Automating Health Economic Model Quality Check With a Model Generator

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BACKGROUND

Health economic models play a critical role in informing decision-makers, making accuracy essential. These models inherently rely on a range of assumptions, simplifications, and technical expertise. As a result, they are susceptible to errors that can compromise their reliability and credibility. Therefore, conducting a thorough quality check (QC) is a critical component of the model development process.

Various types of checklists are commonly employed for performing QC[1]. The checks implemented in this tool address multiple aspects of the model, including the modeling approach, input accuracy, cross/external validation, and technical verification. As outlined by Büyükkaramikli (2019)[2], technical verification can be assessed through three primary methods: (i) black-box testing, which assesses whether model outputs are appropriate; (ii) white-box testing, which involves a detailed, cell-by-cell examination of the model; and (iii) full model reconstruction, which is the most resource-intensive approach but offers the highest likelihood of detecting programming errors. These tests are generally conducted sequentially, as presented in Figure 1, with escalation to more intensive methods if earlier tests do not provide sufficient assurance.

Due to the substantial time and effort required cell-by-cell reviews are often conducted without enough care and precision, increasing the risk of overlooking critical errors. Although model reprogramming can effectively address this limitation, it is typically avoided unless results appear problematic, given its resource-intensive nature.

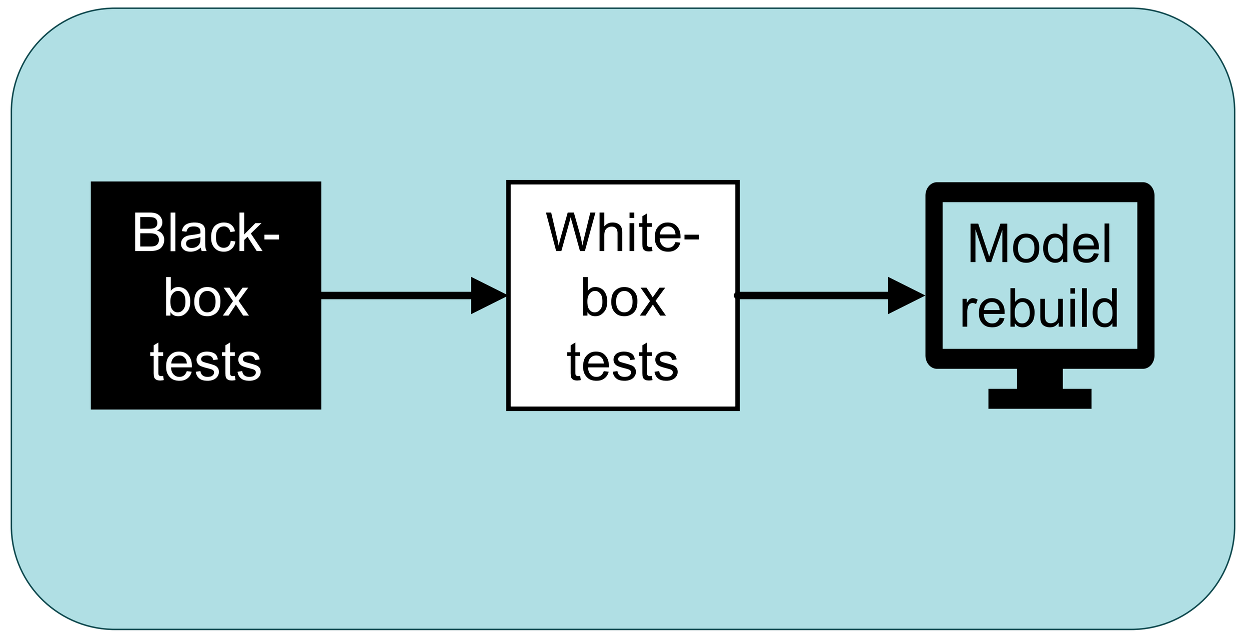

Figure 1. Three types of technical verification

Currently, there is a growing trend toward the automation of model programming. The most common approach to rebuilding models involves the use of AI, but the increasing interest in this area may facilitate more frequent model reconstruction and the exploration of new methods for rebuilding models.

OBJECTIVE

This study aimed to evaluate the potential of an automated model generator to improve QC. It focused on assessing the time required to develop a model using the generator and the accuracy of the resulting model.

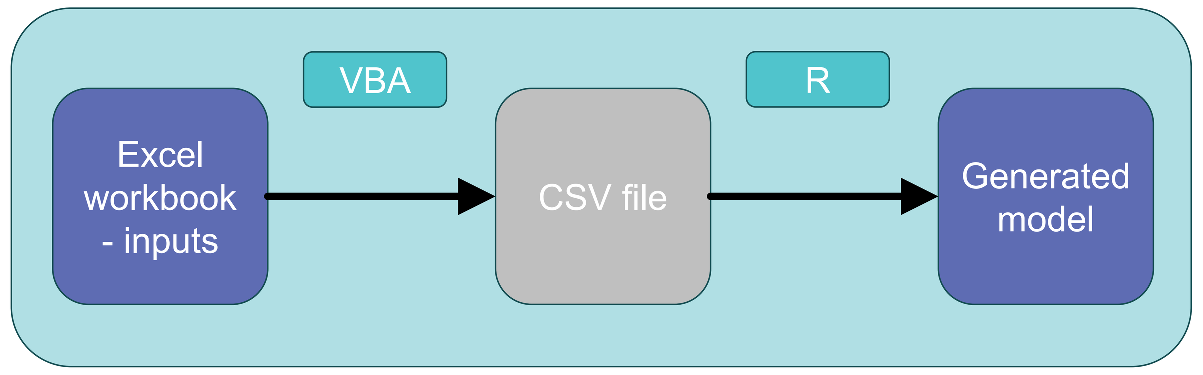

Figure 2. Workflow of model generator

METHODS

An automated model generator was developed using a combination of Visual Basic for Applications (VBA) and R to construct health economics models. The user inputs parameters into a predefined MS Excel workbook, which generates a CSV file. Based on this file, an R script produces the model in MS Excel, as shown in Figure 2.

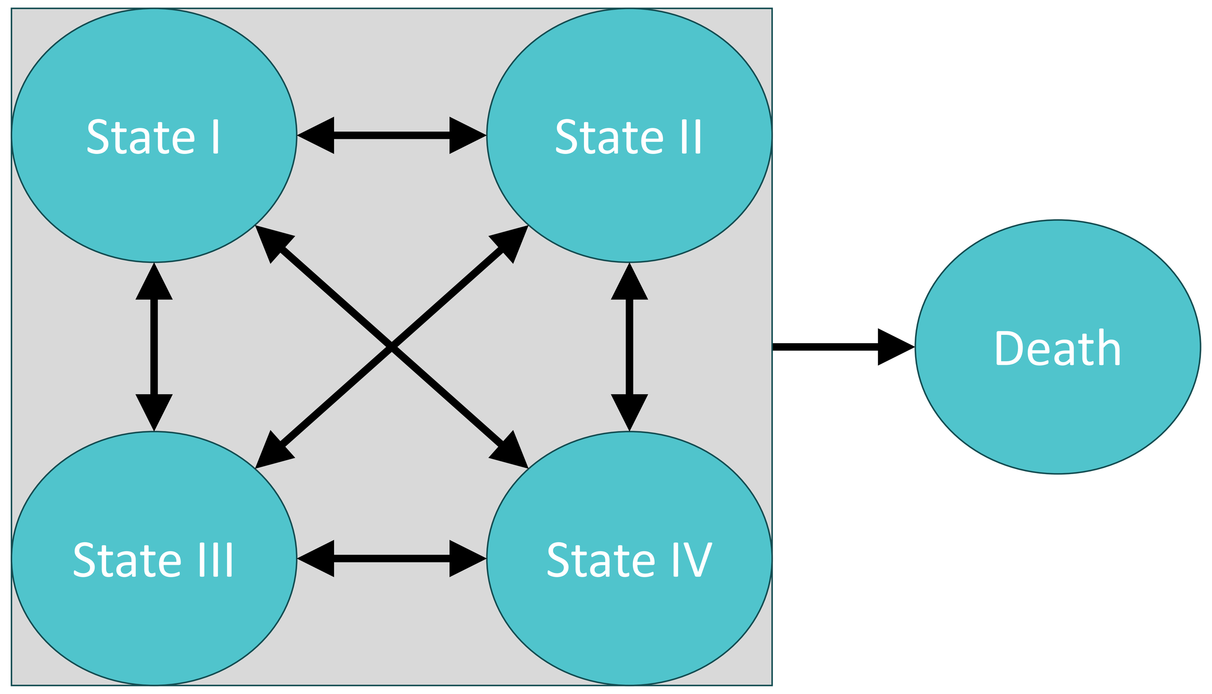

Figure 3. Structure of the replicated model

The tool operates on a fully deterministic algorithm, ensuring consistent results for given inputs. The generator was employed during the QC of a Markov model comparing New Drug with standard of care (SOC). The model included five health states (States I-IV and Death), with three-month cycle length and lifetime time horizon, as presented on Figure 3.

Prior to rebuilding the model, technical verification was conducted. Several errors were identified and corrected, including mis-implementation of half-cycle correction and discounting. These adjustments resulted in a version referred to as the "partially fixed model".

A few simplifications were necessary to enable replication of the model, such as using the same transition matrix for every cycle. This version of the model is referred to as the "adjusted model".

RESULTS

After minor manual adjustments to the model programmed with the model generator, replication was successful. Initially, the results generated by the replicated model differed from both the original and the partially fixed model, as presented in Table 1. A comprehensive analysis of these discrepancies revealed an issue in the original model that had not been identified in earlier QC phases — patients who discontinue treatment in each cycle did not switch states in that cycle.

Table 1. Comparison of discounted results in simplified models

	Partially fixed model - adjusted		Replicated model		Fully fixed model - adjusted	
Treatment	New Drug	SOC	New Drug	SOC	New Drug	SOC
LYs	4.69	3.70	4.70	3.70	4.70	3.70
QALYs	3.04	2.27	3.05	2.27	3.05	2.27
Costs ($k)	72	26	72	26	72	26

Fixing this issue reduced the difference between the replicated and adjusted model to less than 0.0001%. Applying this change to the partially fixed model resulted in the final version, named the "Fully fixed model." A comparison of the results between different models is presented in Table 2.

Table 2. Comparison of discounted results

	Original model		Partially fixed model		Fully fixed model	
Treatment	New Drug	SOC	New Drug	SOC	New Drug	SOC
LYs	4.80	3.82	4.72	3.76	4.73	3.76
QALYs	3.12	2.39	3.07	2.35	3.08	2.35
Number of hospitalizations	1.23	1.68	1.21	1.65	1.21	1.65
Costs ($k)	74	26	72	26	72	26

The entire replication process — including adjustments to the original model, inputting the correct parameters into the model generator, and refining the replicated model — was completed within three days.

CONCLUSIONS

- **The cost-effectiveness model generator proved to be useful in model QC by facilitating a rapid and less error-prone reconstruction of the model.**
- **This process helped to identify issues in the original model that had been overlooked during manual checks.**
- **Although the additional errors identified did not qualitatively affect the model results, the successful model rebuild enhances its reliability.**

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