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Evaluating the impact of a Critical Time Intervention adaptation on health care utilization among homeless adults with mental health needs in a large urban centre

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Key Words:	Critical Time Intervention, Case management, Homeless, Mental Health Services, Addictions, Healthcare utilization
Abstract:	Objective: This study evaluated the impact of a Critical Time Intervention (CTI) adaptation on health care utilization outcomes among adults experiencing homelessness and mental health needs in a large urban centre. Method: Provincial population-based administrative data from Ontario, Canada were used in a pre-post design for a cohort of 197 individuals who received the intervention between January 2013 and May 2014 and were matched to a cohort of adults experiencing homelessness who did not receive the intervention over the same time period. Changes in

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	<p>health care utilization outcomes in the year pre- and post-intervention were evaluated using generalized estimating equations and post-hoc analyses evaluated differences between groups.</p> <p>Results: Pre-post analyses revealed statistically significant changes in health care utilization patterns among intervention recipients, including reduced inpatient service use and increased outpatient service use in the year following the intervention compared to the year prior. However, the matched cohort analysis found non-significant differences in health service use changes between a subgroup of intervention recipients and their matched counterparts.</p> <p>Conclusions: An adapted CTI model was associated with changes in health care utilization among people experiencing homelessness and mental health needs. However, changes were not different from those observed in a matched cohort. Rigorous study designs with adequate samples are needed to examine the effectiveness of CTI and local adaptations in diverse health care contexts.</p> <p>Abstract.docx</p>



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12 Evaluating the impact of a Critical Time Intervention adaptation on health care utilization
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14 among homeless adults with mental health needs in a large urban centre
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Abstract

Objective: This study evaluated the impact of a Critical Time Intervention (CTI) adaptation on health care utilization outcomes among homeless-adults experiencing homelessness andwith mental illness-health needs in a large urban centre.

Method: Provincial population-based administrative data from Ontario, Canada were used in a pre-post design for a cohort of 197 individuals who received the intervention between January 2013 and May 2014 and were matched to a cohort of homeless-adults experiencing homelessness who did not receive the intervention over the same time period. Changes in health care utilization outcomes in the year pre- and post-intervention were evaluated using generalized estimating equations and post-hoc analyses evaluated differences between groups.

Results: Pre-post analyses revealed statistically significant changes in health care utilization patterns among intervention recipients, including reduced inpatient service use and increased outpatient service use in the year following the intervention compared to the year prior. However, the matched cohort analysis found non-significant differences in health service use changes between a subgroup of intervention recipients and their matched counterparts.

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9 Conclusions: An adapted CTI improved-model was associated with changes in health care
10 utilization among homeless-people- experiencing homelessness andwith mental
11 illnesshealth needs. However, changes were not different from those observed in a matched
12 cohort. Rigorous study designs with adequate samples are needed to examine the
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18 effectiveness of CTI and local adaptations in diverse health care contexts.
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24 **Keywords:** Critical Time Intervention, case management, homeless, mental health services,
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26 addiction, health care utilization
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1. Introduction

Internationally, rates of homelessness continue to rise^{1,2}; and in Canada, national data show an increase in demand for shelter beds over time, with at least 235,000 Canadians experiencing homelessness in a year³. Homeless individuals People experiencing homelessness also experience higher rates of mental health and addiction challenges⁴, neurocognitive impairment^{5,6,7,8}, physical health problems and premature mortality^{7,8,9}, compared to their housed counterparts. Despite the health disparities, this population generally has limited access to appropriate, high quality health care and supports, even in settings with universal health insurance^{9,10,11}. Together, these factors contribute to high rates of hospital service use and costs^{12,13,14}.

~~With rising rates of homelessness in Canada and internationally¹⁴⁻¹⁶, Given~~ increasing rates of homelessness and the impact of homelessness on health¹⁷, t there is an urgent need for interventions to improve health outcomes in this population, including avoidable hospital service utilization^{15,12}. ~~Fo~~ For adults experiencing ~~homelessness and~~ mental illness, care following discharge from hospital for a mental health condition is reportedly the most important factor in reducing reliance on subsequent inpatient care^{18,7}. ~~Yet this population~~ Adults experiencing mental illness and homelessness, however, are is

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9 less likely to be referred to and access community-based services upon discharge from
10 hospital, compared to housed individuals^{198,2019}.

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14 Among ~~homeless populations~~ people experiencing homelessness, strategies to
15 improve continuity of care by offering intensive time-limited services to support the
16 transition from hospital to community-based services have shown promising findings²¹⁰⁻²⁶⁵.
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18 Critical time interventions (CTI) was designed to support homeless individuals during
19 transitions of care, including the period post-hospital discharge in which people
20 experiencing mental illness are at high risk of experiencing first-episode or recurrent
21 homelessness in particular, offering.^{27,28} Critical time interventions involve time-limited
22 intensive case management over a period of six to nine months and aim to help service
23 users navigate the complex service system and establish (or re-establish) access to longer-
24 term community-based connections, resources and interventions. This particular model,
25 hasve been shown to decrease early psychiatric readmission rates^{243,296,3027}, improve
26 perceived quality of care^{221,254}, and improve health and quality of life outcomes^{243,3027}, and
27 reduce rates of homelessness^{27,31}. Past evaluations of CTIs have also suggested that this
28 approach is cost-effective³²²⁸ in supporting transitions of care.

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47 More evidence of the impact of CTI models, and their adaptations in diverse
48 settings, is urgently needed to support implementation of effective and cost-effective
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9 strategies to improve health and housing outcomes among people experiencing
10 homelessness and who have unmet mental health needs. A recent pre-post evaluation of a
11 CTI adaptation for ~~homeless adults~~ adults experiencing homelessness and mental health
12 needs who were transitioning from hospital to community services in Toronto, Canada,
13 reported significant improvements in mental and physical health, substance use, and quality
14 of life in the six months following the intervention²⁴³. Expanding on this work, the primary
15 objective of this study was to use administrative health care utilization data to evaluate
16 whether a brief CTI adaptation for ~~homeless adults~~ adults experiencing homelessness and
17 mental health needs who were discharged from hospital services was associated with
18 significant ~~improvements~~ changes in health care utilization outcomes in the year post-
19 intervention compared to the year prior. This analysis in addition ~~compared~~ ds changes in
20 health care utilization among participants with a recent hospitalization to those of a
21 matched cohort of people experiencing homelessness over the same time period who did
22 not receive the intervention.

2. Methods

2.1 Intervention

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48 The Coordinated Access to Care for Homeless adults (CATCH-Homeless) program
49 is a CTI adaptation in Toronto, Canada, supporting adults experiencing homelessness and
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9 mental health needs following discharge from hospital. The program is facilitated through
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11 partnerships between three local hospitals serving large numbers of people experiencing
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13 homelessness, a primary care team, a homeless shelter, a large community mental health
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15 agency, and a physician practice plan. The program accepts referrals from all partner
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17 hospital emergency departments (EDs) and inpatient units, or from community agencies,
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19 and connects participants with transitional case managers who coordinate access to a full
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21 range of post-discharge community-based services, including mental health and addiction
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23 services, medical care, peer support, housing assistance, and other resources described in
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25 depth elsewhere³³²⁹.
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30 *2.2 Study design*

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33 This study is part of a larger mixed-methods evaluation described elsewhere^{221,3329}.
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35 Using provincial population-based administrative databases at ICES (formerly known as
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37 the Institute for Clinical Evaluative Sciences), a single-arm pre-post analysis among
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39 intervention participants was conducted to evaluate health care utilization outcomes in the
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41 year following enrolment in the intervention compared to the year prior. In addition,
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43 changes in health service utilization of a subgroup of intervention participants with a recent
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45 hospitalization were compared to those of a matched cohort of people-adults experiencing
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9 homelessness with at least one psychiatric hospitalization over the same time period who
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11 did not receive the intervention.
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13 14 *2.3 Data sources* 15

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17 All administrative health care data were obtained from ICES. ICES is an
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19 independent, non-profit research institute funded by an annual grant from the Ontario
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21 Ministry of Health (MOH). As a prescribed entity under Ontario's privacy legislation,
22
23 ICES is authorized to collect and use health care data for the purposes of health system
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25 analysis, evaluation and decision support. Secure access to these data is governed by
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27 policies and procedures that are approved by the Information and Privacy Commissioner of
28
29 Ontario. The Ontario Mental Health Reporting System (OMHRS) and the Canadian
30
31 Institute for Health Information's Discharge Abstract Database (DAD) include data on all
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33 psychiatric and acute hospitalizations, respectively. The Ontario Health Insurance Plan
34
35 (OHIP) claims database contains physician billings data, and the National Ambulatory Care
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37 Reporting System gathers data on hospital- and community-based ambulatory care, such as
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39 ED visits. The Ontario Registered Persons Database (ORPD^B) is a registry of all
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41 individuals living in Ontario who are eligible for public health care insurance and holds
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45 data on patient demographics, such as age, sex, and postal code.
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49 50 *2.4 Sample* 51 52 53 54 55 56 57 58 59 60

2.4.1 Intervention participants

Intervention participants were those referred to the intervention by partner sites following discharge from EDs and inpatient units. Intervention eligibility criteria included current homelessness status (defined as living in a crisis/emergency shelter, living on the street, or couch surfing), provider-determined unmet mental health needs, and participant-identified need for support services. ~~Individuals were ineligible for~~ ~~Participants were excluded from the program~~ this community-based intervention if they had recent a history of severe aggression or required ~~severe aggression or illness severity that required~~ residential-institutional care. Study eligibility criteria included being a resident of the province of Ontario, age 18 years and older, and not having previously received services from the program. For the current analysis, 197 individuals, who received the intervention between an index date of January 7, 2013 and May 16, 2014, completed a baseline interview, and agreed to health care record linkage were included. Twenty-six individuals (11.7% of total participants enrolled in the intervention) did not consent to health care record linkage and were excluded from the current analysis. These individuals were not different from consenting individuals in terms of gender but were younger (mean age: 34.9 years vs. 40.3 years; $P=.021$). Furthermore, they were not different in terms of baseline ED visits but had fewer baseline hospitalizations (mean: 0.7 vs. 1.2; $P=.022$). –Additional

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9 ~~e~~Exclusion criteria for this analysis included missing patient identifier (required for data
10 linkage), not being enrolled in OHIP, and/or missing data on sex and/or age.
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13 14 2.4.2 Matched cohort participants 15

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17 The comparison group ~~obtained from the ORPD~~ was composed of individuals
18 aged 18 years and older with recorded homelessness (as identified by a residence variable
19 in the OMHRS or a homelessness variable in the DAD), who had at least one
20 hospitalization for mental health or substance use during the exposure period (index date:
21 January 1, 2013 to May 31, 2014). ~~These individuals were then matched to the intervention~~
22 ~~participants who had at least one hospitalization in the 12 months prior to their index date.~~
23 Individuals who received the intervention and who had at least one hospitalization in the 12
24 months prior to the index date were then matched 1:2 with the comparison group of adults
25 experiencing homelessness who had not received the intervention using propensity score-
26 based matching. Variables used to calculate the propensity score included having a
27 hospitalization in the 12 months prior to the index date, age, sex, neighbourhood income
28 quintile and administrative health region of residence. We selected the closest control that
29 met the following criteria: age within two years at the index date, same sex (hard match)
30 and a propensity score within a caliper width of 0.20. To evaluate matching success,
31 standardized baseline differences were calculated between the subset of intervention
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9 participants and the matched cohort. Standardized differences of 0.10 or less are considered
10 negligible³⁴. Individuals were excluded from the matched group if they were ineligible for
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OHIP and/or had missing sex and/or age data.

2.5 Outcome measures

To evaluate changes in acute health care utilization, count outcomes including the total number of all-cause and mental health and substance use-specific ED visits, hospitalizations, and total hospital days were calculated, ~~in addition to.~~ Dichotomized outcomes indicating whether or not a participant had any all-cause and mental health and substance use-specific ED visits and hospitalizations during the observation period were also calculated. To evaluate changes in outpatient service use, count outcomes including the total number of psychiatrist visits, all-cause and mental health ~~and~~ and addiction substance use-specific general practitioner (GP) visits, and the sum total of outpatient visits were calculated, as well as dichotomized outcomes indicating whether or not a participant had any psychiatrist visits and all-cause and mental health ~~and~~ and addiction substance use-specific GP visits during the observation period. Diagnostic codes used to determine mental health and addiction substance use-specific hospital and outpatient visits are provided in Supplemental Table 14.

2.6 Data collection

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9 Intervention participants' demographic and administrative health care records, held
10 by ICES, were linked using unique encoded identifiers; deterministic linkage was applied
11 using OHIP numbers. Health care records were examined for the 12 months pre- and post-
12 index date. The index date for exposure was the intervention enrollment date, ranging from
13 January 7, 2013 to May 16, 2014; the study period was January 2012 to May 2015. All
14 participants provided written informed consent and the study received Research Ethics
15 Board approval from Unity Health Toronto. To identify the matched cohort used in
16 comparative analyses, population-based administrative demographic and health records
17 were retrieved and reviewed for the same time periods.
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30 *2.7 Statistical analyses*

31 *2.7.1 Single arm pre-post analysis*

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36 Baseline characteristics for both intervention participants and individuals included
37 in the matched cohort were calculated using frequencies and proportions for categorical
38 variables and means and standard deviation for continuous variables. In the pre-post
39 evaluation, inferential analyses for each count outcome included rates and rate ratios and
40 their respective 95% confidence intervals estimated using generalized estimating equations
41 (GEE) models with a negative binomial distribution and a log link. For each binary
42 outcome, predicted probabilities and prevalence ratios and their respective 95% confidence
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9 intervals were estimated using GEE models with a Poisson distribution and a log link. All
10 models were adjusted for age, sex and neighbourhood income quintile (measured at the
11 Census tract level). An offset variable for person-years was included to adjust for different
12 follow-up lengths.
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19 All analyses were conducted using SAS Enterprise Guide 7.1. A significance level
20 of .05 was used to interpret statistical significance.
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23 *2.7.2 Matched cohort selection*

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27 ~~Individuals who received the intervention and who had at least one~~
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29 ~~hospitalization in the 12 months prior to the index date were matched 1:2 with homeless~~
30 ~~individuals who had not received the intervention using propensity score-based matching.~~
31
32 ~~Variables used to calculate the propensity score included having a hospitalization in the 12~~
33 ~~months prior to the index date, age, sex, neighbourhood income quintile and administrative~~
34 ~~health region of residence. We selected the closest control that met the following criteria:~~
35 ~~age within two years at the index date, same sex (hard match) and a propensity score within~~
36 ~~a caliper width of 0.20. To evaluate matching success, standardized baseline differences~~
37 ~~were calculated between the subset of intervention participants and the matched cohort.~~
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39 ~~Standardized differences of 0.10 or less are considered negligible³⁰.~~
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2.7.2 *Post-hoc comparative analysis*

Baseline demographic characteristics were calculated between intervention participants with at least one hospitalization in the 12 months pre-index date and their matched counterparts using frequencies and proportions for categorical variables and means and standard deviation for continuous variables. To show trends between groups and over time, GEE models specifying a negative binomial distribution and a log link were conducted for each count outcome to estimate rate ratios and relative rate ratios; for each binary outcome, GEE models specifying a Poisson distribution and a log link were conducted to calculate prevalence ratios and relative prevalence ratios. All post-hoc models were adjusted for age, sex and neighbourhood income quintiles and included group, time and group by time interaction variables.

3. Results

The cohort selection is detailed in Figure 1. Of the 197 eligible individuals who received the intervention during the study period, 11 health records were unlinkable (six were blank and five were invalid), resulting in a cohort of 186 participants. Of those, 51 individuals were excluded from the matched analysis because they did not have a hospitalization for mental health or substance use in the 12 months prior to the index date required for comparison with the matched sample, leaving a subset of 125 individuals.

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9 Among 3,555 administrative records of homeless individuals people experiencing
10 homelessness with a mental health or substance use-specific hospitalization during the
11 exposure period, 250 individuals (1:2 matching) were selected for inclusion in the matched
12 cohort.
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18 *3.1 Demographic characteristics*

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22 The demographic characteristics of intervention participants (n=186) are presented
23 in Supplemental Table 24. The majority of the sample (78.5%) was male. Participants had a
24 mean age of 40.3 years ($SD=12.0$), with an even distribution across age brackets between
25 18 and 59 years; only 4.3% of participants were over the age of 60.
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32 Table 1 shows the demographic characteristics of the 125 intervention participants
33 included in the matched cohort analysis and their matched counterparts; these were similar
34 to those of the full cohort of intervention participants in age, sex, and neighbourhood
35 income quintile as indicated by no standardized difference between the two groups being
36 greater than 0.10.
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44 *3.2 Pre-post analysis*

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47 Rates per person-year and rate ratios (RR) for intervention participants (n=186) in
48 the 12 months pre- and post-intervention enrolment for the number of hospital admissions,
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9 hospital days, ED visits and outpatient visits are presented in Table 2; results for binary
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11 outcomes are presented in Supplemental Table 32. Overall, results reveal changes in health
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13 care utilization patterns, with decreased inpatient care and increased outpatient care in the
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15 12 months following enrolment in the intervention, compared to the 12 months prior.
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17 Inpatient hospital use decreased significantly among intervention participants in the 12
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19 months following enrolment, especially for mental health and substance use-specific visits.
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21 Adjusted admission rates decreased significantly for both all cause and mental health and
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23 substance use--specific causes, by 33% (95% CI 15%-47%; $P=.001$) and 43% (95% CI
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25 26%-66%; $P<.001$), respectively, in the 12 months post-intervention relative to 12 months
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27 prior. The total number of hospital days also decreased significantly, by 54% (95% CI
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29 36%-77%; $P<.001$) for all-cause days and by 63% (95% CI 48%-74%; $P<.001$) for mental
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31 health and substance use days. While the number of ED visits did not change significantly
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33 over time, the overall prevalence of ED visits did decrease significantly, by 14% for any
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35 reason (95% CI 7%-20%; $P<.001$); and by 31% for mental health and substance use
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37 reasons (95% CI 12%-39%; $P<.001$) (Supplemental Table 32). In contrast to the decrease
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39 in acute hospital service use, outpatient psychiatrist visits increased by 40% (95% CI 1.15-
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41 1.70; $P=.001$) in the 12 months following the intervention compared to the 12 months prior;
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43 GP visits did not change significantly.
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3.3 Matched cohort analysis

Rate ratios and relative rate ratios (RRR) for the subset of intervention participants with at least one hospitalization in the 12 months prior to the index date (n=125) compared to matched controls (n=250) 12 months pre- and post-intervention, for the number of hospital admissions, hospital days, ED visits and outpatient visits are presented in Table 3. Prevalence ratios (PR) and relative prevalence ratios (RPR) are presented in Supplemental Table 4. For both count and binary outcomes, results of the matched cohort analysis suggest that while results generally trended in the same direction as the pre-post analysis, the changes in health service use experienced by intervention participants in the year following receipt of the intervention as compared to the year prior were not significantly different than the changes experienced by their matched counterparts (Table 3).

4. Discussion

Care continuity³⁵³⁴ is essential to the delivery of high quality services for people living with chronic health conditions, including mental illness and addictions, and is associated with improved health and service use outcomes³⁶². Our findings of decreased acute care service use and increased outpatient service use in the 12 months following the intervention as compared to the 12 months prior are consistent with previous outcomes of critical time intervention (CTI) studies, finding significant improvements-changes in

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9 outcome measures^{243,296,3027}. In addition, our findings further support and are supported by
10 previous qualitative research suggesting improved experiences of continuity of care among
11 ~~homeless adults~~adults experiencing homelessness receiving CTI or CTI adaptations^{224,373}.
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13 Notably, our findings highlight continued high rates of emergency department (ED) visits
14 post-intervention among participants, suggesting that this population may have more acute
15 and/or enduring needs than the brief CTI adaptation can address in our local context.
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17 Access to housing and high quality intensive case management in Toronto, for example, are
18 extremely limited and hindered by long wait lists; it is possible that participants continued
19 to visit the ED for immediate shelter and support post-intervention, as intervention
20 resources were limited and not linked to housing. Persisting high ED use among
21 participants reaffirms the need for inclusion of housing in mental health policy priorities.¹⁷
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35 Although prior controlled studies of CTI have demonstrated improvements in acute
36 care utilization in some settings²⁶⁵, the addition of a matched cohort analysis in the current
37 study indicates that changes in service use patterns of recipients of a brief CTI adaptation
38 within our setting of universal health insurance and a relatively service-rich environment
39 are not significantly different than those of their matched counterparts.
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47 Similar to this analysis, a prior post-hoc analysis of intervention participants using
48 self-reported data and a comparison group of ~~homeless adults-~~ adults experiencing
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9 homelessness with and mental illness-mental illness who were receiving usual care found
10 successful reduction in mental health symptoms and alcohol and drug use problems among
11 intervention participants, but increased ED visits and days spent in hospital over six
12 months²⁴³. The current post-hoc analysis, in using administrative data and a cohort matched
13 on prior hospitalizations, ~~adds~~ was intended to build off the limitations of the
14 aforementioned prior analysis²⁴ by focusing on service use outcomes using administrative
15 data and exploring between-group differences with added methodological ~~additional~~ rigor
16 and identifies no significant difference in service use patterns among intervention and
17 matched cohort participants. Additional measures including clinical characteristics such as
18 diagnosis and acuity, and demographic and service use factors such as geographical
19 location and resource availability, may help to better explain the identified non-significant
20 differences between groups in future studies.

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37 Our findings further highlight the need for rigorous methods in evaluating new
38 interventions in diverse contexts. ~~Furthermore, it points to the need to ensure fidelity to key~~
39 ~~ingredients when adapting evidence-supported interventions in diverse contexts.~~ The brief
40 CTI adaptation evaluated in the current study was set in a large urban centre under a
41 universal health insurance system and included a dedicated, low-barrier, multidisciplinary
42 weekly physician clinic in addition to brief case management support with limited training
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9 and supervision of frontline staff, in keeping with a pragmatic field intervention. Our
10 findings suggest that participants' access to preventative outpatient services~~s-use~~ was
11 successfully facilitated by ~~appropriately designed and dedicated~~streamlined access to GPs
12 and psychiatrists. Such an approach may be particularly relevant to similarly large urban
13 centre where timely access to ~~appropriate physician and case management~~ resources is
14 hindered by rapid general and homeless population growth and corresponding demand for
15 services.
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26 While fidelity standards for CTI have been developed, detailing the key model
27 components requiring adherence, and the contextual structures and staff competencies
28 needed to ensure model integrity³⁸⁴⁻⁴⁰³⁶, a recent systematic review indicates that fidelity
29 and adaptations remain highly variable²⁶⁵ and should be a required component of rigorous
30 evaluations. The fidelity of the intervention to the CTI model was not formally assessed in
31 this study. Future efforts should ensure that local adaptations of evidence-based
32 interventions balance local needs and resources with fidelity to key intervention
33 ingredients, so that evidence generated can be reliably attributed to the model of interest.
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45 *4.1 Strengths and limitations*

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48 Our findings contribute to the growing evidence on the impact of CTI and its
49 adaptations on health service use. Results are strengthened by the study's methodological
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9 approach, which included the use of population-based administrative data and a rigorous
10 selection process to ensure the appropriateness of comparators. However, the identification
11 of a matched cohort was challenged by the lack of a baseline acuity measure, requiring us
12 to match on recent hospitalizations as a proxy for acuity, although post-matching
13 demographic comparisons suggested the groups were minimally different. Additionally,
14 intervention participants were selected using some clinical criteria that could not be applied
15 to matched individuals identified from administrative data. In the absence of a built-in
16 control group, this an acknowledged design limitation that could have resulted in selection
17 bias.

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31 Additionally, we We were also limited by our sample size and underpowered to
32 detect hospitalization differences. It is possible that the lower relative rates of psychiatric
33 hospitalizations observed in the intervention group would be significantly different with a
34 larger sample. Still, without a randomized design, it is possible the improvements in health
35 care use observed in the pre-post analysis are due to regression to the mean, rather than the
36 effect of the intervention.

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45 Given the high cost of hospitalizations and from a quality of care perspective, future
46 research should focus on rigorous evaluations using experimental methods with large
47 samples and robust sets of explanatory variables, in addition to approaches to strengthening
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9 fidelity of local adaptations to evidence-supported treatments. Related research should
10 investigate the cost-effectiveness of these interventions to maximize health outcomes given
11 the limited resources available.
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15 16 **5. Conclusions** 17

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19 Study findings suggest that participants of a brief Critical Time Intervention (CTI)
20 for adults experiencing homelessness and unmet mental health needs had decreased acute
21 care use and increased outpatient service use post-intervention. Post-hoc analyses, however,
22 found that changes in service use patterns were not significantly different from those of a
23 matched cohort of adults experiencing homelessness. While ~~Critical Time Intervention-CTI~~
24 and its adaptations hold promise in improving continuity of care and health outcomes
25 among homeless people with mental illness for this population, more r. Rigorous study
26 designs with adequate sample sizess are needed to further examine the effectiveness of CTI
27 and local adaptations in diverse health care contexts.
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Data Access

Data included in this publication are not publicly available and were collected by ICES. As a prescribed entity under Ontario's privacy legislation, ICES is authorized to collect and use health care data for the purposes of health system analysis, evaluation and decision support. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario. For further questions regarding data accessibility, please contact the corresponding author.

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14 or should be inferred.
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Tables

Table 1: Demographic characteristics of CATCH-H participants *with at least one hospitalization in the 12 months-pre-intervention* (n=125) and matched controls (n= 250)

Demographic variables	CATCH-H participants with hospitalization (n=125)		Matched controls (n=250)		Standardized difference	
	n	%	n	%		
Age (years)	18 to 29	29	23.2	58	23.2	0
	30 to 39	27	21.6	52	20.8	0.02

	40 to 49	36	28.8	73	29.2	0.01
	50 to 59	25	20	49	19.6	0.01
	60 and over	8	6.4	18	7.2	0.03
	Mean (SD)	41.1 (12.4)	41	12.3		0
Sex	Female	27	21.6	52	20.8	0
	Male	98	78.4	19	79.2	
				8		
Neighbourhood income quintile	1* (low)	39	31.2	90	36	0.09
	2 (medium low)	30	24	55	22	0.05
	3 (medium)	26	20.8	49	19.6	0.03
	4 (medium high)	13	10.4	23	9.2	0.04
	5 (high)	17	13.6	33	13.2	0.01

Legend: SD = standard deviation

*1: includes individuals in the 1st income quintile and those where this information was missing

Table 2: Rates per person-year and rate ratios (RR) for CATCH-H participants (n=186) 12 months pre-intervention vs. 12 months post-intervention for number of hospital admissions, hospital days, ED visits and outpatient visits estimated from adjusted generalized estimating equations with negative binomial distribution

Outcome variable		CATCH-H participants (n=186)						
		Rate per person-year				Rate ratio (RR)		
		12 months pre-intervention		12 months post-intervention		RR	95% CI	P-value
		Rate	95% CI	Rate	95% CI			
Hospital admissions	All cause	2.00	1.54-2.60	1.35	0.96-1.88	0.67	0.53-0.85	.001
	Mental health <u>and substance use</u>	1.22	0.92-1.63	0.69	0.48-1.01	0.57	0.44-0.74	<.001
Days in hospital	All cause	24.66	18.93-32.12	11.37	8.09-15.99	0.46	0.33-0.64	<.001
	Mental health <u>and substance use</u>	17.67	12.34-25.32	6.47	4.22-9.93	0.37	0.26-0.52	<.001
ED visits	All cause	8.98	6.76-11.94	9.57	6.90-13.29	1.07	0.90-1.25	.446
	Mental health <u>and substance use</u>	3.77	2.79-5.08	3.57	2.49-5.11	0.95	0.75-1.19	.645
Outpatient visits	Psychiatrist	3.16	2.36-4.25	4.42	3.32-5.88	1.40	1.15-1.70	.001
	GP	7.49	6.30-8.91	7.70	6.63-8.94	1.03	0.88-1.20	.725
	Total outpatient visits	11.05	9.35-13.07	12.64	10.81-14.77	1.14	1.00-1.31	.049

(Psychiatrist +
GP)

Legend: CI = confidence interval; GP = general practitioner

Table 3: Rate ratios (RR) and relative rate ratios (RRR) for *CATCH-H* participants with at least one hospitalization in the 12 months pre-intervention (n=125) compared to matched controls (n=250) 12 months pre-intervention vs. 12 months post-intervention for number of hospital admissions, hospital days, ED visits and outpatient visits estimated using adjusted generalized estimating equations with negative binomial distribution

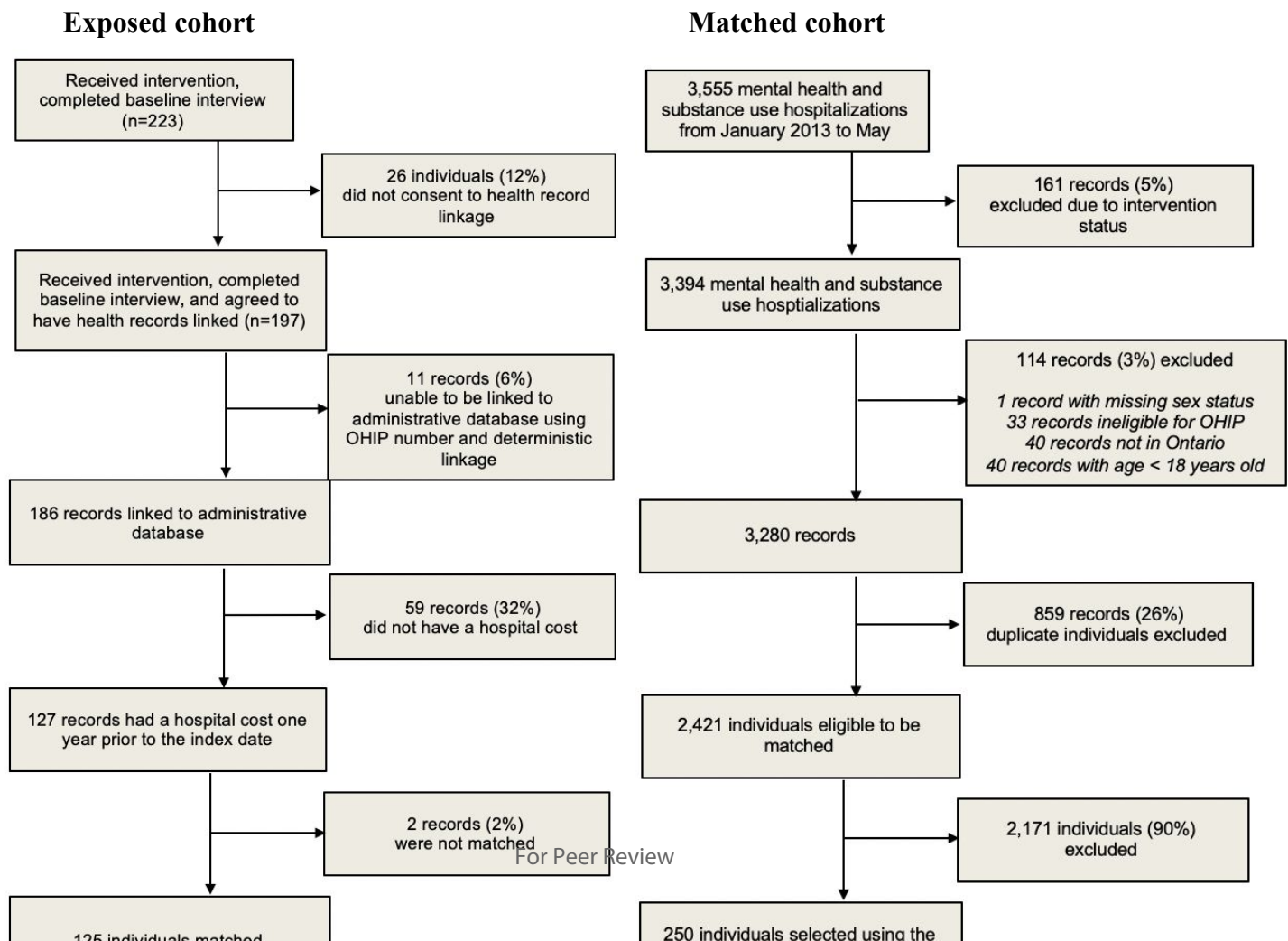
Outcome variable	12 months pre-intervention			12 months post-intervention			Relative rate ratio (RRR) 12 months post-intervention vs. 12 months pre-intervention					
	RR	95% CI	P-value	RR	95% CI	P-value	RR	95% CI	P-value			
Hospital admissions	All cause	0.99	-	1.20	0.82-1.45	.057	1.17	0.71-1.66	.38	0.97	0.71-1.33	.870
	Mental health and substance use	0.87	-	1.06	0.64-1.29	.565	0.95	0.63-1.39	.78	0.89	0.63-1.26	.522
Days in hospital	All cause	0.75	-	1.04	0.51-1.43	.808	0.77	0.46-1.17	.22	0.74	0.46-1.20	.225
	Mental health and substance use	0.67	-	0.93	0.38-1.29	.667	0.60	0.38-0.95	.03	0.64	0.38-1.10	.104
ED visits	All cause	1.01	-	1.35	1.19-1.79	.040	1.69	2.42	.004	1.26	0.95-1.67	.113

	Mental health <u>and substance</u> <u>use</u>	0.95 -			1.11- 2.43		1.2 3	0.89- 1.71	.212
Outpatient visits	Psychiatrist	0.96 -			1.02- 1.77		1.0 4	0.77- 1.40	.806
	All cause	0.96 -	.10 2		1.06- 1.75		1.1 1	0.86- 1.44	.409
	G P Mental health <u>and</u> <u>substance</u> <u>use</u>	0.85 -	.35 6	1.32	0.98- 1.77		1.1 4	0.84- 1.55	.408
	Total outpatient visits (Psychiatrist + GP)	1.02 -		1.33	1.10- 1.62	.003	1.0 7	0.87- 1.33	.522

Legend: CI = confidence interval; GP = general practitioner

Figures

Figure 1. Exposed and matched cohort selection



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9 **Title**

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12 Evaluating the impact of a Critical Time Intervention adaptation on health care utilization
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14 among homeless adults with mental health needs in a large urban centre
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Abstract

Objective: This study evaluated the impact of a Critical Time Intervention (CTI) adaptation on health care utilization outcomes among adults experiencing homelessness and mental health needs in a large urban centre.

Method: Provincial population-based administrative data from Ontario, Canada were used in a pre-post design for a cohort of 197 individuals who received the intervention between January 2013 and May 2014 and were matched to a cohort of adults experiencing homelessness who did not receive the intervention over the same time period. Changes in health care utilization outcomes in the year pre- and post-intervention were evaluated using generalized estimating equations and post-hoc analyses evaluated differences between groups.

Results: Pre-post analyses revealed statistically significant changes in health care utilization patterns among intervention recipients, including reduced inpatient service use and increased outpatient service use in the year following the intervention compared to the year prior. However, the matched cohort analysis found non-significant differences in health service use changes between a subgroup of intervention recipients and their matched counterparts.

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9 Conclusions: An adapted CTI model was associated with changes in health care utilization
10 among people experiencing homelessness and mental health needs. However, changes were
11 not different from those observed in a matched cohort. Rigorous study designs with
12 not different from those observed in a matched cohort. Rigorous study designs with
13 adequate samples are needed to examine the effectiveness of CTI and local adaptations in
14 adequate samples are needed to examine the effectiveness of CTI and local adaptations in
15 diverse health care contexts.
16 diverse health care contexts.
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24 **Keywords:** Critical Time Intervention, case management, homeless, mental health services,
25 addiction, health care utilization
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1. Introduction

Internationally, rates of homelessness continue to rise^{1,2}; and in Canada, national data show an increase in demand for shelter beds over time, with at least 235,000 Canadians experiencing homelessness in a year³. People experiencing homelessness also experience higher rates of mental health and addiction challenges⁴, neurocognitive impairment^{5,6}, physical health problems and premature mortality^{7,8}, compared to their housed counterparts. Despite the health disparities, this population generally has limited access to appropriate, high quality health care and supports, even in settings with universal health insurance⁹⁻¹². Together, these factors contribute to high rates of hospital service use and costs¹³⁻¹⁶.

Given increasing rates of homelessness and the impact of homelessness on health¹⁷, there is an urgent need for interventions to improve health outcomes in this population, including avoidable hospital service utilization¹⁵. For adults experiencing mental illness, care following discharge from hospital for a mental health condition is reportedly the most important factor in reducing reliance on subsequent inpatient care¹⁸. Adults experiencing mental illness and homelessness, however, are less likely to be referred to and access community-based services upon discharge from hospital, compared to housed individuals^{19,20}.

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9 Among people experiencing homelessness, strategies to improve continuity of care
10 by offering intensive time-limited services to support the transition from hospital to
11 community-based services have shown promising findings²¹⁻²⁶. Critical time intervention
12 (CTI) was designed to support homeless individuals during transitions of care, including
13 the period post-hospital discharge in which people experiencing mental illness are at high
14 risk of experiencing first-episode or recurrent homelessness.^{27,28} Critical time interventions
15 involve time-limited intensive case management over a period of six to nine months and
16 aim to help service users navigate the complex service system and establish (or re-
17 establish) access to longer-term community-based connections, resources and interventions.
18 This particular model has been shown to decrease early psychiatric readmission rates^{24,29,30},
19 improve perceived quality of care^{22,25}, improve health and quality of life outcomes^{24,30}, and
20 reduce rates of homelessness^{27,31}. Past evaluations of CTIs have also suggested that this
21 approach is cost-effective³² in supporting transitions of care.
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39 More evidence of the impact of CTI models, and their adaptations in diverse
40 settings, is urgently needed to support implementation of effective and cost-effective
41 strategies to improve health and housing outcomes among people experiencing
42 homelessness and who have unmet mental health needs. A recent pre-post evaluation of a
43 CTI adaptation for adults experiencing homelessness and mental health needs who were
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9 transitioning from hospital to community services in Toronto, Canada, reported significant
10 improvements in mental and physical health, substance use, and quality of life in the six
11 months following the intervention²⁴. Expanding on this work, the primary objective of this
12 study was to use administrative health care utilization data to evaluate whether a brief CTI
13 adaptation for adults experiencing homelessness and mental health needs who were
14 discharged from hospital services was associated with significant changes in health care
15 utilization outcomes in the year post-intervention compared to the year prior. This analysis
16 in addition compared changes in health care utilization among participants with a recent
17 hospitalization to those of a matched cohort of people experiencing homelessness over the
18 same time period who did not receive the intervention.
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31 32 **2. Methods**

33 34 *2.1 Intervention*

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38 The Coordinated Access to Care for Homeless adults (CATCH-Homeless) program
39 is a CTI adaptation in Toronto, Canada, supporting adults experiencing homelessness and
40 mental health needs following discharge from hospital. The program is facilitated through
41 partnerships between three local hospitals serving large numbers of people experiencing
42 homelessness, a primary care team, a homeless shelter, a large community mental health
43 agency, and a physician practice plan. The program accepts referrals from all partner
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9 hospital emergency departments (EDs) and inpatient units, or from community agencies,
10 and connects participants with transitional case managers who coordinate access to a full
11 range of post-discharge community-based services, including mental health and addiction
12 services, medical care, peer support, housing assistance, and other resources described in
13 depth elsewhere³³.
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21 *2.2 Study design*

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24 This study is part of a larger mixed-methods evaluation described elsewhere^{22,33}.
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26 Using provincial population-based administrative databases at ICES (formerly known as
27 the Institute for Clinical Evaluative Sciences), a single-arm pre-post analysis among
28 intervention participants was conducted to evaluate health care utilization outcomes in the
29 year following enrolment in the intervention compared to the year prior. In addition,
30 changes in health service utilization of a subgroup of intervention participants with a recent
31 hospitalization were compared to those of a matched cohort of adults experiencing
32 homelessness with at least one psychiatric hospitalization over the same time period who
33 did not receive the intervention.
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45 *2.3 Data sources*

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9 All administrative health care data were obtained from ICES. ICES is an
10 independent, non-profit research institute funded by an annual grant from the Ontario
11 Ministry of Health (MOH). As a prescribed entity under Ontario's privacy legislation,
12 ICES is authorized to collect and use health care data for the purposes of health system
13 analysis, evaluation and decision support. Secure access to these data is governed by
14 policies and procedures that are approved by the Information and Privacy Commissioner of
15 Ontario. The Ontario Mental Health Reporting System (OMHRS) and the Canadian
16 Institute for Health Information's Discharge Abstract Database (DAD) include data on all
17 psychiatric and acute hospitalizations, respectively. The Ontario Health Insurance Plan
18 (OHIP) claims database contains physician billings data, and the National Ambulatory Care
19 Reporting System gathers data on hospital- and community-based ambulatory care, such as
20 ED visits. The Ontario Registered Persons Database (RPDB) is a registry of all individuals
21 living in Ontario who are eligible for public health care insurance and holds data on patient
22 demographics, such as age, sex, and postal code.

23 *2.4 Sample*

24 *2.4.1 Intervention participants*

25 Intervention participants were those referred to the intervention by partner sites
26 following discharge from EDs and inpatient units. Intervention eligibility criteria included
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9 current homelessness status (defined as living in a crisis/emergency shelter, living on the
10 street, or couch surfing), provider-determined unmet mental health needs, and participant-
11 identified need for support services. Individuals were ineligible for this community-based
12 identified need for support services. Individuals were ineligible for this community-based
13 intervention if they had recent severe aggression or illness severity that required
14 institutional care. Study eligibility criteria included being a resident of the province of
15 Ontario, age 18 years and older, and not having previously received services from the
16 program. For the current analysis, 197 individuals, who received the intervention between
17 an index date of January 7, 2013 and May 16, 2014, completed a baseline interview, and
18 agreed to health care record linkage were included. Twenty-six individuals (11.7% of total
19 participants enrolled in the intervention) did not consent to health care record linkage and
20 were excluded from the current analysis. These individuals were not different from
21 consenting individuals in terms of gender but were younger (mean age: 34.9 years vs. 40.3
22 years; $P=.021$). Furthermore, they were not different in terms of baseline ED visits but had
23 fewer baseline hospitalizations (mean: 0.7 vs. 1.2; $P=.022$). Additional exclusion criteria
24 for this analysis included missing patient identifier (required for data linkage), not being
25 enrolled in OHIP, and/or missing data on sex and/or age.
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46 *2.4.2 Matched cohort participants*

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9 The comparison group was composed of individuals aged 18 years and older with
10 recorded homelessness (as identified by a residence variable in the OMHRS or a
11 homelessness variable in the DAD), who had at least one hospitalization for mental health
12 homelessness variable in the DAD), who had at least one hospitalization for mental health
13 or substance use during the exposure period (index date: January 1, 2013 to May 31, 2014).
14 Individuals who received the intervention and who had at least one hospitalization in the 12
15 months prior to the index date were then matched 1:2 with the comparison group of adults
16 experiencing homelessness who had not received the intervention using propensity score-
17 based matching. Variables used to calculate the propensity score included having a
18 hospitalization in the 12 months prior to the index date, age, sex, neighbourhood income
19 quintile and administrative health region of residence. We selected the closest control that
20 met the following criteria: age within two years at the index date, same sex (hard match)
21 and a propensity score within a caliper width of 0.20. To evaluate matching success,
22 standardized baseline differences were calculated between the subset of intervention
23 participants and the matched cohort. Standardized differences of 0.10 or less are considered
24 negligible³⁴. Individuals were excluded from the matched group if they were ineligible for
25 OHIP and/or had missing sex and/or age data.
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45 46 *2.5 Outcome measures* 47 48 49 50 51 52 53 54 55 56 57 58 59 60

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9 To evaluate changes in acute health care utilization, count outcomes including the
10 total number of all-cause and mental health and substance use-specific ED visits,
11 hospitalizations, and total hospital days were calculated. Dichotomized outcomes indicating
12 whether or not a participant had any all-cause and mental health and substance use-specific
13 ED visits and hospitalizations during the observation period were also calculated. To
14 evaluate changes in outpatient service use, count outcomes including the total number of
15 psychiatrist visits, all-cause and mental health and substance use-specific general
16 practitioner (GP) visits, and the sum total of outpatient visits were calculated, as well as
17 dichotomized outcomes indicating whether or not a participant had any psychiatrist visits
18 and all-cause and mental health and substance use-specific GP visits during the observation
19 period. Diagnostic codes used to determine mental health and substance use-specific
20 hospital and outpatient visits are provided in Supplemental Table 1.
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36 37 *2.6 Data collection* 38 39

40 Intervention participants' demographic and administrative health care records, held
41 by ICES, were linked using unique encoded identifiers; deterministic linkage was applied
42 using OHIP numbers. Health care records were examined for the 12 months pre- and post-
43 index date. The index date for exposure was the intervention enrolment date, ranging from
44 January 7, 2013 to May 16, 2014; the study period was January 2012 to May 2015. All
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9 participants provided written informed consent and the study received Research Ethics
10 Board approval from Unity Health Toronto. To identify the matched cohort used in
11 comparative analyses, population-based administrative demographic and health records
12 were retrieved and reviewed for the same time periods.
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19 *2.7 Statistical analyses*

20 *2.7.1 Single arm pre-post analysis*

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25 Baseline characteristics for both intervention participants and individuals included
26 in the matched cohort were calculated using frequencies and proportions for categorical
27 variables and means and standard deviation for continuous variables. In the pre-post
28 evaluation, inferential analyses for each count outcome included rates and rate ratios and
29 their respective 95% confidence intervals estimated using generalized estimating equation
30 (GEE) models with a negative binomial distribution and a log link. For each binary
31 outcome, predicted probabilities and prevalence ratios and their respective 95% confidence
32 intervals were estimated using GEE models with a Poisson distribution and a log link. All
33 models were adjusted for age, sex and neighbourhood income quintile (measured at the
34 Census tract level). An offset variable for person-years was included to adjust for different
35 follow-up lengths.
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9 All analyses were conducted using SAS Enterprise Guide 7.1. A significance level
10 of .05 was used to interpret statistical significance.
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13 14 *2.7.2 Post-hoc comparative analysis* 15

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17 Baseline demographic characteristics were calculated between intervention
18 participants with at least one hospitalization in the 12 months pre-index date and their
19 matched counterparts using frequencies and proportions for categorical variables and means
20 and standard deviation for continuous variables. To show trends between groups and over
21 time, GEE models specifying a negative binomial distribution and a log link were
22 conducted for each count outcome to estimate rate ratios and relative rate ratios; for each
23 binary outcome, GEE models specifying a Poisson distribution and a log link were
24 conducted to calculate prevalence ratios and relative prevalence ratios. All post-hoc models
25 were adjusted for age, sex and neighbourhood income quintiles and included group, time
26 and group by time interaction variables.
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41 **3. Results** 42

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44 The cohort selection is detailed in Figure 1. Of the 197 eligible individuals who
45 received the intervention during the study period, 11 health records were unlinkable (six
46 were blank and five were invalid), resulting in a cohort of 186 participants. Of those, 51
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9 individuals were excluded from the matched analysis because they did not have a
10 hospitalization for mental health or substance use in the 12 months prior to the index date
11 required for comparison with the matched sample, leaving a subset of 125 individuals.
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13 Among 3,555 administrative records of people experiencing homelessness with a mental
14 health or substance use-specific hospitalization during the exposure period, 250 individuals
15 (1:2 matching) were selected for inclusion in the matched cohort.
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23 *3.1 Demographic characteristics*

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26 The demographic characteristics of intervention participants (n=186) are presented
27 in Supplemental Table 2. The majority of the sample (78.5%) was male. Participants had a
28 mean age of 40.3 years ($SD=12.0$), with an even distribution across age brackets between
29 18 and 59 years; only 4.3% of participants were over the age of 60.
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36 Table 1 shows the demographic characteristics of the 125 intervention participants
37 included in the matched cohort analysis and their matched counterparts; these were similar
38 to those of the full cohort of intervention participants in age, sex, and neighbourhood
39 income quintile as indicated by no standardized difference between the two groups being
40 greater than 0.10.
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48 *3.2 Pre-post analysis*

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9 Rates per person-year and rate ratios (RR) for intervention participants (n=186) in
10 the 12 months pre- and post-intervention enrolment for the number of hospital admissions,
11 hospital days, ED visits and outpatient visits are presented in Table 2; results for binary
12 hospital days, ED visits and outpatient visits are presented in Table 2; results for binary
13 outcomes are presented in Supplemental Table 3. Overall, results reveal changes in health
14 care utilization patterns, with decreased inpatient care and increased outpatient care in the
15 12 months following enrolment in the intervention, compared to the 12 months prior.
16
17 Inpatient hospital use decreased significantly among intervention participants in the 12
18 months following enrolment, especially for mental health and substance use-specific visits.
19
20 Adjusted admission rates decreased significantly for both all cause and mental health and
21 substance use-specific causes, by 33% (95% CI 15%-47%; $P=.001$) and 43% (95% CI
22 26%-66%; $P<.001$), respectively, in the 12 months post-intervention relative to 12 months
23 prior. The total number of hospital days also decreased significantly, by 54% (95% CI
24 36%-77%; $P<.001$) for all-cause days and by 63% (95% CI 48%-74%; $P<.001$) for mental
25 health and substance use days. While the number of ED visits did not change significantly
26 over time, the overall prevalence of ED visits did decrease significantly, by 14% for any
27 reason (95% CI 7%-20%; $P<.001$); and by 31% for mental health and substance use
28 reasons (95% CI 12%-39%; $P<.001$) (Supplemental Table 3). In contrast to the decrease in
29 acute hospital service use, outpatient psychiatrist visits increased by 40% (95% CI 1.15-

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9 1.70; $P=.001$) in the 12 months following the intervention compared to the 12 months prior;
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11 GP visits did not change significantly.
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14 *3.3 Matched cohort analysis*

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17 Rate ratios and relative rate ratios (RRR) for the subset of intervention participants
18 with at least one hospitalization in the 12 months prior to the index date ($n=125$) compared
19 to matched controls ($n=250$) 12 months pre- and post-intervention, for the number of
20 hospital admissions, hospital days, ED visits and outpatient visits are presented in Table 3.
21
22 Prevalence ratios (PR) and relative prevalence ratios (RPR) are presented in Supplemental
23
24 Table 4. For both count and binary outcomes, results of the matched cohort analysis suggest
25
26 that while results generally trended in the same direction as the pre-post analysis, the
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28 changes in health service use experienced by intervention participants in the year following
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30 receipt of the intervention as compared to the year prior were not significantly different
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32 than the changes experienced by their matched counterparts (Table 3).
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41 **4. Discussion**

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44 Care continuity³⁵ is essential to the delivery of high quality services for people
45 living with chronic health conditions, including mental illness and addictions, and is
46 associated with improved health and service use outcomes³⁶. Our findings of decreased
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9 acute care service use and increased outpatient service use in the 12 months following the
10 intervention as compared to the 12 months prior are consistent with previous outcomes of
11 critical time intervention (CTI) studies, finding significant changes in outcome
12 measures^{24,29,30}. In addition, our findings further support and are supported by previous
13 qualitative research suggesting improved experiences of continuity of care among adults
14 experiencing homelessness receiving CTI or CTI adaptations^{22,37}. Notably, our findings
15 highlight continued high rates of emergency department (ED) visits post-intervention
16 among participants, suggesting that this population may have more acute and/or enduring
17 needs than the brief CTI adaptation can address in our local context. Access to housing and
18 high quality intensive case management in Toronto, for example, are extremely limited and
19 hindered by long wait lists; it is possible that participants continued to visit the ED for
20 immediate shelter and support post-intervention, as intervention resources were limited and
21 not linked to housing. Persisting high ED use among participants reaffirms the need for
22 inclusion of housing in mental health policy priorities.¹⁷
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42 Although prior controlled studies of CTI have demonstrated improvements in acute
43 care utilization in some settings²⁶, the addition of a matched cohort analysis in the current
44 study indicates that changes in service use patterns of recipients of a brief CTI adaptation
45 within our setting of universal health insurance and a relatively service-rich environment
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9 are not significantly different than those of their matched counterparts. Similar to this
10 analysis, a prior post-hoc analysis of intervention participants using self-reported data and a
11 comparison group of adults experiencing homelessness and mental illness who were
12 receiving usual care found successful reduction in mental health symptoms and alcohol and
13 drug use problems among intervention participants, but increased ED visits and days spent
14 in hospital over six months²⁴. The current post-hoc analysis, in using administrative data
15 and a cohort matched on prior hospitalizations, was intended to build off the limitations of
16 the aforementioned prior analysis²⁴ by focusing on service use outcomes using
17 administrative data and exploring between-group differences with added methodological
18 rigor. Additional measures including clinical characteristics such as diagnosis and acuity,
19 and demographic and service use factors such as geographical location and resource
20 availability, may help to better explain the identified non-significant differences between
21 groups in future studies.
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39 Our findings further highlight the need for rigorous methods in evaluating new
40 interventions in diverse contexts. The brief CTI adaptation evaluated in the current study
41 was set in a large urban centre under a universal health insurance system and included a
42 dedicated, low-barrier, multidisciplinary weekly physician clinic in addition to brief case
43 management support with limited training and supervision of frontline staff, in keeping
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9 with a pragmatic field intervention. Our findings suggest that participants' access to
10 preventative outpatient services was successfully facilitated by streamlined access to GPs
11 and psychiatrists. Such an approach may be particularly relevant to similarly large urban
12 and psychiatrists. Such an approach may be particularly relevant to similarly large urban
13 centre where timely access to physician and case management resources is hindered by
14 rapid general and homeless population growth and corresponding demand for services.
15 While fidelity standards for CTI have been developed, detailing the key model components
16 requiring adherence, and the contextual structures and staff competencies needed to ensure
17 model integrity³⁸⁻⁴⁰, a recent systematic review indicates that fidelity and adaptations
18 remain highly variable²⁶ and should be a required component of rigorous evaluations. The
19 fidelity of the intervention to the CTI model was not formally assessed in this study. Future
20 efforts should ensure that local adaptations of evidence-based interventions balance local
21 needs and resources with fidelity to key intervention ingredients, so that evidence generated
22 can be reliably attributed to the model of interest.
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38 39 40 *4.1 Strengths and limitations*

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42 Our findings contribute to the growing evidence on the impact of CTI and its
43 adaptations on health service use. Results are strengthened by the study's methodological
44 approach, which included the use of population-based administrative data and a rigorous
45 selection process to ensure the appropriateness of comparators. However, the identification
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9 of a matched cohort was challenged by the lack of a baseline acuity measure, requiring us
10 to match on recent hospitalizations as a proxy for acuity, although post-matching
11 demographic comparisons suggested the groups were minimally different. Additionally,
12 intervention participants were selected using some clinical criteria that could not be applied
13 to matched individuals identified from administrative data. In the absence of a built-in
14 control group, this an acknowledged design limitation that could have resulted in selection
15 bias.
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25 We were also limited by our sample size and underpowered to detect hospitalization
26 differences. It is possible that the lower relative rates of psychiatric hospitalizations
27 observed in the intervention group would be significantly different with a larger sample.
28 Still, without a randomized design, it is possible the improvements in health care use
29 observed in the pre-post analysis are due to regression to the mean, rather than the effect of
30 the intervention.
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40 Given the high cost of hospitalizations and from a quality of care perspective, future
41 research should focus on rigorous evaluations using experimental methods with large
42 samples and robust sets of explanatory variables, in addition to approaches to strengthening
43 fidelity of local adaptations to evidence-supported treatments. Related research should
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9 investigate the cost-effectiveness of these interventions to maximize health outcomes given
10 the limited resources available.
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13 14 **5. Conclusions** 15

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17 Study findings suggest that participants of a brief Critical Time Intervention (CTI)
18 for adults experiencing homelessness and unmet mental health needs had decreased acute
19 care use and increased outpatient service use post-intervention. Post-hoc analyses, however,
20 found that changes in service use patterns were not significantly different from those of a
21 matched cohort of adults experiencing homelessness. While CTI and its adaptations hold
22 promise in improving continuity of care and health outcomes for this population, more
23 rigorous study designs with adequate sample sizes are needed to further examine the
24 effectiveness of CTI and local adaptations in diverse health care contexts.
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Data Access

Data included in this publication are not publicly available and were collected by ICES. As a prescribed entity under Ontario's privacy legislation, ICES is authorized to collect and use health care data for the purposes of health system analysis, evaluation and decision support. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario. For further questions regarding data accessibility, please contact the corresponding author.

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Conflict of Interest Disclosure: none.

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Tables

Table 1: Demographic characteristics of CATCH-H participants *with at least one hospitalization in the 12 months pre-intervention* (n=125) and matched controls (n= 250)

Demographic variables	CATCH-H participants with hospitalization (n=125)		Matched controls (n=250)		Standardized difference	
	n	%	n	%		
Age (years)	18 to 29	29	23.2	58	23.2	0
	30 to 39	27	21.6	52	20.8	0.02
	40 to 49	36	28.8	73	29.2	0.01
	50 to 59	25	20	49	19.6	0.01
	60 and over	8	6.4	18	7.2	0.03
	Mean (SD)	41.1 (12.4)		41	12.3	0
Sex	Female	27	21.6	52	20.8	0
	Male	98	78.4	19	79.2	
Neighbourhood income quintile	1* (low)	39	31.2	90	36	0.09
	2 (medium low)	30	24	55	22	0.05
	3 (medium)	26	20.8	49	19.6	0.03
	4 (medium high)	13	10.4	23	9.2	0.04
	5 (high)	17	13.6	33	13.2	0.01

Legend: SD = standard deviation

*1: includes individuals in the 1st income quintile and those where this information was missing

Table 2: Rates per person-year and rate ratios (RR) for CATCH-H participants (n=186) 12 months pre-intervention vs. 12 months post-intervention for number of hospital admissions, hospital days, ED visits and outpatient visits estimated from adjusted generalized estimating equations with negative binomial distribution

Outcome variable		CATCH-H participants (n=186)						
		Rate per person-year				Rate ratio (RR)		
		12 months pre-intervention		12 months post-intervention		RR	95% CI	P-value
		Rate	95% CI	Rate	95% CI			
Hospital admissions	All cause	2.00	1.54-2.60	1.35	0.96-1.88	0.67	0.53-0.85	.001
	Mental health and substance use	1.22	0.92-1.63	0.69	0.48-1.01	0.57	0.44-0.74	<.001
Days in hospital	All cause	24.66	18.93-32.12	11.37	8.09-15.99	0.46	0.33-0.64	<.001
	Mental health and substance use	17.67	12.34-25.32	6.47	4.22-9.93	0.37	0.26-0.52	<.001
ED visits	All cause	8.98	6.76-11.94	9.57	6.90-13.29	1.07	0.90-1.25	.446
	Mental health and substance use	3.77	2.79-5.08	3.57	2.49-5.11	0.95	0.75-1.19	.645
Outpatient visits	Psychiatrist	3.16	2.36-4.25	4.42	3.32-5.88	1.40	1.15-1.70	.001
	GP	7.49	6.30-8.91	7.70	6.63-8.94	1.03	0.88-1.20	.725
	Total outpatient visits	11.05	9.35-13.07	12.64	10.81-14.77	1.14	1.00-1.31	.049

(Psychiatrist +
GP)

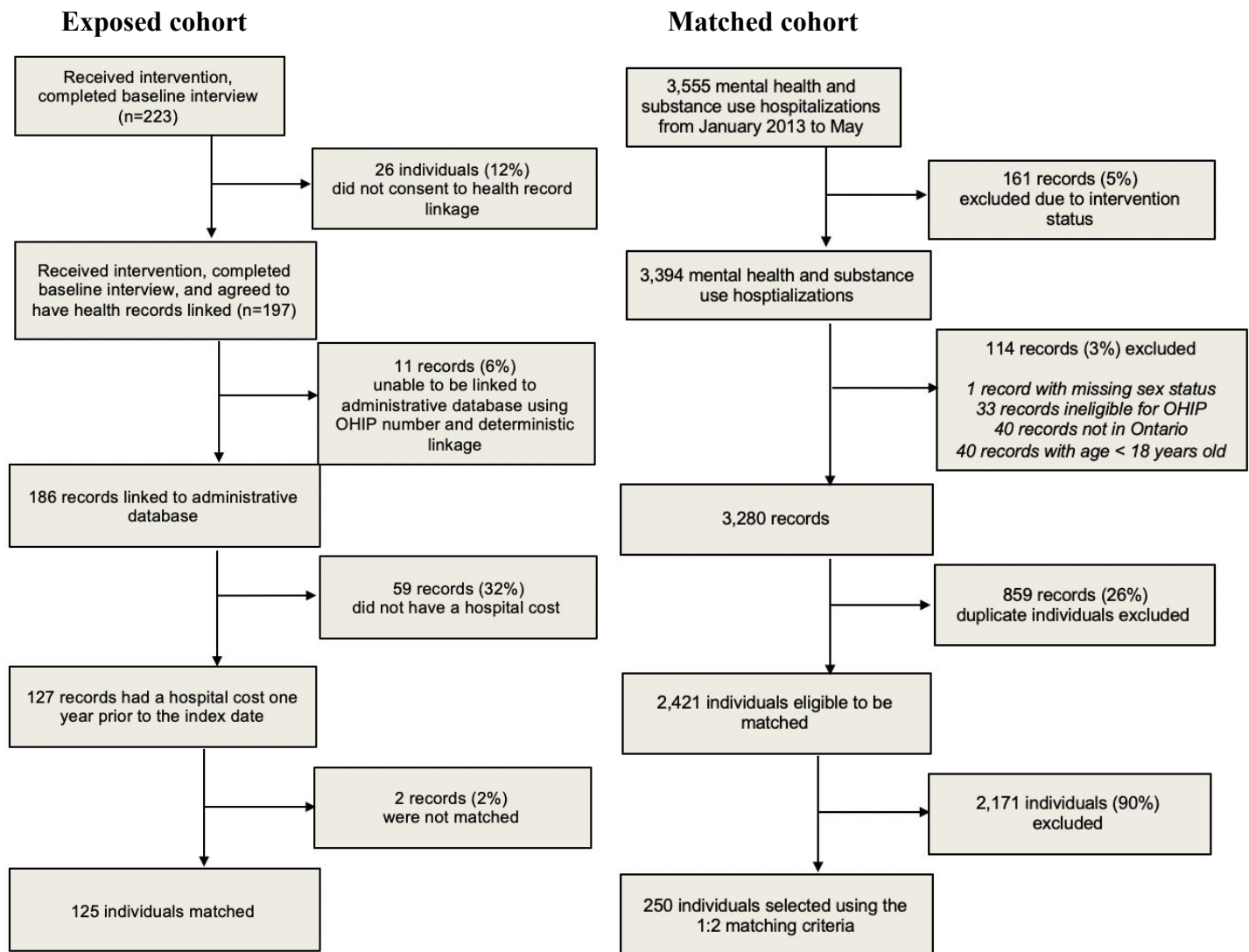
Legend: CI = confidence interval; GP = general practitioner

Table 3: Rate ratios (RR) and relative rate ratios (RRR) for *CATCH-H* participants with at least one hospitalization in the 12 months pre-intervention (n=125) compared to matched controls (n=250) 12 months pre-intervention vs. 12 months post-intervention for number of hospital admissions, hospital days, ED visits and outpatient visits estimated using adjusted generalized estimating equations with negative binomial distribution

Outcome variable	12 months pre-intervention			12 months post-intervention			Relative rate ratio (RRR) 12 months post-intervention vs. 12 months pre-intervention					
	RR	95% CI	P-value	RR	95% CI	P-value	RR	95% CI	P-value			
Hospital admissions	All cause	0.99	-	1.20	0.82-1.45	.057	1.17	0.71-1.66	.38	0.97	0.71-1.33	.870
	Mental health and substance use	0.87	-	1.06	0.64-1.29	.565	0.95	0.63-1.39	.78	0.89	0.63-1.26	.522
Days in hospital	All cause	0.75	-	1.04	0.51-1.43	.808	0.77	0.46-1.17	.22	0.74	0.46-1.20	.225
	Mental health and substance use	0.67	-	0.93	0.38-1.29	.667	0.60	0.38-0.95	.03	0.64	0.38-1.10	.104
ED visits	All cause	1.01	-	1.35	1.19-1.79	.040	1.69	1.19-2.42	.004	1.26	0.95-1.67	.113

Figures

Figure 1. Exposed and matched cohort selection



Supplementary Materials

Supplemental Table 1: Diagnostic codes used in cohort selection

Mental health outcomes	Diagnostic Codes
Hospitalizations	ICD-10-CA: all F codes (main diagnosis) OMHRS: all discharges
Emergency department visits	ICD-10-CA: F04 to F99 (main diagnosis) ICD-10-CA: X60-X84, Y10-Y19, Y28 (any diagnosis)
Psychiatrist visits	OHIP visit/consult to a psychiatrist [SPEC = 19]
General practitioner outpatient visits	OHIP visit/consult to a general practitioner [SPEC = 00] AND a mental health diagnostic code: 295, 296, 297, 298, 300, 301, 302, 306, 309, 311, 303, 304, 897, 898, 899, 900, 901, 902, 904, 905, 906, 909

Supplemental Table 2: Demographics of CATCH-H cohort (n=186)

Demographic variables	N	%	
Age (years)	18 to 29	43	23.1
	30 to 39	46	24.7
	40 to 49	51	27.4
	50 to 59	38	20.4
	60 and over	8	4.3
	Mean (SD)	40.3 (12.0)	
Sex	Female	40	21.5
	Male	146	78.5
Neighbourhood income quintile	Missing	6	3.2
	1 (low)	56	30.1
	2 (medium low)	44	23.7
	3 (medium)	41	22.0
	4 (medium high)	16	8.6
	5 (high)	23	12.4

Legend: SD = standard deviation

Supplemental Table 3: Predicted probabilities and prevalence ratios (PR) for CATCH-H participants (n=186) 12 months pre-intervention vs. 12 months post-intervention for any hospital admission, any ED visit, and any outpatient visit estimated from adjusted generalized estimating equations with Poisson distribution

Outcome variable		CATCH-H participants (n=186)						
		Predicted probability (PP)				Prevalence ratio (PR)		
		12 months pre-intervention		12 months post-intervention		PR	95% CI	P-value
		PP	95% CI	PP	95% CI			
Any hospital admission	All cause	0.77	0.68-0.86	0.48	0.40-0.57	0.62	0.52-0.74	<.001
	Mental health	0.58	0.46-0.73	0.31	0.24-0.41	0.54	0.44-0.67	<.001
Any ED visit	All cause	0.96	0.91-1.01	0.83	0.77-0.89	0.86	0.80-0.93	<.001
	Mental health	0.79	0.71-0.87	0.54	0.47-0.63	0.69	0.61-0.78	<.001
Any outpatient visit	Psychiatrist	0.74	0.65-0.85	0.69	0.60-0.79	0.93	0.84-1.03	.174
	GP	0.86	0.80-0.93	0.89	0.83-0.95	1.03	0.96-1.10	.392
	Mental health	0.73	0.65-0.80	0.76	0.68-0.84	1.04	0.94-1.16	.449
	Total outpatient visits (Psychiatrist + GP)	0.95	0.92-0.99	0.98	0.95-1.01	1.03	0.98-1.07	.231

Legend: CI = confidence interval; GP = general practitioner

Supplemental Table 4: Prevalence ratios (PR) and relative prevalence ratios (RPR) for *CATCH-H* participants with at least one hospitalization in the 12 months pre-intervention (n=125) compared to matched controls (n=250) 12 months pre-intervention vs. 12 months post-intervention for any hospital admission, ED visit and outpatient visit estimated using adjusted generalized estimating equations with Poisson distribution

Outcome variable		12 months pre-intervention			12 months post-intervention			Relative prevalence ratio (RPR) 12 months post-intervention vs. 12 months pre-intervention		
		PR	95% CI	P-value	PR	95% CI	P-value	RP R	95% CI	P-value
Any hospital admission	All cause	1.00	0.99-1.01	.982	0.89	0.72-1.10	.30	0.89	0.72-1.10	.297
	Mental health	0.86	0.80-0.92	<.001	0.78	0.60-1.00	.047	0.91	0.71-1.17	.450
Any ED visit	All cause	1.03	0.99-1.06	.142	1.07	0.96-1.20	.20	1.05	0.94-1.17	.428
	Mental health	0.97	0.89-1.05	.456	0.91	0.75-1.11	.36	0.94	0.78-1.14	.546
	Psychiatrist	1.13	1.01-1.26	.040	1.09	0.96-1.25	.18	0.97	0.83-1.14	.728
Any outpatient visit	GP All cause	1.08	0.98-1.19	.120	1.16	1.06-1.27	.002	1.07	0.96-1.20	.239
	GP Mental health	1.14	0.99-1.32	.066	1.26	1.10-1.45	.001	1.10	0.93-1.31	.259
	Total outpatient visits (Psychiatrist + GP)	1.03	0.97-1.09	.368	1.03	0.98-1.09	.24	1.01	0.93-1.08	.890

Legend: CI = confidence interval; GP = general practitioner

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3 **Évaluer l'effet d'une adaptation de l'intervention en temps critique sur l'utilisation**
4 **des soins de santé chez des adultes itinérants ayant des besoins de santé mentale dans**
5 **un grand centre urbain**
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10 **Objectif** : La présente étude a évalué l'effet d'une adaptation de l'intervention en temps
11 critique (ITC) sur les résultats de l'utilisation des soins de santé chez des adultes en
12 situation d'itinérance et ayant des besoins de santé mentale dans un grand centre urbain.
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18 **Méthode** : Des données administratives provinciales dans la population de l'Ontario,
19 Canada, ont servi à une méthode avant et après pour une cohorte de 197 personnes qui ont
20 reçu l'intervention entre janvier 2013 et mai 2014, et ont été appariées à une cohorte
21 d'adultes en situation d'itinérance qui n'ont pas reçu l'intervention durant la même période.
22 Les changements des résultats de l'utilisation des soins de santé dans l'année avant et après
23 l'intervention ont été évalués à l'aide d'équations d'estimation généralisées et des analyses
24 a posteriori ont évalué les différences entre les groupes.
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35 **Résultats** : Les analyses avant et après ont révélé des changements statistiquement
36 significatifs des modèles d'utilisation des soins de santé chez les bénéficiaires de
37 l'intervention, notamment une utilisation réduite des services pour les patients hospitalisés
38 et une utilisation accrue des services pour les patients ambulatoires dans l'année suivant
39 l'intervention comparé à l'année précédente. Toutefois, l'analyse de la cohorte appariée a
40 constaté des différences non significatives dans les changements d'utilisation des services
41 de santé entre un sous-groupe de bénéficiaires de l'intervention et leurs homologues
42 appariés.
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3 **Conclusions** : Un modèle adapté d'ITC était associé à des changements de l'utilisation des
4 soins de santé chez les personnes en situation d'itinérance et ayant des besoins de santé
5 mentale. Cependant, les changements n'étaient pas différents de ceux observés dans une
6 cohorte appariée. Il faut des méthodes rigoureuses et des échantillons adéquats dans les
7 études qui examinent l'efficacité de l'ITC et les adaptations locales dans divers contextes
8 de soins de santé.
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