



Annual and Seasonal Trends in Ambulatory Visits for Pediatric Concussion in Ontario between 2003 and 2013

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Objective To investigate annual and seasonal trends in physician office and emergency department (ED) visit rates for pediatric concussion in Ontario between 2003 and 2013.

Study design A retrospective, population-based study was conducted using linked health administrative data from all concussion-related visits to ED and physician office by children aged 5 through 18 years. Time series analysis was used to assess whether periodic components exist in the monthly number of concussion-related visits.

Results Over the 11-year study period, there were 176 685 pediatric visits for concussion in EDs and physician offices in Ontario. Standardized concussion-related visits showed a 4.4-fold (95% CI 4.37-4.45) increase per 100 000 from 2003 to 2013, with nearly 35 000 total visits in 2013. Concussion-related visits demonstrated a steep increase from 2010 onward. The greatest increases in standardized visits were in females (6.3-fold, 95% CI 6.23-6.46 vs 3.6-fold, 95% CI 3.56-3.64 in males) and 13-18.99 year olds (5.0-fold, 95% CI 4.93-5.08 vs 4.1-fold, 95% CI 3.99-4.27 in 9-12 years and 2.3-fold, 95% CI 2.23-2.42 in 5-8 years). A strong seasonal variability ($R^2_{\text{autoreg}} = 0.87$, $P < .01$) in the number of concussion-related visits was present, with most occurring in fall and winter.

Conclusions Pediatric concussion-related ED and physician office visit rates have greatly increased in the last decade, particularly since 2010. Prevention strategies may be targeted at those most at risk and at seasonal-related activities carrying the greatest risk of concussion. (*J Pediatr* 2017;181:222-8).

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Concussion is placing an increasing demand on healthcare systems worldwide. Children and adolescents are at greater risk of concussion compared with adults, and take longer to recover^{1,2} with a significant impact on mental, physical, and academic performance and social encounters.^{3,4} The number of outpatient visits for concussion in childhood has increased dramatically in the last decade,^{2,5} ranging from a 2- to 4-fold increase in visit rates to primary care providers and emergency departments (EDs).^{6,7}

However, exact estimates of the incidence and health care utilization for pediatric concussion remain unclear as previous studies either used a composite definition of concussion and other types of mild traumatic brain injury,^{5,7} did not distinguish between incident and follow-up visits for concussion,^{5,6} or used broader age groups or convenience samples to derive overall concussion visit estimates.^{5,8} Moreover, most studies have reported data collected before 2010,^{2,5,6} before the increase in scientific and media attention along with recently released guidelines for the diagnosis and management of concussion in children and adolescents.⁹ The more recent increase in outpatient care visits may, therefore, be even greater than previously reported. Finally, it remains unknown whether there may be a seasonal variation in the number of concussion-related physician office and ED visits, as only annual trends in the total number of concussion visits have been published so far.^{2,5-7}

This study aimed to determine trends in the annual number of physician office and ED visits for concussion in youth aged 5 through 18 years in Ontario between

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EDs	Emergency departments
ICD-10-CA	<i>International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada</i>
ICES	Institute for Clinical Evaluative Sciences
NACRS	National Ambulatory Care Reporting System
OHIP	Ontario Health Insurance Plan

fiscal years 2003 and 2013. We hypothesized a nonlinear increase in concussion-related visit rates per 100 000, with the greatest increase occurring after 2010 because of heightened scientific and public attention. Further, we examined the periodicity of the total number of physician office and ED visits for pediatric concussion in Ontario between 2003 and 2013 to determine whether a temporal variability, in particular seasonal variability, may be present.

Methods

We conducted a retrospective study using repeated cross-sections of outcome data on population denominators of all concussion-related visits to the ED or physician office by children and adolescents aged 5 through 18 years (at time of visit) in Ontario, Canada between April 1, 2003, and March 31, 2014 (ie, fiscal years 2003-2013). Ontario offers a publicly funded healthcare system that enables accurate data collection. Information on population demographics and healthcare utilization is routinely collected for all residents of Ontario who qualify for a health card number, covering over 99% of the provincial population (13 + million residents comprising 38% of Canada's total population). This study followed STROBE and RECORD reporting guidelines.¹⁰

Unique encoded identifiers were used to link deterministically multiple population-based health administrative databases, which contain information on all medically necessary services received by publicly insured residents of Ontario that are housed at the Institute for Clinical Evaluative Sciences (ICES). Databases included National Ambulatory Care Reporting System (NACRS) for ED visits which started in 2003, maintained by the Canadian Institute for Health Information (Toronto, Ontario); Ontario Health Insurance Plan (OHIP) for physician billings, including physician visits, diagnosis codes, and procedures, which started in 1991; and Registered Persons Database for patient demographics. Postal codes from Registered Persons Database were linked to Canadian census data to obtain mean neighborhood income quintiles and community size (rural vs urban residence) for each patient at time of concussion visit within the study period.

Ontario intercensus and postcensus population estimates were provided to ICES by Statistics Canada. Research Ethics Board approval was obtained from the Children's Hospital of Eastern Ontario (Ottawa, Ontario).

Outcome Measures

Concussion-related ED visits were defined as an *International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada* (ICD-10-CA) diagnosis of S060 ("concussion"), and office visit records with an OHIP diagnosis code of 850 ("concussion"). These codes have not been validated within Ontario health administrative data. OHIP diagnostic codes for outpatient visits are submitted by physicians or their representatives, and are not quality controlled. Physician office visits included all concussion-related outpatient visits that took place in a clinic setting (ie, not inpatient), including visits to primary care physicians and medical

specialists (eg, neurology, sports medicine, neurosurgery). ED visits were derived from NACRS, which uses professional coders to ensure accuracy of diagnostic codes associated with visits. For ED visits, concussion-related diagnosis codes were not restricted to main diagnosis; for office visits, only 1 diagnosis code is permissible through OHIP. For a given patient, we allowed for multiple visits on the same day to be counted if 1 visit took place at a physician office and another one at the ED. Otherwise, multiple visits per facility per day were excluded. Duplicated, overlapped, and transferred ED visits were excluded, and subjects were excluded if they had missing or invalid health card number, age, sex, or Local Health Integration Network (a geographic marker within Ontario) at time of visit.

Statistical Analyses

The total annual number of concussion-related visits to the ED and physician office by sex and age was calculated for fiscal years 2003 to 2013. In accordance with previously identified risk groups for concussion,¹¹ age was a priori categorized into 3 groups (5.00-8.99 years, 9.00-12.99 years, and 13.00-18.99 years). Concussion-related visit rates per 100 000 were calculated using the total number of yearly visits as the numerator, and the Ontario population of at-risk children aged 5 through 18 years as the denominator. These counts were standardized to the 2013 age distribution. The ratio between standardized visits in 2013 and 2003 was computed, and the corresponding CIs approximated using the Delta method. The Mann-Kendal test for trends (R implementation) was used to assess a monotonic increasing trend in standardized counts over time.^{12,13}

As a sensitivity analysis, trends in the total number of physician office and ED visits for head injury other than concussion ("other head injury") in children aged 5 through 18 years between fiscal years 2003 and 2013 were calculated to ensure that an increase in concussion-related visits would not merely be due to a reclassification of head injuries to "concussion." "Other head injury" was defined as ICD-10-CA diagnosis S099 ("unspecified injury of head") in NACRS, or OHIP diagnosis code 854 ("other head injuries").

We used time series analysis to study the order and strength of periodicity observed in the monthly aggregation of concussion-related ED and physician office visits. Through visual inspection of the data series, it was determined that a multiplicative model for the series should be considered. This model is appropriate "for series of positive values in which the size of the seasonal oscillations increase with the level of the series."¹⁴ The trend component of the series was estimated using a centered 12-month moving average. The series was then detrended and demeaned. Detrending and demeaning the data series of total number of ED visits allowed for the analysis to focus on the possible cyclical and periodic structure in the data. Bartlett Kolmogorov-Smirnov test and Fisher kappa test were used to rule out the possibility that the remaining series was white noise and to confirm that there was a deterministic cyclical, periodic structure in the series. To quantify the strength of seasonality, an autoregressive model was fit on the detrended, demeaned data, and magnitude of the model's

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