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A Framework for Developing the Structure of Public Health Economic Models

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ABSTRACT

Background: A conceptual modeling framework is a methodology that assists modelers through the process of developing a model structure. Public health interventions tend to operate in dynamically complex systems. Modeling public health interventions requires broader considerations than clinical ones. Inappropriately simple models may lead to poor validity and credibility, resulting in sub-optimal allocation of resources. **Objective:** This article presents the first conceptual modeling framework for public health economic evaluation. **Methods:** The framework presented here was informed by literature reviews of the key challenges in public health economic modeling and existing conceptual modeling frameworks; qualitative research to understand the experiences of modelers when developing public health economic models; and piloting a draft version of the framework. **Results:** The conceptual modeling framework comprises four key principles of good practice and a proposed methodology. The key principles are that 1) a systems approach to modeling should be taken; 2) a documented understanding of the problem is imperative before and alongside developing and justifying the model structure;

3) strong communication with stakeholders and members of the team throughout model development is essential; and 4) a systematic consideration of the determinants of health is central to identifying the key impacts of public health interventions. The methodology consists of four phases: phase A, aligning the framework with the decision-making process; phase B, identifying relevant stakeholders; phase C, understanding the problem; and phase D, developing and justifying the model structure. Key areas for further research involve evaluation of the framework in diverse case studies and the development of methods for modeling individual and social behavior. **Conclusions:** This approach could improve the quality of Public Health economic models, supporting efficient allocation of scarce resources. **Keywords:** conceptual modeling, guidance, methods, public health.

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Introduction

Conceptual modeling is the abstraction of elements of reality at an appropriate level of simplification for the problem [1]. It is the first part of a modeling project, which guides and affects all other stages. If done poorly, the subsequent analysis, no matter how mathematically sophisticated, is unlikely to be useful for decision makers [2]. The absence of formal conceptual modeling may lead to a plethora of errors including answering the wrong (or less useful) question; poor validity and credibility; no basis for model verification, structural uncertainty analysis, or specification of key areas for further research; poor transparency for stakeholders and model reuse; ignorance of system variation; and inefficient model development.

In 2011 Chilcott et al. [3] highlighted the lack of formal methods for health economic model development. Given the scientific rigor

of technical methods such as probabilistic sensitivity analysis (PSA) for representing parameter uncertainty and the importance placed on these approaches for health care decision making [4], methods for the development of the model structure are relatively underdeveloped. If the model structure is inadequate, the PSA will provide misleading results, leading to inappropriate policy decisions. The lack of formal conceptual modeling approaches is particularly problematic for economic models of public health interventions. Public health economic models are models of any intervention preventing disease, prolonging life, or promoting health. A key objective of public health is sometimes to reduce inequities rather than maximize the health of the society. In addition, public health interventions tend to operate in dynamically complex social systems that include the social determinants of health [5]. The modeling described in this article seeks to capture the complexities involved. Key challenges associated with

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developing the structure of public health economic models are described in detail by the authors in an existing article [6].

This article aims to provide a conceptual modeling framework for developing models of public health interventions, that is, a methodology that helps to guide modelers through the development of a model structure, from developing and describing an understanding of the decision problem to the abstraction and nonsoftware-specific description of the quantitative model, using a transparent approach that enables each stage to be shared and questioned. It is intended to be used by any modeler undertaking public health economic evaluations. It also provides a standardized approach that will help stakeholders to input into and use the model developed.

During the development of this framework an important obstacle had to be confronted. Given the lack of guidance on conceptual modeling in health economic evaluation more generally, we did not have a platform on which to build the additional considerations and differences for public health. Thus, the aim to present a conceptual modeling framework for developing the structure of public health models necessarily involved developing guidance that was general and also outlining specific public health considerations that may otherwise be overlooked. While our work has been underway, the lack of conceptual modeling guidance has been recognized as an issue within the wider health economics community, with the International Society for Pharmacoeconomics and Outcomes Research and the Society for Medical Decision Making (ISPOR-SMDM) Joint Modeling Good Research Practices Task Force developing guidance to inform conceptual modeling for health economics [7]. The ISPOR guidance describes *what* modelers should do, but it does not describe *how* they might do it. Thus all parts of the framework are new in that they describe methods to help health economic modelers develop model structures, whilst specific public health considerations are mainly outlined in those areas of the framework dealing with developing an understanding of the decision problem. When methods or processes in the framework are established we provide references to key literature. Methods or processes are outlined in detail if they have not been described previously for health economic modeling.

The parallel development of our framework and the ISPOR guidance highlights the importance and timely nature of this work. We intend that this guidance will complement and add to the ISPOR conceptual modeling guidance by helping modelers think about their approach to model development. It is not intended to provide a checklist for developing “good” model structures. Given its purpose, it is necessary to provide a good deal of detail.

Methods for Developing the Conceptual Modeling Framework

The conceptual modeling framework was informed by two literature reviews, qualitative research with modelers, including in-depth interviews, observation of modeling practice and focus groups with key experts, and a pilot study. The literature reviews aimed to 1) describe the key challenges in public health economic modeling and 2) review conceptual modeling frameworks in the broader modeling literature. The qualitative research aimed to understand the experiences of modelers when developing public health economic model structures and their views about the barriers and benefits of using a conceptual modeling framework. These are each described briefly here, although a more detailed description of the methods is available in the doctoral thesis by Squires [8].

Review of Key Challenges in Public Health Economic Modeling

An iterative search process was undertaken to identify literature describing the key challenges in public health economic evaluation. Articles relating to economic evaluation resulting from the work of the Public Health Excellence Centre at the National Institute for Health and Care Excellence (NICE) were identified by searching for key people from the NICE website as authors in MEDLINE, publications written by the Public Health Research Consortium [9] were handsearched, and a MEDLINE search for terms relating to problems in public health economic modeling was undertaken. Key public health journals were subsequently searched using search terms relating to economic evaluation. The review included methodological articles on economic modeling in public health. It excluded case studies of economic evaluations, methods for valuing equity or health outcomes (as against the incorporation of these in a model), and “gray literature” if the content was already published in a peer-reviewed journal. After the initial searching process, additional targeted searches were undertaken to develop more in-depth knowledge about the key challenges identified from relevant discipline-specific literature. Further details of this review are described in a paper by Squires et al. [6].

Review of Existing Conceptual Modeling Frameworks

Existing conceptual modeling frameworks were identified via an iterative search process following the NICE Technical Support Document Guidance, including citation, reference, and key author searching in MEDLINE, Scopus, and Web of Science in 2011 [10]. Three sets of search terms were combined with “AND”: 1) terms for conceptual models (limited to title with the aim of ensuring that this is the main focus of the article); 2) terms for quantitative models (to help to limit studies to those in which the aim of the conceptual model is to develop a quantitative model); and 3) terms for development (to help focus the search on methods for the development of conceptual models rather than on case studies reporting the output of a conceptual model). Searches were not limited by discipline, study type, publication date, or language. After article retrieval, the key characteristics of the methods described in the articles were identified using a data extraction form that was specifically developed for this review.

Qualitative Research

The qualitative research involved 1) tracking the development of a specific public health economic model including observing key meetings and undertaking in-depth interviews with the two modelers involved; 2) systematically analyzing notes from a previous modeling project assessing the cost-effectiveness of interventions to encourage young people to use contraceptives; and 3) holding a focus group meeting with modelers from five different UK centers. The participants were identified purposively for their varied experience in public health economic modeling projects so that the views presented would be relevant, varied, and comprehensive. Topic guides were developed for the interviews and the focus group, and the sessions were audio-recorded and subsequently transcribed. The focus group aimed to capture both agreement and disagreement between modelers. Analysis involved copying each sentence of the transcripts and notes systematically to an MS Excel (Microsoft) spreadsheet into emergent categories, which were then grouped into themes. A reflexive approach was taken (in which meaning was developed on the basis of the complex relationship between the understanding of the participants and the researchers before the research combined with the additional meaning gained from the research), and alternative meanings for each piece of data and opposing views were actively considered.

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