Rates of concussions and minor head injuries in Quebec, 2003 and 2016, in children under 18 years old, and comparisons with Ontario's rates of mild traumatic brain injuries

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Abstract

Objectives Increases of mild traumatic brain injuries in children have been reported in the USA and Ontario over the past decade. The main objective of this study is to calculate the pediatric rates of mild traumatic brain injury in Quebec, and our second objective is to compare them with those in Ontario.

Methods Analysts from the Régie de l'Assurance Maladie du Québec (RAMQ, Quebec Health Insurance Board) compiled tables, by age and sex, of all medical services for mild traumatic brain injuries (concussions and minor head injuries) between 2003 and 2016. Quebec's population rates were calculated and yearly graphs were plotted by age and sex.

Results In Quebec, there were statistically significant increases in rates of mild traumatic brain injury (concussion and minor head injury) in older children: a 2.0-fold increase for those aged 13–17 years, and 1.4-fold increase for those aged 9–12 years. When only considering concussions, girls (13–17 years) had more concussions than boys in 2015 and 2016. The increase in the rates of concussion was significantly higher in Ontario than in Quebec: 4.4- vs. 2.2-fold increase.

Conclusions The recent increase in rates of mild traumatic brain injuries reported in the scientific literature has also been observed in Quebec. The fact that the rate of visits for mild traumatic brain injury, per person, remained the same from 2003 to 2016 suggests that the increase was not the result of parents seeking more medical services, but that more of them consulted when their child injured his/her head.

Résumé

Objectifs Des augmentations de taux de traumatismes crâniens (commotions et traumatismes crâniens mineurs) chez les enfants, ont été rapportés aux États-Unis et en Ontario au cours de la dernière décennie. L'objectif principal de cette étude est de calculer les taux de traumatismes crâniens au Québec et comme second objectif, les comparer avec ceux de l'Ontario.

Méthode Les analystes de La Régie de l'Assurance Maladie du Québec ont compilé des tableaux, par groupe d'âge et sexe, de tous les actes médicaux pour un traumatisme crânien, entre 2003 et 2016. Les taux populationnels du Québec ont été calculés par âge et sexe, et présentés sous formes de graphiques.

Résultats Au Québec, il y a eu des augmentations significatives dans les taux de traumatismes crâniens (commotion et traumatisme crânien mineur) chez les enfants de plus de 13 ans : augmentation de 2,0 fois plus chez les 13–17 ans, et de 1,4 chez les 9–12 ans. Depuis 2015 les filles (13–17 ans) ont eu plus de commotions cérébrales que les garçons. L'augmentation des taux de commotions cérébrales fut significativement plus élevée en Ontario qu'au Québec: 4,4 contre 2,2.

Conclusions Comme aux États Unis et en Ontario, les taux de traumatismes crâniens ont aussi augmenté au Québec au cours des dernières années. Le fait que le taux de visites pour traumatismes crâniens, par personne, soit demeuré le même de 2003 à 2016,

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suggère que l'augmentation ne résulte pas d'une augmentation dans les services, mais que plus de parents consultent lorsque leur enfant se blesse à la tête.

Keywords Adolescents · Children · Mild traumatic brain injury · Concussion

Mots-clés Adolescents · Enfants · Traumatismes crâniens mineurs · Commotion

Introduction

The increase in rates of mild traumatic brain injuries (mTBI) over the past decade, particularly in the pediatric population, has been the topic of numerous studies (Bakhos et al. 2010; Centers for Disease Control and Prevention 2013, 2014a; Colvin et al. 2013; Coronado et al. 2015; Gardner and Yaffe 2015; Marin et al. 2014; Taylor et al. 2015; Zonfrillo et al. 2015). In the USA, a recent research on ambulatory care visits in Massachusetts for mTBI (concussion and minor head injury (MHI)) reported a 4-fold increase between 2007 and 2013 (children 6–21y) (Taylor et al. 2015). In another study, Zhang et al. (2016) described how the increase in concussion rates varied between 2007 and 2014 according to the age of the child: no variations in children under 5, a 2.3-fold increase in the 5–9 years old, a 2.9-fold increase in 10–14 years old and 2.2 for the 15–19 years old. However, this study reported a decrease in 2014. The most recent American data, where the health insurance company Blue Cross/Blue Shield of America compared billing data for concussions between 2010 with 2015, reported a 1.7-fold increase in the 10–19 years old and 1.2-fold increase for those under 10, but unlike previous reports, the increase was higher in girls, 2.2-fold increase, than in boys, 1.5-fold increase (Blue Cross Shields 2016).

In Canada, the most recent study (Zemek et al. 2017) calculated the rates of concussions in children 5–18 years old living in Ontario (from 2007 to 2013), using data from the Ontario Health Insurance Plan and the National Ambulatory Care Reporting System. Zemek et al. found that the increases in the number of concussions varied according to age of the child: a 2.3-fold increase for those 5–8 years old a 4.1-fold increase for those 9–12 years old and a 5.0-fold increase for those 13–18 years old.

Epidemiological studies of mTBI are often biased by a lack of clear definition for mTBI. Ever since Rimel et al. (1981) redefined the severity of mTBI in 1981, the terminology to describe injuries to the head has come to include head injury, minor head injury, mild traumatic brain injury, and concussion (including mild, moderate, and severe concussion). These variations led the World Health Organization to create a task force on mTBI in 2004 (Carroll et al. 2004), but to this day, there is no clear consensus on the definition of mTBI, nor is there consensus on how to assess the severity of mTBI (Centers for Disease Control and Prevention 2014b; McCrory et al. 2013; Moscote-Salazar 2016; Peeters et al. 2015; Tator 2013). Specialists keep insisting on the need for improved standardization because of wide variations between studies (Brazinova et al. 2016; Chan et al. 2015;

Roozenbeek et al. 2013). Kristman et al. (2014) sum up the problem in saying: “the accuracy of coding mTBI in an emergency setting is likely low because of many factors, including the lack of a universal definition.”

In Quebec, Kostylova et al. (2005) showed that relying only on the ICD-9 concussion code of 850 greatly underestimated the rate of concussions diagnosed by physicians, or their coders, to the Régie de l'Assurance Maladie du Québec (RAMQ) since they often used other diagnosis codes instead of 850 when billing for mTBIs (concussions or MHI). As an example, Kostylova describes a high frequency of non-specific diagnosis codes in physician billings, like cases that were billed for “multiple unspecified wound or trauma,” that were classified by the Canadian Hospitals Injury Reporting and Prevention Program (Mackenzie and Pless 1999) as a mTBI.

Our first objective was to calculate the rates of mTBI (concussion and MHI) in Quebec in children under 18 years old, between 2003 and 2016, using data from RAMQ (Ministère de la santé du Québec 2017a), an organization within Quebec's Health Ministry that administers the public health, the prescription drug insurance plan, and the reimbursement of health professionals. Our second goal was to compare the Quebec rates with those in Ontario to assess if there were differences, as research from the USA already showed wide variations in the increases of mTBI between studies.

Methods

For each patient's visit, the physician submits a billing claim to RAMQ using a specific code for the medical service and one for the diagnosis. RAMQ collects information regarding all medical services performed on the province's population of eight million residents with the exception of those not eligible to RAMQ, such as a child born to parents who are in Quebec as tourists or born in Quebec to a foreign student not covered by a social security agreement (Ministère de la Santé du Québec 2017b). RAMQ's administrative database contains data on diagnosis, according to ICD-9 coding, that physicians have the option to include on their claims, for both inpatients and outpatients. Claims with missing data (that did not include an ICD-9 diagnosis) are rare, occurring in less than 0.1%.¹

¹ As calculated by RAMQ analysts.

Analysts from RAMQ compiled two tables: one for concussions (ICD-9: 850) and one for MHI (ICD-9: 854), providing the total numbers of medical services filled for each diagnosis by year, and further broken down by age group (0–4 years, 5–8 years, 9–12 years, and 13–17 years) and gender.

Statistical Analysis

Results are presented as yearly rates of concussions and MHI using the corresponding Quebec population for each group (sex and age) as denominators, provided by l'Institut de la Statistique du Québec (2017) which compiles results from the Registre des Événements Démographiques du Québec. All results are presented as figures. Trend analysis for yearly variations was performed using Kendall Tau-b correlation test.

Results

Quebec

In Quebec, between 2003 and 2016, a total of 354,497 mTBI (concussion and MHI) were diagnosed by physicians, for patients under 18 years of age. Statistically significant increases between 2008 and 2014 were only present in the two oldest groups: a 2.0-fold increase for those aged 13–17 years old ($KT, p < 0.018$) and 1.4-fold increase for those 9–12 years ($KT, p < 0.011$). For children under 13, mTBI rates have been decreasing since 2014. The youngest, 0–4 years old, always had the highest rates but as of 2016 it was the oldest group, 13–17 years old, which had the highest rates (Fig. 1).

The variations in rates were different according to the diagnosis. For the two older groups, 9–12 years old and 13–17 years old,

concussions (Fig. 2) followed the same trends: a slow decline from 2003 to 2009, then a sharp and statistically significant increase ($KT, p < 0.015$) from 2010 to 2014 (2.4-fold increase (95% CI [2.02–2.76]) for the 13–17y and 2.6 (95% CI [2.7–3.23]) for the 9–12y.) One common trend between all age groups is that the concussion rates increases peaked in 2014 and began to decrease afterwards. For MHI (Fig. 3), there was only one statistically significant trend: a 1.9-fold increase (95% CI [1.75–2.05]) between 2008 and 2016 for those aged 13–17 years. If concussion rates increased with age it was not the case for MHI where the youngest children, 0–4 years old, had nearly twice the rate of MHI than the older groups.

Gender also played a role (Fig. 4). Boys had higher mTBI rates than girls for all age groups except for those 13–17 years old. The gap in mTBI rates between boys and girls slowly disappeared over the years. If in 2003 boys had twice the concussion rates of girls, the rates were the same for both genders by 2014, and by 2015, girls were at 1.09 per 100,000 more concussions than boys.

Concussions and MHI rates varied according to where they were diagnosed. For children treated in emergencies, the proportions of mTBI diagnosed as MHI increased over the years, and consequently, the proportions of mTBI diagnosed as concussions decreased. It was the reverse for physicians working in private offices, clinics, or CLSC (Centre Local de Services Communautaires) who diagnosed more concussions over the years, and less MHI (Fig. 5).

Quebec vs. Ontario

Rates of mTBI increased in both provinces. While rates fluctuated between 2003 and 2007, they were identical by 2008. From 2008 onward, the increases were significant for both

Fig. 1 Rates of mild traumatic brain injury-related visits to physicians (concussion and minor head injury), by age group, in Quebec

Fig. 2 Rates of concussion-related visit to physicians, by age group, in Quebec

provinces, but more notable in Ontario, 2.2-fold increase, compared to 1.4 in Quebec (Fig. 6).

When separating concussions and MHI, results showed that the differences between both provinces were more pronounced. There was a 4.4-fold increase in concussion rates in Ontario (2003 to 2013), while in Quebec, concussion rates steadily decreased from 2003 to 2009 and then increased by 2.2-fold from 2010 to 2014 (Fig. 7). However, for MHI, the situation is reversed. In Quebec, MHI rates were always higher than in Ontario, and increased by 1.3-fold (2003 to 2014), while in Ontario, there was a 1.2-fold decrease for the same period (Fig. 8).

Discussion

Quebec

The recent increase in pediatric rates of mTBI (concussions and MHI) in the USA (Bakhos et al. 2010; Centers for Disease Control and Prevention 2013, 2014a; Colvin et al. 2013; Coronado et al. 2015; Gardner and Yaffe 2015; Marin et al. 2014; Taylor et al. 2015; Zonfrillo et al. 2015) and Ontario (Zemek et al. 2017) has also occurred in the province of Quebec. Between 2010 and 2014, the rates of concussions diagnosed by physicians in Quebec increased by 2.4-fold for those 9–12 years old, and 2.6 for those 13–17 years old. By 2015, the concussion rates began decreasing for all age groups. Unlike concussions, the increase in MHI rates was only present for the oldest group: those aged 13–17 years old had a 1.9-fold increase between 2008 and 2016.

Gender in particular was an important factor. Our data showed that for the oldest group, those aged 13–17 years old, the gap between mTBI rates closed over the years, and even reversed. If in 2003, 2.9 per 100,000 more boys suffered an mTBI than girls, in 2016 girls had 1.1 per 100,000 more mTBI. Other studies have also reported on a higher increase in mTBI for girls compared to boys. Taylor et al. (Taylor et al. 2015) reported that the proportions of mTBI in girls (aged 6–21 years old) increased from 35 to 42% between 2007 and 2013. Data from a high-volume interprofessional concussion clinic² also noticed this shift, where 36% of all outside visits for patients 13–17 years old were for girls in 2009, and in 2016, this proportion climbed to 67%. Already in 2012, the *American Medical Society for Sports Medicine* reported that “in sports with similar playing rules, the reported incidence of concussion is higher in female athletes than in male athletes” (Harmon et al. 2013).

Several factors could explain the increase in mTBI rates observed in Quebec. As others pointed out, the recent focus, whether by the media (Keays and Pless 2010; Mannix et al. 2016; Schlosser 2016), governments (Birchard 2014; Caron et al. 2015; LaRoche et al. 2016; Lowrey and Morain 2014), medical organizations (Wolfe 2015; Zemek et al. 2014a, b), or sports organizations (Fainaru-Wada and Fainaru 2013; Greenhow and East 2015; Pabian et al. 2017), on the danger of mTBI may have encouraged more parents, schools, coaches, and others, to consult when a child hit his/her head. Where the visit took place, ED vs. private office was also a factor. Our data showed that, over the years, ED physicians diagnosed fewer concussions and more MHI, while physicians from private offices, or CLSC, diagnosed more

² Statistics from The Montreal Children’s Hospital Trauma Centre

Fig. 3 Rates of minor head injury-related visit to physicians, by age group, in Quebec

concussions and fewer MHI. It is difficult to venture an explanation as to why ED physicians and those from private clinics tend to prefer one diagnosis, but it may have to do with teaching and special training as ED physicians will often benefit from their associations with teaching hospitals and thus be more aware of the most recent diagnostic tools regarding concussions and MHI.

Quebec vs. Ontario

Ontario's concussion rates were different than Quebec's. Not only were they twice as high in 2003, but by 2013, they were

eight times those of Quebec. While there was an increase in Quebec's concussion rates, it was significantly less than that reported by Zemek et al. (2017). On the other hand, MHI rates were always highest in Quebec compared to Ontario. In addition, where Ontario saw a decrease in MHI rates between 2003 and 2013, Quebec's MHI rates increased. This alludes to a discrepancy between both provinces regarding the diagnosis of concussions vs. MHI. When combining both concussion and MHI diagnosis, mTBI rates were similar between both provinces from 2003 to 2008. The differences increased in 2011, and by 2013, mTBI rates were 1.6 times higher in Ontario than in Quebec. We do not have a definitive

Fig. 4 Rates of concussion and minor head injury (MHI)-related visits to physicians, by gender, for children aged 13 to 17 years old, in Quebec

Fig. 5 Proportions of concussion and minor head injury-related visits by setting (emergencies vs. private offices, clinics, CLSC*) in Quebec

explanation as to why physicians operating under very similar health care systems would favour one diagnosis (concussions for Ontario) over another one (MHI in Quebec). Because both pediatric populations are likely the same, we do not believe it is a question of Ontario children suffering more head injuries than Quebec children. In fact, from 2003 to 2008, the mTBI rates were the same for both populations. One possible explanation is that the interest in concussions (media, sports federations, medical associations) may have had a stronger impact in Ontario, and encouraged more Ontario parents to consult a doctor when their child hit her/his head. One study (Keays and Pless 2010) that would support this hypothesis

looked at the spike in mTBI-related ED visits, in Montreal, following the death of actress Natasha Richardson in 2009 after she hit her head in a ski accident. The authors reported that the increase was greater at the English pediatric hospital than at the French one.

Limitations

The main limitation of this study, and one that is common in studies using administrative data, is that the data used to derive the presented rates consisted of medical services (billing codes) with attached diagnosis ICD-9 codes 850 and 854,

Fig. 6 Rates of mild traumatic brain injury-related visits to physicians (concussions and minor head injury) in Quebec and in Ontario

Fig. 7 Rates of concussion-related visits to physicians in Quebec and in Ontario

which may not equate to a single mTBI for each billing code. In some cases, for the same injury, patients/parents will consult more than once, resulting in multiple billings with an mTBI diagnosis. In Quebec, every year from 2003 to 2016, for each patient with an mTBI diagnosis, physicians billed an average of 1.7 medical services to the RAMQ (either the patient came back for another mTBI or consulted more than once for the same mTBI). This suggests that the Quebec data overestimate the true mTBI rates by 1.7 times. The Ontario (Zemek et al. 2017) and American studies (Taylor et al. 2015; Zhang et al. 2016; Blue Cross Shields 2016) also

reported on the rates of visits for an mTBI and not actual mTBI rates.

It is difficult to determine the degree of overestimation as some children will have more than one head injury during the year. As an example, a study (Swaine et al. 2007) that used RAMQ data in 2004 determined that 6.6% (or 1.1 times) of patients 0–17 years of age, who consulted for a mTBI, consulted for a new mTBI within a year. From a local perspective, using emergency data from the CHIRPP Montreal Children's Hospital, we determined that 21% of patients who consulted for an mTBI came back to the emergency for the same

Fig. 8 Rates of minor head injury-related visits to physicians in Quebec and in Ontario

mTBI (either because of follow-up or out of concern) within 2 months. The Ontario study (Zemek et al. 2017) was able to eliminate patients with multiple medical services for a concussion within the same day, which only accounted for 0.6% of all concussion-related visits, because they had access to the data, but every follow-up visit where the physician used a mTBI code was included when calculating the population rate, a bias that other studies shared (Marin et al. 2014; Zonfrillo et al. 2015; Blue Cross Shields 2016) because of the underlying problem of using diagnosis codes data, which makes it impossible to differentiate between the index visit, and whether a subsequent visit is for the same injury or a new one.

The type of health care facility where the physician works also introduced a bias when determining mTBI rates in Quebec and, to some extent, in the Ontario study (Zemek et al. 2017) and American one (Taylor et al. 2015). The latter two studies found variations in the proportions of concussions diagnosed in emergency settings, vs. private offices, over the years. There is also the question of physicians who did not use diagnosis codes for concussions, or MHI, when seeing children who hit their heads. Kostylova et al. (2005), who worked with RAMQ data in 2001, noted that 12% of ED physicians working at either pediatric hospital in Montreal, who wrote an mTBI diagnosis (concussion or MHI) on the emergency report, used other CIM-9 codes besides 850 (concussion) and 854 (MHI) when filling RAMQ claims.

Conclusions

The recent increase in mTBI rates in the pediatric population reported in the scientific literature, and in the media, was also observed in Quebec. The increase of mTBI in Quebec peaked in 2014 and has declined in 2015 and 2016. The increase in mTBI rates was most pronounced in girls (aged 13–17 years old), who, by 2015, suffered more mTBI than boys. The consistency of the number of medical services with an mTBI diagnosis over the years (always around 1.7 medical services per person regardless of the year) indicates that the increase in Quebec was not caused by patients/parents using more health services for these types of injuries, but that more parents/patients consult for an injury to the head. More research is needed to determine if the increase is artificial, i.e., brought on by increased awareness in the public, governments or health authorities, or whether reports from trauma centres and the medical community are real and that more children injure their heads than ever before.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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