Study Protocol

A stakeholder-based system dynamics model of return-to-work: a research protocol

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Significance for public health

While the incidence of occupational injuries and illnesses has declined over the past two decades, the proportion resulting in sickness absence has actually increased. Implementing strategies to address sickness absences and promote return-to-work (RTW) can significantly benefit physical and mental health, and work outcomes like worker engagement, job satisfaction and job strain. As a key social determinant of health, participation in paid work can also ensure that work-disabled individuals generate income necessary for access to housing, education, food, and social services that also benefit health. Improving RTW outcomes can also have significant societal benefits such as a reduction in workers compensation costs, increased economic activity and less burden on social assistance programs. Despite its benefits, returning to work after injury or illness is not a straightforward process and can be complicated by the individual, psychosocial, organizational and regulatory components that influence a disabled person's ability to resume work activities.

Abstract

Background. Returning to work following a job-related injury or illness can be a complex process, influenced by a range of interrelated personal, psychosocial, and organizational components. System dynamics modelling (SDM) takes a sociotechnical systems perspective to view return-to-work (RTW) as a system made up of multiple feedback relationships between influential components.

Design and Methods. To build the RTW SDM, a mixed-method approach will be used. The first stage, that has already been completed, involved creating a baseline model using key informant interviews. Second, in two manufacturing companies, stakeholder-based models will be developed through interviews and focus groups with senior management, frontline workers, and frontline supervisors. Participants will be asked about the RTW process in general and more targeted questions regarding influential components. Participants will also be led through a reference mode exercise where they will be asked to estimate the direction, shape and magnitude of relationships between influential components. Data will be entered into the software program Vensim that provides a platform for visualizing system-structure and simulating the effects of adapting components. Finally, preliminary model validity testing will be conducted to provide insights on model generalizability and sensitivity.

Expected Impact of the study for Public Health. The proposed methodology will create a SDM of the RTW process using feedback relationships of influential components. It will also provide an important simulation tool to understand system behaviour that underlies complex RTW cases, and examine anticipated and unanticipated consequences of disability management policies.

Background

Returning to work following a job-related illness or injury can be a complex process. While many injured workers follow a straightforward return-to-work (RTW) course, a proportion experience variable and unpredictable RTW trajectories including prolonged (*e.g.*, staying out of work for a longer than expected period of time), or intermittent work disability (*e.g.*, a person alternates between being able to perform work tasks and absenteeism). These difficult work disability cases can account for a disproportionate amount of workers compensation costs, have a significant long-term impact on workers' health and financial status, and may be less addressable by traditional employer-based strategies.

A sociotechnical systems thinking perspective can provide researchers with an analytical lens to better understand the dynamics of both straightforward and variable RTW processes. According to sociotechnical systems thinkers, organizations are complex adaptive systems made up of personal, social, and organizational components and their interrelationships.[1] Interrelationships between components can result in the emergence of patterns of systems-level behaviour including self-organization (*i.e.*, new processes or behaviours that arise from component interactions) or brittleness (*e.g.*, the inability of RTW systems to adapt to unusual circumstances and/or sudden or disruptive change) that are manifestations of complexity, and can lead to the messiest RTW problems or unanticipated outcomes.[2]

Work disability researchers have yet to apply perspectives like sociotechnical systems thinking to the RTW process. Conceptual models currently used in research and practice tend to focus on identifying the range of components that make up work disability systems and view RTW as a static step-by-step process.[3,4] These models may not fully account for non-linearity and dynamic activity of the components that influence RTW.[5,6] As a consequence, employer-based work disability strategies informed by contemporary models may be implemented without considering their impact on the breadth of constantly changing components in a complex system.

System dynamics modelling (SDM) is one particular sociotechnical systems methodology that can be used by work disability researchers and practitioners to study complexity in RTW. SDM views systems-level behaviours as a function of multiple feedback interactions among the range of constituent components.[5,6] The structure of an SDM consists of a series of stock (*i.e.*, entities that accumulate or deplete over time) and flow diagrams (*i.e.*, rates of change in stocks) and feedback loops made up of all relevant components and the positive or negative feedback linkages between them.[5,7] Feedback loops may have an amplifying (*e.g.* action generating) or balancing (*e.g.* maintaining *status quo* or dampening) effect on stock and flow.[8] SDM also enables researchers to run dynamic simulations to estimate how changes to components can impact other system components, and outcomes over time. As an example, the Centers for Disease Control and Prevention developed an SDM to examine the factors that influenced the stock and flow of cardiovascular disease in the United States. The model was successful in identifying a range of preventative (*e.g.*, physical activity) and downstream factors (*e.g.*, health care access) related to cardiovascular disease. Through multiple model simulations, the authors were also able to uncover aspects of the system that could be amenable to intervention. A visual depiction of the model was presented by Homer *et al*.[9] SDM may offer similar benefits to work disability researchers and practitioners by enabling them to recognize the range of variables that make up the work disability system and influence RTW. System-based simulations can also provide investigators the opportunity to test a range of work disability management strategies on RTW.[10]

This paper describes a proof-of-concept protocol to determine the applicability of sociotechnical systems thinking and SDM methodology to the RTW process in manufacturing companies in the United States. The study will address the following overarching research objectives: i) describe the individual, social, and organizational components that make up the work disability system, and their feedback relationships. As part of this first objective we will also compare components and feedback relationships between 2 participating companies. ii) Examine anticipated and unanticipated RTW outcomes that may arise from simulating changes to various components within the work disability system. iii) Identify potential leverage points that will improve RTW outcomes, and areas of brittleness in which the system might be unable to adapt to unusual circumstances and/or sudden or disruptive change.

Study design

To build the organizational RTW SDM, a two-staged mixed-method approach is described in the following sections. To pilot the proposed methodology, baseline model development took place using key informant interviews. The lessons learned from the pilot phase has been integrated into the design of the protocol for stakeholder-based models.[8,11] The study protocol has been approved by the New England Institutional Review Board (NEIRB# 14-189).

Role of the model builder

In SDM development the investigator has several key responsibilities as the model builder. The first responsibility is to facilitate a discussion among study participants that elicits the structure of an organizational work disability system. To do this, model builders encourage participants to think about the range of influential system components and their feedback relationships. Model builders are also tasked with translating discussions into the mapping of the SDM and must work iteratively to incorporate new data into feedback relationships. Finally, they must investigate discrepancies in different stakeholder perceptions regarding the structure and behaviour of the system. This may involve additional focus groups or collection of administrative data (*e.g*., work disability records).

Baseline model generation

The initial stage of the SDM development, conducted prior to establishing the final protocol, involved creating a baseline model to understand the scope of work disability systems and pilot study procedures. The baseline model was generated using insights from key informants including work disability scientists (n=4), and occupational health nurses (n=3). All key informants had at least five years of experience with evaluating or managing RTW processes in manufacturing companies. Key informants were identified by the investigators and directly invited to participate in the study.

Semi-structured interviews were conducted with participants who were asked to think about a workplace injury at a generic manufacturing company and to describe each step in the RTW process. The interviewer probed the range of influential components that key informants mentioned and their interrelationships (*e.g., Will a change in component X result in a change to any other components? If so, how*?).[8] As participants discussed the process and influential factors, the model builder translated discussions into feedback loops that made up the baseline model. Once a feedback loop was developed, the interviewer would present it to the key informant and ask for their level of agreement. In cases where there was disagreement, more information was collected and the structure of the feedback loop was adapted until agreement was reached.

The baseline model provided a visualization of the breadth of health, psychosocial, family and organizational components that influence RTW and their feedback relationships. The initial model was used as a guide for interview and focus group questions in subsequent stakeholder-based modelling, and helped researchers understand the ways to frame questions to promote a discussion of feedback structures amongst components of work disability systems. It is important to note that the baseline model will not be directly presented to stakeholders in subsequent research stages to prevent biases and ensure that the model designed within each company will be context specific.

Stakeholder-based return-to-work model development

The protocol for developing stakeholder-based models of the RTW process is discussed in the following sections. Models will be generated in 2 companies and compared at the conclusion of the study.

Recruitment

We will recruit two medium-sized manufacturing firms (*i.e.,* approximately 200 employees). Manufacturing industries were selected because they provide an example of a work context where processes like RTW might be particularly complex. In these settings, flexibility and resources to address the needs of injured workers and accommodate RTW can be constrained by hierarchy in management structures, pace of work, and pressure on frontline supervisors and workers to fulfil production quotas.

Participants who represent different departments and organizational roles within each company will be invited to participate, including senior management (*e.g.,* human resource managers, occupational health managers, return-to-work coordinators and safety coordinators) (n=5/company), frontline supervisors (n=6/company), and frontline workers (n=8/company). To be eligible, all potential participants have to be fluent in English, over the age of 18 years, and have experience with the RTW process (directly or indirectly) within their companies that they are willing to discuss. Study investigators will approach potential participants via email or phone and invite them to take part in model development sessions. All participants will be provided with a consent form in advance of the study that outlines objectives, confidentiality procedures, and the potential harms and benefits of their participation. In order to minimize social desirability biases and encourage critical conversations, model development with senior management, frontline supervisors, and frontline workers will be conducted separately. At the end of the study, findings will be presented to companies and research participants in the form of a summary report.

Model boundary

To align the model with the research objectives the investigators will establish the boundary of the model at the organizational level. In practice, questions asked in interviews and focus groups will be framed to uncover endogenous components, or those within the organizational boundary. When community-, state-, or federal-level factors are discussed as being important to RTW, they will be categorized as exogenous (*i.e.*, outside the system) and not included in the SDM. An organizational model boundary will enable comparisons between similar companies in different States that may have unique exogenous characteristics (*e.g.*, workers compensation policies) that could constrain the RTW process.

Data collection

Data collection in organizations will include in-depth interviews with senior management, and focus groups with frontline workers and supervisors. First, one-hour semi-structured in-depth interviews will be conducted with senior managers. Initially, participants will be asked to describe the general RTW process in their organization (*e.g.*, *Describe the RTW process in your company*; *Can you tell us about a challenging and successful RTW scenario*?). The model-builder will probe specific RTW issues that respondents report as important to their work disability context allowing the investigators to identify the most influential components. Next, using the baseline model as a guide, participants will be asked general questions about whether specific health, family, psychosocial, and organizational components influence the RTW process (Table 1). When participants discuss a component that is influential, they will be probed about how the component might influence RTW and how it could be related to other components in the system.[11,12] Similar to the development of the baseline model, discussions will be translated into feedback loops by the model builder. Feedback loops will be presented to the research participant to confirm it's structure.

The next step in stakeholder model development will involve group-based model building sessions with frontline workers (two sessions/company) and frontline supervisors (one session/company). To take advantage of the group setting, the model builder will encourage participants to critically discuss the RTW process and compare and contrast different views of their organization's work disability system. Question formats in each focus group will follow the same structure as senior manager interviews. Model builders will pay special attention to situations where responses from frontline workers, frontline supervisors and senior management differ. In those cases, the model builder will ask follow-up questions to uncover why differences exist. Additional interviews, focus groups, or observational research may be needed to arbitrate incongruities so that researchers can arrive at a best estimate of the actual system structure. Each focus group is expected to last approximately 90 minutes.

Reference mode development

After determining the structure of the SDM, senior managers, frontline workers, and frontline supervisors will be asked to complete a reference mode exercise for each possible identified relationship among components in the model. Reference modes involve participants estimating the direction, shape and magnitude of relationships between influential components.[13] To do this, they will be presented with a set of axes, each including a component identified as being important during interviews or focus groups (Figure 1). Participants will be asked to discuss the relationship between the two components. During the discussion, the model-builder will draw a line on the axis to visualize the relationship. After each reference mode is drawn, the model-builder will present it to participants to confirm whether it reflects their perceptions of the relationship between the components. Based on the shape of the reference mode, a differential equation will be generated to reflect the relationships between the components. Where possible, organizational administrative data will be collected to supplement reference mode development.

Simulation model

All qualitative (*e.g.,* perceived structure of the model) and quantitative (*e.g.*, reference modes, differential equations and organizational work disability data) information derived from data collection will be entered into the software program Vensim.[13] Vensim provides a platform to illustrate the feedback structure and dynamics of the system, and enables researchers to conduct simulations. As an exploratory exercise the inves-

Table 1. Summary of main research questions posed to interview and focus group participants. Questions based on the key informant model.

Component identified in baseline model development	Questions posed in focus groups and interviews
Motivation and preparedness to RTW	– What does it mean to for a worker to feel prepared to return to work? – In your organization, how motivated are most injured workers to RTW? – What aspects of an employee's work or personal life might influence feeling motivated to RTW?
Access to health services/information	– What is the process for a worker to receive health care after an injury? – How comfortable are most workers with accessing health and rehabilitation services? – Do you feel that you have all of the information you need to understand the work disability process? – In which cases might an individual choose to not disclose a health condition? – What aspects of an employee's work or personal life might influence access to health information?
Family support	– What role do family members or friends play in the RTW process?
Supervisor support	– What role do supervisors play in the RTW process? – What does it mean to have a quality conversation regarding RTW? – How does communication impact the RTW process?
Co-worker support	– What influence does a supervisor and his or her attitudes or behaviours towards an injured worker play in the RTW process? – What role do co-workers play in the RTW process?
Organizational support	– What are strategies that the company has taken to get injured workers back sooner? – Are there scenarios where the company puts pressure on RTW?

RTW, return-to-work.

tigators will examine how adaptations to different components in the system can result in changes to RTW outcomes, as well as other components in the system. Exploratory simulations will also help to investigate if altering a component level can cause changes to system behaviour such as new or unanticipated processes, and identify aspects of the system that might be unable to adapt to a component change.[8]

Preliminary model comparison and validity testing

As a final stage in the SDM development process, investigators will conduct preliminary model validity testing. First, causal loop diagrams (*i.e*., the components and their feedback relationships) will be compared between both companies. Comparing system characteristics may demonstrate whether the models built in the two companies are similar or different, and inform initial insights on generalizability of the findings and the SDM approach. Future research will be required to apply models to a greater diversity of work contexts to determine whether feedback loops are generalizable to a broader range of work contexts. Second, initial sensitivity testing can be conducted using model simulations. Component values can be set to extreme conditions to determine if changes to RTW stock and flow occur as expected. To further verify the model's ability to capture the magnitude and direction of relationships between components that influence RTW, additional research will be needed to compare results from model simulations to objective organizational outcomes.

Discussion

This paper describes a proof-of-concept protocol to demonstrate the applicability of sociotechnical systems thinking and SDM methodology to the field of work disability. Through a collaborative and multi-stakeholder based model building approach, the proposed methodology can create a holistic visual depiction of the feedback relationships between the components that make up the RTW system. It will also provide a simulation tool that can help to understand RTW system behaviour and potential points of intervention. Overall, the SDM development process may provide a systems-focused view of the RTW process and has the potential to advance our understanding of straightforward and variable RTW cases.

System dynamics modelling provides an analytical lens to study the structure and complexity of the work disability system. The outcome of the modelling protocol will be a depiction of the RTW process as a system of personal, social and organizational components. Visualization of the system in itself can be an important contribution to the field and may help work disability professionals understand the various interrelationships that exist in organizations, and how policy and programs may have influence across the range of components in a system. A main feature of SDM is the utilization of feedback loops to describe dynamic relationships between components. Feedback loops have a cumulative balancing or amplifying effect on RTW outcomes.[5,8] The combination of multiple feedback loops may help to identify why RTW outcomes are perpetuated or more difficult to change. These dynamic insights may not be as apparent in linear models.[10]

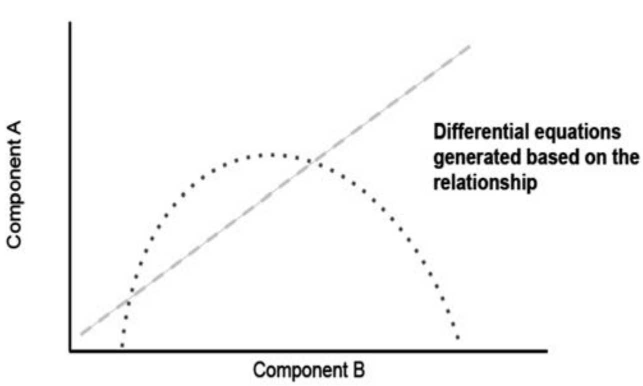
Research participants may also benefit from their involvement in SDM development. By participating in group model building, stakeholders may be afforded an opportunity to learn about their work disability system and understand how multiple components interact with each other and their cumulative effect on RTW processes.[8,14] Insights gained from involvement in model building can be helpful for stakeholders to identify complex strategic issues within their work disability systems and inform the ways in which they implement RTW policies and programs.

The ability to conduct simulations is another important product of SDM development. Simulations provide researchers with a tool to test different hypotheses and examine the potential impact of modifying different components on system behaviour. Within a virtual context, simulations also offer work disability practitioners a way to examine the impact of a broader range of policy and programmatic changes on RTW outcomes and the opportunity to view potential unanticipated consequences that may stem from their implementation.[10,11] This may be critical when testing policies or programs that may be not be feasible in real life settings (*e.g.,* changing the number of workers, increasing communication channels or adding incentives to RTW). In it's previous application to complex public health problems,[6,9] SDM has been useful in identifying leverage points where policy and programmatic decision-making can be directed to have the greatest and sustained impact, and may show similar benefits for work disability prevention.[10,15]

There are several potential limitations we have considered in developing this approach. Encouraging study participants to engage in systems thinking can be challenging, especially for those accustomed to viewing RTW as a linear step-by-step process.[5] By developing probes that promote participants to think holistically and consider feedback relationships among components, investigators can encourage participants to view the RTW process as being impacted by interrelated components.

In our proposed study we will take several steps towards establishing preliminary model validity. However, intensive validity testing is beyond the scope of this proof-of-concept protocol. Upon the completion of this proposed study, we recommend that follow-up research should be conducted to apply models to a greater number of manufacturing companies and organizations in other industries, and compare simulation findings to objective workplace outcomes. These types of follow-up studies will be important to establishing the generalizability and sensitivity of the SDM approach in work disability research.

Inherent in conducting research in workplaces, limited time often exists to engage the required range of stakeholders in comprehensive model development activities. To potentially overcome this limitation, the model-builder will play an important role in integrating various stakeholder perceptions and collecting administrative data to fill-in gaps. Similarly, engaging multiple diverse stakeholders in different organizational roles may pose challenges such as uncovering disagreements in system structure. In these situations, the model builder investigates potential incongruities through additional data collection, and ultimately decides which components are included in the model. Findings from our pilot model development, discussed earlier in this paper suggest that by presenting each feedback loop to stakeholders during the research process, face validity of the SDM can be confirmed, and the need for model builders to impose their views regarding the inclusion or exclusion of components can be reduced.



Lines reflect the potential relationships between components based on responses from the reference mode exercise conducted during stakeholder model building.

Figure 1. Example reference mode axis.

System dynamics modelling can produce a model that is *messy* and difficult to interpret. Model-builders have the challenge of constantly thinking critically about which components provide insight into the researcher question and should be included in the model. To facilitate the process, the SDM should be built iteratively and incorporate insights emerging from each new stakeholder that is engaged across the research process. Our pilot research also suggests that at each phase of SDM development, model builders should critically question whether the components in the SDM address the research objectives and fall within the model boundaries. Those that do not fit those requirements should be excluded from the SDM.

Conclusions

System dynamics modelling provides a potentially promising methodology to investigate complexity in the RTW process. The protocol presented in this paper describes the development of a key informant baseline model and a stakeholder-based model. Through the SDM developed using this protocol, we may be able to better understand the patterns of systems behaviour that underlie RTW processes and potentially understand and develop solutions for simple as well as challenging work disability cases.

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