Cost-Effectiveness Comparison of Sumatriptan and CaffeineErgotamine for Migraine Treatment: A Reproduction of the Evans et al. (1997) Markov Model

Abstract

In this study, a Markov model, faithfully reproducing the model proposed in the paper "Economic evaluation of oral sumatriptan compared with oral caffeine/ergotamine for migraine" by Evans, Boan, Evans, and Shuaib (1997), was developed using the heemod library in R. The model aimed to compare the cost-effectiveness of two migraine treatments: Sumatriptan and CaffeineErgotamine. The analysis revealed that CaffeineErgotamine emerged as the more cost-effective treatment option, offering similar or better health outcomes at lower costs, despite Sumatriptan having slightly higher utility. A Deterministic Sensitivity Analysis highlighted the impact of variations in the probability of no relief with Sumatriptan on its economic favorability. Additionally, a Probabilistic Uncertainty Analysis using gamma distributions confirmed the superiority of CaffeineErgotamine in various scenarios. Overall, this study recommends CaffeineErgotamine as the preferred migraine treatment strategy from a cost-effectiveness standpoint.

Markov model reproduction

Essential data for model implementation was gathered from the provided article. Primarily, this data included transition probabilities between states, costs, and utilities, which were obtained from the decision tree and utility table presented in the article. Markov models are a tool for comparing the effectiveness and cost of different medications or treatment strategies. In this instance, two migraine treatments are compared: Sumatriptan and the combination CaffeineErgotamine.

Figure 1: Table of utilities

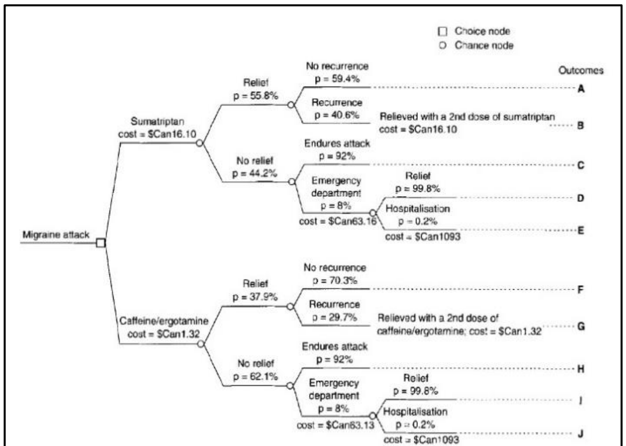


Fig. 1. Decision tree used in the model.

Table 1: Table of utilities

Table II. Table of utilities (outcomes are shown in figure 1)

Outcome	Mean utility	Standard deviation
A	1.0	0.00
B	0.9	0.01
C	–0.3	0.10
D	0.1	0.10
E	–0.3	0.10
F	1.0	0.00
G	0.9	0.01
H	–0.3	0.10
I	0.1	0.10
J	–0.3	0.10

The following table displays the construction of the transition matrix. Variables highlighted in bold indicate that these values differ for each strategy. Values of 1 indicate where the branching of the tree ends. "C" represents the complementary probability to the one following it (e.g., "100% = C + p_NoReliefFromDrug").

Table 2: Odds transition matrix

	Attack	ReliefFromDrug	NoReliefFromDrug	NoRecurrence	Recurrence	EnduresAttack	EmergencyDep	ReliefFromEmergency	Hospitalization
Attack	0	C	**p_NoReliefFromDrug**	0	0	0	0	0	0
ReliefFromDrug	0	0	0	C	**p_Recurrence**	0	0	0	0
NoReliefFromDrug	0	0	0	0	0	C	p_EmergencyDep	0	0
NoRecurrence	0	0	0	1	0	0	0	0	0
Recurrence	0	0	0	0	1	0	0	0	0
EnduresAttack	0	0	0	0	0	1	0	0	0
EmergencyDep	0	0	0	0	0	0	0	C	p_Hospitalization
ReliefFromEmergency	0	0	0	0	0	0	0	1	0
Hospitalization	0	0	0	0	0	0	0	0	1

The model is run over 10 cycles in a population of 1000 individuals. The model results indicate that the CaffeineErgotamine treatment strategy proves to be more cost-effective than the Sumatriptan treatment strategy due to its significantly lower cost while delivering similar or better health outcomes (utility). Although Sumatriptan has a slightly higher utility value, the efficiency frontier indicates that CaffeineErgotamine dominates over Sumatriptan as it is less costly and at least equally effective. Consequently, the CaffeineErgotamine treatment is presented as the preferable option from a cost-effectiveness perspective.

Deterministic Sensitivity Analysis

A sensitivity analysis focused on a single parameter, the probability of not experiencing relief with Sumatriptan (p_NoReliefFromDrug), was conducted. Following the test instructions, a coefficient of variation of 1 was considered for this parameter. As a result:

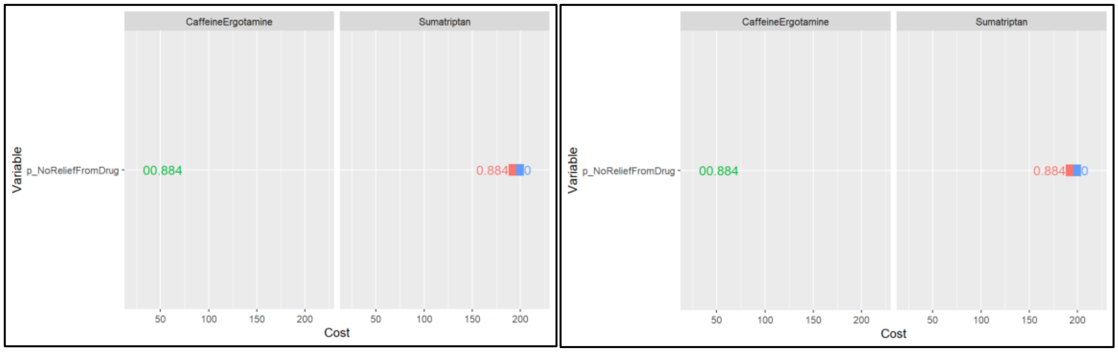
$$CV = \frac{\sigma}{\mu}$$

If $(CV = 1)$, then $(\sigma = \mu)$

Low $= \mu - \sigma = 0.442 - 0.442 = 0$

High $= \mu + \sigma = 0.442 + 0.442 = 0.884$

Figure 2: Extreme values for the sensitive analysis



The sensitivity analysis demonstrates that varying the "p_NoReliefFromDrug" parameter does not drastically affect the utility and cost results for the CaffeineErgotamine and Sumatriptan strategies. However, as the value of this parameter increases, the Sumatriptan strategy becomes less economically beneficial compared to the CaffeineErgotamine strategy. This results in a negative ICER and a reduction in the NMB.

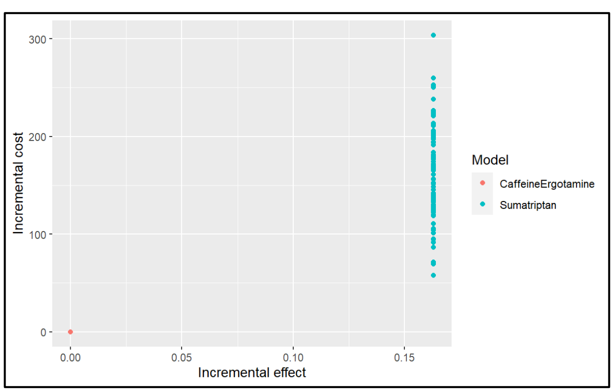
Probabilistic Uncertainty Analysis

The analysis focused on the cost variables for both Sumatriptan and CaffeineErgotamine. The decision to use the gamma probability distribution was made due to its property of always being positive, making it suitable for working with costs.

$$c_{\text{Sumatriptan}} \sim \text{gamma}\left(\text{mean} = 16.1, \text{sd} = \sqrt{16.1}\right)$$

$$c_{\text{CaffeineErgotamine}} \sim \text{gamma}\left(\text{mean} = 1.32, \text{sd} = \sqrt{1.32}\right)$$

Figure 3: Parameter distribution for the uncertainty analysis



The Probabilistic Uncertainty Analysis shows the variation in results due to parameter uncertainty. The analysis reveals that the CaffeineErgotamine strategy is more cost-effective and dominates the Sumatriptan strategy at different threshold values.

References

Evans, K. W., Boan, J. A., Evans, J. L., & Shuaib, A. (1997). Economic evaluation of oral sumatriptan compared with oral caffeine/ergotamine for migraine. *PharmacoEconomics*, *12*(5), 565–577. https://doi.org/10.2165/00019053-199712050-00007/METRICS

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