THE ROLE OF SYSTEMATIC REVIEWS IN THE SYSTEM DYNAMICS MODELING PROCESS

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1 | INTRODUCTION

Systematic literature reviews are widely considered to be a valuable instrument for decision-making applied by individuals responsible for developing science-based recommendations and policies (Bero and Jadad, 1997). Systematic reviews represent a rigorous approach to search, synthesize, evaluate and analyze available scientific evidence and draw conclusions about a given topic (Petticrew, 2001). The aim of systematic reviews is to synthesize the results of multiple original studies by using strategies to minimize bias and arrive at a conclusion about the state of knowledge on a topic (Cook *et al.*, 1997). Essentially, systematic reviews follow these steps:

1) Formulate a clear research question,
2) Develop a search strategy that is comprehensive, objective and reproducible to capture all relevant sources of evidence to answer the research question,
3) Conduct a critical appraisal of the findings using explicit inclusion and exclusion criteria and,
4) Draw a conclusion based on an objective analysis of the existing data and answering to specific review questions.

Systematic reviews show a clear description and detailed documentation of i) how the relevant findings were sought, ii) how decisions were made about which sources to include or exclude and iii) how judgements were arrived at by assessing the methodological quality of the included studies and overall strength of the body of evidence. The synthesis of results is usually presented in the form of a structured narrative, summary tables or a statistical combination (e.g. meta-analysis) which is then used to formulate conclusions and recommendations (Thomas *et al.*, 2012). This procedure aims to provide a reliable set of relevant empirical evidence and a complete interpretation of their findings (Petticrew, 2009). Several organizations such as the Cochrane Collaboration (Higgins and Green, 2011) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher *et al.*, 2009), have established guidance for conducting, and reporting, on systematic reviews.

In the field of public health, for instance, systematic reviews have been widely used to develop clinical and public health practice guidelines, set research agendas, and formulate scientific consensus statements and to make decisions and to provide recommendations (Lichtenstein *et al.*, 2008). While systematic reviews are typically used in clinical research and social sciences, they have found application in various other subject areas for example in advertising, education, international development, public policy, environmental sciences and engineering (Gilbody *et al.*, 2005; Pullin and Stewart, 2006; Zhang and Babar, 2013). It should be noted that systematic reviews are increasingly being conducted and published for Systems Science-related and simulation methodologies (Carey *et al.*, 2015; Luke and Stamatakis, 2012). A number of systematic reviews addressing non-communicable diseases which included System Dynamic studies have been conducted, but these have been mostly combined with other System Science's approaches such as Agent-Based Modeling (ABM) and Discrete-Event Simulation (Levy *et al.*, 2011; Morshed *et al.*, 2019; Nianogo and Arah, 2015; Skinner and Foster, 2013; Xue *et al.*, 2018). Although there are some systematic reviews including System Dynamics studies in the literature, the application of systematic reviews to inform the System Dynamics modeling process is very scarce and barely appreciated (Darabi and Hosseinichimeh, 2020). An aim of this paper is to urge the use of the systematic review approach to support in the different stages of the System Dynamics modeling process, to support this, the following section describes a case of how a systematic review aided in building a system dynamics (SD) model.

1.1 | A systematic review of existing System Dynamics models on childhood and adolescent obesity as part of the CO-CREATE PROJECT

The aim of CO-CREATE is to reduce the prevalence of obesity among adolescents in Europe through policy actions to promote a healthier food and physical activity environment. CO-CREATE will contribute to the evidence and infrastructure for local and national policy changes to make healthy choices the easiest, most appealing, and preferred choices for adolescents across Europe, thus reducing the burden of obesity and related non-communicable diseases, both now and in the future (Norwegian Institute of Public Health, 2018). As part of CO-CREATE, a systematic literature review of existing simulation studies applying SD to investigate obesity in children and adolescents was conducted.

Peer-reviewed and published studies were identified resulting from searches of the Medline, Embase, PsyInfo, CINAHL, Web of Science and Scopus databases. Seventeen studies containing SD simulation modeling were included in the review. The authors presented and described a summary of the key characteristics of SD studies on the relationship between children and adolescents' body weight status and related behaviors (i.e. eating and physical activity) and the environment in which they are embedded in. Following this, environmental determinants and the dynamic mechanisms driving obesity in children and adolescents were identified and illustrated using a causal loop diagram (CLD). Lastly, interventions and policies addressing diet and physical activity were presented according to their level of influence and impact on the intervention targets. The findings obtained from this review will inform the SD model that will be developed later in the project.

Conducting this systematic review provided an important benefit through the early stages of the modeling process for the CO-CREATE project. Applying such detailed protocols and following these systematic steps took significant time and effort. The results and synthesis of this review provided the structural foundations of the SD model that is being developed for the project, particularly, the CLD facilitated a clear view of the system's boundary and the key dynamic mechanisms driving childhood obesity. It also provided a solid overview of what has been modeled about childhood obesity, and what is yet to be modeled in that area. Besides providing structural confirmation for the model construction, the results of the review allowed the modelers to parameterize an initial quantitative model.

On the other hand, what the reviewers found most challenging when applying the systematic review methodology regarding childhood obesity, was the quality assessment of the included studies. The reviewers developed a model assessment checklist to evaluate whether all models met the structural and behavioral validation tests and documentation requirements recommended in the SD field for building confidence in models. However, only a few of the included studies satisfied such requirements. This made it difficult for reviewers to assess the overall quality of the studies. Based on our experience with using the systematic review method, we are of the view that there is an opportunity to apply these insights to the system dynamics modeling process.

2 | SYSTEMATIC REVIEWS AND THE SYSTEM DYNAMICS MODELING PROCESS

Here, we present the main stages of the SD modeling process, and how a systematic review can provide support on each of the stages:

2.1 | Problem identification and system conceptualization

The SD modeling process begins with the identification and definition of a puzzling problem and the interacting causal relationships of its components (Richardson and Pugh, 1981). The conceptual stages of the modeling process are among the most difficult but having a clear model purpose and boundary (i.e. defining endogenous and exogenous variables), is extremely helpful throughout the conceptualization stage (Randers, 1980).

Systematic reviews can aid modelers in the conceptualization stage by delineating a framework of the body of knowledge in the literature related to the problematic behavior. Given that systematic reviews address specific research questions, it supports the conceptualization stage by identifying what has been modeled and what is needed for further modeling. For instance, a systematic review can shed light on questions on a specific research topic such as: What are the likely effects of a given policy?, What is the time development of interest (i.e. reference mode)?, What are the main feedback loops that drive the reference mode?.

2.2 | Model formulation and analysis

The formulation stage transforms the chosen perspective into a formal representation. The resulting model provides a precise description of a part of reality and is capable of generating options for alternative scenarios (Saeed, 1992). Comparing and extracting common model structures in the included studies in a systematic review can help in the model formulation by applying and connecting those structures to the modeling purpose. Additionally, the identified model structures found in the systematic review provide pointers towards knowing which could be the main stocks or state variables, flows or rate variables, determinants and data requirements.

Results of the review process can also serve as a reference point for modelers to identify common behavioral patterns of important variables. This can also be thought of as using other authors' analyses as archetype-based analyses and apply them into the current context. Factors that could be favorable to consider with respect to the modeling analyses in the existing literature may include analysis techniques, calibration methods and performance metrics for the model.

2.3 | Model validation

The model validation process entails establishing sufficient confidence in a model to be prepared to use it for a particular purpose, for instance, formulating policies (Lane, 2015). System Dynamics models are validated through structural and behavioral tests to understand their robustness and limitations (Barlas, 1996; Sterman, 2000) and to verify whether the basic mechanisms create the reference mode or the model assumptions are reasonable and the parameter values plausible. The goal of validating a model is to identify weak points for further improvement and to establish the extent of model usefulness.

One of the strongest advantages of systematic review results during this modeling stage is the model structure validation. The interacting variables in a System Dynamics model are judged by whether they were appropriately chosen according to the model purpose and boundary; each piece of the structure is examined and contrasted against their real system counterpart. Then, the confirmation of structure is tied to the behavior of the model which has to replicate or have similar characteristics of any observed data in the reference mode. Additional to structure, parameter confirmation is something that results of a systematic review can help with since the parameters introduced in the models of the included articles, were evaluated against the knowledge of the real system, both conceptually and numerically.

2.4 | Policy analysis and implementation

This modeling stage allows testing the response of policies and experimenting with different scenarios (Homer and Hirsch, 2006). Systematic reviews' findings help by showing policy alternatives that have been already designed, modeled, analyzed and implemented and their

impact to the specific dynamic problem. This can help illuminate which policies work, which do not, and also provide insights for further research.

3 | CONCLUSION

A systematic review is an overview of the evidence that is currently available on a specific topic or the effect of a new intervention, it stresses the need for decisions to be based on relevant evidence from good quality research (Charrois, 2015). Therefore, as an analytic framework it helps to clarify key questions and delineate the connecting logic between them. Systematic reviews can benefit SD modelers as they provide tested structures, good practices and comparable and reproducible model results to build on, and therefore modelers avoid spending time and effort on something that already exists, or making the same mistakes previously made. This ensures that the model is used to answer the appropriate research questions, filling clear knowledge gaps in the literature, indicating areas where further research is needed, and serve as the foundation for later updates as new data emerge. Evidently, SD modelers should complement the results of a systematic review with other information sources and expert judgment to support the model construction process. Finally, systematic reviews can be a valuable resource that provides advantages to SD researchers, especially to new authors, to refine their knowledge on the subject area of interest, develop new research ideas, and gain critical skills in synthesizing existing literature.

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