Title: Simulation modelling for psychiatric service planning: a mixed methods protocol

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ABSTRACT..................................................................................................................................3

Background....................................................................................................................................3

Objective.......................................................................................................................................3

Methods.........................................................................................................................................3

Results...........................................................................................................................................4

Conclusion.....................................................................................................................................4

Keywords.....................................................................................................................................4

Decision-making; health care; health services administration; mental health; protocol; mixed methods; modelling; simulation....................................................................................4

Background....................................................................................................................................4

Objectives......................................................................................................................................5
Methods ........................................................................................................................................6
Study design ......................................................................................................................................6
Intervention design ..........................................................................................................................6
Evaluation design ................................................................................................................................7
Study setting ........................................................................................................................................7
Recruitment ........................................................................................................................................8
Adaption to sample scope ................................................................................................................9
Intervention .........................................................................................................................................9
Phase 1: Development of a conceptual framework ............................................................................9
Phase 2: Integration with Arena® .....................................................................................................11
Phase 3: Validation of the model .........................................................................................................12
Phase 4: Implementation of the model ...............................................................................................12
Adaptations to intervention ................................................................................................................12
Evaluation ..........................................................................................................................................13
Process change ..................................................................................................................................13
Mental model change ........................................................................................................................13
Adaptations to evaluation ..................................................................................................................14
Data collection and management ......................................................................................................15
Analyses .............................................................................................................................................16
Mental Models ...................................................................................................................................16
Linguistic coding framework ..............................................................................................................16
Thematic analysis ...............................................................................................................................17
Discussion .........................................................................................................................................17
List of abbreviations used ..................................................................................................................18
Declarations .......................................................................................................................................18
Ethics approval and consent to participate .....................................................................................18
Research ethics approval ................................................................................................................18
Consent to participate .......................................................................................................................19
Discontinuing participants ...............................................................................................................19
Consent to publish ............................................................................................................................19
Availability of data and materials .....................................................................................................19
Competing interests ........................................................................................................................19
Funding ...............................................................................................................................................20
Author contributions ........................................................................................................................20
ABSTRACT

Background

Mental health service managers must take into account multiple factors when making decisions about the best way to deliver care to clients across increasingly larger service areas. This task is made more difficult by the lack of evidence and tools historically available to inform these decisions. In recent decades the increasing availability of epidemiological and service use data for mental illness has solved the problem of evidence, but there still exists a challenge to make this data easily accessible and understandable for managers.

Objective

This study aims to develop a simulation modelling tool to allow managers to explore various service configurations in virtual reality, enabling predictions to be made about the cost and quality of care.

Methods

The design is a longitudinal mixed methods case study, comprising overlapping intervention and evaluation phases. In partnership with senior managers of a mental health program, the researchers will develop a series of simulation models in Arena® to address key strategic issues facing the service. Thematic and content analysis of semi-structured interviews, meeting observations and document analysis will be used to evaluate the process of model implementation and the outcomes for both researchers and managers. The study is conducted in Australia.
Results

Data collection has been ongoing since late 2013. Three prototype simulation models have been developed and presented to senior managers, and 18 evaluation interviews have been conducted. The project is expected to conclude in late 2018.

Conclusion

Findings have the potential to shape decision-making in mental health service delivery, by providing key examples of how to integrate patient data using simulation modelling. It will also provide key insights into how researchers and consultants can effectively implement simulation modelling in real world healthcare organisations.

Keywords

Decision-making; health care; health services administration; mental health; protocol; mixed methods; modelling; simulation

BACKGROUND

The health care sector is characterised by complexity, where balancing the demands of multiple stakeholders in geographically disparate areas makes the task of service-wide strategy planning extraordinarily difficult. In mental health, this is exacerbated by the heterogeneity of illness severity, persistence, treatment response and treatment need; and the multitude of entry points and patient pathways through the mental health system.

In the clinical space, this complex environment is managed through the use of evidence-based practice, and clinical simulations to provide staff with decision-making experience in a low-risk environment. In healthcare management, mechanisms for evidence-based decision-making are much less ubiquitous. Instead managers have traditionally relied on personal knowledge and experience to make small incremental service changes within a quality improvement framework. Unfortunately, the inherent risks of the “try it and see” approach
make it unsuitable for the large scale service reforms currently being called for in the Australian mental health sector. Thankfully, ongoing improvements in technology and electronic patient records have created a fertile environment for the translation of decision support tools from others sectors, including that of simulation modelling.

Simulation models are simplified abstractions of real systems, often created on a computer. They allow the user to predict future states by tracking changes in the system over time, with these changes determined by: attributes assigned to individuals or entities (agent-based modelling); time-specific state transitions (Markov models); events (Discrete Event Simulation); or system flows (System Dynamics). Simulation modelling is claimed to improve the rationality of decision makers and therefore improve decision quality, by allowing problem boundaries and alternatives to be explored safely and inexpensively.

However, there is little direct evidence provided to support these claims. Published reviews of healthcare simulation continually highlight the lack of implementation reporting as a main problem facing the literature. Indeed, a recent review of mental health care simulation found only 10 articles reporting basic details of model implementation. While this lack of reporting may simply reflect a publication bias, it more likely reflects the difficulty in implementation, including the time and financial costs associated with increasing model complexity to match the clinical complexity of the healthcare environment. However, it is this very complexity that calls for the use of simulation, and the transparent reporting of implementation.

Hence this paper describes the protocol for the development and implementation evaluation of a simulation model depicting the real-world activities of an Australian public Mental Health Service (MHS).

**Objectives**

The study has two primary aims.
1. a) To develop a sophisticated healthcare management decision support tool, and b) bring it into practical use by managers of mental health services as they go about service reform and redevelopment.

2. To evaluate the effectiveness of this decision support tool in improving the: a) process, and b) outcome, of strategic decision-making by the mental health service managers.

**METHODS**

**Study design**

The intervention and evaluation follow an iterative, mixed method design. The intervention and evaluation timelines are staggered, but intentionally overlap, to allow evaluation results to inform refinements to the intervention in the latter stages of the study.

**Intervention design**

The intervention has four major phases: 1) Development of a conceptual framework for the simulation model; 2) Integration with simulation software; 3) Validation of the model; and 4) Implementation of the model within the MHS (see Figure 1). In the first phase, we will analyse the components and functionalities of a mental health system and develop the architecture of a generic framework for the simulation model so that it can be embedded into any commercially available simulation modelling tool. In the second phase we will embed the framework into Arena® simulation software (a widely used modelling tool). The third phase will involve extensive validation of the model using data from the MHS. In the final phase, the model will be implemented as a decision-making tool within the MHS. The tasks in the phases will occur in parallel with some overlap between phases to provide a mechanism for each component to benefit from the outcomes of the progressive development and evaluation.
Evaluation design

The evaluation design is a longitudinal mixed method case study that parallels the intervention. Analysis focuses on two levels, outcome and process.

Outcome will be measured by changes in mental models reflecting increased decision process agreement, and increased similarity to the rational decision making model. Outcome will also be measured by researcher and participant perceptions of intervention success, behavioural change, and cognitive change, as extracted by thematic analysis from exit interviews.

Process will be assessed by group changes in behavioural and linguistic patterns during the intervention workshops, reflecting increased similarity to the features of good group decision-making processes. These observations will be triangulated against participants’ self-report of workshop success extracted via an evaluation questionnaire.

Study setting

The research was conducted with the cooperation of the senior leadership group (SLG) of a major public Mental Health Service (MHS) in Australia. The MHS provides government-funded inpatient and community mental health services across the age spectrum, with different, but overlapping catchment areas for Early in Life Mental Health Services (ELMHS, under 25 years), adult, and aged (over 65 years) services. There are three operational service groups, ELMHS, community services, and bed based services, and three primary hospital sites, which were added to the organisational chart in 2016. The MHS employs approximately 800 staff who provide approximately 250,000 client contacts per year, at a total cost of $125 million, 8.0% of the health provider’s operating expenditure.
Strategic decision-making for the MHS lies with the SLG. Members of the group attend monthly meetings as representatives of their clinical specialty (psychiatrists, psychologists, allied health and nurses), operational units, administrative units (finance and human resources), and allied research/university groups. Membership of the SLG include the Chief Investigator (CI) and an Associate Investigator of the intervention project, who brokered access to the group.

Recruitment

At the start of the evaluation project, off-the-record interviews were conducted with organisational gatekeepers (i.e. MHS managers who were also investigators on the project) to gain a basic understanding of strategic decision-making in the MHS. The Executive Director also invited the researchers to brief the participants on the project (October 2013) and informally observe a senior leadership meeting (November 2013).

The SLG emailing list was then used to invite participants to workshops and interviews. This ensured that data was collected only from active decision-makers and members of the SLG. All participants were contacted at least three times for each data collection point, unless they had previously withdrawn from the study. All communication regarding meeting scheduling was logged, including cancellations and rescheduling. To date, seventeen managers have participated in at least one data collection (see Error: Reference source not found for a summary of participation patterns).
Adaption to sample scope

Due to instability in the membership and meeting schedule of the SLG during 2014/15, participant access for interventions and their evaluation became limited. There was also significant organizational staff turnover, with 9 managerial departures, 8 internal promotions and 4 external hires. Only six of the recruited participants remained in the senior management group for the duration of the project.

For the intervention, engagement became reliant on the interests of individual participants, with ad-hoc one-on-one and small group discussions replacing workshops and presentations with the entire SLG. These interactions were facilitated by the dual membership of the CI as both researcher and participant.

For evaluation, the scope of the project was expanded to include the experiences of the researchers in responding to this environment. Hence all researchers who were actively involved in the project between 2014 and 2016, defined by attendance at a minimum one project meeting, were invited to participate in interviews in 2017. Of the nine investigators named on the project grant, 3 were actively involved and agreed to participate, including the CI. An additional 2 project members, not included on the initial grant, also agreed to participate. Research team meeting minutes and notes were also retrospectively added to the data analysis, with the consent of the research team and the appropriate ethics amendments.

Intervention

Phase 1: Development of a conceptual framework

In the first phase, we will analyse the components of a mental health system and develop a generic framework for the simulation model. Sub-phases will be: a) Scenario generation, b) Entity modelling, c) Parameter modelling, d) Temporal changes modelling and e) Output.
Scenario generation

Participants will be consulted to determine the scenarios to be modelled. However, three
general model scenarios are planned: 1) policy change affecting the structure of services; 2)
population distribution changes; and 3) organisational innovation in delivery of care models.

Entity modelling

The main entities of this model are patients, staff, services and resources (e.g., budget
allocation), with their interactions representing the activities of an actual health care system.
A priority-based queuing model will be adopted to allocate services based on patient severity
and need. A patient will be allocated for a set of services within a selected service component
where a particular service is provided by a set of staff who use a set of resources.

Parameter modelling

Parameter modelling consists of two components, namely, calculation and prediction. During
the model building phase this module will calculate arrival and transition rates and length of
stay using the observational data for a given scenario. During the validation and the
predictive assessment phases, the values of the above parameters will be predicted taking into
consideration the expected changes and the data for validation.

Temporal changes modelling

The temporal changes that mainly influence the mental health system are demographic and
 technological change. Demographic changes largely result from changes in birth and
migration rates, and will be projected from data available through the Australian Bureau of
Statistics.
For assessing the impact of a service component or policy option in terms of health gain we plan to use two quantitative measures, namely, QALY (quality adjusted life year) and DALY (disability adjusted life year).

QALY is an outcome measure for evaluating burden of disease. It takes into account both the quantity and the quality of the extra life provided by a healthcare intervention or policy option and is calculated as the product of the life expectancy and the quality of the remaining years. While QALY is useful for cost-effectiveness analysis, weights used in calculation are not linked to a particular disease, condition or disability, rather they are based on the individual’s health state.

DALY is a measure of disease burden that captures both morbidity and mortality effects for a wide range of disorders and interventions and the baseline information for health status in Australia is readily available. DALY incorporates disability weight that assigns different weights at different ages; and disability weight values for particular mental health disorders and different categories (e.g., mild, severe) are available in the literature.

The model will allow end users to choose either of the measures through a graphical user interface. Apart from the QALY and DALY, impacts on blocking rate and resource utilization will be investigated and specific illness outcomes could be considered, depending on the focus of the scenario chosen.

Phase 2: Integration with Arena®

A specialist in modelling will build a simulation model in Arena®, a widely-used discrete event simulation tool. It will include different modules that represent process, entity, queue and others elements. The output of the simulation model will be used to create custom statistics, a built-in feature in Arena®. Once developed it will require minimal effort by MHS...
managers to upload instances of a particular entity or update them as required, offering
flexibility and the capacity for managers to use the system autonomously.

Phase 3: Validation of the model

The data collected from the MHS will be divided into two sets. One will be used for model
building, while the other will be used for validation, the two sets being mutually exclusive.
To test quantitatively how adequately the model represents the actual system, within the
service components of a particular scenario, we will compare the model output with actual
historical (ground truth) values. For this, the values of the model output parameters (e.g.
changes in QALYs, waiting time, resource utilisation) will be compared with their respective
ground truth values through a statistical goodness of fit test (e.g., chi-squared). In a similar
way to test the model for predictive performance, the output of the model in response to the
validation data will be quantitatively compared with their corresponding ground truth values
(known because the validation set is also part of available historical data). Strong agreement
between the model output and the corresponding actual values will provide assurance of the
model’s accuracy in emulating the actual system.

Phase 4: Implementation of the model

The project will also involve the provision of training to SHMHS managers in the use of the
simulation modelling tool to guide decision making regarding the configuration and
resourcing of SHMHS. Such training and the availability of the simulation model will enable
SHMHS managers to adopt new approaches to service management, with their decision
making being underpinned by much stronger evidence than is currently available.

Adaptations to intervention

To capitalise on participant interest stimulated by the October 2013 project briefing, a
program logic modelling (PLM) workshop was scheduled during the SLG meeting in
December 2013, with a follow up workshop scheduled for July 2014. The aim was to generate inputs for the creation of the simulation models (Phase 1 of the project), and to continue participant engagement in the project. The PLM workshops were facilitated by an experienced external contractor. In the first workshop, participants were prompted to identify strategic issues challenging the MHS, and their consequences for the organisation, staff and consumer. The aims of the second workshop were to validate the outputs of the previous workshop and to confirm the organisational structure of the MHS prior to integration with the modelling software.

**Evaluation**

**Process change**

Research on problem structuring methods and group model building claim that immediate changes in decision-making process will be evaluated through the observation of participant interactions during simulation workshops, and a self-report survey on workshop effectiveness. Survey questionnaire items were derived from a frequency analysis of the claimed benefits of PLM in journal articles focusing on PLM methodology and evaluation. This yielded 14 items rated on a Likert scale (5 = *strongly agree* and 1 = *strongly disagree*; Table 2).

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**Mental model change**

The primary outcome of interest is a change in the strategic decision-making of the SLG to incorporate greater amounts of evidence. This will be captured by comparing the decision-making mental models of SLG members pre- and post- intervention, within the group
314(similarity), and to ideal standard (i.e. rational decision-making; accuracy). Mental model
315similarity and accuracy are both predictive of increased group performance.

316To extract mental models of current decision-making, participants will be asked, “If a new
317staff member arrived today, what would you tell them about how decisions get made by the
318management team?” They will then be prompted with statements such as: “and before that?”
319“after that?”. Concept maps of current decision-making processes were created during the
320interview, and validated against interview transcripts. In order to assess test-retest reliability
321of the elicitation method, during the exit interview, participants were again asked, “If a new
322staff member arrived today, what would you tell them about how decisions get made by the
323management team?”.

324Adaptations to evaluation
325The adaptations in intervention necessitated an adaptation in evaluation. Of most impact was
326the lack of group meetings or workshops, meaning that group processes were no longer able
327to be directly studied through observation or questionnaire. The ad-hoc nature of meetings
328with participants exacerbates the lack of structured data collection, necessitating a greater
329reliance on document analysis and interview content in the analysis stages.

330Document analysis includes business plans, strategic documents, meeting minutes and other
331documentation relevant to the decisions addressed by the study. Documents were released by
332the MHS Office of the Executive Director and the CI. These documents were used to
333establish a decision-making context and to track the development of decisions prior to the
334initiation of this project. Public document sources that provide participant demographic
335information, organisational information, and government policy information were also
336accessed when required.
Interview content was also expanded to include more open-ended reflections from participants and researchers on the project, discussing topics of expectations, learning and possible external factors affecting the implementation (Tables 3 and 4).

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**Data collection and management**

Eighteen interviews were audio-recorded and transcribed verbatim, with one participant refusing a recording of their exit interview, instead allowing note-taking. All audio recordings, notes, and documentation were imported into the qualitative data analysis software NVivo 10 for analysis.

Field notes were kept documenting the time, date, general content and personal emotions and thoughts associated with contact with participants, and beginning in 2015, researchers.

To maintain a close relationship to the data and the participants, study data is stored in identifiable format in password protected files and folders on password protected computers located at the core administration site. These can only be accessed by the research staff. The study data will be stored for a minimum of 7 years, after this time it may be confidentially destroyed.
Analyses

Mental Models

Content analysis of the interview transcript was used to review and refine the interview diagram into a concept map. Each individual’s content map was transcribed into a matrix formation with an arbitrary distance of 1, and input into the network analysis software JPathfinder for quantitative analysis. Participant’s individual models were compared to each other in a pairwise fashion, generating a matrix of similarity values (Pathfinder r). This range was used to represent the overall group model similarity.

Group-level concept maps will be created manually by combining all current concept maps, noting agreement by the count of participants who mentioned each concept or a similar construct. This procedure will be repeated for the second time point. Group-level mental models at each time point will then be compared against each other to assess any changes over the intervention period.

Linguistic coding framework

Linguistic coding will be used to assess the process effects of the PLM workshops. Initial codes were derived from the literature on the benefits of problem structuring methods and group model building, and then matched to concept descriptions and behavioural examples (Error: Reference source not found). Transcripts of the group discussions will be assessed for similarity to ideal behaviour as defined by the literature, for example, equal participation among participants.
Thematic analysis

Participant and researcher interviews will be analysed using thematic analysis. Open coding was used to explore the data prior to an iterative process of thematic refinement involving member checks and the exploration of alternative interpretations. These interpretations will be presented to the participants, providing them with the opportunity to provide further comment. The researcher-participants were also involved in the written publication of the analysis, ensuring shared ownership of the project evaluation and recommendations.

DISCUSSION

This research protocol outlines the implementation and evaluation of simulation modelling in the planning of mental health services in Australia.

As a case study, this research design has both advantages and limitations. The iterative design of the intervention allows easy adaptation to the changing organizational context, however, this comes at the cost of clear data points for quantitative evaluation. This is addressed by favoring a qualitative case study approach for evaluation, at the cost of generalizable findings. However, given the lack of reporting on simulation implementation in the past, such deep access and analysis provides a unique opportunity to understand the realities of translational research in this area.

Following completion of the project, we expect that the modelling system will be a valuable decision support tool to be used by MHS managers, and will be ultimately integrate into the process of decision making around service configuration and allocation of resources within the MHS. The challenges faced by the project thus far, especially the instability of the healthcare context, are not unusual. Hence lessons from this research have the potential to improve the implementation of future research projects, providing greater evidence-based service planning for the mental health sector in Australia.
LIST OF ABBREVIATIONS USED

CI – Chief Investigator

DALY - Disability Adjusted Life Year

ELMHS – Early in Life Mental Health Service

QALY - Quality Adjusted Life Year

MHS – Mental Health Service

SLG – Senior Leadership Group

DECLARATIONS

Ethics approval and consent to participate

Research ethics approval

The project was approved by the Human Research Ethics Committee of the partner Mental Health Service, with approval from 5 December 2013 until 9 January 2019.

The intervention component of the project received reciprocal approval by the Human Research Ethics Committee at Monash University (CF14/1072 – 2014000460 and CF14/48 – 20152013001967). The evaluation component of the project received reciprocal approval by the Human Research Ethics Committee at Monash University (CF14/48 – 2013001967 and CF14/48 - 2013001967).
All protocol amendments were submitted to, and approved by, the Human Research Ethics Committee of the partner Mental Health Service, using the appropriate ethic amendment forms.

Consent to participate

Signed consent is obtained from all participants during their first in-person contact with the study. Any information gained in connection with this research project that can identify individuals will remain confidential. All information will be stored in password protected files and folders on password protected computers. These can only be accessed by the research staff.

Discontinuing participants

All participants are advised at the beginning of participation in the study and in the consent form that they can discontinue participation at any time. Data already collected will still be used in the analysis unless the discontinuing participant specifically requests that it be removed.

Consent to publish

Not applicable.

Availability of data and materials

Only investigators and approved researchers added by ethics approval will have access to the data set.

Competing interests

The authors declare that they have no competing interests.
Funding

This article presents the protocol for independent research conducted within a project funded by the Australian Research Council’s Linkage Projects scheme (LP110200061) titled “Improving management decisions in mental health care through applications of advanced simulation modelling”. Additional research funding was provided by the Department of Psychiatry, Monash University, and the University of Calgary. The views, analyses, interpretations, and conclusions expressed in the article are those of the author, not of the Australian Research Council, Monash University, or University of Calgary.

Author contributions

Graham Meadows was responsible for the design of the intervention. Katrina Long was responsible for the design of the evaluation. All authors read and approved the final manuscript.

Acknowledgements

We acknowledge A/Prof Fiona McDermott, Dr Simon Albrecht for their provision of student supervision for this project and Dr Mehmet Özmen for contributing to the modelling intervention.
Figure 1. Intervention design
Table 1: Sample participation patterns across data collection points to date

<table>
<thead>
<tr>
<th>Participant</th>
<th>Workshop 1</th>
<th>Interview 1</th>
<th>Workshop 2</th>
<th>Interview 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<td>2</td>
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<td>3</td>
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<td>✓</td>
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<td>4</td>
<td>✓</td>
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<td>✓</td>
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<td>5</td>
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<td>6</td>
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<td>✓</td>
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<td>8</td>
<td>×</td>
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<td>✓</td>
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<td>9</td>
<td>×</td>
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<td>✓</td>
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<td>✓</td>
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<td>11</td>
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<td>12</td>
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<td>16</td>
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<tr>
<td>19</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>

N   8   9   8   9

Table 2: Workshop evaluation questionnaire

Please indicate to what extent you agree or disagree with the following statements?

<table>
<thead>
<tr>
<th>This workshop…</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree nor disagree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>…engaged me in the decision-making process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>…helped me think clearly about goals &amp; outcomes</td>
<td></td>
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</tr>
<tr>
<td>… fostered a common language</td>
<td></td>
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<tr>
<td>… fostered discussion</td>
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<td></td>
</tr>
<tr>
<td>… structured knowledge about the program</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
made assumptions explicit

... documented the program

...got everyone ‘on the same page’

...promoted communication

...identified gaps in program logic

...highlighted key performance indicators

...helped me look at the whole picture

...improved my understanding of the program

...clarified intended outcomes

---

Table 3. Semi-structured interview questions for researchers, 2017

<table>
<thead>
<tr>
<th>Topic</th>
<th>Example Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Background</strong></td>
<td>Firstly, can you share any reflections on the project in general?</td>
</tr>
<tr>
<td>What were your</td>
<td>How do you think the organisational change at Monash Health affected the project?</td>
</tr>
<tr>
<td>original plans</td>
<td>What has this project achieved?</td>
</tr>
<tr>
<td>and expectations</td>
<td>Do you believe that we have affected change at the MHS? How?</td>
</tr>
<tr>
<td>for the project?</td>
<td>Why?</td>
</tr>
<tr>
<td>How well do you</td>
<td>Finally, if you could describe the project in one word, what would it be?</td>
</tr>
<tr>
<td>think the reality</td>
<td></td>
</tr>
<tr>
<td>met your</td>
<td>What were the strengths and weaknesses of our approach? What would you change for</td>
</tr>
<tr>
<td>expectations?</td>
<td>next time?</td>
</tr>
<tr>
<td>Project evaluation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>What have you, personally, learnt/gained from this project?</td>
</tr>
<tr>
<td></td>
<td>Has this project changed the way you understand:… mental health? …modelling? …strategic decision-making? … research projects?</td>
</tr>
<tr>
<td></td>
<td>If you could provide one piece of advice for another group doing similar work, what would it be?</td>
</tr>
</tbody>
</table>
Table 4. Semi-structured interview questions for managers

<table>
<thead>
<tr>
<th><strong>Topic</strong></th>
<th><strong>Example Questions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>So we last talked about this time in 2014, two years ago [remind them of the timeline]. So I just wanted to get your thoughts and feelings on the last two years in the Mental Health Service (MHS)?</td>
</tr>
<tr>
<td>Organisational change</td>
<td>You predicted [insert prediction] about the period of change in the MHS. To what extent has your expectation been met?</td>
</tr>
<tr>
<td></td>
<td>What are your predictions for the future of the SLG?</td>
</tr>
<tr>
<td>Mental models</td>
<td>And how about now? Do you have a sense of a decision-making process for the MHS? What is that? Were there any intermediate models?</td>
</tr>
<tr>
<td></td>
<td>Who makes strategic decisions for the MHS at the moment?</td>
</tr>
<tr>
<td>Evaluation of current SLG performance</td>
<td>If you could describe your feelings about the SLG in one word, what would it be?</td>
</tr>
<tr>
<td>Simulation project evaluation</td>
<td>I also wanted to get a sense of how the modelling project sat within all of this organisational change. How relevant was the modelling project to you as a member of the SLG?</td>
</tr>
<tr>
<td></td>
<td>What were your expectations for the project [refer to 2014 interview transcripts]? Were they met?</td>
</tr>
<tr>
<td></td>
<td>Has your personal decision-making practice changed? How? Why?</td>
</tr>
<tr>
<td></td>
<td>If you could describe your feelings about the simulation project in one word, what would it be?</td>
</tr>
</tbody>
</table>

Table 5: Behavioural coding examples for PLM workshops

<table>
<thead>
<tr>
<th><strong>Coding variable</strong></th>
<th><strong>Behavioural / linguistic cue</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem exploration</td>
<td>“But we don’t know…”</td>
</tr>
<tr>
<td></td>
<td>“We need to know…”</td>
</tr>
<tr>
<td>Discussion of alternatives</td>
<td>“What about…”</td>
</tr>
<tr>
<td></td>
<td>“Or we could…”</td>
</tr>
<tr>
<td>Participation</td>
<td>Pattern of speaking duration by gender, role, and over the course of the workshop</td>
</tr>
<tr>
<td>Voice</td>
<td>Interjections</td>
</tr>
<tr>
<td></td>
<td>Speaker participation relative to seniority</td>
</tr>
</tbody>
</table>
Information sharing
“In our service…”
“From my point of view…”

Clarification of meaning
“What do you mean?”
“I mean that…”
“Do you agree?”

Agreement
“I agree”
“Yes”

Disagreement
“No”
“I don’t agree”

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