

# The Who, When and How of Model Validation: A Targeted Literature Review of Roles and Opportunities for Improving Credibility Through All Phases of Model Development

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## Introduction

- Health economic (HE) decision-analytic models are a critical component of health technology assessments (HTAs), and evaluation of model validity can support a decision-maker's ability to trust model results.
- While most models undergo some level of validation, recommendations around how, when, and by whom it should be conducted vary widely.

**Objective:** To assess current literature and summarise published guidance on HE model validation.

## Methods

- A targeted literature review was conducted via an electronic search in PubMed followed by citation searching of key papers.
- Additionally, model validation documents published by national HTA bodies were considered. The national bodies were identified from a study which investigated international HTA systems from 32 countries.<sup>1</sup>
- The PubMed search included HE and modelling terminology alongside validation terms. Exclusion criteria included non-HE model types and missing discussion of validation methodology.

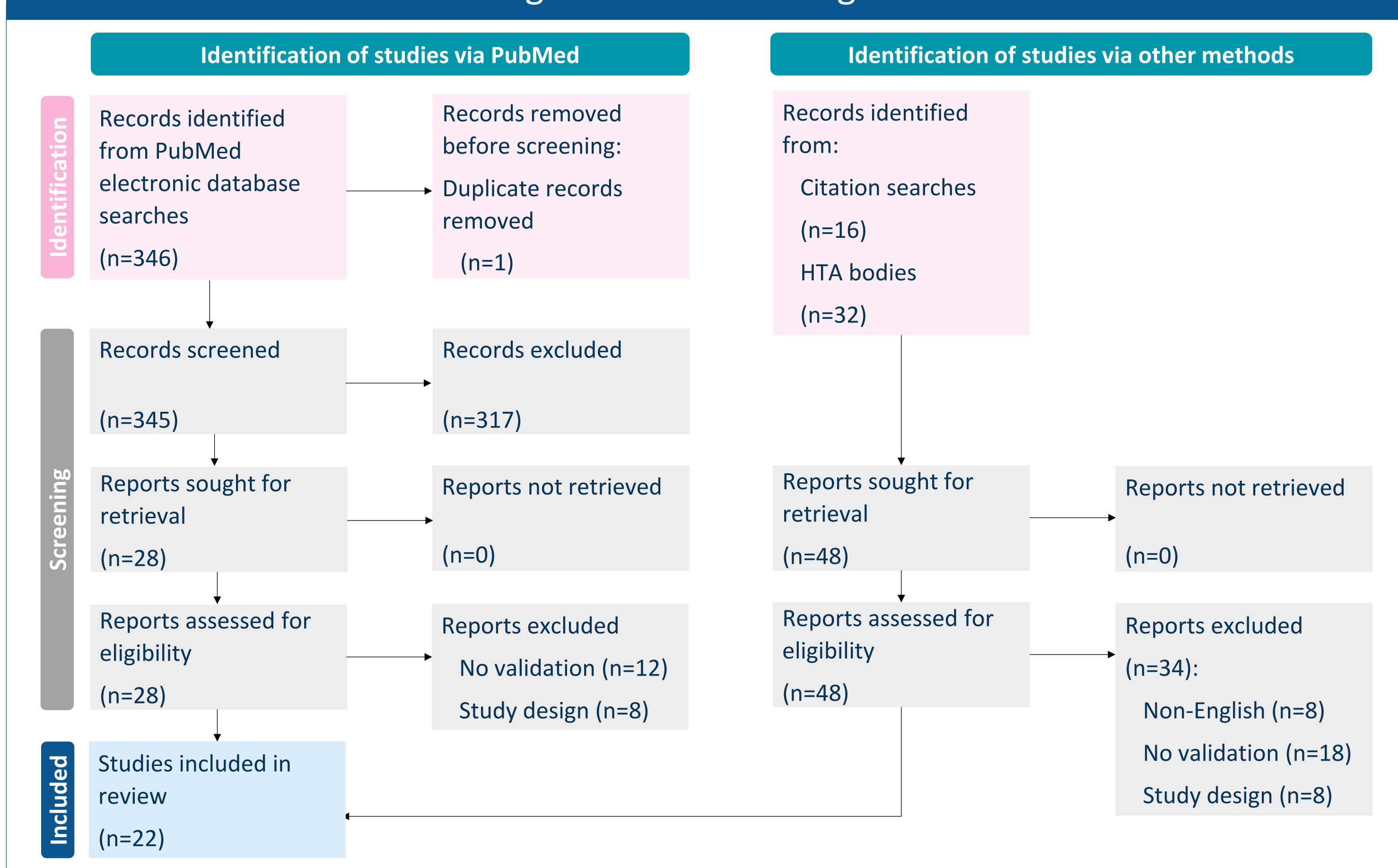
## Results

### Search and screening

- A total of 346 studies were identified following the PubMed, citation and national HTA body searches.
- After title and abstract screening, 317 studies were excluded. Following full-text review, eight articles were identified from the PubMed search, eight from citation searches and six documents from HTA bodies (**Figure 1**).
- Across all studies, key reasons for exclusion were non-English (n=8), no validation methods (n=30) and unsuitable study design (n=16).

- The 22 sources covered 21 unique approaches, which were categorised as conceptual guidance (n=14) and specific validity tools (n=7)<sup>2-8</sup> (**Figure 2**).
- Study authors referenced external data sources including structured literature reviews (n=7) or non-author HTA experts (n=12) (**Figure 3**).
- Most approaches (n=15) reported technical validation methods that required a modeller with expertise to conduct.
- Six provided guidance for decision-makers or model users to check face validity and reporting. Two described the role of clinical experts in validation and how to assess models based on clinical understanding (**Figure 4**).

Figure 1. PRISMA diagram



Abbreviations: HTA, health technology assessment.

Figure 2. Framework of studies

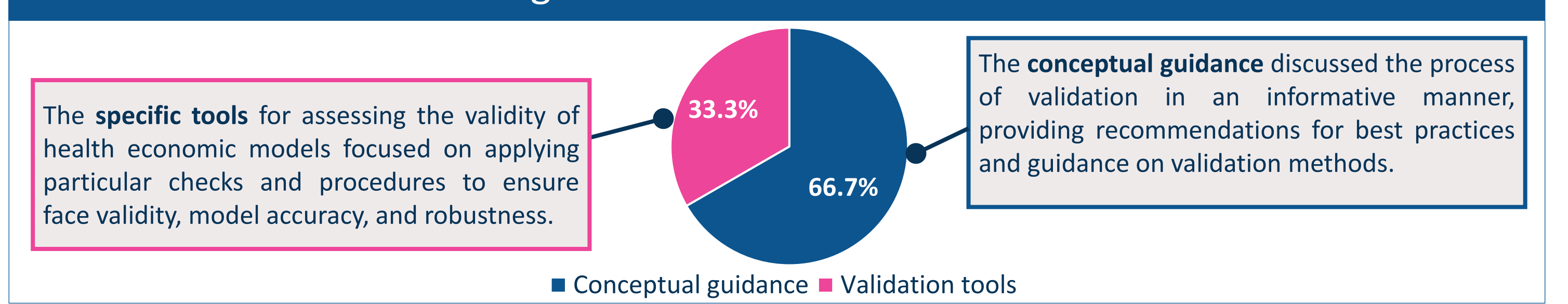


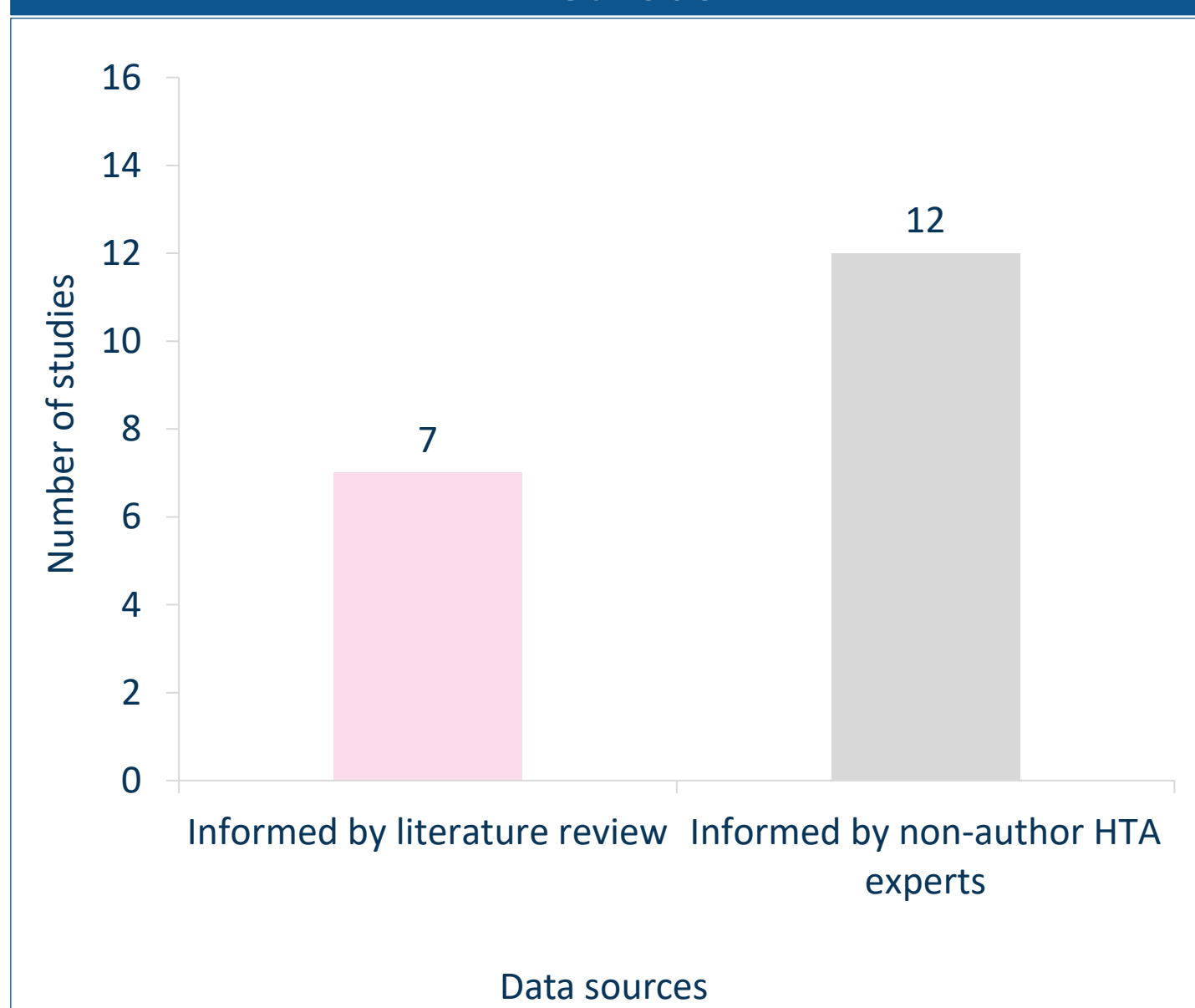
Table 1. Validations throughout stages of model development

Validation	Process	Featured	Model development phases				
			Conceptualisation	Programming	Finalisation	Reporting	Post-completion
Face validity	To check the model reflects the real-world experience of the patient.	20 studies	Clinical expert				Clinical expert
Assess fit for decision problem	To compare the model components to the proposed research question and ensure all aspects are answered.	11 studies	Model developer				External assessor, model user, decision maker
Black box testing	To test the model behaviour through the changing of external input values and observing the impact on the model.	12 studies		Model developer	Model developer		External assessor
Grey-box testing	To assess the data imputation methods using actions such as duplicate programming.	9 studies		Model developer	Model developer	Model developer	External assessor
White box testing	The testing of internal model coding and programming, conducted through methods such as cell by cell formula checks in Excel.	9 studies		Model developer	Model developer	Model developer	External assessor
Cross-model comparisons	Structural and results validation through comparison to available evidence and clinical evidence.	11 studies	Model developer		Model developer		External assessor, decision maker, model user
Transparency actions	To test model transparency through observing the use of input sources, justification of assumptions, uncertainty analysis and the highlighting of potential bias.	6 studies				Model developer	External assessor, decision maker
Post-completion testing	To assess the model by an independent expert modeller(s), clinical expert(s), and sometimes a decision maker (e.g., NICE).	17 studies					External assessor, decision maker

Legend: ● Key action by model developer (green), ● Key action by external party (non-developer) (blue), ● Key action by clinical expert (pink)

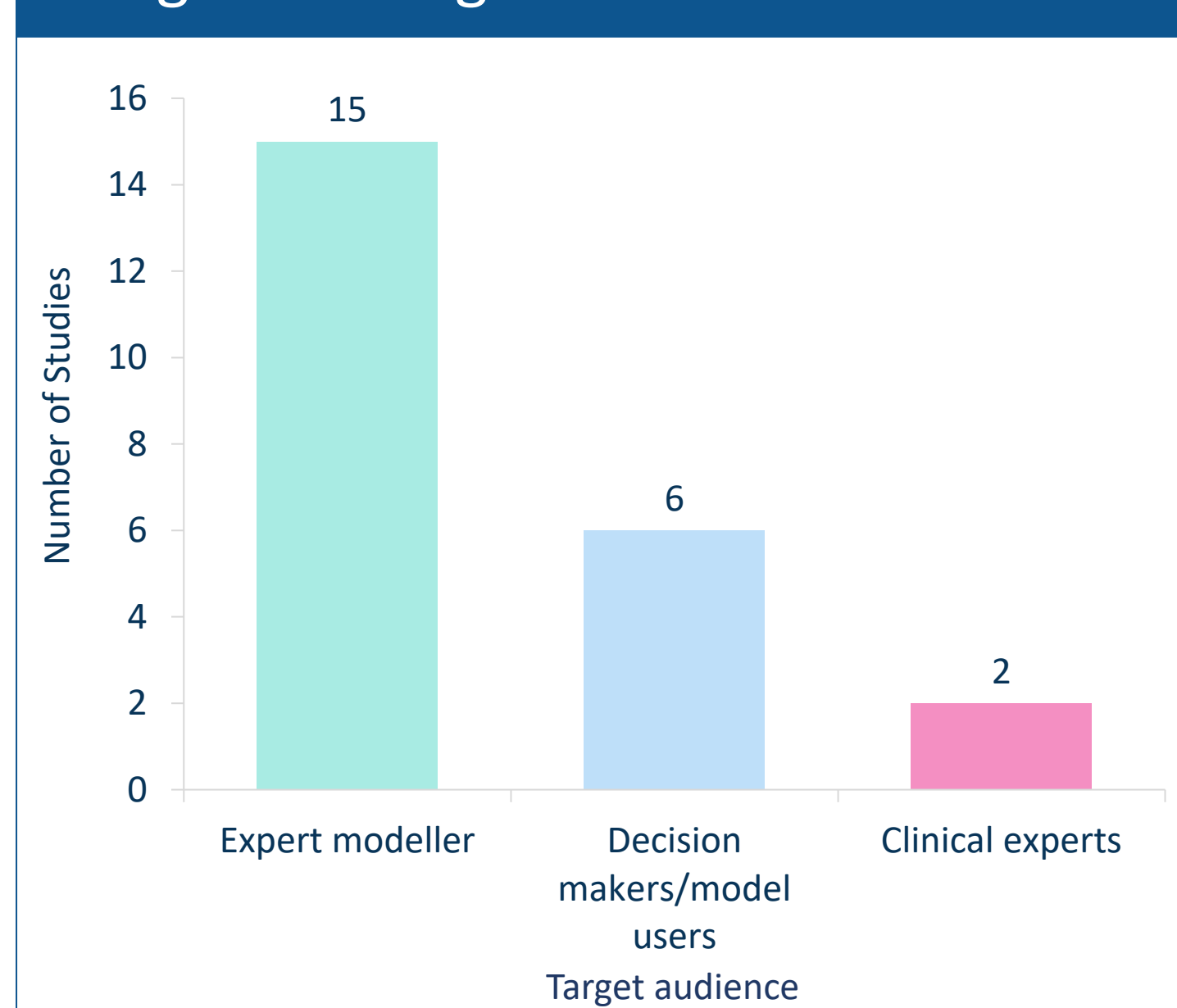
Abbreviations: NICE, National Institute for Health and Care Excellence.

Figure 3. External data sources for validation methods



Abbreviations: HTA, health technology assessment.

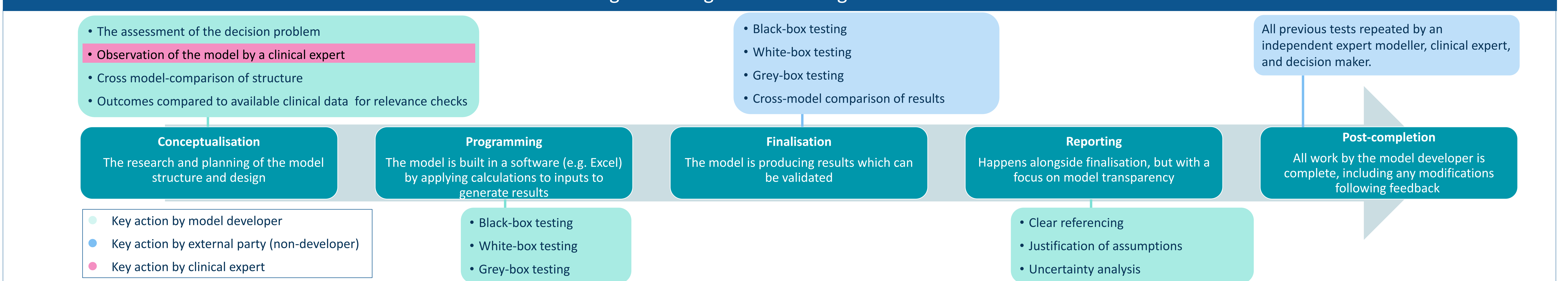
Figure 4. Target audience of studies



## Conducting a validation

- Building a HE model can typically be broken down into five distinct stages, with different validation methods recommended for each one (**Figure 5**).

Figure 5. Stages of validating an HE model



## Conclusions

- Current literature provides a range of theoretical frameworks and assistive tools to guide the critical assessment of HE model validity.
- Most validation approaches were found to be suitable for the final stages or after the full completion of the economic model, with a notably lower number of publications in methods applicable during the model conceptualisation and development phases.
- A key consideration of this study is that it was conducted as a targeted review rather than a full systematic literature review. Consequently, it may not capture every study in the literature.
- This study can help modellers, assessors, and model users better understand role-specific validation recommendations across different stages of model development.

**References:**\* (1) Fontrier A-M, Visintin E, Kanavos P. Similarities and differences in health technology assessment systems and implications for coverage decisions: evidence from 32 countries. *Pharmacoeconomics Open* 2022;1:1-14. (2) Büyükkaramikli NC, Rutten-van Mölken MP, Severens JL, et al. TECH-VER: a verification checklist to reduce errors in models and improve their credibility. *Pharmacoeconomics* 2019;37:1391-1408. (3) Caro JJ, Eddy DM, Kan H, et al. Questionnaire to assess relevance and credibility of modeling studies for informing health care decision making: an ISPOR-AMCP-NPC Good Practice Task Force report. *Value in health* 2014;17:174-182. (4) Chiu C-F, Hay JW, Wallace JF, et al. Development and validation of a grading system for the quality of cost-effectiveness studies. *Medical care* 2003;41:32-44. (5) Gandjour A, Gafni A. Internal validation of models with several interventions. *The European Journal of Health Economics* 2013;14:901-909. (6) SBU. Checklist for assessing the quality of health economic modelling studies. Swedish Agency for Health Technology Assessment and Assessment of Social Services 2018. (7) Coyle D, Haines A, Lee K. The development of a model validation tool to assist in the conduct of economic evaluations. *Canadian Journal of Health Technologies* 2024;4. (8) Vemer P, Corro Ramos I, Van Voorn G, et al. ADVISHE: a validation-assessment tool of health-economic models for decision makers and model users. *Pharmacoeconomics* 2016;34:349-361.

\*For a full reference list of all included studies, please enquire directly with the primary author.

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