Drug and Alcohol Dependence 238 (2022) 109568

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

Rural-urban disparities in post-discharge outcomes following alcohol-related hospitalizations in Ontario, Canada: A retrospective cohort study

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ARTICLE INFO

Keywords:
Alcohol use
Rural health
Alcohol-related hospitalization
Mental health
Health services
Alcohol use disorder

ABSTRACT

Background: Limited access to mental health and addiction (MHA) services in rural areas may increase the risk of recurrent alcohol-related harm among rural, relative to urban, residents. This study evaluated (1) rural-urban differences in clinical trajectories following alcohol-related hospitalizations and (2) whether limited access to MHA services mediates an increased risk of adverse post-discharge outcomes in rural areas.

Methods: This was a population-based retrospective cohort study of individuals in Ontario, Canada, who experienced an alcohol-related hospitalization between 2016 and 2018. The primary exposure was rurality. The outcomes of interest were outpatient MHA care, alcohol-related emergency department visits, alcohol-related hospitalizations, and all-cause mortality within one-year of discharge from the index alcohol-related hospitalization. Data were collected using provincial health administrative databases. The associations between rurality and the time to each outcome were assessed using multivariable time-to-event regression. Mediation analyses were conducted using a counterfactual approach.

Results: 46,657 individuals were included. 11.5% of the cohort died within one year of discharge from the index alcohol-related hospitalization. Relative to urban residents, rural residents were less likely to receive MHA outpatient care (adjusted hazard ratio (aHR): 0.80, 95% confidence interval (CI): 0.75–0.86) and more likely to die (aHR: 1.19, 95% CI: 1.06–1.34) in the year following discharge. The lower likelihood of post-discharge MHA-related care among rural residents mediated 31% (95% CI: 13–46%) of the increased risk of mortality.

Conclusions: A lack of follow-up MHA care mediates an increased risk of short-term mortality following alcohol-related hospitalizations in rural, relative to urban, communities.

1. Introduction

Alcohol use is a leading cause of morbidity and mortality worldwide, and hospitalizations for alcohol-related health conditions are common (Griswold et al., 2018). In Canada, there are more than 80,000 alcohol-related hospitalizations per year, which exceeds the rate of hospitalization for to acute myocardial infarction, and similarly high rates have been reported in the United States (US, Adams et al., 1993; Canadian Institute for Health Information, 2017). There are 52 health conditions listed in the *International Classification of Disease – 10th Edition* (ICD-10) that are entirely attributable to alcohol, insofar as they would not have occurred in the absence of alcohol use (Rehm et al., 2017). These include health conditions related to acute high-volume alcohol use (e.g., alcohol intoxication, poisoning by exposure to alcohol) as well

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https://doi.org/10.1016/j.drugalcdep.2022.109568
Received 4 February 2022; Received in revised form 7 July 2022; Accepted 8 July 2022
Available online 10 July 2022

as those related to long-term high-volume alcohol use (e.g., alcohol withdrawal, alcoholic liver disease).

Given the multitude of alcohol-related diagnoses, alcohol-related hospitalizations can vary in terms of their length, the types of interventions provided in during the inpatient stay, and the types of follow-up outpatient services that are received. However, regardless of the underlying health condition, almost all people who are hospitalized for an alcohol-related reason meet the clinical criteria for an alcohol use disorder (AUD, Kim et al., 2012; Quan et al., 2008), and outcomes following alcohol-related hospitalizations are poor, with high rates of short-term readmission and mortality (Garg et al., 2019; Hoy, 2017; Lee et al., 2019; Weinland et al., 2019; Yedlapati and Stewart, 2018). Therefore, understanding clinical trajectories following alcohol-related hospitalization, including the demographic and clinical subgroups that are at high risk of post-discharge harm, is an important step towards developing effective public health solutions to reduce the risk of recurrent harm in this population.

Individuals living in rural communities are a demographic subgroup that merit attention. In 2017, rates of alcohol-related hospitalization were 50% higher in rural, relative to urban, Canadian communities, and similar disparities have been shown in the US (Friesen et al., 2022; Canadian Institute for Health Information, 2017). The problem also appears to be getting worse. Indeed, rates of alcohol-related harms and deaths in the US and Canada have increased substantially over the past two decades with larger increases in rural compared to urban regions (Myran et al., 2021, 2019). These increases in alcohol-related harms are part of larger trend of increasing morbidity and mortality due to alcohol, drug use, and suicide which have been termed 'deaths of despair' (Stein et al., 2017). It has been proposed that a key driver of these trends are worsening social and economic factors related to a reduction in job opportunities and opportunities for upward social mobility (Stein et al., 2017). However, the impact of geographic disparities in access to mental health and addiction (MHA) services is less well understood.

Individuals living in rural areas of Canada and the US have limited access to MHA services, often due to long travel times to nearest care, resulting in a reduced likelihood of receiving treatment for AUD than individuals living in larger centres (Edmonds et al., 2020; Friesen, 2019; Kurdyak et al., 2014). This is problematic because early AUD treatment following alcohol-related hospitalization is known to reduce the risk of short-term readmission and mortality (Kamath et al., 2020). In turn, rural, relative to urban, residents may be at a higher risk of harm following alcohol-related hospitalization because they are (1) at a higher risk of baseline harm and (2) less likely to receive follow-up MHA-related care to reduce the risk of recurrent harm. To date, however, there has been little research on the association between rurality and clinical outcomes following alcohol-related hospitalization. To address this gap in knowledge, the objectives of this study were to (1) evaluate the association between rurality and clinical outcomes (outpatient MHA-related care, alcohol-related ED visits, readmission, and mortality) following alcohol-related hospitalizations, and (2) understand whether a lack of post-discharge MHA-related care in rural, relative to urban, communities mediates an increased risk of adverse post-discharge outcomes.

2. Methods

2.1. Study design

This was a population-based retrospective cohort study of individuals in Ontario, Canada with an alcohol-related hospitalization discharge between January 1, 2016 and December 31, 2018. For individuals with more than one discharge in the accrual window, one was randomly chosen as the 'index hospitalization'. This was preferable to assigning the first hospitalization as the index event because recurrent alcohol-related hospitalizations are common in this population (a recent study found a 59% 1-year readmission rate for individuals hospitalized for alcohol withdrawal in the US (Yedlapati and Stewart, 2018)), such that this would have resulted in a clustering of index events at the beginning of the accrual window. We included a 2-year lookback for psychiatric and medical comorbidities starting from the date of the index admission and a 1-year follow-up period for study outcomes starting from the date of the index hospitalization discharge. Individuals were excluded from the cohort if they were < 10 or > 105 years old, were not an Ontario resident, had a missing or invalid ICES Key Number (IKN, required for database linkage), had a missing or invalid postal code (required for rurality categorization), were not eligible for public health insurance (via the *Ontario Health Insurance Plan* [OHIP]) for the entirety of the 2-year lookback window (required to determine medical history), or died prior to discharge from the index hospitalization.

2.2. Data sources

Linked health administrative databases housed at ICES, Ontario's largest health data repository, were used to identify all data used for this study. ICES databases contain health service use information for all Ontarians with healthcare coverage through OHIP, which represents virtually all residents of the province. In this study, only 1.2% of individuals ($n = 1072$) were excluded because they were not eligible for OHIP (Supplementary Table 1), with the main reason for ineligibility being that an individual had lived in Ontario for less than three months after moving from another province or country. The use of the data in this project is authorized under section 45 of Ontario's Personal Health Information Protection Act (PHIPA) and does not require review by a Research Ethics Board.

Alcohol-related ED visits and hospitalizations were identified using a previously described *Canadian Institute for Health Information* (CIHI) indicator "Hospitalizations Entirely Caused by Alcohol", which is based on *International Classification of Disease – 10th Edition* (ICD-10) and *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) codes (Supplementary Table 2; Canadian Institute for Health Information, 2020). Using these codes, ED visits were identified in the *National Ambulatory Care Reporting System* (NACRS) database and hospitalizations were identified in the CIHI *Discharge Abstract Database* (DAD) and *Ontario Mental Health Reporting System* (OMHRS). Outpatient psychiatrist and MHA-related primary care visits were identified in the *OHIP Claims Database*, using a previously validated algorithm. Mortality data and demographic variables were obtained from the *Registered Persons Database* (RPDB). Neighborhood-level material deprivation (a measure of socioeconomic status) was obtained from the *Ontario Marginalization Index* (ON-Marg). Medical comorbidity burden was measured via service use in the two-year lookback window using The Johns Hopkins ACG® System Aggregated Diagnosis Groups (ADG) Version 10 score, as previously described (Austin et al., 2011), using the DAD, NACRS, OHIP and *Same Day Surgery* (SDS) databases. Psychiatric comorbidity burden was defined using a previously described 'psychiatric utilization gradient' (PUG, Klaassen et al., 2019) that evaluates whether an individual received hospital-based, ED-based, outpatient, or no psychiatric care in the two-year lookback window, as identified in the OMHRS/-DAD, NACRS, and OHIP Claims databases, respectively. These datasets were linked using unique encoded identifiers and analyzed at ICES.

2.3. Exposure

The primary exposure was rurality, which was measured by *Statistical Area Classification* (SAC) type. SAC type is an ordinal variable developed by Statistics Canada that ranges from one to seven and is based on population size and work-related commuting patterns. The defining features of each SAC type are outlined in Supplementary Table 3; however, for reference, SAC type 1 represents large urban centres (population size >100,000 with >50,000 residing in a downtown core), SAC type 4 represents rural communities with a strong 'urban influence' (population size <10,000 with >30% of residents

traveling to an urban centre for work), and SAC type 7 represents the most remote communities (population size <10,000 with <40 residents traveling to an urban centre for work). The inclusion of population size and urban influence likens this measure of rurality to those used in the US, such as rural-urban continuum codes. Measures of rurality with multiple categories yield more information than dichotomous measures of rural-urban status (Friesen et al., 2022); however, many population-based studies in Ontario use dichotomous measures of rurality, the most common of which involve the *Rurality Index of Ontario* (RIO; where a RIO score ≥40 defines rural (Kralj, 2008)) and SAC type (where type 4–7, i.e., population sizes <10,000, defines rural). Therefore, we used these two dichotomous measures to conduct sensitivity analyses.

For context, Ontario is the most populous province in Canada with an estimated 2016 population of 13.4 million (Statistics Canada, 2016). On average, population density is higher in the Southern part of the province, which contains most major cities (e.g., Toronto, Ottawa), and lower in the Northern part of the province, which is more geographically remote. This resembles the population distribution of other Canadian provinces and has relevance to the accessibility of health services. For example, in remote Northern communities, health services can be sparse or non-existent, requiring individuals to travel long distances for care either by ground or air. Rural and remote communities also exist in southern Ontario but, in general, face less extreme geographic barriers to accessing health services. In turn, using a 7-point measure of rurality is more suited to the Ontario context than a dichotomous rural-urban comparison as it can delineate between these different types of rural and remote communities rather than grouping them all into a single 'rural' category.

2.4. Outcomes & covariates

There were four outcomes of interest in the 1-year following discharge from the index alcohol-related hospitalization: outpatient MHA-related care (from either a psychiatrist or primary care physician, assessed separately and as a composite), alcohol-related ED visits, alcohol-related hospital readmissions, and all-cause mortality. MHA services that are not provided by physicians were not captured within the provincial health administrative databases used in this study. The time between discharge and the first occurrence of each outcome was calculated, with the maximum follow-up time being 1-year following discharge. The models for these outcomes were adjusted for variables chosen a priori that could foreseeably confound the association between rurality and each outcome based on clinical rationale and a literature review (Friesen et al., 2022). These included: age, sex, material deprivation quintile, ADG score (medical comorbidity burden), length of the index hospitalization, number of previous alcohol-related ED visits and hospitalizations, the category of index hospitalization (see Supplementary Table 2), and psychiatric comorbidity (PUG, see above).

2.5. Statistical analysis

Descriptive statistics for all variables, stratified by rurality, were tabulated. Differences between groups were gauged using Chi-square tests for independence (categorical variables) and analysis of variance (ANOVA, continuous variables). The associations between rurality and time to first outpatient MHA-related care, alcohol-related ED visit, and alcohol-related hospital readmission were evaluated using multivariable Fine and Grey subdistribution hazard models with all-cause mortality as a competing risk. The association between rurality and time to all-cause mortality was evaluated using a multivariable Cox proportional hazards model. The results from both unadjusted and adjusted models were tabulated.

In line with our second objective, a significant association between rurality and post-discharge mortality was followed with a counterfactual mediation analysis to understand whether post-discharge MHA-related care mediated an association between rurality and adverse outcomes. This was accomplished using a marginal structural model approach described by (Lange et al., 2012). Briefly, the total effect (TE) of the exposure (rurality) on an outcome (mortality) was decomposed into the natural direct effect (NDE) of the exposure on the outcome and the natural indirect effect (NIE) of the exposure on the outcome mediated by the effect of the exposure on an intermediate ('mediator') variable (see Fig. 1). Outpatient MHA-related care (a composite of psychiatric and MHA-related primary care) following discharge from the index hospitalization and preceding an adverse event was the mediator of interest. Receiving either psychiatric or MHA-related primary care were combined as a composite mediator because they were significantly associated with one another and, in turn, could not be assessed independently. All models were adjusted for study covariates and 95% confidence intervals for the TE, NDE, and NIE were generated via bootstrapping (n = 500), as previously described (Mondor et al., 2020).

2.6. Software

All analyses were conducted in SAS version 9.4 (SAS, 2020).

3. Results

3.1. Descriptive statistics

The final cohort consisted of 46,657 individuals who had an alcohol-related hospital discharge between 2016 and 2018. A table describing cohort creation, including the count and percentage of individuals excluded by reason, is provided in Supplementary Table 1. Notable demographic differences were observed between urban, rural, and remote individuals hospitalized for alcohol- related reasons (Table 1). Relative to large urban centres, individuals in rural areas with a strong urban influence tended to be older (*rural – strong urban influence* average age = 53.91; *large urban* average age = 52.34), male (*rural – strong urban influence* % female = 28.15; *large urban* % female = 30.17), and high income (*rural – strong urban influence* % highest income quintile = 22.45; *large urban* % highest income quintile = 14.27), whereas individuals in remote areas tended to be younger (average age = 39.54), female (% female = 43.20), and low income (% highest income quintile = 0.60).

In the year following discharge from the index hospitalization, 43.44% of the cohort received outpatient MHA-related care, 19.62% had an alcohol-related ED visit, 19.14% had an alcohol-related readmission, and 11.53% died (Table 2).

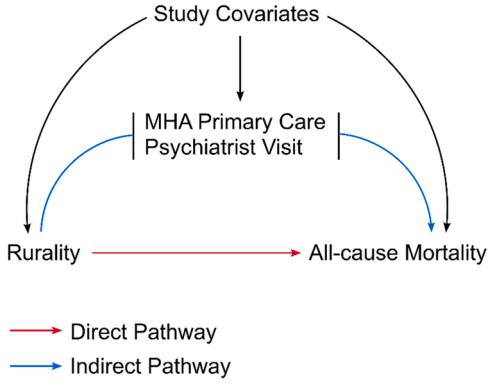

Fig. 1. Directed Acyclic Graph for the mediation analysis. Direct pathway: the effect of increasing rurality on all-cause mortality after controlling for rural-urban differences in the likelihood of receiving post-discharge mental health and addiction (MHA) services from either a psychiatrist or primary care physician (composite). Indirect pathway: the effect of increasing rurality on all-cause mortality mediated by the lower likelihood of receiving MHA services in increasingly rural communities.
Adapted from Lange et al. (2012).

Table 1
Demographic and healthcare characteristics of the cohort by rural category.

Characteristic	Large Urban* n = 34,553	Mid-sized Urban* n = 1366	Small Urban* n = 4063	Rural (strong urban influence)* n = 2490	Rural (moderate urban influence)* n = 2193	Rural (weak urban influence)* n = 1330	Remote* n = 662
Age (Mean, SD)	52.3 (17.2)	53.4 (16.8)	53.1 (17.1)	54.9 (16.8)	54.6 (16.9)	46.5 (18.3)	39.5 (15.9)
Female (%)	30.2	32.9	30.9	28.2	30.9	35.6	43.2
Material Deprivation Quintile (%)							
1 (lowest)	30.9	38.2	31.5	16.1	30.9	35.0	77.8
2	22.3	19.9	21.0	16.4	27.0	17.7	4.8
3	17.9	16.3	18.7	20.1	20.0	13.6	1.0–2.0
4	14.7	14.6	15.8	24.5	12.3	15.3	15.7
5 (highest)	14.3	11.0	13.0	22.5	9.9	18.3	<1.0
ADG Score (Mean, SD)	24.3 (16.5)	22.9 (16.5)	22.7 (16.7)	23.0 (16.4)	22.1 (16.7)	21.3 (16.5)	20.3 (18.3)
Length of Initial Stay (Median, IQR)	5 (11)	5 (10)	5 (10)	6 (11)	5 (11)	4 (8)	4 (5)
% With Previous Alcohol-related ED Visit	36.1	28.3	30.1	26.6	25.5	38.5	47.3
% With Previous Alcohol-related Hospitalization	23.3	24.0	22.3	18.0	19.4	26.4	25.4
Diagnostic Category for Index Hospitalization							
Alcohol Use Disorder	43.2	48.5	44.1	45.3	47.5	43.1	30.4
Harmful Alcohol Use	15.0	12.1	14.2	13.6	15.6	15.9	24.2
Acute Intoxication	5.2	6.7	5.7	4.7	6.6	13.5	16.3
Alcoholic Liver Disease	10.4	8.5	9.8	10.6	9.5	7.3	5.4
Other	7.4	7.0	8.0	7.3	6.0	6.3	6.5
Multiple diagnoses	18.8	17.4	18.2	18.6	14.8	13.9	17.2
Psychiatric Comorbidity (%)							
No previous service use	31.5	38.4	35.7	42.1	40.5	30.7	35.2
Previous outpatient psychiatric care	16.4	12.3	14.8	16.4	14.3	9.2	4.8
Previous psychiatric ED visit	23.2	18.1	20.0	19.1	19.3	27.1	29.0
Previous psychiatric hospitalization	28.9	31.2	29.5	22.4	25.9	33.0	31.0

ADG: Johns Hopkins ACG® System Aggregated Diagnosis Groups
*Definitions for these classifications are provided in Supplementary Table 3

Table 2
1-year incidence of study outcomes by rural category.

	Overall (%)*	Large Urban† (%)	Mid-sized Urban (%)	Small Urban (%)	Rural (strong urban influence) (%)	Rural (moderate urban influence) (%)	Rural (weak urban influence) (%)	Remote (%)
Any Outpatient MHA Care	43.44	45.32	37.63	40.78	35.78	37.85	36.92	33.69
Psychiatrist Visit	22.47	24.65	18.74	18.95	16.18	15.87	11.13	6.19
MHA Primary Care Visit	32.79	33.69	27.23	31.55	27.87	31.01	32.18	30.51
Alcohol-related ED Visit	19.62	20.11	19.47	17.89	12.29	15.28	24.66	36.86
Alcohol-related Readmission	19.14	19.49	19.18	18.48	15.62	17.37	20.30	21.45
All-cause mortality	11.53	11.54	11.13	12.58	13.17	11.40	8.42	5.74

*percentage reflects the % of individuals in that group that had the outcome occur within 1-year of discharge from the index alcohol-related hospitalization
†Definitions for these classifications are provided in Supplementary Table 3

3.2. The association between rurality and post-discharge MHA care

The likelihood of receiving post-discharge MHA-related care declined with increasing rurality. Relative to large urban centres, individuals in mid-sized urban areas had an 19% lower likelihood (adjusted HR (aHR): 0.81, 95% CI: 0.74–0.88) and individuals in remote areas had a 43% lower likelihood (aHR: 0.57, 95% CI: 0.50–0.65) of receiving any post-discharge outpatient MHA-related care. When outpatient MHA-related care was separated into psychiatric versus MHA-related primary care, this trend was more pronounced for psychiatric care (*remote* versus *large urban* aHR: 0.16, 95% CI: 0.12–0.22) than for MHA-related primary care (*remote* versus *large urban* aHR: 0.86, 95% CI: 0.75–0.99; Fig. 2, Supplementary Table 4).

3.3. The association between rurality and post-discharge adverse health outcomes

There was a non-linear association between rurality and adverse post-discharge health outcomes (Fig. 2, Supplementary Table 4). Relative to large urban centres, individuals in rural areas with a strong urban influence had a lower hazard of a post-discharge alcohol-related ED visit (aHR: 0.73, 95% CI: 0.65–0.82) but a higher hazard of mortality (aHR: 1.19, 95% CI: 1.06–1.34), whereas individuals living in remote areas had a higher hazard of post-discharge alcohol-related ED visit (aHR: 1.51, 95% CI: 1.31–1.75) but no significant difference in the hazard of mortality (aHR: 0.78, 95% CI: 0.57–1.08). No association was observed between rurality and alcohol-related readmission (Fig. 2, Supplementary Table 4).

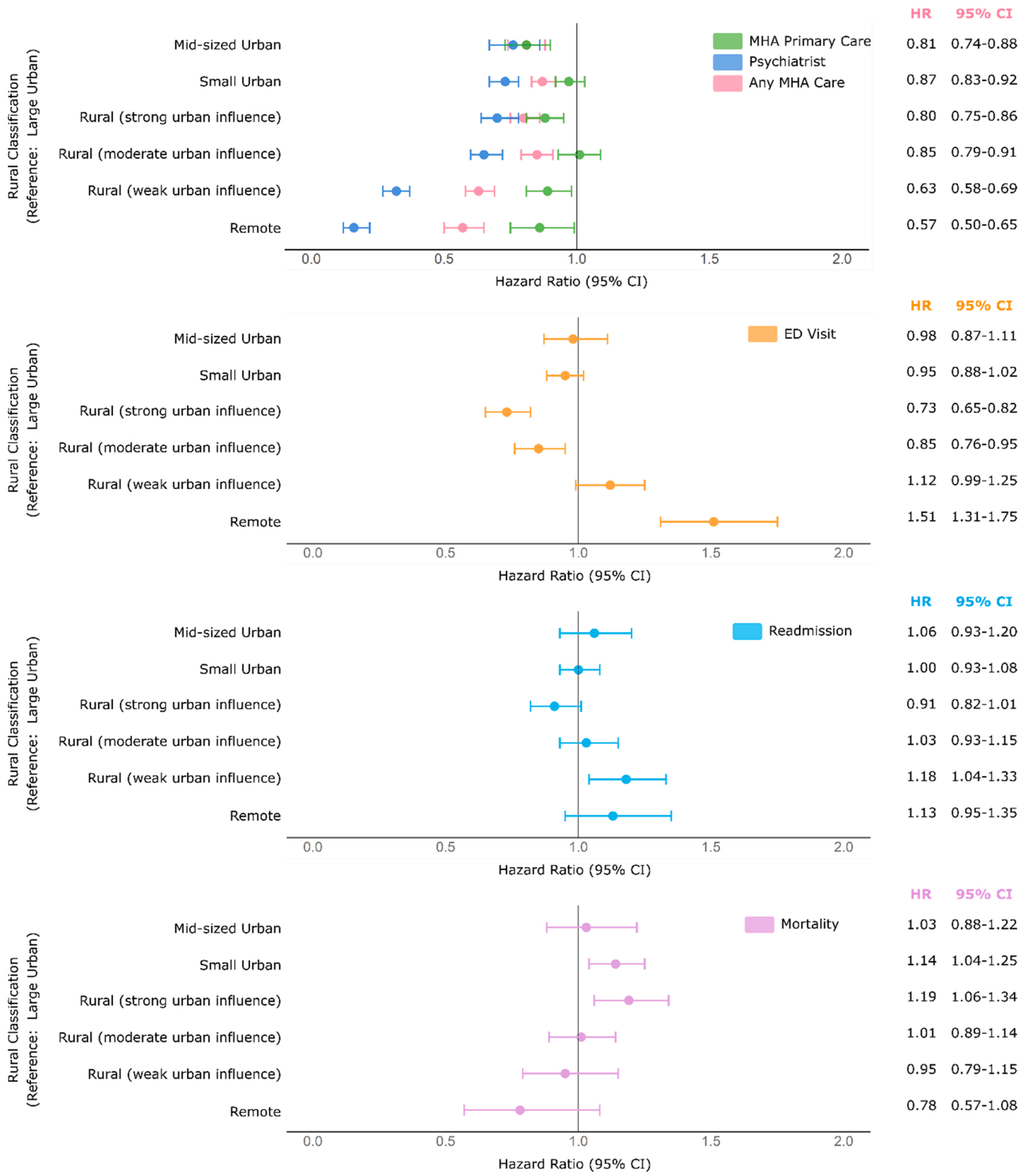

Fig. 2. The association between rurality and study outcomes: results from the adjusted Fine and grey subdistribution hazard (outpatient MHA care, emergency department (ED) visits, readmissions) and Cox proportional hazard (death) models. Hazard ratios (HRs) are relative to large urban centres. Results from the unadjusted models are available in Supplementary Table 4. HRs for outpatient care are those for the composite outcome of either outpatient psychiatric or MHA-related primary care ('any MHA care', pink).

3.4. Sensitivity analysis: alternative definitions of rurality

When dichotomous definitions of rurality were considered in a sensitivity analysis, rural, relative to urban, residence was associated with a reduced likelihood of receiving outpatient MHA-related care (*RIO definition* aHR: 0.78, 95% CI: 0.74–0.82; *SAC definition* aHR: 0.76, 95% CI: 0.73–0.80) but not consistently associated with alcohol-related ED visits, hospital readmissions, or mortality (Supplementary Table 5).

3.5. The mediating effect of post-discharge MHA-related care on all-cause mortality

The lower likelihood of receiving follow-up outpatient MHA-related care in rural areas mediated an increased hazard of all-cause mortality (Table 3). The indirect effect represents the increased hazard of all-cause mortality mediated by a lower likelihood of receiving post-discharge MHA-related care in non-urban areas, which was + 6% in rural areas with a strong urban influence (95% CI: 2–10%) and + 14% in remote areas (95% CI: 10–19%; Table 3). In rural communities with a strong urban influence, which were identified to have the highest hazard of post-discharge mortality (Fig. 2), 31% (95% CI: 13–46%) of the increased hazard of mortality was mediated by a lower likelihood of receiving post-discharge MHA-related care (Table 3).

4. Discussion

In the year follow discharge from an alcohol-related hospitalization, approximately 10% of the cohort died and 20% of the cohort was readmitted to hospital. Despite the high risk of short-term morbidity and mortality, less than half of the cohort received follow-up outpatient MHA care from a psychiatrist or primary care physician. The likelihood of receiving MHA care declined with increasing rurality, which mediated an increased the risk of short-term mortality in rural and remote, relative to urban, areas. For example, individuals living in rural areas with a strong urban influence had the highest hazard of post-discharge mortality, and nearly a third of this increased risk was conferred by a lower likelihood of receiving follow-up MHA-related care.

The reduced likelihood of receiving MHA care in rural and remote, relative to urban, areas aligns with previous Canadian and US data on rural healthcare access. For example, Edmonds et al. (2020) found that individuals with AUD living in small rural areas in the US had a lower odds of receiving either specialized addiction treatment or AUD medications than individuals living in urban centers (Edmonds et al., 2020).

Table 3
Reduced use of outpatient mental health and addiction services mediates an increased risk of post-discharge mortality among rural, relative to urban, residents.

	Direct Effect*	Indirect Effect*	Total Effect*	% Mediated
Statistical Area Classification	aHR (95% CI)	aHR (95% CI)	aHR (95% CI)	
Large Urban	Ref.	Ref.	Ref.	Ref.
Mid-Sized Urban	0.99 (0.93–1.06)	1.06 (1.02–1.10)	1.06 (0.99–1.13)	NA†
Small Urban	1.12 (1.08–1.16)	1.03 (0.99–1.07)	1.15 (1.10–1.22)	19.3 (−7.7 to 38.9)
Rural (strong urban influence)	1.14 (1.09–1.18)	1.06 (1.02–1.10)	1.21 (1.14–1.27)	31.0 (12.9–45.8)
Rural (moderate urban influence)	0.98 (0.94–1.03)	1.04 (1.00–1.08)	1.02 (0.96–1.08)	NA†
Rural (weak urban influence)	0.86 (0.80–0.93)	1.10 (1.06–1.14)	0.95 (0.87–1.04)	NA†
Remote	0.65 (0.57–0.74)	1.14 (1.10–1.19)	0.74 (0.64–0.85)	NA†

**Direct effect:* the hazard of 1-year mortality conferred by increasing rurality after controlling for rural-urban disparities in the likelihood of receiving post-discharge MHA-related care. *Indirect effect:* the hazard of 1-year mortality specifically conferred by the lower likelihood of post-discharge outpatient MHA care in non-large-urban areas. *Total effect:* the composite of the direct and indirect effects. See Fig. 1 for a graphical depiction of direct and indirect effects.
† percent mediated is not interpretable in scenarios where the indirect and direct effects have opposite associations with the outcome (a scenario referred to as inconsistent mediation)

Furthermore, in Canada, increasing rurality was associated with reduced access to healthcare across various indicators, including receiving flu shots, primary care, specialist physician services (including psychiatric care (Kurdyak et al., 2014; Kurdyak et al., 2017)), or having a regular medical doctor (Sibley and Weiner, 2011). While reduced access to health services in rural areas is known to contribute to poor health outcomes generally, this was the first quantification of the extent to which limited rural access to MHA-related care increases the risk of short-term harm among individuals who have been hospitalized for alcohol-related health conditions.

Interestingly, however, the associations between rurality and adverse post-discharge health outcomes were not linear, and these non-linear trends could not be explained by geographic differences in access to MHA-related care. Indeed, the lower likelihood of receiving post-discharge MHA-related care was ubiquitously associated with an increased the risk of mortality in rural *and* remote, relative to urban, areas. In turn, there are presumably unmeasured patient-, physician-, and community-level factors that underlie these non-linear trends, such as differences in alcohol regulation, local drinking cultures, or the availability of other health services.

For example, the increased likelihood of alcohol-related ED visits in remote communities could relate to a higher propensity to use EDs for non-urgent care in more remote relative to more urban areas, which occurs, in part, due to the reduced access to outpatient health services in remote areas (Greenwood-Ericksen and Kocher, 2019). There were also notable demographic differences between individuals hospitalized for alcohol use in rural versus remote areas. Namely, individuals in urban-adjacent rural areas tended to be older, male, and live in high income neighborhoods, while those in remote communities tended to be younger, more female (although still predominantly male), and live in low-income neighborhoods. While these factors were controlled for in the multivariable analyses, unmeasured processes that underlie these demographic differences may have contributed to the non-linear association between rurality and post-discharge health outcomes, which will require clarification in future research.

The high rate of short-term mortality observed in this study aligns with recent North American data. For example, a recent study from Ontario reported an 8.8% 1-year mortality rate among individuals with 5 or more alcohol-related ED visits in the preceding year (Hulme et al., 2020), and a recent US study reported a 14.0% 1-year mortality rate among individuals discharged from hospitalizations for alcoholic hepatitis (Kamath et al., 2020). This, in turn, emphasizes that individuals receiving ED- or hospital-based care for alcohol use require improved intervention strategies to reduce the risk of short-term harm.

In rural areas, specifically, our results suggest that part of this strategy should include improving the accessibility and use of outpatient MHA services. This could include increasing the physical availability of these services, such as by increasing recruitment and retention of psychiatrists, psychologists, and other mental healthcare workers, or promoting the use of telehealth resources, such as addiction information and referral hotlines or telepsychiatry services (Davey, 2008; Serhal et al., 2017). However, not all rural and remote communities are alike, and caution must be taken to ensure that these services are tailored to meet the unique needs of individual communities through extensive community involvement in service development and implementation (Friesen, 2019). Furthermore, not all communities have equal access to the technologies required to participate in telehealth services, which must be addressed when considering telemental health solutions to geographic disparities in access to MHA services. Addressing (1) non-physical barriers to accessing MHA care, such as the stigmatization of substance use and addiction, a lack of culturally appropriate care, or the cost of some addiction services, and (2) upstream determinants of alcohol-related harm, such as poverty and housing instability, are also important considerations in improving access to MHA service in rural communities (Bloomfield, 2020).

While there are several programs operating in Ontario that aim to

improve the accessibility of high-quality MHA service to rural and remote populations (e.g., the Northern Psychiatric Outreach Program, Project ECHO – Ontario Mental Health) and financial incentives to recruit and retain rural physicians, additional support will be required from the provincial government to address existing rural-urban disparities in access to MHA services. Indeed, the Ontario chapter of the Canadian Mental Health Association expressed concern that MHA funding may be increasingly redirected to large urban centers in Ontario and have highlighted that even providing equal funding to rural and urban populations is not equitable given the higher cost of providing MHA services in remote areas (Canadian Mental Health Association, 2009). It is also important to acknowledge that, while rural populations appear to merit prioritization, the high rates of short-term harm and low rates of MHA service use observed in the *entire* cohort indicate that these public health efforts should be extended to all individuals who are hospitalized for alcohol-related reasons, regardless of rural-urban status.

Finally, from a methodological standpoint, our results caution against the use of dichotomous rural-urban definitions to study the impact of rurality on alcohol-related health outcomes. Indeed, the non-linear associations between rurality and post-discharge ED visits and all-cause mortality were obscured when conventional measures of rural-urban status were used. Future work should therefore consider using multiple strata along a rural-urban continuum, as was done here, or conducting more sophisticated geospatial analyses (Friesen et al., 2022). This is especially important given the frequency with which dichotomous rural-urban status is used either as an exposure or a covariate in quantitative analyses of population-level alcohol use and alcohol-related harms (Friesen et al., 2022).

4.1. Limitations

This study has several limitations. First, only physician-based MHA-related services were captured. This does not encompass all MHA services available to Ontarians, such as those available from psychologists or private addiction treatment facilities. If these non-physician-based services were differentially accessed by urban, rural, and remote residents, this could have biased the results of this study. However, just like physician-based health services, psychologists and private addiction treatment facilities also become less available with increasing geographic remoteness, which reduces the foreseeable impact of this limitation. Second, only hospitalizations for health conditions entirely attributable to alcohol were captured; however many more hospitalizations can be partially attributed to alcohol use (Rehm, 2011). This was done intentionally to capture a population that was *specifically* being harmed by alcohol use. Nonetheless, future studies on rural-urban disparities in alcohol-related harm may consider including hospitalizations partially attributable to alcohol to gain an understanding of geographic disparities in alcohol-related harm across the full spectrum of alcohol-related diagnoses. Finally, this study is limited in its ability to comment on the reasons why geographic differences in clinical outcomes following alcohol-related hospitalization exist. We provide compelling evidence that a lack of follow-up MHA-related care in rural and remote communities contributes to an increased risk of post-discharge mortality in these areas. However, the reasons why there is a relatively high risk of mortality in urban-adjacent rural communities but relatively low risk of mortality in remote communities remain unclear. It is possible that these differences relate to complex, and likely intersecting, sociocultural and health system factors that can be challenging to capture using quantitative data. In turn, follow up research may benefit from considering qualitative or mixed-method approaches to answering these questions.

5. Conclusion

This study demonstrated that outcomes following alcohol-related hospitalizations are poor, with 1 in 6 individuals being readmitted to hospital and 1 in 10 individuals dying within one year of discharge. The risk of adverse post-discharge outcomes varied substantially between urban, rural, and remote communities. Notably, relative to individuals in large urban centres, individuals in urban-adjacent rural communities had a higher risk of 1-year mortality, whereas individuals in remote communities did not. Despite these rural-remote differences, individuals in both rural *and* remote communities had a lower likelihood of receiving post-discharge, outpatient MHA-related care than individuals in large urban centres, which ubiquitously increased the risk of post-discharge mortality in rural and remote areas. Improving access to MHA-related health services in rural and remote communities will therefore be an important step in minimizing rural-urban disparities in alcohol-related harm. Additional research is required to understand the factors that contribute to non-linear trends in post-discharge outcomes along the rural-urban continuum such that alcohol-related public health strategies can be tailored to the unique needs of individuals in urban, rural, and remote communities.

Role of funding source

EF is supported by a Frederick Banting & Charles Best Canada Graduate Scholarships-Doctoral Award from the Canadian Institutes of Health Research (CIHR). This study was also supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health (MOH) and the Ministry of Long Term Care (MLTC). The analyses, conclusions, opinions and statements expressed herein are solely those of the authors and do not reflect those of the funding or data sources; no endorsement is intended or should be inferred.

Contributors

EF, LR, PS and PK conceptualized the manuscript. WY collected the data. EF and DM conducted the data analysis. EF wrote the manuscript. All authors interpreted the results, edited the manuscript, and approved the final version.

Acknowledgments

The authors thank ICES Research Analyst Kinwah Fung for assisting with data collection.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.drugalcdep.2022.109568.

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