Hospitalizations During the COVID-19 Pandemic Among Recently Homeless Individuals: a Retrospective Population-Based Matched Cohort Study

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BACKGROUND: Hospitalizations fell precipitously among the general population during the COVID-19 pandemic. It remains unclear whether individuals experiencing homelessness experienced similar reductions.

OBJECTIVE: To examine how overall and cause-specific hospitalizations changed among individuals with a recent history of homelessness (IRHH) and their housed counterparts during the first wave of the COVID-19 pandemic, using corresponding weeks in 2019 as a historical control.

DESIGN: Population-based cohort study conducted in Ontario, Canada, between September 30, 2018, and September 26, 2020.

PARTICIPANTS: In total, 38,617 IRHH, 15,022,368 housed individuals, and 186,858 low-income housed individuals matched on age, sex, rurality, and comorbidity burden.

MAIN MEASURES: Primary outcomes included medical-surgical, non-elective (overall and cause-specific), elective surgical, and psychiatric hospital admissions.

KEY RESULTS: Average rates of medical-surgical (rate ratio: 3.8, 95% CI: 3.7–3.8), non-elective (10.3, 95% CI: 10.1–10.4), and psychiatric admissions (128.1, 95% CI: 126.1–130.1) between January and September 2020 were substantially higher among IRHH compared to housed individuals. During the peak period (March 17 to June 16, 2020), rates of medical-surgical (0.47, 95% CI: 0.47–0.47), non-elective (0.80, 95% CI: 0.79–0.80), and psychiatric admissions (0.86, 95% CI: 0.84–0.88) were significantly lower among housed individuals relative to equivalent weeks in 2019. No significant changes were observed among IRHH. During the re-opening period (June 17–September 26, 2020), rates of non-elective hospitalizations for liver disease (1.41, 95% CI: 1.23–1.69), kidney disease (1.29, 95% CI: 1.14–1.47), and trauma (1.19, 95% CI: 1.07–1.32) increased substantially among IRHH but not housed individuals. Distinct hospitalization patterns were observed among IRHH even in comparison with more medically and socially vulnerable matched housed individuals.

CONCLUSIONS: Persistence in overall hospital admissions and increases in non-elective hospitalizations for liver disease, kidney disease, and trauma indicate that the COVID-19 pandemic presented unique challenges for recently homeless individuals. Health systems must better address the needs of this population during public health crises.

KEY WORDS: homelessness; COVID-19; hospitalizations; matched cohort; administrative health data.

INTRODUCTION

Emergency department visits and hospital admissions for a wide range of conditions fell precipitously at the onset of the COVID-19 pandemic.[1–4] Part of this decline was attributable to hospitals reducing elective surgeries and procedures due to increased strain on health system capacity.[5,6] However, substantial reductions in acute care utilization have also been observed for emergent and life-threatening conditions, such as acute myocardial infarction, ischemic stroke, and appendicitis.[7,8] This has raised concern that avoidance of care has likely contributed to the rise in excess deaths throughout the pandemic.[9,10] Many patients have reported delaying necessary care because of stay-at-home-orders, fears of being exposed to COVID-19, financial burdens, and inability to take time off from essential work and caregiving responsibilities.[11–13]

Growing evidence suggests that individuals experiencing homelessness have borne a disproportionate burden of the COVID-19 pandemic.[14–16] Homeless shelters are high-risk environments for viral transmission and rates of health

conditions and behaviors that elevate risk of COVID-19 mortality are much higher among the homeless population.[15,17] However, little is known about how the pandemic has impacted hospitalizations among this vulnerable population. Prior to the pandemic, rates of emergency department visits and hospital admissions were several fold higher among individuals experiencing homelessness compared to housed individuals with low incomes.[18–20] This is due in part to competing priorities, lack of reliable access to primary care providers, and difficulties adhering to outpatient treatment regimens.[21,22] Closure of community-based services, higher acuity disease presentations, and less access to alternative modalities of care such as telemedicine during the pandemic may have led to even greater reliance on acute care settings among the homeless population and consequently smaller reductions in acute care utilization.[23–25] However, exacerbation of systemic and structural barriers to care during the pandemic may have potentially resulted in greater reductions in acute care utilization among individuals experiencing homelessness. Understanding patterns of hospitalizations is critical for helping health systems meet the unique needs of this population during the current pandemic and future public health crises.

This study had three main objectives. First, we assessed the rates of overall and cause-specific hospital admissions in 2020 among individuals with a recent history of homelessness (IRHH) relative to housed individuals. Second, we evaluated how rates of hospitalizations changed during the 2020 pandemic among IRHH and their housed counterparts, using corresponding weeks in 2019 as historical controls. Third, we assessed whether changes in hospitalizations between 2019 and 2020 were different between IRHH and housed individuals.

METHODS

Study Design and Setting

We conducted a retrospective population-based cohort study in Ontario—the most populous province of Canada with a population of 14.8 million as of 2021—using administrative health data. Over 99% of Ontarians receive universal access to essential medical and hospital services through the single-payer Ontario Health Insurance Plan (OHIP).[26] Linkage across patient encounters in all available datasets is possible because patients present unique OHIP health card numbers at every health care encounter. Datasets were linked using unique encoded identifiers and analyzed at ICES. ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. This study followed the Reporting of Studies Conducted Using Observational Routinely Collected Data (RECORD) reporting guidelines.[27]

Data Sources

We used a number of data sources to define participants, outcomes, and covariates, including: the Discharge Abstract Database (DAD) and the Same Day Surgery (SDS) databases; the National Ambulatory Care Reporting System database; the Ontario Mental Health Reporting System (OMHRS) database; the ICES Registered Persons Database demographic and postal year databases; the OHIP physician billing claims database; and several ICES-derived population-surveillance databases, including the Chronic Obstructive Pulmonary Disease Database, the Ontario Asthma Database, the Ontario Diabetes Database, the Congestive Heart Failure Database, and the Ontario Hypertension Database. Descriptions of data sources are provided in Appendix Table 1.

Participants

All participants were followed from September 30, 2018, to September 26, 2020. Individuals were excluded if they died or entered long-term care on or before September 30, 2018, or if they did not have any contact with the healthcare system in the 9 years prior to the observation window (to remove participants unlikely to be residing in Ontario). We defined three groups of participants. The first group was IRHH, which included all individuals eligible for OHIP coverage and identified as experiencing homelessness between September 30, 2018, and September 26, 2020, through an established and previously described algorithm.[28] In brief, the algorithm identifies IRHH if an individual is documented to be experiencing homelessness during a hospital-based healthcare encounter or provided a residential address associated with shelter services at any point during the study period. The second group consisted of all Ontario residents eligible for OHIP coverage and not identified as having a recent history of homelessness. This group will be referred to as housed individuals for brevity. The third group (matched housed individuals) was created by restricting the second group to those with at least one hospital-based healthcare encounter during the study period and residing in a lowest income quintile neighborhood. This group was matched 5:1 (using greedy matching) to the IRHH group based on age (± 2 years), sex (exact), level of rurality (exact), and Charlson Comorbidity Index score (exact). Level of rurality was defined through Census Metropolitan Areas (CMAs), which are one or more neighboring municipalities situated around a core population. Categories included large CMAs (>500,000 population), medium CMAs (100,000–500,000 population), small CMAs (10,000–10,000 population), and non-CMAs.

Outcomes

The main outcomes of this study were medical-surgical admissions, non-elective admissions, elective surgical admissions, and psychiatric admissions. Databases and data fields used to identify categories of hospitalizations are listed

in Appendix Table 2. Briefly, medical-surgical admissions included all entries in DAD and SDS, non-elective admissions included entries labeled as urgent or emergent in DAD, elective surgical admissions included all entries in SDS and entries labeled as elective and surgical in DAD, and psychiatric admissions included all entries in OMHRS. *International Classification of Diseases, 10th Revision* (ICD-10) codes were used to identify non-elective admissions with the following most responsible diagnoses: diabetes, heart disease, cerebrovascular disease, influenza and pneumonia, chronic lower respiratory disease, liver disease, kidney disease, skin and soft tissue infection, and trauma (Appendix Table 3). These causes represented the leading causes of non-psychiatric hospital admissions and mortality before the COVID-19 pandemic among the homeless population.[29,30] Outcomes were ascertained between January 5 and September 26, 2020, along with corresponding weeks in 2019.

Covariates

We obtained sociodemographic characteristics for all groups at the start of the observation window (September 30, 2018), including age, sex, neighborhood income quintile, and level of rurality. To compare comorbidity burden across groups, we calculated Charlson Comorbidity Index scores using hospitalization data from 2 years prior to the observation window and ascertained past diagnoses of asthma or chronic obstructive pulmonary disease (COPD), diabetes, congestive heart failure, hypertension, and chronic liver disease. Additionally, we measured care received for psychotic disorders, non-psychotic mental health disorders, and substance use disorders in the year prior to the observation window.

Statistical Analysis

We used χ^2 and Cochran-Armitage tests to compare group characteristics at baseline. Because IRHH and housed individuals included nearly all residents of Ontario, we also reported standardized differences between groups, which assess differences between group means as a percentage of the pooled standard deviation. Standardized differences of 0.1 or more were considered meaningful.[31]

We calculated weekly rates (per 100,000 individuals) of hospitalization categories for each group throughout the study period, using the cohort at risk that week as the denominator. Individuals were excluded from the denominator if they died or entered long-term care. Weekly rate ratios were calculated by dividing weekly rates in 2020 with corresponding weekly rates in 2019.

Two pandemic periods of interest in 2020 were defined for this analysis based on two major events during the first wave of the COVID-19 pandemic in Ontario. The first event was the initial declaration of a state of emergency and province-wide lockdown in Ontario, which occurred on March 17, 2020. The second event was the staggered province-wide re-opening in Ontario, which began in the middle of June 2020. Therefore,

the pandemic periods of March 17–June 16 and June 17–September 26 were designated as the peak and re-opening periods in 2020, respectively.

Poisson regression models with population size offsets were first used to compute rate ratios and 95% confidence intervals (CIs) for each outcome. These models compared groups between January 2020 and September 2020. Second, separate models were then constructed for each group and pandemic period to compare weekly rates of hospitalization categories and cause-specific admissions in 2020 to corresponding weekly rates in 2019. Finally, interaction terms between group (IRHH vs housed individuals or IRHH vs matched housed individuals) and year (2020 vs 2019) were added to another set of models to evaluate whether changes in hospitalization categories and cause-specific admissions from 2019 and 2020 were different between groups for each pandemic period.

Two-sided $p<0.05$ defined statistical significance. Analyses were performed using R 4.0.0 and SAS 9.4. This study was reviewed and approved by the Research Ethics Board of Unity Health Toronto.

RESULTS

We identified 38,617 IRHH, 15,022,369 housed individuals, and 186,858 matched housed individuals (Appendix Figure 1). IRHH were more likely than housed individuals to be young adults (36.3% vs 21.7%) and male (68.0% vs 49.3%), reside in lowest income quintile neighborhoods (41.7% vs 19.6%), have higher Charlson Comorbidity Index scores, have asthma/COPD (22.8% vs 15.0%) and chronic liver disease (11.8% vs 2.1%), and have received recent care for psychotic disorders (25.3% vs. 1.1%), non-psychotic mental health disorders (48.3% vs 11.3%), and substance use disorders (40.9% vs 1.3%) (Table 1). Matched housed individuals were similar to IRHH in terms of age, sex, level of rurality, and overall level of comorbidity. However, IRHH were still more likely to have received recent care for mental health and substance use disorders.

The number and average rates (per 100,000 individuals) of medical-surgical admissions, non-elective admissions, elective surgical admissions, and psychiatric admissions between January 2020 and September 2020 for IRHH, matched housed individuals, and housed individuals are shown in Table 2. Compared to housed individuals, IRHH had significantly higher rates of medical-surgical admissions (rate ratio [RR]: 3.8, 95% CI: 3.7–3.8), non-elective admissions (RR: 10.3, 95% CI: 10.1–10.4), and psychiatric admissions (RR: 128.1, 95% CI: 126.1–130.1). After matching, rates of medical-surgical admissions (RR: 1.67, 95% CI: 1.65–1.69), non-elective admissions (RR: 3.6, 95% CI: 3.5–3.7), and psychiatric admissions (RR: 21.1, 95% CI: 20.4–21.7) remained higher among IRHH compared to matched housed individuals. Rates of elective surgical admissions were lower among IRHH compared to matched housed individuals (RR:

Table 1 Group Characteristics at Index

Characteristics	IRHH (N=38,617)	Housed individuals (N=15,022,369)	Matched housed individuals[1] (N=186,858)	STD difference (IRHH vs housed)	P-value (IRHH vs housed)	STD difference (IRHH vs matched)	P-value (IRHH vs matched)
Age group, N (%)							
Youth (< 25 yrs)	7429 (19.2)	4,117,377 (27.4)	36,311 (19.4)	0.19	<0.001	0.01	0.008
Young Adults (25 to 39 yrs)	14,021 (36.3)	3,254,132 (21.7)	66,192 (35.4)	0.33		0.02	
Older Adults (40 to 64 yrs)	14,557 (37.7)	5,108,358 (34.0)	71,300 (38.2)	0.08		0.01	
Seniors (65+ yrs)	2610 (6.8)	2,542,502 (16.9)	13,055 (7.0)	0.32		0.01	
Female, N (%)	12,346 (32.0)	7,620,547 (50.7)	61,569 (32.9)	0.39	<0.001	0.02	<0.001
Income quintile[2]							
Quintile 1 (lowest)	16,091 (41.7)	2,942,457 (19.6)	186,858 (100.0)	0.49	<0.001	N/A	N/A
Quintile 2	8126 (21.0)	2,923,710 (19.5)	0 (0.0)	0.04			
Quintile 3	7130 (18.5)	3,176,456 (21.1)	0 (0.0)	0.07			
Quintile 4	3807 (9.9)	2,983,780 (19.9)	0 (0.0)	0.28			
Quintile 5 (highest)	3463 (9.0)	2,995,966 (19.9)	0 (0.0)	0.32			
Level of rurality, N (%)							
Large CMA (>500K)	22,004 (57.0)	9,184,393 (61.1)	107,068 (57.3)	0.08	<0.001	0.01	<0.001
Medium CMA (100-500K)	10,237 (26.5)	3,060,852 (20.4)	49,275 (26.4)	0.15		0	
Small CMA (10-100K)	2963 (7.7)	1,013,810 (6.7)	14,487 (7.8)	0.04		0	
Non-CMA regions	2343 (6.1)	1,291,557 (8.6)	11,579 (6.2)	0.10		0.01	
Unknown or missing	1070 (2.8)	471,757 (3.1)	4449 (2.4)	0.02		0.02	
Charlson Comorbidity Index score, N (%)[3]							
No hospitalizations	28,658 (74.2)	13,612,789 (90.6)	142,877 (76.5)	0.44	<0.001	0.05	<0.001
0	6647 (17.2)	1,028,454 (6.8)	28,502 (15.3)	0.32		0.05	
1	1699 (4.4)	161,215 (1.1)	7789 (4.2)	0.20		0.01	
2+	1613 (4.2)	219,911 (1.5)	7690 (4.1)	0.16		0	
Specific comorbidities, N (%)							
Asthma or COPD	8799 (22.8)	2,256,288 (15.0)	34,994 (18.7)	0.20	<0.001	0.1	<0.001
Diabetes	4142 (10.7)	1,422,309 (9.5)	22,929 (12.3)	0.04	<0.001	0.05	<0.001
Congestive heart failure	841 (2.2)	253,322 (1.7)	4179 (2.2)	0.04	<0.001	0	0.481
Hypertension	5793 (15.0)	3,041,309 (20.2)	35,948 (19.2)	0.14	<0.001	0.11	<0.001
Chronic liver disease	4547 (11.8)	322,277 (2.1)	8836 (4.7)	0.39	<0.001	0.26	<0.001
Care for mental health disorders, N (%)[4]							
Psychotic disorders	9782 (25.3)	168,340 (1.1)	7002 (3.7)	0.77	<0.001	0.64	<0.001
Non-psychotic disorders	18,666 (48.3)	1,704,326 (11.3)	37,315 (20.0)	0.88	<0.001	0.63	<0.001
Substance use disorders	15,810 (40.9)	198,616 (1.3)	11,932 (6.4)	1.11	<0.001	0.89	<0.001

[1]*Community-dwelling Ontarians living in income quintile 1 neighborhoods with recent contact with the healthcare system who are matched to individuals with a recent history of homelessness (5:1) on age, sex, level of rurality, and Charlson Comorbidity Index score*
[2]*Dissemination area level income quintile, derived from 2016 Census data. Missing and unknown values were recoded to income quintile 3.*
[3]*Calculated using hospitalization data from the past 2 years*
[4]*Occuring in the past year*
STD standardized, CMA Census Metropolitan Area, COPD chronic obstructive pulmonary disease, IQR interquartile range

0.51, 95% CI: 0.50–0.52) and were similar compared to housed individuals (RR: 1.00, 95% CI: 0.97–1.03).

Weekly rate ratios of hospital admissions in 2020 versus 2019 for IRHH, matched housed individuals, and housed individuals are shown in Figure 1. During the peak period in 2020 (March 17–June 16), rates of medical-surgical admissions were marginally lower among IRHH (RR: 0.93, 95% CI: 0.89–0.97) and much lower among matched housed individuals (RR: 0.54, 95% CI: 0.52–0.55) and housed individuals (RR: 0.47, 95% CI: 0.47–0.47) compared to

corresponding weeks in 2019 (Table 3). Rates of non-elective admissions were lower among matched housed individuals (RR: 0.80, 95% CI: 0.77–0.84) and housed individuals (RR: 0.80, 95% CI: 0.79–0.80), but no changes were observed for IRHH (RR: 1.02, 95% CI: 0.98–1.07). Rates of elective surgical admissions were lower among IRHH (RR: 0.55, 95% CI: 0.49–0.61) and substantially lower among matched housed individuals (RR: 0.34, 95% CI: 0.33–0.36) and housed individuals (RR: 0.32, 95% CI: 0.32–0.32). Rates of psychiatric admissions were lower among matched housed

Table 2 Hospital Admissions Among IRHH Compared with Other Groups, January 2020 to September 2020

Categories	Group	Events	Average rate (per 100,000)	Rate ratio IRHH vs matched (95% CI)[2]	Rate ratio IRHH vs housed (95% CI)[2]
Medical-surgical admissions	IRHH	13,420	957.0	1.67 (1.65–1.69)	3.8 (3.7–3.8)
	Matched1	35,228	505.6	Ref	-
	Housed	1,233,187	218.6	-	Ref
Non-elective admissions	IRHH	10,915	778.3	3.6 (3.5–3.7)	10.3 (10.1–10.4)
	Matched1	14,073	202.0	Ref	-
	Housed	402,198	71.3	-	Ref
Elective surgical admissions	IRHH	2136	147.2	0.51 (0.50–0.52)	1.00 (0.97–1.03)
	Matched1	18,957	272.0	Ref	-
	Housed	769,746	136.4	-	Ref
Psychiatric admissions	IRHH	10,335	737.0	21.1 (20.4–21.7)	128.1 (126.1–130.1)
	Matched1	2,381	34.2	Ref	-
	Housed	31,637	5.6	-	Ref

[1]Housed Ontarians residing in lowest income quintile neighborhoods with a recent hospital-based healthcare encounter matched to IRHH (5:1) on age, sex, level of rurality, and Charlson Comorbidity Index score
[2]Rate ratios and 95% confidence intervals estimated using Poisson regression models

individuals (RR: 0.87, 95% CI: 0.79–0.96) and housed individuals (RR: 0.86, 95% CI: 0.84–0.88). No changes were observed for IRHH (RR: 0.99, 95% CI: 0.95–1.04). Significant interaction terms between group and year for all hospitalization categories indicate that reductions in medical-surgical, non-elective, elective surgical, and psychiatric admissions during the peak period were more pronounced among matched housed individuals and housed individuals relative to IRHH.

During the re-opening period (June 17–September 26), rates of all categories of hospitalizations rebounded to near pre-pandemic levels. No differences in hospitalization rates were observed among IRHH between 2019 and 2020 during this period. However, reductions in medical-surgical admissions (10–13%), non-elective admissions (3–4%), and elective surgical admissions (14–18%) were still observed among matched housed individuals and housed individuals. Changes between 2019 and 2020 for these categories of hospitalizations among matched housed individuals and housed individuals were still significantly different compared to those among IRHH.

Rate ratios of cause-specific non-elective hospital admissions in 2020 versus 2019 for IRHH, matched housed individuals, and housed individuals during the peak and re-opening periods are shown in Table 4. During the peak period, rates of admissions declined among matched housed individuals and housed individuals compared to corresponding 2019 weeks across all causes. Reductions in hospitalizations exceeding 20% were observed for diabetes, heart disease, chronic lower respiratory disease, liver disease, skin and soft tissue infection, and trauma. No meaningful reductions were observed for any cause-specific admissions among IRHH during the peak period. During the re-opening period, rates of hospitalizations for liver disease (RR: 1.41, 95% CI: 1.23–1.69), kidney disease (RR: 1.29, 95% CI: 1.14–1.47), and trauma (RR: 1.19, 95% CI: 1.07–1.32) increased among IRHH compared to equivalent 2019 weeks. Interaction

terms between group and year were significant for all three causes, indicating that IRHH experienced larger relative increases in admissions for liver disease, kidney disease, and trauma during the re-opening period compared to both matched housed individuals and housed individuals.

DISCUSSION

During the first 4 months of the COVID-19 pandemic, medical-surgical, non-elective, and psychiatric admissions decreased by approximately 50%, 20%, and 15%, respectively, among housed individuals compared to equivalent 2019 weeks. Such reductions were not observed among IRHH. Between June and September 2020, hospitalization rates returned to near pre-pandemic periods among housed individuals. However, rates of non-elective hospital admissions for liver disease, kidney disease, and trauma during this period increased substantially among IRHH compared to corresponding 2019 weeks. Either no increases or significantly smaller increases in hospital admissions for these causes were observed among housed individuals.

Our findings demonstrate that sweeping reductions in hospitalizations observed for the housed population did not extend to the homeless population during the COVID-19 pandemic. Rates of all categories of hospital admissions in 2020 remained virtually unchanged among IRHH compared to corresponding weeks in 2019. There are several potential contributors to these distinct patterns. First, the homeless population may be less likely to defer care at hospitals given increased reliance on these care settings and differing determinants of health care utilization relative to the housed population.[18–20] Emerging evidence suggests that fear of COVID-19 was not associated with decreases in hospitalizations among the homeless population.[32] Second, greater comorbidity burden within the homeless population
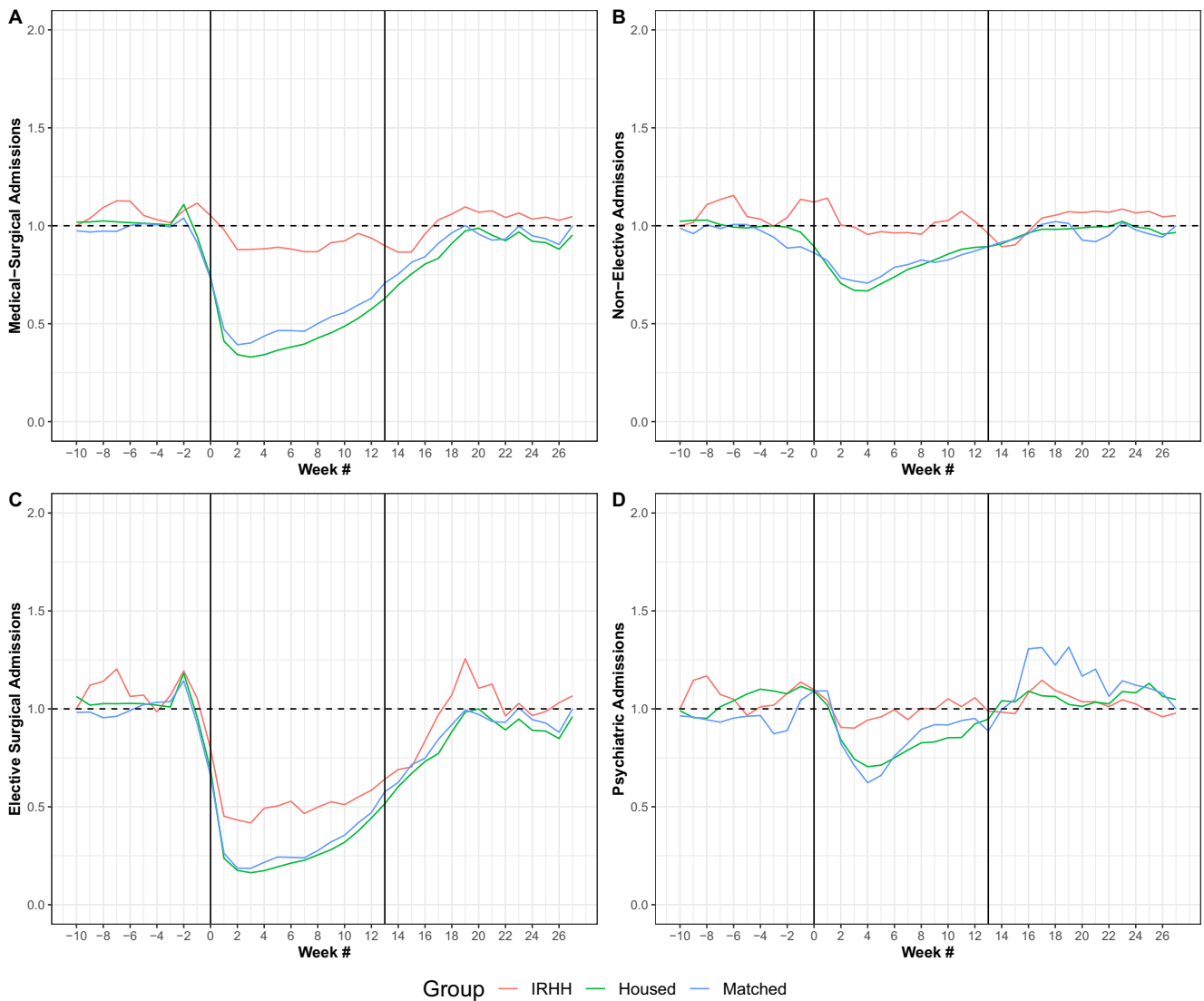
Figure 1. Weekly rate ratios of hospital admissions among IRHH and housed individuals (2020 vs 2019). Weeks -10, 0, and 27 refer to the weeks of January 5, March 15, and September 20 in 2020, respectively. The first vertical line (Week 0) marks the beginning of the peak period, corresponding to the initial state of emergency and province-wide lockdown in Ontario. The second vertical line (Week 13) marks the beginning of the re-opening period. Panel A shows medical-surgical admissions, panel B shows non-elective admissions, panel C shows elective surgical admissions, and panel D shows psychiatric admissions.

may have contributed to higher acuity disease presentations and hospital admissions that were not easily deferred or avoided during the pandemic.[29,33] Third, individuals experiencing homelessness face unique difficulties in managing complex chronic conditions, such as barriers to medication adherence, competing priorities, and lack of social support.[34–36] These difficulties have likely been exacerbated by closures in community-based health services and worse access to innovative and remote supports (e.g., telemedicine, hospital-at-home, and medication delivery) that emerged during the pandemic to fill gaps in care delivery for the general population.[37–39]

We also observed that non-elective hospital admissions for liver disease, kidney disease, and trauma increased greatly for IRHH between June and September 2020. Similar increases were not observed among housed individuals or those with high medical and social vulnerability. More admissions for

liver disease may be attributed to increases in alcohol consumption, secondary to social isolation and other stressors associated with the pandemic.[40] Particularly large barriers to outpatient care and unmet health needs may have contributed to increases in kidney disease burden in this population.[41,42] Greater susceptibility to victimization, intimate partner violence, unintentional injury, and substance use among IRHH may have been further exacerbated by the pandemic, potentially driving increases in trauma admissions.[25,43,44]

These results indicate that the homeless population has been disproportionately harmed by both the direct and indirect effects of the COVID-19 pandemic. Health systems must address the unique health needs of this population during the current pandemic and be prepared to mitigate such harms during future public health crises. Perhaps more importantly, public health and policy efforts are urgently needed to address

Table 3 Changes in Weekly Hospital Admission Rates by Group and Pandemic Period (2020 vs 2019)

Categories	Group	Peak1		Re-opening2	
		Rate ratio (95% CI)3	Interaction *P*-value4	Rate ratio (95% CI)3	Interaction *P*-value4
Medical-surgical admissions	IRHH	**0.93 (0.89–0.97)**	Ref	1.01 (0.97–1.04)	Ref
	Matched5	**0.54 (0.52–0.55)**	**<0.001**	**0.90 (0.88–0.92)**	**<0.001**
	Housed	**0.47 (0.47–0.47)**	**<0.001**	**0.87 (0.86–0.87)**	**<0.001**
Non-elective Admissions	IRHH	1.02 (0.98–1.07)	Ref	1.02 (0.98–1.06)	Ref
	Matched5	**0.80 (0.77–0.84)**	**<0.001**	**0.96 (0.92–0.99)**	**0.02**
	Housed	**0.80 (0.79–0.80)**	**<0.001**	**0.97 (0.96–0.98)**	**0.02**
Elective surgical admissions	IRHH	**0.55 (0.49–0.61)**	Ref	0.93 (0.86–1.02)	Ref
	Matched5	**0.34 (0.33–0.36)**	**<0.001**	**0.86 (0.83–0.88)**	0.07
	Housed	**0.32 (0.32–0.32)**	**<0.001**	**0.82 (0.82–0.82)**	**0.004**
Psychiatric admissions	IRHH	0.99 (0.95–1.04)	Ref	1.03 (0.98–1.07)	Ref
	Matched5	**0.87 (0.79–0.96)**	**0.02**	**1.11 (1.02–1.22)**	0.112
	Housed	**0.86 (0.84–0.88)**	**<0.001**	**1.05 (1.02–1.08)**	0.405

Bolded results are significant at the P<0.05 level
[1]*Peak pandemic period: March 17, 2020, to June 16, 2020, versus equivalent 2019 weeks*
[2]*Re-opening period: June 17, 2020, to September 26, 2020, versus equivalent 2019 weeks*
[3]*Rate ratios and 95% confidence intervals estimated using Poisson regression models including an interaction term between group and year*
[4]*Interaction between group (IRHH vs housed individuals or IRHH vs matched housed individuals) and year (2020 versus 2019).*
[5]*Housed Ontarians residing in lowest income quintile neighborhoods with a recent hospital-based healthcare encounter matched to IRHH (5:1) on age, sex, level of rurality, and Charlson Comorbidity Index score*

the upstream social determinants that drive acute care utilization such as homelessness and poverty.[17,45]

Limitations

There are several limitations to note regarding this study. First, outcomes were ascertained from linked health administrative data, which allowed us to follow all Ontarians eligible for OHIP coverage. While health insurance is near-universal in Ontario, OHIP eligibility does not encompass certain groups such as Indigenous persons living on reserves and refugee claimants who do not meet the definition outlined by the 1951 Geneva Convention. Both groups are overrepresented in the Canadian homeless population; and therefore, study findings should only be generalized to recently homeless individuals with provincial insurance coverage in similar settings.[46] Second, our case definition of recent history of homelessness relies on interactions with hospital-based healthcare or documented residential addresses associated with shelter services. This methodology has been shown to be highly specific (>99.9%) but relatively insensitive, failing to capture a subgroup of the homeless population who do not use health or shelter services.[28] However, we sought to address this limitation by creating a matched group of medically and socially vulnerable housed individuals based on a similar requirement of recent interaction with hospital-based healthcare, allowing for more direct comparisons. Relatedly,

such identification criteria based on recent interaction with hospital-based healthcare likely inflated rates of observed hospital admissions among IRHH and matched housed individuals. Third, homelessness is a heterogenous experience and we could not differentiate between subgroups of individuals experiencing homelessness with available data, such as the chronically homeless, unsheltered, or those who were temporarily sheltered in hotels and other facilities during the pandemic. Changes in patterns of acute care utilization across these subgroups throughout the pandemic should be further explored. Finally, this study did not investigate factors associated with acute care utilization among homeless and housed individuals during the COVID-19 pandemic. This remains an important area for future investigation through both quantitative and qualitative methodologies.

CONCLUSIONS

Unlike their housed counterparts, recently homeless individuals did not experience large reductions across all categories of hospital admissions during the COVID-19 pandemic. This population also had significantly higher rates of non-elective hospitalizations for liver disease, kidney disease, and trauma during the summer months of 2020. These observed patterns were distinct even in comparison with more medically and socially vulnerable housed individuals,

Table 4 Changes in Causes of Hospital Admissions by Group and Pandemic Period (2020 vs 2019)[1]

Outcomes	Group	Peak[1]		Re-opening[2]	
		Rate ratio (95% CI)[3]	Interaction *P*-value[4]	Rate ratio (95% CI)[3]	Interaction *P*-value[4]
Diabetes	IRHH	0.93 (0.85–1.02)	Ref	0.95 (0.87–1.03)	Ref
	Matched[5]	**0.65 (0.62–0.69)**	**<0.001**	**0.93 (0.88–0.98)**	0.702
	Housed	**0.58 (0.58–0.59)**	**<0.001**	**0.90 (0.89–0.91)**	0.230
Heart disease	IRHH	0.98 (0.88–1.10)	Ref	1.10 (0.99–1.21)	Ref
	Matched[5]	**0.77 (0.72–0.83)**	**<0.001**	**0.90 (0.83–0.96)**	**<0.001**
	Housed	**0.72 (0.71–0.73)**	**<0.001**	**0.96 (0.94–0.97)**	**0.008**
Cerebrovascular disease	IRHH	1.10 (0.82–1.48)	Ref	1.17 (0.86–1.59)	Ref
	Matched[5]	0.90 (0.73–1.13)	0.291	1.07 (0.88–1.30)	0.639
	Housed	**0.87 (0.84–0.90)**	0.123	1.01 (0.98–1.04)	0.362
Influenza and Pneumonia	IRHH	1.11 (0.97–1.28)	Ref	0.92 (0.79–1.08)	Ref
	Matched[5]	**0.82 (0.73–0.93)**	**0.001**	1.03 (0.90–1.19)	0.287
	Housed	**0.82 (0.80–0.84)**	**<0.001**	**0.84 (0.82–0.86)**	0.198
Chronic lower respiratory disease	IRHH	1.10 (0.98–1.24)	Ref	1.11 (0.99–1.25)	Ref
	Matched[5]	**0.69 (0.61–0.78)**	**<0.001**	**0.76 (0.67–0.86)**	**<0.001**
	Housed	**0.63 (0.62–0.65)**	**<0.001**	**0.79 (0.77–0.80)**	**<0.001**
Liver disease	IRHH	0.98 (0.83–1.17)	Ref	**1.44 (1.23–1.69)**	Ref
	Matched[5]	**0.73 (0.63–0.85)**	**0.01**	**0.87 (0.76–0.99)**	**0.04**
	Housed	**0.71 (0.68–0.73)**	**<0.001**	1.02 (0.99–1.05)	**<0.001**
Kidney disease	IRHH	1.03 (0.90–1.18)	Ref	**1.29 (1.14–1.47)**	Ref
	Matched[5]	**0.90 (0.82–0.99)**	0.105	1.07 (0.98–1.18)	**0.02**
	Housed	**0.90 (0.88–0.91)**	**0.04**	**1.08 (1.06–1.09)**	**0.006**
Skin and soft tissue infection	IRHH	1.10 (0.97–1.24)	Ref	1.09 (0.98–1.23)	Ref
	Matched[5]	**0.78 (0.66–0.91)**	**<0.001**	1.15 (1.00–1.33)	0.590
	Housed	**0.64 (0.62–0.66)**	**<0.001**	**0.91 (0.88–0.93)**	**0.002**
Trauma	IRHH	0.89 (0.79–1.01)	Ref	**1.19 (1.07–1.32)**	Ref
	Matched[5]	**0.75 (0.67–0.84)**	**0.04**	0.96 (0.88–1.06)	**0.004**
	Housed	**0.77 (0.75–0.78)**	**0.02**	**1.03 (1.02–1.05)**	**<0.001**

Bolded results are significant at the P<0.05 level
[1]*Peak pandemic period: March 17, 2020, to June 16, 2020, versus equivalent 2019 weeks*
[2]*Re-opening period: June 17, 2020, to September 26, 2020, versus equivalent 2019 weeks*
[3]*Rate ratios and 95% confidence intervals estimated using Poisson regression models including an interaction term between group and year*
[4]*Interaction between group (IRHH vs housed individuals or IRHH vs matched housed individuals) and year (2020 versus 2019)*
[5]*Housed Ontarians residing in lowest income quintile neighborhoods with a recent hospital-based health care encounter matched to IRHH (5:1) on age, sex, level of rurality, and Charlson Comorbidity Index score.*

suggesting that the experience of homelessness presented unique challenges during the pandemic. Public health and policy interventions are required to address persistent gaps in support and meet the unique health needs of this population during and beyond the COVID-19 pandemic.

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Declarations:

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