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Information Systems and Health Care XI: Public Health Knowledge Management Architecture Design: A Case Study

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INFORMATION SYSTEMS AND HEALTH CARE XI: PUBLIC HEALTH KNOWLEDGE MANAGEMENT ARCHITECTURE DESIGN: A CASE STUDY

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ABSTRACT

This paper presents the results of a case study based on the creation of a knowledge management program architecture in the public health domain. Data were gathered in the study using the program logic model as a framework for conducting a series of six focus groups. Results illustrate major elements and branches of the final design with commentary on the knowledge management implications of outcomes of this design effort. The methodology used provides an artifact in the form of an information requirement process that may be suited to other contexts. Discussion of findings focuses on six themes regarding knowledge management systems, particularly in the public health context and during the design process.

KEYWORDS: Public health informatics, knowledge management, information requirements determination

I. INTRODUCTION

The importance of public health information systems is apparent in addressing social issues and concerns, including emerging antibiotic resistant infections and risks of chemical and biological terrorism. Such information systems may be directed at providing highly detailed and scientifically correct public health information to professional providers, but must be presented as accessible information geared to the general population.

Public health information systems are distinct from medical and nursing information systems [Yasnoff et al., 2001]. Although there is overlap in some areas of concern, public health information systems are distinguished by:

- A primary concern for the health of populations rather than individuals;
- A focus on prevention rather than treatment;
- A concern for all stages in the causal chain including social, behavioral, and environmental influences on health; and

- A concern for government and policy issues regarding the health of populations. [Yasnoff et al., 2001]

The evolution of information technology, with its availability of reasonable pricing and its ever-expanding functionality, affords opportunities as well as challenges for public health practitioners. Key challenges and opportunities include:

- Developing national and worldwide public health information clearinghouses;
- Integrating public health and clinical care; and
- Including sensitivity to issues of security and privacy. [Yasnoff et al., 2001].

Public health organizations are responding to these opportunities and challenges in many ways, including the development of systems that provide new functionality as well as expanded access to pre-existing data and applications (e.g., see the Wonder system developed by the Centers for Disease Control and Management at http://wonder.cdc.gov/).

Institutions devoted to various aspects of public health have dual roles as both users and creators of public health information. As users, they acquire and assemble information regarding best methods for delivery of public health from a diverse range of sources; as creators, they conduct research and gather information for distribution to other agencies involved in supporting public health. The result is that public health institutions interact with a wide range of dispersed constituents. Addressing the varied needs of both users and creators represents a central challenge for public health agencies. One mechanism for addressing this type of decentralized and multi-purpose communication involves the development and deployment of knowledge management systems to serve a broad range of heterogeneous users.

It is important to distinguish between the development of a knowledge management system limited in scope to addressing the needs of a select and clearly-defined group of users (e.g., a system used to profile research staff and provide algorithmic means for matching researchers of like interests) and the development of a broad program for the not so clearly defined purpose of providing a wide range of knowledge creation and distribution pathways to a broad base of users. Although both must rely on the insights, knowledge, and preferences of potential users, the programmatic architecture that seeks to serve multiple constituents will emphasize identification of the range of functions performed by a diverse group of potential users. The architectural challenge is to modularize this diverse collection of functions into logical knowledge patterns that can be recognized by all users for subsequent development where each module can be produced relatively independently from the others.

This paper reports on efforts to create such an architecture in a particular research public health setting through use of a case study. The higher education institution where this case study took place was a pioneer in creating a formal curriculum leading to a degree in hospital administration in 1947. Eventually, the focus of this program expanded from hospital to health services management and policy. The School of Public Health was founded in 1991 as an essential component of the University's commitment to population-based education that prepares students for careers in health services, health promotion, and disease prevention. The School serves as the only school of public health in its region. A significant feature of the School is its early and continuing recognition of the need to establish strong ties between the School and the practice of public health in communities, counties, cities, states, and the nation. The School prides itself as a learning community dedicated to enhancing human life through the discovery, integration and dissemination of public health and health services knowledge and the application of this knowledge to promote the health and well-being of all persons.

With respect to process, this paper demonstrates the application of a particular information requirements approach that couples the logic model framework with conducting focus groups. This case study illustrates the utility of this approach as a method for gathering and assessing complex, strategic requirements from various stakeholders within and external to the sponsoring

institution. We present this approach to information requirements determination from the perspective of "design science" [Simon, 1996; Hevner et.al., 2004]. Design science seeks to "extend the boundaries of human and organizational capabilities by creating new and innovative artifacts" [Hevner, et.al., 2004] rather than on testing propositions regarding causal relationships among selected variables. In this study, the artifacts include the documented process for capture of content level requirements using the logic model as a framework as well as a high level abstraction of a "to be constructed" knowledge management system.

In the next section, we will present the background and literature regarding knowledge management and requirements determination that forms the basis of this study. We will then discuss the use of the case method to provide study data. We will follow the discussion of the case method with the major content of the developed public health knowledge management program architecture and lessons learned from the case. We will conclude by discussing the study's limitations, future research, and the study's contributions.

II. LITERATURE REVIEW

KNOWLEDGE MANAGEMENT

Knowledge can be an elusive concept. It has been defined as "a justified belief that increases an entity's capacity for effective action" [Alavi and Leidner, 2001]. Knowledge has also been recognized as coming in two forms: explicit and tacit. Explicit knowledge is generally thought of as facts, relationships, concepts, and ideas that can be stated in concrete language. This "stated" knowledge can be refined to higher or lower levels of aggregation and can express uncertainty (e.g., fuzzy logic statements) or contingency (e.g., situations where it does or does not hold true). In contrast, implicit knowledge is generally embodied in individuals and is genuinely known and used, but cannot be stated concretely in language. This distinction is generally attributed to Polanyi [1962].

Knowledge management applications can be viewed as the amalgamation of organizational computing, infrastructure, and human actions designed to create, capture, store, retrieve, exchange, and utilize knowledge. Knowledge management applications may also access routes to knowledge for organizational purposes. As Alavi and Leidner [2001] point out, knowledge can be viewed from several perspectives including "(1) a state of mind, (2) an object, (3) a process, (4) a condition of having access to information, or (5) a capability." The authors further note that differing views can lead to different types of knowledge management systems. The "state of mind" and "capability" views of knowledge will tend to result in training of various kinds and learning through practice.

Viewing knowledge as a collection of objects will lead to storage and manipulation of knowledge through tools analogous to database management or digital library systems. Viewing knowledge as a process will focus on methods of applying expertise. Knowledge perceived as access to people or documents with expertise will lead to various kinds of accessing and indexing. An organizational knowledge management program may approach expertise in multiple ways by building from components that emphasize these different views of knowledge. For example, a knowledge management program may collect complex documents using tools resembling digital libraries with additional modules supporting the expert utilization of these documents through various training applications and virtual team communication tools (e.g., groupware, blogs, etc.). Further insight from existing documents and data might be revealed using quantitative and qualitative data mining components.

MIS KNOWLEDGE MANAGEMENT OVERVIEW

Schultze and Leidner [2002] found that the majority of knowledge management research fits the normative category. This category addresses knowledge as an asset (embodied in individuals or as objects), emphasizes generalizability and accumulation of knowledge. The normative

approach tends to focus on explicit knowledge and the goal of competitive advantage for the individual organization. Indeed, a focus of MIS literature (e.g., Nah, Siau, and Tian, 2005) relates to identifying, storing, and making knowledge available within an organizational context. This presents a distinction between many of the findings of the current stream of MIS knowledge management literature and knowledge management in the public health arena. Namely, the concept of knowledge management in public health generally encompasses a broader agenda of disseminating knowledge for the public welfare.

Schultze and Leidner [2002] also noted a significant number of interpretive knowledge management studies in the MIS literature, which may be useful in a diverse, multi-organizational context. These focused largely on the social construction of knowledge through organizational culture and practices. In this sense, knowledge itself remains elusive; but through communication and interactions, particular approaches to organizational or individual activities emerge. It is important to note that creating the environment for such unpredictable emergent knowledge behaviors to occur can be considered a valid goal for an organization's knowledge management program.

Alavi and Leidner [2001] identify three categories of knowledge management applications: "(1) the coding and sharing of best practices, (2) the creation of corporate knowledge directories, and (3) the creation of knowledge networks." Berndt, Hevner, and Studnicki [2003] describe an additional approach of gathering raw data from diverse sources that relate to the public health context. In their case study, the data warehouse that aggregates the multi-source data provides summary, comparative, and detailed data for individual counties in a larger statewide context.

A corporate portal provides a central hub and access point that links various tools and stored content in order to provide a link among numerous individual systems. In discussing the corporate portal as a tool for synchronizing knowledge management, Benbya, Passiante, and Belbaly [2004] describe many of the tools currently available that can support an integrated knowledge management program. They subdivide knowledge management tools into four categories:

1. Content management, largely aimed at organization of websites;
2. Knowledge sharing tools;
3. Knowledge search and retrieval systems; and
4. General knowledge management systems.

Each of these tools is, in turn, comprised of many components specifically addressing particular aspects of publishing, storing, communicating, retrieving, and processing knowledge.

KNOWLEDGE MANAGEMENT IN THE PUBLIC HEALTH DOMAIN

The domain of public health provides a natural opportunity for implementation of knowledge management programs. Alavi and Leidner [2002] present an organizing framework for knowledge management research distinguishing between knowledge creation, storage/retrieval, transfer, and application components. Public health knowledge management would include support for each of the four identified processes. Knowledge creation support would target both the transformation of data created through transactions into useful formats (e.g. best practices) and the development of new knowledge through research that conceptualizes and refines this data into useful forms. Knowledge storage and retrieval would include strategies for organizing knowledge and physically and electronically holding and maintaining that knowledge. Knowledge transfer would include identifying the location of relevant information, and using push-and-pull strategies to proactively distribute it where it can be useful. Knowledge transfer would also provide search and browse opportunities to locate and acquire knowledge of interest. Finally, public health knowledge management would include application components possibly as straightforward as variance analysis (which compares local performance on a given metric with an overall statewide measure) or as complex as sophisticated algorithms for forecasting epidemiological trends. In the public health domain, it is not difficult to envision scenarios where individual clinicians, public health officials, or public citizens can benefit from the availability of public health data structured

in usable formats or arrayed to provide support for public health decisions or actions. Data structures may include the development of knowledge portals to be used by a broad range of stakeholders with objectives that transcend (1) the coding and sharing of best practices, (2) the creation of corporate knowledge directories, (3) the creation of knowledge networks, and (4) gathering summary, comparative, and detailed data from distributed sources for collective analysis.

The goal of this research project is to follow the design of a public heath knowledge management system with the objectives of:

- Defining the components of a knowledge management program for a public health enterprise, and
- Reflecting on the processes by which such a knowledge management program is developed.

By providing details regarding the development of a knowledge base system in a specific public health environment and process, we intend to provide a strong basis for evaluating the applicability of both the architectural content and the approach to information requirements determination for other contexts.

APPROACHES TO INFORMATION REQUIREMENTS DETERMINATION

Numerous studies on the subject of information requirements point out that eliciting requirements for developing new systems is critical and difficult (e.g., Browne and Ramesh, 2002; Brown and Rogich, 2001; Byrd, Cossick, and Zmud, 1992; Duggan and Thachenkary, 2002; Duggan and Thachenkary, 2003; Houdeschel and Watson, 1987; Montezemi and Conrath, 1986; Shi, Specht, and Stolen, 1996; Vessey and Conger, 1994). Dalal and Yadav [1992] go so far as to assert that "No matter how efficient the design or how effective the implementation, if the requirements are incorrect and inconsistent, the information system is doomed to failure." The task is crucial because subsequent development processes are all based upon these findings. Correction of mistakes in requirements specification discovered in later stages of development can be extremely costly. As stated by Wetherbe [1991], "The cost and time required to remedy a system that fails to meet management's needs can often exceed the cost and time required to develop the initial system."

The task is difficult for several reasons, including the following four proposed by Davis [1982]: "(1) constraints on humans as information processors; (2) the variety and complexity of information requirements; (3) communication issues between analysts and users; and (4) the unwillingness of users to provide requirements". Browne and Ramesh [2002] describe significant and varied biases and recall limits that can influence users' ability and willingness to communicate requirements. Shi, Specht, and Stolen [1996] extend the list of barriers by noting that users are not always aware of the capabilities of the information technology, thus limiting their imagination regarding potential business process improvements.

Traditional approaches to information requirements determination include examination of existing documents, input forms and reports-in-use, supplemented by data gathered from surveys, interviews, and observations of work in practice. Byrd, Cossick, and Zmud [1992] present a listing of eighteen specific techniques organized into five categories: (1) observation; (2) unstructured; (3) mapping; (4) formal analysis; and (5) structured techniques. The authors extend the traditional approaches by including techniques such as protocol analysis, prototyping, open interviews, brainstorming, cognitive mapping, text analysis, and card sorting in their listing. The authors contrast specific techniques with benefits derived by addressing three distinct communication issues, which can create challenges: (1) within an individual or issue - challenged by cognitive processing abilities and recalling all aspects of the problem domain; (2) between individuals or issues - challenged by developing common understandings; and (3) among individuals or issues - challenged by resolution of different values.

As observed by Browne and Rogich [2001], the most prevalent approach to requirements elicitation is through individual interviews. These researchers developed and tested a set of prompts that they call the "Task Characteristics Prompting" technique. This technique has the objective of providing a theory-based, demonstrably effective approach to requirements gathering interviews. In comparison to competing approaches, the technique elicited significantly more total requirements and more detail level requirements. However, the technique did not elicit significantly more "goal" or highest-level requirements. High-level requirements consist of "organizational or strategic issues relevant to system design…. (and) include a description of the current state of the organization, the preferred state, and the means and strategies that might be used to achieve the future state" [Browne and Rogich, 200]. In fact, the "Task Characteristics Prompting" technique garnered fewer goal requirements than the contrasted techniques (though the difference in the number of goals was not significant).

Leifer, Lee, and Durgee [1994] make a convincing argument that most traditional information requirements elicitation techniques used in combination provide a reasonable picture of "surface"-level knowledge regarding the new system, but that they do not penetrate beneath the surface to the "deeper" level of knowledge regarding values, purposes, and underlying relationships that permeate the domain of interest. A wide range of techniques for acquiring this deeper knowledge is presented by Browne and Ramesh [2002]. Overall, these techniques include group discussion in varied formats for the efficient and detailed listing of such knowledge, and various forms of mapping or graphical representation for displaying and validating this knowledge.

Two major group discussion approaches that may be used for information gathering purposes are Joint Application Development (JAD) and Focus Groups. These approaches share the drawing out of information through group discussion and recording of statements and preferences among group members. However, material differences exist between these approaches as presented in Table 1. JAD is rooted in systems analysis and design and often has the objective of specifying system requirements and design through consensus and negotiation [Kettelhut, 1993]. JAD participants are selected due to their expertise and/or ability to represent a group in discerning requirements and design feasibility. The general nature of JAD is to emphasize structure and agenda as evidenced by cookbook forms and "to do" lists that can be found in JAD guideline materials [Carmel, 1993]. Modeling and prototyping of *a priori* design concepts are often employed as part of the JAD process to ground design points [Davidson, 1998 and Carmel, 1993].

The focus group approach may be more in line with explicating requirements of knowledge base systems and especially on attempting to capture knowledge base structures and strategies using a social constructive approach. This may be especially true for knowledge base systems created for diverse, multi-organizational contexts, as with this case study, where knowledge shared and developed from various cultures and practices may be elusive.

As we explore the nature of knowledge management in the public health context through this case study, we will demonstrate a process using the program logic model to guide a series of focus groups for developing high-level requirements and the creation of "deep knowledge" intrinsically needed to develop knowledge base systems. This deep knowledge includes explication of values and priorities, realistic social and technical tradeoffs, and conceptualization of an umbrella system architecture within which numerous stakeholders can be served.

III. METHODOLOGY

The development of a public health knowledge management program is a large and complex undertaking, without clear boundaries. The central focus of this study is the content of the public health knowledge management program architecture. A secondary focus is describing the environment and process by which this architecture was developed.

The case method is particularly suited to this study as it provided a means to explore contemporary phenomena within its real-life context, especially when the boundaries between

phenomena and context are not clearly evident [Yin, 1984]. This study is a holistic, single-case study [Yin, 1984].

Table 1. Comparing JAD and Focus Group Approaches

Point of Comparison	**JAD [adapted and expanded from Carmel, et. al., 1993]**	**Focus Groups as applied to system definition/ information gathering in this case [derived from Morgan, 1997; Kruger and Casey, 2000; Puchta and Potter, 2004; Fern, 2001]**
Background/theory	Group dynamics, software engineering	Consumer dynamics; social and marketing theory and research methods
Themes	Teamwork, accelerated design, completeness	Democracy of the system, social context, environmental context, humanization
Focal Activity	The meeting: • Published agenda. • Topics delimited by time	Group processes/conversation: • Agenda negotiable • Satisfaction/sharing delimited
Techniques' Emphasis	Structure	Creativity
Suggested Room set up and tools	U-shape	Round table
Tools	• Flip charts, white boards • May include group support systems • Prototyping tools	• Tape recorder
Perspective on Users	• User selection based upon competency criteria (typically direct users and/or developers) • Each user viewed as a subject matter expert in their area and serves as a representative of that specialty.	• Users are a range of stakeholders (indirect and direct system users) • Expert opinion derived through collective contributions from participants. • Indirect and direct users viewed as primary source of knowledge.
Participants	• Users, executive sponsor, IS project team, meeting leader/facilitator, scribe • Participants generally consistent over multiple meetings	• Indirect and direct users, moderator, sometimes a scribe • Participants change with each focus group
When Typically used in Systems Development Life Cycle (SDLC)	Requirements stage	Not generally noted as an SDLC stage (except perhaps indirectly through interviewing as a group interviewing process in analysis stage or as a method of evaluating the technology product)
Role of Prototyping/ Model	JAD typically is supported by prototyping tools so that initial construction of actual systems and system components can be viewed, discussed, and moved forward within the elicitation context	Not typically used (although a prop or list may be used to stimulate conversation)

THE PROJECT TEAM

The knowledge management system project was led by a project leader (an academic in the School of Public Health) and supported by a core steering committee of four (including the project manager), who organized and executed most project activities. The core committee was periodically supported by a steering committee composed of a cross section of approximately ten individuals interested in health information systems. These individuals were associated with various colleges within the university and support units such as the library.

During the course of the project, the authors took a passive role (observation) in some of the strategic planning meetings and in focus groups 1 and 2. The authors took an active role in facilitating the execution of focus groups 3 through 6. Facilitation consisted of the development of the focus group protocol according to the project parameters, coding of the focus groups, and caring for various logistic matters (e.g., arranging for a meeting site, organizing the room, locating a professional facilitator, and acting as a scribe during the focus group sessions). The researchers participated in the development of protocols to conform to the guidelines of the program logic model and the scribing of the focus group sessions.

PROGRAM LOGIC MODEL

Program leaders for this project proposed a program logic model structure as an integrative framework to guide the process of developing a design concept for the public health knowledge base. The logic model is a causal process model generally used as a guideline for evaluating running programs. The evaluation process follows the causal chain as defined by stakeholder assumptions to convey key program resources/inputs, activities, outputs, outcomes, and impact, and how these elements relate to each other (see Figure 1). The specification of the logic model (causal chain) for a specific program is referred to as the "program's theory" [Weiss, 1997].

Utilization of program logic models has historically involved the development of evaluation programs for grant and social service programs (e.g., Chen and Rossi, 1980). From an evaluative perspective, a logic model process attempts to:

1. Focus evaluative data collection on relevant activities and outcomes,
2. Structure the data, and
3. Support data triangulation in the validation process. [Cooksy, Gill, and Kelly, 2001]

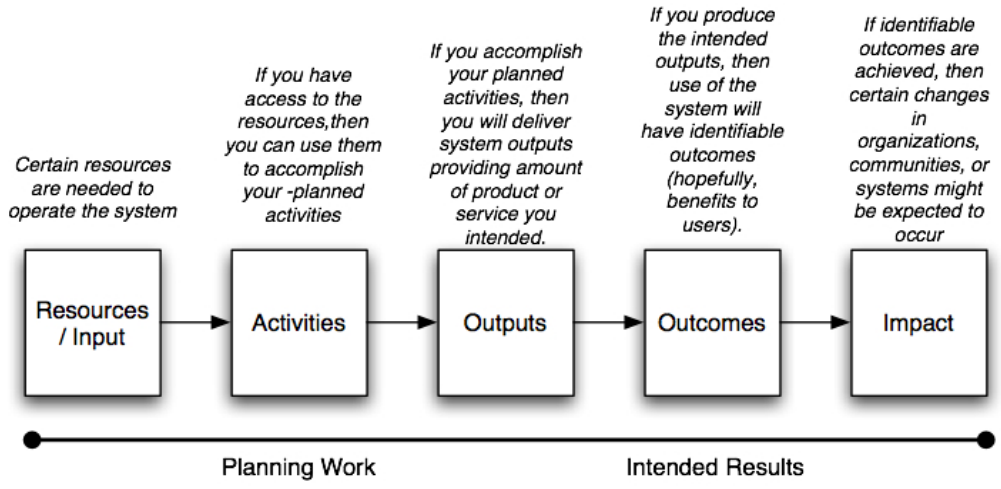

Figure 1. Basic Logic Model Annotated with Implied Causal Statements (adapted to IS context from W. K. Kellogg Foundation [2004].

The practical objective in using a logic model framework is to dictate evaluation procedures and measures by program design rather than by generalized instruments or methodologies [Chen and Rossi, 1980]. Underlying this objective is an assertion that evaluation using logic models bridges research and practice by linking basic and applied social science [Chen and Rossi, 1980].

Recent literature has investigated the use of the program logic model for a variety of purposes throughout the lifespan of human service and grant programs including feasibility analysis, program development, developing program monitoring systems, program readiness for evaluation and for building program knowledge [Savaya and Waysman, 2005]. The purpose of employing a program logic model framework in the program development stage is to develop the program theory *a priori* including the specification of resource/input, activity, and output assumptions.

The case study at hand exemplifies using the program logic model as an integrative framework for program planning and conceptualization. The project leader for the public health knowledge management system initiative was very familiar with the program logic model through grant and administrative service activity experience (and specifically familiar with model templates developed by the Kellogg Foundation [W. K. Kellogg Foundation, 2004]). It is of note that the program leader was unfamiliar with "classic" requirements definition processes and frameworks often used in information systems and software engineering domains. As such, the framework was selected as a result of related experience rather than as a result of searching across the range of possible requirements definition strategies such as those discussed in the literature review with the selection of an optimal approach.

THE FOCUS GROUP APPROACH

Focus groups were used as a mechanism for gathering stakeholder data. A focus group is a form of qualitative inquiry rooted in market and social research [Morgan, 1997]. Participants are selected, screened, and gathered for creative and exploratory discussion of a specific topic, usually in great detail (e.g., development of product concept and identification of opinions and feelings on an issue). A key feature of groups is that participants, typically, four to 12, are able to interact with, and react to, each other in response to questions and prompts posed by a moderator [Krueger and Casey, 2000]. Open-ended, discursive questions are generally used in the protocol to gain a deeper understanding of respondents' attitudes and opinions. Focus groups provide a means to obtain assessment from a cadre of stakeholders through collaborative construction, rather than consensus or negotiation [Morgan, 1997]. The focus group participants are collectively seen as "experts" through collaborative construction [Morgan, 1997]. In order to facilitate this group dynamic it is therefore important to ensure that participants are broadly "compatible" [Puchta and Potter, 2004].

In relation to product development, focus groups are often used as a validation of sorts, after a product is prototyped or fully developed. Similarly, in the information systems domain, focus groups are most often seen as a means to validate, for example to validate survey items (e.g., [Brown and Venkatesh, 2005]). However, the IS domain does provide opportunities for focus groups related to exploratory issues or when expertise regarding a phenomenon is not manifested in individuals, but may emerge from group interaction situations. In these situations, focus groups may be a very strong means of primary data collection [Krueger and Casey, 2000]. Focus groups may also prove useful when there is value in capturing the comments or language used by the target audience as they interact regarding specified topics [Krueger and Casey, 2000].

In this particular case study, the focus group approach provided three major advantages. First, the parameters of what constitutes candidate system knowledge in this and perhaps many organizational contexts may be somewhat elusive. In this case, the definition of knowledge in the form of "strategic requirements" was not known *a priori* and was derived from the study process. Similarly, stakeholder perspectives of the scope and potential of knowledge management

systems were limited as the study began. By focusing on conceptual issues, the focus group method highlighted individual stakeholders' reflections in building these conceptual insights.

Second, focus groups allow contextual development to be prompted by participant statements as well as prompts from the research team [Krueger and Casey, 2000]. Without these participant prompts, a level of understanding may be lost. Likewise, requirements gathering of systems such as knowledge bases may involve complex or vague topics as stakeholders look at new technologies or multifaceted constructs. When soliciting data from the field, it is sometimes difficult to achieve full explanation and understanding in surveys, especially in initial stages of research. Focus groups allow the gaps to be filled in by fellow participants. Limited moderator prompts may help ensure the topics and issues are understood, yet avoid excessive intervention by project directors, sponsors, or researchers.

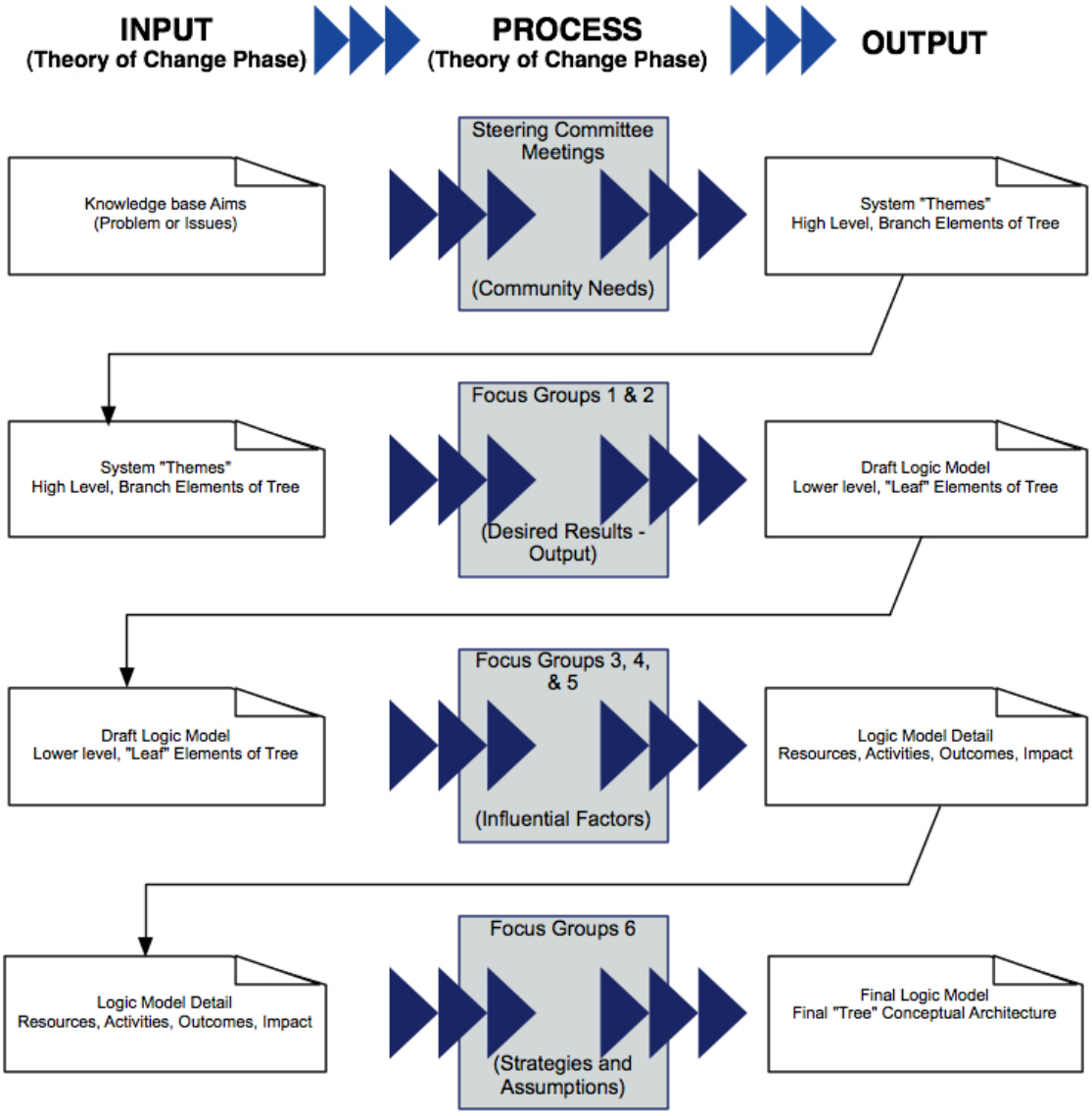

Figure 2. Sequence of Interactive Processes

Third, because the focus group draws participants from the full set of involved stakeholders, and because the participants are exposed to a wide range of ideas regarding the overall knowledge management program, these participants are themselves positioned to more easily continue diffusing knowledge about the program to nonparticipating stakeholders. There is increasing recognition of the role of organizational and user attributes along with technical design as critical success factors in implementation of health management information systems [Tan, 1995].

PROCESS AND PROTOCOL

The sequence of interactive group processes that were used to develop strategic requirements for the knowledge management system is depicted in Figure 2. The general protocols for each focus group followed aspects of the logic model (Figure 1) and the Theory of Change Template (Figure 3). The general aims of the knowledge management system determined by the core project team related to step 1 in the Theory of Change Template, "Problem or Issue."

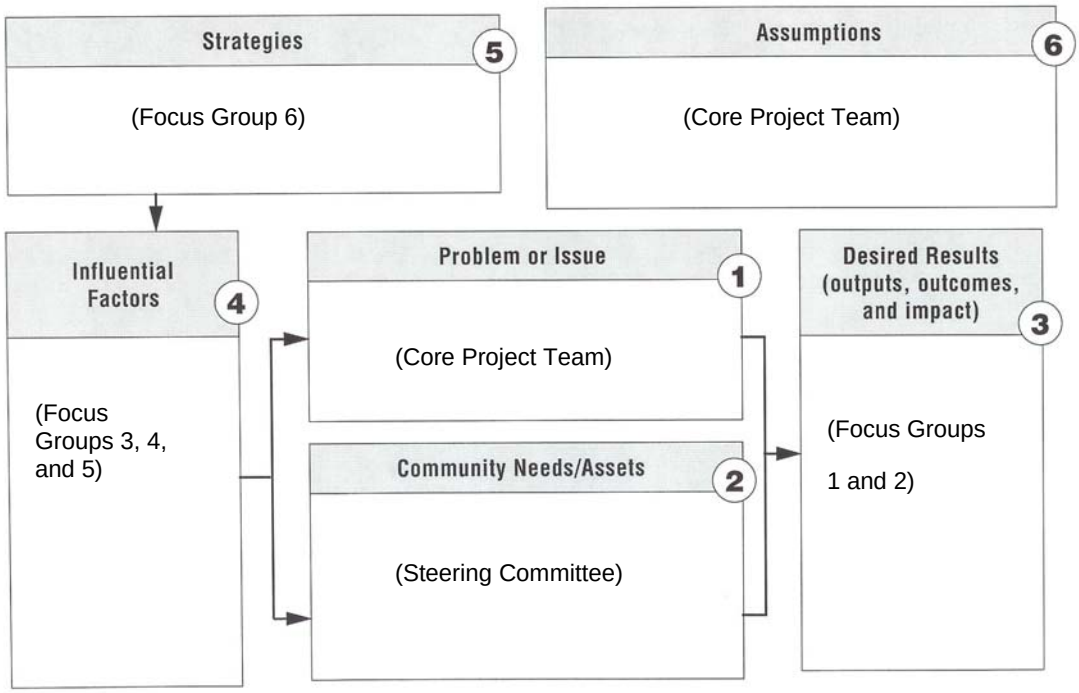

Figure 3. Theory of Change Template [W. K. Kellogg Foundation, 2004] with Primary Actors in Process Noted

SESSIONS

The knowledge management undertaking had three broad aims:

Aim 1. To create an interconnected educational and research environment that is responsive to the shifting needs of public health. The project should create an environment that provides a broad range of information tools for productive collaborations, encourages the development of computable new knowledge, and offers information network tools for education and effective dissemination.

Aim 2. To serve practitioners of community health with electronic information that connects public health data with scientifically sound knowledge for the local, state, and national

levels and supports broad dissemination of health information, including patient education. Particular emphasis should be placed on the integration of information coming from diverse sources, but being relevant to certain typical, health-related decisions.

Aim 3. To advance the methods of public health informatics by demonstrating new opportunities of integrating electronic resources, developing web portals and other software tools for decision support, offering directly computable health knowledge, contributing to not only the application but also advancement of health information standards, and establishing innovative electronic repository and other library services to support education, research, and community action.

The steering committee considered the aims specified by the core project team to identify the following knowledge base themes for the knowledge management system, referred to hereafter as community needs:

- Library of Databases & Digital Knowledge Sources
- Library of Research Synthesis Software
- Integrated Inquiry Interface
- Electronic Education Programs
- Active Distribution Service Centers

The objectives of steering committee meetings towards this purpose correspond to Phase 2 of the Theory of Change Template, identifying "Community Needs/Assets."

Focus groups were then used to develop a knowledge management system model based upon the aforementioned community needs. Three to five groups per project is the rule of thumb for the number of focus groups required to reach saturation [Morgan, 1997]. Saturation is defined as the point at which additional data collection no longer generates new understanding [Glaser and Strauss, 1967]. In consideration of the goals of this effort, it was determined that six focus groups would permit the desired coverage to explore a framework for the knowledge base. The core project team was open to the possibility of additional groups if coding efforts did not indicate that the initial groups provided saturation of ideas and sufficient strategic requirement structure. The size of individual focus groups may vary, with seasoned researchers reporting productivity with groups of three to 15 participants [Morgan, 1997]. The core project team balanced their desire for detailed information from each participant with a sensitivity to group dynamics to arrive at a desired group size of four to six participants.

It was deemed that for groups one through five, a cross section of anticipated users including researchers, college administrators (e.g., a research office and health science library director), public health graduate students, public agency representatives (e.g., a public library director and city public health manager), and academic leaders (e.g., college deans and center directors) was needed to achieve the desired diversity of potential user perspectives, yet form a compatible group. Potential participants were identified through university directories, civic directories, and project team personal contacts and recruited through an invitation letter and follow-up phone call.

All sessions were conducted in meeting rooms on campus. Importance was placed on providing a comfortable atmosphere that would support conversation, as well as getting participants away from their normal duties and inherent interruptions [Puchta and Potter, 2004]. All sessions were audio recorded and a scribe took detailed notes, both of which were used in the construction of a professional transcription.

The first two focus groups identified potential output (desired elements) associated with the community needs of a broad public health knowledge management system identified by the steering committee and articulated via system aims (Phase 3 in the Theory of Change Template). The agenda was predetermined and managed by the project leader. These two focus groups identified desired outputs associated with the community needs. Participation by steering committee members in each of these initial focus groups was used to facilitate understanding of

the spirit of each of the high-level community needs and the general aims of the project as questions arose during the focus group discussion.

The protocol used by the moderators consisted of a general presentation of the knowledge management system, program logic model orientation, and facilitation of a discussion that led to completion of the output boxes of the logic model (Figure 1) under the auspice of the community needs identified by the steering committee. The focus groups were instructed to freely brainstorm and not to exclude ideas based upon cost or other limitations. Possible resources to support each activity or output identified were explored as time permitted. Coding by two core steering committee members consisted of reviewing focus group transcripts and notes to identify system elements and to create a detailed definition of each element. Seventeen elements were identified. Some key element definitions are referenced in the findings and discussion section (additional definitions are available by contacting the authors). The metaphor of a tree with the knowledge management system as the trunk, the community needs as branches, and the elements as leaves was verbally and pictorially depicted. The graphical representation was constructed to help future focus group participants visualize some of the potential contents of such a management system as well as to create an initial organization for the various components. Validation of the initial model was achieved by distributing the tree structure along with the list of represented elements and their definitions to focus group participants with a request for feedback and commentary regarding accuracy, completeness, and understandability. Only minor adjustments resulted from the feedback.

The purpose of the next three focus groups (3, 4, and 5) was related to Phase 4 of the Theory of Change Template—Influential Factors. To this end, these groups sought to confirm or disconfirm the overall structure of the system, to ensure that elements were arranged in reasonable categories, to elaborate on the potential value and barriers for the various leaves, and to create a sense of enthusiasm among the focus group participants (potential future project stakeholders). Groups 3, 4, and 5 were comprised of heterogeneous individual project stakeholders including practitioners in public health, clinicians, business school representatives, graduate students in related areas, librarians, and external public health information users. Steering committee members did not participate in groups 3, 4, and 5. Unlike the first two groups, groups 3, 4, and 5 had the graphical model and corresponding definitions as a basis for discussion. Hence, groups 3, 4, and 5 did not have to address ambiguities that existed with brainstorming high-level elements, making steering committee participation unnecessary. In fact, core project team members felt steering committee presence could evoke a Hawthorne effect towards the framework of components they helped to create and thereby stifle critical analyses. Additionally, the steering committee did not want to disrupt the social interaction and contextual sharing among potential users regarding the knowledge management system.

Focus group participants were provided summary materials regarding the knowledge management system including the tree representation of logic model outputs and definitions of corresponding branches (community needs) and leaf elements (outputs). The protocol was predetermined and based upon logic model components—resources/input, activities, outcomes and potential impact (see Appendix A for outline of protocol). The core project team engaged a professional group facilitator to moderate the discussions.

All unit leaders, as well as the dean and assistant dean of the Public Health College, participated in the sixth group. The sixth group provided an assessment of the aggregated results of the prior groups (tree elements as prioritized, detailed, and specified by focus groups 3, 4, and 5). The purpose of this session corresponds with the “Strategies Phase” of the Theory of Change Template (Figure 3) and included fine tuning the content of the architecture, providing thoughts on execution, as well as drawing senior management support for the program. The protocol for this group paralleled the protocol for groups 3, 4, and 5 with the exception that a summary of responses for groups 3, 4, and 5 was presented to the group for each section of the protocol with a request for their reactions, assessment, and advice in moving forward toward developing a plan of action. Among the by-products of this session was a contact list to help with development and delivery of priority elements.

It was not feasible to provide participants in focus groups 3 through 6 with reports summarizing focus group coding. However, cursory validation was achieved at the close of each group by having the scribe ask for clarification of comments and make a summary of discussion highlights with a request for confirmatory feedback or correction, if needed.

Two researchers independently coded all focus group transcripts for groups 3 through 6. The researchers generally agreed on coded data (though different formats were used) and reconciled minor differences to reach consensus. Two forms of coding were used. The first form of analysis involved purposeful, axial coding (see Strauss and Corbin 1990 for complete description of axial coding). This coding technique was used to inform the systems development process via reports back to the project team. The axial coding process involved a combination of inductive and deductive reasoning with the goals of relating branch elements, determining priority elements in the model, assessing general interpretation of user reactions to the model, and fitting specific aspects of each element into a basic logic model frame (i.e., identifying resources/input, activities, outcomes and potential impact for each priority element). Table 1 provides the basic logic model frame used to code detail comments for each element explored by the focus group.

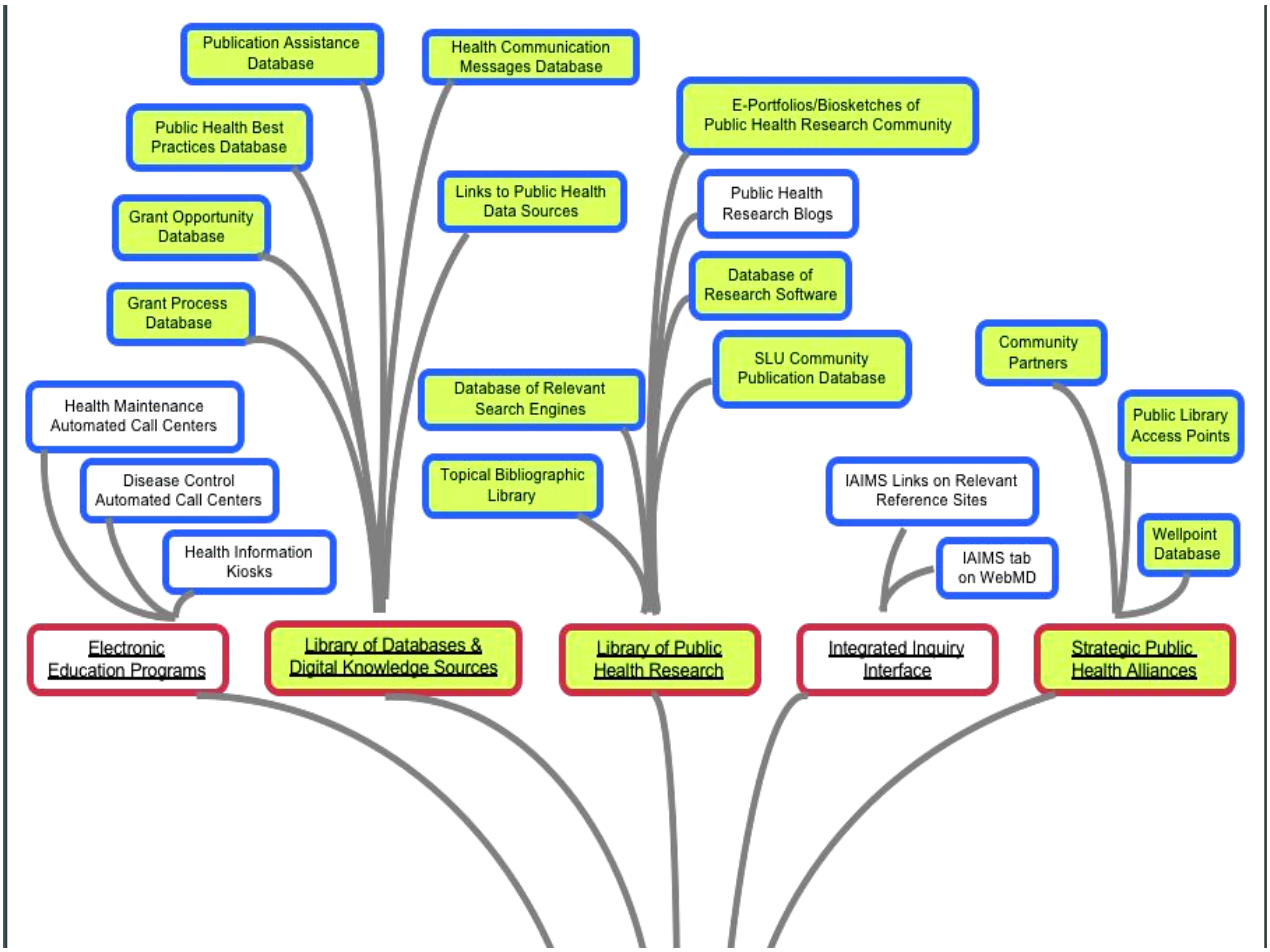

Figure 4. Full Strategic Model - Final Model Elements are Darkened

The second form of coding used was open coding (a.k.a. generative coding; see Strauss and Corbin 1990 for a more complete description). This was an interpretive process driven by

research objectives. Specifically, we used open coding techniques to discover themes and overarching issues related to the knowledge management and general information systems domains. The themes emerged from comments that transcended individual focus groups, branches, elements, and participants. The results of coding processes are discussed in the findings section.Core members of the project team performed a final pruning of the logic model to establish project priorities based upon collective assessment of logic model factors related to each element. The final model is presented in Figure 4. The core team also considered the assumptions behind how and why the identified public health knowledge management framework would serve the needs of user groups, corresponding with the "Assumptions Phase" of the Theory of Change template.

IV. FINDINGS

Focus group participants assessed relative importance of each of the major branches. They identified three branches as having the greatest importance: 1) library of databases and digital knowledge sources, 2) library of public health research, and 3) strategic public health alliances. The next section presents a brief discussion of those branches and highlights their evolution. The final model is depicted in Figure 4.

BRANCHES AND ELEMENTS

We discuss the major branches and associated elements using the language of the various components of the basic logic model—resources/inputs, activities, outputs, outcomes, and impact. We follow this discussion with the final refinement of the model provided by focus group 6 and the core project team.

Branch 1—Library of Public Health Research

Participants expanded the existing list of elements associated with this branch by adding an element - "a database of core facilities". This new element was initially viewed as a mechanism for researchers to locate useful tools with the possibility of lowering costs or shifting funds internally rather than spending them with outside vendors. However, it was not long into the discussion before this concept was extended to include providing additional services, such as online reservations of research tools. Table 2 illustrates the development of focus group discussion regarding this particular element and serves as a general example of the focus of interpreting and coding transcripts from focus groups 3, 4, and 5 using the lens of the Theory of Change.

This addition to the overall model showed the strength of using the focus group approach to architecture design. Not only did a new element emerge from the experience of the end-users, but also the interaction among participants quickly expanded the discussion from automation of existing services to the creation of new ones. From a knowledge management perspective, the development of a facilities inventory and automated reservation system may sound fairly mundane, but consider the knowledge transfer involved in the accumulation of local information about stand-alone facilities scattered among organizational units and organizations, not to mention the knowledge created by the potential discovery of redundancies and gaps. Further, institutionalization of rules for reservation (e.g., priorities, chargeback, scheduling methods) represent a significant shift in organizational learning, moving the need for expertise in accessing these facilities from laborious information gathering by each individual to a simple and universally-accessible process.

Branch 2—Library of Database and Digital Knowledge Sources

The focus group members did not augment this branch in their assessment of each of the original elements in this branch. Focus Group members did, however, add much detail toward extending the notion of a database for grant processes including templates, boilerplates, and guidelines. The hurdles or difficulties to be overcome were also apparent in this discussion. Resource and

input hurdles to overcome included: transferring existing paper documents to electronic format, motivating people to contribute segments of successful applications, sharing successful procedures, and ensuring that efforts would not be duplicated relative to the research service office. One participant expressed that this database could impact the entire research component of the university by leading to reengineering of the grant application process at the institution. In regard to impact, multiple members expressed the need to "strip out" proprietary or sensitive information to avoid potential impacts of publishing such data including deterring participation and violating agreements with granting agencies.

Table 2. A Database of Core Facilities Findings Depicted in the Form of the Logic Model.

Resource/Input	Human resources to implement such a system (limited) Existing software for tracking equipment and utilization
Activities	Start with a simple list of equipment and facilities, then evolve to online reservations
Outputs	Database of Core Facilities
Outcomes	Increased utilization of existing equipment
Impact	Financial Impact Less duplication of purchasing Lowering costs due to aggregated purchases Lowering costs due to shifting equipment and funds internally rather than to vendors

From a knowledge management perspective, this discussion highlights the relationship between organizational learning and the transformation of business processes. That is, the relationship between documents with embedded knowledge (e.g., templates) and the way they are used by personnel (including procedures, timing, and specification of individual activities) presents an opportunity for shifting the type of knowledge required from complex individual knowledge of process and procedure to a much more explicit model following specific action items. Explication of embedded experiential knowledge should allow the grant seeker the opportunity to focus on the grant application rather than be distracted with arcane preparation steps. In addition, the identification of negative impact factors related to "over-sharing" knowledge further shapes the knowledge management system by evoking new processes (desensitizing data) and explicating aspects of existing knowledge that are best managed via means outside of the system.

Branch 3—Strategic Public Health Alliances

The focus group members assessed each of the original elements in this branch without adding new branches. Discussion regarding the element "library access points" significantly extended the original conception. Concept expansion involved brainstorming additional access points extending beyond the library, such that similar access points could be located in health clinics, laundromats, shopping centers, and grocery stores. Resource hurdles identified included the potential need for new equipment if existing equipment would not suffice. Focus group discussion of resources also raised the question of whether data would be stored on equipment located at the access point or centralized at the college and accessed via website.

Explicating perceptions regarding the boundaries of public health knowledge prompted further discussion of the scope of inputs associated with this branch. With respect to inputs, the question was raised regarding how to distinguish between public health and medical information systems. This was viewed as important because ultimate users could have questions that traversed the traditional boundaries of these areas.

From a knowledge transfer perspective, this discussion highlighted several key issues. First, it is difficult to establish boundaries for knowledge transfer that can accommodate domains of knowledge (e.g. medicine and public health) that are growing rapidly and somewhat unpredictably. Second, recognizing different audiences can create the need for a variety of interfaces and non-traditional access points to the knowledge base system. In this case, knowledge about public health best practices was visualized as a common core that could be formatted for different audiences. The discussion of where to locate access points such as kiosks highlights that although one might expect uses across laundromats, grocery stores, and shopping centers to be relatively similar; their differences may be nuanced in one way or another requiring even more specialized interfaces for optimal transfer of common core knowledge.

Third, providing knowledge to diverse constituents across organizations created a demanding infrastructure. In this case, it was also noted that obtaining, cataloguing, and maintaining existing knowledge from outside the public health school would itself be an immense job, not to mention the on-going need for maintenance and preparation of multiple access routes.

Refinement—Final Model

The final focus group session was comprised of public health school leaders and high-level constituents. This group discussed and evaluated the findings of the prior focus groups. The core project team used the findings of all the focus groups to determine the architecture for a core system (represented in Figure 4). The core project team recognized determining a solid architecture and components for the core system was necessary to develop a solid foundation that afforded early benefits and to allow for phased development that minimized integration issues and rework as each new phase layer was added on to the existing system. This core system would dictate the scope of the immediate project. The determination of which elements to include in the core system (version 1), was chiefly based upon the identification of resources and the potential impact that was identified through the focus group discussions.

In reflecting on the entire process, many members of the steering committee expressed the view that the development of a comprehensive vision of a knowledge management system identifying all relevant elements and relationships was necessary for understanding and to afford compatible system expansion. It also provided deeper understanding regarding stakeholder commonalities, differences, and needs.

OBSERVED THEMES

In considering the collection of data that surfaced throughout the case study activities, a number of themes related to the development of knowledge base systems became apparent. To a large extent these issues mirror difficulties, such as defining scope and providing management control and coordination that are likely to be found in any large IT project. Though generalization cannot be achieved with a single case study, it is possible that these six themes may extend to other knowledge management contexts, and thus, should be considered in project planning and systems development. To inspire potential consideration in other contexts, we selected names for the issues that reflect a more generalized MIS perspective, yet are descriptive of the nature of the issue in this case study. The discussion of these themes is intended to show how these issues manifest themselves specifically in the public health knowledge management architecture context and to share lessons learned from this context. No claim is made that these issues are comprehensive of all concerns or observations uncovered during the study. We discuss these six issues below.

ISSUES WITH SCOPE

Overall issues of system scope surfaced repeatedly in the sessions. It was evident the entire model could not be addressed in the short term with given resources. One of the clearest issues of scope dealt with the degree to which project priorities should address internal university needs or external “service to the community” needs. The effort to reconcile internal and external

objectives creates an ambiguous scope issue for a public health knowledge management system when trying to develop a unified core system. The ambiguity was driven by the recognition that partial motivation for improving the internal systems was to ultimately provide better service to the community.

A second persistent scope issue pertained to the distinction between public health and clinical/medical information. Although there is no fine line that delineates the border of these in some absolute manner, each has a distinct central tendency and different institutional adherents. The thrust of this project is public health information, but navigating the border was not clear for some knowledge base elements. This issue highlighted the fact that those creating new knowledge may need detailed and clear domain and sub domain definitions, however, these may not be important to those receiving knowledge as part of the transfer process.

Project leaders learned that to provide the full range of information that would encompass public community citizens' interests, the knowledge base might require significant scope expansion beyond the boundaries of the public health information domain. The expansion of scope would result in an increase in work, cost, organizational alliances, and possibly moving into areas of less expertise.

ISSUES WITH KNOWLEDGE TYPE

It was not always clear what sort of knowledge resources already existed to serve as inputs (how refined was the initial data feeding the knowledge system) and what activities would be necessary to develop the desired output. In some cases, it was unclear whether knowledge within a particular domain had already been gathered and formatted either internally or externally. Data in a refined format would relieve the knowledge management system from some processing burden. For example, existing knowledge already available via various web sites may only require the knowledge management system to create the appropriate links, indices, and access paths. If the knowledge had not yet been gathered or formatted, then the knowledge management system might include knowledge creation or structuring.

Even when the existence of available knowledge sources was known, there was recognition of a "make versus adapt" decision. The following statements illustrate a "make versus adapt" question that emerged: Is it the will of the group to create a new set of best practices (knowledge creation) or to identify and link to existing lists (knowledge formatting and dissemination), or both? It is interesting that there was no articulation of a recommended course of action in response to such questions.

The knowledge type issues provided enlightenment regarding the delicate balance between not duplicating what already may exist in other forms (e.g. just providing a link) and providing a cohesive form to support knowledge creation and efficiency that can result from combining data from multiple sources. This balance challenges acceptance, system value, and optimizing utilization of scarce development time and resources.

ISSUES WITH PROGRAM PERSISTENCE

In relation to several of the elements, participants noted that initial funding, while not necessarily easy to obtain, was a viable reality. However, the question of how to sustain programs, once initiated, emerged for most elements. Stakeholders recognized the temporal nature of relevant knowledge within this domain. This raised concerns about issues of distributing out-of-date and possibly erroneous information if system information was not actively monitored and maintained. This may be a less dramatic though very important issue in other knowledge management contexts. Research models (e.g. Alavi and Leidner, 2001) stress input (knowledge acquisition), process (knowledge creation), output (knowledge transfer), and storage; however, the value of the knowledge base will rise and fall with the amount of incorrect, outdated, and misleading information. The lesson learned related to this issue was that the manicuring of the knowledge

base itself must be viewed as a major element for the effective deployment of a knowledge management program.

ISSUES WITH ORGANIZATIONAL CULTURE

In relation to multiple elements, focus group participants raised questions of how to encourage participation by researchers or public community members. The usefulness and value of some elements relied on input contributions from a majority of stakeholders to create a holistic resource. For example, programs like e-portfolios profiling expertise and skills to internal and external constituencies have little relevance if a majority of information suppliers do not contribute input. This motivational challenge was exacerbated in instances where the suppliers of input and users of output for certain knowledge elements were different. Stakeholders recognized that such structures would be difficult to populate.

One difficult, expensive, and time-consuming task in knowledge management systems is collecting data. Those who have collected and continue to hold data can display a natural tendency to want to control that data and to gain a return on their investment for having collected it. In contrast, the owners of the knowledge management system are generally concerned with providing ultimate users with the maximum value based on the underlying data.

The lesson regarding this issue is one of balancing key users' costs of contribution to one or more parts of the system with the rewards of analysis, integration, and distribution of data gathered throughout the system. It is essential to address directly how benefits from the use of the data accrue, in some reasonable measure, to those that invested in its collection and storage. A situation could exist where contributors to one element may not actually receive value from the element they contributed to, but may see the value of their system in an alternative element or branch. To illustrate using elements from Figure 4, some key contributors to the e-portfolios (Biosketches of Public Health Research Community) element may not derive value from that element, but may actually "buy-in" to the system due to value they may receive from the Strategic Public Health Alliance branch. One response may be that of promotion and education so that all users understand the specific benefits that accrue to them from system use. Another response may affect design; architectural decision makers may consider the balance of contribution with reward structure for key contributors when making decisions on how to prune the model or when considering version one and subsequent components.

ISSUES WITH MANAGEMENT AND CONTROL

On several occasions within the focus groups and at steering committee meetings, assigning responsibility for both the content and tools involved in the knowledge management system was noted as an issue. Easy access and expansive use are considered success measures. On the other hand, guaranteeing appropriate access, accuracy, and completeness is a serious, and potentially costly, responsibility. This is particularly the case where system elements are used by both internal and external stakeholders whose authorization levels may differ in multiple and subtle ways. The responsibility and legal and ethical issues related to the use of knowledge embodied in a knowledge management system is complex and difficult to sort through.

Disclosing knowledge, particularly in the health care arena, has risks as well as rewards that can be difficult to predict. To what extent is the creator of knowledge responsible for results from its application? How does responsibility change when control for the circumstances of application, the processes of application, and various application decisions are not under one's direct authority and supervision? It was mentioned that potential breaches of sensitive information may not be vested in any particular element of the system, but could emerge from combinations of data derived from various elements. The resulting question raised was whether the owners of the system would be responsible for data permutations. If responsible, how could system owners anticipate all sensitive permutations?

These issues illustrate that knowledge is not a commodity and risks are as varied as the content of the knowledge. Additionally, the implications in taking those risks may be difficult to calculate when the responsibilities are vague and the possible variations of use are speculative. Hence, this is a particularly difficult issue of servicing and protecting both knowledge consumers and suppliers, particularly in the area of health.

ISSUES WITH TECHNOLOGY

Although the focus group sessions did not emphasize implementation of the identified knowledge management elements, participants raised a number of technical issues. Technical issues included the importance of selecting tools that were adaptable to multiple situations, yet not forcing users (particularly university users) to adopt tools that did not ideally fit their needs. Participants also noted issues related to ensuring integrity and security of tool use, integration with legacy systems, and the ability to migrate to emerging tools and technologies.

V. DISCUSSION

This case study demonstrates the use of a logic model as a framework and focus groups as an appropriate methodology to serve as mechanisms for developing architecture for a public health knowledge management system. We focus our discussion on the purpose of higher-level reflection of the processes by which such a knowledge management system is created.

KNOWLEDGE MANAGEMENT OBSERVATIONS

We begin this discussion by recalling Benbya et al.'s [2004] four categories of knowledge management systems:

1. Content management, largely aimed at organization of websites;
2. Knowledge sharing tools;
3. Knowledge search and retrieval systems; and
4. General knowledge management systems.

In light of this categorization, we see that the ultimate architectural design in this case does not fit one category, some elements cannot be classified into mutually-exclusive categories, and the categories enumerated above may not be all encompassing. For example, the elements dealing with "best practices database" and "grant support database" are likely to fall into the content management group. Elements like blogs fit into the knowledge sharing tools. However, elements such as the facilities database, which includes pieces such as an index to find who was responsible for each site that would serve as another kind of knowledge management system, do not clearly fit into one of the existing four categories. Perhaps closest in application fit for this element would be the "general knowledge management," though the term does not really capture the result of this particular project.

Rather than classifying this project into one of the aforementioned categories, we would see the outcome of this project as a set of knowledge management modules that together comprise a large-scale knowledge management program. By the end of the project, the vision of the entire package, (if fully implemented) would be that of a kind of knowledge management portal where a dense set of linkages would filter various stakeholders to the elements likely to be relevant to them and where following those links would lead them to accessing the specific element's features. Hence, the results of this study made it apparent that the system may be best defined as a type of object-oriented structure, with objects (i.e. elements) linked by an overall architecture that provided semantic congruence. By creating the overall architecture, various objects could:

- Be built from the same underlying tools for overall simplicity and coherence;
- Be built to the same standards for ease of combining lower-level elements or data from different elements; and

- Be implemented gradually as increasing numbers of elements are brought online over time.

Another lesson learned regarding knowledge management is the degree to which it presents not only innovation, but also a new way of looking at existing projects. For example, the grant writing process can simply be updated with the purchase of an off-the-shelf package and some process reengineering. However, when viewed within the larger knowledge management program, it becomes clear that this is also an opportunity to rethink what the organization "knows" within a domain (e.g., grant writing) and whether there are benefits in explicating embedded knowledge in public documents and processes. The ultimate product of such a transformation may look similar to the original document or process; yet have subtle, expressed additions that render it of a different level of value.

PUBLIC HEALTH OBSERVATIONS

When discussing the potential impact or benefits of the project, it became clear that many valuable resources for supporting public health information already exist, such as the Center for Disease Control website. It is also clear that within a given institution, many valuable elements of an overall knowledge management presence may already exist but are without supporting integration and access paths facilitating easy, appropriate, and effective use.

However, given the first two concerns of the public health domain with populations rather than individuals and with prevention rather than treatment [Yasnoff et al., 2001], the amount and kind of relevant knowledge is indeed large and complex. Discussions regarding stakeholders to be served by public health knowledge and activities included consideration of potential patient groups, for example, lower-income inner city residents, to public health providers, for example, public health clinicians. Allowing access was not just a matter of security, but also a matter of understandability. The knowledge base may contain information that could be useful to multiple groups of users, but not all groups would have the capacity to understand the information in its generic form. Furthermore, complexity is exacerbated by scope; consideration of public health issues ranged from the diffusion of relatively well known diseases like tuberculosis to environmental issues such as the effects of toxic wastes.

As the content of public health knowledge is complex, so too is the means of creating and distributing it. The progression from creation and utilization of knowledge goes through multiple stages and involves many disciplines and stakeholders. This case also reveals that there are numerous steps between the creation of new knowledge by researchers and distribution of such knowledge. This relates to the third area of concern for public health, the concern for all stages in the causal chain including social, behavioral, and environmental influences on health, noted in the introduction [Yasnoff et al., 2001]. Addressing multiple stages and stakeholders increases the complexity and need for communication while it also helps define how the creation of more accessible paths to existing knowledge can create value. Public health professionals can enhance their ability to inform various constituencies about the latest and most important developments though automated processes and tools. Such processes and tools should allow developers of new knowledge to do so more effectively as well as smooth the flow from creation to distribution. In the process of creating access, the combination of elements can create opportunities to envision and implement new features (such as the online site inventory reservation system deriving from discussion of a simple site inventory).

The fourth area of concern, government and policy issues regarding the health of populations [Yasnoff et al., 2001], was not addressed in terms of particular lobbying or formal efforts to shape policy. In the context of the research participants' concerns, policy issues were more salient in terms of knowing and understanding policy to coordinate efforts in order to create and distribute knowledge. Concerns regarding government were expressed in terms of understanding funding opportunities and potential for collaborating with official agencies for more effective public health actualization.

It is critical that efforts to design and implement public health information systems fully account for their linkage to ultimate users. Research participants frequently observed and commented on the need to not only fund the building of knowledge management systems, but also to fund processes, procedures, and staffing for integrating these with actual user activities and to track their use. This showed up in the concern for alternative locations of "kiosks" in public libraries, supermarkets, and even laundromats. It showed up in the concern for whether systems could be designed in such a way that individuals in these settings would actually use the systems. It was very clear from discussions among these research participants that one of the lessons learned over time and now engrained in practice is that new technology systems by themselves are often not sufficient for creating genuine value. This study demonstrates the need for better understanding in both research and practice regarding which cost effective efforts can act as strong magnets to attract system awareness and ultimate use in the public health context.

ASSESSING THE PROGRAM LOGIC MODEL AND FOCUS GROUP PROTOCOL

We illustrate the use of a Logic Model as a framework and focus groups as a methodology as mechanisms for developing architecture and strategic requirements for a public health knowledge management system. Both of these techniques are typically applied in alternative contexts and for purposes other than the case at hand. Additionally, though the techniques may both be used in the case of evaluating programs, there is no obligatory connection in using focus groups to support information gathering in light of a Program Logic Model framework. We can suggest that other data gathering within a Program Logic Model framework might also work; focus groups using a different framework might also work, but we see that at least in one instance that using both together does work.

THE PROGRAM LOGIC MODEL

As a first level of assessment, the Program Logic Model approach did produce a draft architecture and detailed observations and refinements leading to updating where needed (See Figure 4 for architecture). Additionally, developing specific logic models for each element (see Table 2 for an example) creates a clear link between activities and outcomes and highlights resource issues. In the case of the current study, stakeholders were able to prioritize and clarify elements for further pursuit in light of identified outcomes and focus plans for future efforts. Additionally, elaborating the program "theory" (logic model relationships) *a priori* for complex and/or elusively defined systems can help with activities later in the system life cycle including system evaluation.

THE FOCUS GROUP PROTOCOL

The focus group strategy followed the Theory of Change Template (see Figure 2) to perform five sequential tasks as illustrated in Figure 4 in order to identify system themes (branches), create a draft architecture, to analyze in some detail the branches and elements of that architecture, to confirm the architecture while generating buy-in for the program with senior leaders at the institution, and to prune the architecture for initial core activities of focus.

An informal measure of merit of the focus group process for eliciting high level knowledge management system requirements is that important information is, in fact, derived from its use (and from the perspective of stakeholders). The segment of the focus group protocol that targeted detailed discussion of the knowledge management system elements paralleled logic model adapted constructs—resources and outputs, activities/features, outcomes/measures, and impact.

When discussing potential impact or benefits in a group setting, one might expect a tendency for the group to "want everything" and subordinate nothing. However, we did not observe this. The focus group members were quite clear in differentiating between elements of greater and lesser potential value. For example, both online biographical sketches and e-portfolios were viewed as having high potential value for individuals preparing proposals and quickly needing to include

such information among other uses. Other elements, such as researcher blogs, were seen to have theoretical potential, but much less immediate value and organizational or community impact.

Discussions regarding activities and features were also of significant assistance in information requirements elicitation, as they filled out specifics regarding particular elements. For example, in discussing e-portfolios for researchers, participants noted several specific features that would be helpful if development activities were pursued. These features/activities to be included in the e-portfolios consisted of:

- Including lessons learned from the research efforts of contributors that did not go as planned;
- Including technology skills and technologies developed for each e-portfolio contributor; and
- Providing expansive search capabilities by key words, by departments, by discipline—"really any field should be searchable."

It was helpful to ask about input and resources to ensure a realistic appraisal of the elements' costs and risks to balance their potential benefits. It is also of note that discussion of input and resource hurdles to be addressed tended to bleed into discussion of specific features. For example, for a number of elements, concern was expressed regarding copyright and intellectual property protection in general. Such protection should be a "feature" of some elements, but creating assured protection was sometimes also viewed as a hurdle. It was helpful to ask about input and resources to ensure a realistic appraisal of the elements' costs and risks to balance their potential benefits.

By considering the management activities and content sources of input, the participants were able to identify stakeholders and others who would be concerned with particular elements. These were both specific in terms of departments or individuals on campus as well as generic in terms of institutions like libraries or local public health agencies. These questions led to core steering committee members pooling contact information from the participants across focus groups (and particularly became apparent in the sixth focus group of School of Public Health leaders). In the long run, this contact information can lead to identification of potential partners in providing elements or services, potential sources of formatted information that can be linked or accessed, and additional individuals who can provide feedback and details of the knowledge management program as it develops.

The discussion of impact and outcome measures showed that some potential benefits repeat across several elements. For example, generating new successful grants and reducing the time for grant proposal creation were mentioned as an outcome for multiple elements. Similarly, more efficient use of existing resources was also mentioned regarding inputs for multiple elements. The measurement of new grants and more efficient resource uses may be very difficult to tie specifically to particular elements or modules of a knowledge management program, but may be a legitimate outcome measure for the program as a whole. Ironically, it is by identifying this outcome measure for multiple individual elements that its relationship to the whole program can be more realistically assessed.

The participants also conceived many specific measures of success for individual elements such as number of hits, number of people using, length of use, how many alliance partners are gathered, and a survey to see what value was found in partnership as measures of a public library access-point element.

The conversational, focus group approach among a diverse group of stakeholders can facilitate communication and interactions that illuminate particular approaches to knowledge base systems in order to support emergent organizational or individual knowledge behaviors as well as those that create barriers. For example, participants readily discussed concerns over user acceptance

and adoption of the system including concerns over sharing data. Ensuing discussion included ways to address such issues. As a result of this discussion, system design and change management plans may attempt to address some of these concerns.

Exploratory discourse in the focus groups may actually create an environment for unpredicted, emergent knowledge behaviors to occur. In this study, various participants noted after the focus group that they had learned things they did not know or mentioned that the discussion spawned ideas they intended to apply to other contexts. The focus group may be a catalyst for this type of sharing which, in itself, can be considered a valid goal for an organization's knowledge management program. Additionally, focus group participants could conceivably serve as system ambassadors when confronted with acceptance and adoption issues by non-participants.

STATUS

Program logic model activities were conducted in the spring semester of 2005 and at the time of this writing, work is moving forward vigorously on at least two of the elements—the grant opportunity database and connecting with external databases. An analysis of the processes involved in developing major public health grants, including documentation to meet Institutional Review Board requirements, is currently underway. Additionally, significant steps have been made to partner with a health management organization to gain access to de-identified claims management data that will provide opportunities for innovative public health analyses (especially when combined with other data sources the program is seeking) for research and to support outside agencies with analytical capabilities. The knowledge management program architecture provides a vision, in recognition of key priorities and feasibility, of how the elements in the core structure and additional elements would be potentially linked together as new components are added.

VI. CONCLUSION

The purpose of this study was to observe knowledge elicitation in a live case involving the development of a conceptual architecture for a public health knowledge management system. Particular emphasis was placed on understanding the content of the architecture developed in this case.

The context also allowed us to study the effectiveness of using a Program Logic Model framework and focus group methodology for information requirements gathering. When applied to information gathering, the Program Logic Model/Focus Group approach facilitates the creation of a program architecture and articulation of a project/program "theory", i.e. a chain of proposed causal relationships by integrating insight from various stakeholders.

Like all research studies, this one should be interpreted understanding its limitations. This study presents the results of a particular case and findings should be generalized to other situations very cautiously. The Program Logic Model/Focus Group approach seemed to work well within the context of this particular information gathering exercise; however, no conclusions can be made regarding whether alternative approaches would have worked better, worse, or equally as well, as the study does not test alternative approaches for contrasting results. This paper concentrates on the logic model process and the focus groups used to develop the knowledge program framework. Although efforts were made through careful scribing and transcription to provide a straightforward reflection of the views of participants, it is possible that observations based on additional project information and activities observed by the researchers, which are not elaborated in this paper, may have shaded the interpretation of the findings.

Future research based on this study will fall into three categories. First, from the perspective of a roll-out of a public health knowledge management program, the methods, content, and evaluation of the full program using the logic models constructed for individual elements deployed will be of on-going interest. This continued investigation can provide insight into the use of public health knowledge internally to an educational institution as well as by external stakeholders. Continued

investigation of deployment of knowledge management systems in contexts with a diversity of stakeholders spanning organizations can also provide perspective on the relationship between a knowledge management program and the role of its various components.

Second, as stakeholders move toward specifying functional and nonfunctional requirements for each element, the observation of information requirements activities, and contrasting them with those appropriate for conceptual architectural development (and strategic requirements), can provide insight into the role of different approaches and techniques across a large multi-staged program. And third, from the perspective of knowledge management, observations regarding the link between knowledge types, functionality, and particular tool use can add to the literature on implementation practices in the knowledge management arena.

This paper provides a contribution to four areas. First, it provides some insight into the nature of requirements determination, particularly the potential need for a conceptual architecture/"strategic requirements" in the knowledge management arena. Second, it provides some insight into the nature of knowledge management as applied in the public health care context. Third, it provides some insight into the public health informatics domain, illustrating some of the branches and elements that comprise both the internal support and external knowledge transfer elements supporting its mission. And fourth, the paper provides some insights and artifacts regarding the use of the program logic model supported by focus groups for the development of knowledge management program architecture. The contribution of the artifacts of this study can be likened to the introduction of joint application design [Liou and Chen, 1993] or the application of cognitive mapping [Montezemi and Conrath, 1986] to the information systems requirements domain.

The Program Logic Model process described supports the building of a complex, interactive system based upon the relationships among simple, understandable constructs (specified inputs/resources, activities/features, output/system components, outcomes/measures and impact) associated with system outputs/components. Such a framework may improve stakeholder development and understanding of the complete knowledge management environment and the specification of a complex and ambiguous system. As well, this methodology may provide a baseline conceptual structure for system evaluation. The Program Logic Model/Focus Group approach may be thought of as eliciting "strategic requirements" in that information acquired may help system decision makers understand the value of one system component as it relates to other system components.

It is clear that public knowledge exists in many separate detailed compartments pertaining to specific maladies (e.g., their epidemiology, association with geographic regions, health effects reach, precautionary actions, and notification systems). It is tantalizing to think about programs to link these different islands of information, but such linking involves major inter-organizational and technical integration issues. In exploring the strategic development of a knowledge management program intended to provide this linkage, it became clear that a modular design that would address pieces of the domain and loosely couple access to data pertaining to each piece was more likely to provide value in this complex domain than a singular system design that would encapsulate knowledge across populations and issues. As motivation to create such integrated systems increases, there is undoubtedly a need to show the utility of unifying compartmentalized information by contrasting the benefits of independent sets of data and information to a holistic structure.

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APPENDIX I. OUTLINE OF PROTOCOL FOR FOCUS GROUPS 3, 4, AND 5

The protocol was set to generally explore phases 3 and 4 of the Theory of Change Management (Desired Results and Influential Factors). To accomplish this goal, the protocol was informed by the logic model and focused on eight steps:

1. Preliminary greeting/ arrangements.

2. Welcoming participants.

3. Investigating whether the model, as derived from focus groups 1 and 2, was complete and if each branch appropriately identified community needs under the scope of the project.

4. Determining the branch(es) with the most potential impact.

5. Investigating, for at least one priority branch, whether the elements (leaves) were appropriate and complete and exploring the potential impact of that element.

6. Investigating for elements with the most potential benefit (i.e., relatively "do-able" details of design and implementation) using questions inspired by the logic model (components of model are in bold below):

6.1. Activities—What should (targeted output) allow users to do?

6.2. Activities—How do you envision users would interact with (targeted resource)?

6.3. Resources/Input—What, if any, barriers do you see would have to be overcome to implement this sort of resource?

6.4. Resources/Input—Where would you see the content of this element coming from among those on campus?

6.5. Impact—How could we determine that the resource is being successfully used?

6.6. Outcomes—What would be a measure of success?

7. Validation of results by reviewing key statements with participants.

8. Wrap up including thanking individuals for their participation.

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