

Technology Enabled Knowledge Exchange: Development of a Conceptual Framework

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Abstract As the need for knowledge exchange grows, so does the need to find new ways for researchers, decision makers, and educators to communicate and collaborate with each other on how to improve drug prescribing and use. In this paper, we introduce a conceptual framework for evaluating knowledge exchange activities within drug policy groups. The framework is grounded in the information and communication technologies (ICT) and knowledge exchange literature and is composed of various inputs, processes, and outputs. Inputs into the framework are *research task*, *communication medium* (face-to-face, teleconferencing, and web-conferencing), *group characteristics* (size, experience, goals, and roles), and *context* (description of linkage and exchange within the policy domain and

group type). The inputs will affect how the *social interaction process*, *knowledge brokering process*, and *information exchange process* between drug policy groups (decision-makers, researchers, and educators) develop as part of the linkage and exchange knowledge exchange process. The inputs and how they shape the linkage and exchange knowledge exchange process will lead to different levels of *engagement* outputs and *linkage and exchange* outputs. Results of a refined conceptual framework based on a 2-year case study are also provided in the model where new inputs and processes are introduced.

Keywords Conceptual framework · Knowledge exchange · Technology · Information and communication technology · Knowledge transfer · Knowledge exchange

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Statement of the problem

In 2004, the Canadian Optimal Medication Prescribing and Utilization Service (COMPUS) was created to facilitate communication linkages and information exchanges between health researchers, physicians, physician educators, and drug policy decision-makers. Its purpose is to produce best practice information that would improve drug prescribing and use among health care providers and patients/consumers. Because drug policy is a complex and often volatile policy domain, a nationally funded organization such as COMPUS provides the necessary coherence needed to coordinate the efforts of drug policy groups working to improve drug prescription and usage.

For the COMPUS initiative to be successful, the use of traditional face-to-face communication for linkage and exchange alone may not work for geographically dispersed working groups. COMPUS will need to invest in various

information and communication technologies (ICT) to facilitate distance knowledge exchange between researchers, physician educators, and drug policy decision-makers. How ICT will transform face-to-face linkage and exchange process within drug policy remains unknown.

The purpose of this research is to develop a refined conceptual framework for studying knowledge exchange processes of technology-enabled drug policy groups. The Canadian Health Services Research Foundation (2009) defines knowledge exchange as:

Collaborative problem-solving between researchers and decision makers [which] involves interaction between decision makers and researchers and results in mutual learning through the process of planning, disseminating, and applying existing or new research in decision-making.

Further, one can define linkage as the frequency of interactions between researchers, decision-makers, and other groups. In a similar vein, one can define exchange as the exchange of any information (personal opinion, experience, literature, or study results) between decision-makers and researchers during the research process [7, 12]. The development of the conceptual framework is based on the knowledge exchange and information and communication technology literatures.

Methods

Two different methods were used for this paper. First, a literature review on knowledge exchange and information and communication technologies (ICTs) was carried out. The literature helped in the design of the conceptual framework. Second, the conceptual framework was tested in the field and the results helped refine the original conceptual framework derived from the literature.

The focus of the literature review was to gather evidence on the impacts of information and communication technologies on knowledge exchange groups. First, a literature review was carried out on knowledge exchange using databases such as PubMed, CINAHL, ERIC, and Academic Search Premier between 2003 and 2005. Key words used were: knowledge exchange, knowledge transfer, knowledge broker, and knowledge translation. Google was also searched using the same keywords.

Second, a broad search strategy was used covering separate electronic databases including Pubmed, ERIC, IEEE Xplore, and Academic Search Premier between 2004 and 2006. Search terms used were: ICT, group decision supports systems, electronic meetings, technology, and groupware. The purpose of the search was to determine the impacts of ICTs on group interactions. The first and

second searches yielded results that contributed to the creation of the conceptual framework.

Once the conceptual framework was created, it had to be tested in the field to determine its validity. A case study on the use of ICTs within a drug policy knowledge exchange network was used to test the conceptual framework. For the case study, three drug policy groups were observed over a 2-year period between 2004 and 2006. There was an education task group, research task group, and decision-making task group. The education task group consisted of academic detailers who worked collaboratively on producing research reviews regarding new drugs to disseminate to physicians. Of the 26 potential participants in the education task group, 20 were included in the study. The six that were excluded were observers and administrative assistants. The 20 participants included in the education task group were researchers, educators, and decision-makers.

This research task group was charged with the task of evaluating the cost-savings of physician educational interventions. It included collaborations between researchers and decision-makers working on the evaluation of education for quality improvement in patient care. Of the 17 potential participants in the group, 14 were included in the study. The three excluded were observers and administrative assistants. The included participants were either researchers or decision-makers.

For the drug policy task group, decision-makers and their staff met on a monthly basis using live teleconferencing as a communication method. A designated researcher would disseminate research information on the latest drug policy research trends. Of the 32 potential participants in the decision-making task group, 27 were included. The five excluded were observers and administrative assistants. The 27 participants included in the decision-making task group were researchers and decision-makers and staff from provincial Canadian drug plans.

Data collection and analysis

Different data were collected for the three drug policy groups between 2004 and 2006. The data were collected in three phases. Phase 1 data included a compilation of baseline interview and observation data for the education task group and the research task group. No baseline data were collected for the decision-making task group because they were not available. Phase 2 data included recorded meeting transcript data for the three drug policy groups. Phase 3 data included post-interview data and survey data results for the three drug policy groups.

With regard to transcription of meetings and interviews, the researcher transcribed all baseline interview data and hired a transcription company to transcribe the meetings

and the post-interview data. The baseline interview, meeting, and post-interview data were transcribed verbatim.

Content analysis was utilized to analyze the data. In general, content analysis is a data analysis approach that can be used to analyze qualitative data; it is a systematic process of analyzing communication messages and making inferences based on the analysis [1, 8]. Content analysis involves the interpretation of textual data that has been categorized into concepts. Once the identification of concepts or categories has taken place, they are categorized into themes based on their relationships with each other [9].

Background on the technology-enabled linkage and exchange conceptual framework

According to [13], the study of groups requires three sets of variables: those describing inputs into the group; those describing the group process; and those describing group outputs. The proposed Technology-Enabled Linkage and Exchange (TELE) framework builds on the previous ICT conceptual frameworks; however, it is contextually sensitive to the inputs, processes, and outputs relevant to knowledge exchange group inputs, processes, and outputs. The previous conceptual frameworks of [16, 17], and [21] are generic conceptual frameworks focused on evaluating the impacts of technology on group process outputs, whereas the TELE conceptual framework is focused on evaluating the linkage and exchange process of distant technology-enabled drug policy groups.

Figure 1, the initial conceptual framework, depicts a sample of some of those variables, categorized into input, process, and output variables. Generally, input variables describe the makeup of the group in terms of the

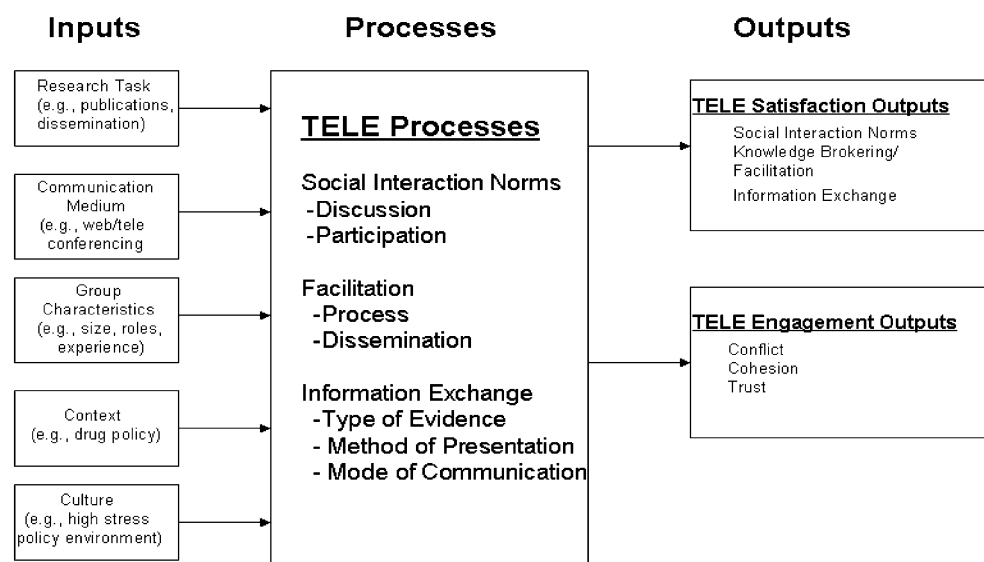
communication medium, the research task, the knowledge brokering mode, and group characteristics. Process variables are concerned with how the group works together, how members interact with each other, and how the group develops over time. Output variables reflect the end-results of group efforts, such as how well a group performed its task.

Generally, research studies investigating the effects of technology on groups have analyzed some combination of input variables and their consequences to group processes and outputs. Certainly not all researchers would agree with the framework proposed in Fig. 1. Some may see some of the process variables as outputs or some of the output variables as processes. Others might see some of the variables in different categories. For example, some might see the social interaction process as an output variable, while group cohesion and trust may be categorized as process variables. Furthermore, the framework presented in Fig. 1 does not present a comprehensive conceptual framework for evaluating the effects of technology-enabled linkage and exchange on group processes; rather, it places some of the concepts of interest in a context that provides a basis for further discussion and analysis.

Creation of the technology-enabled linkage and exchange framework

The basis of the conceptual framework lies in the information and communication technology (ICT) and the knowledge exchange literature. For inputs, *group characteristics*, *research task*, context, and *communication medium* originated in the ICT literature [16, 17, 21, 22]. For group knowledge exchange group processes, *social interaction process*, *knowledge brokering process*, and the

Fig. 1 Technology-enabled linkage and exchange conceptual framework



information exchange process are included. One can find a discussion of these processes in the knowledge exchange literature [7, 10, 11, 18, 19].

The output variables included in the conceptual framework fall into two groups: TELE engagement outputs and TELE group process outputs. The TELE group process outputs originate in the knowledge exchange literature. For linkage and exchange group process outputs, *social interaction process*, *knowledge brokering process*, and the *information exchange process* were included. These processes derive from the knowledge exchange literature [7, 10, 11, 18, 19]. For engagement outputs, *conflict level*, *cohesion*, and *trust* are group engagement process outputs of interest to this study discussed in the ICT and knowledge exchange literature [2, 6, 15, 19].

Explaining the technology-enabled linkage and exchange conceptual framework

Inputs into the framework are *research task* (based on the Canadian Institute for Health Research (CIHR) knowledge exchange process), *communication medium* (face-to-face, teleconferencing, web-conferencing, or some type of mixed mode session), *group characteristics* (size, experience, goals, and roles), and *context* (description of linkage and exchange within the policy domain and group type). The inputs will affect how the *social interaction process*, *knowledge brokering process*, and *information exchange process* between drug policy groups (decision-makers, researchers, and educators) develop as part of the linkage and exchange knowledge exchange process. The inputs and how they shape the linkage and exchange knowledge exchange process will lead to different levels of *engagement* outputs and *linkage and exchange* outputs.

Operationalizing inputs, processes, and outputs

The study goal is to develop a refined conceptual framework to evaluate the knowledge exchange process of distant technology-enabled drug policy groups. To do this, the variables in the conceptual framework must be operationalized. This is done in the following manner:

Inputs: Inputs are factors that can influence the linkage and exchange process. Different inputs influence linkage and exchange processes and outputs in different ways. For example, one can assume that decision-makers and researchers perform a task involving the definition of a research question (research task input) within the drug policy domain (i.e., context). Because researchers and decision-makers work at a distance from one another, the

group may want to use teleconferencing for communication (communication medium input). The group's size is about six individuals (three researchers and three decision-makers), each with different roles (a researcher role or a decision-maker role), with different levels of research and decision making experience, and with different program goals and objectives.

These four inputs (communication medium, group characteristics, context, and research task) can transform group linkage and exchange processes such as social interaction, information exchange, and knowledge brokering. Each different input will have different effects on group linkage and exchange processes and outputs. The four inputs described in the TELE framework are research task, communication medium, context, and group characteristics.

Research Task: For inputs, one can define a research task as a series of six key steps where communication linkages and information exchanges between researchers and decision-makers occur throughout the entire research process. The six steps are (1) defining research questions and methodologies; (2) conducting research; (3) publishing research findings in plain language and accessible formats; (4) placing research findings into the context of other knowledge and socio-cultural norms; (5) making decisions and taking action informed by research findings; and (6) influencing subsequent rounds of research based on the results of knowledge use. Each of the groups may be working within one or more of these knowledge exchange processes [3].

Communication Medium: For inputs, one can define the communication medium for linkage and exchange between group members as a process that can occur synchronously or asynchronously. Synchronous communication can occur in face-to-face, distant, or mixed mode methods. In face-to-face meetings, the group can use technologies such as a projector and Power Point, where all the members are present during the meeting. In distant synchronous communication modes, the group would use either teleconferencing or web-conferencing to communicate with each other via distance. In a mixed mode session, group members may meet face-to-face and have a distant audience communicate via teleconference or web-conference. Asynchronous modes can include e-mail, recorded web-conferencing, and teleconferencing sessions.

Group Characteristics: For inputs, one can define group characteristics as basic background information on the group, including the size of the group, the roles of various members of in the group, the experience of the members within their domain of work, and the goals of the members. Different groups may have different group sizes, roles, experience, and goals that

can influence the linkage and exchange process and which one needs to take into account.

Context: Linkage and exchange can take shape in different type of policy domain areas and groups. Context is the policy domain in which the linkage and exchange occurs and the type of group involved in the linkage exchange process and the various barriers and opportunities that exist between decision makers, educators, and researchers. Different drug policy domains and groups will develop different linkage and exchange processes and outputs and it is, therefore, imperative to describe the context of the linkage and exchange process.

Processes: One can describe and characterize processes in terms of how the group works together in relation to linkage and exchange. Each group will work together differently depending on the type of inputs influencing the linkage and exchange process. This study examines three different linkage and exchange processes: group social interactions, knowledge brokering, and information exchange. Continuing with the example above, the various inputs can have different effects on each of the group processes. Using teleconferencing for communication, the social interactions (i.e., social norms) may change in comparison with face-to-face communication, because group members may need to develop social norms for communication in different communication media. Furthermore, how group members share information may be restricted by the teleconferencing session. Group members may share verbally only information based on personal experience or opinion since it may be difficult to share documents within a teleconferencing communication medium. The group processes included in this study are social interaction, information exchange, and knowledge brokering process.

Social Interactions: for processes, one can define social interaction according to how the group develops social norms within the group when members use different technologies to communicate with each other. This study will examine new social norms created for linkage and exchange within the different communication media such as face-to-face, teleconferencing, and web-conferencing over the period of collaboration.

Information Exchange Process: for processes, the information exchange process is defined in the context of the type of evidence used by group members, the method through which group members transfer information, and the mode by which they transfer it. A method adapted from [14] helps to classify the evidence into four categories: (1) data from one's own research experience; (2) data from external literature; (3) data from the work experience of

colleagues; and (4) data from task-related discussions. With regard to the method by which members exchange information during the meeting, it can be oral, power-point, or text message. With regard to mode of transfer, it can be done via face-to-face, by distance (teleconferencing or web-conferencing), or by a mixed mode (teleconferencing and web-conferencing or teleconferencing and face-to-face).

Knowledge Brokering Process: for processes, one can define the knowledge brokering process in terms of how the knowledge broker facilitates the group linkage and exchange process and, specifically, group communication and collaboration in technology-enabled environments [5] suggest the following dimensions to conceptualize the knowledge brokering process: the knowledge broker encourages group participation, proposes technology use, summarizes discussion, asks and answers questions, explains the purpose of the technology, greets participants when they arrive, introduces self, manages conflict within the groups, guides participants through the meeting and/or discussion. The Canadian Health Services Research Foundation [4] framework for assessing the traits of a knowledge broker presenting to decision-makers will be used. This framework includes the process of how the knowledge broker uses graphics, humour, and plain language during a presentation of research findings to decision-makers. The present study will examine other processes such as how the knowledge broker presents key messages up front and notes the limitations of the research findings.

Outputs: Outputs can be thought of as the end-result of group efforts. How well a group performed its tasks is an example. In this study, outputs fall into one of two categories: linkage and exchange outputs and engagement outputs. Linkage and exchange outputs of technology-enabled groups relate to social interactions, information exchange, and knowledge brokering. With respect to engagement outputs trust, cohesion, and conflict are included. Going back to a scenario, the group using teleconferencing to communicate may feel that the teleconferencing or technology in general may reduce social interaction processes of groups and limit how the group exchanges information, and restrict the knowledge brokering process. Furthermore, in technology-enabled groups, group members may feel that developing group cohesion and trust may be more difficult in comparison to face-to-face groups. Finally, the level of conflict may be higher in technology-enabled groups because people are unable to read other group members' non-verbal cues and expressions. Definitions of the linkage and exchange process outputs follow.

Social Interaction: for outputs, social interaction outputs are studied in terms of how satisfied group members are with social interactions within different communication media (face-to-face, distant, or mixed).

Information Exchange: for outputs, information exchange outputs are studied in terms of how satisfied group members are with information exchanges within different communication media (face-to-face, distant, or mixed).

Knowledge Brokering: for outputs, knowledge brokering outputs are studied in terms of how satisfied group members are with knowledge brokering within different communication media (face-to-face, distant, or mixed).

Engagement Outputs (trust, cohesion, and conflict): for outputs, engagement outputs include trust, cohesion, and conflict. Engagement outputs are studied in terms of how satisfied group members are with the levels of conflict, trust, and cohesion within different communication media (face-to-face, distant, or mixed).

Field test

The conceptual framework was tested using a case study approach over a 2-year period. Case study research appears in the social sciences, health informatics, knowledge exchange, and the ICT literatures. A widely accepted research methodology, it serves to describe the real-life context in which an intervention has occurred and demonstrates the details of participant viewpoints through the use of multiple data sources [25].

Technologies used

The web-conferencing technology used in the study was Elluminate Live V-Class edition. The version of the technology employed in the study allowed for half-duplex audio communication that permitted users to speak one-at-a time. Elluminate allowed users to upload the agenda to the whiteboard, share documents via application sharing, use instant text message, vote/poll participants, use emoticons, raise hands, and see participant names. These were the most relevant features used by the groups in the study.

The education and research task groups used Elluminate Live V-Class edition to participate in the meetings. To participate, group members needed a computer, microphone, speaker or headphones, and an Internet connection.

For teleconferencing, the education and decision-making task groups used audio teleconferencing technology. The technology used was audio only communication where

multiple participants could speak at a time; there was no video or other media for communication. A participant simply dialed a telephone number, entered a conference code, and responded to a prompt requesting his or her name; a beep sound let other participants know that someone had joined the meeting. To use this technology, group members needed access to e-mail and a telephone. E-mail was necessary to inform the participants about the meeting details (time, numbers to dial, and the agenda). A telephone was required to participate in the meeting.

During face-to-face meetings, group members met in a designated room where the chairs were arranged around a space or a table. The space in the middle of the meeting setup had an image projector connected to a computer. The image projector projected items onto a screen; the agenda and other related meeting documents were projected throughout the meeting. In addition, paper copies of the material presented on the screen were made available to group members. Within the meeting room, there was also a chalk board and a flip chart; however, these items were not used by the groups included in the study.

Refined conceptual framework and preliminary findings

The initial TELE conceptual framework has been built on previous ICT conceptual frameworks; however, it is contextually sensitive to the inputs, processes, and outputs relevant to linkage and exchange. The previous conceptual frameworks of [16, 17, 21] were generic conceptual frameworks, which focused on evaluating the effects of technology on group process outputs, whereas the TELE conceptual framework focused on evaluating the linkage and exchange process of distant technology-enabled drug policy groups.

The application of the initial conceptual framework to drug policy groups produced new and refined inputs and processes. Within the education and research task groups, web-conferencing allowed only one person to speak at a time. As a result, the research task group respondents found that this rigid approach to communication within web-conferencing dampened socio-emotional interactions. Within the education task group, respondents noted that this limitation restricted group discussions; for example, it made it difficult to interrupt the speaker. Therefore, communication structure (i.e., the impact of technology in influencing group communication) became an important input influencing group processes. Social presence was another input added to the conceptual framework based on the data from the field. The concept of social presence suggests that a higher degree of interaction between individuals materializes with a greater presence of non-verbal cues, body

movement, and eye contact, which increase sensory stimulation (Mehrabian, cited. in [20]). Such high-level interactions are found primarily in face-to-face interactions. According to the study results, both of the education and research task groups preferred meeting face-to-face because of the groups' preference for a higher degree of interaction. However, due to budget and geographical constraints, the education task group communicated via teleconferencing and web-conferencing, whereas the research task group, not affected by the same constraints, was able to meet face-to-face.

With regard to implications for the conceptual framework, this finding demonstrates that drug policy groups prefer meeting face-to-face because of higher social presence. As the group interaction moves from a communication medium of high social presence (face-to-face) to one with a low social presence (teleconferencing), this shift may affect the relationship-building process that is important for a successful linkage and exchange process.

For processes, social interaction norms remained focused on discussion and participation. For facilitation, they remained focused on two facilitation styles: process facilitation and dissemination facilitation. Another facilitation function was found to be important in the study and that of a technical facilitator. The technical facilitator helped trouble shoot communication issues in the meeting. They were particularly useful in web-conferencing meetings where more technology was used in the group discussions. The information exchange process remained the same.

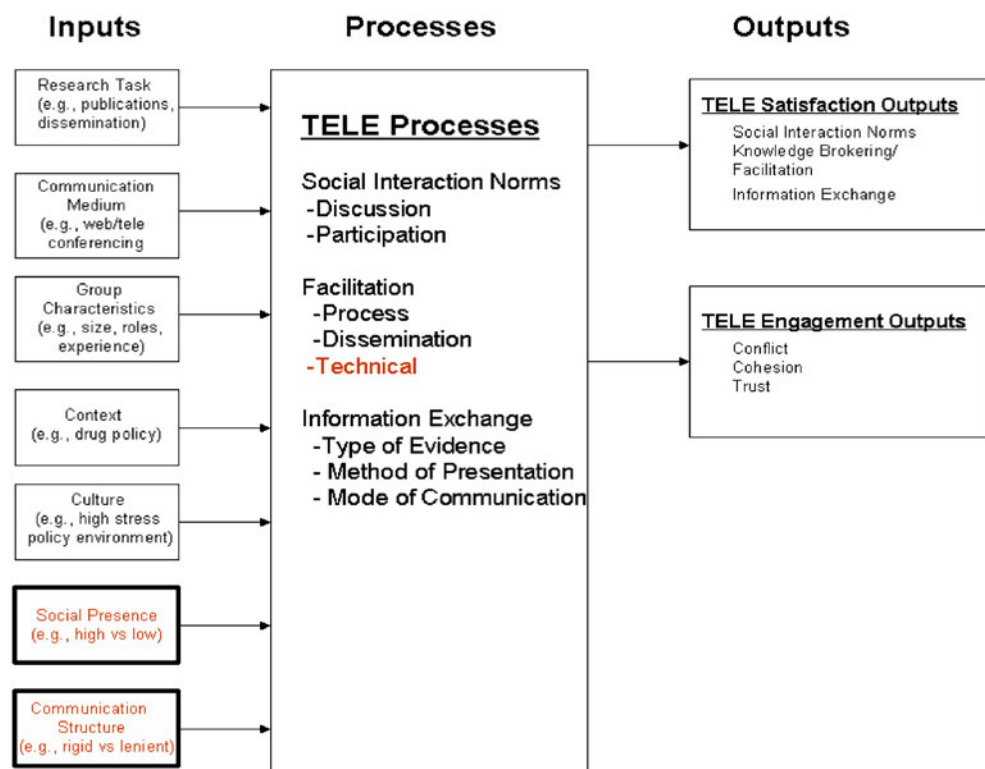
Figure 2 presents the refined TELE conceptual framework based on the results of the study.

Conclusions

In this paper we presented the initial TELE conceptual framework and a refined TELE conceptual framework that was tested in the field. The review of the literature in ICT and linkage and exchange lead to the development of an initial conceptual framework to study linkage and exchange processes within drug policy groups. The initial conceptual framework examined previous conceptual models from the ICT literature—[17, 21], and [16]—which uncovered numerous constructs that could be used for group inputs, processes, and outcomes in the study of the use of ICT in groups. Common inputs between the conceptual models were included in the initial conceptual framework used to study drug policy groups. These inputs, used in the ICT literature, were contextualized to fit the study of linkage and exchange within drug policy groups. For example, the group input, the task used in ICT conceptual models, was changed to research task to represent it within the context of linkage and exchange and specifically within drug policy.

As for the group processes included in the TELE conceptual framework, they were initially identified in the literatures of ICT and linkage and exchange. In the literature review on linkage and exchange, social interactions, knowl-

Fig. 2 Refined technology-enabled linkage and exchange conceptual framework



edge brokering (facilitation), and information exchange were found to be important linkage and exchange processes. Within the ICT literature, similar processes were found, which were studied, however, neither within the context of linkage and exchange nor within the context of drug policy. Drawing parallels between the two literatures was an important step in the development of a conceptual framework to study technology-enabled drug policy groups. Similarly, group outputs were created as a result of linking both the ICT and linkage and exchange literature. Linking these two separate literatures together is a contribution to the advancement of the ICT and linkage and exchange literature.

Applying the conceptual framework as a framework from which to study technology-enabled linkage and exchange within drug policy groups led to the development of a more refined conceptual framework. This validated and expanded the use of the original inputs, processes, and outputs described in the initial conceptual framework. As a result, the refined conceptual framework provided a representation of important inputs, processes, and outputs relevant to linkage and exchange within drug policy groups. Such a conceptual framework can be used to study future linkage and exchange processes of drug policy groups.

There are a number of limitations in the study. Limitations follow from using the Case Study methodology. Although well-established in the social sciences, health informatics, knowledge translation, and ICT literature and therefore a widely accepted research methodology, case studies have received criticisms related to reliability, validity, and generalizability (Colorado State, 2005). Furthermore, case study methods have been criticized for not being generalizable to other times, places, or settings. For case studies, generalizations or transferability of findings are limited to case or to cases with similar attributes [23].

There is no assumption that the refined TELE conceptual framework represents a final or complete listing of elements. However, the concepts embedded within the refined TELE conceptual framework will at least be sufficient for studying how technology can impact the linkage and exchange process within drug policy groups. However, research studies investigating the effects of technology on groups have analyzed some combination of input variables and their effects on group processes and outputs within ICT models. And of course, not all researchers would agree with the proposed TELE conceptual framework. Some may prefer to see some of the output variables as processes and some of the process variables as potential outputs.

The TELE conceptual framework is not intended to be a comprehensive conceptual framework for evaluating the effects of technology-enabled knowledge exchange on group processes; rather, it is intended to place some of the concepts of interest in a context that provides a basis for

further discussion and analysis. The impact of generalizing the framework and its use in other health fields or areas outside healthcare is not known. Future studies can use this conceptual framework as an initial starting point for understanding the impacts of technology on the linkage and exchange process.

Furthermore, the thesis focused on linkage and exchange, a process that occurs within knowledge exchange. Future studies should focus on the impacts of technology, such as, web-conferencing and teleconferencing, and other technologies, such as, videoconferencing on knowledge synthesis, knowledge exchange, the contextualization of research findings, the application of research, and decision-making processes.

More complete exploration of the potential of web-conferencing software to replace face to face and teleconferencing should be undertaken. For instance, since the version of the Elluminate web-conferencing technology employed in the study allowed for half-duplex audio communication that allowed users to speak one at a time future studies, should look at the impacts of full-duplex web-conferencing technology on technology-enabled linkage and exchange processes.

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