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## Research Article

**Keywords:** Rehabilitation, Stroke, Cost-Effectiveness, Markov Model, Home, Hospital, Stroke unit

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# Evaluating the Cost-effectiveness analysis of rehabilitation methods for patients with stroke

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## Abstract

**Aims:** This study evaluated and compared the cost-effectiveness of rehabilitation interventions in patients with stroke in the three alternatives of hospitals, units and homes due to the fact that one of the stroke management challenges is how to provide a rehabilitation service to these patients in Iran.

**Methods:** This is a cost-effectiveness analysis from the perspective of a health system. A Markov model with a 20-year time horizon in 3-month cycles was used to analyze the costs and outcomes. Cost data were collected from the 210 patients undergoing rehabilitation in the hospital, home and unit. Utility data were extracted from previously published literature with the same setting. The cost-effectiveness analysis was conducted by calculating ICER using TreeAge Software. Basic and probabilistic sensitivity analyses were also conducted at the end.

**Results:** The average cost of rehabilitation in home strategy (\$ 2306) was less than hospital (\$2955) and unit (\$3485) strategies. Furthermore, the utility of home strategy (26.03) was 8 units higher than hospital utility (17.99) and 19 units higher than utility of the stroke unit (7.03). The Acer values of hospital, stroke unit and home groups were \$11424, \$33159 and \$7233 per utility, respectively. According to the results, the home-based rehabilitation strategy is cost effective compared to hospital and unit rehabilitation strategy. The results of the probabilistic sensitivity analysis also showed that the ICER of home strategy is always cost-effective than the other strategies.

**Limitation:** limitation of the present study was the reliance on utility values of other studies.

**Conclusion:** Rehabilitation at home is the most cost-effective strategy for stroke patients. Given the high rates of this disease in Iran and the high cost of it, it is suggested that policy makers lay the groundwork for providing these services at home.

**Keywords:** Rehabilitation, Stroke, Cost-Effectiveness, Markov Model, Home, Hospital, Stroke unit

## **Introduction:**

Stroke, as the second leading cause of death and the third major cause of disability in adults, imposes many financial and social burdens on individuals (1). According to the World Health Organization (WHO) in 2014, 6.7 million deaths were related to stroke from 17.5 million deaths due to cardiovascular disease (2). The incidence of stroke in developing countries of the Middle East is increasing (3). Also, according to the burden profile of diseases which published by GBD and WHO, stroke is the second leading cause of death in Iran with 10.5% (4 and 5). The annual incidence of this disease in Iran is 372 per 100,000 persons, which is significantly higher than developed countries (6 and 7).

Despite the availability of advanced facilities and medical technologies, nearly 30 % of stroke patients lose their lives, 10% of them become completely dependent on others to live, and 60% of them suffer from varying degrees of disability that create burdens on their families and communities (8) and has an adverse effect on the patient's family and health system. Patients with functional impairment due to stroke require rehabilitation services (9). Rehabilitation at a proper time has demonstrated better outcomes in improving function, reducing dependency, increasing the quality of life and increasing participation in social activities compared to non- rehabilitation (10, 11).

Three methods of hospital rehabilitation, rehabilitation in stroke units and home-based rehabilitation are commonly used in different countries (12). Considering the increasing demand on health services, especially in the elderly population, it is important that managers and policymakers evaluate the most effective and acceptable methods of managing stroke patients.

In some developed countries, such as Australia and England, there is a heavy reliance on hospitals for rehabilitation of stroke patients. A strong argument in support of this method is quick access of patients to precise diagnosis and treatment and nursing care and multidisciplinary rehabilitation which are most easily provided in the hospital than at home (13). Although, length of staying in hospital is the largest determinant of direct cost for stroke care (14).

On the other hand, there is an early discharge from hospital and patient's home rehabilitation, which its supporters have mentioned several benefits for this method including; patient satisfaction, reducing the risks associated with inpatient care by reducing the length of the patient's stay, focusing more on rehab outcomes and saving on direct costs (15 and 16).

In the third approach, there are specialized stroke units (clinics or centers) which improve significantly health outcomes; also, some studies have demonstrated that rehabilitation in stroke units leads to improve patient survival, but they also cost more. Therefore, if all patients are rehabilitated in the stroke units, additional costs will be imposed on the infrastructure and health system (17).

In Iran, some of these stroke units are operating in the private sector, and some of patients are referred to these units for rehabilitation services. Of the units of rehabilitation, only one specialized unit in Tehran is currently providing services to stroke patients, and the rest of the units provide general rehabilitation services to patients with disabilities (18).

Regarding the high burden of stroke disease in the country and its financing problems, and considering that there have been no studies in Iran on the evaluation of different methods of rehabilitation for patients with stroke, this study has been conducted to achieve this aim. The results of this study are expected to provide new insights for policymakers to decide on the best and most cost-effective option for providing rehabilitation services to patients with stroke.

## **Method**

This is a cost-effectiveness analysis study which was conducted from a health system perspective. Markov model was used for modeling in this study. In this model two types of input information were used in terms of cost and utility.

Medical records of patients were used in order to collect costs. A rehabilitation hospital in Tehran was selected as the first and only specialist rehabilitation hospital and a rehabilitation unit in Tehran was also selected as the only unit to provide rehabilitation services for stroke patients both in the unit and at their homes.

Each patient has a medical record in each of the three groups. In the home-based rehabilitation group, in Iran, the rehab team, which includes physiotherapists, occupational therapists, speech therapists, physicians, nutritionists and counselor, are sent to patient homes from the rehabilitation units and provide some services to them. Each patient has a medical record at the unit in which the costs are recorded.

70 stroke patients referred to the hospital for rehabilitation purpose in 2017. Therefore, a census of all patients in this hospital was investigated this year and for comparability, the same number of patients from the rehabilitation stroke unit as well as patients undergoing rehabilitation at home was reviewed.

It should be noted that we used three different groups of patients but with similar and comparable clinical status. Based on the Markov model, three states were considered in each of the groups of patients. So, in each rehabilitation group (hospital, home and unit), there were patients from all three similar clinical states were defined in the Markov model which is explained in the following. In addition, the rehabilitation package offered to patients in all three groups was the same.

Also, the following inclusion criteria were considered for patients in order to participate in the study:

- Patients with stable clinical status were eligible for rehabilitation services by the doctor's diagnosis and ensuring that rehabilitation services for the patient can be beneficial.
- Ensuring that the patient has no previous physical disability before the stroke, and that the disability is just the result of a stroke.
- Obtaining informed consent from patient to participate in study and use of their medical records information.

Outcome data are obtained from other studies with similar setting to this study.

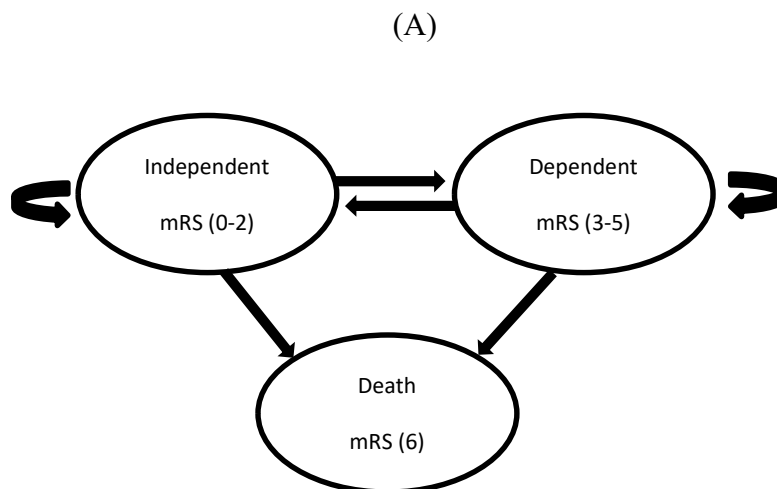
### ***Analytical Model***

The Three-State Markov model was used to measure the cost-effectiveness using TreeAge Pro 2013 Software. The model consisted of three possible health states for stroke patients: independent, dependent and death. These states determined the possible status of people after stroke depending on the severity of disability or modified Rankin Scale (mRS) (19).

In the present study, patients were categorized into 3 groups based on this scale. The first group of patients with a mRS of 0-2 included patients with complete health or were independent in activities of daily living. The second group of patients with mRS of 3-5 was those who were dependent and required assistance for activities of daily living. The third group included patients who have mRS of 6 and died. This scale (mRS) is continuously measured and recorded in the medical records of patients undergoing rehabilitation in Iran in order to evaluate the improvement of their functional status. In each group, we used recorded mRS three months after the start of rehabilitation.

It should be also mentioned that we incorporated the deaths from other causes in designing the model, using WHO's life table for Iran, apart from the three main states of disease (20).

All rehabilitation states are the same for all three rehabilitation strategies. So, the Markov model is the same as well (Figure 1: A).



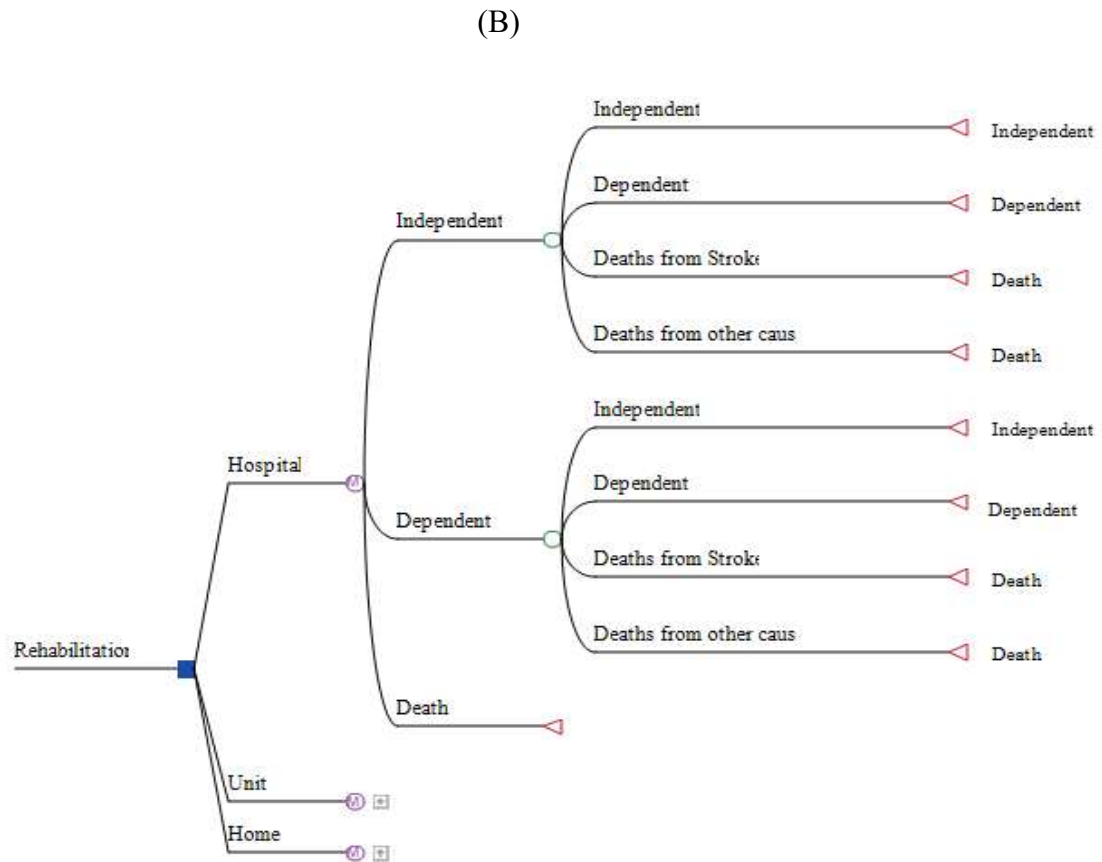


Fig. 1: (A) Markov Model: different Stroke health states. (B) Decision tree model: simulation of possible states for the rehabilitation of patients with stroke

According to expert opinions and related evidences, transitions between different states of disease occur in such a way that patients in the first group with mRS 0-2 are likely to maintain the same health state or change into another two states, this is the case for those patients with mRS 3-5. The model included a decision tree, which compares all three strategies (Fig. 1: B).

Since life expectancy in Iran is 75 years and the average age of patients who participate in this study was 55; so, the time horizons were considered 20 years. According to previous studies, the length of the Markov model cycle was considered 3 months. (21)

The initial distribution of the patients for entering the Markov model was calculated based on the sample of our study as well as the approval of clinical experts.

### ***Costs and outcomes***

The total costs of rehabilitation of patients were collected from their medical records, as well as interviews with patients and relevant experts, and then this data were entered into the model. These costs included hospitalization, CT scan, MRI, echocardiography, medicine and supplies, staff time (physician, nurse, physiotherapist, occupational therapy, speech therapy, nutrition expert and counseling) and overhead costs. Also, the patients were categorized into three mentioned health states based on the values of the recorded mRS.

Since no study in Iran calculated directly the utility of stroke patients, we used the utilities of Alan L and Amiri A studies in order to measure the outcomes, because both of them had the same setting with our study. (22 and 23)

One of the benefits of the Markov model is that costs and outcomes that may occur at different times can easily be discounted. In this study, we considered the discount rate of (0-03) for utilities and discount rate of (0-06) for costs (24). Therefore, the final and incremental cost with a discount rate of (0-06) and the final and incremental utility with a discount rate of (0-03) for a 20-year time horizon in 80 cycles were calculated and entered into the model.

All costs were calculated based on the US dollar value in 2017. All analyzes were also conducted using the TreeAge Pro 2013 Software.

### ***Sensitivity analysis***

Regardless of the accuracy used in cost effectiveness analysis, there is usually uncertainty associated with input parameter values. Sensitivity analysis was used to determine the effect of these uncertain parameters on the results of the study.

One-way, two-way and tornado diagram and probabilistic sensitivity analysis (PSA) were conducted using a variation range of 20%. The distribution of variables in the model for PSA analysis was determined using EasyFit 5.5 Professional software (Table 1).

Table 1: Markov model parameters for sensitivity analysis per patient

Parameter	Base Case	Variation range		Distribution	References number
		Minimum	Maximum		
Transition probabilities					
Home					
Dependent to death	0.05	0.36	0.00		23
Dependent to independent	0.12	0.61	0.00		23

Independent to death	0.017	0.27	0.00		23
Independent to dependent	0.031	0.44	0.00		23
Hospital					
Dependent to death	0.05	0.36	0.00		23
Dependent to independent	0.06	0.41	0.00		23
Independent to death	0.017	0.27	0.00		23
Independent to dependent	0.10	0.90	0.00		23
Unit					
Dependent to dependent	0.7407	0.81	0.65		22
Dependent to independent	0.1111	0.18	0.03		22
Independent to dependent	0.0938	0.11	0.07		22
Independent to independent	0.875	0.89	0.77		22
Cost (\$)					
Home					
Death	1970	2363	1575		
Dependent	4678	5613	3742	Gamma	
Independent	2693	3231	2154	Normal	
Hospital					
Death	2295	2754	1836		
Dependent	3868	4641	3094	Log-normal	
Independent	2702	3242	2161	Uniform	
Unit					
Death	2943	3531	2354		
Dependent	4500	5399	3599	Normal	
Independent	3113	3615	2410	Log-normal	
Utility					
Home					
Dependent	0.56	0.94	0.13	Beta	23
Independent	0.79	1.00	0.52	Beta	23
Hospital					
Dependent	0.65	1.00	0.22	Beta	23
Independent	0.79	1.00	0.51	Beta	23
Unit					
Dependent	0.38	0.58	0.18	Uniform	22
Independent	0.74	0.94	0.54	Uniform	22

## Results

### *Costs*



Direct costs of 210 patients with stroke were investigated over a year. Table 2 shows the information about these patients and their costs in each of the three strategies.

Table 2: Demographic characteristics and rehabilitation costs of patients with stroke

	Hospital	Unit	Home
Number of patients, n	70	70	70
Women, n	34	28	39
Men, n	36	42	31
Age (mean)	51.1	55.2	60.1
<b>Costs (\$)</b>	2955	3485	2306

The total number of patients was 210. From each strategy, 70 patients were included in the study. The mean age of the participants was 55 years. The percentage of women who participate in the study in the three strategies of the hospital, unit and home was 48, 40 and 55 percent, respectively. And the average total direct cost per patient was 2955, 3485 and \$2306, respectively. So, the highest cost is for the unit strategy and the lowest cost is for home strategy. Also, the cost of each three health states was calculated in each group to evaluate the cost effectiveness using the Markov model, which has been shown in Table 2.

### *Cost Effectiveness Analysis*

Table 3 shows the results of the cost-effectiveness analysis of the rehabilitation of patients with stroke in the hospital compared to the out of the hospital (home and unit) per 1000 patients.

Table 3: Cost-effectiveness analysis of the rehabilitation of patients with stroke in the hospital compared to the out of the hospital (home and unit) per 1000 patients

Strategy	Effectiveness	Cost	ACER	ICER
Hospital*	17.99	205527	11424	
Unit	7.03	233114	33159	2517.06
Home	26.03	188277	7233	2145.52

\*Hospital is considered as the current strategy.

As the table shows, the average cost-effectiveness ratio (Acer) of rehabilitation at hospital, unit and home groups are 11424, 33159, and \$7233 per utility, respectively. According to results from ACER, home-based rehabilitation is always cost-effective than hospital and unit rehabilitation.

The ICER of unit rehabilitation in comparison with hospital rehabilitation was \$2517 per utility, which indicates in 20-year time horizon, 10.96 utilities have obtained and costs have been decreased by \$27587 in the hospital group per 1000 patients. Therefore, the unit-based strategy is not cost effective compared to hospital-based strategy.

The ICER of home rehabilitation in comparison with hospital rehabilitation was \$2145 per utility, which indicates in 20-year time horizon, 19 utilities have obtained and costs have been decreased by \$17250 in the home group per 1000 patients. Therefore, the home-based rehabilitation strategy is cost effective compared to hospital-based rehabilitation strategy and this strategy is definitely accepted.

### ***Sensitivity analysis***

The basic sensitivity analysis was conducted for all uncertain parameters of the model including utility, the cost, transition probability, and the initial distribution based on variation range presented in Table 1..

According to the tornado diagram, the model was most sensitive to the transition probabilities of different states of home, transition probabilities of different states of hospital and the incremental cost of dependent states of home, respectively (Fig. 2). One-way and two-way sensitivity analysis was conducted on these variables which had the greatest effect on the ICER. Changes of these parameters did not affect the results of the analysis.

A probabilistic sensitivity analysis (PSA) was conducted on uncertain variables with a specific distribution for 10,000 cohorts (Table 1). According to the results, home-based rehabilitation is always cost-effective than unit and hospital-based rehabilitation.

Also, the results of acceptability curve (Fig. 3) show that home-based rehabilitation has the most willingness to pay for patients, and is always a cost-effective strategy in various thresholds.

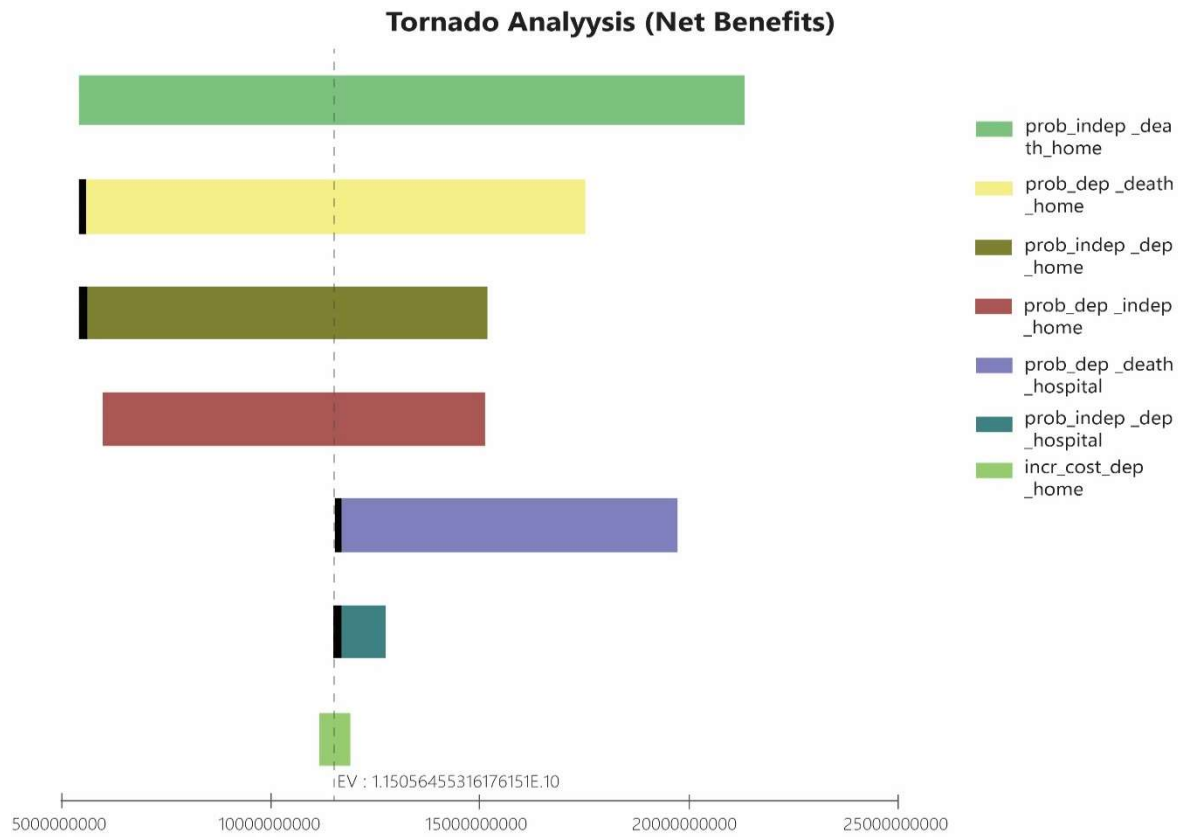


Fig. 2 : Tornado diagram for uncertain parameters. Abbreviation: prob: probability; indep: independent; dep: dependent; incr: incremental.

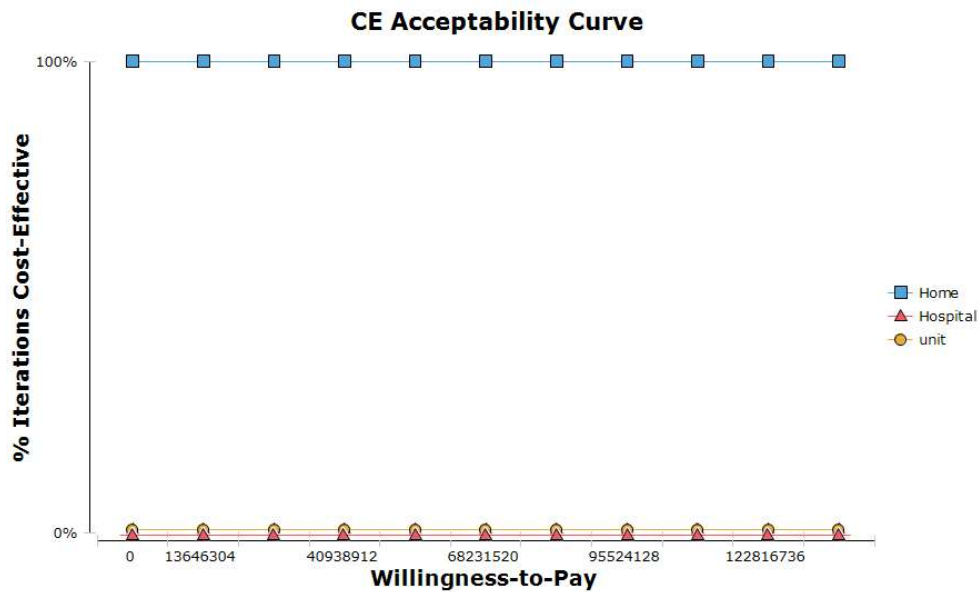


Fig. 3: Cost-effectiveness acceptability curve for three strategies of rehabilitation.

## Discussion

Based on the results of this study, home-based rehabilitation is cost effective compared to unit and hospital-based rehabilitation from a health system perspective. So, providing home-based rehabilitation is both less costly and more effective.

(Patel, 2004) found similar results in a study entitled "Alternative strategies for stroke care". The costs of care were compared for 447 stroke patients who were assigned to stroke unit, stroke team (on general medical wards) and domiciliary stroke care. He used retrospective and prospective method to identify the resources which were used over 12 months. The results showed that the most expensive care was for stroke units and the less cost was for home care. This result was the same in incremental cost-effectiveness and cost-utility analysis (25). Also, (Allen et al., 2018) conducted a study to evaluate the effect of a home-based stroke rehabilitation program, which indicated a home-based rehabilitation is more cost effective than a conventional service (at the hospital). The analysis of this study showed that providing home-based rehabilitation through CSRT (Community Stroke Rehabilitation Teams) is both less costly (incremental cost=-\$17,255) and more effective (incremental effect=1.65 QALYs) compared to usual cares (23).

It seems that hospital-based rehabilitation services impose additional costs as well as lower efficacy. According to the available evidence, the long-term hospitalization of stroke patients leads to the involvement of other people such as a family members or friends in addition to the patient himself. These conditions have a different effect on the economic situation and the daily performance of the family (26). In addition, the length of staying increases the risk of infections, especially in Iran, which most infections have been resistant due to the high consumption of antibiotics and it has led to deterioration of the patient's condition and prolonged hospitalization. Subsequently, poor sanitation, limitation of the use of disposables, the use of contaminated blood products, the inappropriate use of pressure sterilizers and antibiotics are involved in increasing costs for patients and hospitals (27). On the other hand, direct hospital costs are high due to the medical services. These costs include medical tests, speech therapy, physiotherapy, neurology, medical specialists and their assistants. Also, direct non-medical costs for these patients in the hospital are too high. These costs are directly related to the various services which the patient receives, but are essentially non-medical costs, including transportation, lodging and food (28).

Therefore, it can be said that the rehabilitation of patients at home reduces the hospitalization rate and length of staying the patient in the hospital as well. Furthermore, additional hospitalization costs will be avoided. Also, home-based rehabilitation can improve the patient's performance and quality of life, and totally increase the outcomes based on the results of this study and some of the available evidence (29, 30).

## **Limitations**

Lack of data on the utility and quality of life of patients with stroke in Iran are considered as the limitations of this study, so we had to use the utility values of other studies. Certainly, using the specific utility data for patients with stroke in Iran could help to a more realistic analysis of this issue.

It was tried to reduce the effect of these restrictions and increase the validity of the results by conducting a basic and probabilistic sensitivity analysis as well as selecting studies with the same setting as our study,

## **Conclusion**

The results of this study demonstrated that the rehabilitation of patients at home is more effective than providing these services in hospitals and stroke units. Also, the costs of home-based rehabilitation were less than the other two groups and as a result, it's the most cost-effective strategy. Hospital-based rehabilitation is in the second place after rehabilitation at home, this strategy is more cost effective than the unit-based rehabilitation. Hence, rehabilitation in stroke units is the least cost-effective strategy.

The cost-effectiveness of home-based rehabilitation strategy results in the optimum use of resources in country. Considering the high rates of stroke in Iran and the high cost of it, it is suggested that policy makers lay the groundwork to provide these services at home.

## **Declarations**

The authors confirm that all methods were carried out in accordance with relevant guidelines and regulations and all experimental protocols were approved by Research Committee of Shahid Beheshti University of Medical Sciences .

### ***Ethics approval and consent to participate***

The authors confirm that the informed consent was obtained from all subjects.

### ***Consent for publication***

The authors confirm that the appropriate permission from patients to publish their information has been granted.

### ***Availability of data and materials***

All data generated or analyzed during this study are included in this published article.

### ***Competing interests***

The authors declare that they have no competing interests.

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### ***Declaration of financial/other relationships***

The authors have no financial or other relationships to disclose.

### ***Authors' contributions***

This article is taken from Farzaneh Miri's dissertation and most of the main work has been done by her, but Dr.Nader.Jahanmehr and Dr.Reza.Goudarzi, as supervisors and consultants, have cooperated step by step, especially in the field of data analysis and interpretation. All authors read and approved the final manuscript.

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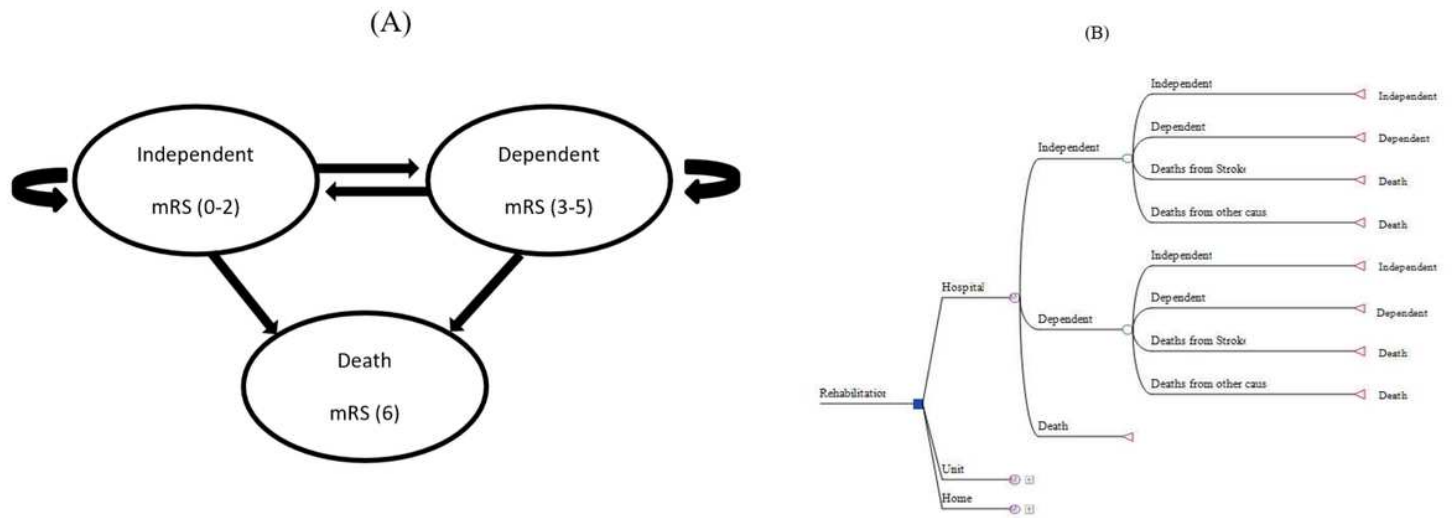
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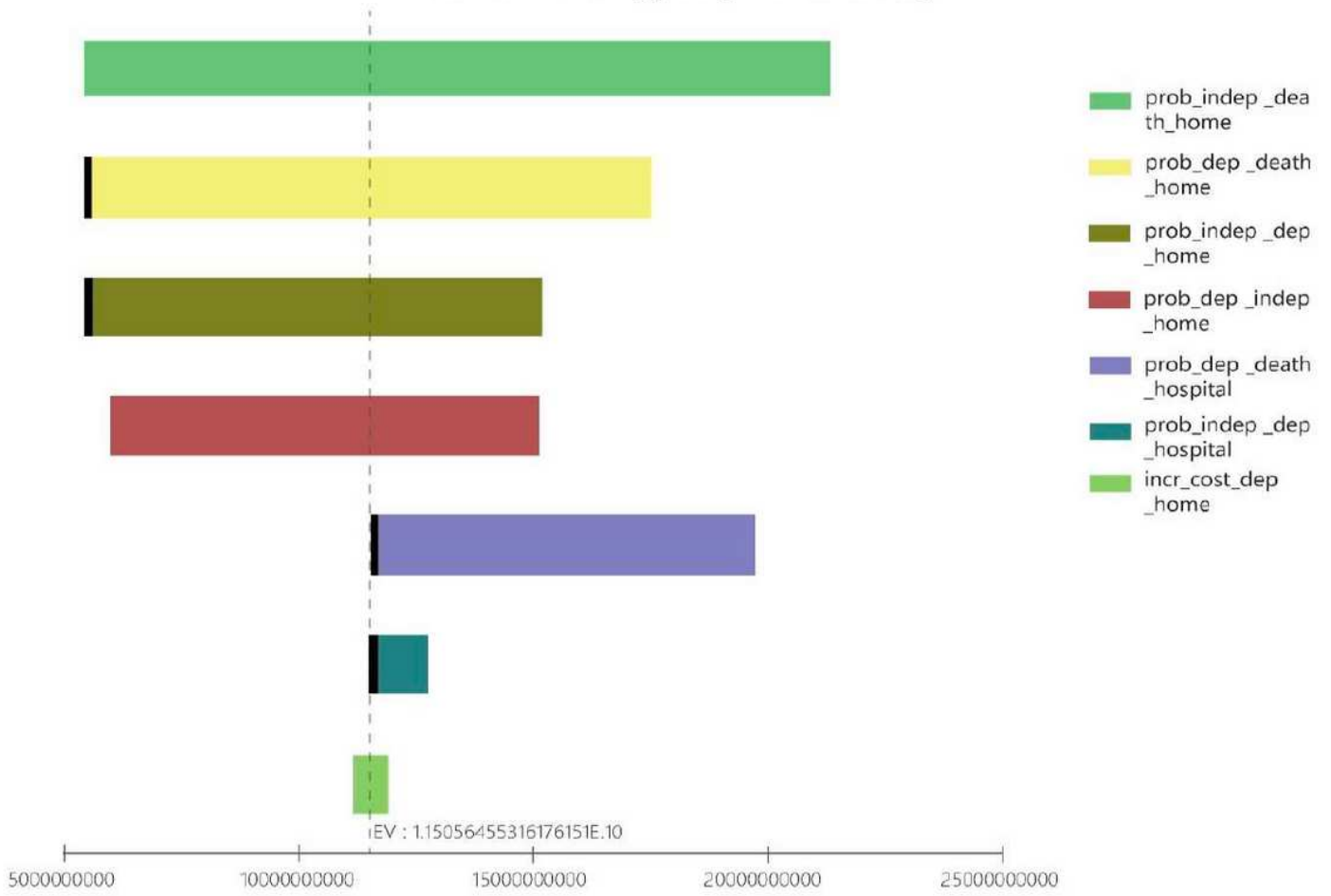
# Figures



**Figure 1**

(A) Markov Model: different Stroke health states. (B) Decision tree model: simulation of possible states for the rehabilitation of patients with stroke

### Tornado Analysis (Net Benefits)



**Figure 2**

Tornado diagram for uncertain parameters. Abbreviation: prob: probability; indep: independent; dep: dependent; incr: incremental.

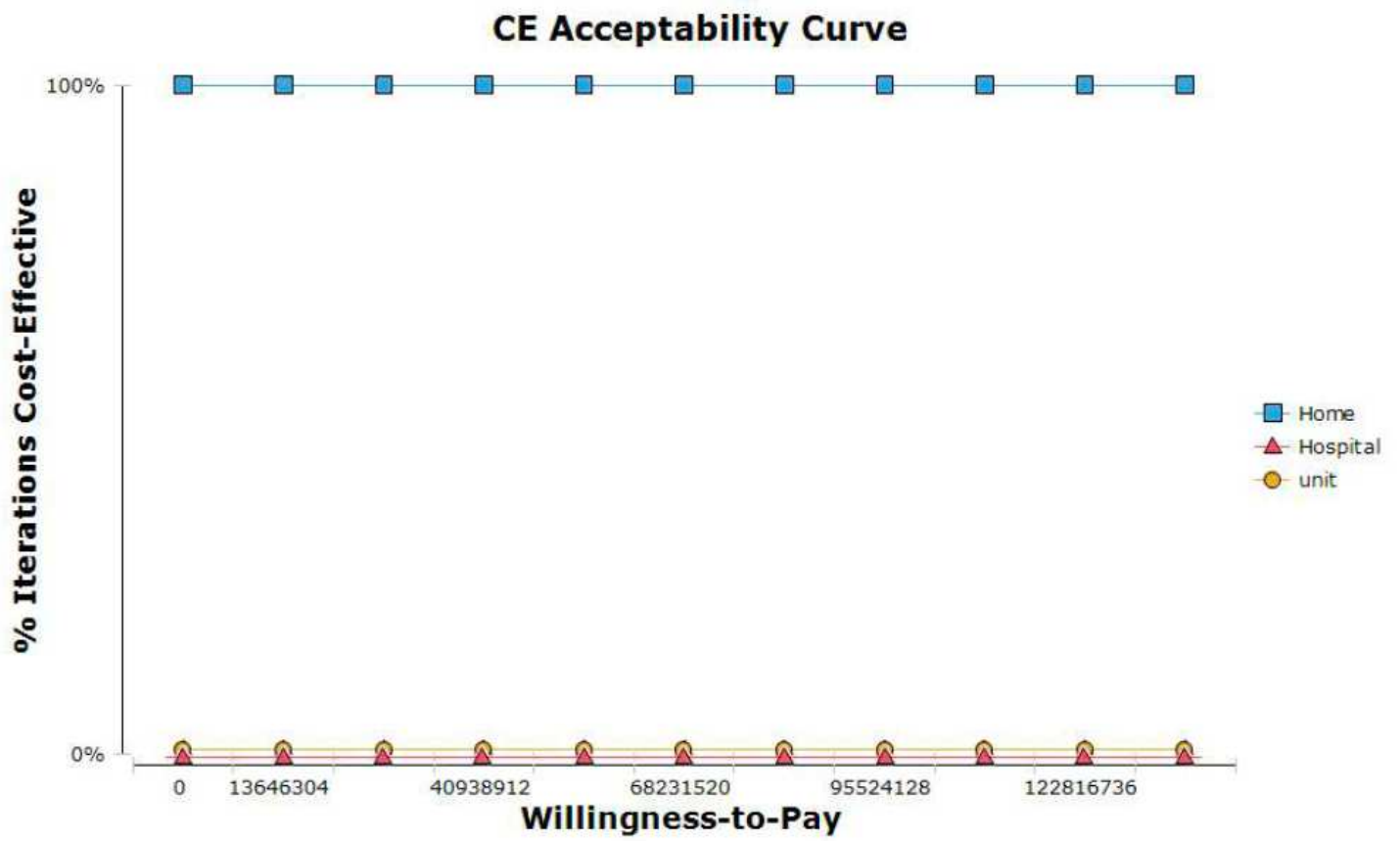


Figure 3

Cost-effectiveness acceptability curve for three strategies of rehabilitation.