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Title: Population-based cohort study to determine the association between home-time and disability after stroke by age, sex, stroke type, and study year

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Abstract

Objective: Home-time is an emerging patient-centered stroke outcome metric, but it is not well described in the population. We aimed to determine the association between 90-day home-time and global disability after stroke. We hypothesized that longer home-time would be associated with less disability.

Design: Population-based cohort study of patients with ischemic stroke or intracerebral hemorrhage admitted to an acute care hospital between April 1st 2002 and March 31st 2013.

Setting: All regional stroke centres and a simple random sample of patients from all other hospitals across the province of Ontario, Canada.

Participants: We included 39,417 adult patients (84% ischemic, 16% hemorrhage), 53% male, with a median age of 74 years. We excluded non-residents of Ontario, patients without a valid health insurance number, patients discharged against medical advice or those who failed to return from a pass, patients living in a long-term care centre at baseline, and stroke events occurring in-hospital.

Primary outcome measure: 90-day home-time, defined as the number of days spent at home in the first 90 days after stroke, obtained using linked administrative data.

Results: Compared to people with no disability, those with minimal disability had less home-time (adjusted rate ratio (aRR) 0.96, 95% confidence intervals (CI_{95}) [0.93,0.98]) and those with the most severe disability had the least home-time (aRR 0.05 CI_{95} [0.04,0.05]). We found no clinically relevant modification by stroke type, sex, or study year. However, for a given level of disability, older patients experienced less home-time compared to younger patients.

Conclusions: Our results provide content validity for home-time to be used to monitor stroke outcomes in large populations or to study temporal trends. Older patients experience less home-time for a given level of disability, suggesting the need for stratification by age.

Strengths and limitations of this study

- Population-based analysis of home-time, a graded stroke outcome metric that can be derived from administrative data.
- First study to assess the association between home-time and global disability in subgroups, including stroke type, sex, age groups, and study year.
- Lack of data on disability after hospital discharge.
- Lack of data on social support or private funds, which may influence ability to return home.

Introduction

Stroke is a leading cause of severe disability.[1 2] The lack of a routinely collected graded stroke outcome metric is a critical limitation to population-based stroke outcome research. The modified Rankin Scale (mRS) is the most frequently used measure of functional outcome in stroke clinical research, but it cannot be routinely obtained for all patients as it requires prospective patient follow-up and testing.[3] Home-time is a novel stroke outcome indicator that is correlated with the mRS when assessed in clinical trial populations with ischemic stroke.[4-6] Home-time is defined as the total number of days a patient is living outside of a healthcare institution after stroke. This metric is patient-centered[7 8] and is ideal for pragmatic studies evaluating real-world outcomes because it can be derived for large populations using administrative data.[5 6]

There are nevertheless several gaps in knowledge about home-time. Prior studies focused on patients with ischemic strokes enrolled in clinical trials[4 9] and few have described the relationship between home-time and mRS in the general population.[5] Understanding whether the association between home-time and mRS holds true in a population-based sample, in different stroke types, in important patient subgroups, as well as in different time periods is necessary to inform whether home-time can be used as an outcome metric to evaluate quality of stroke care. Finally, because home-time may be sensitive to the structures of healthcare systems, it is relevant to validate this metric in different jurisdictions.[10]

We aimed to determine the association between 90-day home-time and disability at discharge, measured using the mRS score, in a population-based cohort of patients with ischemic or

hemorrhagic stroke. We hypothesized that home-time would be strongly associated with the mRS score and that this association would not be significantly modified by stroke type, temporal trends, or patient demographics.

Methods

Cohort identification

We identified all hospital admissions for ischemic stroke or intracerebral hemorrhage in the Ontario Stroke Registry (formerly known as the Registry of the Canadian Stroke Network) between April 1st 2002 and March 31st 2013. The registry collected data on all consecutive patients with stroke seen in the emergency department or admitted to regional stroke centres and a simple random sample of patients from all other hospitals across Ontario, Canada's most populous province with a population of 13 million people.[11] We excluded patients with subarachnoid hemorrhage. Other exclusion criteria were patients aged less than 18 years, non-residents of Ontario or those without a valid health insurance number, patients discharged against medical advice or those who failed to return from a pass, patients living in a long-term care centre at baseline, and any strokes occurring during hospitalization for a different health condition. Only the first presentation was included in individuals who presented with stroke more than once during the study period.

Outcomes and covariates

The 90-day home-time was the primary outcome and was defined as the total number of days a patient was living outside of a healthcare institution in the first 90 days after stroke. Home-time was calculated for each individual patient using linked administrative health databases

(Supplemental Table 1) by subtracting the number of days spent in emergency care, acute care, inpatient rehabilitation, long-term care institution, as well as any re-hospitalizations from the first 90 days after the date of admission for the index event. By definition, patients who died during the index hospitalization have 0 home-time days. Patients who were discharged from health care institutions and subsequently died in the first 90 days after stroke may have accumulated home-time days. We also determined whether Ontario public home care services were provided to patients who were assumed to be at home. Canadian administrative databases include data on the entire population and have been extensively validated for research purposes.[12] These datasets were linked using unique encoded identifiers and analyzed at ICES.

Data on discharge mRS were obtained from the registry (<1% missing data). The mRS is an ordinal scale ranging from 0 for no symptoms, to 3 for moderate disability (able to walk without assistance, but requiring some help), to 5 for severe disability (bedridden, requiring constant nursing care), and to 6 for death.[3] Data validation by duplicate chart abstraction showed excellent agreement (kappa score or intraclass correlation coefficient of greater than 0.9) for key variables.[13]

The covariates in our analyses were age, sex, stroke type (ischemic stroke versus intracerebral hemorrhage), stroke severity (mild stroke defined as a National Institutes of Health Stroke Scale (NIHSS) < 5), Charlson comorbidity index (dichotomized to <2 or ≥ 2), independence in activities of daily living prior to the index stroke, location of residency (small population centre: less than 10,000, medium population centre: 10,000 to 100,000, and large urban population centre: >100,000), and neighborhood income quintile. The covariates were obtained from the

Ontario Stroke Registry, except for the Charlson comorbidity index, the location of residency, and the neighborhood income quintile which were obtained from linked administrative data.[14]

Statistical methods

Patient characteristics were described using proportions for categorical variables and median with 25th and 75th percentiles (Q_1,Q_3) for continuous variables. We used Spearman's rank correlation to quantify the correlation between 90-day home-time and discharge mRS stratified by stroke type. Because the distribution of home-time is bucket-shaped with peaks around its minimum value (0) and maximum value (90), we considered four regression models: the negative binomial model, the Poisson model, and their respective zero-inflated counterparts.[15] The zero-inflated negative binomial regression model best fit our observed data. Accordingly, this model was used to determine the association between discharge mRS and 90-day home-time with adjustment for the covariates. The zero-inflated negative binomial model yields two sets of regression coefficients: one from an underlying logistic model that is modeling excess zeros and one from an underlying negative binomial model for counts. To simplify presentation and interpretation of the two sets of regression coefficients, we used a previously described method for summarizing the effect of the predictor variables to yield an adjusted summary rate ratio (aRR), which is interpreted as the ratio of the mean number of home-time days among those exposed to the covariate of interest to the mean number of home-time days among those who were not.[15] We used bootstrapping to obtain 95% confidence intervals (CI_{95}). In order to determine whether the association between home-time and mRS was significantly modified by stroke type, sex, age, and study year, we used likelihood ratio tests to compare the models with and without the appropriate multiplicative interaction terms. If a statistically significant

interaction was present, we reported the stratum-specific aRR derived from the model with the appropriate main effects and interaction terms.

Research Ethics Approval

ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. The use of data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act.

Results

Our study sample consisted of 39,417 patients (84% ischemic stroke and 16% intracerebral hemorrhage), with a median (Q_1,Q_3) age of 74 years (63,82), of whom 53% were male. Table 1 describes patient characteristics, disability at discharge, the median 90-day home-time, and the location of the patient at 90 days by stroke type. The median 90-day home-time was 55 days (0,82) for patients with ischemic stroke and 0 (0,58) for those with intracerebral hemorrhage. By definition, patients who died during the index hospitalization (n=6,052, 15%) did not accumulate any home-time days.

More 90-day home-time (i.e. more days at home) was associated with lower mRS at discharge (i.e. less disability) for ischemic stroke (Spearman correlation coefficient -0.78) and intracerebral hemorrhage (Spearman correlation coefficient -0.80). Table 2 shows the median (Q_1, Q_3) and mean (standard deviation) home-time for each mRS category as well as the results of the multivariable zero-inflated negative binomial analyses.

We showed that people with higher disability at discharge from the acute-care hospitalization experienced less home-time. Compared to people discharged with no disability (mRS=0), those discharged with minimal disability had slightly less home-time (mRS=1 aRR 0.96, CI_{95} [0.93,0.98]), but those discharged with the most severe disability had the least home-time (mRS=5 aRR 0.05 CI_{95} [0.04,0.05]). In addition, older people, those with a higher comorbidity burden, and those with higher stroke severity experienced less home-time; while those who were independent at baseline experienced more home-time (Table 2). Patients living in medium urban regions had slightly more home-time than those living in small towns or in large urban regions. Home-time was not associated with the neighborhood income quintile, a proxy for socioeconomic status.[14]

Figure 1 shows the relationship between discharge mRS and 90-day home-time by stroke type, age, sex, and study year. There was no evidence of effect modification by stroke type (p for interaction=0.06), but there was a statistically significant interaction for age, sex, and study year (p for interaction < 0.001 for all three covariates). In the sub-analysis by age, we observed that for almost all levels of the mRS, except those with the most severe disability, older patients experienced less home-time compared to their younger counterparts (Figure 2). In the sub-analysis by sex, we observed that compared to women, men experienced slightly more home-time in the subgroup of patients discharged with lower disability (mRS=1 aRR CI_{95} 1.02 [1.00,1.05], mRS=2 aRR CI_{95} 1.03 [1.00,1.05], and mRS=3 aRR CI_{95} 1.05 [1.03,1.07]), but men had less home-time among those with the most severe disability (mRS=5 aRR CI_{95} 0.69 [0.52,0.92], Figure 3). Finally, in the sub-analysis by study years, despite a statistically

significant p-value for interaction, we did not observe any consistent or clinically meaningful trends in effect modification (Supplemental Figure 1).

Discussion

In this large population-based study of patients with stroke, we demonstrated that 90-day home-time was associated with global disability as measured by the mRS at discharge, for both ischemic stroke and intracerebral hemorrhage, and that this association was stable over an 11-year period. We showed a clear gradient between home-time and functional outcomes, across the levels of disability measured by the mRS, with people discharged from hospital with the highest disability experiencing the least home-time. In addition, home-time was responsive to covariates known to be associated with stroke outcomes as people who were older, dependent at baseline, had higher comorbidity burden, or presented with severe strokes had less home-time.[16 17]

Home-time has been identified as a patient-centered outcome in stroke[7] as well as in other medical conditions, such as cancer.[8] This metric is associated with healthcare costs and is important to policy-makers.[10 18] With the availability of new stroke treatments; for example, acute revascularization treatments up to 24 hours after stroke onset,[19-21] systematic evaluation of outcomes with a graded and patient-centered metric is urgently needed for monitoring the quality and equity of care across populations. Our findings support the use of home-time derived from administrative data to study real-world stroke outcomes as well as in pragmatic clinical trials.[22]

Our inclusion of patients with intracerebral hemorrhage is important because home-time has not yet been evaluated in this population, where acute treatment options are limited and systematic

evaluation of outcomes may be particularly relevant for testing potential treatments or identifying prognostic markers.[23] Further, the temporal stability of the relationship between home-time and mRS is important for studies on temporal trends in stroke outcomes. The sex differences in the relationship between home-time and mRS are of small magnitude, suggesting that home-time is a valid indicator for post-stroke disability in both men and women.

In the stratified analysis by age, we found that compared to younger patients, older ones with the same degree of disability at discharge experienced less home-time. For example, considering that the mean home-time for patients discharged with mild disability (mRS=1) was 77 days, an aRR of 0.96 for patients aged 71-80 years compared to those aged 21-60 years translates into a difference of 3 days and an aRR of 0.90 for those older than 80 years translates into a difference of 8 days. This gradient was not seen in patients with severe disability (mRS=5), likely because few home-time days were accumulated overall in this category. Older patients are likely experiencing less home-time compared to younger ones because of more comorbid medical illnesses, post-stroke complications, and higher pre-stroke dependence.[16 17] Stratified analyses by age groups may be necessary when using home-time to investigate outcomes after stroke.

Our findings are consistent with other studies calibrating home-time with the mRS in patients with ischemic stroke enrolled in clinical trials[4 6 9] as well as in United States (U.S.) Medicare beneficiaries admitted to hospital with ischemic stroke.[5 24] Home-time is likely influenced by the organization of healthcare systems.[6 10] Although we were unable to perform direct comparisons, we found that the median home-time after ischemic stroke in Ontario (55 days [0,82]) was less than that reported in the U.S. (79 days [52,86]),[5] suggesting that home-time should be calibrated

in the setting where it is intended to be used. A recent study using data from the Scottish National Health Service reported a mean home-time of 49 days after ischemic stroke and 27 days after intracerebral hemorrhage,[25] which is similar to our findings (46 days after ischemic stroke and 26 days after intracerebral hemorrhage). Both Canadian and Scottish health systems operate under a single-payer universal healthcare model. Understanding home-time in different health systems will inform the use of this metric as a pragmatic outcome in multinational studies.

The strengths of our study are its population-based design, the inclusion of patients with intracerebral hemorrhages, the large sample size, and the long study duration allowing for the evaluation of temporal trends. Our study nevertheless has limitations. First, the registry database only includes mRS at the time of discharge and the 90-day mRS was not available for analysis. While disability may change between discharge and 90 days, early disability has been shown to be a predictor of outcome at 90 days.[26] Further, we showed strong associations between home-time and discharge mRS in subgroup analyses, providing validity for the clinical relevance of home-time. Second, returning home may be contingent on social support or private funds, which are not captured in the administrative data calculation of home-time. We did however include neighborhood income quintile as a measure of socioeconomic status and did not find an association with home-time. We also included the use of publicly-funded home care services, which may range from a few hours a week to a few hours a day for assistance with activities of daily living or instrumental activities of daily living, but these do not include around the clock support. Finally, admission to long-term care may be underestimated prior to the fiscal year 2009/2010 because the Continuing Care Reporting System Long-Term Care database was

incomplete[27], but we did not find any clinically meaningful differences in the association between mRS and home-time by study years.

Conclusions

Home-time is associated with global disability after ischemic stroke and intracerebral hemorrhage. Its key advantage is that it can be calculated using routinely collected administrative data, allowing for the measurement of stroke outcomes for large populations. Our findings inform the application of home-time as a quality indicator of stroke care and its use as a pragmatic outcome in stroke health services research.

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Competing interest statement: Dr. Yu, Dr. Fang, Ms. Porter, Dr. Austin, Dr. Smith, and Dr. Kapral report no competing interests.

Contributorship statement: Dr. Yu contributed to the study concept and design, interpretation of data, drafting and revision of the manuscript. Dr. Fang contributed to the acquisition, analysis and interpretation of the data, and revision of the manuscript. Ms. Porter contributed to the acquisition, analysis and interpretation of the data, and revision of the manuscript. Dr. Austin contributed to data analysis and interpretation and revision of the manuscript. Dr. Smith contributed to the study concept and design, interpretation of data, and revision of the manuscript. Dr. Kapral contributed to the study concept and design, acquisition and interpretation of data, and revision of the manuscript.

Data sharing statement: The dataset from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the dataset publicly available, access may be granted to those who meet pre-specified criteria for confidential access.

Patient and Public Involvement: No patient involved.

Table 1 Patient baseline characteristics, disability at discharge, and 90-day location

	All (n=39,417)	Ischemic stroke (n=32,982)	ICH (n=6,435)
Median age (Q_1,Q_3)	74 (63,82)	75 (64,83)	71 (59,80)
Male sex	20,693 (52.5%)	17,201 (52.2%)	3,492 (54.3%)
Median NIHSS (Q_1,Q_3)	5 (2,12)	5 (2,11)	9 (2,16)
Minor stroke (NIHSS<5)	16,113 (40.9%)	14,205 (43.1%)	1,908 (29.7%)
Home location			
Large urban	31,238 (79.3%)	26,028 (78.9%)	5,210 (81.0%)
Medium population	3,120 (7.9%)	2,627 (8.0%)	493 (7.7%)
Small population	5,059 (12.8%)	4,327 (13.1%)	732 (11.4%)
Neighborhood income quintile			
Lowest	9,161 (23.2%)	7,748 (23.5%)	1,413 (22.0%)
Next to lowest	8,446 (21.4%)	7,069 (21.4%)	1,377 (21.4%)
Middle	7,483 (19.0%)	6,217 (18.8%)	1,266 (19.7%)
Next to highest	7,083 (18.0%)	5,897 (17.9%)	1,186 (18.4%)
Highest	7,244 (18.4%)	6,051 (18.3%)	1,193 (18.5%)
Baseline independence	29,688 (75.3%)	24,691 (74.9%)	4,997 (77.7%)
CCI ≥ 2	20,851 (52.9%)	17,775 (53.9%)	3,076 (47.8%)
Diabetes	10,095 (25.6%)	8,869 (26.9%)	1,226 (19.1%)
Hypertension	27,156 (68.9%)	23,136 (70.1%)	4,020 (62.5%)
Dyslipidemia	15,160 (38.5%)	13,307 (40.3%)	1,853 (28.8%)
Active smoking	7,174 (18.2%)	6,251 (19.0%)	923 (14.3%)
Prior stroke	7,131 (18.1%)	6,231 (18.9%)	900 (14.0%)
Atrial fibrillation	7,150 (18.1%)	6,232 (18.9%)	918 (14.3%)
Coronary artery disease	9,168 (23.3%)	8,210 (24.9%)	958 (14.9%)
Dementia	2,780 (7.1%)	2,342 (7.1%)	438 (6.8%)
Median acute care length of stay (Q_1,Q_3)	9 (5,18)	9 (5,17)	10 (4,24)
Discharge mRS			
Median mRS (Q_1,Q_3)	3 (2,4)	3 (2,4)	4 (3,6)
mRS = 0	2,513 (6.4%)	2,263 (6.8%)	250 (3.9%)
mRS = 1	4,495 (11.4%)	4,073 (12.3%)	422 (6.6%)
mRS = 2	6,429 (16.3%)	5,896 (17.9%)	533 (8.3%)
mRS = 3	8,413 (21.3%)	7,423 (22.5%)	990 (15.4%)
mRS = 4	9,372 (23.8%)	7,772 (23.6%)	1,600 (24.9%)
mRS = 5	2,143 (5.4%)	1,609 (4.9%)	534 (8.3%)
mRS = 6	6,052 (15.4%)	3,946 (12.0%)	2,106 (32.7%)
Median 90-day home-time (Q_1,Q_3)	47 (0,81)	55 (0,82)	0 (0,58)
Mean 90-day home-time (SD)	42 (36)	46 (36)	26 (34)
90-day location			
Acute care	1,686 (4.3%)	1,367 (4.1%)	319 (5.0%)
Rehabilitation	1,816 (4.6%)	1,412 (4.3%)	404 (6.3%)
LTC/CCC	2,910 (7.4%)	2,408 (7.3%)	502 (7.8%)

Death	8,083 (20.5%)	5,628 (17.1%)	2,455 (38.2%)
Home with home-care	2,140 (5.4%)	1,913 (5.8%)	227 (3.5%)
Home without home-care	22,782 (57.8%)	20,254 (61.4%)	2,528 (39.3%)

Q_1,Q_3: 25th and 75th percentile, SD: standard deviation, ICH: intracerebral hemorrhage, NIHSS: National Institutes of Health Stroke Scale, CCI: Charlson comorbidity index, mRS: modified Rankin Scale (0-no symptoms, 1-no significant disability despite symptoms, 2- slight disability, 3-moderate disability, 4-moderately severe disability, 5-severe disability, 6-dead), LTC/CCC: long-term care/complex continuing care

Table 2 Adjusted summary rate ratio of home-time by predictor variables using multivariable zero-inflated negative binomial model

Predictor variables	Median home-time (Q_1,Q_3)	Mean home-time (SD)	aRR [CI_{95}]
Age categories			
21-60 years	68 (12,84)	53 (35)	Reference
61-70 years	60 (0,83)	48 (36)	0.97 [0.95,0.99]
71-80 years	46 (0,80)	42 (36)	0.94 [0.92,0.95]
≥ 80 years	12 (0,71)	32 (35)	0.89 [0.87,0.91]
Sex			
Female	40 (0,79)	40 (36)	Reference
Male	53 (0,82)	45 (36)	1.01 [0.99,1.02]
mRS category			
mRS 0	84 (81,87)	80 (16)	Reference
mRS 1	84 (79,86)	77 (19)	0.96 [0.93,0.98]
mRS 2	81 (68,85)	73 (21)	0.92 [0.90,0.94]
mRS 3	57 (29,76)	50 (29)	0.60 [0.59,0.62]
mRS 4	9 (0,45)	23 (27)	0.23 [0.22,0.24]
mRS 5	0 (0,3)	7 (17)	0.05 [0.04,0.06]
Home location			
Large urban	46 (0,81)	42 (36)	Reference
Medium population	50 (0,82)	43 (37)	1.04 [1.02,1.07]
Small population	53 (0,82)	44 (37)	1.02 [1.00,1.04]
Neighborhood income quintile			
Lowest	43 (0,80)	41 (36)	Reference
Next to lowest	46 (0,81)	42 (36)	1.02 [0.99,1.04]
Middle	49 (0,81)	43 (36)	1.02 [1.00,1.04]
Next to highest	50 (0,81)	43 (36)	1.02 [0.99,1.04]
Highest	50 (0,82)	43 (36)	1.02 [1.00,1.05]
Charlson comorbidity index			
Score < 2	62 (0,83)	49 (36)	Reference
Score ≥ 2	30 (0,76)	36 (36)	0.91 [0.90,0.93]
Pre-admission dependence			
Dependent	7 (0,68)	30 (35)	Reference
Independent	56 (0,82)	46 (36)	1.06 [1.04,1.08]
Stroke severity			
Mild (NIHSS < 5)	78 (46,85)	62 (30)	Reference
Severe (NIHSS ≥ 5)	5 (0,63)	29 (34)	0.82 [0.80,0.83]

Q_1,Q_3: First and third quartile, SD: standard deviation, aRR: adjusted summary rate ratio, CI_{95}: 95% confidence intervals, NIHSS: National Institutes of Health Stroke Scale

Figure 1 Box plots of home-time by mRS stratified by stroke type (A), age (B), sex (C), and study years (D)

Figure 2 Age-specific adjusted summary rate ratio for 90-day home-time by mRS with ages 21-60 years as the reference group

Figure 3 Sex-specific adjusted summary rate ratio for 90-day home-time by mRS with female as the reference group

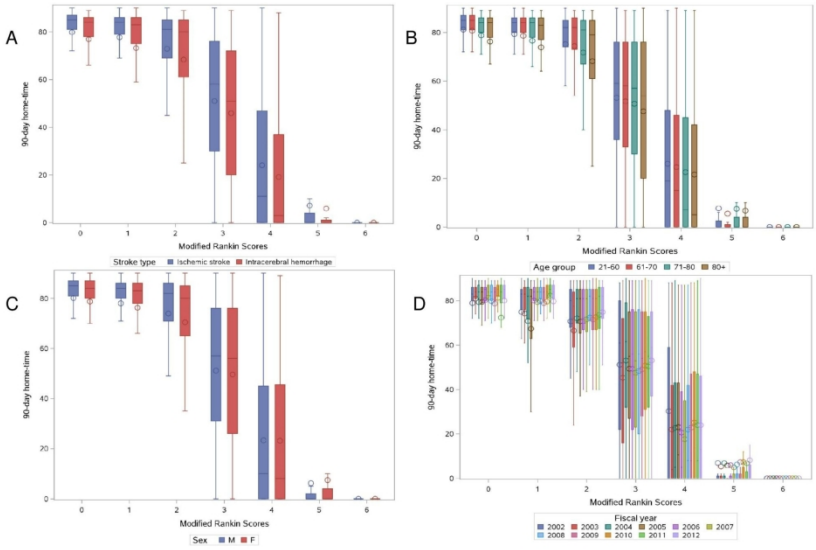


Figure 1 Box plots of home-time by mRS stratified by stroke type (A), age (B), sex (C), and study years (D)

279x215mm (300 x 300 DPI)

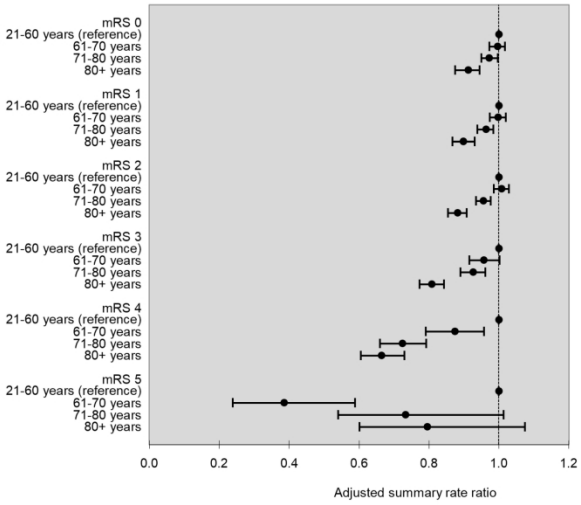


Figure 2 Age-specific adjusted summary rate ratio for 90-day home-time by mRS with ages 21-60 years as the reference group

215x279mm (300 x 300 DPI)

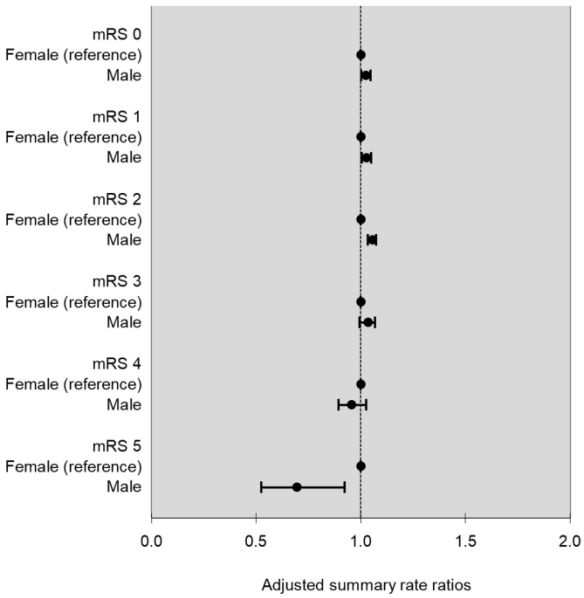


Figure 3 Sex-specific adjusted summary rate ratio for 90-day home-time by mRS with female as the reference group

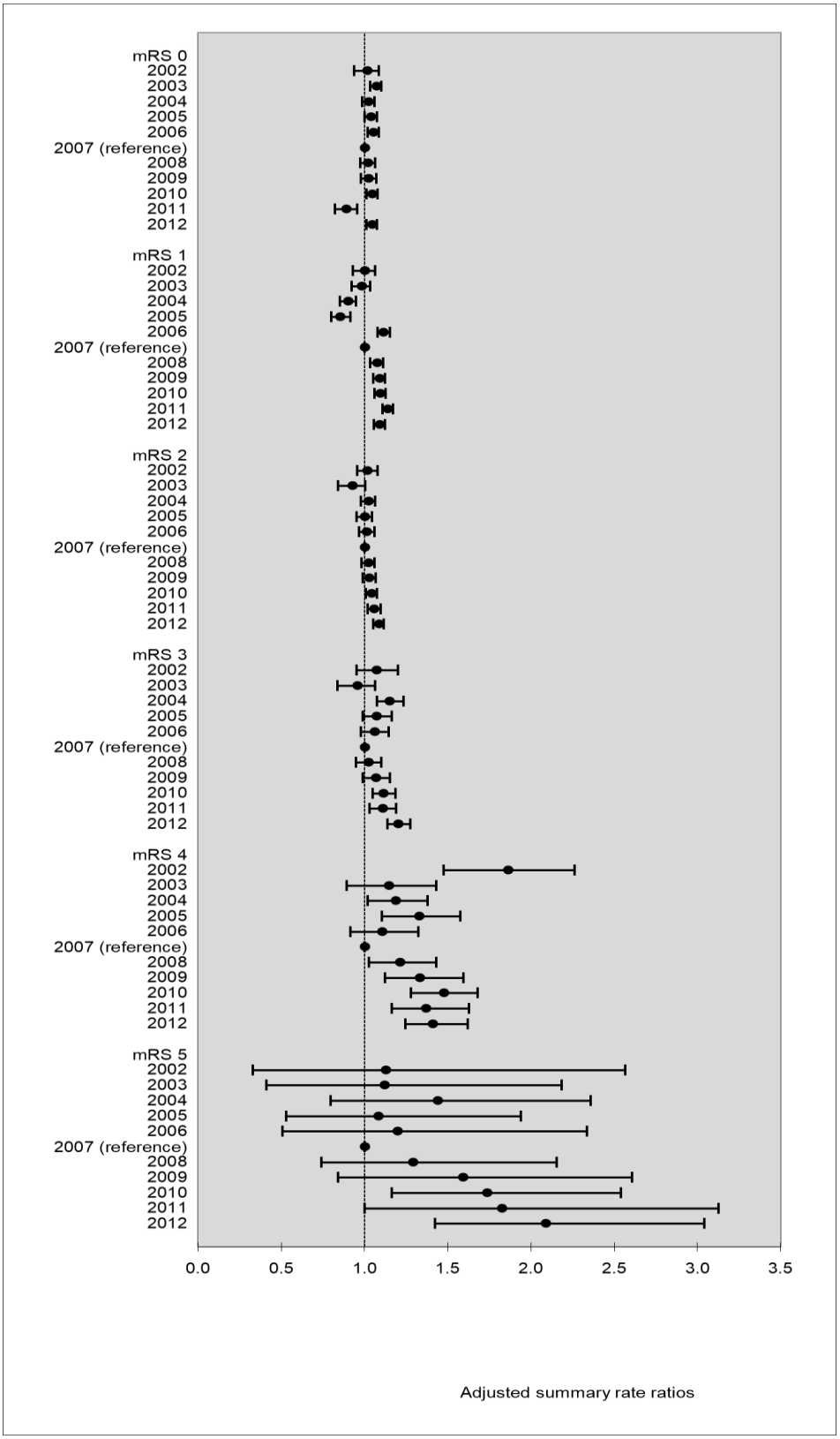
215x279mm (300 x 300 DPI)

Supplemental Table 1 Administrative data sources

Database	Full database name	Description
DAD	Discharge Abstract Database	Inpatient hospitalization data
NACRS	National Ambulatory Care Reporting System	Emergency department data
NRS	National Rehabilitation Reporting System	Rehabilitation data
CCRS	Continuing Care Reporting System	Complex continuing care
CCRS-LTC[a]	Continuing Care Reporting System Long-Term Care	Long-term care data
HCD	Ontario home care database	Home-care data
OHIP	Ontario Health Insurance Plan	Outpatient physician billings data
ODBP	Ontario Drug Benefit Program	Pharmacy data
RPDB	Ontario Registered Persons Database	Mortality data
OSR	Ontario Stroke Registry	Disease-specific registry

[a]CCRS-LTC was incomplete prior to the 2009/2010 fiscal year. To identify patients admitted to long-term care prior to 2009/2010, we used a validated algorithm with 2 ODB records or 2 OHIP records or 1 ODB and 1 OHIP record within 30 days of each other with a long-term code flag. The date of admission to long-term care was defined as the date of the first record.

Supplemental Figure 1 Study year-specific adjusted summary rate ratio for 90-day home-time by mRS with year 2007 as the reference group



Yu et al. Population-based analysis of home-time after stroke by age, sex, stroke type, and study year

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p. 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p. 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p. 4
Objectives	3	State specific objectives, including any prespecified hypotheses	p. 5
Methods			
Study design	4	Present key elements of study design early in the paper	p. 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p. 5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	p. 6-7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p. 6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p. 6-7
Bias	9	Describe any efforts to address potential sources of bias	p. 6-7
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p. 7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	p. 7-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	p. 8-9
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	p. 8-9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	p. 9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	p. 9-10
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	p. 10
Discussion			
Key results	18	Summarise key results with reference to study objectives	p. 10-11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	p. 12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p. 12
Generalisability	21	Discuss the generalisability (external validity) of the study results	p. 12-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p. 15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Hospital-based cohort study to determine the association between home-time and disability after stroke by age, sex, stroke type, and study year in Canada

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Title: Hospital-based cohort study to determine the association between home-time and disability after stroke by age, sex, stroke type, and study year in Canada

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Figures: 3

Abstract

Objective: Home-time is an emerging patient-centered stroke outcome metric, but it is not well described in the population. We aimed to determine the association between 90-day home-time and global disability after stroke. We hypothesized that longer home-time would be associated with less disability.

Design: Hospital-based cohort study of patients with ischemic stroke or intracerebral hemorrhage admitted to an acute care hospital between April 1st 2002 and March 31st 2013.

Setting: All regional stroke centres and a simple random sample of patients from all other hospitals across the province of Ontario, Canada.

Participants: We included 39,417 adult patients (84% ischemic, 16% hemorrhage), 53% male, with a median age of 74 years. We excluded non-residents of Ontario, patients without a valid health insurance number, patients discharged against medical advice or those who failed to return from a pass, patients living in a long-term care centre at baseline, and stroke events occurring in-hospital.

Primary outcome measure: Association between 90-day home-time, defined as the number of days spent at home in the first 90 days after stroke, obtained using linked administrative data, and modified Rankin Scale score at discharge.

Results: Compared to people with no disability, those with minimal disability had less home-time (adjusted rate ratio (aRR) 0.96, 95% confidence intervals (CI_{95}) [0.93,0.98]) and those with the most severe disability had the least home-time (aRR 0.05 CI_{95} [0.04,0.05]). We found no clinically relevant modification by stroke type, sex, or study year. However, for a given level of disability, older patients experienced less home-time compared to younger patients.

Conclusions: Our results provide content validity for home-time to be used to monitor stroke outcomes in large populations or to study temporal trends. Older patients experience less home-time for a given level of disability, suggesting the need for stratification by age.

Strengths and limitations of this study

- Hospital-based analysis of home-time, a graded stroke outcome metric that can be derived from administrative data.
- First study to assess the association between home-time and global disability in subgroups, including stroke type, sex, age groups, and study year.
- Lack of data on disability after hospital discharge.
- Lack of data on social support or private funds, which may influence ability to return home.

Introduction

Stroke is a leading cause of severe disability.[1 2] The lack of a routinely collected graded stroke outcome metric is a critical limitation to population-based stroke outcome research. The modified Rankin Scale (mRS) is the most frequently used measure of functional outcome in stroke clinical research, but it cannot be routinely obtained for all patients as it requires prospective patient follow-up and testing.[3] Home-time is a novel stroke outcome indicator that is correlated with the mRS when assessed in clinical trial populations with ischemic stroke.[4-6] Home-time is defined as the total number of days a patient is living outside of a healthcare institution after stroke. This metric is patient-centered[7 8] and is ideal for pragmatic studies evaluating real-world outcomes because it can be derived for large populations using administrative data.[5 6]

There are nevertheless several gaps in knowledge about home-time. Prior studies focused on patients with ischemic strokes enrolled in clinical trials[4 9] and few have described the relationship between home-time and mRS in the general population.[5] Understanding whether the association between home-time and mRS holds true in a population-based sample, in different stroke types, in important patient subgroups, as well as in different time periods is necessary to inform whether home-time can be used as an outcome metric to evaluate quality of stroke care. Finally, because home-time may be sensitive to the structures of healthcare systems, it is relevant to validate this metric in different jurisdictions.[10]

We aimed to determine the association between 90-day home-time and disability at discharge, measured using the mRS score, in a hospital-based cohort of patients with ischemic or

hemorrhagic stroke. We hypothesized that home-time would be strongly associated with the mRS score and that this association would not be significantly modified by stroke type, temporal trends, or patient demographics.

Methods

Cohort identification

We identified all hospital admissions for ischemic stroke or intracerebral hemorrhage in the Ontario Stroke Registry (formerly known as the Registry of the Canadian Stroke Network) between April 1st 2002 and March 31st 2013. The registry collected data on all consecutive patients with stroke seen in the emergency department or admitted to regional stroke centres and a simple random sample of patients from all other hospitals across Ontario, Canada's most populous province with a population of 13 million people.[11] We excluded patients with subarachnoid hemorrhage. Other exclusion criteria were patients aged less than 18 years, non-residents of Ontario or those without a valid health insurance number, patients discharged against medical advice or those who failed to return from a pass, patients living in a long-term care centre at baseline, and any strokes occurring during hospitalization for a different health condition. Only the first presentation was included in individuals who presented with stroke more than once during the study period.

Outcomes and covariates

The 90-day home-time was the primary outcome and was defined as the total number of days a patient was living outside of a healthcare institution in the first 90 days after stroke. Home-time was calculated for each individual patient using linked administrative health databases

(Supplemental Table 1) by subtracting the number of days spent in emergency care, acute care, inpatient rehabilitation, long-term care institution, as well as any re-hospitalizations from the first 90 days after the date of admission for the index event. By definition, patients who died during the index hospitalization have 0 home-time days. Patients who were discharged from health care institutions and subsequently died in the first 90 days after stroke may have accumulated home-time days. We also determined whether Ontario public home care services were provided to patients who were assumed to be at home. Canadian administrative databases include data on the entire population and have been extensively validated for research purposes.[12] These datasets were linked using unique encoded identifiers and analyzed at ICES.[13]

Data on discharge mRS were collected in the registry through retrospective chart abstraction by trained chart abstractors, mainly nurses, with stroke expertise (<1% missing data). The mRS is an ordinal scale ranging from 0 for no symptoms, to 3 for moderate disability (able to walk without assistance, but requiring some help), to 5 for severe disability (bedridden, requiring constant nursing care), and to 6 for death.[3] Data validation by duplicate chart abstraction showed excellent agreement (kappa score or intraclass correlation coefficient of greater than 0.9) for key variables.[14]

The covariates in our analyses were age, sex, stroke type (ischemic stroke versus intracerebral hemorrhage), stroke severity (mild stroke defined as a National Institutes of Health Stroke Scale (NIHSS) < 5), Charlson comorbidity index (dichotomized to <2 or ≥ 2), independence in activities of daily living prior to the index stroke, location of residency (small population centre: less than 10,000, medium population centre: 10,000 to 100,000, and large urban population

centre: >100,000), and neighborhood income quintile. The covariates were obtained from the Ontario Stroke Registry, except for the Charlson comorbidity index, the location of residency, and the neighborhood income quintile which were obtained from linked administrative data.[15]

Statistical methods

Patient characteristics were described using proportions for categorical variables, mean and standard deviation (SD), and median with 25th and 75th percentiles (Q_1,Q_3) for continuous variables. We used Spearman's rank correlation to quantify the correlation between 90-day home-time and discharge mRS stratified by stroke type. Because the distribution of home-time is bucket-shaped with peaks around its minimum value (0) and maximum value (90), we considered four regression models: the negative binomial model, the Poisson model, and their respective zero-inflated counterparts.[16] The zero-inflated negative binomial regression model best fit our observed data. Accordingly, this model was used to determine the association between discharge mRS and 90-day home-time with adjustment for the covariates. The zero-inflated negative binomial model yields two sets of regression coefficients: one from an underlying logistic model that is modeling excess zeros and one from an underlying negative binomial model for counts. To simplify presentation and interpretation of the two sets of regression coefficients, we used a previously described method for summarizing the effect of the predictor variables to yield an adjusted summary rate ratio (aRR), which is interpreted as the ratio of the mean number of home-time days among those exposed to the covariate of interest to the mean number of home-time days among those who were not.[16] We used bootstrapping to obtain 95% confidence intervals (CI_{95}). In order to determine whether the association between home-time and mRS was significantly modified by stroke type, sex, age, and study year, we used

likelihood ratio tests to compare the models with and without the appropriate multiplicative interaction terms. If a statistically significant interaction was present (defined as $p<0.05$), we reported the stratum-specific aRR derived from the model with the appropriate main effects and interaction terms.

Research Ethics Approval

ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. The use of data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act. We have permission to access the data.

Results

Our study sample consisted of 39,417 patients (84% ischemic stroke and 16% intracerebral hemorrhage), with a median (Q_1,Q_3) age of 74 years (63,82), of whom 53% were male. The median in-hospital length of stay was 9 days (5,18). Table 1 describes patient characteristics, disability at discharge, the median 90-day home-time, and the location of the patient at 90 days by stroke type. The median 90-day home-time was 55 days (0,82) for patients with ischemic stroke and 0 (0,58) for those with intracerebral hemorrhage. By definition, patients who died during the index hospitalization (n=6,052, 15%) did not accumulate any home-time days.

More 90-day home-time (i.e. more days at home) was associated with lower mRS at discharge (i.e. less disability) for ischemic stroke (Spearman correlation coefficient -0.78) and intracerebral

hemorrhage (Spearman correlation coefficient -0.80). Table 2 shows the median (Q_1, Q_3) and mean (standard deviation) home-time for each mRS category as well as the results of the multivariable zero-inflated negative binomial analyses.

We showed that people with higher disability at discharge from the acute-care hospitalization experienced less home-time. Compared to people discharged with no disability (mRS=0), those discharged with minimal disability had slightly less home-time (mRS=1 aRR 0.96, CI_{95} [0.93,0.98]), but those discharged with the most severe disability had the least home-time (mRS=5 aRR 0.05 CI_{95} [0.04,0.05]). In addition, older people, those with a higher comorbidity burden, and those with higher stroke severity experienced less home-time; while those who were independent at baseline experienced more home-time (Table 2). Patients living in medium urban regions had slightly more home-time than those living in small towns or in large urban regions. Home-time was not associated with the neighborhood income quintile, a proxy for socioeconomic status.[15]

Figure 1 shows the relationship between discharge mRS and 90-day home-time by stroke type, age, sex, and study year. There was no evidence of effect modification by stroke type (p for interaction=0.06), but there was a statistically significant interaction for age, sex, and study year (p for interaction < 0.001 for all three covariates). In the sub-analysis by age, we observed that for almost all levels of the mRS, except those with the most severe disability, older patients experienced less home-time compared to their younger counterparts (Figure 2). In the sub-analysis by sex, we observed that compared to women, men experienced slightly more home-time in the subgroup of patients discharged with lower disability (mRS=1 aRR CI_{95} 1.02

[1.00,1.05], mRS=2 aRR CI_{95} 1.03 [1.00,1.05], and mRS=3 aRR CI_{95} 1.05 [1.03,1.07]), but men had less home-time among those with the most severe disability (mRS=5 aRR CI_{95} 0.69 [0.52,0.92], Figure 3). Finally, in the sub-analysis by study years, despite a statistically significant p-value for interaction, we did not observe any consistent or clinically meaningful trends in effect modification (Supplemental Figure 1).

Discussion

In this large hospital-based study of patients with stroke, we demonstrated that 90-day home-time was associated with global disability as measured by the mRS at discharge, for both ischemic stroke and intracerebral hemorrhage, and that this association was stable over an 11-year period. We showed a clear gradient between home-time and functional outcomes, across the levels of disability measured by the mRS, with people discharged from hospital with the highest disability experiencing the least home-time. In addition, home-time was responsive to covariates known to be associated with stroke outcomes as people who were older, dependent at baseline, had higher comorbidity burden, or presented with severe strokes had less home-time.[17 18]

Home-time has been identified as a patient-centered outcome in stroke[7] as well as in other medical conditions, such as cancer.[8] This metric is associated with healthcare costs and is important to policy-makers.[10 19] With the availability of new stroke treatments; for example, acute revascularization treatments up to 24 hours after stroke onset,[20-22] systematic evaluation of outcomes with a graded and patient-centered metric is urgently needed for monitoring the quality and equity of care across populations. Our findings support the use of home-time derived from administrative data to study real-world stroke outcomes as well as in pragmatic clinical trials.[23]

Our inclusion of patients with intracerebral hemorrhage is important because acute treatment options are limited for this condition and systematic evaluation of outcomes may be particularly relevant for testing potential treatments or identifying prognostic markers.[24] A recent study reported that discharge mRS is associated with 90-day home-time after admission for aneurysmal subarachnoid hemorrhage,[25] but the association between home-time and mRS has not yet been reported in patients with intracerebral hemorrhage. Further, the temporal stability of the relationship between home-time and mRS is important for studies on temporal trends in stroke outcomes. The sex differences in the relationship between home-time and mRS are of small magnitude, suggesting that home-time is a valid indicator for post-stroke disability in both men and women.

In the stratified analysis by age, we found that compared to younger patients, older ones with the same degree of disability at discharge experienced less home-time. For example, considering that the mean home-time for patients discharged with mild disability (mRS=1) was 77 days, an aRR of 0.96 for patients aged 71-80 years compared to those aged 21-60 years translates into a difference of 3 days and an aRR of 0.90 for those older than 80 years translates into a difference of 8 days. This gradient was not seen in patients with severe disability (mRS=5), likely because few home-time days were accumulated overall in this category. Older patients are likely experiencing less home-time compared to younger ones because of more comorbid medical illnesses, post-stroke complications, and higher pre-stroke dependence.[17 18] Stratified analyses by age groups may be necessary when using home-time to investigate outcomes after stroke.

Our findings are consistent with other studies calibrating home-time with the mRS in patients with ischemic stroke enrolled in clinical trials[4 6 9] as well as in United States (U.S.) Medicare beneficiaries admitted to hospital with ischemic stroke.[5 26] Home-time is likely influenced by the organization of healthcare systems.[6 10] Although we were unable to perform direct comparisons, we found that the median home-time after ischemic stroke in Ontario (55 days [0,82]) was less than that reported in the U.S. (79 days [52,86]),[5] suggesting that home-time should be calibrated in the setting where it is intended to be used. A recent study using data from the Scottish National Health Service reported a mean home-time of 49 days after ischemic stroke and 27 days after intracerebral hemorrhage,[27] which is similar to our findings (46 days after ischemic stroke and 26 days after intracerebral hemorrhage). Both Canadian and Scottish health systems operate under a single-payer universal healthcare model. Understanding home-time in different health systems will inform the use of this metric as a pragmatic outcome in multinational studies.

The strengths of our study are its population-based design, the inclusion of patients with intracerebral hemorrhages, the large sample size, and the long study duration allowing for the evaluation of temporal trends. Our study nevertheless has limitations. First, the registry database only includes mRS at the time of discharge and the 90-day mRS was not available for analysis. While disability may change between discharge and 90 days, early disability has been shown to be a predictor of outcome at 90 days.[28] Further, we showed strong associations between home-time and discharge mRS in subgroup analyses, providing validity for the clinical relevance of home-time. Second, returning home may be contingent on social support or private funds, which are not captured in the administrative data calculation of home-time. We did however include neighborhood income quintile as a measure of socioeconomic status and did not find an

association with home-time. We also included the use of publicly-funded home care services, which may range from a few hours a week to a few hours a day for assistance with activities of daily living or instrumental activities of daily living, but these do not include around the clock support. Finally, admission to long-term care may be underestimated prior to the fiscal year 2009/2010 because the Continuing Care Reporting System Long-Term Care database was incomplete[29], but we did not find any clinically meaningful differences in the association between mRS and home-time by study years.

Conclusions

Home-time is associated with global disability after ischemic stroke and intracerebral hemorrhage. Its key advantage is that it can be calculated using routinely collected administrative data, allowing for the measurement of stroke outcomes for large populations. Our findings inform the application of home-time as a quality indicator of stroke care and its use as a pragmatic outcome in stroke health services research.

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Contributorship statement: Dr. Yu contributed to the study concept and design, interpretation of data, drafting and revision of the manuscript. Dr. Fang contributed to the acquisition, analysis and interpretation of the data, and revision of the manuscript. Ms. Porter contributed to the acquisition, analysis and interpretation of the data, and revision of the manuscript. Dr. Austin contributed to data analysis and interpretation and revision of the manuscript. Dr. Smith contributed to the study concept and design, interpretation of data, and revision of the manuscript. Dr. Kapral contributed to the study concept and design, acquisition and interpretation of data, and revision of the manuscript.

Data sharing statement: The data from this study were anonymized prior to analysis and are held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the dataset publicly available, access may be granted to those who meet pre-specified criteria for confidential access. Information on permissions to access the data can be found at https://www.ices.on.ca/Research/Information-for-researchers

Patient and Public Involvement: Patients and the public were not involved in the design or the planning of the study

Table 1 Patient baseline characteristics, disability at discharge, and 90-day location

	All (n=39,417)	Ischemic stroke (n=32,982)	ICH (n=6,435)
Median age (Q_1,Q_3)	74 (63,82)	75 (64,83)	71 (59,80)
Male sex	20,693 (52.5%)	17,201 (52.2%)	3,492 (54.3%)
Median NIHSS (Q_1,Q_3)	5 (2,12)	5 (2,11)	9 (2,16)
Minor stroke (NIHSS<5)	16,113 (40.9%)	14,205 (43.1%)	1,908 (29.7%)
Home location			
Large urban	31,238 (79.3%)	26,028 (78.9%)	5,210 (81.0%)
Medium population	3,120 (7.9%)	2,627 (8.0%)	493 (7.7%)
Small population	5,059 (12.8%)	4,327 (13.1%)	732 (11.4%)
Neighborhood income quintile			
Lowest	9,161 (23.2%)	7,748 (23.5%)	1,413 (22.0%)
Next to lowest	8,446 (21.4%)	7,069 (21.4%)	1,377 (21.4%)
Middle	7,483 (19.0%)	6,217 (18.8%)	1,266 (19.7%)
Next to highest	7,083 (18.0%)	5,897 (17.9%)	1,186 (18.4%)
Highest	7,244 (18.4%)	6,051 (18.3%)	1,193 (18.5%)
Baseline independence	29,688 (75.3%)	24,691 (74.9%)	4,997 (77.7%)
CCI ≥ 2	20,851 (52.9%)	17,775 (53.9%)	3,076 (47.8%)
Diabetes	10,095 (25.6%)	8,869 (26.9%)	1,226 (19.1%)
Hypertension	27,156 (68.9%)	23,136 (70.1%)	4,020 (62.5%)
Dyslipidemia	15,160 (38.5%)	13,307 (40.3%)	1,853 (28.8%)
Active smoking	7,174 (18.2%)	6,251 (19.0%)	923 (14.3%)
Prior stroke	7,131 (18.1%)	6,231 (18.9%)	900 (14.0%)
Atrial fibrillation	7,150 (18.1%)	6,232 (18.9%)	918 (14.3%)
Coronary artery disease	9,168 (23.3%)	8,210 (24.9%)	958 (14.9%)
Dementia	2,780 (7.1%)	2,342 (7.1%)	438 (6.8%)
Median acute care length of stay (Q_1,Q_3)	9 (5,18)	9 (5,17)	10 (4,24)
Discharge mRS			
Median mRS (Q_1,Q_3)	3 (2,4)	3 (2,4)	4 (3,6)
mRS = 0	2,513 (6.4%)	2,263 (6.8%)	250 (3.9%)
mRS = 1	4,495 (11.4%)	4,073 (12.3%)	422 (6.6%)
mRS = 2	6,429 (16.3%)	5,896 (17.9%)	533 (8.3%)
mRS = 3	8,413 (21.3%)	7,423 (22.5%)	990 (15.4%)
mRS = 4	9,372 (23.8%)	7,772 (23.6%)	1,600 (24.9%)
mRS = 5	2,143 (5.4%)	1,609 (4.9%)	534 (8.3%)
mRS = 6	6,052 (15.4%)	3,946 (12.0%)	2,106 (32.7%)
Median 90-day home-time (Q_1,Q_3)	47 (0,81)	55 (0,82)	0 (0,58)
Mean 90-day home-time (SD)	42 (36)	46 (36)	26 (34)
90-day location			
Acute care	1,686 (4.3%)	1,367 (4.1%)	319 (5.0%)
Rehabilitation	1,816 (4.6%)	1,412 (4.3%)	404 (6.3%)
LTC/CCC	2,910 (7.4%)	2,408 (7.3%)	502 (7.8%)

Death	8,083 (20.5%)	5,628 (17.1%)	2,455 (38.2%)
Home with home-care	2,140 (5.4%)	1,913 (5.8%)	227 (3.5%)
Home without home-care	22,782 (57.8%)	20,254 (61.4%)	2,528 (39.3%)

Q_1,Q_3: 25th and 75th percentile, SD: standard deviation, ICH: intracerebral hemorrhage, NIHSS: National Institutes of Health Stroke Scale, CCI: Charlson comorbidity index, mRS: modified Rankin Scale (0-no symptoms, 1-no significant disability despite symptoms, 2- slight disability, 3-moderate disability, 4-moderately severe disability, 5-severe disability, 6-dead), LTC/CCC: long-term care/complex continuing care

Table 2 Adjusted summary rate ratio of home-time by predictor variables using multivariable zero-inflated negative binomial model

Predictor variables	Median home-time (Q_1,Q_3)	Mean home-time (SD)	aRR [CI_{95}]
Age categories			
21-60 years	68 (12,84)	53 (35)	Reference
61-70 years	60 (0,83)	48 (36)	0.97 [0.95,0.99]
71-80 years	46 (0,80)	42 (36)	0.94 [0.92,0.95]
≥ 80 years	12 (0,71)	32 (35)	0.89 [0.87,0.91]
Sex			
Female	40 (0,79)	40 (36)	Reference
Male	53 (0,82)	45 (36)	1.01 [0.99,1.02]
mRS category			
mRS 0	84 (81,87)	80 (16)	Reference
mRS 1	84 (79,86)	77 (19)	0.96 [0.93,0.98]
mRS 2	81 (68,85)	73 (21)	0.92 [0.90,0.94]
mRS 3	57 (29,76)	50 (29)	0.60 [0.59,0.62]
mRS 4	9 (0,45)	23 (27)	0.23 [0.22,0.24]
mRS 5	0 (0,3)	7 (17)	0.05 [0.04,0.06]
Home location			
Large urban	46 (0,81)	42 (36)	Reference
Medium population	50 (0,82)	43 (37)	1.04 [1.02,1.07]
Small population	53 (0,82)	44 (37)	1.02 [1.00,1.04]
Neighborhood income quintile			
Lowest	43 (0,80)	41 (36)	Reference
Next to lowest	46 (0,81)	42 (36)	1.02 [0.99,1.04]
Middle	49 (0,81)	43 (36)	1.02 [1.00,1.04]
Next to highest	50 (0,81)	43 (36)	1.02 [0.99,1.04]
Highest	50 (0,82)	43 (36)	1.02 [1.00,1.05]
Charlson comorbidity index			
Score < 2	62 (0,83)	49 (36)	Reference
Score ≥ 2	30 (0,76)	36 (36)	0.91 [0.90,0.93]
Pre-admission dependence			
Dependent	7 (0,68)	30 (35)	Reference
Independent	56 (0,82)	46 (36)	1.06 [1.04,1.08]
Stroke severity			
Mild (NIHSS < 5)	78 (46,85)	62 (30)	Reference
Severe (NIHSS ≥ 5)	5 (0,63)	29 (34)	0.82 [0.80,0.83]

Q_1,Q_3: First and third quartile, SD: standard deviation, aRR: adjusted summary rate ratio, CI_{95}: 95% confidence intervals, NIHSS: National Institutes of Health Stroke Scale

Figure 1 Box plots of home-time by mRS stratified by stroke type (A), age (B), sex (C), and study years (D)

Figure 2 Age-specific adjusted summary rate ratio for 90-day home-time by mRS with ages 21-60 years as the reference group

Figure 3 Sex-specific adjusted summary rate ratio for 90-day home-time by mRS with female as the reference group

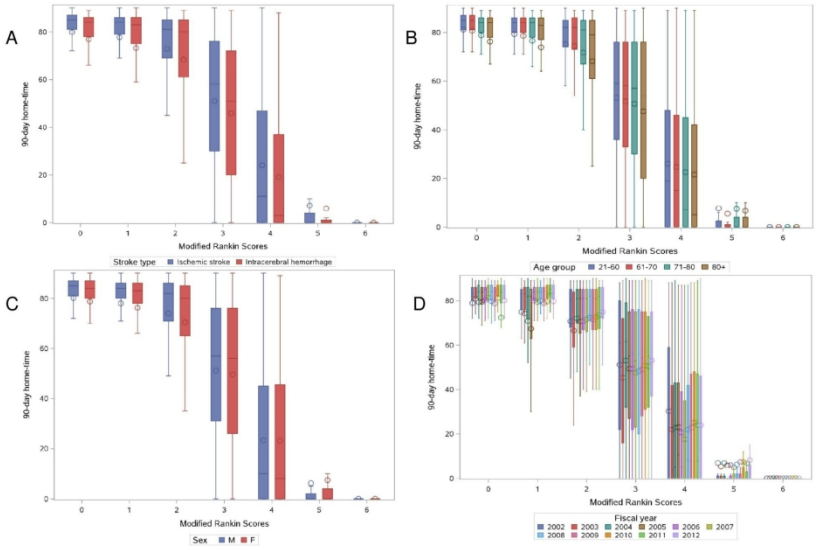


Figure 1 Box plots of home-time by mRS stratified by stroke type (A), age (B), sex (C), and study years (D)

279x215mm (300 x 300 DPI)

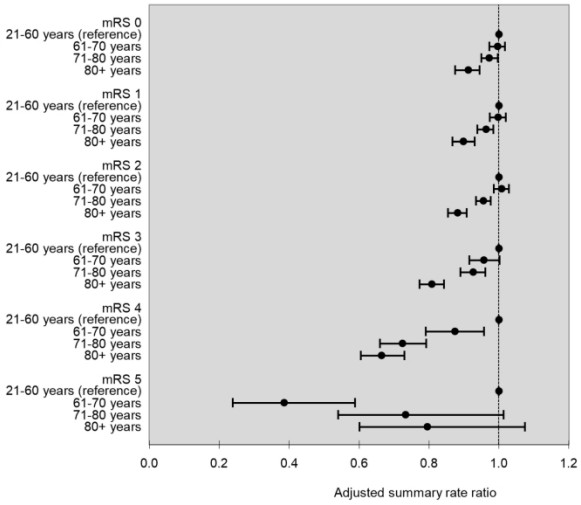


Figure 2 Age-specific adjusted summary rate ratio for 90-day home-time by mRS with ages 21-60 years as the reference group

215x279mm (300 x 300 DPI)

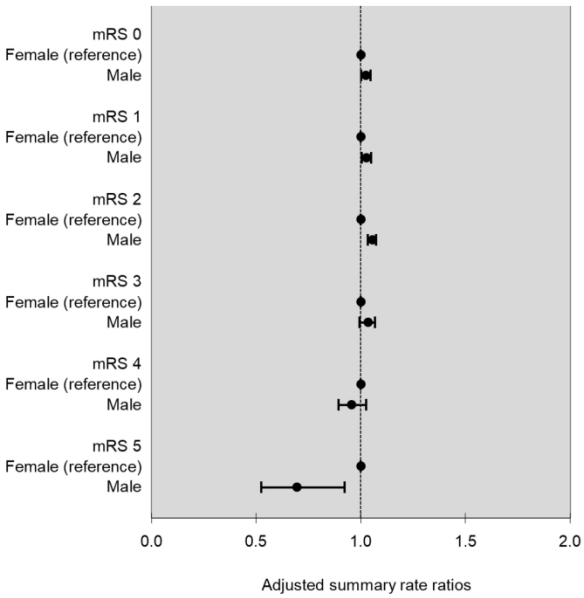


Figure 3 Sex-specific adjusted summary rate ratio for 90-day home-time by mRS with female as the reference group

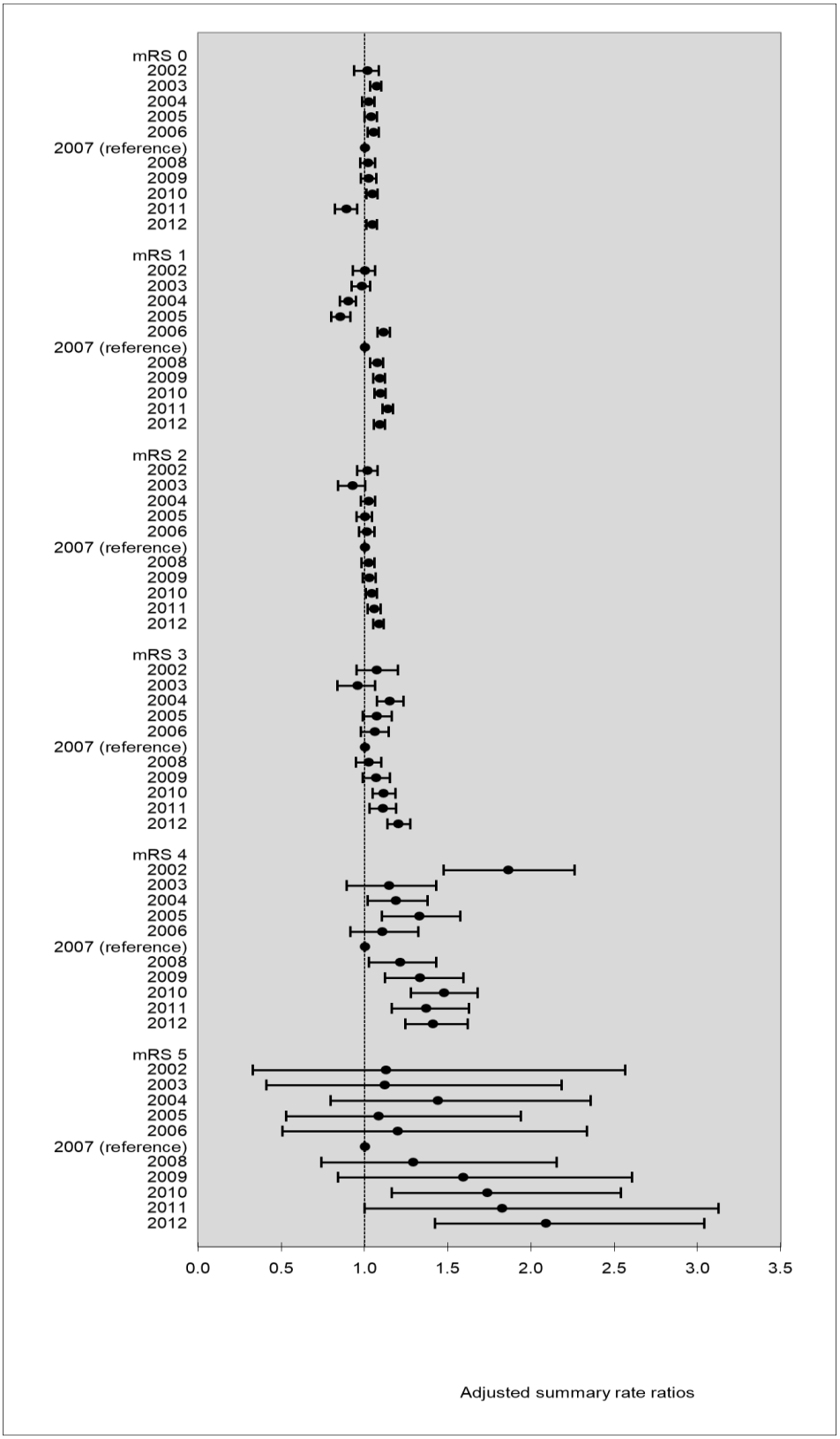
215x279mm (300 x 300 DPI)

Supplemental Table 1 Administrative data sources

Database	Full database name	Description
DAD	Discharge Abstract Database	Inpatient hospitalization data
NACRS	National Ambulatory Care Reporting System	Emergency department data
NRS	National Rehabilitation Reporting System	Rehabilitation data
CCRS	Continuing Care Reporting System	Complex continuing care
CCRS-LTC[a]	Continuing Care Reporting System Long-Term Care	Long-term care data
HCD	Ontario home care database	Home-care data
OHIP	Ontario Health Insurance Plan	Outpatient physician billings data
ODBP	Ontario Drug Benefit Program	Pharmacy data
RPDB	Ontario Registered Persons Database	Mortality data
OSR	Ontario Stroke Registry	Disease-specific registry

[a]CCRS-LTC was incomplete prior to the 2009/2010 fiscal year. To identify patients admitted to long-term care prior to 2009/2010, we used a validated algorithm with 2 ODB records or 2 OHIP records or 1 ODB and 1 OHIP record within 30 days of each other with a long-term code flag. The date of admission to long-term care was defined as the date of the first record.

Supplemental Figure 1 Study year-specific adjusted summary rate ratio for 90-day home-time by mRS with year 2007 as the reference group



STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	p. 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	p. 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	p. 4
Objectives	3	State specific objectives, including any prespecified hypotheses	p. 5
Methods			
Study design	4	Present key elements of study design early in the paper	p. 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	p. 5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	p. 6-7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	p. 6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	p. 6-7
Bias	9	Describe any efforts to address potential sources of bias	p. 6-7
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	p. 7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	p. 7-8
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	p. 8-9
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	p. 8-9
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	p. 9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	p. 9-10
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	p. 10
Discussion			
Key results	18	Summarise key results with reference to study objectives	p. 10-11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	p. 12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	p. 12
Generalisability	21	Discuss the generalisability (external validity) of the study results	p. 12-13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	p. 15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.