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Estimation and predictors of direct hospitalisation expenses and in-hospital mortality for patients who had a stroke in a low-middle income country: evidence from a nationwide cross-sectional study in Iranian hospitals

Zohreh Kazemi ,[1,2] Sara Emamgholipour Sefiddashti ,[1] Rajabali Daroudi,[1,2] Askar Ghorbani,[3] Masud Yunesian ,[4] Mohammad Sadegh Hassanvand,[5] Zahra Shahali[2]

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For numbered affiliations see end of article.

Correspondence to
Professor Sara Emamgholipour Sefiddashti;
s-emamgholipour@tums.ac.ir

ABSTRACT

Objective Stroke is the second most prevalent cardiovascular disease in Iran. This study investigates the estimation and predictors of hospitalisation expenses and in-hospital mortality for patients who had a stroke in Iranian hospitals.

Setting Patients who had a stroke in Iran between 2019 and 2020 were identified through the data collected from the Iran Health Insurance Organization and the Ministry of Health and Medical Education. This study is the first to conduct a pervasive, nationwide investigation.

Design This is a cross-sectional, prevalence-based study. Generalised linear models and a multiple logistic regression model were used to determine the predictors of hospitalisation expenses and in-hospital mortality for patients who had a stroke.

Participants A total of 19 150 patients suffering from stroke were studied.

Results Mean hospitalisation expenses per patient who had a stroke in Iran amounted to US$590.91±974.44 (mean±SD). Mean daily hospitalisation expenses per patient who had a stroke were US$55.18±37.89. The in-hospital mortality for patients who had a stroke was 18.80%. Younger people (aged ≤49 years) had significantly higher expenses than older patients. The OR of in-hospital mortality in haemorrhagic stroke was significantly higher by 1.539 times (95% CI, 1.401 to 1.691) compared with ischaemic and unspecified strokes. Compared with patients covered by the rural fund, patients covered by Iranian health insurance had significantly higher costs by 1.14 times (95% CI, 1.186 to 1.097) and 1.319 times (95% CI, 1.099 to 1.582) higher mortality. There were also significant geographical variations in patients who had a stroke's expenses and mortality rates.

Conclusion Applying cost-effective stroke prevention strategies among the younger population (≤49 years old) is strongly recommended. Migration to universal health insurance can effectively reduce the inequality gap among all insured patients.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Nationally representative samples were used to generate nationwide estimates.
⇒ Outcome determinants are presented as an average cost ratio and OR for comparability and usability by policymakers worldwide.
⇒ This study is limited by the absence of stroke co-morbidities and severity data.

INTRODUCTION

Cardiovascular disease (CVD) is a non-communicable disease frequently identified as a leading cause of premature death and increased healthcare expenses.[1 2] In general, CVD incidences and mortality rates vary across regions because of appropriate and adequate healthcare accessibility, dietary habits, lifestyle, etc. For instance, less educated patients in low-income and middle-income countries (LMICs) suffer higher rates of CVD incidence and mortality.[3 4]

Patients from LMICs, mostly in the Eastern Mediterranean Region (EMR), suffer 50% of all CVD mortalities and bear 80% of the global CVD burden. CVD has been a progressive epidemic problem in recent years.[5 6] Iran suffers the highest CVD burden in the EMR,[6 7] as CVDs account for the third most important contributor to the burden of disease in Iran.[8]

Stroke is the primary cause of CVD. Globally, stroke is the second most common cause of mortality, and the stroke burden in terms of disability-adjusted life years (DALYs) is increasing. Between 1990 and 2019, the total number of prevalent cases, deaths and DALYs because of stroke has increased steadily,

reaching 101 million (85.3% increase), 6.55 million (43.3% increase) and 143 million (32.4% increase), respectively, by 2019. The global stroke burden increases can be largely attributed to population growth and ageing.[9]

Likewise, LMICs bear the majority of the CVD burden. Stroke is more prevalent in LMICs and poses a larger mortality risk, disability and recurrence.[10–12] Stroke is the second most prevalent type of CVD in Iran, more prevalent than in western countries.[6]

Stroke complications are not limited to physical and psychological effects on the patient; they also affect the patient's family and society economically.[13] Despite resources spent on its treatment, the cost component of stroke and the difference in expenses based on patient characteristics and healthcare providers remain unclear. Most LMICs do not have a comprehensive disease registration system or accurate financial records, the absence of which impedes disease-specific expense analysis.[14] The numerous studies conducted on the expenses and burden of diseases in Iran have been limited to data sets from one or a few local hospitals. This study is the first to conduct a nationwide investigation because Iran Health Insurance Organization (IHIO) has provided access to nationwide data for the first time.

Objectives

Increasing social expectations and scarcity of resources have made resource prioritisation necessary to meet healthcare needs.[13] A stroke affects the survivors' physical, psychological and social well-being and the financial aspects of their lives. Therefore, identifying the components and determinants of hospitalisation expenses is essential for further developing socioeconomic intervention strategies targeting stroke survivors.[15]

Analysis of hospitalisation expenses provides valuable information on such various healthcare decision-making processes as planning, prioritising and allocating resources; economic evaluation of health interventions; evaluation of funding distribution inefficiencies; as well as identification of cost reduction opportunities for policymakers, insurance organisations and healthcare providers.[14 16 17] Therefore, this study aims to identify: (1) hospitalisation expenses of strokes in Iran and their components, (2) predictors of stroke hospitalisation expenses in Iran and predictors of in-hospital mortality in Iran.

METHODS

Study design and setting

A prevalence-based, cross-sectional survey was conducted on the population of the people covered by the IHIO. There are three types of basic health insurance in Iran. The IHIO and the Iranian Social Security Organization are the largest insurance institutions in Iran. IHIO covers about half of the Iranian population (over 42 million people) that includes rural and urban residents, employees and non-employees. These institutions are covered by the Supreme Council of Health Insurance (SCHI) and because they follow the policies and decisions of the SCHI, they have the same benefits package according to article 2 of Iran's health universal Insurance Law. The demographic structure and gender age distribution of the population covered by IHIO are similar to Iran population structure.[18] Therefore, the study of the population covered by IHIO can be generalised to the whole population of Iran.

IHIO maintains a database that gathers patient files (containing diagnosis and treatment data) and financial records from Iranian hospital information systems. The IHIO database was queried for this study, extracting data between 23 August 2019 and 21 June 2020.

A healthcare system perspective with a bottom-up (micro-costing) approach was used to determine hospitalisation expenses of patients who had a stroke, in which patient-specific data were collected based on their usage of evaluated hospital services.[19]

Data, participants, and eligibility criteria

Hospitalised cerebrovascular patients with the ICD-10 (International Classification of Diseases) diagnosis code I60–I64 were included in the study, and their afflictions were classified as haemorrhagic strokes (ICD-10: I60–I62), ischaemic strokes (ICD-10: I63) or unspecified strokes (ICD-10: I64). Under a neurologist's opinion, ischaemic and unspecified strokes were combined so that some physicians may have used the unspecified code for ischaemic stroke cases.

A predesigned, structured case report form (CRF) was used to collect data from medical records on patient demographics (14 items), cost components and resource consumption (55 items), disease and patient hospitalisation processes (36 items) and hospital characteristics (7 items). Patient data were obtained from IHIO information records extracted by experts at the Iranian National Center for Health Insurance Research (NCHIR). In contrast, information about hospitals was obtained from the accreditation sources of the hospitals of the Ministry of Health and Medical Education (MHME). The two data sets were combined, and cost components were summarised and categorised into eight groups: Medical examination and consultation, hospital accommodation and nursing, laboratory tests, medical imaging, medicine, and medical materials, rehabilitation, surgery and medical interventions.

The present study was carried out via a complete enumeration method, also known as the census. This is thus a pervasive study, encompassing all hospitalised patients who had a stroke under IHIO coverage at the affiliated hospitals across Iran. Herein 30 615 medical records were reviewed, of which 11 465 cases were excluded because they did not meet the criteria elaborated below, leaving this study with 19 150 records to analyse. The participants were not directly involved in this study. The study

population was limited to the unidentified records in the IHIO database.

Grounds for elimination include: (1) Persistent and temporary emergency room patients, as they were not considered hospitalised (n=85). (2) Patients with a length of stay (LoS) of 1 day (n=4306) and 2 days (n=4368) were excluded because, according to the neurologist's opinion, suspected cases of stroke should be excluded, and only confirmed cases of stroke should be included in the study. (3) Medical records lacking critical data such as LoS (n=2702) and medical records of newly established hospitals that MHME had not accredited at the time (n=4), and we could not find hospital characteristics.

Variables

Hospitalisation expenses and in-hospital mortality were the two outcome variables studied in this research. Hospitalisation expenses are the direct expenses incurred by patients who had a stroke during their hospitalisation period. Hospitalisation expenses were recorded in Iranian rials (IRR) before being converted to and expressed in US dollars (US$) for comparability purposes (1 US$=149 000 rials, as of 19 March 2020). The second outcome variable, in-hospital mortality, is an important index in measuring clinical quality.[20] It is used in this study to evaluate the health outcome of patients.

Independent predictor variables in this study include age, gender, marital status, the insurance fund covering the patient, province of residence, lengths of stay in the intensive care unit (ICU LoS), LoS in another ward for patients without injury or critical conditions, stroke subtype, surgery reception, the outcome of hospitalisation, hospital accreditation grade, hospital ownership and hospital size.

Hospital accreditation is a 'systematic, external evaluation of a hospital's structure, processes and outcomes by an independent, professional, accreditation body, using published optimum, evidence-based and achievable standards'.[21] MHME defines different tariffs depending on the hospital accreditation grade, such that grade 1 hospitals have higher tariffs and thus charge their patients more.[22]

In ownership, there are four groups of Iranian hospitals: governmental, private sector, social security and special (military, charity and other organisations). While their tariffs depend on their accreditation grade, governmental hospitals have subsidised tariffs, while private sector hospitals are more expensive.[23] Social security and special hospitals have a mixture of the two tariff levels.

Statistical analysis

All collected data were imported into Microsoft Excel spreadsheet CRFs, where randomly selected entries were double-checked for accuracy and consistency. The data were then cleaned up for export into Stata V.14.1 (Stata, College Station, Texas, USA) for statistical analysis.

Cost distributions reported in this study possess a positive, intense skewness and are non-negative. This is in concordance with commonly reported observations in previous health data sets. Generalised linear models (GLM) with gamma family distribution and the log link function were used to determine the predictors for hospitalisation expenses of patients who had a stroke.

The dependent variable of in-hospital mortality was a binary parameter expressed as either zero or one. Thus, multiple logistic regression was used to model potential predictors and investigate in-hospital mortality determinants.

Skewness and Kurtosis normality tests were used to check for the normality of continuous data. Descriptive statistics were used to summarise expenses, patient demographics, disease, hospitalisation process and hospital characteristics. Categorical variables were summarised as count and percentage, while continuous variables were presented as mean with SD or median with a lower and upper quartile (ie, 25th and 75th percentiles). To estimate daily hospitalisation expenses, total expenses and cost components (each of our eight cost groups), both means and medians for central tendency, SD with 25th and 75th percentiles (upper and lower quartiles) for variability and dispersion were reported, yielding a comprehensive sense of cost distribution data. Hospitalisation expenses are the sum of all medical and non-medical expenses incurred by patients who had a stroke during hospitalisation.[20]

GLM with gamma distribution has been shown to predict mean costs as well as total hospitalisation costs closely. In addition, the log link function has the advantage of ensuring non-negative results by preserving the original scale of the data, as opposed to log transformation.[16 24]

The Box-Cox approach was used to find the appropriate functional form and the linkage function, while the modified Park test was used to select the distribution family. In addition, non-nested selections from six different patterns of gamma, Gaussian and Poisson distribution families with log and the second root linkage functions were iterated 40 times, and their Akaike and Bayesian criteria were compared. The log link and gamma family distributions had the smallest Akaike and Bayesian criteria, confirming the fitting model's decency. P values less than 0.05 were considered statistically significant. Multivariate analysis was used to eliminate the effect of confounders.

Patient and public involvement

Patients and/or the public were not involved in this research's design, conduct, reporting or dissemination plans.

RESULTS

A total of 19 150 patients who had a stroke were included in the study, of which 14 234 (74.33%; mean age: 71±15; gender: 51.5% men) had suffered from an ischaemic and unspecified stroke (I&US), and 4916 (25.67%; mean age: 64±18; gender: 54.5% men) had endured a haemorrhagic

Table 1 Demographic and hospitalisation characteristics of the studied population

Characteristics	Ischaemic & unspecified n=14 234, (proportion=74.33%)	Haemorrhagic stroke n=4916, (proportion=25.67%)	Total n=19 150, (proportion=100%)
Age, years, mean±SD (min–max)	71±15 (1–119)	64±18 (1–106)	69±16 (1–119)
Gender			
Male	7330 (51.50)	2679 (54.50)	10 009 (52.27)
Female	6904 (48.50)	2237 (47.50)	9141 (47.73)
Marital status			
Married	5470 (38.43)	1899 (38.63)	7369 (38.48)
Single	8659 (60.83)	2986 (60.74)	11 645 (60.81)
Unspecified	105 (0.74)	31 (0.63)	136 (0.71)
Health insurance coverage			
Rural Fund	6472 (45.47)	2234 (45.44)	8706 (45.46)
Others	1230 (8.64)	376 (7.65)	1606 (8.39)
Civil Servants Fund	2835 (19.91)	885 (18.00)	3720 (19.42)
Iranian Fund	687 (4.83)	343 (6.98)	1030 (5.38)
Universal health insurance	1933 (13.58)	776 (15.79)	2709 (14.15)
Imam Khomeini Relief Committee	1077 (7.57)	302 (6.14)	1379 (7.20)
ICU LoS (mean±SD)	2.90±9.45	6.68±12.44	3.87±10.43
Other ward LoS (mean±SD)	5.72±6.99	5.64±8.13	5.70±7.30
Total LoS (mean±SD)	8.62±11.76	12.33±14.48	9.57±12.62
Hospital accreditation grade			
Grade 1	13 223 (93.50)	4677 (95.96)	17 900 (94.12)
Grade 2	836 (5.91)	173 (3.55)	1009 (5.31)
Grades 3 and 4	84 (0.59)	24 (0.49)	108 (0.57)
Hospital ownership			
Governmental	14 021 (98.50)	4866 (98.98)	18 887 (98.63)
Private	69 (0.48)	24 (0.49)	93 (0.49)
Military, charity, other organisations	123 (0.86)	22 (0.45)	145 (0.76)
Social security	21 (0.15)	4 (0.80)	25 (0.13)
Hospital size			
≤100 beds or S	713 (5.04)	113 (2.32)	826 (4.35)
100–320 beds or M	8244 (58.33)	2523 (51.75)	10 767 (56.64)
320–600 beds or L	3210 (22.71)	1260 (25.85)	4470 (23.52)
600–1000 beds or XL	1903 (13.46)	976 (20.02)	2879 (15.15)
>1000 beds or HC	63 (0.45)	3 (0.06)	66 (0.35)
Outcome of treatment			
Full recovery	4199 (29.50)	1183 (24.06)	5382 (28.10)
Partial recovery	6977 (49.02)	1874 (38.12)	8851 (46.22)
Death	2122 (14.91)	1479 (30.09)	3601 (18.80)
Discharge against medical advice	792 (5.56)	254 (5.17)	1046 (5.46)
Referral to another hospital	144 (1.01)	126 (2.56)	270 (1.41)
Surgery reception			
Yes	2486 (17.47)	2248 (45.73)	4734 (24.72)
No	11 748 (82.53)	2668 (54.27)	14 416 (75.28)
In-hospital mortality ratio	2121 (14.91)	1485 (30.17)	3606 (18.83)

ICU LoS, lengths of stay in the intensive care unit.

stroke (HS). Table 1 displays the demographic and hospitalisation characteristics of the studied population.

The mean LoS was 8.62±11.7 days (mean±SD) for I&US, 12.33±14.48 days for HS and 9.57±12.62 days overall. The mean ICU LoS and other ward LoS were 3.87±10.43 days and 5.70±7.30 days, respectively. The in-hospital mortality ratio was 14.91% for patients who had a ischaemic stroke (IS), 30.21% for patients who had an HS and 18.83% overall.

Total and daily hospitalisation expenses per patient who had a stroke

Mean hospitalisation expenses per patient who had a stroke was US$482.59 (SD±US$844.53) for I&US, US$904.41 (SD±US$1225.34) for HS and US$590.91 (SD±US$974.44) overall. Mean daily hospitalisation expenses per patient who had a stroke was US$49.91 (SD±US$33.01) for I&US, US$70.43 (SD±US$46.09) for HS and US$55.18 (SD±US$37.89) for stroke. Patients who had an HS had higher mean hospitalisation expenses per patient than patients who had a I&US. This was also higher in all age groups for patients with HS than I&US. Online supplemental table 1 illustrates total and daily hospitalisation expenses for patients who had a stroke, stratified by LoS and stroke type. Online supplemental table 2 displays hospitalisation expenses for patients who had a stroke, stratified by age, gender and stroke type.

Table 2 presents the different hospitalisation cost components for the patients who had a stroke studied. Hospital accommodation and nursing (55.11%) represent the main component of hospitalisation expenses for patients who had a stroke. Medicine and medical materials (17.16%), medical examination and consultation (11.72%), medical imaging services (6.76%), laboratory tests (4.23%), surgery (3.93%) and rehabilitation (0.81%) are the next components in severity. On the contrary, medical interventions (0.29%) represent the lowest proportion of hospitalisation expenses per patient.

Predictors of hospitalisation expenses for patients who had a stroke

Table 3 displays the predictors of hospitalisation expenses for patients who had a stroke in Iran. Independent predictor variables for the GLM model were age, gender, insurance funds, province of residence, ICU LoS, other ward LoS, stroke subtype, surgery reception, outcome of hospitalisation, hospital accreditation grade, hospital ownership and hospital size.

This study has found no significant difference in average expenses between the patients insured by other insurance institutions and reference groups. However, significant differences were observed between hospitalisation expenses among various age groups, such that 0—49 years old patients had the highest average hospitalisation expenses. The average hospitalisation expenses for the 50—59, 60—69, 70—79 and over 80 years old patients were, respectively, 0.934, 0.930, 0.940 and 0.921 times smaller than that of the 0—49 years old patients. Hospitalisation costs for men were significantly higher than for women (1.017 times).

There was a significant difference between the average expenses for people under the Civil Servants Fund and the Iranians Fund insurance coverage, compared with those covered by the Rural Fund; such that their average expenses were 1.03 and 1.14 times higher, respectively, than that of the Rural Funds reference group.

The average hospitalisation expenses of Alborz, Fars, Kohkiluyeh and Boyer-Ahmad, Markazi, Sistan and Baluchestan, and Zanjan provinces showed no significant differences from the Tehran province (the reference group). The expenses in the Hamadan province were 1.075 times higher than in Tehran. All other provinces had significantly lower hospitalisation expenses than Tehran. The lowest average belongs to the Kermanshah province.

ICU and other ward LoS had a significant positive association with the average hospitalisation expenses for patients who had a stroke, such that LoS longer than 7 days were 3.098 times higher, compared with other ward LoS of 1–3 days and 7.689 times higher than single-day ICU LoS.

No significant differences were observed in average hospitalisation expenses between patients who had an HS and I&US. However, the mean hospitalisation expenses of patients who had a stroke who underwent surgery were significantly 1.602 times higher than that of the reference group members who had no surgery. However, significant differences of, respectively, 1.599 and 2.442 times higher average hospitalisation expenses for patients who had a stroke were observed at special (military, charity, other organisations) and private hospitals, compared with public hospitals.

With the increase in size and number of hospital beds, the average hospitalisation expenses for patients who had a stroke were significantly raised above small hospitals (S) by 1.046 times in medium hospitals (M), 1.116 times in large hospitals (L), 1.176 times in very large hospitals (XL), and 1.347 times in hospital complexes (HC).

Analysing hospitalisation outcomes such as death, discharge against medical advice and referral to another hospital, compared with full recovery (designated as a reference group), revealed significant differences in mean hospitalisation expenses of patients who had a stroke with such outcomes. Therefore, their average hospitalisation expenses were 1.361, 1.108 and 1.278 times higher compared with the full recovery reference group.

Predictors of in-hospital mortality for patients who had a stroke

Table 4 presents predictors of in-hospital mortality for patients who had a stroke. Independent predictor variables in the multiple logistic regression model include age, gender, marital status, insurance fund, province of residence, ICU LoS, other ward LoS, stroke subtype, surgery reception, hospital accreditation grade and hospital ownership. Where the other variables were

Table 2 Hospitalisation expenses for patients who had a stroke, stratified by resource usage and stroke type

Cost component	Ischaemic & unspecified stroke	Haemorrhagic stroke	Total
Accommodation and nursing			
Mean (SD)	208.42 (481.85)	410.61 (637.50)	260.14 (533.40)
Median (25th–75th percentile)	70.15 (46.77–151.90)	175.37 (76.71–460.87)	81.84 (46.77–217.49)
Sum (% of total hospital costs)	3 808 553.87 (53.61)	2 644 728.39 (57.49)	6 450 576.38 (55.10)
Medicine and medical materials			
Mean (SD)	65.83 (153.89)	125.03 (212.48)	80.98 (172.74)
Median (25th–75th percentile)	17.63 (7.92–54.95)	46.68 (19.73–134.70)	22.85 (9.33–74.23)
Sum (% of total hospital costs)	1 203 534.78 (16.94)	805 978.98 (17.53)	2 009 109.79 (17.16)
Visit and consultation			
Mean (SD)	54.21 (70.39)	60.20 (75.90)	55.73 (71.87)
Median (25th–75th percentile)	34.79 (23.00–57.22)	38.09 (21.85–69.30)	35.42 (22.71–60.44)
Sum (% of total hospital costs)	987 736.96 (13.90)	380 181.35 (8.26)	1 371 848.09 (11.72)
Medical imaging services			
Mean (SD)	32.46 (30.24)	30.98 (31.21)	32.08 (30.50)
Median (25th–75th percentile)	26.06 (16.35–39.34)	22.98 (13.09–38.28)	25.39 (15.40–39.08)
Sum (% of total hospital costs)	590 264.49 (8.31)	197 880.09 (4.30)	790 937.07 (6.76)
Laboratory tests			
Mean (SD)	17.23 (30.19)	28.07 (41.96)	20.00 (33.93)
Median (25th–75th percentile)	7.92 (4.44–17.05)	13.65 (5.98–32.80)	8.88 (4.70–20.69)
Sum (% of total hospital costs)	314 328.42 (4.42)	180 324.38 (3.92)	495 004.43 (4.23)
Surgery			
Mean (SD)	38.42 (68.64)	114.77 (122.33)	74.67 (105.03)
Median (25th–75th percentile)	11.64 (5.64–36.55)	85.14 (18.29–166.21)	27.30 (8.05–108.26)
Sum (% of total hospital costs)	122 959.70 (1.73)	340 604.95 (7.40)	459 610.82 (3.93)
Rehabilitation			
Mean (SD)	10.75 (26.38)	21.60 (36.01)	13.84 (29.85)
Median (25th–75th percentile)	4.01 (2.41–8.63)	8.42 (3.61–25.00)	4.81 (2.41–12.34)
Sum (% of total hospital costs)	51 850.42 (0.73)	42 513.29 (0.92)	94 228.28 (0.81)
Medical interventions			
Mean (SD)	11.41 (18.25)	10.81 (18.71)	11.26 (18.37)
Median (25th–75th percentile)	8.03 (4.86–11.14)	8.03 (4.86–10.98)	8.03 (4.86–11.03)
Sum (% of total hospital costs)	25 518.65 (0.36)	8259.71 (0.18)	33 903.56 (0.29)
Total hospital cost			
Mean (SD)	482.59 (844.53)	904.41 (1225.34)	590.91 (974.44)
Median (25th–75th percentile)	214.62 (137.94–436.62)	457.96 (230.71–1031.14)	252.93 (148.84–564.98)
Sum (% of total hospital costs)	7 104 747.29 (60.70)	4 600 471.15 (39.30)	11 705 218.44(100)

All prices are in US dollars (US$).

constant, the OR of in-hospital mortality for 60–69, 70–79 and over 80 years old patients were 1.538, 2.119 and 3.233 times higher than the 0–49 years old patients, respectively. There were no significant differences in the chance of in-hospital mortality between men and women. But there was a significant difference between single and married patients. Thus, the chance of mortality for single patients was 1.332 times higher than for married patients. There was also a significant difference in hospital mortality rates of patients under Civil Servants Fund and Iranians Fund insurance coverage, compared with patients covered by the rural fund insurance, so that their OR was 0.886 and 1.319 times higher, respectively.

The ORs of in-hospital mortality in Alborz (1.753), East Azerbaijan (1.965), Fars (1.329), Gilan (2.135), Golestan (1.651), Khorasan Razavi (1.451), Khuzestan (1.942), Sistan and Baluchestan (1.662) and Zanjan (1.415) were significantly higher than Tehran. The lowest and highest

Table 3 Predictors of hospitalisation expenses for patients who had a stroke in Iran

Variables	N	%	Coefficient	Lower	Upper	P value
Age						
≤49	2081	10.87	1			
50–59	2496	13.03	0.934	0.903	0.967	<0.001
60–69	4440	23.19	0.935	0.903	0.968	<0.001
70–79	4510	23.55	0.940	0.912	0.970	<0.001
≥80	5623	29.36	0.921	0.934	0.950	<0.001
Gender						
Female	9141	47.73	1			
Male	10009	52.27	1.017	1.000	1.034	0.049
Health insurance coverage						
Rural Fund	8706	45.46	1			
Others	1606	8.39	1.031	0.999	1.064	0.054
Civil Servants Fund	3720	19.43	1.033	1.009	1.057	0.006
Iranian Fund	1030	5.38	1.140	1.097	1.186	<0.001
Universal health insurance	2709	14.15	0.987	0.962	1.013	0.332
Imam Khomeini Relief Committee	1379	7.20	0.978	0.946	1.011	0.193
Province						
Tehran	788	4.11	1			
Alborz	302	1.58	1.024	0.947	1.107	0.546
Ardabil	436	2.28	0.806	0.751	0.865	<0.001
Bushehr	215	1.12	0.885	0.809	0.967	0.007
East Azarbaijan	1063	5.55	0.875	0.828	0.925	<0.001
Fars	1768	9.23	0.957	0.909	1.008	0.094
Qazvin	336	1.75	0.768	0.713	0.828	<0.001
Qom	335	1.75	0.836	0.775	0.902	<0.001
Gilan	676	3.53	0.751	0.704	0.802	<0.001
Golestan	619	3.23	0.770	0.723	0.820	<0.001
Hamadan	493	2.57	1.075	1.005	1.149	0.034
Chaharmahal and Bakhtiari	295	1.54	0.865	0.799	0.937	<0.001
Hormozgan	412	2.15	0.804	0.749	0.864	<0.001
Ilam	163	0.85	0.780	0.703	0.865	<0.001
Isfahan	1298	6.78	0.912	0.864	0.962	0.001
Kerman	677	3.54	0.863	0.812	0.918	<0.001
Kermanshah	527	2.75	0.712	0.665	0.762	<0.001
Razavi Khorasan	1806	9.43	0.768	0.729	0.809	<0.001
Khuzestan	1143	5.97	0.832	0.788	0.880	<0.001
Kohkiluyeh and Boyer-Ahmad	187	0.98	0.987	0.899	1.084	0.793
Kurdistan	438	2.29	0.889	0.830	0.953	0.001
Lorestan	667	3.48	0.767	0.721	0.817	<0.001
Markazi	336	1.75	0.928	0.860	1.001	0.054
Mazandaran	1224	6.39	0.842	0.798	0.888	<0.001
North Khorasan	293	1.53	0.787	0.727	0.852	<0.001
Semnan	117	0.61	0.789	0.704	0.883	<0.001
Sistan and Baluchestan	571	2.98	0.971	0.911	1.036	0.378
West Azerbaijan	969	5.06	0.862	0.814	0.912	<0.001

Continued

Table 3 Continued

Variables	N	%	Coefficient	Lower	Upper	P value
Yazd	235	1.23	0.852	0.781	0.930	<0.001
Zanjan	523	2.73	0.983	0.918	1.051	0.613
South Khorasan	238	1.24	0.768	0.705	0.837	<0.001
ICU LoS						
0–1 days	13 169	69.09	1			
2–4 days	1952	10.24	2.016	1.957	2.077	<0.001
5–7 days	1213	6.36	3.072	2.962	3.187	<0.001
>7 days	2728	14.31	7.689	7.471	7.915	<0.001
Other ward LoS						
0–3 days	7688	40.33	1			
4–5 days	5008	26.27	1.247	1.219	1.275	<0.001
6–7 days	2550	13.38	1.633	1.589	1.679	<0.001
>7 days	3816	20.02	3.098	3.022	3.176	<0.001
Stroke type						
Ischaemic & unspecified	14 234	74.33	1			
Haemorrhagic	4916	25.67	1.015	0.994	1.036	0.151
Surgery						
No	14 416	75.28	1			
Yes	4734	24.72	1.602	1.566	1.639	<0.001
Hospital accreditation grade						
Grades 3 and 4	108	0.57	1			
Grade 1	17 900	94.12	0.968	0.863	1.086	0.580
Grade 2	1009	5.31	0.963	0.854	1.087	0.545
Hospital ownership						
Governmental	18 887	98.62	1			
Military, charity, other organisations	145	0.76	1.599	1.450	1.762	<0.001
Social security	25	0.13	1.134	0.903	1.425	0.279
Private	93	0.49	2.442	2.145	2.780	<0.001
Hospital size						
≤100 beds (S)	826	4.35	1			
100–320 beds (M)	10 767	56.64	1.046	1.000	1.093	0.048
321–600 beds (L)	4470	23.51	1.116	1.063	1.172	<0.001
601–1000 beds (XL)	2879	15.15	1.176	1.116	1.239	<0.001
>1000 beds (HC)	66	0.35	1.347	1.161	1.563	<0.001
Outcome of hospitalisation						
Full recovery	5382	28.10	1			
Partial recovery	8851	46.22	1.013	0.991	1.036	0.236
Death	3601	18.80	1.361	1.325	1.399	<0.001
Discharge against medical advice	1046	5.46	1.108	1.064	1.153	<0.001
Referral to another hospital	270	1.41	1.278	1.189	1.375	<0.001

ICU LoS, lengths of stay in the intensive care unit.

chances of mortality were found in Fars and Gilan provinces, respectively. The ORs in Kermanshah and Kohkiluyeh Boyer-Ahmad provinces were 0.613 and 0.444 times lower than in Tehran, respectively.

The in-hospital mortality OR for patients who had a stroke with more than 3 days LoS in the other ward was significantly lower than those in the reference group. This ratio was significantly higher for ICU patients, compared

Table 4 Predictors of in-hospital mortality for patients who had a stroke in Iran

Variables	Died (person)	Discharged (person)	Mortality (%)	OR	Lower	Upper	P value
Age							
≤49	302	1779	14.51	1			
50–59	311	2185	12.46	1.0429	0.861	1.263	0.667
60–69	722	3718	16.26	1.538	1.301	1.818	<0.001
70–79	864	3646	19.16	2.119	1.794	2.502	<0.001
≥80	1402	4221	24.93	3.233	2.751	3.800	<0.001
Gender							
Female	1729	7412	18.91	1			
Male	1872	8137	18.70	0.988	0.909	1.074	0.776
Marital status							
Married	1157	6212	11.16	1			
Single	2393	9252	20.55	1.332	1.213	1.463	<0.001
Insurance funds							
Rural Fund	1590	7116	18.26	1			
Others	319	1287	19.86	1.074	0.920	1.253	0.365
Civil Servants Fund	730	2990	19.62	0.886	0.789	0.995	0.042
Iranian Fund	249	781	24.17	1.319	1.099	1.582	0.003
Universal health insurance	457	2252	16.87	0.985	0.861	1.128	0.833
Imam Khomeini Relief Committee	256	1123	18.56	0.999	0.843	1.182	0.988
Province							
Tehran	150	638	19.04	1			
Alborz	67	235	22.19	1.753	1.290	2.542	0.003
Ardabil	74	362	16.97	1.222	0.853	1.752	0.274
Bushehr	43	172	20.00	1.270	0.820	1.968	0.285
East Azarbaijan	249	814	23.42	1.965	1.507	2.561	<0.001
Fars	339	1429	19.17	1.329	1.037	1.704	0.025
Qazvin	57	279	16.96	1.443	0.986	2.113	0.059
Qom	66	269	19.70	1.333	0.916	1.940	0.133
Gilan	151	525	22.34	2.135	1.572	2.900	<0.001
Golestan	146	473	23.59	1.651	1.223	2.228	0.001
Hamadan	81	412	16.43	1.094	0.779	1.537	0.602
Chaharmahal and Bakhtiari	41	254	13.90	0.756	0.495	1.156	0.197
Hormozgan	75	337	18.20	1.078	0.756	1.537	0.679
Ilam	19	144	11.66	0.717	0.387	1.328	0.290
Isfahan	224	1074	17.26	0.929	0.712	1.211	0.586
Kerman	135	542	19.94	1.220	0.901	1.653	0.199
Kermanshah	71	456	13.47	0.613	0.433	0.868	0.006
Razavi Khorasan	370	1436	20.49	1.451	1.133	1.857	0.003
Khuzestan	234	909	20.47	1.942	1.482	2.544	<0.001
Kohgiluyeh and Boyer-Ahmad	17	170	9.09	0.444	0.241	0.819	0.009
Kurdistan	69	369	15.75	0.774	0.542	1.107	0.161
Lorestan	141	526	21.14	1.332	0.981	1.809	0.066
Markazi	61	275	18.15	1.060	0.723	1.556	0.764
Mazandaran	167	1057	13.64	0.834	0.629	1.104	0.205
North Khorasan	65	228	22.18	1.425	0.973	2.088	0.069
Semnan	22	95	18.80	0.705	0.404	1.230	0.218
Sistan and Baluchestan	113	458	19.79	1.662	1.212	2.279	0.002
West Azerbaijan	187	782	19.30	1.182	0.892	1.568	0.245
Yazd	38	197	16.17	0.640	0.405	1.012	0.056
Zanjan	88	435	16.83	1.415	1.011	1.981	0.043

Continued

Table 4 Continued

Variables	Died (person)	Discharged (person)	Mortality (%)	OR	Lower	Upper	P value
South Khorasan	41	197	17.23	0.923	0.599	1.420	0.714
Other ward LoS							
0~3 days	2080	5608	27.06	1			
4~5 days	477	4531	9.52	0.526	0.465	0.594	<0.001
6~7 days	267	2283	10.47	0.515	0.443	0.600	<0.001
>7 days	761	3055	19.94	0.823	0.736	0.921	0.001
ICU LoS							
0~1 days	1289	11 880	9.79	1			
2~4 days	527	1425	27.00	2.556	2.240	2.916	<0.001
5~7 days	479	734	39.49	4.206	3.633	4.869	<0.001
>7 days	1290	1438	47.29	4.629	4.127	5.193	<0.001
Stroke type							
Ischaemic & unspecified	2122	12 112	14.91	1			
Haemorrhagic	1479	3437	30.09	1.539	1.401	1.691	<0.001
Surgery							
No	1787	12 629	12.40	1			
Yes	1814	2920	38.32	2.616	2.378	2.878	<0.001
Hospital accreditation grade							
Grade 1	3353	14 547	18.73	1			
Grade 2	191	818	18.93	0.865	0.709	1.055	0.151
Grades 3 and 4	28	85	24.78	0.924	0.559	1.529	0.759
Hospital ownership							
Private	11	82	11.83	1			
Governmental	3575	15 312	18.93	2.374	1.130	4.987	0.022
Military, charity, other organisations	13	132	8.97	1.399	0.535	3.656	0.494
Social security	2	23	8.00	0.740	0.135	4.065	0.729

ICU LoS, lengths of stay in the intensive care unit.

with the reference group, such that chances of in-hospital mortality in patients with a 2–4, 5–7 and over 7 days LoS, were 2.556, 4.206 and 4.629 times higher than that of the reference group, respectively.

At 2.616 times, in-hospital mortality for patients who had a stroke who underwent surgery was significantly different from that of patients who did not undergo surgery. At about 1.539 times, this ratio was significantly higher in HS compared with I&US.

There were no significant differences in hospital mortality OR for patients who had a stroke across hospitals with different accreditation grades. At about 2.374 times, mortality OR was significantly higher in governmental hospitals than in private hospitals. Online supplemental table 3 shows hospitalisation costs of patients who had a stroke by death/life, gender and type of stroke.

DISCUSSION

This study found mean hospitalisation expenses per patient who had a stroke in Iran (US$590.91) to be lower than Philippines (US$781.42) and China (US$2,008); the former is an Asian LMIC while the latter is a developed country.[17 25] A root cause of this difference is the lower prevalence of traditional medical technologies in Iran compared with modern, expensive ones.[26] Furthermore, the difference in mean expenses is likely because of the differences in standards of care, payment systems, modern medical technologies and services, sanctions against Iran and the steep fall in the value of the IRR, the national currency. In Iran, public hospitals are subsidised by the state, rendering their therapy costs lower than the actual cost of services. As such, these prices do not reflect the true value of their services.

Estimates for the hospitalisation expenses of patients who had a stroke demonstrate that average expenses per patient who had an HS were higher than patients who had a I&US. Moreover, obtaining overall hospital estimates revealed that more than half of the hospitalisation expenses of patients who had a stroke (60%) are related to IS. These findings are consistent with similar, relevant studies.[16 25 27] Patients suffering from HS have a longer average other ward LoS compared with other ward patients who had a I&US (12.33±14.48 days) and significantly longer ICU LoS (6.68±12.44 days). In addition, patients who had an HS undergo more brain surgery than patients who had a IS, adding to their expenses, which may partly explain some differences.

In a study, Alene *et al* showed that Ethiopia's overall in-hospital stroke mortality was 18%. The pooled result of her systematic review and meta-analysis study revealed that nearly one-fifth of the patients who had a stroke studied had died during hospitalisation.[28] This is very close to the mortality rate in our hospital (18.83%). This measurement is lower than that of previous studies conducted in such LMICs as Kenya (21.6%) and Burkina Faso (28.7%)[29 30] but higher compared with such developing countries as China (2.30%) and Germany (9.50%).[31 32] The disparity is likely caused by improved stroke care and prevention in developed countries. Furthermore, the lack of intermediate care departments such as specialised stroke care units and neurology ICU, as well as the lack of trained human resources in hospital wards for care, transportation and rehabilitation of patients who had a stroke, is another factor affecting the in-hospital mortality of patients who had a stroke in Iran. Thus, LMICs, including Iran, need improvements, both in terms of care and treatment of patients who had a stroke and in terms of acute stroke care service accessibility, to ensure a reliable and effective stroke care.[31–34]

In concordance with previous studies, this study found significant differences in hospitalisation expenses by age.[25 27 35] Also consistent with previous studies was the observation that younger people (0–49 years) had significantly higher expenses than older patients.[27] This may be because of their higher use of rehabilitation services, medical interventions, surgery and more invasive diagnostic and therapeutic methods. Therefore, it is economically rational to emphasise using cost-effective prevention strategies in the 0–49 years old population.[27 36]

Increasing age was associated with higher expenses for 50–79 years old patients and higher in-hospital mortality for 60 and above patients, according to the age-adjusted and gender-adjusted models. The age-related increase in stroke mortality patterns was similar among developed and developing countries.[37] Several studies confirm advanced age as a risk factor for death and poor prognosis of stroke.[29]

Hospitalisation expenses in men are 1.017 times higher than in women. This difference may depend on factors such as stroke severity and comorbidities. Evidence from hospital studies show that a significant percentage of patients who had a stroke suffer from high blood pressure, diabetes, blood cholesterol level and other cardiovascular problems. Therefore, the management and treatment of stroke may require the treatment of other comorbidities too; In addition, patients in advanced stages and with higher stroke severity may have more costs than those in the early stages. Failure to account for these factors can lead to bias in the results.[38 39] Despite the power of the present study to obtain information at the national level compared with Aminde *et al*'s study in two hospitals in Cameroon or Diestro *et al*'s study in one hospital in the Philippines,[16 17] there is also a limitation in obtaining information on the severity of the disease and comorbidities in the IHIO data similar to other LMICs countries, which is due to the incomplete registration of diseases.[14] However, there was no significant difference in in-hospital mortality between women and men. The combination of these data with epidemiological data of stroke in Iran shows that the incidence, prevalence, and age-standardised death of men compared with women, respectively, (134.02 vs 143.73), (1159.26 vs 1349.66) and (64.78 vs 68.16), indicating a lower ratio in men.[40] Therefore, based on the results of this study, gender differentiation cannot be considered for stroke prevention strategies, and it seems that health policymakers should consider both sex groups of Iranian—men and women—, while more studies are needed in this regard.

Patients covered by the Civil Servants Fund insurance coverage had significantly higher expenses (1.033 times) and lower mortality OR (0.886 times) than the reference group, probably because they could afford better services and care. These patients are government employees who enjoy supplemental health insurance, allowing them to afford starred and VIP beds. This can explain the cost increase and mortality decrease in this group. In contrast, the Iranian Fund coverage patients have significantly higher expenses (1.140 times) and higher mortality OR (1.319 times) than the reference group. The highest in-hospital mortality ratio in these patients might be attributed to failure to receive high-quality care on time due to discrimination in the behaviour of service providers based on their socioeconomic status,[41 42] which requires further research to address this ambiguity. Patients insured by the Iranian Fund, are often in poor socioeconomic conditions, thus in financially justified need of special attention by the government and health insurance policymakers. In this regard, migration to universal health insurance can effectively reduce the inequality gap across health insurance plans.

Differences in expenses between provinces could be because of variations in physicians' fees, the cost of medicine and medical materials and the use of VIP or starred beds. Other factors include the prices of specialised services and complexities associated with patient conditions in different provinces. The most plausible explanation for the higher mortality in the 11 mentioned provinces may be demographic differences, socioeconomic status, the level of risk factors (such as hypertension, hypercholesterolaemia, obesity and diabetes), stroke complications, service quality flaws, the ineffectiveness of treatments and the lack of healthcare facilities and budget in the geographic area.[4]

With increasing LoS, the average hospitalisation expenses for a patient who had a stroke increases. This is consistent with the findings of other studies.[17 20] However, patients with more than 4 days LoS had less mortality than a patients who had a stroke with 1–3 days of LoS; the death rate for patients admitted to the ICU increases with their length of stay. Liu C *et al* showed that with increasing LoS, the mortality rate among patients decreases.[20] Because LoS is adjustable, it can be used as a target to control

hospitalisation expenses and improve hospitalisation care.

The surgical intervention significantly increases the average expenses and mortality for patients who had a stroke. This finding is similar to that of another study.[43] Patients who undergo surgery have the possibility of perioperative stroke, which increases the risk of death after surgery, along with the patient's physiological conditions, other comorbidities and differences in surgical and treatment methods.[44 45] A suitable interpretation for this increase in expenses and mortality rate in correlation with surgery could not be found, either in this study or in others. It was also not possible to access further clinical information. Therefore, we suggest subsequent studies to identify predictor factors of stroke mortality for patients who undergo surgery among the Iranian population so that high-risk surgical patients can be identified and the necessary arrangements can be made for effective surgical management and postoperative care.

There were no significant differences in the average hospitalisation expenses among patients suffering various strokes. This finding is inconsistent with the findings of Diestro *et al* in the Philippines.[46] On the other hand, there are significant differences in hospital mortality based on stroke type, which is similar to the findings of Pucciarelli *et al*.[47]

Based on our estimates, the average hospitalisation expenses in private hospitals are 2.449 times higher than in public hospitals. Other studies have estimated that mean expenses of patients who had a ischaemic stroke, primary intracerebral haemorrhage and subarachnoid haemorrhage in Brazilian private hospitals are 1.94, 6.28 and 3.75 times higher, respectively, than in Brazilian public hospitals. These figures are slightly higher than our estimates. Fundamental differences in health systems and pricing could explain some of these observed differences.[48 49]

We have further observed an increase in the average hospitalisation expenses of patients who had a stroke in conjunction with an increase in hospital size. One potential reason is the slow adoption of new treatments and technologies in smaller hospitals with fewer resources, as they lack access to specialty care and advanced therapies for stroke. Another possibility is the lack of clinical expertise in many small and medium hospitals because of the difficulties of attracting and retaining specialist physicians. These hospitals may also lack the infrastructure for rapid imaging procedures or highly specialised clinical support services such as neurocritical care and dedicated stroke units.[50] These factors can lead to the hospital accommodation of patients with higher stroke severity and, consequently, higher expenses to larger hospitals.

A surprising observation in our study was that treatments ending in death had the highest expenses relative to treatments with other outcomes. This is in contrast to the findings of Liu *et al* in China, who found that hospitalisation costs for surviving patients were approximately five times higher than for patients who died.[20] The discrepancy could stem from more complex procedures and specialised therapies because of the acute condition of dying patients or their stay in the ICU and the difference in hospital Accommodation and nursing tariffs for ICU beds.

Compared with other studies, one of the weaknesses of this study is that ischaemic and unspecified strokes were combined in one category. By reviewing patients' files with a neurologist, we found that the number of unspecified strokes is more than ischaemic strokes, and the proportion of ischaemic strokes is unacceptable and does not match with other studies.[15 16 24 47 48] Therefore, we recommend policymakers use practical measures to sensitise physicians to record medical diagnoses and correct stroke'-related coding accurately.

Suggestions and future research

It was impossible to extract comorbidity and stroke severity data from the IHIO databases. As such, we advise policymakers to encourage physicians to detailed registration of stroke and reflect on stroke severity indices and comorbidity data in electronic patient files.

More research is needed to solve the knowledge gaps in our study. Future studies may benefit from taking into account clinical variables such as disease severity and comorbidities. In future studies, socioeconomic indicators such as patient income and education level can also be considered determinants of hospitalisation costs and in-hospital mortality.

According to the study results, reducing the length of stay and encouraging reasonable prescription and consumption of drugs are effective strategies for policymakers and healthcare authorities to control hospitalisation expenses.

CONCLUSION

Hospitalisation expenses and mortality rates can be associated with numerous factors, many of which may help develop evidence-based policies. Populations of patients who had a stroke insured by the Iranian Fund and regions with higher hospitalisation expenses and in-hospital mortality should be a priority target for policymakers to improve effective medical care outreach and increase access to affordable hospitalisation and medications. Migration to universal health insurance can effectively reduce the inequality gap between all insured patients. Applying cost-effective stroke prevention strategies in the younger population (aged 0–49 years) is strongly recommended.

Author affiliations
[1]Department of Health Management and Economics, Tehran University of Medical Sciences, Tehran, Iran
[2]National Center for Health Insurance Research, Tehran, Iran
[3]Department of Neurology, Tehran University of Medical Sciences School of Medicine, Tehran, Iran
[4]Department of Research Methodology and Data Analysis, Tehran University of Medical Sciences, Tehran, Iran

[5]Department of Environmental Health Engineering, Tehran University of Medical Sciences, Tehran, Iran

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ORCID iDs
Zohreh Kazemi http://orcid.org/0000-0002-5852-9375
Sara Emamgholipour Sefiddashti http://orcid.org/0000-0001-8654-6554
Masud Yunesian http://orcid.org/0000-0002-2870-7433

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