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## IS SIMULATION IN HEALTH DIFFERENT AND IS IT MORE DIFFICULT?

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### ABSTRACT

It is often stated that health simulation is quite different and even that it is more difficult. But, is simulation in health really different to simulation in other sectors? In this paper we explore this question through a survey of simulation modellers and academics. We elicit their opinions across a range of factors concerning the difficulties of health modelling against modelling in other domains. The results seem to corroborate the view that health simulation is different and that it is more difficult. However, further investigation into the backgrounds of those responding and the development of objective measures for the factors surveyed may show quite a different picture.

**Keywords:** Health Modelling, Simulation

### 1 INTRODUCTION

It is often stated that the application of simulation in health is different and even that it is more difficult. This is posited as one of the reasons why simulation has been less successful in health when compared to other sectors such as manufacturing and military applications (Brailsford et al, 2009; Naseer et al, 2009; Jahangirian et al, 2010). The difficulty for health modelling arises from factors such as complexity, multiple decision makers and busy stakeholders, which all pose particular challenges to simulation modelling in health (Eldabi 2009; Brailsford et al 2009; Harper and Pitt 2004; Kuljis et al, 2007). However, there does not appear to be any empirical evidence to back-up such a claim. Indeed, there is a danger of modellers from one application area making judgements about the relative ease or difficulty of their modelling task as compared to modelling in other sectors when they have only limited experience outside their immediate domain of interest. It may be that simulation modellers in any sector - be it health, manufacturing, military, services etc. - consider their modelling task to be very different, and possibly more difficult, than for any other sector.

In this paper we explore the question of whether health modelling is different and whether it is more difficult. A survey is carried out of simulation modellers' perceptions about the differences between modelling in health and other sectors. We start by providing a brief summary of the key differences proposed in the literature. Then we describe the questionnaire, how the survey was performed and the nature of the respondents. The results of the survey are reported before discussing what they might mean and further work that needs to be performed.

### 2 THE CHALLENGES OF SIMULATION IN HEALTH

A range of authors discuss the challenges and differences of simulation and modelling in health care. Brailsford et al (2009) suggest that simulation is an established part of the decision-making process in both manufacturing and the military, while in health there is no such widespread adoption of simulation.

They see a key issue being that it is very difficult to identify the stakeholders in a health environment. This relates to where the boundary of the problem being investigated lies, the accessibility of stakeholders, the differing time-scales to which health professionals and academics (modellers) work, and research ethics.

Eldabi (2009) also identifies stakeholder issues as a barrier to the implementation of simulation in health. In particular, he discusses the conflicting interests of the stakeholders leading to a set of conflicting goals. He also identifies issues emerging from a lack of relevant tools; most simulation software was originally developed for manufacturing applications. Again, the problem of a mismatch between the expectations of the modellers and the stakeholders is identified as problematic.

Young et al (2009) highlight three challenges for health modelling: developing models of appropriate detail, understanding how modelling is linked to decision-making, and dealing with the cultural barriers to modelling in the health sector. Meanwhile, Kuljis et al (2007) discuss seven axes of differentiation that set health modelling apart: patient fear of death, medical practitioners, healthcare support staff, healthcare managers, political influence and control, society's view, and utopia.

In their report on simulation for strategic planning in healthcare, Pitt et al (2008) identify many of the challenges listed above. In addition they point to the heterogeneity of healthcare organisations and the constantly changing environment. This makes the development of generic models particularly challenging. Indeed, Gunal and Pidd (2010) point out that many simulation studies reported in the literature are unit or facility specific and are never re-used.

In summary, the literature discussed above highlights some opinions, largely expressed by academics specialising in health, about the differences and challenges that differentiate simulation in health from its use in other domains. There does not appear to be any empirical evidence to back-up these claims. For all that we know, modellers in other domains could be facing difficulties of a similar nature. Our motivation for this research is to test the opinions expressed in the literature utilising a survey questionnaire on the views of health and non-health modellers.

### 3 THE SURVEY

The questionnaire that was used for the survey was developed from a review of the literature on the differences and challenges of modelling in health. What emerged was a range of factors that might differentiate health modelling which we classified under four headings as follows:

- *The Problem Perspective*: evident structure of problems, complexity of systems, rate at which the nature of the problem changes, messiness of the problems
- *The Cost and Data Perspective*: effort required to collect the data, difficulty in accessing data, problems created through ethical issues, ease of results interpretation
- *External Factors Perspective*: influence of political events, rate at which results become obsolete, appropriateness of simulation software
- *Organisational Factors Perspective*: incentive to initiate change, resistance to change, acceptance of study results, ease of developing generic models, clients lack of time, implementation difficulties due to busyness of clients, ease of identifying stakeholders

The questionnaire provided a statement about each of the above factors (e.g. 'in health there is less evident structure') and asked for a response according to a four-point Likert scale ('strongly agree', 'agree', 'disagree' and 'strongly disagree'), with a fifth 'not sure' option. As such, we were asking respondents to state whether they perceived health modelling to be more difficult or not. An 'or not' response ('disagree' or 'strongly disagree') would mean that they either perceived that no difference exists, or that modelling in other sectors for that factor is more difficult. Meanwhile, a 'not sure' response meant that they felt unable to comment, perhaps because they had limited experience of encountering that factor in health and in other sectors.

We recognise from the outset that the survey was measuring perceptions of the relative difficulties of health modelling. This in itself is almost certainly subject to bias based on the respondents' experience in performing simulation studies in different sectors. As such, the results provide a subjective measure of

the differences, based on perceptions, rather than an objective measure. We shall return to this issue in the conclusion of the paper.

At the end of the questionnaire the respondents were asked to state their overall opinion regarding the statement that simulation in health is different to other sectors. As for the other statements, they rated their response according to a four-point Likert scale with the fifth option to respond with ‘not sure’.

Prior to sending the questionnaire out, it was tested with two colleagues who provided useful feedback on how to improve the questionnaire. A pilot survey was also run with 14 randomly chosen attendees at the 2010 Winter Simulation Conference in Baltimore, Maryland. The preliminary results were analysed and some slight changes were made. The questionnaire was set-up on-line using the Bristol Online Survey (<http://survey.bris.ac.uk> accessed October 2011).

### 3.1 The Administration of the Survey

A request to complete the survey was sent to all authors of papers at the 2010 Winter Simulation Conference in Baltimore, Maryland. The data on conference paper authors is publically available from the proceedings which are held online at [www.informs-sim.org](http://www.informs-sim.org) (accessed October 2011), but it does take time to manually extract their email addresses. The list of authors does not cover all attendees at the conference and not all authors will necessarily have attended the conference, with some deferring the presentation of their paper to their co-authors.

An email was sent to all 444 conference authors; around 30 were returned as undeliverable. The email outlined the background to the survey and pointed the recipients to the web address for the questionnaire. To incentivise responses, all respondents who identified themselves were entered into a prize draw. The first prize was an Amazon Kindle and the two runners-up prizes were a copy of a book on conceptual modelling for simulation (Robinson et al, 2010).

### 3.2 The Survey Respondents

In total 121 responses were received, giving a response rate of about 29%, of which 113 were usable. Table 1 provides basic demographic data for the respondents according to the first three questions in the questionnaire. These show the simulation modelling experience of the respondents, the split of their modelling activity (research, teaching, consulting, other), and the split of their modelling work in different sectors (health, manufacturing, government, services, other). For the latter two, each respondent was asked to state the percentage split of their modelling work between the different activities and sectors. The results in Table 1 summarise the average of those percentages.

**Table 1 Demographic Data for the Survey Respondents**

<b>Experience in Simulation Modelling</b>				
Less than 3 years		3 - 10 years		More than 10 years
19%		36%		45%
<b>Split of Simulation Modelling Activity</b>				
Research	Teaching	Consulting	Other	
64%	20%	15%	1%	
<b>Split of Modelling Work by Sector</b>				
Health	Manufacturing	Government	Service	Other
24%	33%	17%	11%	15%

The respondents generally have a high level of experience with 45% having spent more than 10 years working in simulation. As would be expected from authors at a primarily academic conference, the respondents spend most of their time in research activities and only 15% in consulting work. However, given the applied nature of much simulation research and the papers at the Winter Simulation Conference, it is likely that a significant proportion of the respondents’ research involves working on real problems.

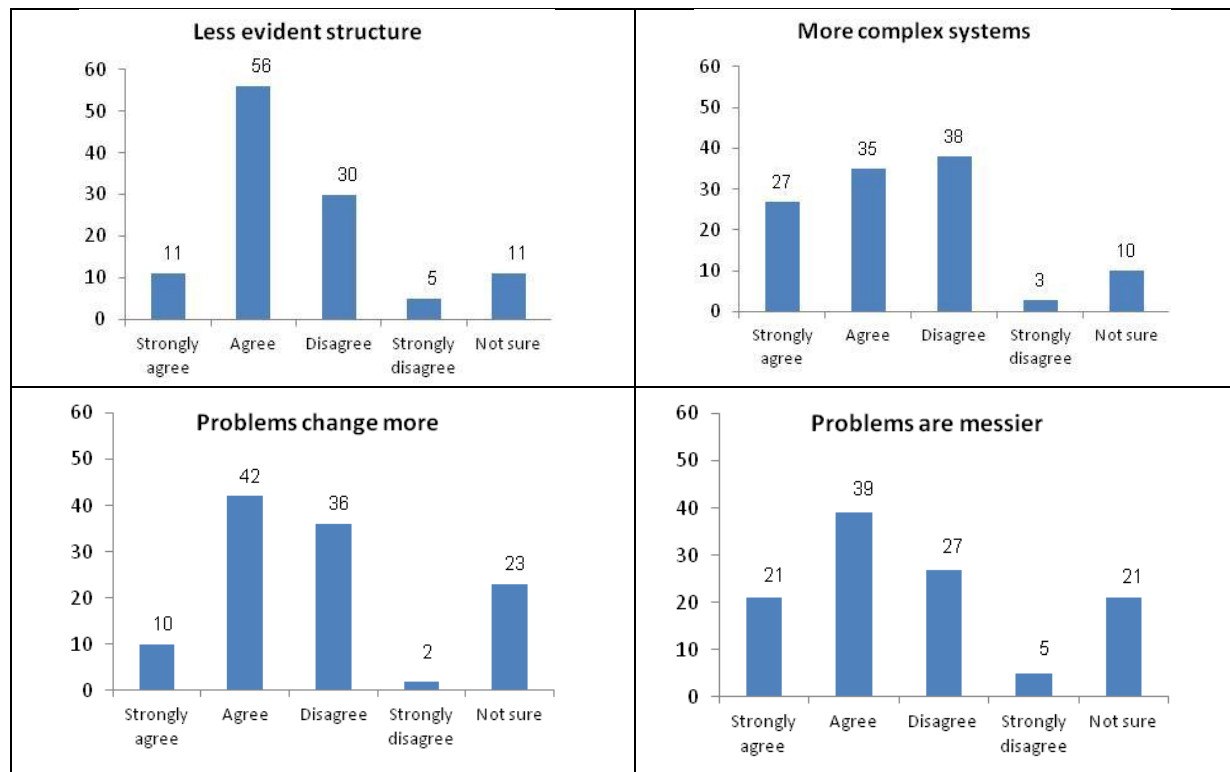
The highest proportion of the respondents' time involves working in the manufacturing sector, with health coming in second at 24%. The percentage of work in health is surprisingly high, but probably reflects a higher interest in the survey from those working on health related problems.

#### 4 RESULTS OF THE SURVEY

We now present the results from the survey based on the factors under the four perspectives outlined in section 3. We also report the results of the overall opinions about whether health modelling is different to other sectors.

##### 4.1 The Problem Perspective

The four statements on the problem perspective aimed at gauging respondents' opinions about the difference in the nature of problems modelled in health compared to other domains. The bar charts in Figure 1 show respondents' opinions on a 4-point Likert scale and a 'not sure' option, for the four separate statements included under the problem perspective.



**Figure 1** Frequencies of respondents' opinions about the difference between modelling in health and other domains with respect to the nature of problems

A close observation of the bar charts (Figure 1) reveals that on the whole there are proportionally more responses in agreement with the statements on the less evident structure, more complex systems and messier problems (including both strongly agree and agree positions), compared to disagreement positions (including both disagree and strongly disagree). This suggests that there is a tendency in respondents' opinions to agree that modelling in health is more difficult in relation to these factors. On the contrary, respondents' opinions on the statement that problems change more, are reasonably equally divided between agree and disagree positions. In this paper we are mainly interested in identifying whether there is a difference between the agree and disagree positions for these statements. Hence, to confirm these observations, we use the binomial test (Sheskin 2007), where we compare the proportion of

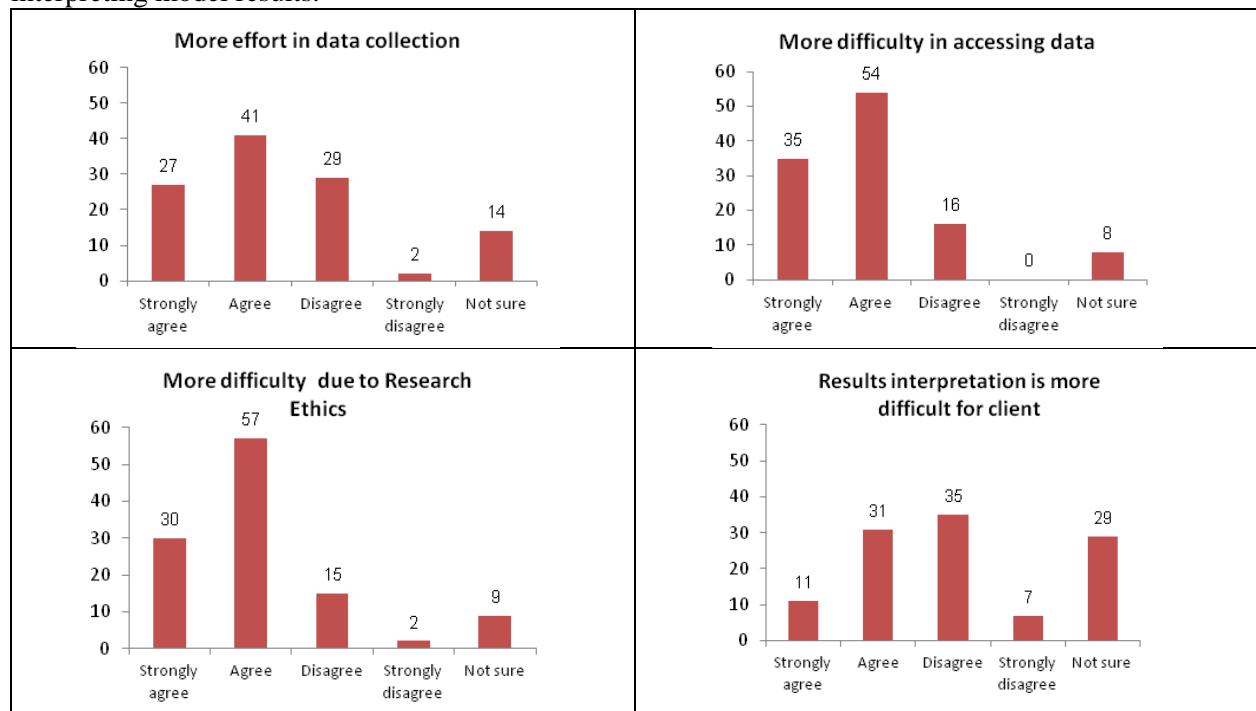
respondents’ opinions between the amalgamated agree and disagree categories. We test against the null hypothesis that there is no difference in the level of difficulty between modelling in health and other sectors. At a 5% level of significance, the test confirms these observations (Table 2), hence concluding that respondents tend to support the view that modelling in health is more difficult due to the less evident structure, more complex systems and messier problems, but respondents’ views were almost equally divided on the statement that problems change more in health than in other sectors.

**Table 2** Proportion of grouped agree and disagree opinions on the nature of problems and the results of the Binomial test comparing the two groups against the  $H_0$ : there is no difference in the level of difficulty between modelling in health and in other sectors

	Agree	Disagree	Binomial test (p-value)	Conclusion: Is health modelling more difficult?
Less evident structure	66%	34%	p-value = 0.02	Yes (Reject $H_0$ )
More complex systems	60%	40%	p-value = 0.049	Yes (Reject $H_0$ )
Problems change more	58%	42%	p-value = 0.171	No (Do not reject $H_0$ )
Problems are messier	65%	35%	p-value = 0.005	Yes (Reject $H_0$ )

#### 4.2 The Cost and Data Perspective

The four statements included in this question aim to identify respondents’ opinions about the differences in the difficulties faced in health and other sectors in terms of cost and data requirements involved. For each statement the number of responses on the 4-point Likert scale and a ‘not sure’ option is presented in Figure 2. The majority of respondents agree or strongly agree with the first three statements that issues related to data collection, data access and research ethics make modelling in health more difficult. A different view is taken by respondents with respect to difficulties encountered due to client difficulties in interpreting model results.



**Figure 2** Frequencies of respondents’ opinions about the difference between modelling in health and other domains with respect to data issues

To confirm the above observations, the binomial test is used (Table 3) showing that at a 5% level there is a significantly higher proportion of agree and strongly agree responses that modelling in health is more difficult for the first three factors. However, opinions are equally divided on the difficulties encountered due to the client finding the interpretation of model results difficult.

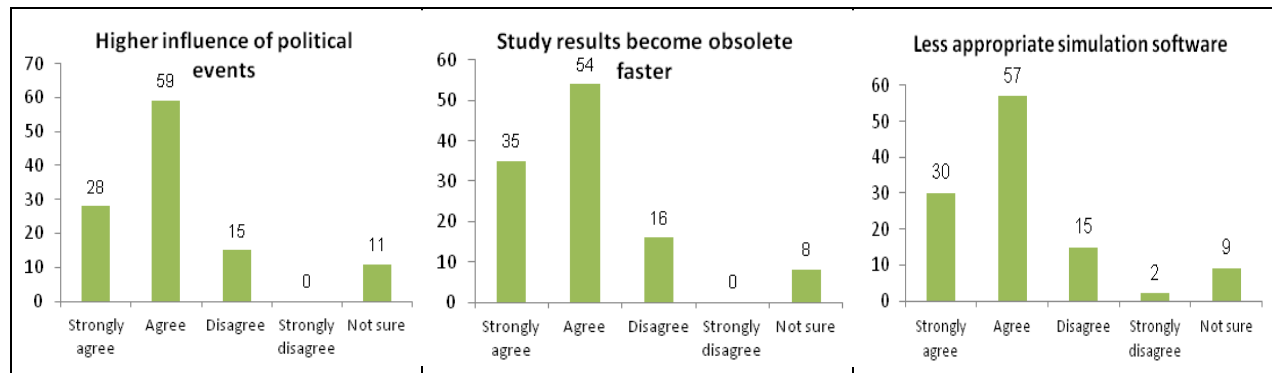
**Table 3** Proportion of grouped agree and disagree opinions on data issues and the results of the Binomial test comparing the two groups against the  $H_0$ : there is no difference in the level of difficulty between modelling in health and in other sectors

	Agree	Disagree	Binomial test (p-value)	Conclusion: Is health modelling more difficult?
More effort in data collection	69%	31%	0.000	Yes (Reject $H_0$ )
More difficulty in accessing data	85%	15%	0.000	Yes (Reject $H_0$ )
More difficulties due to Research Ethics	84%	16%	0.000	Yes (Reject $H_0$ )
Client finds interpretation of results more difficult	50%	50%	1.000	No (Do not reject $H_0$ )

### 4.3 External Factors Perspective

Three statements aimed to identify whether modelling in health is more difficult due to the effect of external factors: the influence of political events, the availability of simulation software and the rate at which results become obsolete. Figure 3 shows the frequency of respondents’ opinions about each statement on the 4-point Likert scale and the ‘not sure’ option. The majority of the respondents seem to agree that these factors are more difficult to deal with in health than in other domains.

The binomial test (Table 4) shows that at a 5% level there is a significant difference between the agree and disagree positions. This implies that modelling in health is more difficult due to these three external factors.



**Figure 3** Frequencies of respondents’ opinions about the difference between modelling in health and other domains with respect to the effect of external factors

**Table 4** Proportion of grouped agree and disagree opinions on effect of external factors and the results of the Binomial test comparing the two groups against the  $H_0$ : there is no difference in the level of difficulty between modelling in health and in other sectors

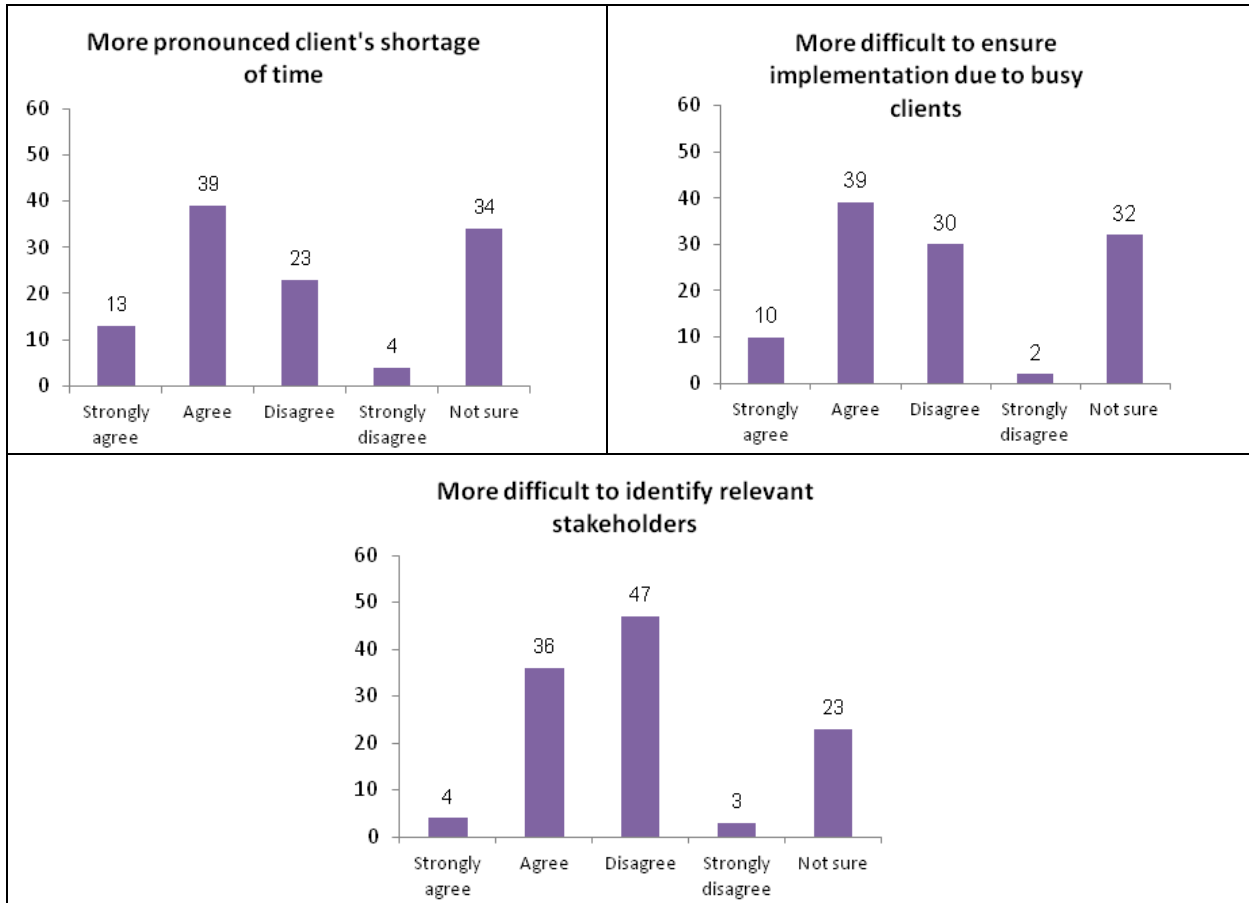
	Agree	Disagree	Binomial test (p-value)	Conclusion: Is health modelling more difficult?
Higher influence of political events	85%	15%	0.000	Yes (Reject $H_0$ )
Study results become obsolete faster	85%	15%	0.000	Yes (Reject $H_0$ )
Less appropriate simulation software	84%	16%	0.000	Yes (Reject $H_0$ )

#### 4.4 Organisational Factors Perspective

Seven statements investigated perceptions about the organisational differences between simulation in health and other sectors. The bar charts in Figure 4 show the respondents’ answers. A relatively higher number of agree responses are observed for the statements: less incentive to initiate change, more resistance to change, difficulty in developing generic models, more pronounced shortage of client time, and more difficulty in ensuring results are implemented. For the latter 2 statements, a relatively high number of ‘not sure’ answers can be also observed. An equal number of agree and disagree responses is observed for the statement that there is more resistance to accepting simulation results in health, where a relatively high number of ‘not sure’ responses is also present. However, there are relatively more disagree responses with respect to the statement that in health it is more difficult to identify relevant stakeholders.



**Figure 4** Frequencies of respondents’ opinions about the difference between modelling in health and other domains with respect to organisational factors



**Figure 4 cont ...** Frequencies of respondents' opinions about the difference between modelling in health and other domains with respect to organisational factors

The binomial test (Table 5) confirms the observations above with the exception that there is no significant difference between the agree and disagree responses for the factor: more difficulty in ensuring results are implemented.

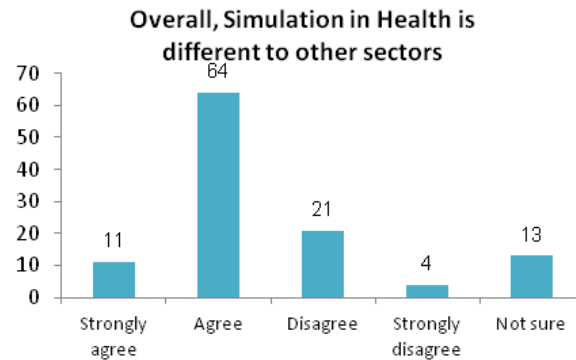
**Table 5** Proportion of grouped agree and disagree opinions on effect of organisational factors and the results of the Binomial test comparing the two groups against the  $H_0$ : there is no difference in the level of difficulty between modelling in health and in other sectors

	Agree	Disagree	Binomial test (p-value)	Conclusion: Is health modelling more difficult?
Less incentive to change	61%	39%	0.038	Yes (Reject $H_0$ )
More resistance to change	66%	34%	0.002	Yes (Reject $H_0$ )
Resistance to simulation results	55%	45%	0.445	No (Do not reject $H_0$ )
More difficult to develop generic models	71%	29%	0.000	Yes (Reject $H_0$ )
Clients shortage of time	66%	34%	0.007	Yes (Reject $H_0$ )
More difficult to ensure implementation	60%	40%	0.075	No (Do not reject $H_0$ )
More difficult identifying stakeholders	44%	56%	0.343	No (Do not reject $H_0$ )



#### 4.5 Overall Opinions: Health Modelling is Different to Other Sectors?

The final question of the survey asked for respondents' opinions about whether modelling in health is different to other sectors. The responses are displayed in Figure 5, where the majority (64) of the respondents (57%) agree and 10% (11) strongly agree with this statement. The binomial test comparing the proportions between the combined agree and disagree positions confirms that there is a significant difference in the answers to the two positions with  $p\text{-value} = 0.000$ .



**Figure 5** Frequencies of respondents' opinions about the overall difference between modelling in health and other domains

## 5 DISCUSSION AND CONCLUSION

The results show that for most of the factors a significant majority of respondents perceive that health modelling is more difficult than in other sectors. In summary, according to the respondents' opinions in health modelling there is:

- Less evident structure
- More complex systems
- Messier problems
- More effort required for data collection
- More difficulty in accessing data
- More difficulties due to research ethics
- Greater influence from political events
- More rapid obsolescence of study results
- Less appropriate simulation software
- Less incentive to initiate change
- More resistance to change
- Greater difficulties in developing generic models
- Less client time available

Added to these, the overall perception of the survey respondents is that health modelling is different.

Of course, we must discuss the validity of these results. We have already recognised that the survey measured the respondents' perceptions and as such it is not based on objective evidence. What the survey shows is that many of the respondents agreed with the literature statements about the difficulties of health modelling. It would be useful now to try and identify objective evidence to corroborate these perceptions. For instance, could we measure the time spent collecting and analysing data in typical simulation studies in health and other sectors? Can we measure the complexity of the systems and models generated in different sectors? Could we determine the availability of clients in different sectors? These are not necessarily easy to measure, but it might be possible to identify and measure indicators for each factor.

Given the relative high percentage of simulation work performed in health by the respondents, this might suggest some bias in the results. We might assume that most modellers consider their own domain

of application to be more complex than others, because they know the detailed requirements for modelling in that sector. If this is the case, then there would be a tendency towards a perception of greater difficulty in health modelling due to the demographics of those that responded. To mitigate this, we intend to perform a more detailed analysis based on the individual respondent's areas of expertise. For instance, what is the difference in the opinions of the respondents with no experience in health modelling, and what about those that have significant experience in both health and other sectors?

Although a significant majority perceived greater difficulty in health modelling for most of the factors, there are many respondents that do not agree. What we do not know is whether they believe there is no difference for those factors, or whether they believe that modelling in the other sectors is more difficult. It would be interesting to investigate this in more detail.

For now, our results show that it is perceived that there are significant differences in health modelling and that health modelling is generally more difficult. Further investigation is required to determine whether these results continue to hold when more objective measures are applied.

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