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Original Article

Medical Care Among Individuals with a Concussion in Ontario: A Population-based Study

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ABSTRACT: ***Background:*** Concussion affects 1.2% of the population annually; rural regions and children have higher rates of concussion. ***Methods:*** Using administrative health care linked databases, all residents of Ontario with a physician diagnosed concussion were identified using ICD-9 code 850 or ICD-10 code S06. Cases were tracked for 2 years for concussion-related health care utilization with relevant specialist physicians (i.e., neurology, otolaryngology, physiatry, psychiatry, ophthalmology). Billing codes, specialist codes, and time from index to visit were analyzed. Factors associated with increased specialist visits were also examined. ***Results:*** In total, 1,022,588 cases were identified between 2008 and 2014 with 2 years of post-concussion health care utilization available. Follow-up by physician within 3 days of injury occurred in only 14% of cases. Mean time between ED diagnosis and follow-up by a physician was 83.9 days, whereas for rural regions it was >100 days. About half of adults (51.9%) and children (50.3%) had at least 1 specialist visit following concussion. Mean time between injury and first specialist visit was 203.8 (SD 192.9) days for adults, 213.5 (SD 201.0) days for rural adults, and 276.0 (SD 202.6) days for children. There were 67,420 neurology visits, 70,404 psychiatry visits, 13,571 neurosurgery visits, 19,780 physiatry visits, 101,788 ENT visits, and 103,417 ophthalmology visits in the 2 years tracking period. Factors associated with more specialist use included age > 18 years, urban residence, and pre-injury psychiatric history. ***Conclusions:*** There are discrepancies in post-concussion health care utilization based on age group and rural/urban residence. Addressing these risk factors could improve concussion care access.

RÉSUMÉ : L'utilisation des soins médicaux après une commotion cérébrale, en Ontario : étude fondée sur la population. ***Contexte :*** Les commotions cérébrales frappent chaque année 1,2 % de la population, plus particulièrement en milieu rural et chez les enfants. ***Méthode :*** Une recherche à l'aide de bases de données administratives liées sur la prestation des soins de santé a permis de repérer tous les patients demeurant en Ontario chez qui un diagnostic de commotion, correspondant aux codes 850 selon l'ICM9 ou S06 selon l'ICM10, a été posé par un médecin. Les cas ont fait l'objet d'un suivi de 2 ans quant à l'utilisation des soins de santé en lien avec la commotion chez des spécialistes dans des domaines appropriés (c.-à-d. neurologie, otorhinolaryngologie [ORL], physiatrie, psychiatrie, ophtalmologie). Il y a eu analyse des codes de facturation, des codes de spécialité et du temps écoulé entre le moment de l'accident et la consultation, de même que des facteurs associés à un nombre accru de consultations chez des spécialistes. ***Résultats :*** Il existait des données de suivi sur l'utilisation des soins de santé après une commotion, sur la période de 2 ans, dans 1 022 588 cas, entre 2008 et 2014. Un suivi médical a été réalisé dans les 3 jours suivant l'accident dans 14 % des cas seulement. Le temps moyen écoulé entre le moment de la pose du diagnostic au service des urgences et le suivi médical était de 83,9 jours; en milieu rural, il était supérieur à 100 jours. Après la commotion, environ la moitié des adultes (51,9 %) et la moitié des enfants (50,3 %) ont consulté un spécialiste au moins une fois. Quant au temps moyen écoulé entre le moment de l'accident et la première consultation d'un spécialiste, il était de 203,8 jours (écart type [σ] : 192,9) chez les adultes; de 213,5 jours (σ : 201,0) chez les adultes en milieu rural et de 276,0 jours (σ : 202,6) chez les enfants. Ont été relevées dans l'ensemble 67 420 consultations en neurologie; 70 404, en psychiatrie; 13 571, en neurochirurgie; 19 780, en physiatrie; 101 788, en ORL et 103 417, en ophtalmologie, sur la période de suivi de 2 ans. Parmi les facteurs associés à un nombre plus élevé de consultations de spécialistes figuraient un âge supérieur à 18 ans, le milieu de vie urbain et des antécédents de troubles psychiatriques avant la survenue de l'accident. ***Conclusion :*** Des écarts ont été relevés entre l'utilisation des soins de santé après une commotion et les tranches d'âge ainsi que les milieux de vie urbain et rural. Le fait de porter une attention particulière à ces facteurs de risque pourrait faciliter l'accès aux soins de santé après une commotion.

Keywords: Concussion; Pediatric concussion; Adult concussion; Administrative health data; Health system analysis; Rural-urban linkages

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Introduction

Concussions are common injuries that affect 1.2% of the population in Ontario, Canada, annually.[1] The most common mechanisms of injury are falls, motor vehicle collisions (MVCs), and sports-related concussions.[2] Children, particularly those in early childhood (0–4 years), and adults over the age of 60 are at the highest risk for concussion and the rate of diagnosed concussions have been increasing every year.[1,3–5]

It has been demonstrated that earlier access to clinical care is associated with faster recovery after concussion.[6] A recommendation of follow-up by primary care physicians within 72 hours of diagnosis has been established to monitor for more severe injuries that were not at first recognized. There is also need for acute concussion management such as injury education and treatment of post-traumatic headaches, cervicogenic injuries, and sleep disturbances.[7] Most concussions resolve within three months of injury; however, between 10 and 20% of adults[8–10] and 30–40% of pediatrics[11] with concussion continue to experience prolonged symptoms that may require additional specialized care. Traumatic brain injuries (TBIs) are estimated to cost the Ontario health care system $120.7 million per year,[12] but this estimate includes both concussions and moderate/severe TBIs.

The patterns of health care utilization following concussion are not as well understood as moderate and severe injuries, and system-wide analysis of post-concussion health care usage has not been undertaken at a population-based level using administrative health records. Other studies investigating health care utilization following a concussion are typically restricted to adults or only those diagnosed at trauma centers such as the TRACK-TBI cohort.[13,14] or are smaller scale cohorts.[15] The objective of this study was to describe and compare the patterns of health care utilization following a concussion, based upon age, sex, geographical region of Ontario, and rural indication, and determine any factors associated with specialized health care usage. We hypothesize that pediatric cases and rural residing residents will have reduced access to specialized health care following concussion and have greater delays in accessing appropriate health care because previous research have identified issues around timely access to health care for rural residents of Ontario, fewer specialists that focus on pediatric patients, and the lack of knowledge about concussion in children.

Methods

Ethics Statement

This study was approved by the Research Ethics Board at the University Health Network (ID# 15-9532). Consent to use the administrative health records housed at ICES (formerly known as the Institute for Clinical Evaluative Sciences) was waived, as ICES is a prescribed entity under section 45 of Ontario's Personal Health Information Protection Act. Section 45 authorizes ICES to collect personal health information, without consent, for the purpose of analysis or compiling statistical information with respect to the management of, evaluation or monitoring of, the allocation of resources to or planning for all or part of the health system. ICES is an independent, non-profit research institute funded by an annual grant from the Ontario Ministry of Health and the Ontario Ministry of Long-Term Care.

Setting and Study Design

Health care data for more than 13 million residents[16] of Ontario, Canada's most populous province, can be tracked through their unique Ontario Health Insurance Plan (OHIP) number. By linking administrative health databases at ICES, cohorts can be created using diagnostic codes and health care utilization (e.g., doctor visits, emergency department visits, hospitalizations, etc.) can be tracked for the entire province's population. Ontario was stratified into 14 administrative health regions called Local Health Integration Networks (LHINs) (Supplemental Figure 1).

Data Sources

Records for concussion were identified in the data through the use of the (1) National Ambulatory Care Reporting System (NACRS), for cases diagnosed in an emergency department (ED) using ICD-10 diagnostic codes (S06) and the (2) Ontario Health Insurance Plan (OHIP) Physician Billing Database, for records containing diagnoses given by a primary care physician using ICD-9 diagnostic codes (850). NACRS contains data for all hospital-based ambulatory visits such as ED visits and tracks most responsible diagnosis or reason for seeking ambulatory medical care. The OHIP is a taxpayer funded health insurance plan for all eligible residents of Ontario. Physicians, laboratories, and diagnostic facilities submit the patient's OHIP identifier, type of visit, diagnosis, test(s) performed, etc. to OHIP to receive payment. All subsequent physician visits for the concussion were identified and linked using the individuals' unique OHIP identifier and abstracted from the OHIP Physician Billing Database. The premorbid health retrospective review for each individual five years prior to the concussion was conducted using the relevant ICD-9 diagnostic codes (S1 Table Premorbid Health Conditions Diagnostic Codes) in the OHIP Physician Billing Database as well as the Ontario Mental Health Reporting System (OMHRS) database for psychiatric hospital admissions. Demographic data were abstracted from the Registered Persons Database (RPDB), which contains demographic information such as sex, age, and postal code, for all residents of Ontario with a valid OHIP card. Data were then anonymized and data sets were linked using unique encoded identifiers at ICES. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario. All data were reported in aggregate, and cells with less than six were suppressed, as per ICES Privacy Policy.

Ontario Concussion Cohort Creation

As previously published,[1] all residents of Ontario with a physician diagnosed concussion between 2008 and 2016 were identified. Duplicate records, such as those with identical variables or multiple records with the same diagnostic billing code per person per physician per day (only one record was counted), were removed. Records were excluded if there were incomplete demographic data, the individual was not a resident of Ontario, age was greater than 105 years, or if a date of death was listed before the index event date (the date recorded by the physician at the initial point of access to the health care system associated with concussion diagnosis code). There was a 365-day washout period for previous traumatic brain injury diagnosis by either primary care or ED to ensure the cohort would not have duplication of identified index cases. To ensure cohort data contained only mild traumatic brain injuries (mTBIs), records of anyone with admission to hospital or death within 30 days of the index event were excluded. This

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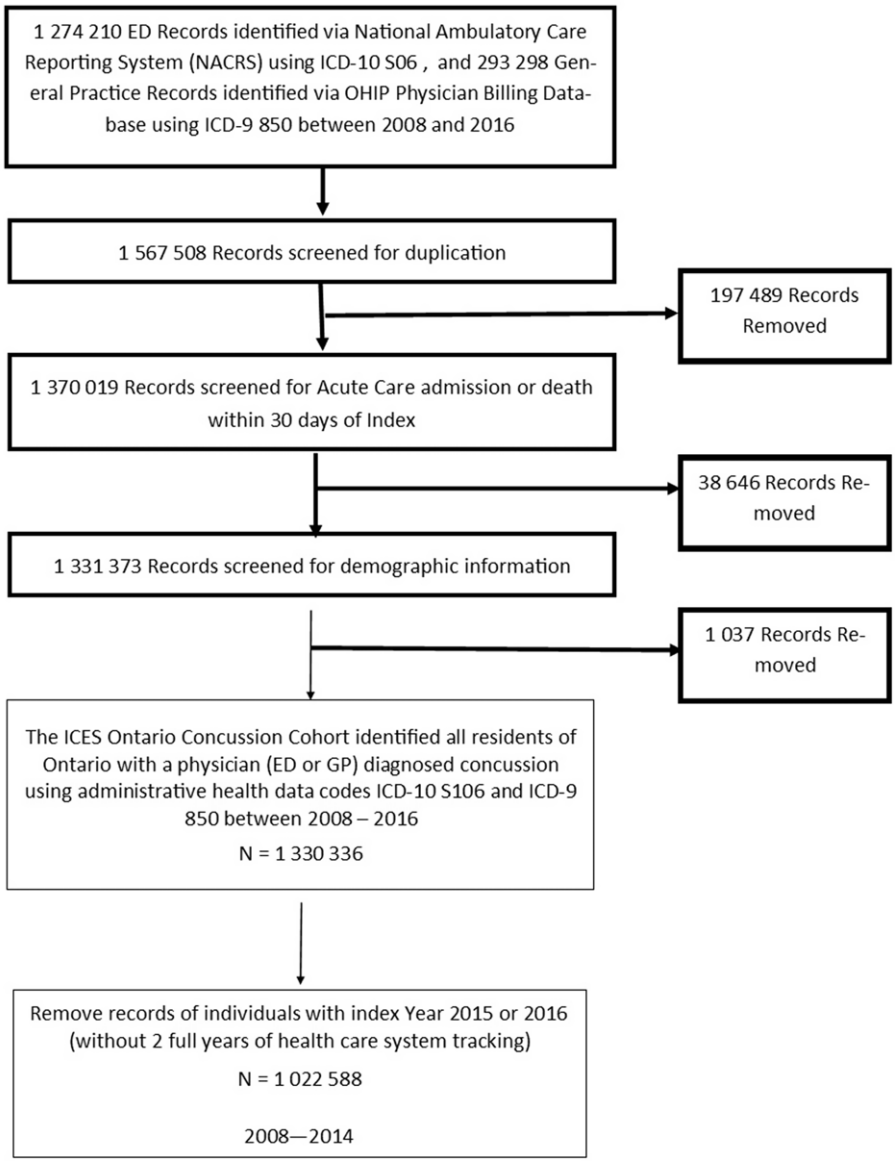

Figure 1: Cohort creation.

concussion cohort was tracked for two years after their index date of injury (first date of diagnosis was coded) using their unique OHIP identifier for concussion related follow up care in the OHIP Physician Billing Database. Specialists, identified via their OHIP Specialty Code identifier, that were included for providing relevant concussion care were: neurosurgery, neurology, physical medicine/physiatry, otolaryngology, ophthalmology, and psychiatry. Data for the 5 year retrospective analysis were abstracted from the OHIP Physician Billing Database and OMHRS. Due to delay in OHIP reporting to ICES, records with index date in 2015 and 2016 did not have follow-up health care usage data available (Figure 1).

Variables Collected

Concussion-related health care was tracked for two years following index date. Variables collected included time between the date for the index concussion (index date) and follow-up by primary care physician, number of relevant specialist (neurology, neurosurgery, physiatry, psychiatry, ophthalmology, otolaryngology, or ENT) visits, time between index date and first visit with a relevant specialist, number of visits by specialist type per record and time between index date and first visit with the specialist physician, diagnosis code for visits, visit fee code, and codes for tests performed or ordered. Demographic information was also collected including age group at time of injury, sex, administrative health care region of Ontario, the individual resided in, and whether the address was classified as rural or not. Variables for factors associated with requiring additional health care for concussion management by a particular type of specialist included demographic variables as well as pre-injury health care system utilization and pre-morbid health conditions. Co-morbid diagnoses of interest were selected based on a literature review of predictive factors for prolonged concussion recovery and included: depression and anxiety, personality disorders, bipolar disorder, schizophrenia, substance abuse disorders, migraine, headache without migraine, sleep disorders, pain disorders, neurological disorders (i.e., multiple sclerosis, dementia, stroke, etc.), vestibular disorders

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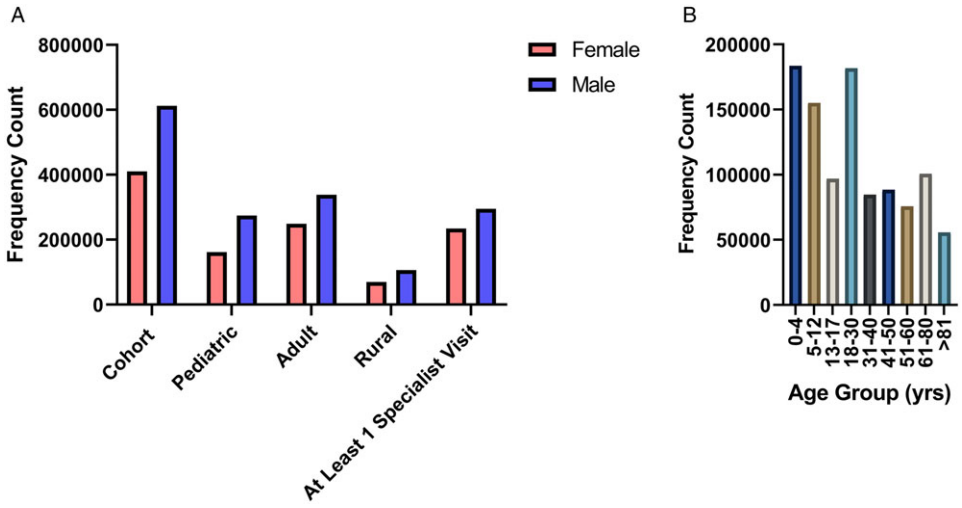

Figure 2: **(a)** The number of males and females in the total cohort, pediatric (under 18 years) cases, adult (18 years and over), by rural indicator index, and with at least 1 specialist visit in the 2 year follow-up period after index date. **(b)** Age group distribution of Concussion Cohort.

(i.e., ataxia, gait disorders, dizziness not caused by a primary disease like hypotension or a neurological disorder), temporomandibular joint (TMJ) disorders, and prior traumatic brain injuries (TBI).[9,10]

Statistical Analyses

All statistics were performed using SAS 9.4 (SAS Institute, North Carolina, USA) for Windows. Descriptive statistics examined the percentage of patients with follow-up by a primary care physician following index date and time between index date and date of follow-up with primary care physician, the number of specialist visits and time between index date and date of first specialist visit, and specialty specific number of visits and time between index date and first specialist visit. Group comparisons of pediatric and adult records, sex differences, rural-non rural records of pediatric and adult patients, and administrative health care region of Ontario where health care was accessed were analyzed via chi squares, t-tests, and ANOVA for parametric data and Wilcox Mann-Whitney tests for non-parametric data. Kurtosis was assessed in continuous variables. Alpha was set a priori at 0.01 for group comparisons. A Spearman correlation was performed to determine the relationship between the number of specialist visits and the time between index date and follow-up by primary care physician. Least absolute shrinkage and selection operator (LASSO) analysis, a regression modeling technique that performs subset selection and reduces overfitting, was used to select variable associated with above average specialist health care utilization following concussion.

Results

Cohort Creation

The records of 1,567,508 individuals were initially identified between 2008 and 2016. A total of 197,489 duplicate records were excluded and 39,683 records were excluded for insufficient demographic data or potentially more severe injuries. The Ontario Concussion Cohort totaled 1,330,036 cases between 2008 and 2016. The cohort was further restricted to records identified between 2008 and 2014 (1,022,588 cases) as cases diagnosed between 2015 and 2105 did not have two years of complete health care tracking post-injury data available. There were 410,140 (40.1%) females and 612,448 (59.9%) males in the cohort (Figure 2a). The mean age of the cohort was 30 years (SD 25.8) and 435,531 (42.6%) of cases were pediatric cases (under 18 years of age) (Figure 2b). There were 137,710 (13.5%) records of rural-residing residents in the cohort, 58,238 (42.2%) were rural pediatric cases.

Primary Care Follow-up

Fewer than 14% (139,357) of patients were seen by a primary care physician within 3 days of index injury. Within one-year of injury, over 95% (980,380) were seen by a primary care physician. The mean time between index date and primary care follow-up was 83.9 days (SD 123.3) and a median of 25 days (IQR 6–105). (Figure 3) For non-rural residing adults, the mean time between index and follow-up was 74.9 (SD 126.9) days and a median of 16 days (IQR 5–89). Children with concussion residing in more urban areas had a mean of 90.0 days (SD 131.0) and a median of 36 days (IQR 7–125). Residents in rural-classified parts of the province had significantly longer mean follow-up times ($p < 0.0001$) than those not residing in rural areas with mean follow-up of 107.9 (SD 150.9) days (adults 95.7 days, SD 145.2 and children 124.6 days, SD 156.9) and a median follow-up time of 39 days (IQR 7–145) (28 days IQR 7–120 for adults, 59 days IQR 11–177 for children). Children also had significantly longer time between index date and primary care follow-up compared to adults in both rural and non-rural areas ($p < 0.0001$).

Follow-up by Specialist Physician

In two years of health care tracking following injury, 51.9% of adults (304,683) and 50.3 % (233,427) of children (<18 y-o) were referred for at least one specialist visit for their concussion (Table 1, Figure 4a). The mean number of specialist visits was 4.6 (SD 9.2) (Figure 5b) and a median of 2 visits for those who were referred for specialized care after their concussion; the mean time between index and first specialist visit was 203.8 (SD 192.9) days for adults median 135 days (IQR 40–323), 213.5 (SD 201.0) days for rural adults (median 152 IQR 48–335), 202.3 days (SD 197.0) for non-rural adults (median 133 days IQR 39–321) ($p < 0.001$ between rural and non-rural adults). Children had a mean wait time of 276.0 days (SD 202.6) and a median of 242 days (IQR 98–424) to see a specialist after index date with no difference ($p = 0.21$) between rural (277.3 days SD 202.2, median 244 days IQR 102–421) and non-rural (275.8 days SD 204.3, median 242

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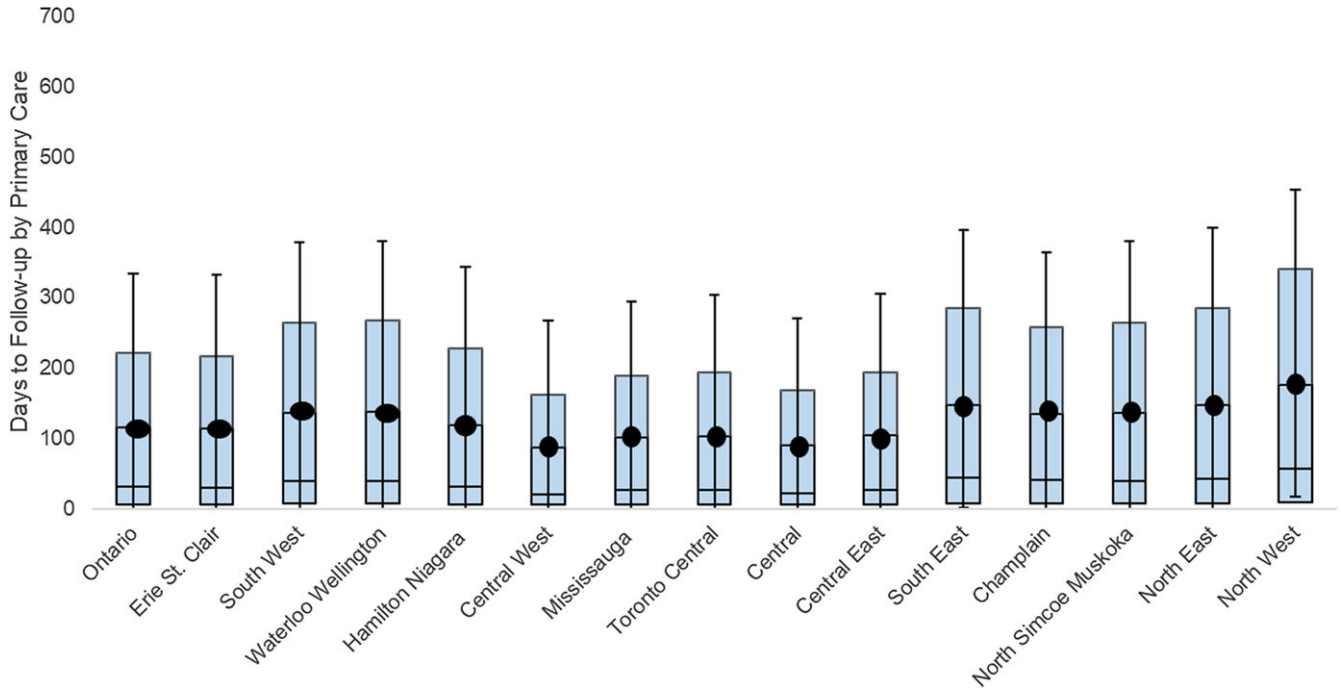

Figure 3: Box and whiskers plot showing interquartile range, median, and mean time in days between index date and follow-up by primary care physician for Ontario Canada and each Local Health Integration Network (LHIN).

days IQR 97–425) children. Ophthalmologists were the earliest specialists seen regardless of rural status for adults, both males and females overall; pediatric patients had the shortest time between index date and first visit for neurosurgery consults. Neurology consults were common for all groups and had the second shortest interval between index date and first visit. Physiatry had the longest interval between index date and first visit for all analyzed groups and only accounted for approximately 4% of specialist seen.

A total of 234,174 females (57.1%) had at least one specialist visit in the two years following their concussion; 295,177 males (48.2%) had at least one specialist visit in the two-year follow-up period ($p < 0.0001$) (Figure 4c). Females had significantly faster ($p < 0.0001$) access to specialist appointments than males and significantly more ($p < 0.0001$) specialist visits than males (Table 1).

There was a weak though significant ($p < 0.0001$) negative relationship between the number of days between index date and follow-up with primary care physician and the number of specialist visits (rho = −0.12, unadjusted r^2 0.0073) suggesting longer wait for initial visit was associated with fewer special visits.

Neurology Follow-up

There were a total of 67,420 records with neurology visits with a mean of 2.6 (SD 3.7) visits per person. The mean time between index date and first neurologist visit was 254.7 days (SD 213.9) and a median of 194 days (IQR 66–418). There were 10,307 (15.2%) pediatric cases (Figure 5) that required concussion-related health care from a neurologist and 22,585 (33.5%) people over the age of 61 sought a neurologist for their concussion related symptoms. An almost equal number of males and females (49.6% female, 50.4% male) saw a neurologist following their concussion. 6260 (9.3%) of neurology visits were for rural residing individuals. Males had a shorter time period between index date and first neurologist visits than females ($p = 0.0005$). Rural residing individuals also had a longer time between index date and first neurologist visit ($p < 0.0001$). There were also significant differences ($p < 0.0001$) in the time between index date and first neurology visit for the different age groups (Supplemental Figure 2). There were no sex differences in the number of visits per person ($p = 0.57$) and though there was a statistically significant difference ($p < 0.0001$) between rural and non-rural patients. Patients under 18 years of age had significantly fewer ($p < 0.0001$) visits than adults.

Neurosurgery Follow-up

A total of 13,571 individuals required at least one neurosurgery visit in the two years following their concussion with a mean of 3.1 (SD 5.5) visits per person. The average time between index date and first neurosurgery visit was 251.2 days (SD 220.0) median 186 days (IQR 51–425). Of those, 2500 (18.4%) were for patients under 18 years. Pediatric patients also had significantly faster times between index date and first visit with a neurosurgeon than adults ($p < 0.0001$). There were 1532 (11.3%) rural-residing individuals that had a follow up with a neurosurgeon and had a longer time between index and first visit than non-rural residents ($p = 0.0002$). There were 5,907 (43.5%) females that required neurosurgery follow-up for their concussion and no sex differences in the wait time for a consult ($p = 0.027$). Males had significantly more neurosurgery visits than females ($p = 0.008$) and there was a significant effect ($p < 0.0001$) of age group on the number of visits with a neurosurgeon post-concussion. There was no difference in the number of visits based upon rural indicator ($p = 0.92$).

Psychiatry Follow-up

There were 70,404 individuals with psychiatry visits and a mean of 9.5 (SD 19.3) visits per person and a mean of 244.5 days (SD 220.7)

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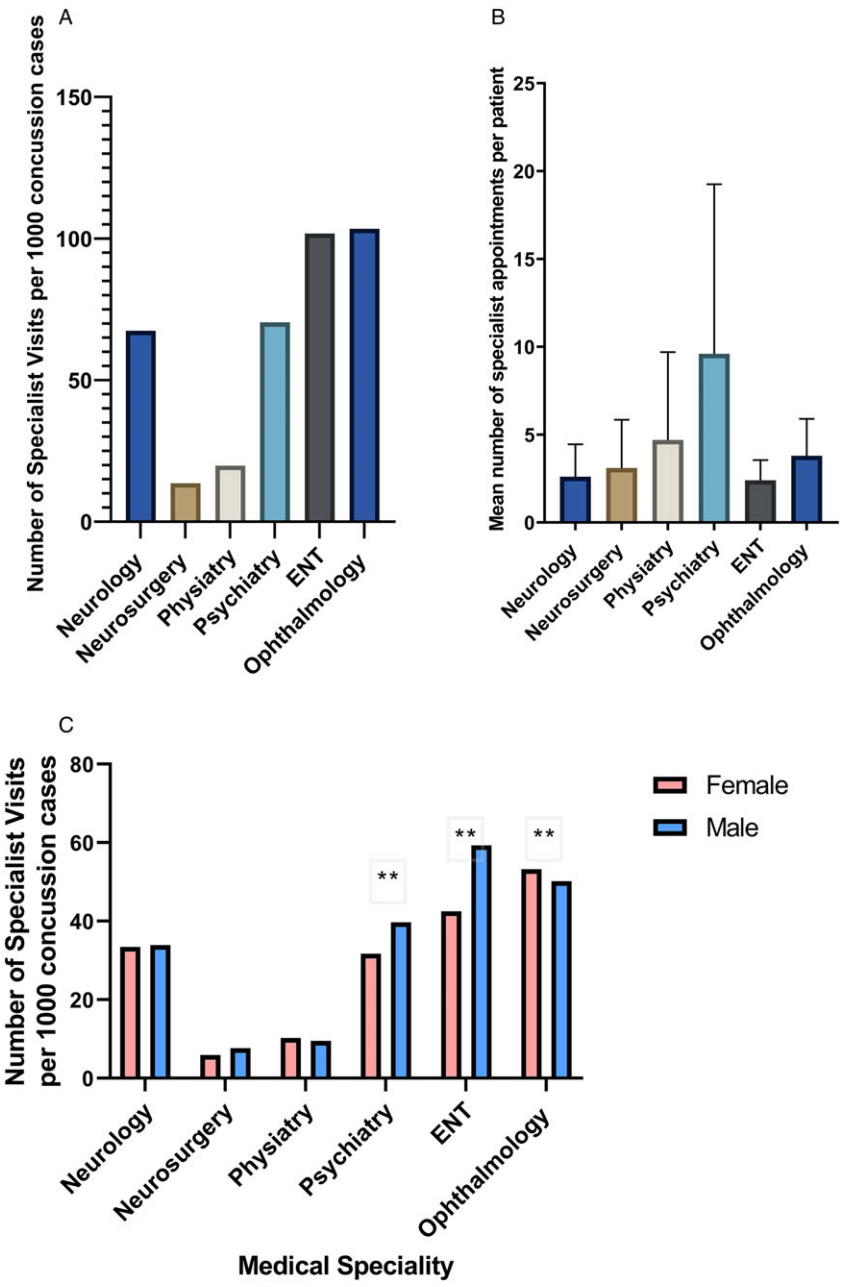

Figure 4: **(a)** Number of tracked visits 2 years following concussion by specialty physician type per 1000 concussion cases. PM&R = Physical medicine and rehabilitation/ physiatry. ENT = Ear, nose, and throat surgeon/ otolaryngology. **(b)** The mean number of visits per patient for each specialty physician type in the 2 years following concussion. ENT = Ear, nose, and throat surgeon/ otolaryngology. **(c)** Number of visits by specialty per 1000 concussion cases by sex. ENT = Ear, nose, and throat surgeon/ otolaryngology. ** $p < 0.0001$.

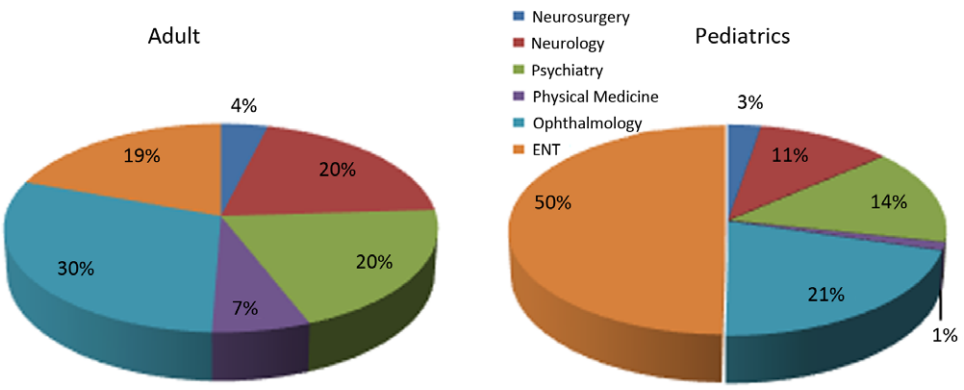

Figure 5: Number of specialist physician seen by adults (over 18 years) and pediatrics (under 18 years) in the 2 years following concussion. 50% of pediatrics that had a referral for a specialist physician saw and ENT. ENT = Ear, nose, and throat surgeon/ otolaryngology.

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Table 1: Number of cases with a referral to a specialist for concussion symptoms in 2 years following index injury, time between index date and first visit, and number of visits per patient. ENT = ear, nose, throat surgeon/otolaryngologist

			Total	At least 1 visit	Neurology	Neurosurgery	Psychiatry	Physiatry (PM&R)	Ophthalmology	ENT
Total		N	1,022,588	529,351 (51.8%)	67,420 (12.7%)	13,571 (2.6%)	70,404 (13.3%)	19,780 (3.7%)	103,417 (19.5%)	101,788 (19.2%)
		Days to 1st visit Mean (SD)/ median (IQR)		235.7 (SD 203.3)/ 181 (IQR 88–371)	254.7 (SD 213.9)/ 194 (IQR 66 – 418)	251.2 (SD 220.0)/ 186 (IQR 51 – 425)	244.5 (SD 220.7)/ 176 (IQR 44 – 419)	310.3 (SD 216.9)/ 283 (IQR 114 – 493)	228.2 (SD 203.4)/ 163 (IQR 52 – 364)	227.0 (SD 218.8)/ 233 (IQR 77 – 456)
		Number of visits per patient		4.6 (SD9.2)	2.6 (SD 3.7)	3.5 (SD 8.5)	9.5 (SD 19.3)	4.7 (SD 10.0)	3.8 (SD 4.2)	2.3 (SD 2.4)
Sex	Female	N	410,140 (40.1%)	234,174 (57.1%)	33,438 (14.3%)	5,907 (2.5%)	31,680 (13.5%)	10,265 (4.4%)	53,262 (22.7%)	42,518 (18.2%)
		Days to 1st visit Mean (SD)/ median (IQR)		227.0 (200 SD)**/ 169 (IQR 59–356)	257.6 (SD 213.4)**/ 198 (IQR 69 – 422)	256.2 (SD 219.4)/ 197 (IQR 56 – 432)	238.2 (SD 219.3)**/ 167 (IQR 42 – 407)	310.3 (SD 216.3)/ 282 (IQR 115 – 495)	226.7 (SD 203.2)/ 162 (IQR 55 – 357)	280.2 (SD 217.9)**/ 238 (IQR 82 – 458)
		Number of visits per patient		5.0 (SD 9.7)**	2.6 (SD 3.5)*	3.0 (SD 4.9)*	10.0 (SD 9.8)**	4.5 (SD 8.9)*	3.9 (SD 3.9) **	2.4 (SD 2.2)**
	Male	N	612,448 (59.9%)	295,177 (48.2%)	33,982 (13.1%)	7,664 (3.0%)	38,724 (14.9%)	9,515 (3.8%)	50,155 (19.3%)	59,270 (22.9%)
		Days to 1st visit Mean (SD)/ median (IQR)		242.7 (SD205.5)/ 191 (IQR 62 – 384)	251.8 (SD 214.4)/ 189 (IQR 62 – 415)	247.3 (SD 220.1)/ 179 (IQR 48 – 419)	249.6 (SD 221.7)/ 184 (IQR 47 – 428)	310.2 (SD 217.7)/ 283 (IQR 113 – 495)	229.8 (SD 209.8/ 165 (IQR 48 – 372)	274.8 (SD 219.3)/ 228 (IQR 74 – 458)
		Number of visits per patient		4.3 (SD 8.8)	2.6 (SD 3.8)	3.5 (SD 6.4)	9.0 (SD 8.8)	5.0 (SD 11.0)	3.6 (SD 3.6)	2.5 (SD 2.3)
Pediatric		N	435,531 (42.6%)	233,427 (50.3%)*	10,307 (4.4%)	2,500 (1.1%)	13,628 (5.8%)	1,104 (0.5%)	18,398 (7.9%)	46,527 (19.9%)
		Days to 1st visit Mean (SD)/ median (IQR)		276.0 (SD 202.6)**/ 242 (IQR 98 – 424)	277.0 (SD 222.3)*/ 232 (IQR 72 – 459)	216.9** (SD 209.4) 157 (IQR 42 – 351)	307.4 (SD 225.5)**/ 282 (IQR 94 – 503)	307.9 (SD 219.9)*/ 286 (IQR 107 – 498)	254.1 (SD 211.1)*/ 199 (IQR 70 – 408)	283.7 (SD 218.2)**/ 241 (IQR 85 – 465)
		Number of visits per patient		2.5 (SD 3.8)	2.0 (2.6)	2.3 (SD 3.0)	5.9 (SD 11.3)**	2.2 (SD 3.8)**	2.5 (2.4)*	2.6 (SD 2.3)**
Adult		N	587,057 (57.4%)	304,683 (51.9%)	57,113 (18.7%)	11,071 (3.6%)	56,776 (18.6%)	18,676 (6.1%)	85,019 (27.9%)	55,261 (18.1%)
		Days to 1st visit Mean (SD)/ median (IQR)		203.8 (SD 192.9)/ 135 (IQR 40 – 323)	250.7 (SD 212.2)/ 188 (IQR 65 – 411)	258.9 (SD 221.6)/ 201 (IQR 84 – 437)	224.4 (SD 216.8)/ 184 (IQR 38 – 392)	310.4 (SD 216.8)/ 282 (IQR 114 – 355)	222.6 (SD 204.9)/ 156 (IQR 49 – 355)	271.4 (SD 219.0)/ 225 (IQR 72 – 448)
		Number of visits per patient		6.3 (SD 11.6)	2.7 (SD 3.8)	3.3 (SD 5.9)	10.3 (SD 20.7)	4.9 (SD 10.2)	4.1 (SD 4.5)	2.3 (SD 2.3)
Rural		N	137,710 (13.5%)	69,597 (50.5%)*	6,260 (9.0%)	1,532 (2.2%)	6,514 (9.4%)	2,412 (3.5%)	11,564 (16.6%)	11,355 (16.3%)
		Days to 1st visit Mean (SD)/ median (IQR)		241.6 (SD 201.5)**/192 (IQR 66 – 375)	265.1 (SD 208.0)**/211 (IQR 82 – 422)	270.9 (SD 218.1)*/ 228 (IQR 68 – 448)	269.4 (SD 222.4)*/ 217 (IQR 62 – 452)	329.8 (SD 213.6)**/ 319 (IQR 140 – 511)	232.5 (SD 209.9)/ 167 (IQR 53 – 370)	274.4 (SD 217.8)/ 227 (IQR 77 – 451)
		Number of visits per patient		3.9 (SD 6.9)**	2.4 (SD 2.9)**	3.1 (SD 3.1)	6.9 (SD 6.6)**	3.8 (SD 8.5)*	3.8 (SD 3.7)	2.4 (SD 2.3)**
Non-Rural		N	884,878 (86.5%)	459,754 (60.0%)	61,160 (13.3%)	12,039 (2.6%)	63,890 (14.0%)	17,368 (3.8%)	91,853 (20.0%)	90,433 (19.7%)
		Days to 1st visit Mean (SD)/ median (IQR)		234.8 (SD 203.5)/ 179 (IQR 57 – 371)	253.6 (SD 214.4)/ 192 (IQR 64 – 418)	248.7 (SD 220.1)/ 182 (IQR 49 – 422)	241.9 (SD 220.4)/ 172 (IQR 43 – 414)	307.6 (SD 217.3)/ 278 (IQR 110 – 491)	227.6 (SD 205.9)/ 163 (IQR 52 – 364)	277.4 (SD 218.8)/ 233 (IQR 77 – 457)
		Number of visits per patient		4.7 (SD 9.6)	2.6 (SD 3.7)	3.1 (SD 2.9)	9.7 (SD 9.7)	4.5 (SD 10.2)	3.8 (SD 3.7)	2.5 (SD 2.3)

*$P < 0.01$.
**$P < 0.0001$.

median 176 (IQR 44–419) between index date and first psychiatry visit. A total of 13,628 (19.4%) pediatric cases had at least one psychiatry visit and had the longest ($p < 0.0001$) times between index date and first visit. Females accounted for 45.0% (31,680) of those that visited a psychiatrist after their concussion and had significantly faster time ($p < 0.0001$) between index date and first visits than males. 6514 (9.3%) rural residents had visits with a psychiatrist following their concussion and had significantly longer ($p < 0.0001$) time between index date and first psychiatrist visit. Females had significantly more ($p < 0.0001$) visits than males. Rural residents also had significantly fewer visits (6.9 SD 6.6) than non-rural residents (9.7 SD 9.7) ($p < 0.0001$). There were significant differences ($p < 0.0001$) in the number of visits based upon age group.

Physiatry/ Physical Medicine and Rehabilitation Follow-up

There were 19,780 individuals with at least one physiatry visit with a mean of 4.7 (SD 10.0) visits per person and a mean of 310.3 days SD 216.9, median 283 days (IQR 114–493). Approximately 5.6% (1,104) were pediatric patients with significant differences in time between index date and first visit based upon age group ($p = 0.008$). More than half of those with physiatry follow-up were female (10,265 51.9%) and there were no sex differences in time between index date and first physiatry visit ($p = 0.88$). Rural residents ($n = 2412$, 12.2%) had almost an extra month between index date and first visit compared to non-rural residents ($p < 0.0001$) and also had significantly fewer ($p < 0.0001$) visits with a physiatrist than the non-rural group. Males had significantly more visits than females ($p = 0.003$). The number of visits by age groups differed significantly ($p < 0.0001$).

Ophthalmology Follow-up

There were 103,417 individuals with ophthalmology visits with a mean of 3.8 (SD4.2) visits per person in the two years following their concussion, with a mean time between index date and first visit of 228.4 days (SD 206.4), median 163 days (IQR 52–364). A total of 18,398 (17.8%) pediatric cases had ophthalmology visits and children had the longest overall time between index date and first visit ($p < 0.0001$). More than half (53,262 51.5%) of the visits were for females, and the time between index date and first visit did not have any sex differences ($p = 0.015$). Rural residents comprised 11.1% ($n = 11,564$) of the visits to an ophthalmologist and there were no differences in time to first visit based upon rural indicator ($p = 0.019$). Females had significantly more ($p < 0.0001$) visits than males, and there were significant differences ($p < 0.0001$) in the number of visits based upon age group. There was no difference ($p = 0.20$) in the number of visits based upon rural indicator.

Otolaryngology, Ear, Nose, and Throat Surgeon (ENT) Follow-up

There were 101,788 individuals with ENT visits and a mean of 2.4 (SD 2.3) visits per person and a mean time to first visit of 277.0 days (SD 218.7), median 233 days (IQR 77–456). Pediatrics made up almost half ($n = 46,527$ 45.7%) of those that sought an ENT for concussion symptoms and 50% of all pediatric cases that recorded a follow-up specialist visit was with an ENT. The pediatric age group had longer time to first visit than adults ($p < 0.0001$). Totally, 42,518 (41.7%) females had a visit with an ENT and had a significantly longer time to first visit than males ($p < 0.0001$). Rural residents comprised 11.2% ($n = 11,355$) of those with an ENT visit and there was no difference ($p = 0.246$) in time to first visit based upon rural indicator. Though there were statistically significant sex differences ($p < 0.0001$) in the number of visits, the actual difference between males and females was negligible (males 2.5 visits SD 2.4, females 2.4 visits SD 2.2). The difference between rural (2.5 SD 2.3) and non-rural (2.4 SD 2.3) residents was also statistically significant ($p < 0.0001$) though not clinically significant. There were statistically significant differences ($p < 0.0001$) in the number of visits based upon age group.

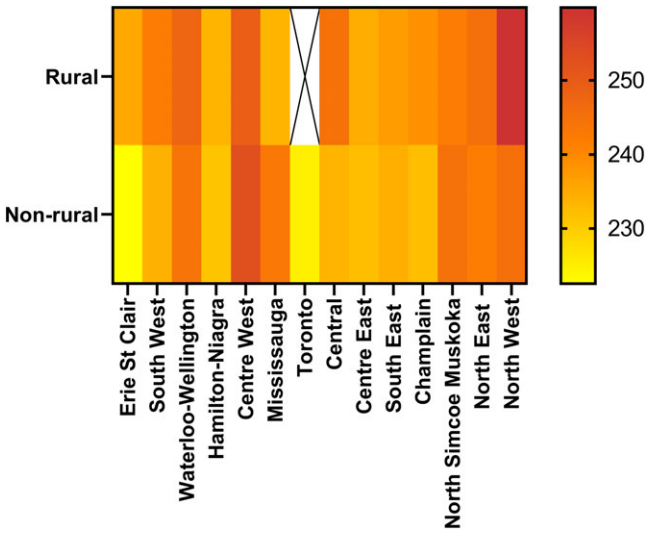

Figure 6: Wait times in days from index date to first visit with a specialist by Local Health Integration Network (LHIN) and rural indicator compared to the provincial mean wait time. There were no rural residing Toronto residents.

Regional Patterns in Follow-up Care

Ontario was stratified into 14 health care administrative zones called Local Health Integration Networks (LHINs) until 2020 (Supplemental Figure 1). Most of the residents of the province live in the southern part of Ontario along the United States border. Toronto, the most populous city, has approximately 2.8 million residents. Rural residents account for 15% of the population.

Early follow-up by primary care physician varied by regions ($p < 0.0001$), with the Central West and Central LHINs having the shortest mean (56.3 and 56.7 days respectively) and median time (13 and 15 days, respectively) to primary care follow-up. The Northern part of the province and the Southwest LHIN had the longest delays for primary care follow-up (Figure 3).

Time from index date to first specialist visit also varied by region ($p < 0.0001$) (Figure 6). The Erie St Clair region had the shortest mean time to first specialist 223.9 days and Central West region had the longest 252. 4 days and the northern part of the province also had wait time for specialist above the provincial average (235.1 days). When LHINs were further stratified by rural indicator, rural areas had longer time to first specialist visit then the non-rural areas ($p < 0.0001$). The Toronto Central LHIN had the most specialist visits (6.5 SD 15.0) of the province than other LHINs ($p < 0.0001$), ranging from 3.9 to 4.9 specialist visits.

Factors Associated with Above Average Specialist Utilization

Twenty-eight variables were retained in the LASSO model for greater specialist health care utilization in the two years following a concussion (Supplemental Table 2, Supplemental Figure 3). The

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adjusted r square for the model was 0.14. Variables with positive estimated coefficients were being male, between 31 and 80 years, previous history of psychiatric disorders like bipolar disorder and personality disorder, previous diagnosis of anxiety and/or depression and other mental health issues, neurological disorders, pain disorders, more frequent primary care utilization in the year before injury, shorter time between index date and follow-up by primary care, and residing in LHINs in the southwest, or surrounding major urban centres like Toronto or Ottawa. Retained variables with negative estimated coefficients included being under 18 years old, rural residing, longer time between index date and first visit with a specialist, and residing in LHINs in the northern part of the province or larger less urban areas such as Central West and East.

Discussion

This is the largest and most robust system wide analysis of medical specialist utilization in Canada following a concussion using the records of over 1 million people diagnosed with a concussion. There were differences in access to care in terms of time between index date and accessing a specialist and/or the number of visits with the specialist, with younger children (0–4 years) having less access to care than adults and rural residing residents having longer wait times to visit specialists than non-rural residents. Differences by sex were specialist type dependent. The northern region of the province also had longer time between the index date and the first visit with a specialist.

This is also one of the largest population-based analysis of health care access following an index diagnosis, as it was possible to track individuals for 2 years and across services. The use of administrative health data also reduced certain biases, such as selection and recall biases, which would have been present in community survey of health care usage type studies.

Age Differences in Access to Specialist

Though there were significant differences in time between index date and first specialist visit and the number of visits, there was no consistency in which age group had the longest wait time to access care. Children under 18 years had fewer visits with specialists than adults. Some specialties such as neurology and psychiatry had much longer wait times for pediatrics than adults as there are far fewer pediatric neurologists and psychiatrists in Ontario than those that treat adults[17] and children may have had counseling appointments with their primary care physician but was not included in this analysis due to primary care washout. Older adults (over 61 years) have more visits with specialists; they may have more comorbidities that require a greater need for specialized care. Different ages may have different needs post-concussion[18,19] and appropriate medical care for children following their concussion[20,21] needs to be easily and timely accessible.

Rural Access to Specialists

Rural residents with a concussion had a longer time between the index date and follow-up by primary care physician and a first visit with a specialist. This may reflect an issue in access to appropriate health care providers for rural residents. The delay in accessing primary care may then compound to increase the delay between index date and first specialist visit for rural residents. The longest wait times for all specialists were in the northern parts of the province and the Southwest region and rural children (under 18 years). There were also significantly fewer specialist visits for physiatry and psychiatry for rural residents. Previous research on moderate and severe TBI health care utilization has found limited access to rehabilitation specialists or undue financial or transportation burden to access appropriate health care.[22,23] These issues have negative consequences on TBI recovery[24] such as re-hospitalization.[25] These findings are similar to what is seen in the moderate-severe TBI literature regarding rural access to health care following injury.[26] Previous research looking at access to specialists in Ontario found that community factors such as rurality and type of specialist available influences referral to specialized health care more than specialist supply.[27,28] There is a need for improving access to appropriate medical care for concussion in rural areas of Ontario to improve patient quality of life and potentially reduce further health care needs.

Regional Differences in Post-concussion Care in Canada

In addition to the differences in accessing care following concussion based upon rural indicator, there were regional discrepancies in wait times to access a specialist and the number of specialist visits, with wait times for those residing in northern parts of the province several weeks or longer than centrally residing resident. Concussion incidence was found to be the highest in northern parts of the province and lower in more urban settings[1] as well. Areas surrounding major metropolitan areas had fewer days between index and follow up by primary care and between index date and first specialist visit. These areas are more populated than rural or more northern parts of the province and have more primary care physicians and have academic hospitals as well as community hospitals and community based specialists. These factors may enable primary care physicians and specialists to meet the demand of their local patients. Patients from more remote regions of Ontario may also require care from these specialists and, prior to wide-spread virtual care as a consequence of the COVID-19 pandemic, scheduling issues and driving/flying several hundreds of kilometers to access specialists could be a barrier to timely access or being able to attend multiple visits.[26]

Sex Differences in Access to Specialty Care Following a Concussion

Overall, females had more visits and shorter times between index date and first specialist visits than males. However, sex differences in time between index date and first specialist visit and in some cases the number of visits per specialist when further analyzed at the specialist type level but the differences were dependent upon the specialist seen. Females may be more likely to seek out health care following concussion than males as there is some literature suggesting females may be at higher risk for prolonged symptoms.[29–31]

Factors Associated with Above Average Health Care Utilization Following Concussion

Some factors that were positively associated with the number specialist visits included prior history of psychiatric disorders and neurological disorders, being over 18 years, more frequent primary care physician visits in the year prior, and living in areas close to major metropolitan areas. Mental health and psychiatric history is associated with increased risk of prolonged concussion symptoms[8,32,33] though some of these specialist visits could have booked prior to index injury as part of regular medical care for their mental health conditions. Factors negatively associated with the number of

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specialist visits including being under 18 years and residing in more rural or northern parts of the province. The authors cannot speculate if more specialist visits, or fewer specialist visits, indicate most appropriate medical care following a concussion as each concussion is individual and what might take three specialist visits in one patient to adequately manage their symptoms may be insufficient in another patient or inappropriately too many for a third patient. Longer time from index date to primary care follow-up was also negatively associated with the number of specialist visits indicating that timely follow-up by primary care may enable faster triage for prolonged symptoms and initiation of the referral process.

Clinical/Policy Implications

There is variation in access to the specialized concussion care in Ontario. Only 14% of people diagnosed with a concussion are seen by a primary care physician within 72 hours of injury; health service leaders and physicians should strive to develop pathways to ensure that people diagnosed with concussion receive follow-up within 3 days more consistently to ensure access to the ideal education and treatment. Specific recommendations to address the gap in early primary care follow-up for concussion patients requires further study to identify the reasons for this shortfall, as policy recommendations would differ based on the underlying reason. For example, if the reason for the low follow-up numbers is due to inability to obtain appointment times with primary care physicians, the policy implication (primary care capacity) would be much different than if the low follow-up numbers was due to lack of communication/education of patients in emergency department settings of the importance of obtaining follow-up with their primary care provider (this would require policies to change practice patterns/habits in the emergency room setting). Medical education on concussion is improving though still some deficiencies exist,[34,35] and there is increasing awareness of concussion in the general public as well[1] along with policies such as Rowan's Law (Concussion Safety), 2018, S.O. 2018, c. 1[36] in Ontario, which influence health care seeking/ referrals for concussions. Widespread implementation of available risk score calculators may ensure that those who are at high risk of prolonged symptoms received earlier referrals to specialist care.[8,11] It appears that there is a need for more training of pediatric specialists in concussion care or training of primary care pediatricians in concussion management. There is a need for increased access to specialist care in rural settings and implementation of virtual or telephone rehabilitation care may help to reduce this inequity in access. This study raises a number of hypotheses for future exploration. Given the variation in wait times and in use of specialists by type, raises the question of whether interprofessional clinics with multiple specialists available simultaneously would result in better outcomes. It also highlights that there is no one specialty that can address all aspects of concussion given the breadth of symptoms.

Limitations

This study had some limitations that are worthy of note. The administrative health databases used do not contain clinical data such as assessments or specific concussion symptoms and as well do not link to all databases in particular, other relevant databases such as motor vehicle accident insurance funded care and Workplace Safety Insurance Board (WSIB) data were unavailable, which would have included data on non-OHIP covered services such as physiotherapy or psychotherapy and would enable a more complete image of the true costs of treating concussion. Only physicians that submitted to OHIP were included; as such, health care providers such as physiotherapists or community psychologists were not tracked. Due to the index event washout period, it is not possible to track primary care physicians, some of whom have expertise in treating concussions or specialized sports medicine doctors, as they are considered primary care physicians in Ontario for analysis and these health care events were missed. The frequency of specialist physician utilization prior to injury was not tracked. A limitation of using administrative health databases is that it is not possible to confirm the accuracy of the billing/ diagnosis information submitted. The time frame is prior to introduction of mandatory concussion reporting laws in Ontario such as Rowan's Law and before COVID-19 and as such findings may differ.

Future Directions

Future directions for this data include estimation of all direct physician costs associated with concussion care including other variables such as socioeconomic status, ethnicity, immigration status, distance traveled for care, and frequency of pre-injury specialist physician utilization

Conclusions

Access to appropriate care following a concussion diagnosis in Ontario varies based upon the patient's age and where in the province they live. Rural areas, those in northern part of the province, and children under 18 years have the most inequality to access of care following a concussion. Only 14% of patients are seen for follow-up by their primary care physician with 3 days of injury. These data can highlight areas that require improvement and could lead to improved access to health care following a concussion and improve the quality of life of the 150,000 Ontarians diagnosed with a concussion every year.

Supplementary Material. To view supplementary material for this article, please visit https://doi.org/10.1017/cjn.2022.346.

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Map of LHIN boundaries of Ontario curtesy of Statistics Canada (Health Regions: Boundaries and Correspondence with Census Geography, catalog no. 82-402-X. Produced by the Geography Division for the Health Statistics Division, Statistics Canada, 2015).

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MTB – study design, data interpretation, writing, literature search
CL – data interpretation, editing
SEPM -– data interpretation, editing

DWL – data interpretation, editing
AT – data interpretation, editing, literature search
CeO – Study design, data interpretation, writing, literature search

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