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Trends in alcohol-attributable hospitalisations and emergency department visits by age, sex, drinking group and health condition in Ontario, Canada

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Abstract

Introduction: Alcohol-attributable harms are increasing in Canada. We described trends in alcohol-attributable hospitalisations and emergency department (ED) visits by age, sex, drinking group, attribution and health condition.

Methods: Hospitalisation and ED visits for partially or wholly alcohol-attributable health conditions by age and sex were obtained from population-based health administrative data for individuals aged 15+ in Ontario, Canada. Population-level alcohol exposure was estimated using per capita alcohol sales and alcohol use data. We estimated the number and rate of alcohol-attributable hospitalisations (2008–2018) and ED visits (2008–2019) using the International Model of Alcohol Harms and Policies (InterMAHP).

Results: Over the study period, the modelled rates of alcohol-attributable health-care encounters were higher in males, but increased faster in females. Specifically, rates of alcohol-attributable hospitalisations and ED visits increased by 300% (19–76 per 100,000) and 37% (774–1,064 per 100,000) in females, compared to 20% (322–386 per 100,000) and 2% (2563–2626 per 100,000) in males, respectively. Alcohol-attributable ED visit rates were highest among individuals aged 15–34, however, increased faster among individuals aged 65+ (females: 266%; males: 44%) than 15–34 years (females:+17%; males: −16%). High-volume drinkers had the highest rates of alcohol-attributable health-care encounters; yet, low-/medium-volume drinkers contributed substantial hospitalisations (11%) and ED visits (36%), with increasing rates of ED visits in females drinking low/medium volumes.

Discussion and Conclusions: Alcohol-attributable health-care encounters increased overall, and faster among females, adults aged 65+ and low-/medium-volume drinkers. Monitoring trends across subpopulations is imperative to inform equitable interventions to mitigate alcohol-attributable harms.

KEYWORDS
alcohol, alcohol drinking, alcohol-related disorders, drinking behaviour, hospitalisation

Key Points

- We estimated that rates of alcohol-attributable hospitalisations (2008–2018) and emergency department (2008–2019) visits were higher in males, but increased faster in females in Ontario, Canada.
- Over the study period, males, younger (aged 15–34, emergency department visits only) and middle-aged (aged 35–64) adults and high-volume drinkers (>-Canada's Low Risk Drinking Guidelines) contributed the greatest burden to hospitalisations and emergency department visits.
- Of concern, we found an increasing burden of alcohol health-care encounters among females, individuals aged 65+ (particularly among partially attributable conditions) and low- and medium-volume female drinkers (emergency department visits only).

1 | INTRODUCTION

Alcohol is a leading risk factor for premature death and disability internationally, affecting males three times higher than females [1]. The relationship between alcohol and health harms is complex, as alcohol is a component cause in more than 200 negative chronic and acute health outcomes including cancer, neuropsychiatric diseases, hypertensive disease, haemorrhagic stroke, communicable diseases and injury [1, 2]. Consequently, alcohol is a significant contributor to health-care encounters. In Canada, alcohol is annually responsible for CAD $5.4B in health-care costs [3] and more hospitalisations for wholly alcohol-attributable conditions than heart attacks [4].

Globally, alcohol-attributable hospitalisations and emergency department (ED) visits have been increasing steadily over the past two decades overall and among key population subgroups [5–8]. In Ontario, Canada's most populous province, wholly alcohol-attributable ED visit rates increased 4.4 times the rate of all-cause ED visits between 2003 and 2016, with the largest relative increase among individuals aged 19–35 [9]. Of additional concern, alcohol-attributable health-care encounters are increasing disproportionately in lower-risk populations. Although males have two-fold higher rates of wholly alcohol-attributable hospitalisations and ED visits, rates increased more rapidly among females (hospitalisations:18%; ED visits: 94%) than males (hospitalisations: 6%; ED visits: 57%), respectively, in Ontario between 2003 and 2018 [10]. Furthermore, a study from British Columbia, Canada found that in 2014, drinkers following Canada's national alcohol guidance (201.75 g of ethanol per week (g/week) for males and 134.50 g/week for females) accounted for 27% of alcohol-attributable hospitalisations [11]. These studies highlight the importance of monitoring local trends in alcohol-attributable harms across population subgroups.

In Canada, few studies have included partially alcohol-attributable conditions when estimating alcohol-attributable harms. In the UK, partially attributable conditions accounted for 64% of total alcohol-attributable hospitalisations in 2018/2019 [12]. An improved understanding of the true alcohol-attributable health-care burden, including both partially and wholly alcohol-attributable conditions, and how it differs over time and across age, sex and drinking group (an important factor in developing alcohol harms [1]) is required to inform effective and equitable population-level alcohol control policies in Canada.

An investigation of alcohol harms in Ontario is particularly timely due to the ongoing deregulation of alcohol sales across the province, starting in 2015 [13]. Despite the proven effectiveness of increasing taxes on and restricting alcohol availability for reducing alcohol harms [14], increases in scheduled wine and beer tax have been paused, the unit minimum price of beer has been reduced by 25% [13] and the number of alcohol retail outlets has increased by 30% between 2015 and 2019 [15]. Initial studies from Ontario observed that a 15% increase in alcohol retail outlets in 2015 coincided with an 11% increase in alcohol retail sales [16], and an 18% increase in wholly alcohol-attributable ED visits between 2013 and 2017 [17]. As alcohol deregulation continues in Ontario, it is imperative to investigate the full impact on health-care use overall and across priority subgroups.

This study aims to describe trends in alcohol-attributable hospitalisations (2008–2018) and ED visits (2008–2019) in Ontario by age, sex, drinking group and health condition. Our study extends previous research in Ontario by accounting for partially alcohol-attributable hospitalisations and ED visits using the most recent 12 years of population-based data available. Moreover, we examine intersecting trends in alcohol-attributable health-care encounters to provide evidence to inform effective population-level interventions to reduce alcohol use and harms.

2 | METHODS

2.1 | Study design

A population-based, repeat cross-sectional study was conducted to assess alcohol-attributable hospitalisations and ED visits in individuals aged 15+ in Ontario, Canada. The International Model of Alcohol Harms and Policies (InterMAHP Version 3.0) [18, 19] is an open-access alcohol harms estimator used to quantify 12 wholly and 31 partially alcohol-attributable health conditions. Briefly, InterMAHP employs a health condition-based epidemiological alcohol-attributable fraction (AAF) approach to estimate AAFs for specific age, sex and drinking group using population-level exposure to alcohol. This approach is methodologically consistent with international studies, including Global Burden of Disease Study estimates [1]. Detailed descriptions of InterMAHP are published elsewhere [18, 19].

2.2 | Data sources

Health administrative data on hospitalisations (2008–2018; Discharge Abstract Database and Ontario Mental Health Reporting System) and ED visits (2008–2019; National Ambulatory Care and Reporting System) for partially or wholly alcohol-attributable conditions were extracted using the Ontario Ministry of Health's IntelliHEALTH tool using the most recent data available at the time of the study.

Population-level exposure to alcohol was estimated using Ontario-specific alcohol sales, population estimates and alcohol use data. Specifically, annual alcohol per capita consumption (APC) sales in litres of ethanol of all alcoholic beverages from liquor authorities and other retail outlets were obtained for individuals aged 15+ from Statistics Canada's Control and Sale of Alcoholic Beverages dataset. Population-based estimates of the self-reported prevalence of alcohol use were derived from the Canadian Substance Use Exposure Database [20]; a combined dataset including estimates from the Canadian Alcohol and Drug Use Monitoring Survey (2009–2012) and the Canadian Tobacco, Alcohol and Drugs Survey (2013, 2015, 2017). Canadian Substance Use Exposure Database prevalence data were available up to 2017, as such we used alcohol prevalence estimates from 2017 with APC data from 2018 and 2019 to estimate population exposure to alcohol for these years. Yearly age- and sex-specific population estimates were obtained from Statistics Canada's Annual Demographic Estimates to provide denominators for rates of alcohol-attributable harms [21].

2.3 | Estimating alcohol-attributable health-care encounters

For each year, we enumerated the number of hospitalisations and ED visits for each alcohol-attributable condition by InterMAHP-defined age (15–34, 35–64 and 65+ years) and sex (female and male) groups. InterMAHP health conditions were selected for inclusion based on previous research informing global comparative risk assessments to be causally related to alcohol consumption [22]. Alcohol-attributable condition diagnostic codes and attribution are included in Table S1. Hospitalisations and ED visits were identified based on most responsible diagnosis code, except for injuries and motor vehicle accidents which were included if any diagnosis code was alcohol related.

2.3.1 | Population exposure to alcohol

InterMAHP automates the estimation of continuous prevalence distributions of average daily alcohol consumption for each age-sex subgroup, assuming a gamma distribution [23], as in the Global Burden of Disease study [1]. InterMAHP inputs include recorded APC and the prevalence of current, former, lifetime abstainers and monthly binge drinkers (i.e., consuming ≥4 and ≥5 Canadian standard drinks per day for females [53.8 g/day] and males [67.25 g/day]) for each of the six age-sex population subgroups. A 0.8 correction factor was applied to average daily alcohol consumption to account for underreporting in epidemiological survey data [24].

The population was divided into five drinking groups: (i) *lifetime abstainers* consumed less than one Canadian standard drink (13.45 grams of ethanol) in their life; (ii) *former drinkers* consumed one standard drink or more, but not in the past year; (iii) *low-volume drinkers* consumed up to 5 standard drinks per week (0.037–9.61 g/day); (iv) *medium-volume drinkers* consumed between 5 and 10 SD/week (9.62–19.21 g/day) for females and 5–15 SD/week (9.62–28.82 g/day) for males; and (v) *high-volume drinkers* consumed >10 SD/week (19.22–250 g/day) for females and >15 SD/week (28.83–250 g/day) for males, corresponding to levels above weekly limits in Canada's Low Risk Drinking Guidelines [25].

We used default InterMAHP relative risk estimates for each alcohol-attributable condition (sourced from Canadian Substance Use Costs and Harms) derived from high-quality published meta-analyses [18]. Where available, we used sex-specific (i.e., HIV, colorectal cancer, type 2 diabetes, hypertension, ischaemic heart disease, haemorrhagic and ischaemic stroke, liver cirrhosis and acute pancreatitis) instead of sex-combined risk

functions and morbidity (i.e., ischaemic heart disease, haemorrhagic and ischaemic stroke, liver cirrhosis, motor vehicle accidents, unintentional and intentional injuries) instead of combined morbidity and mortality risk functions [18].

InterMAHP calculated AAFs for each partially attributable conditions using population exposure to alcohol and relative risk inputs. AAFs for conditions where both chronic and acute drinking impact harms were calculated using a formula that further divides the drinking population into chronic bingers, non-chronic bingers and non-bingers. The risk was augmented for binge drinkers to remove any protective effect for ischaemic heart disease, ischaemic stroke [26], motor vehicle accidents, and unintentional and intentional injuries [18].

Furthermore, we set an upper consumption limit of 250 g/day, to align with alcohol use observed in managed alcohol programs in Canada [27].

2.4 | Statistical analysis

Age and sex-specific AAFs and enumerated hospitalisations or ED visits were multiplied to produce alcohol-attributable counts for all years, age and sex subgroups, attribution status and health conditions. We calculated the percent change of alcohol-attributable hospitalisations (2008–2018) and ED visits (2008–2019) for each subgroup. Percent change may underestimate increases in alcohol harms when protective effects are eroded, going from a negative to positive number of health-care encounters. We estimated trends in age and sex-specific trends in the rate per 100,000 population aged 15+ of alcohol-attributable health-care encounters by attribution, drinking status and health condition. We completed analyses using SAS Enterprise Guide 8.2 and RStudio v1.4.

3 | RESULTS

3.1 | Burden of alcohol-attributable hospitalisations

We estimate 240,577 alcohol-attributable hospitalisations between 2008 and 2018 (Table 1). The largest number of hospitalisations were among males (87%), individuals aged 35–64 (54%), for partially attributable conditions (60%) and in high-volume drinkers (79%). The most prevalent health conditions associated with alcohol-attributable hospitalisations were neuropsychiatric (34%), unintentional injuries (30%), digestive (21%) and cancers (10%).

3.2 | Trends in alcohol-attributable hospitalisations

Between 2008 and 2018, we estimated a 62% increase in the number of alcohol-attributable hospitalisations compared to a 13% increase in all-cause ED visits, including increases of 380% in females (976–4689) and 42% in males (16,044–22,811) and in almost all age groups, drinking groups and health conditions (Table 1 and Table S2). Estimated alcohol-attributable hospitalisations represented between 1.8% and 2.6% of all hospitalisations in 2008 and 2018, respectively. Similarly, rates of alcohol-attributable hospitalisations were higher in males (322 per 100,000) than females (19 per 100,000) in 2008, yet increased faster in females (300%) than males (20%) over the study period (Table S3). Looking at specific subgroups among females and males, the greatest increases in alcohol-attributable hospitalisation rates were observed in individuals aged 65+ (females: 123%; males: 28%) and partially alcohol-attributable conditions among females (214%).

The rates of partially and wholly alcohol-attributable hospitalisations were higher in males than females across all age groups, with notable increases between 2008 and 2018 in partially attributable hospitalisations among individuals 65+ in both sexes (Figure 1a).

High-volume drinkers had the highest alcohol-attributable hospitalisation rates compared to other drinking groups (Figure 1b). Rates increased in high-volume drinkers aged 65+ in both sexes, but to a much greater extent in males. Males aged 65+ also had the highest rates of alcohol-attributable hospitalisations among medium-volume drinkers compared to other age-sex groups.

The highest rates of alcohol-attributable hospitalisations by health conditions were observed in males aged 65+ for unintentional injuries (290 per 100,000 in 2018), followed by males aged 35–64 for neuropsychiatric conditions (154 per 100,000 in 2018) and females aged 65+ for unintentional injuries (131 per 100,000 in 2018), all of which increased between 2008 and 2018 (Figure 1c). Among individuals aged 65+, higher rates of hospitalisations for cancers, and cardiovascular disease, communicable disease and digestive conditions were observed relative to other age groups.

3.3 | Burden of alcohol-attributable ED visits

We estimated 2,348,435 alcohol-attributable ED visits occurred between 2008 and 2019, 73% of which were among males (Table 2). Individuals aged 15–34 and 35–64 accounted for the largest number of ED visits (44% in each group). The majority of alcohol-attributable ED visits were

TABLE 1 Sex-specific alcohol-attributable hospitalisations by age, attribution, drinking status and health condition between 2008 (total population 15+ = 10,655,281) and 2018 (total population 15+ = 12,047,457), in Ontario, Canada.

	Total alcohol-attributable hospitalisations (2008–2018)			Alcohol-attributable hospitalisations between 2008 and 2018					
				Females			Males		
	Total % (n)	Females % (n)	Males % (n)	2008	2018	% Change	2008	2018	% Change
Total	100 (240,577)	13 (30,642)	87 (209,936)	976	4,689	380	16,044	22,811	42
Age group, years									
15–34	20 (47,028)	46 (14,094)	16 (32,933)	1,001	1,619	62	2,839	3,482	23
35–64	54 (128,948)	72 (22,204)	51 (106,744)	1,503	2,577	71	8,737	10,673	22
65+	27 (64,601)	−18 (−5,657)	33 (70,258)	−1,528	493	132	4,468	8,656	94
Attribution									
Partially	60 (144,899)	6 (1,694)	68 (143,205)	−1,152	1,562	236	11,284	15,277	35
Wholly	40 (95,678)	94 (28,947)	32 (66,731)	2,128	3,126	47	4,760	7,534	58
Drinking status									
Former consumers	10 (25,124)	49 (14,995)	5 (10,129)	1,237	1,484	20	837	995	19
Low volume	−1 (−3410)	−57 (−17,407)	7 (13,997)	−2,273	−1,080	52	1,141	1,457	28
Medium volume	12 (29,612)	−8 (−2458)	15 (32,071)	−471	−35	93	2,658	3,290	24
High volume	79 (189,251)	116 (35,512)	73 (153,739)	2,483	4,320	74	11,409	17,070	50
Health condition									
Cancer	10 (24,654)	19 (5,752)	9 (18,903)	505	574	14	1,669	1,772	6
Cardiovascular	−9 (−22,599)	−140 (−42,779)	10 (20,180)	−4,367	−3,602	18	1,550	2,011	30
Communicable	6 (14,619)	12 (3,639)	5 (10,980)	232	492	112	704	1,370	95
Digestive	21 (49,579)	49 (14,961)	16 (34,618)	1,079	1,652	53	2,691	3,428	27
Endocrine	−1 (−3,040)	−18 (−5,467)	1 (2,427)	−473	−598	26	189	259	37
Intentional injuries	6 (14,905)	17 (5,271)	5 (9,634)	437	548	25	909	897	−1
Motor collisions	3 (8,023)	6 (1,903)	3 (6,120)	164	195	19	547	597	9
Neuropsychiatric	34 (82,680)	81 (24,950)	27 (57,730)	1,861	2,707	45	4,064	6,701	65
Unintentional injuries	30 (71,756)	73 (22,412)	24 (49,344)	1,538	2,721	77	3,721	5,776	55

Note: Columns may not add up due to rounding. Negative numbers are the result of the protective effects arising from protective effects of relative risk curves.

for partially attributable conditions (75%), and among high-volume drinkers (62%), yet 36% occurred in low or medium-volume drinkers. Overall, alcohol-attributable ED visits were most commonly related to unintentional injuries (58%) and neuropsychiatric conditions (25%).

3.4 | Trends in alcohol-attributable ED visits

Between 2008 and 2019, we estimated a 34% increase in alcohol-attributable ED visits compared to a 23% increase in all-cause ED visits, including increases of 64% (40,504–66,480) in females and 24% (127,770–158,208) in males and in almost all age, drinking groups and health conditions (Table 2 and Table S4). Estimated alcohol-attributable ED visits represented between 3.8% and 4.2% of all ED visits in 2008 and 2019, respectively. The largest increases in rates of alcohol-attributable ED visits were observed among females, individuals aged 65+, wholly attributable conditions, former drinkers (male), low and high-volume drinkers (females), females with digestive conditions and neuropsychiatric conditions among both sexes (Table S3).

Alcohol-attributable ED visit rates were higher among males compared to females and partially compared to wholly attributable conditions (Figure 2a). Partially attributable ED visit rates were highest in males aged 15–34 (2,327 per 100,000 in 2019), but decreased across the study period. In contrast, partially attributable ED visit rates in males aged 65+ and 35–64 and all age-sex groups of wholly attributable conditions increased across the study period.

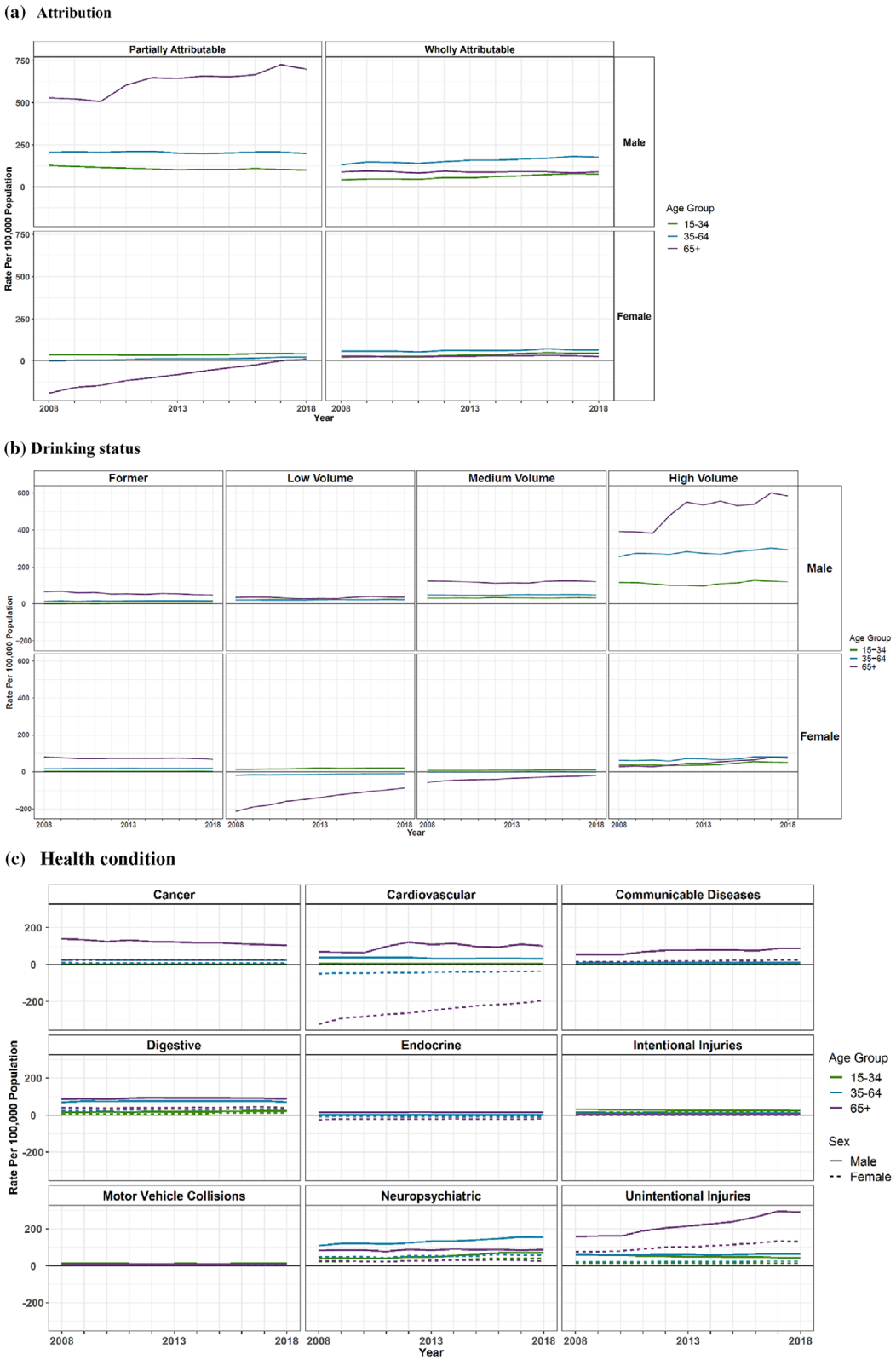

FIGURE 1 Age and sex-specific rate of alcohol-attributable hospitalisations by (a) attribution, (b) drinking status, (c) health condition between 2008 and 2018, in Ontario, Canada.

Alcohol-attributable ED visit rates increased among high-volume drinkers across all age-sex groups, except males aged 15–34, where rates decreased over the study period (Figure 2b). Alcohol-attributable ED visit rates were highest in individuals aged 15–34 across all drinking groups, and were relatively higher in male (618 per

TABLE 2 Sex-specific alcohol-attributable emergency department (ED) visits by age, attribution, drinking status and health condition in 2008 (total population 15+ = 10,655,281) and 2019 (total population 15+ = 12,274,182), in Ontario, Canada.

	Total alcohol-attributable ED visits (2008–2019)			Alcohol-attributable ED visits between 2008 and 2019					
				Females			Males		
	Total, % (*n*)	Females, % (*n*)	Males, % (*n*)	2008	2019	% change	2008	2019	% change
Total	100 (2,348,435)	27 (638,193)	73 (1,710,242)	40,504	66,480	64	127,770	158,208	24
Age group, years									
15–34	44 (1,026,248)	48 (308,562)	31 (717,686)	22,132	29,733	34	60,023	61,122	2
35–64	44 (1,032,856)	42 (268,312	33 (764,544)	16,741	28,011	67	56,004	70,630	26
65+	12 (289,331)	10 (61,319)	10 (229,331)	1630	8,737	436	11,744	26,457	125
Attribution									
Partially	75 (1,758,546)	71 (450,679)	56 (1,307,866)	29,707	47,185	59	104,307	116,704	12
Wholly	25 (589,890)	29 (187,514)	18 (402,376)	10,796	19,295	79	23,464	41,504	77
Drinking status									
Former	1 (34,952)	3 (21,832)	1 (13,120)	1485	2,090	41	739	1,449	96
Low volume	18 (425,639)	29 (184,895)	13 (240,744)	10,949	19,112	75	17,530	22,612	29
Medium volume	18 (424,834)	16 (99,966)	11 (324,868)	6575	9951	51	24,632	29,877	21
High volume	62 (1,463,009)	52 (331,500)	48 (1,131,509)	21,494	35,006	63	84,869	104,270	23
Health condition									
Cancer	0 (7,416)	0 (1,944)	0 (5,472)	126	186	48	373	532	43
Cardiovascular	1 (28,990)	−5 (−29,800)	3 (58,791)	−3,284	−1,619	51	3,645	5,944	63
Communicable	3 (69,883)	3 (20,036)	3 (49,847)	1,147	2,008	75	2,993	4,700	57
Digestive	3 (60,622)	3 (17,694)	3 (42,928)	1,024	1,891	85	2,761	4,249	54
Endocrine	0 (−11,013)	−3 (−17,402)	0 (6,389)	−1,310	−1,626	−24	458	613	34
Intentional injuries	5 (121,373)	5 (34,935)	5 (86,438)	2,617	3,580	37	8,229	6,959	−15
Motor collisions	5 (117,815)	8 (43,073)	4 (74,741)	3,257	4,013	23	5,944	6,794	14
Neuropsychiatric	25 (583,904)	29 (182,378)	23 (401,526)	10,386	18,738	80	23,094	41,236	79
Unintentional injuries	58 (1,369,445)	60 (385,334)	58 (984,111)	26,451	39,309	49	80,273	87,181	9

Note: Columns may not add up due to rounding.

100,000 in 2019) and female (559 per 100,000 in 2019) low-volume drinkers aged 15–34 compared to other age groups.

Alcohol-attributable ED visit rates were highest among males for unintentional injuries, declining in males aged 15–34 but increasing in all other age-sex groups across the study period (Figure 2c). Rates of alcohol-attributable ED visits for neuropsychiatric conditions were among the highest and increasing in all age-sex groups. Individuals aged 65+ had increasing alcohol-attributable ED visit rates for cardiovascular and communicable diseases (males only) relative to other age groups.

Among females, alcohol-attributable hospitalisations and ED visits rates were negative for cardiovascular and endocrine conditions, specifically among low- or medium-volume drinkers and individuals aged 65+. These findings result from AAFs generated using InterMAHP assumptions and risk estimates that presume protective effects of alcohol for these conditions, a contested evidence base [26] with recent global research showing the safest level of alcohol use is none [1].

4 | DISCUSSION

This population-based study provides the most comprehensive assessment of trends in alcohol-attributable health-care encounters in Ontario, Canada over the past decade, a time of significant alcohol deregulation, including weakening price and availability policies [17]. Overall, we estimated that while males experienced the greatest burden of alcohol-attributable hospitalisations (87%) and ED visits (73%), rates increased to a greater extent in females compared to males (hospitalisations:

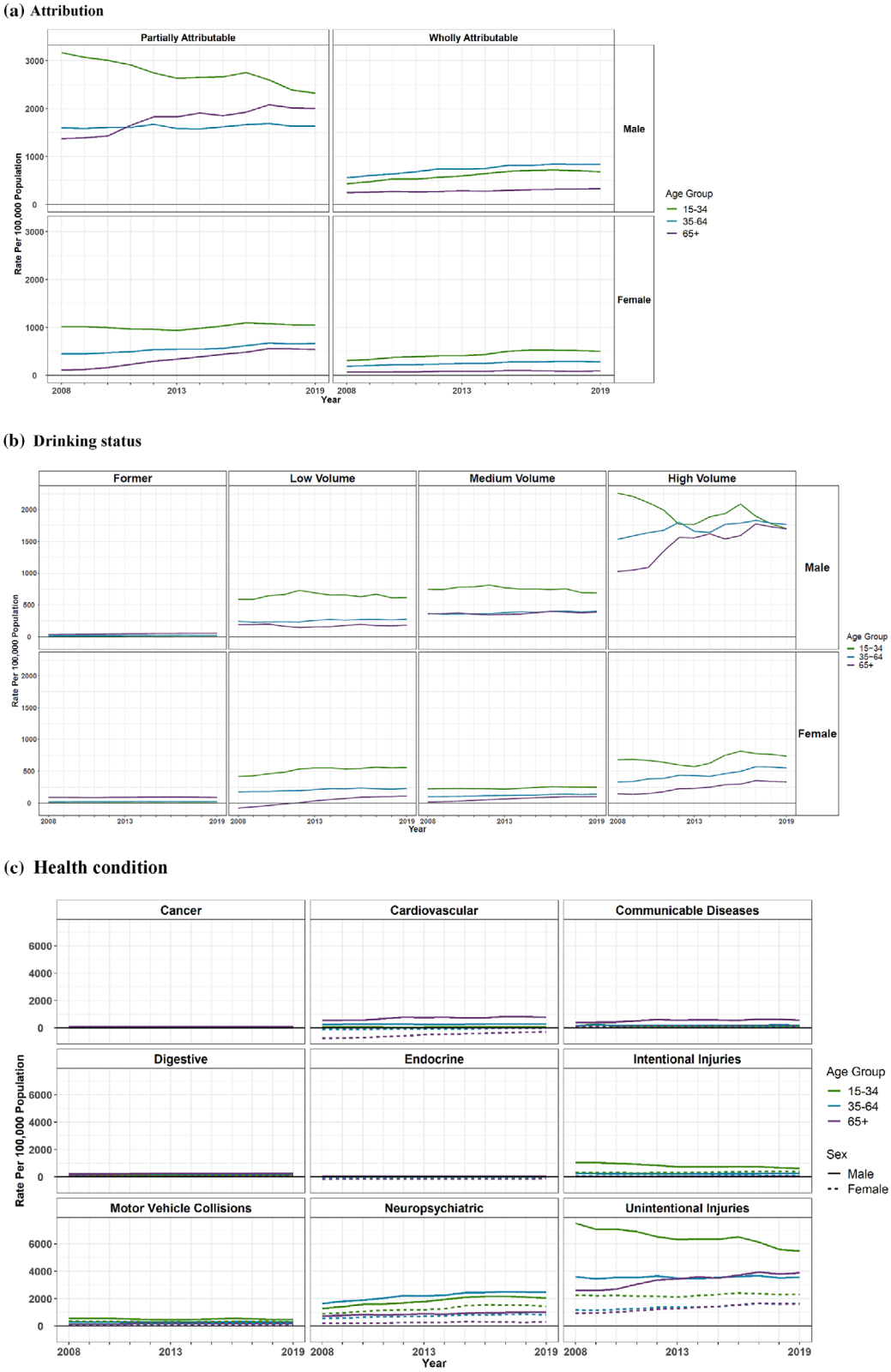

FIGURE 2 Age and sex-specific rate of alcohol-attributable emergency department visits by (a) attribution, (b) drinking status, (c) health condition between 2008 and 2019, in Ontario, Canada.

300% vs. 20%; ED visits: 37% vs. 2%). These estimates are similar in magnitude and expand on sex differences in wholly attributable hospitalisations and ED visits in, Ontario [9, 10], Canada [4], the USA, England and Australia [5–7]. One hypothesised mechanism is increased alcohol branding and marketing targeting females [28].

Furthermore, the normalisation of increased alcohol use among higher socioeconomic status females has also been suggested [29]. Additional evidence elucidating the mechanisms underlying the increasing alcohol harms among females is urgently needed [30]. In particular, given females are more susceptible than males to alcohol-attributable harms sooner and at lower levels of alcohol use [30].

No studies have estimated wholly and partially alcohol-attributable hospitalisations and ED visits in Ontario over our study period. However, our findings align with Ontario estimates from the Canadian Substance Use Costs and Harms report, which used interMAHP, showing modest increases in the rates of wholly and partially alcohol-attributable hospitalisations (12%) and ED visits (7%) between 2015 and 2017 [3]. The increasing rates of alcohol-attributable health-care encounters are concerning, and likely to continue given the increasing population-level alcohol use reported early in the COVID-19 pandemic in Canada [31] and a systematic review from 17 countries [32].

The current study extends this work as it identifies important differences by age, sex and volume-based drinking groups. Males, younger (aged 15–34, ED visits only) and middle-aged (aged 35–64) adults and high-volume drinkers contributed the greatest burden to hospitalisations and ED visits. Of concern is the increasing burden of alcohol health-care encounters among females, individuals aged 65+ (particularly among partially attributable conditions) and low/medium volume female drinkers (ED visits) over the study period.

Furthermore, individuals aged 65+ had the highest rate of alcohol-attributable hospitalisations, most commonly related to unintentional injuries and partially attributable health conditions, including cancers (i.e., oral, oesophageal, colorectal, liver, pancreatic, laryngeal, breast) and cardiovascular conditions (i.e., hypertension, ischaemic heart disease, cardiomyopathy, atrial fibrillation, arrhythmia, stroke). These results are broadly consistent with a Canadian study that found among those aged 65+, cancer, digestive, unintentional injuries and cardiovascular diseases were leading causes of alcohol-attributable deaths in 2016 [33]. The high rate of harms may be partially explained by accrued exposure to alcohol in older adults, allowing time for chronic conditions to develop, although this was not measured in our study and requires further investigation.

In our study, we inferred drinking volumes of patients with alcohol-attributable hospitalisations and ED visits based on population exposure to alcohol. We estimated that high-volume drinkers accounted for 79% and 62% of alcohol-attributable hospitalisations and ED visits, confirming findings from Canada [34] and Spain [35]. As such, a relatively small proportion of high-risk drinkers (approximately 20% of drinkers in Ontario) [36] experienced a disproportionately high burden of alcohol-attributable health-care encounters. However, importantly, low- and medium-volume drinkers also accrued a substantial number and higher rate of alcohol-attributable health-care encounters, particularly ED visits for low-volume drinkers aged 15–34 and females. One potential explanation may be binge drinking, which increases risk of impulsive or dangerous behaviours [37] and is more common among adolescents and young adults [37]. Therefore, in addition to targeting high-volume drinkers, population-level alcohol policies should aim to reduce APC by shifting the whole distribution of drinkers [38], to reduce alcohol-attributable health-care encounters in low- and medium-volume drinkers.

Our study suggests that neuropsychiatric conditions had the highest rate of alcohol-attributable hospitalisations. Similarly, a Canadian report found that nearly 3 out of 4 wholly alcohol-attributable hospitalisations in 2015–2016 were due to mental and behavioural disorders such as alcohol dependence and intoxication [4] and globally, neuropsychiatric diseases contributed most to alcohol-attributable disability-adjusted life years in 2000 [39]. Furthermore, we observed sex differences in health conditions. Among females the largest increase in alcohol-attributable health-care encounters was in communicable diseases (i.e., tuberculosis, HIV, lower respiratory tract infection) and digestive conditions (i.e., gastritis, cirrhosis, pancreatitis), whereas among males, the largest increase were in communicable diseases and neuropsychiatric conditions. The vast contribution of alcohol use to these health conditions emphasises the need for intervention to reduce the health-care system burden, as well as on individuals and their families. Reversing recent deregulation policies in Ontario, such as reenacting the annual tax increases on beer and wine and strengthening restrictions on alcohol availability, are proven strategies for reducing alcohol consumption and harm across the drinking population [14], and there is increasing evidence for their distinct impacts on high-volume drinkers [40]. In addition, continued promotion of low-risk drinking guidelines and widespread adoption of alcohol health warnings and standard drink labels would help to reduce consumption and high-volume drinking [41].

The major strength of this study is that it combines detailed data on alcohol use, sales, published meta-analyses relative risks and all hospitalisations and ED visits for partially and wholly alcohol-attributable conditions to estimate alcohol harms. Furthermore, we used internationally standardised methodologies in InterMAHP to automate the calculation of AAFs, with customisation based on regional data. Alcohol-attributable hospitalisations and ED visits would have been underestimated by 60% and 75% in our study if partially attributable conditions were omitted,

highlighting the importance of including both partially and wholly attributable conditions in alcohol harms surveillance in Canada.

Our study is not without limitations. InterMAHP's limitations are considered in detail elsewhere [19]. Briefly, the accuracy of AAF estimated by InterMAHP is dependent on model inputs. For example, the gamma distribution used to estimate AAFs may result in higher AAFs compared to using a best-fit distribution in each subgroup [42]. Furthermore, relative risks from meta-analyses used are from different countries, time periods and reflect mortality when morbidity estimates were unavailable [11]. As a best estimate, these relative risks were applied to estimate alcohol-attributable health-care encounters in Canada given the lack of Canadian-specific meta-analyses estimating alcohol use and health harms. Using alternative options may change our conclusions. Furthermore, using sex-pooled relative risk functions for some conditions may have resulted in alcohol health-care encounters being underestimated in females for conditions where females suffer disproportionally from alcohol-attributable harms compared to males when drinking equal volumes of alcohol [30]. We are unable to estimate previous level or lifetime alcohol consumption for former drinkers which may impact health-care use, and therefore have grouped them separately [11]. The true burden of wholly alcohol-attributable health-care encounters is likely underestimated in our study by only considering most responsible diagnosis (with noted exceptions). However, over 99% of the health-care encounters with alcohol-attributable secondary diagnostic codes were included in our study as partially alcohol-attributable conditions. Therefore, our estimates quantify the contribution of alcohol to health conditions most responsible for health-care encounters. Estimates of acute injuries based on average weekly consumption may be underestimated resulting from higher-risk binge drinking episodes being averaged over a week. In addition, we did not adjust sales data for unrecorded alcohol (approximately 0.9 L in 2016) and therefore APC and alcohol harms are likely underestimated in our study.

5 | CONCLUSIONS

Our findings highlight increasing alcohol-attributable hospitalisations and ED visits in Ontario, Canada over the study period. The highest burden was observed in males, younger and middle-aged adults and high-volume drinkers, with rates increasing in females and adults 65+ and in ED visits for low- and medium-volume drinkers. Monitoring trends is imperative for understanding the impacts of alcohol deregulation, occurring in jurisdictions across Canada, overall and in population subgroups more vulnerable to alcohol-caused harms.

AUTHOR CONTRIBUTIONS

Each author certifies that their contribution to this work meets the standards of the International Committee of Medical Journal Editors.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

This study received ethics clearance from Public Health Ontario's Research Ethics Board (File number: 2020-003.01).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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