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THE ISSUE OF TRUST AND IMPLEMENTATION OF RESULTS IN HEALTHCARE MODELING AND SIMULATION STUDIES

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ABSTRACT

The issue of real world implementation of the results of modeling and simulation (M&S) studies in healthcare has been the focus of research interest for decades. Using a model of trust which focuses on a three-way conceptualization of trust between modelers, the model and stakeholders across the M&S study process, this paper investigates reported project features of a subset of healthcare studies that describe results implementation. Differentiating between credibility and trust, the paper provides a preliminary evaluation of aspects of implemented studies that can be mapped to the trust model. The findings align with previous empirical results that have investigated implementation in healthcare M&S, and support the value of the Trust model for structuring an evaluation or implementation plan for M&S studies in the healthcare domain.

1 INTRODUCTION

Tangible changes to a system informed by simulation results enable researchers to determine the value of an individual modeling and simulation (M&S) study, and more widely of simulation as a method for supporting health and social care planning. Assuming the results of the study are trusted, the knowledge gained can offer value by suggesting improvements to the system under investigation. However, evidence from healthcare continues to report very low levels of implementation, for example, Brailsford et al. (2009) and Katsaliaki and Mustafee (2011) found that only 5% of published studies reported implementation of results. A review of 139 papers on hybrid simulation found only three papers that described real-world implementation, of which only one paper was on healthcare (Brailsford et al. 2019). A recent review of healthcare M&S for internal logistics (Roy et al. 2021) found that nearly 80% of studies focused on an applied problem - using real-world data, with a significant level of user engagement in the M&S process - a marked increase from 7% real-world applications found in previous work (Jahangirian et al. 2010). Yet surprisingly Roy et al. (2021) found that this escalation in applied studies was not matched by implementation, with similar levels to those found a decade or more ago.

Healthcare is a sociotechnical system, an interconnected network of people and technology. The relevance for M&S is that competing objectives are intrinsic to organizational decision-making, and will influence an understanding of the credibility of M&S results for driving decisions. Credibility is the quality of being believable; this can focus on a person or an artefact (Wang and Benbasat 2005), although it is generally seen as an attribute of the decision-maker (Robinson 2002). Sargent (2015) defined credibility as being concerned with developing the confidence needed by potential users to use the model, and in the knowledge derived from the model, assuming it is sufficiently accurate for its purpose. *Trust* can be seen as a precursor to *confidence*. Confidence has been variously defined in relation to trust, for example: (i)

Confidence is a certain expectation that something will happen, with no consideration of the possibility of failure, while trust involves the conscious consideration of alternatives (Blomqvist 1997); (ii) Mayer et al. (1995) contrasted the two terms as per Luhmann (2000), whereby trust recognizes and assumes risk, while confidence accepts the risk; (iii) Trust suggests certainty of feeling based on inconclusive evidence, while confidence implies stronger cognitive grounds for certainty, and the content of experience, thus performance (Ebert 2009). These definitions clearly differentiate between 'trust' and 'engaging in trusting action', where the action is an outcome of model credibility, or confidence in the model and its results. This itself is the outcome of trust.

Several authors have addressed the question of what constitutes success or failure in a simulation study (e.g. Gogi et al. 2016; Jahangirian et al. 2017). Lack of implementation of the results of a simulation model do not necessarily equate to failure of the study (Crowe et al. 2017; Tsioptsias 2018), where the aim of an M&S study is to provide insight and understanding toward informing action. Nonetheless, the decision to implement changes based on the results of the study belongs to the domain stakeholders, and it remains difficult to determine the value of M&S with few published studies elaborating or evaluating the approach toward results implementation. For this reason, focusing on the aspects of the modeling process that influence trust is essential in healthcare M&S studies. This paper utilizes a model of trust for M&S (Harper et al. 2021) in relation to a subset of applied healthcare studies that have reported results implementation. The purpose is to examine the features of the *Trust model* with respect to relevant aspects of the reported study. The paper is structured as follows: Section 2 briefly reviews the literature examining implementation challenges in healthcare alongside the trust model for M&S studies. Section 3 selects a subset of papers reporting results implementation and Section 4 examines them against the Trust model. Section 5 discusses the implications and recommendations for conducting and reporting M&S studies in healthcare.

2 THE TRUST MODEL FOR M&S

With many M&S studies, the challenge of meeting the requirements for trust needs more than technological rigor. Harper et al. (2021) proposed a trust model for M&S (Figure 1) which conceptualizes a three-way, interdependent relationship between the modelers, stakeholders, and the simulation model over time. The *modeler-stakeholder* facet focuses on dyadic interactions and the trustworthiness, competence and motivations of the modeler as perceived by the stakeholder. The *model-modeler* facet addresses the actual and perceived accuracy and validity of the model relevant to its intended purpose, and other context-specific factors such as model functionality and transparency. The *stakeholder-model* facet is focused on the perceived trustworthiness of the model and its results, the level of perceived risk involved in implementing recommended interventions, and individual, sociopolitical and other contextual factors that may influence a decision.

An M&S study starts with a problem for a real or future system (Brooks and Robinson 2000). A conceptual model is then developed and validated, followed by model coding, verification and validation. Experimental scenarios are developed and verified. Finally, the results of the simulation may be implemented. Throughout the lifecycle of an M&S study, the process of building trust starts at the beginning of the study, and dynamically evolves as the study progresses through a process of social learning. Van Ittersum and Sterk (2015) underlined how different elements become important at different phases of a study, including social learning processes that contain the values and aspirations of the modeler, fitting the model to the context, and interpreting the results in relation to other knowledge sources such as expertise, experience, and goals of stakeholders. Where the results are required to inform practice, confidence in the results is a precursor to 'trusting action' (shown in Figure 1 by the link from the three-way trust relationship to the 'informing practice' stage of an M&S study). An ethical caution was issued by Yilmaz and Yiu (2022), who warn against designing for maximizing trust, suggesting that design should be context-sensitive to mitigate against over-trust as well as distrust. However we argue that if the aim of the study is to inform change in a healthcare setting, aspects of each dynamic facet of this model - between modelers and stakeholders, between modelers and the model, and between stakeholders and the model - require attention and consideration toward actively managing evolving trust relationships.

The following subsections define trust with respect to these facets of the Trust model.

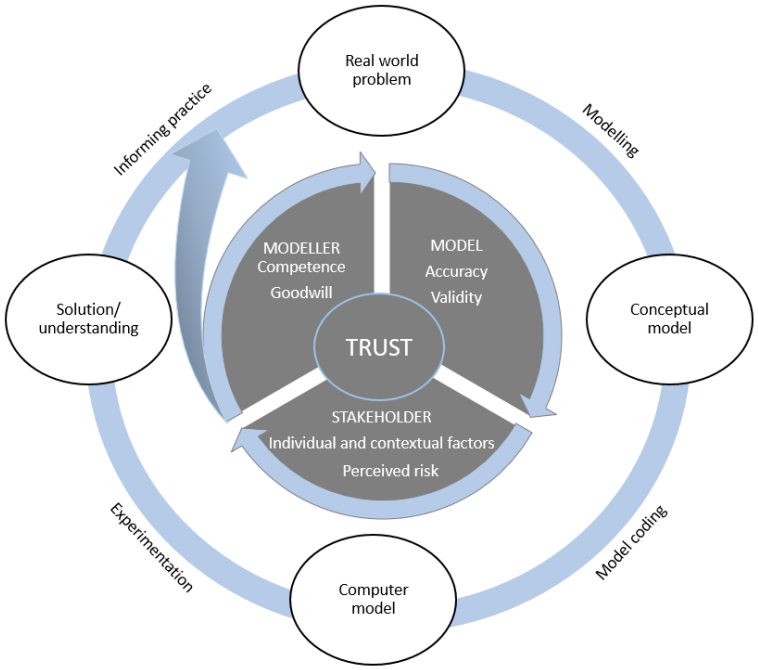

Figure 1: Trust model for M&S (Harper et al. 2021).

2.1 Stakeholder-Model Facet: Defining Trust

From the management literature, Mayer et al. (1995) offered a well-accepted definition of trust as the "willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor…" (p. 712). This definition encompasses positive expectations of trustworthiness, referring to expectations or perceptions about the competence and motivations of the modeler, researcher or research team, and the willingness of stakeholders or users to take a risk. The use of the term 'vulnerable' does not imply defenselessness, but describes a willingness or intention to depend on the model results with relative security, even though there is an element of uncertainty.

Mayer et al. (1995) proposed that the level of trust is compared to the *level of perceived risk* in a given situation. If the level of trust exceeds the threshold of perceived risk, then the decision-maker will engage in action. Trust will increase the likelihood of action, however whether or not a specific risk is taken will be influenced by both the amount of trust and the perception of risk inherent in the action. For example, where the simulation is used to make high-risk decisions or to allocate large amounts of resources, significantly more trust may be required in the results compared with simulations of physical systems, particularly where some decision-makers do not like the outcome (Johnson 2000). *Individual, sociopolitical and other contextual factors* naturally influence this trade-off (Harper and Pitt 2004; Pitt et al. 2016).

2.2 Modeler-Stakeholder Facet: Interpersonal Barriers to Implementation

From the trust literature, antecedents of trust, those conditions which lead to interpersonal trust, include competence, benevolence, integrity, loyalty, rapport, cooperation, honesty, collaboration, commitment and reciprocity (Mayer et al. 2005; Wang and Benbasat 2005; Welsh 2006; Ebert 2009; Fulmer and Gelfand 2012; Söllner et al. 2016). Blomqvist (1997) synthesized the more abstract dimensions which imply moral

responsibility and good intentions into *goodwill*, which together with *competence* forms a parsimonious, two-dimensional conceptualization of trustworthiness between modelers and stakeholders. For all constructs, participatory practice can be viewed as a tool for communicating these features, and in practice, most real-world research benefits from some form of bi-directional participatory practice (Ormerod 2017).

The healthcare domain is a particular focus of research for challenges, failures and successes in simulation studies. The process of conducting a simulation study is considered to be as important as its technical aspects as OR is a collaborative discipline, and modelers engage with stakeholders in the system to define and develop solutions to problems. Harper and Pitt (2004), Brailsford (2005), Brailsford et al. (2013), Tako and Robinson (2015), Steins and Persson (2015), and Long et al. (2020) have all investigated the research and implementation challenges of healthcare simulation studies, finding broad agreement with constructs influencing implementation of results. For example, organizational barriers include lack of senior management support, problem relevance, and timeliness. Project management barriers include perceived costs/benefits and communication between researchers and stakeholders. Of five critical success factors for M&S studies derived from the simulation literature (Jahangirian et al. 2017), four of these factors were related to the relationship between modelers and stakeholders, including communication, involvement, and responsiveness to stakeholder needs. Similarly, Ormerod (2008) outlined a set of competencies required by modelers and stakeholders, including the ability of each to manage the process, and to articulate and understand contextual factors.

Many of these criteria can be influenced by the modeler or project team, emphasizing that the usefulness of a simulation model cannot be isolated from the context in which it is used, and that unless a modeling study is aligned with the perceived reality of organizational decision-making, it is unlikely to be trusted or accepted. This means acknowledging the natural dynamics of relationships, the importance of both modelers' and stakeholders' shifting interpretations and cognitive processes, and the nature of knowledge creation and dissemination (Nikolova and Devinney, 2012).

2.3 Model-Modeler Facet: Model Characteristics as Barriers to Implementation

The perceived usefulness of a model, its usability, model quality and appropriate visualization have all been found to influence model implementation in healthcare (Robinson and Pidd 1998; Brailsford 2005; Brailsford et al. 2013; Monks et al. 2015). Ethical responsibilities are related to accountability to stakeholders, the presentation of results, communicating uncertainty, validation of data and simulations, and access to data and analyses. For trust in technology, the counterpart to competence is functionality, to benevolence is helpfulness, and to integrity is reliability (McKnight et al. 2011; Oksuz et al. 2016). A model for measuring trust in artefacts (Söllner et al. 2010; 2012) includes similar dimensions, those of competence, accuracy, reliability, functionality, consistency, understandability and predictability. These describe the degree to which the technology functions as promised, provides *adequate and accurate* results, and operates predictably. Accuracy is linked to the purpose of the model (e.g. for demonstration, understanding or prediction). Compared with data-driven models of physical systems, in a sociotechnical system, model assessment is not an entirely technical, quantitative process. Barlas (1996) emphasized that such models describe aspects of the operations of real systems, hence the validity of the internal structure of the model ('right output for the right reasons') is of more importance than generating accurate output behavior alone. As simulation is an abductive methodology, focusing only on the aggregate output accuracy of the model using an inadequate methodology constitutes an 'abductive fallacy' (Lorenz 2009).

Additionally, models lose credibility when perceived to be inaccurate, and this is continuous across the M&S lifecycle. Using both qualitative and quantitative processes, a model needs to be established as *structurally and operationally valid* before it can be trusted, both by stakeholders, and by the modeler themselves. Oral and Ketani (1993) described validation at the levels of managerial situation, conceptual modeling, formal modeling, and decision-making. This enables shifting the focus across stages of an M&S study, where 'modeling' and 'simulation' may be of varying importance throughout the study lifecycle. While underlining the interdependence between validation of each of these aspects, this practical and inclusive conceptualization also positions the process of validation as dependent on the nature and specific

objectives of the practical problem being considered, rather than applying a universal validation methodology. Transparency of assumptions and limitations, and of uncertainty where validation and verification is insufficient, is essential where models and simulations have real-world consequences. Tolk et al. (2021) emphasized that aspects of validation and verification can raise ethical questions in sociotechnical systems, for example stakeholders may be inpatient for change, or resistant to it, and viewpoints and cognitive biases are formed in context.

2.4 Trust Over the M&S Lifecycle

Trust is considered to have a strong temporal component, as its development is a dynamic process, progressing gradually during an interaction and requiring maintenance over time (Gambetta 2000; Tang et al. 2015; 2018). Trust dimensions change as relationships, attitudes and beliefs between the modeler, the model and stakeholders mature throughout the project lifecycle (Kolkman et al. 2016). Models can support negotiations and reflect incremental changes over time in group members toward common agreement and new knowledge about the problem situation being addressed. According to Schoorman et al. (2007), judgements of ability and integrity are formed quickly, while judgements of benevolence or goodwill take more time, shifting as relationships develop.

Trust in the model itself can be influenced incrementally and iteratively through observation of model behavior, reliability and usability, moderated by the level of accuracy required for the study, the importance and the level of risk involved in model outcomes, and the tolerance level for using the model. The process of trust-building is seen as self-enforcing, whereby trust creates trust, and distrust creates distrust (Blomqvist 1997). Viewing trust as a dynamic process has important implications for M&S studies in healthcare, as it can be seen as a process that needs to be managed.

The next section identifies a set of relevant papers for examination against the M&S Trust model.

3 METHODOLOGY

A structured Web of Science article and proceedings search was undertaken using the following free-text search terms: [Simul* OR health* (Title)] AND [Simul* AND health* (Abstract)] AND [implement* OR impact OR evaluation (All fields)] for the years 2013-2022. The category was limited to Operations Research and Management Science as the most relevant category, and the query returned 110 results (April 2022).

The results were filtered by abstract to identify real-world M&S applications in the healthcare domain that reported that simulation results informed real-world change. Thirteen abstracts were reduced to four by full text. Papers that did not report results' implementation were excluded. Of the final set of papers, three reported results' implementation, and the fourth provided an in-depth narrative of the research process to enable conclusions to be made regarding the conditions under which the study was able to report success.

Each of these four studies will be analyzed against the Trust model according to the three-way interrelationships between the stakeholder, modeler and the model as reported in the papers.

4 FINDINGS

Table 1 summarizes the four studies identified, and aspects of each of the three facets of trust as reported in the papers, to evaluate the contribution of these facets to the success of the study.

Table 1: Studies reporting results implementation.

	Modeler-Stakeholder	**Modeler-Model**	**Stakeholder-Model**
Willoughby et al. (2016)	Compelling motivation including patient benefits; conceptual model clearly described;	Validation and verification (V&V) reported. Comprehensive	Results provided as indicative but low risk, low cost changes are recommended. Simple

	pragmatic, realistic scenarios selected. All stages reported engagement with stakeholders.	description of parameters and conceptual model. Description of model suggests that accuracy is not of high importance.	model supports transparency.
Demir and Southern (2017)	Motivated by improving service for patients and reducing costs. Conceptual modeling and parameter estimation described in detail, including staff involvement. A mixed method approach was used to find solutions that maximized patient benefits and minimized costs.	Comprehensive reporting of V&V in particular with regard to continuous involvement of stakeholders with the aim of increasing confidence in model validity.	Focus on usability/user experience. Simplifications and assumptions discussed with stakeholders. Flexible KPIs, attention to relevant results and visualizations for interpretability.
Baril et al. (2016)	Patient outcome focused. Participative facilitated methodology used, combined with a Kaizen event for solution generation and rapid implementation. Stakeholders engaged in all processes.	V&V reported, including stakeholder engagement. Kaizen event to reduce barriers to implementation but model coded separately for sufficient detail and accuracy. Reported expertise in both facilitation and in data collection and model building.	Implementation was the goal from the start of the M&S process. Model coded separately but validated with staff and demonstrated in Kaizen event to stimulate discussion/ convergence.
Lamé et al. (2020)	Mixed methods study using ethnography, soft systems methodology (SSM), and DES. In-depth problem structuring, conceptual modeling, data collection, and scenario development in collaboration with stakeholders.	Researcher-in-residence research model. Calibration and validation reported to be limited by inadequate data, stakeholders involved in V&V process.	Apart from reported limitations to calibration and validation, limited information was provided about the DES model itself.

Of the four papers, Willoughby et al. (2016) provided the least descriptive narrative of the study and implementation processes, however the problem description (reducing wait times for speech pathology services) is comprehensive and strongly motivated with a patient focus. The use of triangular distributions and parameter estimates suggest that a simple model is used that provides a good indication of the direction of travel for each scenario, rather than an accurate set of outputs. The paper reports that the scenarios investigated were developed in collaboration with stakeholders, and that recommended system changes are low risk and low cost. Implementation is reportedly "based in large part on the results of this analysis".

While difficult to make judgements about the engagement process, the paper suggests that the modeling team were able to communicate their relevant skills, motivations and understanding of the problem situation and context. They used best practice given the requirements of the application to produce a model that was sufficiently accurate and valid for its purpose, and that relevant stakeholders were involved throughout the process. It remains possible that the simulation results told stakeholders what they already knew. However given the features described, it seems that the level of trust developed through a well-conducted study exceeded the threshold of perceived risk to enable decision-makers to engage in action, and in general, adherence to the Trust model appears high for its applicability and intended purpose.

Demir and Southern (2017) developed a complex decision-support tool for deep vein thrombosis patients (DVT) adapted with the sociotechnical allocation of resources (STAR) method to better address questions around costs, which were important to stakeholders. The motivation of the study was to provide the highest benefit for patients and the best value for money. Comprehensive domain-level understanding was demonstrated in the problem description and parameter estimation. Throughout the paper, significant emphasis was placed on the collaborative approach taken across the M&S lifecycle, for example: "The main strength of this decision support tool is the adoption of a team approach to studying the system, involving DVT specialist nurses across the country". The tool addressed usability issues, and was transparent regarding assumptions and simplifications. The paper suggests that comprehensive engagement and validation processes increased model and modeler credibility toward action and the reporting of the study enabled readers to gain an understanding of what processes were undertaken during the research. Some aspects of reporting were unclear, for example while the decision-support tool is implemented in practice, issues of updating and maintenance were not discussed, and model adaptation/re-use/replication were not addressed, although the authors emphasize the potential of the tool for NHS decision-makers. Again, adherence to each facet of the Trust model can be considered high, according to the reporting.

Baril et al. (2016) adopted a mixed-method approach using Lean methodology, facilitated modeling (*PartiSim*: Tako and Kotiadis 2015), and discrete-event simulation (DES) to focus the study on implementation from the beginning. This paper comprehensively records the study processes to improve patient pathways for outpatient hematology/oncology clinics. A structured project team included multi-level stakeholders, an experienced facilitator, modelers, and frontline staff. In particular, it was considered important to involve doctors in the research process. The model is described as accurate and validation is reported. The methodology is thorough and reported as time-consuming for both staff and researchers, but described successful implementation and evaluation. The authors describe the study process as a shared learning culture, where methods, role understandings, competences, interpersonal relationships and contextual factors are all directly relevant to the outcomes of the study. This process can provide feedback, enhance perceptions of model quality, and deepen stakeholders' understanding and ownership of the problem and its context. Adherence to the Trust model can be considered to be high.

Lamé et al. (2020) combined SSM with DES to reduce patient waits for outpatient chemotherapy using ethnographic methodology. Comprehensive problem-structuring, conceptual modeling and scenario generation was undertaken by the researcher-in-residence (RIR) with a team of stakeholders, including frontline staff. The model was reported to have undergone verification and validation. Solution generation proved to be a barrier in the research process, and the RIR was required to act as an analyst, a facilitator, and a knowledge provider, for example to patients. Following solution generation, implementation stalled as the risks of the extra costs required were not seen to outweigh the benefits due to plateaued activity levels. Simultaneously, significant environmental changes in the hospital were reported to have redirected the attention of decision-makers. Limited information was provided about the DES itself, which may have been a weakness of the study. This means that aspects of trust between the model and the stakeholder are unclear, although the model is reported as the core element for arguing implementation of proposed changes, which ultimately were not successful. Nonetheless, this paper detailed empirical analysis between stakeholders and the modeler, focusing attention on what worked (structuring the problem, generating options for change, synthesizing recommendations), and what did not (ultimately the results were not implemented). Due to uncertainty in the modeler-stakeholder and model-modeler facets, adherence to the

Trust model can be considered to be medium, based on reporting of the study. However, this reflective, critical approach to reporting an M&S study, focusing on problem clarity, individual impacts, and key factors and inter-relationships acknowledges how contextual factors can influence and inform trust in the knowledge gained by the study, and provides a basis for learning. The healthcare M&S literature continues to focus on technical applications, yet dissemination about the modeling process, the progression toward implementation, and contextual influences, even where projects 'fail', enables a better understanding of the factors that influence the effectiveness and generalizability of M&S.

5 DISCUSSION

Implementation of results of simulation studies remains sporadic in the healthcare domain. We argue that viewing M&S practice through the lens of trust can focus our attention on those areas of practice which enhance credibility and confidence, and therefore increase the likelihood of informing real-world practice. The review by Roy et al. (2020) has highlighted that neither model accuracy, nor user engagement and real-world application alone are adequate prerequisites to trust. The development of trust is multi-faceted and temporal, and depends on the type of decision-making activity being supported. Aspects include the competence and motivations of the modeler; the accuracy, validity, usefulness and transparency of the model with respect to its purpose; and the perceived level of risk involved in proposed recommendations. These aspects lie alongside environmental, contextual and individual factors such as competing objectives and change readiness, and are not static features, but continuous outcomes of processes over time.

These features were examined in a small subset of applied healthcare studies which reported impact. In line with previous reviews, our Web of Science query found 4 out of 110 healthcare simulation studies in the last ten years (2013-2022) - under 4% - reported results implementation. While this number is very small, some similarities across the studies were found. For example, all of the studies described comprehensive participatory problem-structuring and scenario definition phases, demonstrating a relevant, in-depth understanding of the problem situation. As the start of the process of trust-building, this greatly influences the acceptability and credibility of model results as stakeholders perceive that the modeler has achieved a good understanding (Tully et al. 2019). It establishes both the motives of the researcher and the purpose and context of the simulation study. Notably, three of the four studies used a mixed-methods approach to support rigor in capturing these aspects.

While none of the papers reported patient and public involvement, all of the papers explicitly stated improving patient outcomes as a goal, alongside operational performance measures such as reducing costs or increasing efficiency. Wider learning from healthcare quality improvement emphasizes the need to balance risks to quality and safety of patient care against potential efficiency gains toward delivering value. This shift from a 'quality' focus to a 'value' focus reflects the necessary emphasis on cost, while delivering quality outcomes for patients (Jabbal and Lewis 2018). For healthcare staff, the focus on value underlies all improvement efforts, and simulation studies in healthcare should be no different in their focus, conduct and application.

Competing objectives and conflicting priorities affect all sociotechnical systems, including healthcare organizations. The tension between managers, who drive goal-directed behavior and maintain operational performance, and clinical staff, who provide care, is well-recognized worldwide (e.g. Ranawat et al. 2009). A similarity across all four studies is that each engaged with frontline staff members. Managers are frequently viewed as decision-makers (Harper and Pitt 2004), however frontline staff are more likely to be involved in results implementation. Frontline staff may know how they would like to improve the service they deliver, but lack the expertise to frame those improvements in an acceptable manner for service managers. Additionally, all of the studies reported engaging with stakeholders across all stages of the M&S process, beyond the problem definition/conceptual modeling stages. This can enable a plurality of objectives and opinions in each phase, supports a process of social learning, and can increase stakeholder commitment through enhanced confidence in the modeler, the modeling approach and the recommendations.

While V&V was a reported feature of all four papers, Tolk et al. (2021) emphasized an aspect to the model-modeler trust facet, that of constraints on validation and verification in sociotechnical systems where 'truth' and 'trust' emerge from a constructivist view of knowledge creation. According to their argument, it is insufficient to limit ethical discussions to the modeler-stakeholder and model-stakeholder facets. The process of model construction and dissemination, including verification and validation should also be considered within the context of 'value' in a healthcare study to surface ethical assumptions across the M&S lifecycle, supporting the use of informative case studies such as those reviewed. Three of the four papers described sharing limitations and assumptions and involving stakeholders in V&V, although how these processes may have impacted the research is uncertain.

A notable feature missing from all studies was that of reproducibility and replicability. This is an important aspect of trust between the modeler and the model, as modelers assure themselves, project stakeholders, and the simulation community that their models and results are trustworthy, by adhering to high standards of practice and reporting. Academic modelers are part of a community of researchers, and share the responsibility for the rigorous execution and progress of good research. Confidence in published results is one reason for repeating or replicating a simulation, however it is not the only reason. Given the source code, the parameters, and documentation, other researchers or practitioners are able to study the details of the implementation, allowing the model to be tested under the same or varying conditions. For example, while a successful replication facilitates validation and reliability, a failed replication can produce novel insights, and enable improvements to model structure or data requirements (Zhang and Robinson 2021). With regard to both V&V and reproducibility, paying attention to the model-modeler facet of trust mitigates against issues of 'overtrust' (Yilmaz and Liu 2022).

Clearly when reporting on a study, decisions are undertaken regarding what aspects of the study to include and to omit. This restricts analysis of published papers using the method described. For example, a well-developed and appropriately detailed simulation model can require a complex process of investigation, which can be difficult to communicate in a written report (Monks et al. 2017). Additionally, many published studies may include a significant and complex level of stakeholder engagement which is not communicated in the paper. For this reason, a comprehensive understanding of contributing and moderating factors, and their relative strengths is unknown from this small sample of papers. Nonetheless, similarities were found across the implemented studies, and many of these features, such as a focus on improving patient outcomes, are infrequently reported in healthcare M&S studies.

Long and Meadows (2018) and Salmon et al. (2018) recommended exploring models of stakeholder engagement and implementation designed specifically for the healthcare domain, concluding that an implementation or evaluation plan should form part of an M&S study in healthcare. We recommend taking an approach to this which focuses on each trust facet (modeler-stakeholder, modeler-model, stakeholder-model) and addressing how these two-way interactions shift and can be managed across the M&S study processes, and how to communicate these features. Future research is needed to focus on aspects of these facets and their relationship to trust, such as the problem of knowledge transfer, communication and cognition between stakeholders and modelers; the empirical relationship between problem-structuring and trust (for example, as initiated by Tully et al. 2019); the social, ethical and theoretical implications of V&V in sociotechnical M&S applications (for example, as outlined by Tolk et al. 2021); and the trust implications of transparent documentation and communication, use of reporting guidelines, and other contributions to open science for reproducibility, reuse, and enhanced scrutiny in M&S (e.g. Grimm et al. 2020; Monks et al. 2019).

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