Cost-Effectiveness of Stroke Unit Compared with Routine Treatment for Stroke Patients in Iran

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Abstract

Background: Two approaches including stroke unit and routine treatment, are used to address stroke patients. Although stroke unit is a new intervention in Iran and its effectiveness has been proven, but there is little information on its costs. It is necessary to utilize the results of the studies of economic evaluation in order to choose the better treatment option between two alternatives. Due to the lack of studies in this field in Iran, the current study was done to compare the cost-effectiveness of stroke unit and routine treatment.

Methods: The present study investigated cost-effectiveness of stroke unit compared with routine treatment from health system perspective. Markov model incorporating three health states of independent, dependent and death for a time horizon of 10 years with a 3-month cycle length was applied. Direct medical and non-medical costs including pharmaceutical and hospital expenses, were calculated based on 2018 data. Quality-adjusted life-years (QALYs) were taken as the outcome measure. The analysis of cost-effectiveness and sensitivity for uncertain parameters was carried out using TreeAge 2020.

Results: Stroke unit had more costs and QALYs gain in comparison with routine treatment with $1926 per QALY. Probabilistic sensitivity analysis showed that stroke unit cost-effectiveness probability is 77 percent, in the threshold of willingness to pay three times GDP per capita.

Conclusion: Incremental cost-effectiveness ratio of stroke unit is far less than the threshold of willingness to pay, indicating the strategy is cost-effective. Therefore, implementing stroke unit in Iran health system leads to optimal use of resources.

Background

Stroke is one of the leading causes of morbidity and the second cause of mortality in the world. Stroke occur for fifteen million people annually and according to the statistics, two-third of them survive but suffer from severe and long-term morbidities for the rest of their lives. Most of stroke happens in low and middle-income countries[1–3].

Different numbers on prevalence and incidence of stroke in Iran are reported[4, 5]. Overall, it can be stated that the incidence of the first-ever stroke in Iran is 139 cases per 10000 people[6]. Studies have also shown that the age of chronic stroke in Iran has been lower than the average number of other countries, but they lead to more mortalities[5, 7].

Stroke, due to many side effects, increases the costs of health system. The results of a study in England showed that the total cost of patients with chronic stroke in the first five years after reception in the hospital was 3.60 billion pounds[8]. Also, this cost was 6.855 billion dollars in South Korea[9], 3.6 billion dollars in Canada and 34 billion dollars in the United States of America[10].

One of the interventions which leads to decrease in morbidities after stroke as confirmed in many countries is stroke unit (SU) in which a team consisting of multiple experts in managing stroke carry out treatments at proper time[11–13]. The studies show that stroke unit has been successful and could decrease mortality by up to 20 percent[14, 15].

In Iran like other developing countries patients with stroke might under or over utilize health care services. On the one hand, due to shortage of specialized centers for stroke care in Iran, most of patients with stroke are hospitalized in general or non-related wards, facing higher rates of morbidity and mortality. On the other hand, a considerable percentage of these patients are hospitalized in ICUs, with many of them do not need all ICU services, and they occupy the beds[16].

Few studies have investigated the cost-effectiveness of stroke unit. For instance, some studies have been done in the UK[17], France[18], and Australia[14, 19] revealing that stroke unit intervention is cost-effective.

Given the high costs of treatment and rehabilitation of stroke patients and the importance of cost-effective interventions for health system policymakers and the limited generalizability and comparability of economic evaluation studies from one place to another due to differences in conditions and the health systems of the countries[20]. Hence this study aimed to determine the cost-effectiveness of stroke unit compared to routine treatment (RT) in Iran.

Materials

Study Design

This was a cost-effectiveness study that compared two strategies of stroke unit and routine treatment for treating patients with stroke in 10-year time horizon from health system perspective. Data of 231 and 205 stroke patients who received stroke unit and routine treatment strategies, respectively, were collected from two Iranian hospitals from June 2016 to June 2017. Costs and outcomes were discounted by 6% and 3%, respectively [21].

Strategies

In this study, two strategies, stroke unit, and routine treatment, were compared. A stroke unit comprises a multidisciplinary team of clinicians and nursing staff that cares for stroke patients exclusively. In Iran, the only Firoozgar hospital in Tehran had a stroke unit to care for stroke patients. Therefore, we used the data of this hospital for the stroke unit strategy.

A routine treatment is a section of the hospital providing medical care without the usual multidisciplinary input. The Shafa Hospital in Kerman has a general medical facility, and we used the data from this hospital.

Model structure

Markov model, including three health states of Independent, Dependent, and Death with 3-month cycles, was used to evaluate and compare costs and long-term consequences (Fig. 1). Health states were driven from stroke patients score on modified-Rankin-Scale (mRS). According to this scale, stroke patients fall into three groups: Independent (mRS = 0, 1, 2), Dependent (mRS = 3, 4, 5) and Death (mRS = 6). Patients in Independent state are in good health and carry out their daily activities without the help of other people, patients in Dependent state rely on others for their daily activities, and ultimately Death state. In this model, Recurrent Stroke is not considered due to insufficient data.

Costs

Costs included direct medical and non-medical costs. Direct medical costs covered medication costs, physician visits, consultation, nursing services, diagnostic tests, therapists and so on. Direct non-medical cost addressed hospitalization costs such as meals on wheels, homemaking services and so on. These costs were calculated based on the patient's medical record for different health states (Table 1). It should be noted that if the patients who died at the hospitals, their costs were considered for the death state.

All costs were converted to US dollars at the average rate reported by the Central Bank of Iran in 2018[22] (1 US doller = 42,000 Rials).

Outcome

Quality-adjusted Life Years (QALY), a combination of length and quality of life was used as the outcome measure. The quality of life, utility scores for each Markov model state were extracted from the study of Sandercock et al[23]. It should be noted that since alterplase was used in both strategies, it did not vary in terms of utilities, and thus utilities were assumed to be the same for both strategies.

Probabilities

The transition probability between different states was extracted from previous studies[23–25] (Table 1). The patient in the Independent state is more likely to remain in his / her state and is less likely to fall into the Dependent and Death states. The patient in the Dependent state is also more likely to remain in his/her state. Stroke unit reduced the relative risk of death by 41% [26]. Thus, the stroke unit strategy decreases the risk of transmission to death compared to the RT strategy.

Table 1
Model Parameters and Range of Values for Sensitivity Analysis: Transition probabilities, Utility Values, Efficacy and Cost Inputs

Parameter	Base case value	Distribution	Distribution parameters		Range	References
			α	β		
Transition probabilities						
Independence to Independence	0.8750				0.77–0.89	[23–25]
Independence to Dependence	0.1111				0.03–0.18	[23–25]
Dependence to Independence	0.0938				0.07–0.11	[23–25]
Dependence to Dependence	0.7407				0.65–0.81	[23–25]
Utility Values						
Independence	0.74	Beta	683	3021	0.69–0.79	[23]
Dependence	0.38	Beta	60	590	0.29–0.47	[23]
Efficacy						
Relative risk (RR) of death in Stroke Unit	0.59				0.42–0.84	[26]
Costs ($)						
Independent SU	3225	Gamma	2.55	1264		
Dependent SU	3916	Gamma	2.29	1712		
Dead SU	5047	Gamma	1.11	4543		
Independent CC	1146	Gamma	1.49	768		
Dependent CC	1987	Gamma	0.76	2621		
Dead CC	4527	Gamma	0.84	5410		

Cost-effectiveness analysis

Incremental cost-effectiveness ratio (ICER) was measured using the following formula in TreeAge 2020:

$$ICER = \frac{Cost(SU) - Cost(RT)}{QALY(SU) - QALY(RT)}$$

Sensitivity analysis

Deterministic and probabilistic sensitivity analysis were used to investigate the effect of uncertain parameters of the model including cost per health state, transition probabilities, utilities and discount rates at a 95 % confidence interval. Probabilistic sensitivity analysis (PSA) using Monte Carlo simulation was carried out 5000 iterations and the effect of the parameters on the outcome of cost-effectiveness was investigated. The threshold of willingness to pay was set three times of GDP per capita, according to the recommendation of the World Health Organization [27], which was $ 16,650 for Iran in 2018 [28].

Results

The results showed most stroke unit patients were male(65%), while most who were treated by standard approach were female(51%). Mean age of the patients was 63 years and 68 years for stroke unit and routine treatment, respectively.

Base case result

The base case results are shown in Table 2. The mean QALY for SU and ST interventions were 10.18 and 4.08, respectively. Long-term costs for SU were estimated $ 129,776 and $ 118,023 for RT. The cost-effectiveness ratio of SU was $ 1,926 per QALY. The results show that ICER of SU is less than GDP per capita indicating that studied strategy is more cost-effective over the alternative strategy.

Table 2
Base case results: Cost, Effectiveness and Incremental cost-effectiveness ratio

Strategies	QALYs	Incremental QALYs	Costs($)	Incremental Costs	ICER	ACER
Routine treatment	4.08	-	118,023	-	-	28,945
Stroke Unit	10.18	6.10	129,776	11,753	1,926	12,747

Sensitivity analysis

Deterministic sensitivity analysis (DSA) findings as illustrated in tornado diagram shows that changing any of the parameters alone had no effect on cost-effectiveness results. Finally, this diagram demonstrates that cost of death state in stroke unit strategy and exchange rate are the most important parameters affecting ICER (Fig. 2).

Figure 3 illustrates the scatter plot of the uncertainty pertaining to incremental costs and effects expected. The cost-effectiveness acceptability plane consists of four separated areas each having different cost and effect. Strategies placed in northeast (NE) area improve effects with higher costs; those in southeast (SE) improve effects and save costs; those in southwest (SW) reduce effects and save costs; and those in northwest (NW) decrease effects and increase costs. Dominant strategies are always located in SE; deciding to prefer strategies in NE and SW depends on the willingness to pay for incremental increases in QALYs. As shown in Fig. 4, most trial points are in the NE (38 %) and SE (39 %) areas; hence the cost-effectiveness probability is 77 %.

Moreover, as illustrated in Fig. 4, the cost-effectiveness acceptability curve shows that the probability of cost-effectiveness of stroke unit strategy in threshold of willingness to pay is $ 16,650 which equals 77%.

Discussion

This study sought a cost-effective strategy for the management of stroke. Findings showed that in the long run, SU had higher costs and QALYs than RT, and ICER of $ 1,926 per QALY was less than the $ 16,650 per QALY threshold of willingness to pay.

The cost of stroke unit intervention for 10 years time horizon was 129,776 USD; this cost was £ 46,900 in a UK study in 2008, 15,383 Australian dollars in an Australian study for 28 weeks; £ 34,638 in French 5-year intervention study. After adjusting the costs of above-mentioned studies for time horizon, year of the study and exchange rate, it can be concluded that SU in Iran is more expensive. One probable explanation for this might be relative higher cost of equipping stroke units regarding the fact the most of them should be imported from other countries.

The incremental cost-effectiveness ratio was $ 1,926 per QALY, which is low compared to the threshold of willingness to pay (three times of GDP per capita) and starting specialized stroke units is worth spending. The findings of other studies are consistent with the present study. For example, a study in the UK showed that the ICER of stroke care unit followed by Early Supported Discharge was 11,615 pounds/QALY which was cost-effective compared to the UK WTP threshold which is £ 30,000/QALY[17]. Another study in Australia also showed that the ICER of stroke care units compared to conventional care varied from $ 9867 to $ 16372 (depending on side effects) per patient[14]. In a study in France, the ICER of stroke care units compared to conventional care was € 1359 per QALY which was cost-effective compared to the France WTP threshold of € 53,400/QALY [18].

The DSA showed that the most important parameters affecting ICER were cost of death state in stroke unit strategy and exchange rate. Similarly, a study by Launois et al. showed that even if the costs of stroke units are 10 times higher than the current cost of conventional care, the cost-effectiveness results would not change.

The findings of the probabilistic sensitivity analysis showed that for the threshold of willingness to pay three times of GDP per capita, stroke unit strategy is more likely (77 %) to be cost-effective. In this regard,

Saka et al. showed that a stroke care unit with Early Supported Discharge is 97% likely to be cost-effective.

There are very few stroke care units, equipped with trained medical and nursing teams, specialized equipment and facilities in Iran. It is very costly to set up a stroke center, and it may seem at first glance that the Stroke unit is not affordable, but in the long run they prove their value for cost spent. It has been shown that the stroke unit lead to less mortality, institutionalized care, and dependence than conventional care[1]. Therefore, it is recommended that policymakers pay special attention to the development of stroke units to treat stroke patients in Iran and consider it as a priority.

This study faced some limitations. This study used utility values and efficacy which were derived from other studies. Also, given that the data were collected from one hospital in Iran that truly had the specific SU conditions and equipment, the generalization of the results to other hospitals should be made with caution.

Conclusion

The results of this study showed that stroke unit is cost-effective in Iran. Stroke patients require a stroke unit with multidisciplinary expertise, and it can be expected to reduce the cost arising from the side effects in long run by implementing a stroke unit. The results of this study are generalizable to other regions that are similar to Iran in terms of economic indicators.

Abbreviations

SU: Stroke unit; RT: Routine treatment; QALYs: Quality-adjusted life-years; ICER: Incremental cost-effectiveness ratio; PSA: Probabilistic sensitivity analysis; DSA: Deterministic sensitivity analysis; WTP: willingness to pay

Declarations

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Authors’ contributions

MTG, RG, MA, and MZ contributed to the conception and design. MZ and MM conducted the data collection and contributed to acquisition. MTG performed the cost-effectiveness analysis. All authors contributed to the interpretation of the results. MTG drafted the manuscript. All authors revisited the manuscript critically. All authors read and approved the final manuscript.

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Availability of data and materials

The dataset used during the current study is available from the corresponding author, RG, on reasonable request.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Kerman University of Medical Sciences (No. IR.KMU.REC.1398.619).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

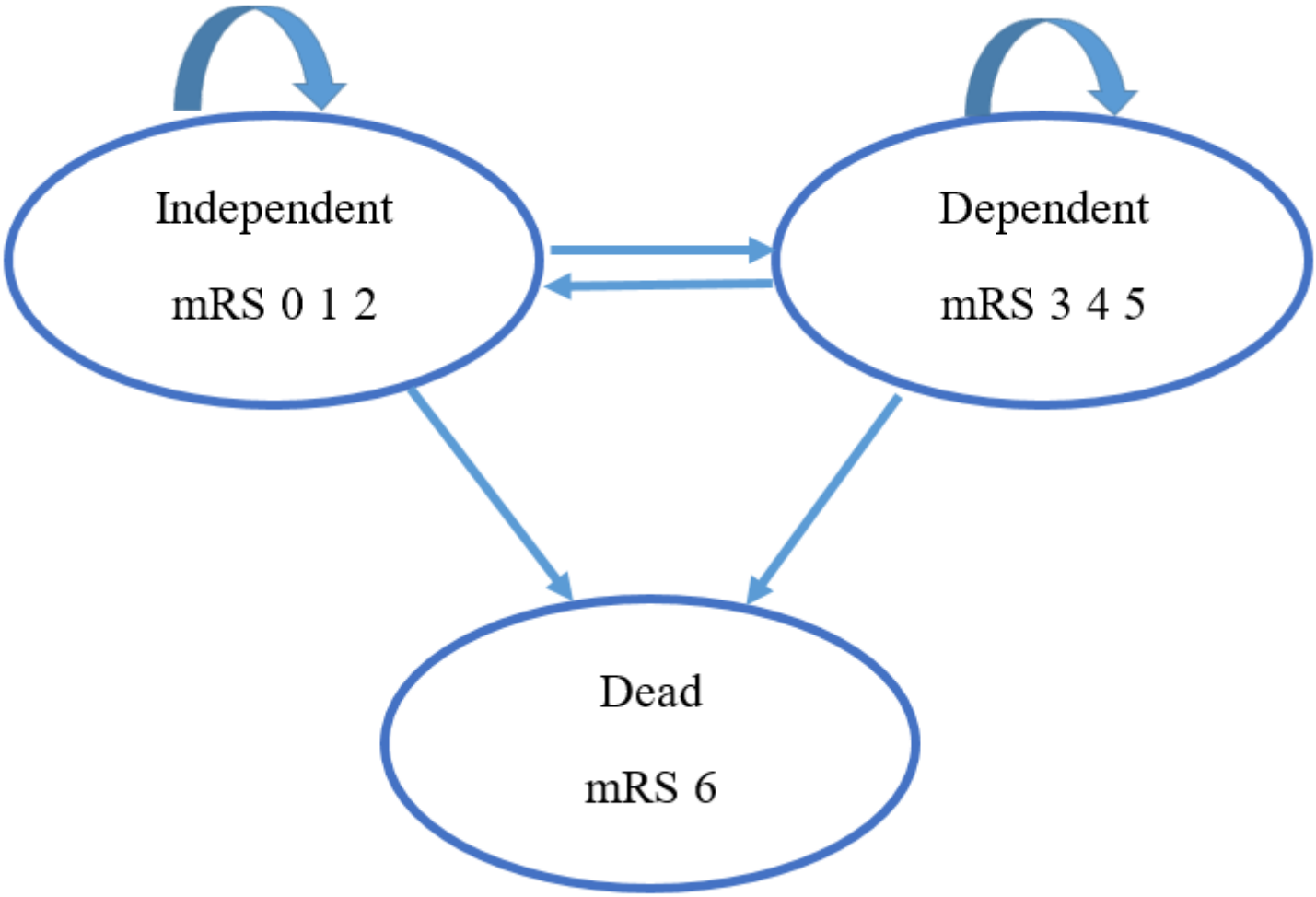

Figure 1

Markov decision-analytic model for the stroke

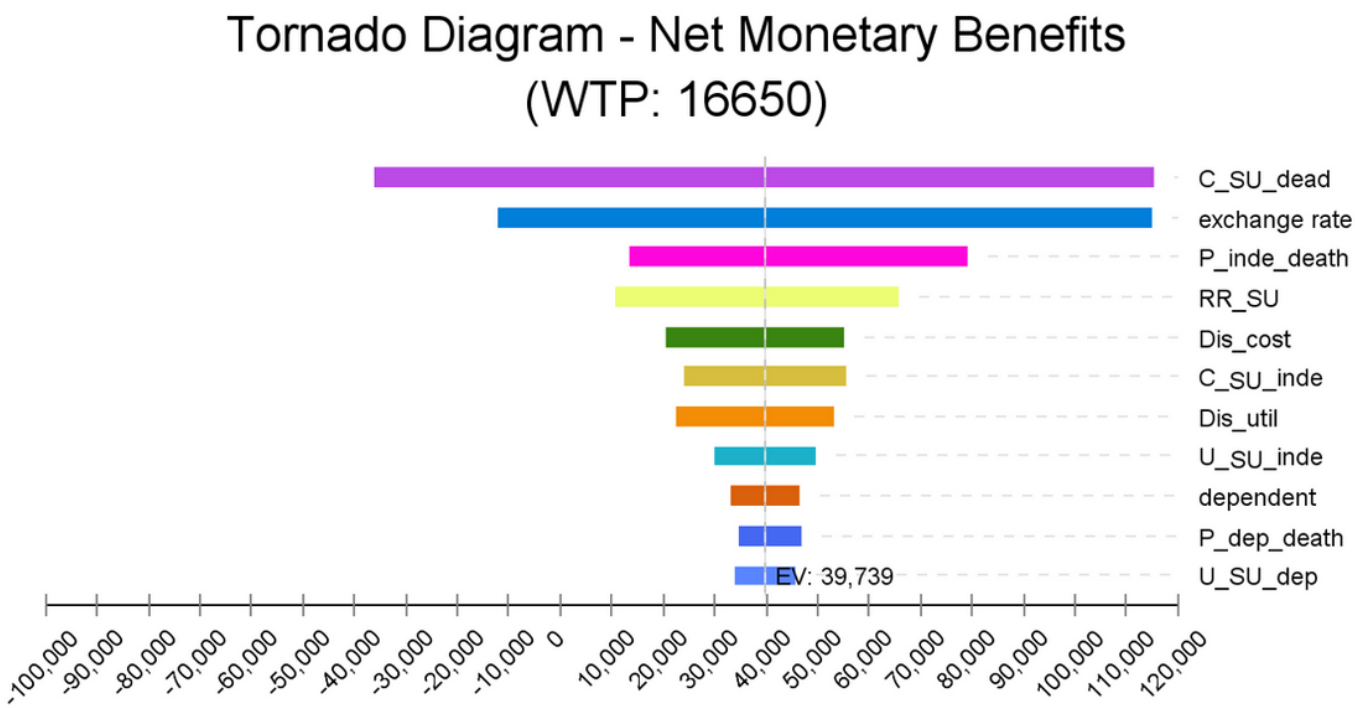

Figure 2

Tornado chart for incremental cost per QALY

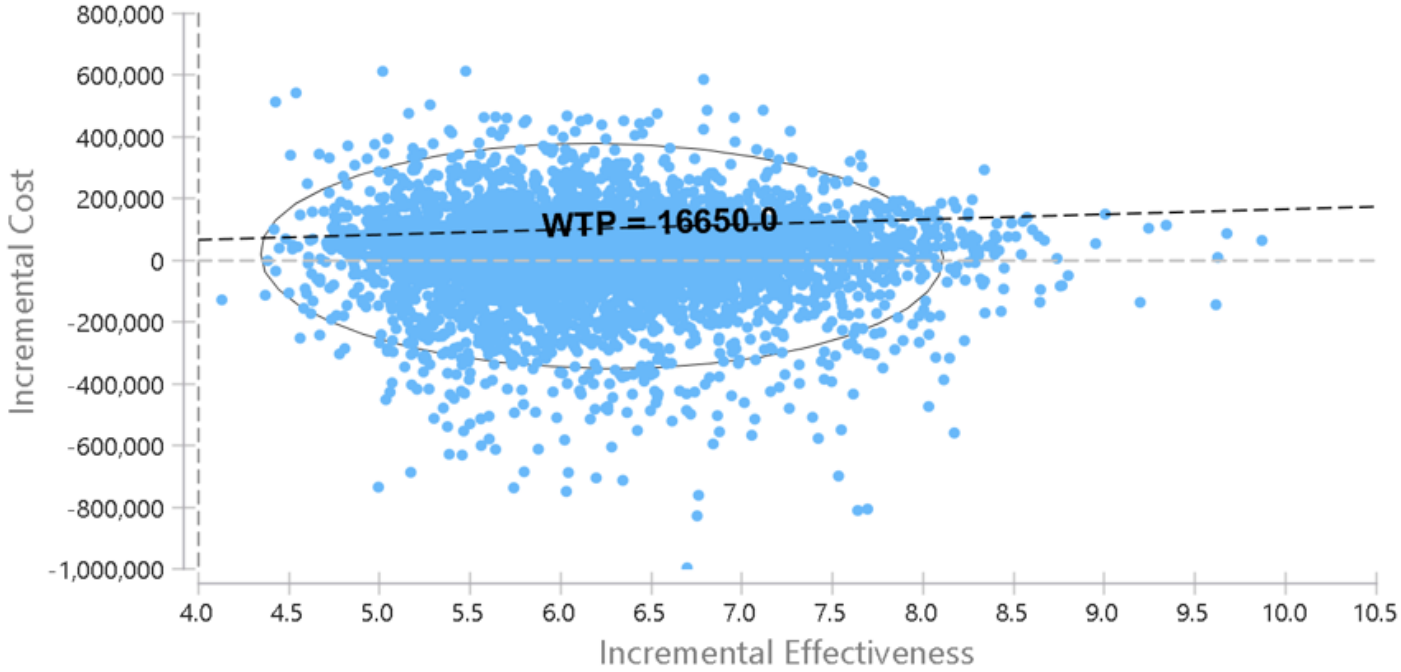

Figure 3

Incremental cost-effectiveness scatter plot for Stroke Unit compared Routine Treatment

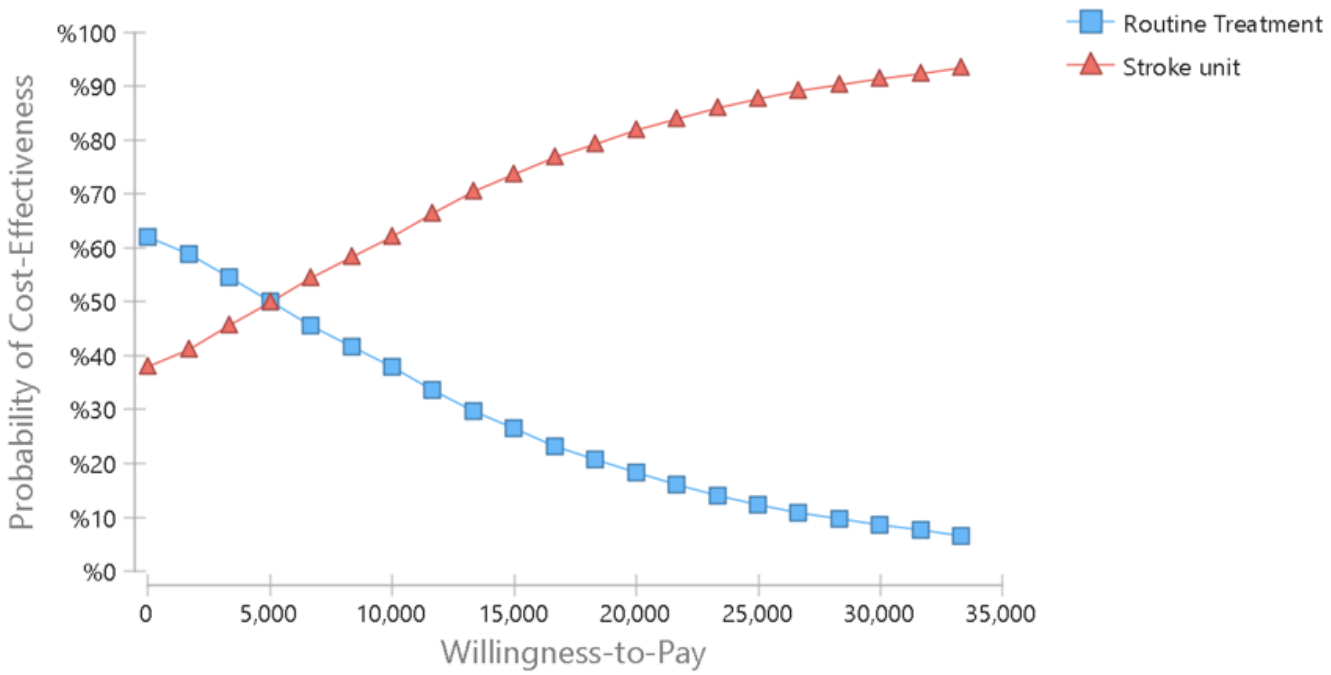

Figure 4

cost-effectiveness acceptability curve for Stroke Unit Versus Routine Treatment