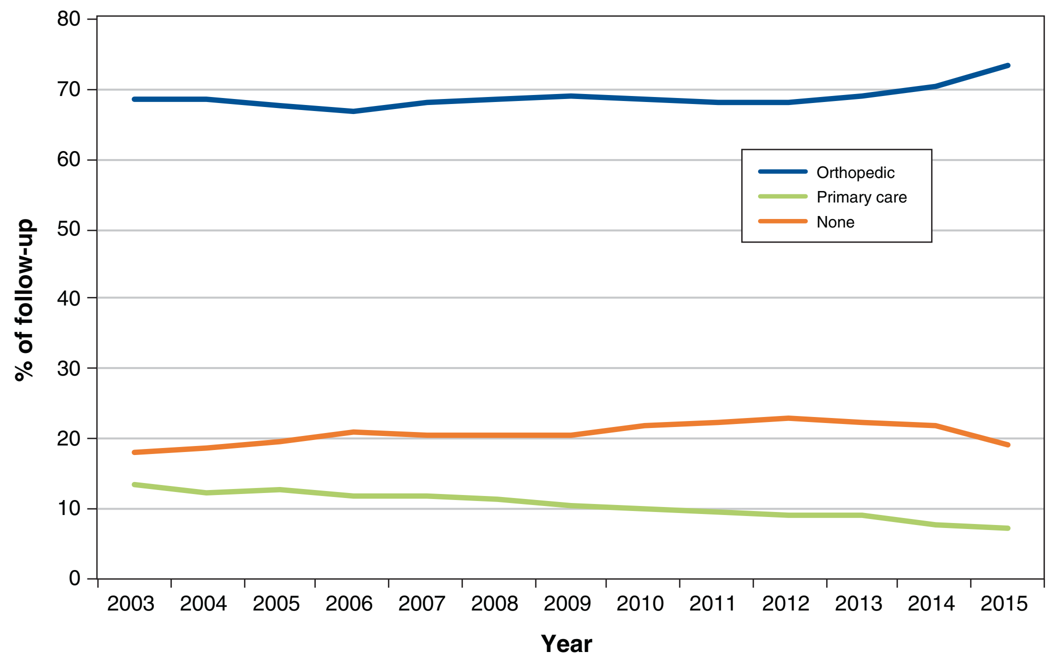

Figure 2: Yearly variation in type of follow-up visit for low-risk pediatric distal radius fractures.

have initially assessed and treated. More likely, however, is that this small number of fractures represent more severe fracture types that may have been miscoded in the administrative data or represent patients with high-risk comorbidities that were not captured or coded in the data.

Although splinting without physician follow-up for low-risk pediatric distal radius fractures is ideal, some patients may need reassurance while the fracture is healing and thus may require a follow-up appointment. A visit with a primary care practitioner is appropriate in this setting. Patients can be referred to an orthopedic surgeon if concerns arise that cannot be addressed in primary care. An orthopedic follow-up visit for distal radius fracture care costs the health system up to $151, whereas a follow-up with a family doctor costs $20–$33;[57] therefore, the potential social and economic impact of this unnecessary care is large.[11–13,18,58–60]

We suggest a multimodal approach to encouraging adoption of best evidence for low-risk pediatric distal radius fractures. At the hospital level, emergency departments require access and funding for materials to provide removable forms of immobilization. Widespread development and implementation of clinical care guidelines, with enthusiastic support from champions of evidence-based care, could help guide decision-making in emergency departments. Fostering a cooperative atmosphere between specialties is imperative for timely and accurate diagnosis and to support emergency department physicians to apply guidelines confidently.

Interactive continuing medical education modules covering musculoskeletal topics are currently being explored as an innovative option at our institution. A "virtual fracture clinic" is one approach used in the United Kingdom; fracture diagnosis is confirmed virtually by an orthopedic surgeon, thereby providing decision support for emergency department physicians and alleviating medicolegal concerns. Ongoing communication and collaboration between orthopedic and emergency physicians are imperative when implementing hospital-based changes. The development of high-quality national guidelines may be of most benefit. Physician concerns regarding lost income resulting from eliminating follow-up or added workload from additional radiograph interpretations could be addressed with instituting bundled fees or salaried work.

For patients, additional information and support based on best-evidence guidelines may be beneficial in the form of Web-based and pamphlet education, printed discharge instructions, and phone applications offering specific fracture care information and virtual follow-up.

Future directions include a multicentre prospective cohort study, which would increase diagnostic accuracy, allow discrimination between subtypes of fractures, and include more detailed hospital, physician and patient factors than were available through ICES. Finally, costing analyses could quantify potential cost savings and inform a revision of funding models or fee schedules to better reflect and support the provision of best-evidence care.

Table 3: Multivariable log-binomial regression analysis of factors predictive of receiving no follow-up after a low-risk pediatric distal radius fracture (n = 70 801)

Predictor of interest	Adjusted RR (95% CI) for receiving no follow-up
Patient sex	
Male	1.00 (Ref.)
Female	1.08 (1.05–1.11)
Patient age	1.00 (0.99–1.01)
Patient deprivation quintile	
1 (least marginalized)	1.00 (Ref.)
2	1.01 (0.97–1.05)
3	1.04 (0.99–1.09)
4	1.06 (1.01–1.10)
5 (most marginalized)	1.03 (0.99–1.08)
Rural patient residence	
Yes	1.44 (1.38–1.50)
No	1.00 (Ref.)
Hospital type	
Pediatric	1.16 (1.07–1.26)
Teaching	1.00 (Ref.)
Community	1.13 (1.06–1.20)
Small	1.86 (1.72–2.01)
Physician specialty	
Emergency medicine residency trained	1.00 (Ref.)
Family medicine + emergency medicine certification	1.00 (0.94–1.06)
Family or general practitioner	1.09 (1.02–1.16)
Pediatrician	1.22 (1.11–1.34)
Pediatric emergency medicine subspecialty	1.73 (1.56–1.92)
Orthopedic surgery	0.76 (0.63–0.91)
Fiscal year	
2003	1.00 (Ref.)
2004	1.05 (0.95–1.16)
2005	1.09 (0.99–1.21)
2006	1.18 (1.07–1.31)
2007	1.13 (1.03–1.25)
2008	1.16 (1.05–1.28)
2009	1.14 (1.04–1.26)
2010	1.19 (1.08–1.32)
2011	1.20 (1.09–1.33)
2012	1.24 (1.12–1.37)
2013	1.21 (1.09–1.33)
2014	1.19 (1.08–1.31)
2015	1.06 (0.95–1.17)

Note: CI = confidence interval, Ref. = reference category, RR = risk ratio.

Limitations

While strengths of this study are the use of prospectively collected administrative data and large sample size, the study has some limitations. These include the use of data that were not intended for health research, unknown data accuracy for isolation of specific fracture types and follow-ups, inability to differentiate scheduled and unscheduled follow-up, lack of data regarding other relevant factors relating to best evidence care, such as method of immobilization and radiographs, and inability to explore behavioural aspects of care provision.

Conclusion

Our results indicate a large gap between what is supported by evidence and what is practically done in the care of low-risk pediatric distal radius fracture. Only 21% of patients in this study received follow-up care consistent with current research evidence, with no substantial variation over time. Canadian guidelines are needed to improve care for this fracture type and provide evidence-based guidance to clinicians.

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Affiliations: Division of Orthopaedic Surgery (Baxter), Faculty of Medicine, University of Toronto; Child Health Evaluative Sciences (To), The Hospital for Sick Children; ICES (Chiu); Division of Epidemiology (Chiu), University of Toronto; Department of Surgery (Camp), The Hospital for Sick Children; Division of Orthopaedics (Howard), Department of Surgery, The Hospital for Sick Children, Toronto, Ont.

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