Knowledge Management for Public Health Professionals

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Acknowledgements

ASSOCIATION OF STATE AND TERRITORIAL HEALTH OFFICIALS (ASTHO)

Contents

Executive Summary

"Knowledge Management" is an approach for addressing the information overload that has evolved over the last few years. ASTHO in partnership with the Centers for Disease Control and Prevention (CDC) has sought the input and expertise of numerous local and state officials in developing this document. This knowledge management primer is meant to provide health officials and other public health practitioners a high level introduction into the concepts involved in knowledge management, and to share some ideas about how experts and practitioners have attempted to organize their information.

This document is organized into three major sections. The first explores knowledge management concepts, tracking the evolution of data to knowledge and identifying key components of knowledge management. The second section relates the concepts of knowledge management to public health activities and goals. This section is built on the input from many public health professionals who participated in discussion sessions, reviewed drafts of the document, and provided examples of public health situations pertinent to knowledge management. The final section describes key activities that contribute to implementing a knowledge management approach in an organization or community.

The goal of knowledge management is to provide a means to deliver the right information to the right person and place at the right time. Knowledge, like the financial and human resources of an organization, is an asset that can be managed to enhance its value. Knowledge is quite different than money, however, in that it can be created inside an organization through research and collaboration. Additionally, knowledge, when distributed, shared, or used often results in more knowledge. Organizations are realizing the value of managing knowledge to develop "learning organizations" where information and practices are improved over time.

Critical reasons to adopt a knowledge management approach within public health agencies are to capture knowledge needed to ensure public health preparedness, to manage existing information more effectively, and to enable public health professionals to work collaboratively in a virtual environment.

The building blocks of knowledge management include data, information, and knowledge. Data can be transformed into information through organization, categorization or indexing. Information in context becomes knowledge. Knowledge is commonly divided into two categories: explicit (written, spoken,

electronic) and tacit (held by individuals, insight). Knowledge management is an organization or community's planned approach to collecting, evaluating, cataloging, integrating, sharing, improving, and generating value from its intellectual and information-based assets.

Organizations develop knowledge management strategies by supporting a data-sharing culture; addressing how data and information are organized; establishing processes to more effectively collect, manage, and disseminate information; and more effectively using technology.

Challenges to implementing knowledge management in a public health context can include lack of leadership commitment, lack of understanding of an organization's business processes, cultural barriers, lack of processes for data sharing and re-use, scope of content (too large and inadequately representative), and lack of appropriate technology and skills. Addressing these challenges is essential to successful implementation of a knowledge management approach.

1 Introduction

"Knowledge Management" is a process used by organizations and communities to improve how business is conducted by leveraging data and information that are gathered, organized, managed, and shared. Many organizations are realizing they suffer from "data glut" and information overload as a result of new technologies and requirements to gather and maintain data. Many have accumulated large collections of data and information that are often housed in separate files and databases and are not easily accessible for analysis and decision-making. The ability to use this information is often limited due to lack of understanding about context, purpose, or assurance about the quality of the information.

This document provides an introduction to knowledge management for public health professionals. The public health community, like many others, increasingly relies on digital information to conduct business. Although technology has improved the ability to collect, analyze and share data rapidly, it has also produced fragmentation of information and systems that are not well integrated—often only replicating existing practices in electronic form. Rapidly changing technology, lack of resources, failure to validate data require-

ments, complex data acquisition structures (e.g., intra-departmental and inter-agency initiatives), and disconnected data sets are challenging practitioners' ability to use existing knowledge to advance public health practices.

The remainder of this document, describing basic knowledge management concepts, is organized into three major sections. The first explores knowledge management concepts, tracking the evolution of data to knowledge and identifying key components of knowledge management. The second section relates the concepts of knowledge management to public health activities and goals. This section is built on the input from many public health professionals who participated in discussion sessions, reviewed drafts, and provided examples of public health situations pertinent to knowledge management. The final section describes key activities that contribute to implementing a knowledge management approach in an organization or community. Throughout the text, sidebars are used as examples of public health activities and situations that may benefit from knowledge management.

Using Knowledge to Manage Information Access: "The CDC Web site"

CDC's Web site makes available approximately 250,000 pieces of content and receives an average of four million visits per month. Finding relevant content through search functions is a major challenge.

CDC instituted three efforts to improve their Web site:

1. Established a process to capture terms commonly used in searches of the Web site.
2. Created a thesaurus of public health terminology.
3. Drafted a policy that sets thresholds for evaluating and taking action on search terms.

Now, each month, search terms are aggregated into the top 1000 terms. This allows CDC to:

» Add common misspellings as synonyms in the thesaurus to support connections such as "herpies" with "herpes."
» Correlate high volume search terms with "topics" to refine matches in the "Related Topics" area above the search results on the search page.

Additionally, CDC is collating the searches that returned "zero results". This provides the ability to evaluate the terms used that result in zero returns and further refine the topic lists, search engine algorithms and thesaurus.

As a result of these changes, CDC saw a drop from 55 percent to 17 percent of the queries being "zero results" returned. CDC's search score on the American Customer Satisfaction Index rose five points between quarterly reports.

2 Knowledge Management Concepts

Knowledge results from the ability to capture, classify, verify, organize, access, comprehend and use information efficiently and effectively. The transition of data and information to knowledge can significantly enhance the ability of organizations and communities to carry out actions to address their goals. Effectiveness is dependent on the ability to access accurate information, perform appropriate analyses, and react as quickly as the situation demands. The public health community exemplifies these needs. The potential to manage and make use of vast quantities of data and information has grown exponentially as technology has improved. Many sectors, however, including public health, have not been able to keep pace with technology changes or to organize data sets to optimize their use. Data and information continue to be difficult to find, their quality is unknown, they are often out-of-date or in unusable formats, and they may not be available at all based on data sharing policies or practices. The following sections explore the fundamentals of changing data into knowledge and the basics of knowledge management.

2.1 Building Blocks

Data are not knowledge. Data, however, can be transformed into information, which in turn can be analyzed and further transformed into knowledge. Initial or working definitions of data, information and knowledge are critical to understanding knowledge management.

Data

Data are often defined as unprocessed representations of raw facts, concepts, or instructions that can be communicated, interpreted, or processed by humans or automatic means.[1] Data can take many forms (e.g., textual, numeric, graphic, cartographic, narrative, or audiovisual).

Information

Data become information when they are assigned meaning. Conventions, such as specific categories of topics, dates, or places, may be used to assign meaning to data.[1] Information is created when data are valued in some way such as categorized, filtered, or indexed.

Knowledge

Knowledge is information in context. Infor-mation becomes knowledge when critical thinking, evaluation, structure or organiza-tion are applied to support decisions or un-derstand concepts.[1] Knowledge differs from data or information in that new knowledge may be created from existing knowledge using logical inference. If information is data plus meaning then knowledge is information plus processing.[2] Knowledge evolves, while information accrues.[3] Knowledge is typically categorized in two ways: explicit knowledge and tacit knowledge.[4] Explicit knowledge can be thought of as "book knowledge," i.e., it is available in a spoken or written form (including electronic) and is the ordering of data and in-formation according to well-defined, formal-ized procedures or rules (such as language). Tacit knowledge is understanding, insight, or instinct, built through experience and training. Tacit knowledge resides within the people of the organization and is not formalized into written or documented forms. It can only be made accessible for others' benefit through conscious efforts such as interviews, docu-mentation of decision-making, mentoring, and other means to gather insight on how in-dividuals carry out their jobs.

Transforming Data to Knowledge

The evolution of data to knowledge is a multi-step process. An organization must first un-derstand the data it holds: Where are the data? What is their quality (e.g., how reliable, how accurate)?   How are they managed? What is their content?   Secondly, the data must be organized in some schema to make them more accessible, such as document-ing the characteristics and quality of the data, developing mechanisms to share data across divisions, categorizing data, struc-turing data for searches, and establishing relationships among different sets of data. Explicit schema for the organization of data provide greater insight into potential relation-ships and relevance of other data sets. These actions help transform data into information. See Figure 1.

Transforming information to knowledge requires that pieces of information be linked in meaningful ways, that relevance to the problem at hand is established, and that in-

formation is understood in a larger context. Understanding what information users make use of and how they use it are important aspects of transforming information to knowledge. Knowledge is created when any of the following occur:

» Information is evaluated for accuracy and relevance.
» Information is transformed to meet current or potential needs.
» Information is structured and organized for retrieval.
» Information is analyzed and the results evaluated.
» Information is routinely delivered or made accessible when and where needed for decisions.

Table 1 provides a public health example of the transformation of asthma and air quality data to knowledge.
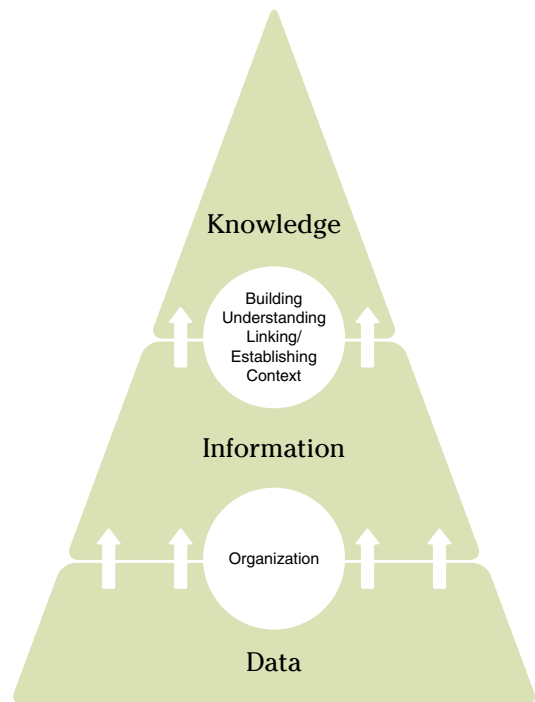
Figure 1: From Data to Knowledge

Table 1: Example of Data, Information, and Knowledge for Asthma and Air Quality

	Data	Information	Knowledge
Asthma	Number of hospital visits due to asthma	Asthma case data organized by geographic location, population, etc.	Understanding of the times and places to alert asthma patients due to risks posed by air quality
Air Quality	Ambient air quality monitoring data	Air quality measurements organized by geographic location and time.	

2.2 What Is Knowledge Management?

There is no universal definition of knowledge management just as there is no universal acceptance of what constitutes knowledge. In a broad sense, knowledge management can be defined as an organization or community's planned approach to collecting, evaluating, cataloging, integrating, sharing, improving, and generating value from its intellectual and information-based assets.

Researchers have used different words to describe the functions that comprise knowledge management, including acquire, value, structure, publish, and use data[5] and gather, organize, refine, and disseminate data.[6] Essentially, they all agree that knowledge management offers a formal, structured, approach to providing knowledge with an explicit strategic intent.[7] In the public health arena, knowledge management can provide an effective and efficient way of organizing what is known and then using this in a variety of capacities to improve public health services. Regardless of the definition(s) employed, knowledge management is a dynamic practice that must be able to adapt to ever changing social, environmental, political and legal landscapes (e.g., Health Insurance Portability and Accountability Act [HIPAA], Severe Acute Respiratory Syndrome [SARS], biological agents, etc.).

2.3 Core Components of Knowledge Management

Knowledge management involves numerous specific activities such as establishing and supporting appropriate practices and procedures, implementing standards, making use of appropriate technologies. Most importantly, however, is understanding how an organization does business, how it collects and uses information, and the nature of the data development and sharing culture.[8] Managing knowledge is likely to change various aspects of the organization. The goal of knowledge management is to move from "not knowing what you don't know" to "knowing what you know" and using that knowledge to improve organizational effectiveness and efficiency.

There are four core components or characteristics of an organization that must be examined as part of the process of embracing a knowledge management approach. These include the: 1) nature of the organizational culture; 2) condition and availability of the content of the organization (e.g., data, information, experience); 3) processes that are used to collect, manage, and disseminate information; and 4) technology infrastructure (e.g., hardware, software, networks). These components are described in more detail below.

Culture

The culture of an organization consists of shared beliefs, values, understandings, myths, and "rituals" within the organization.

Culture is manifested in how an organization envisions, measures, and carries out its responsibilities and mission. Culture can be characterized by many attributes, including how information is communicated, the emphasis on teaming and sharing knowledge, attitudes toward change, and the incentives in place to reward performance. The culture in public health organizations, as in many other sectors, is a complex mix of behaviors that supports and rewards individual research, collaborative research, sharing of practices, protection of privacy, public responsiveness, and interagency coordination.

Content

Organizations collect data and information as well as develop and cultivate skills and expertise. Data, information, skills and expertise can be thought of as the "content" resources of the organization. The nature, amount, format, quality, and accessibility of these resources contribute to their value. The content resources of an organization may be explicit or tacit. Content is often created and managed on an ad-hoc basis, making it difficult to access. Content may reside in places where it is not accessible to others (e.g., tacit in individual brains, or explicit on individual hard drives and in filing cabinets) or in undocumented formats that make it impossible for others to use. Many organizations generate content on an ad-hoc basis and then struggle to try to link pieces of information together. Content management can benefit greatly through planning and development of bigger picture understanding. Critical functions of knowledge management are to use tacit knowledge to help manage and create explicit knowledge and to build more tacit knowledge.

Processes

Processes to manage data and information exist in all organizations in a variety of forms ranging from formal to informal. Formalized processes are critical to ensure the effectiveness of the creation, assessment, management, and dissemination of content. Ideally, processes add value that exceeds the burden of implementing the process. The ability to develop and implement processes to support knowledge management is dependent on the organizational culture and business drivers. At the same time, however, changing processes can assist in changing culture to create an environment that better supports knowledge management. Academic cultures, for example, might be facilitated in knowledge management efforts by encouraging processes that ensure recognition of ideas and content, perhaps by rewarding contributions to shared data repositories. Similarly, the way an organization conducts its business through its administrative processes (e.g., tracking correspondence, archiving, contract management) can also affect content, which can affect how data are subsequently used or not for other purposes. For example, products from contract work may not be indexed, linked, or stored for accessibility to others.

School Surveillance to Track Public Health

The State of Illinois maintains a database of absences for all children across school districts. Public health officials monitor illness trends by tracking the number of absences across space and time. Significant spikes in absentee rates provide a warning of potential disease outbreaks. Knowledge about the patterns and extent of absences over time is used to consider prevention campaigns and potential school closures.

Technology

Technology use has become pervasive throughout most organizations. The nature and current use of technology within an organization, including how effectively it is used, are important to understand when considering implementation of knowledge management initiatives. Existing document and record management systems, e-learning, geographic information systems, situation/emergency management systems, query and search functions, and collaborative technologies are examples of technologies that can contribute to the success of knowledge management. The types of tools an organization has been able to use successfully, levels of expertise in supporting technology use, and approaches to organizing and maintaining technology, are important aspects of an organization's technology infrastructure. This infrastructure and the ability of the organization to use the infrastructure require examination when initiating a knowledge management approach.

Interaction

These four components are highly interrelated. Understanding them together is important for tackling knowledge management. In addition, they are the organizational elements most likely to change as a knowledge management approach is implemented. How successfully an organization uses technology is likely to be a function of content (including skills), processes, and culture. Over time, however, successful use of technology may help to drive the culture and processes in a way that will build a learning organization. Characteristics of the four components in a public health context and actions to implement a knowledge management approach based on these components are described in subsequent sections.

3 Knowledge Management and Public Health

Knowledge management can be a valuable tool for the public health community. Public health is a multi-disciplinary field addressing a broad array of topics pertaining to the health of human populations. Public health professionals rely on research methods to identify causal and contributing health factors, and use a community approach to track, prevent and solve health problems. Public health professionals require accurate data and the ability to access data quickly from disparate sources and transform those data into information and knowledge to do their jobs. They also collaborate with many other organizations to respond effectively to public health issues. Data, information, and knowledge are shared, structured, analyzed and transformed through surveillance, interactions, and interventions. In many interactions, it is not simply the exchange of data that is valued, but the tacit knowledge that has come from training, education, and practice that contributes to knowing how to respond in diverse situations. Knowledge management seeks to capture the tacit knowledge that resides in the workforce, as well as the explicit knowledge that may be directly generated through the organization of information.

3.1 Public Health Need for Knowledge Management

Knowledge, while critical to the success of the practice of public health, is often challenging to share, because it is individually held, not easily accessible, and often lost when individuals leave public health organizations. Public health practitioners, like many others who have come to rely on the use of information technology, need information to be readily available to address their business needs. Information is both a necessary component and product of the Essential Public Health Services (Table 2).[9] Unfortunately, while technology has improved the ability to manage and reuse vast arrays of data and information, public health institutions have not necessarily optimized the management of what they know to improve the delivery of the Essential Public Health Services. Single purpose surveillance and clinical care systems continue to be developed and data are still scattered, of poor quality, and in non-compatible formats. These Services and the role that knowledge management can play in addressing them are described in more detail in Appendix C.

Table 2: Essential Public Health Services

Monitor health status to identify and solve community health problems
Diagnose and investigate health problems and health hazards in the community
Inform, educate, and empower people about health issues
Mobilize community partnerships and action to identify and solve health problems
Develop policies and plans that support individual and community health efforts
Enforce laws and regulations that protect health and ensure safety
Link people to needed personal health services and assure the provision of health care when otherwise unavailable
Assure a competent public and personal health care workforce
Evaluate effectiveness, accessibility, and quality of personal and population-based health services
Research new insights and innovative solutions to health problems

A recent report by the Institute of Medicine echoed these issues.[10] The report's recommendations spanned multiple aspects of public health (e.g., surveillance, client health services, water inspection, disease investigation, public health education, enforcement of public health policies) and concluded that public health officials must have the most up-to-date information to conduct analyses, to report and disseminate pertinent information, and to collaborate with other agencies.

Knowledge management can provide an efficient way of developing and disseminating best practices and of continually assessing those practices for improvement. Knowledge management helps to codify knowledge so all may access it, decreases redundant work practices and system development (because there is access to what has already been done), and helps an organization to retain knowledge when staff departs.

Critical reasons to adopt a knowledge management approach within public health agencies are to:

1. Capture and respond to more of the critical knowledge needed to ensure public health preparedness.
2. Manage and integrate the information that already exists through indexing, cross-referencing, and sharing.
3. Enable virtual teams to work collaboratively with access to shared knowledge.

3.2   Challenges of Knowledge Management in Public Health

Knowledge management can be of obvious benefit to public health organizations, but there are challenges that must be addressed to implement such an approach successfully. Knowledge management requires that an organization be willing to examine how it does work and potentially change some aspects of the current environment. Rarely is knowledge management going to be the purview of a single entity. Additionally, the information needed for an organization to carry out its business must be identified, along with an understanding of the information that is and is not currently available (i.e. gap analysis), the value of current and missing information, current approaches for information

sharing, and current use of information (who uses it and how). Clearly mapping these characteristics into workable schema is often an organizational challenge. Appendices B and C offer a framework of various kinds of knowledge management activities.

Many of the challenges are the result of an increasingly demanding, evolving, and complex public health environment characterized by limited resources (funding and staff); increasing numbers of public health issues; rapidly emerging issues; and difficulties in attracting and retaining staff with the range of information and public health skills needed in a changing and multi-disciplinary environment.

Culture

As noted earlier, culture is the set of beliefs, values, and understanding that exist in an organization or community. Supporting a culture that fosters knowledge management requires an in-depth understanding of how business is currently conducted, how information flows, where knowledge exists, how knowledge is used, and what knowledge management skills an organization possesses and are required to be effective. The varied nature of the work of public health organizations makes this a challenge, as there are many types of organizational culture. Chains of command, responsiveness to public needs, research practices, and many other variables that are part of the practice of public health are likely to affect culture. The challenge is to characterize the components of the culture that affect the sharing of data and information. For example, data from one practice area may be of sig-

nificant value in other contexts, often with a relatively small incremental increase in effort to collect, document, or manage the data. Cross-organizational communication and interaction to better understand how different practices might effectively be leveraged will also aid in knowledge management. In these examples of cross-practice/program leveraging, the cultural components to examine are communications (open versus constrained), support for processes to manage data (in-place versus non-existent), and value placed on data sharing.

Clear vision and leadership are needed to address the coordination and cross-cutting activities that support knowledge management and to sustain the effort over time. Incentives for making data more universally accessible and usable should be considered. In many cases, disincentives exist, for example where information and knowledge are seen as power to be exchanged for favors, "information hoarding" may occur. Also, because public health efforts often involve a multitude of organizations, external coordination outside of an individual health department may be needed, requiring broader leadership skills. Leadership plays a strong role in establishing the cultural "will" to support and maintain practices such as data documentation and dissemination of research results.

Content

Public health organizations have improved access to health data and information primarily through internal and external Web sites. Increased access, however, has not

nizational boundaries. Improved inventories, indexing, integration, evaluation, and presentation could greatly improve both understanding and the ability to use the information in various situations.

Another challenge that public health agencies face is the difficulty of moving from collecting and processing data to a strategy that presents results and instigates behavior change or other interventions. It is much harder to communicate recommended actions or behavior change than to report raw results because judgments and interpretations are needed (e.g., knowledge must be applied).

Tacit knowledge is one of the richest content assets of an organization.[11] One of the most significant challenges, however, in addressing content is capturing the tacit knowledge held by the individuals within an organization. By definition, tacit knowledge is not explicitly stated or communicated. Most people do not have either the time or inclination to try to describe what they know and there is often little incentive to do so. Capturing tacit knowledge means making it easy for individuals to share what they know through training, collaborative opportunities, networking, and other personal interactions. Valuing tacit knowledge and the willingness to share it are also important in creating incentives for encouraging individuals to transfer tacit knowledge to one another. Much of the explicit content that is made accessible will require context or tacit knowledge to ensure appropriate interpretation and use.

Fighting Diabetes

Public health practitioners can use a knowledge management approach to address diseases, such as diabetes.

Accessing population-based **DATA** from health maintenance organizations and hospital discharge statistics allows practitioners to identify populations affected by diabetes (**INFORMATION**).

Populations affected with diabetes can be defined and invited to participate in assessment of risk factors and partake of community interventions Interventions can then be monitored for effectiveness. **KNOWLEDGE** about which diabetes interventions work best in what circumstances thus emerges.

always resulted in increased understanding of public health conditions and trends by either the public or public health practitioners. Many organizations, in both the public and private sectors, present an "organizational view" of their information through their Web sites without spending the time to learn how their customers are likely to find information. Many health issues overlap traditional agency boundaries and the full picture desired by the public or practitioner is much broader than an agency's mandate. Agency content or Web site managers must consider that their customers are interested in issues and knowledge that overlap orga-

Content is often difficult to present to multiple consumers. Different audiences benefit from different presentations and levels of content detail as well as tools to extract, analyze, and display data. For some audiences details such as scientific evidence and methods used in particular trials are needed, but for others this detail would be burdensome.

Processes

Ideally, the data and information management processes that exist in any organization are informed by the needs identified from the agency's business activities. In the practice of public health, the transactions or processes that occur—such as collecting data on cases or patients, organizing those data to understand a trend or pattern, or using the information derived to formulate an intervention strategy—should all be designed to optimize the work that must be done.

Most frequently, data are collected for a single, specific purpose. The practice of knowledge management, however, recognizes the value of collecting, or at least managing data for multiple purposes. This means that organizations must understand not only how work is actually accomplished and the data required to support that work, but also how work flows may intersect. Developing this level of understanding about flows and processes can be a challenge in many organizations, given the compartmentalization of processes, lack of standards, and difficulties in seeing the big picture.

One of the major techniques that enables data sharing is clear documentation in the form of metadata. Metadata are descriptions of the characteristics and quality of a data set (or software tool) and often include key words and geographic reference (if relevant). Metadata are generally searchable, improving the ease of finding, accessing, and using data. Metadata are most easily created by the originator or modifier of the data. Two commonly used metadata standards have been developed by the library and geospatial communities—the library community's "Dublin Core" and the geospatial community's metadata standard.[12-13] Both of these standards are currently being incorporated as part of the International Organization for Standardization (ISO) standards to facilitate global sharing of data. Despite the existence of standards, very few organizations have established processes to formalize the capture of metadata. Data sharing is also facilitated by consistent vocabularies that establish commonly understood meaning. Shared vocabularies are being used in medical libraries (e.g., http://www.nlm.nih.gov) and are being adapted for public health purposes.

The public health sector, due to the distributed nature of responsibilities, must share content both internally and externally with other organizations. This creates significant challenges in establishing processes that help to make data and information both accessible and universally understandable to a diverse array of institutions, partners, practitioners, and customers.

Technology

The ability of many organizations to utilize technology effectively, especially given the pace of technological change, depends primarily on knowing how technology contributes to the business of the organization. Many organizations react to needs as they arise and build or buy separate information systems to meet those specific needs, only recognizing too late the challenges of integration. This is changing, as more agencies recognize the challenges of managing technology and information and are hiring "chief information officers" who report directly to senior managers. These organizations then develop an "enterprise approach" to their information architectures, which means they organize information and technology based on the business practices and activities that the organization conducts.

Public health organizations are increasingly using electronic technology to collect, store, access, analyze, visualize, and communicate data. For example, a survey of technology use in public health departments across the US found that by 2002, 85 percent of employees had access to a computer.[14] However, the survey also identified a variety of challenges that public health practitioners face, including: out-of-date hardware, lack of software to map diseases, lack of quality control, inability to track patients and track community services, lack of training, slow Internet services, and no access to information technology staff.

Another challenge is that many individuals with expertise in information technology do not have knowledge of specific disciplines such as public health, and vice versa. This means that the languages spoken by the technology and public health staff are different, creating communication difficulties. This is compounded by the slow pace of electronic record development in many public health organizations and lack of dedicated funding for cross-program technology infrastructure.

3.3 Knowledge Management and the Public Health Information Network

Over the last several years CDC has begun to work with partners to formulate a strategy to coordinate a number of public health informatics activities under the umbrella of the Public Health Information Network (PHIN). Public health professionals recognize that within the broader public health community there are multiple systems in place for exchanging information between public health laboratories, the clinical community, and state and local health departments. PHIN is conceived as a crosscutting, unifying framework for the many existing data sharing and public health networks. PHIN will provide the means to monitor data streams for early detection of public health issues and emergencies, analyze the data, and disseminate the information to the right people at the right time. PHIN will benefit knowledge management efforts by helping to establish and promulgate standards for data management and communications. CDC's current activities on PHIN, including functional and technical specifications developed to date, can be found at www.cdc.gov/phin.

4 Steps to Public Health Knowledge Management

Public health organizations can engage in specific activities to lay the groundwork for using knowledge management tools. The suggested activities below will help an organization gain a broader perspective on knowledge as an asset. Based on the key components of knowledge management, consideration of the Essential Public Health Services, and discussions about public health functions and requirements (see Appendices B and C), the following are suggestions for actions under each of the major knowledge management components—culture, content, processes, and technology.

4.1 Support a Culture that Cultivates Information Sharing

Knowledge management is an evolutionary process that starts by acknowledging that an organization's information resources are a valuable asset. For many public health organizations, considering knowledge as an asset to be managed and preserved represents a cultural shift. Cultural change is only possible if the leadership of the organization is committed to making change occur. Ideally, the level of commitment will be stable and long-term, but this can be challenging in public agencies where the political process often contributes to rapid turnover of leadership.

Evaluate Readiness for Knowledge Management by Assessing Organizational Culture

Senior management should support an assessment of the current organizational culture and evaluate readiness for knowledge management. Assessments identify how communications flow, how work is accomplished, the skill set of individuals within the organization and the role that information plays in work. Identifying work tasks and activities is an essential early task (see Appendices B and C). An organizational assessment could focus on establishing a shared vision of the possible information architecture for the organization. This is both a process and a product that can help to educate all members of the organization on the potential for improving information integration and access to knowledge. Examples of current information sharing should be identified, recognized, and encouraged.

Recognizing individual efforts to improve the quality of data and to set performance goals to share data openly within and across organizations can help initiate an information-sharing culture. Rewarding efforts that bridge "silos" of segregated information is especially useful. Incentives for improving accessibility could be discussed and implemented, including public recognition, opportunities for acknowledging work well-done, and actual performance evaluation "credits" for reducing barriers to data. Organizations can encourage open discussion of both success stories and impediments and foster a willingness to address concerns about the ability to access and make use of information. Concerns about privacy and confidentiality could be addressed directly and used, as required, to ensure protection. However, it is important to keep privacy concerns from acting as a roadblock for appropriate information sharing.

Organizations can take advantage of best practices for data sharing in other organizations. Opportunities for training and for sharing knowledge about what works and what does not work in both information practices and public health can be encouraged.

Invest In and Build Knowledge Management Skills

Public health organizations must determine and invest in the core competencies of knowledge management (similar to public health organizations' investments in core competencies associated with supporting the Essential Public Health Services[15]). This in-

vestment should include the creation of roles and responsibilities for staff to develop and maintain knowledge management-friendly processes, activities, and behaviors. Top skills for knowledge management include a combination of business awareness, information technology (IT) literacy, information management skills, and awareness of data and content in the context of their use.

Implement Governance and Stewardship for Knowledge Management

Implementing governance and stewardship in an organization means establishing effective decision-making mechanisms for such activities as setting standards, developing policy, establishing data and information protocols, setting goals, and measuring performance. Protocols might include procedures for data maintenance, data and tool documentation, and standards for data acquisition (ensuring reliability and validity). An organization could establish data stewardship roles and responsibilities and establish cross-agency data sharing agreements.

4.2 Develop an Understanding of and Appreciation for Content

As discussed previously, content comes in multiple forms. Content includes data and information sets commonly collected and used by an organization (i.e., that which can become explicit knowledge), as well as the tacit knowledge held by individuals.

The following bullets are specific activities focused primarily on managing an organization's explicit knowledge.

» Assess current information in terms of data structure, elements, common identifiers, etc. Develop approaches to improve the ability to link data sets (e.g., through geographic linkages, time, and common identifiers).
» Identify gaps or deficiencies in the information to determine additional information to capture or create.
» Describe all data and tools to transform, analyze, and display data with standardized metadata (see discussion on page 15).
» Support approaches for linking and cross-referencing information. These links may represent conceptual associations, ordered sequences, causality or other relationships depending on the type of knowledge being stored.

Tacit knowledge is more difficult to capture and manage. Identifying and categorizing its existence is a critical first step. For instance, who in the organization has an innate understanding of essential public health practices or services? Are there means for that individual to bring his/her knowledge into situations effectively, so it can be shared or experienced by others? Mining this content will require a culture that encourages this type of interaction and rewards individuals for doing so. Development of an 'expertise database' can be of significant value to an organization.

4.3 Implement Processes to Support Knowledge Development

Establishing specific processes to manage knowledge is essential but challenging. Setting standards, for example, without stifling creativity and creating burdensome overhead requires a clear understanding of the role of standards. Organizations often launch into standards with an expectation that consistent formatting or identical processes will lead to better information sharing. While this may be true, accomplishing this is difficult for several reasons:

» Challenges knowing exactly what can/ should be standardized.
» Challenges creating or identifying standards to use.
» Challenges ensuring that standards, once identified, are used.

One rule for developing standards is to identify the minimal requirements for consistency in a process or task that facilitates information sharing. These requirements are the best candidates for initial standards. Starting on something of relatively limited scope (e.g., consistency in file naming) may help to identify both a process and means to implement standards that can then be used as additional standards become more complex. Many organizations that have tried to develop comprehensive standards find

themselves still working on standards years later, with little to show as progress.

As described above in section 4.1, defining an organization's business activities and operations is essential. An assessment of the methods, standards, and processes in place that affect the management and quality of data and information is a critical step. Are there requirements for collection of specific components (e.g., location), for documentation (e.g., metadata), for timely reporting, for making data accessible? These practices could be established (e.g., through a governance or strategy process) and implemented. These processes contribute to the ability to re-use data for multiple purposes.

4.4 Explore Technology Approaches

Any technology suitable for knowledge management should provide a flexible, seamless means of capturing, organizing, storing, and disseminating information. Organizations might explore data stores and tools that support indexing of content to allow for ease of retrieval, search, analysis, visualization, reporting, sharing, notification, and collaboration. In addition, an organization can determine the optimal means to store and maintain data for greatest accessibility by public health users and stakeholders, both inside and outside of the agency as well as within and across jurisdictions.

An organization can also leverage existing information technology system initiatives such as directory services, public health databases, client management systems, immunization registries, and surveillance systems to avoid redundancy and ensure systems are integrated and maximized for the greatest utility possible. Special consideration is needed to address processes that disseminate information, including target audience, device type, Web sites, portals, email, hard copy reports, tools for analysis, and table or map formats.

5 Conclusion

Knowledge management is an important tool for public health practitioners and organizations. By using both explicit and tacit knowledge, knowledge management helps an organization deliver the right information to the right place and right person at the right time. Organizations can use knowledge management approaches to more fully leverage their information assets. Knowledge management contributes to the integration of systems, tools and processes, fosters the transfer of competence among individuals, and improves individual competence by promoting more efficient use of available information. Both the effectiveness and efficiency of public health organizations may be improved through the use of knowledge management strategies.

While ASTHO and CDC have gathered a great deal of information from members and partners on knowledge management approaches, it is important to note that public health agencies are just at the beginning stages of taking advantage of their information assets. Important next steps will include:

1. Sharing approaches in more detail across organizations,
2. Agreeing on standards for posting and sharing information, and
3. Working at the national, state, and local level to create a culture that encourages investment in information sharing.

Knowledge, which is the highest degree of the speculative faculties, consists in the perception of the truth of affirmative or negative propositions.

– Locke

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Appendix B: Public Health Knowledge Management Activities Identified by Public Health Professionals

Based on interactions and discussions with public health professionals, a variety of public health information activities have been identified. Table B–1 was developed from facilitated discussions at a PHIN Meeting in Atlanta (May 2004) and a CDC-ASTHO sponsored Knowledge Management Meeting in Chicago (July 2004). Participants were asked questions such as: How can information be made more valuable and what do you do as a public health practitioner that requires knowledge? The activities are displayed under the functional headings that represent aspects of knowledge management. These functions are further subdivided based on specific needs identified during the discussions. Several participants identified technology functions, which are categorized under the "technology" heading. The knowledge management functions are:

Contribute means the ability to add to or enhance the knowledge of an enterprise.
» Publish data (e.g., via peer reviewed process).
» Collect, validate, document, and share a data set.

Find means the ability to search for and identify/locate data and information of interest.
» Context query—ability to query for many different types of information, potentially based on questions such as who, when, how, and/or what.
» Topic query—ability to query for health information related to specific conditions, diseases, activities and/or trends, or activities (e.g., grants)
» Spatial query—ability to query based on location (or where something occurs).

Select means the ability to extract and pull together or consolidate a desired set of data.
» Drill down/data mining—statistical analysis, modeling techniques and database technology to discover facts contained in databases.

Analyze means the ability to integrate, transform, and interpret data.
» Context assessment—ability to link related events (e.g., situation awareness, syndromic surveillance systems).

» Determine cause—search for information and determine potential causes and risk factors for specific health conditions.

» Spatial assessment—ability to examine health data from a spatial perspective (e.g., neighboring jurisdictions) to see trends and comparisons.

Collaborate means the ability to work with others by sharing data, documents, discussions, expertise, tools and resources.

Communicate means the ability to broadcast, alert, distribute information (e.g., bi-directional, omni-directional and regionally).

» Direct communication: with public health leaders and partners.

» General Communication: with general public, media, non-public health community, etc.

» Online Learning/Reference—training materials available via the Internet or an Intranet.

The table provides a starting point for describing public health business activities and operations that rely on information and knowledge.

Table B–1: Examples of Public Health Knowledge Management Activities

Function	Sub-Function	Example Activity
Contribute—add to the knowledge of an enterprise	Publish data in peer reviewed articles, books, etc	None explicitly identified
	Collect, validate, document and share data sets	None explicitly identified
Find—search, identify, locate information of interest	Context query	Find best practices to address specific health conditions
		Find sample press releases related to a specific condition
		Research latest and best practices for addressing certain health issues (e.g., smoking cessation programs)
	Topic query	Explore grant opportunities relevant to a particular health topic and/or level of government or type of organization
		Find hospital and professional association Web sites
		Conduct web research on causes of liver failure
		Research recommendations on specific conditions (e.g., HIV)
		Research new diseases appearing in my community (e.g., La Crosse Encephalitis)
		Reference information for street drugs – what's new and what's changing
		Research statutes and other regulatory information (e.g, HIPAA)
		Find Web sites for analytic techniques
	Spatial query	Find information related to health conditions in a specific geography
		Access spatial data and metadata
		Use data displayed geographically as an interface for keying in on specific information

Function	Sub-Function	Example Activity
Select—extract, consolidate derived set of data	Drill down/data mining	Access data mining tools, data warehouses
		Drill down to local events with all the available resources/expertise at that level
		Develop concise information about complex topics (e.g., HIPAA For Dummies)
		Use glossary to link to white papers/articles/updates
		Access toxicology data in an emergency
		Use glossary and acronym list/dictionary (perhaps a mouse rollover) including current names for street drugs, cultural vernacular, etc.
		Use evidence based guidelines - community prevention guidelines are particularly useful; what interventions work – robust criteria for sorting (e.g., cost, legitimacy)
		Work with outbreak management checklists; preparatory materials
		Access indexed repository of survey questions that have worked
		Calculators and conversion tools (e.g., body mass index)
		Hot links to in-depth information from multiple resources – e.g., images and textbooks
		Peer review reference sources, journals, library resources
Analyze—integrate, transform and interpret data	Context assessment	Stay on top of ongoing changes during an "event" (e.g. which treatments are working during an outbreak and which are not)
		E-records on personal health – automatic alerts when things are out of range (personalized data)
		Access secure Intranet for local news, disease summaries, training opportunities, and status reports of on-going investigations
		Determine available resources quickly during an outbreak (e.g., people, facilities)
		Situation awareness during a bioterrorism event to support incident command process
		Link related events (when something new happens – it can be linked to current, past, and across jurisdictional events or lessons)
		Poison testing and treatment, knowledge about specimens that trigger reactions and treatments that apply
		Research specimens to send based on type of poisoning
	Determine cause	In the case of an outbreak, be able to find all needed details, including causes, transmission, natural reservoirs, and prevention and treatment protocols
		Track symptoms, evaluate conditions (e.g., for acute liver failure of unknown cause in hospitals)
	Spatial assessment	Analyze data regarding cases and risk factors in specific and surrounding localities.
		Research specific demographics for my community (e.g., changes in Hispanic population)
		Examine neighboring jurisdictions to see trends and comparisons
		Determine health issues region-wide, access recommendations, Track public health records

Function	Sub-Function	Example Activity
Collaborate—work with others by sharing data, documents, discussions, expertise tools and resources		Communities of interest for threaded discussions; chat rooms; electronic collaboration areas
		Gather knowledge in a shared public space
		Support for cross government collaboration to reach key stakeholders, including providers (e.g., local health department creating a specific physician view for the locale and tying it to the alert system)
		Better understand organizations providing services locally
		Facilitate collaboration and sharing of materials among project grantees, track progress, report on results
		Post requests for information (e.g., inquiries)
		Share technology solutions
		Share common useful tools that are needed on a regular basis (e.g., "letter to school district" templates)
		Share product review of vendors and products (CNET/opinions for public health IT infrastructure)
		Provide protocols, guidelines, and specific steps on testing for a given agent
		Link to the codes of ethics adopted by specific national organizations
		Ability to access hospital Web sites to download data
Communicate—broadcast, alert, distribute information	Directed communication	Send automated alerts when certain Web sites change (e.g., HIPAA security standards) (and highlighted view of what changed)
		Alert with a FAQ and fact sheet to local emergency responder
		Automated alerts based on event triggers
		Status reporting on whether people have received information and whether it has been read/opened/deleted/ and how long it took to make use of the information
		Reach statewide health workforce with health information
		Integrated communications/messaging systems into state, federal, local agencies (e.g., easy and secure (as necessary) email to the public)
		Facilitated contact database with those who may have expertise – necessary at all levels: local, national, inside agency (e.g., real-time webcasting).
	General Communication	Answer public health questions
		Answer questions of local citizens and legislators
		Ability to reach "a real person" to get information when needed
		24/7 lists of contacts (e.g., FBI, closest hospital)
		Information about whom to call and what to do for various emergencies
		Develop press releases; foster inter-agency communication
		Develop responses to media inquiries (e.g., data on effects of ozone and VOCs)
	Online Learning / Reference	Ensure adequate educational materials
		Distance learning tools
		Training opportunities for the public health workforce; educational opportunities

Function	Sub-Function	Example Activity
Technology	Architecture	Data warehouse with raw data for downloading and analysis for access by public health officials
		Information display to multiple devices, including bidirectional interactions
		No client side software required for access
		Use data-driven content management approach to change Web sites
	User Presentation	Filtering mechanism to provide appropriate information to appropriate recipients
		Ability to customize data presented to each user and form of contact
		Creative search engines to help understand, link, and interpret related similar concepts
		Control over the organization of information based on how it works for particular specific uses or individuals
		Flexible, usable and user customizable reporting
		Segmentation of content for targeted audiences
		Authentication system to determine who sees what content
		Ability to track favorites (URL's, or real-time data requests)
	Navigation	Ability to get back to home page easily
		Ability to easily work backwards through queries
		Ensure the ability to search flexibly – both hierarchically and organically
	Organization	Facilitate contractor adaptations to locally used software to ensure PHIN compatibility
		Topics for public consumption should be accessible by all major search engines – especially Google
		Everything is context-based
		Effective hierarchy of information to view 50000' and 5' levels
		One web portal with all the information that is important to and needed by any given jurisdiction (one-stop shopping)
	Security	Secure location where contact information, key Web sites can be kept
		Automated data integrity validation (may be dependent on intended data use)
	System Specifications	Single login across all systems
		Fast system download and page change
		Fast information dissemination throughout the system
		Feedback system through wireless devices. Content gets pushed and recipients can respond

Appendix C: Examples of Public Health Knowledge Management Functions for the Essential Public Health Services

Examples of specific knowledge management activities (under the functional headings described in Appendix B) that support one of the Essential Public Health Services[9] are presented in Table C–1. The structure of the table presents the Essential Public Health Services as rows, intersected by the six knowledge management functions.

Table C–1: Examples of Knowledge Management Activities to Support Essential Public Health Services

	A. Contribute	B. Find	C. Select	D. Analyze	E. Collaborate	F. Communicate
1. Monitor health status to identify and solve community health problems	Contribute existing data (e.g., cancer registries, vital records, notifi-able disease cases) to a sharable pool of data	Find subsets of data in A1 by selecting on data keys (e.g., all pertussis cases in TN, AL and MS)	Build a working data set from existing data (e.g., con-catenating a particular data element or set of data elements)	Provide secure online access to epidemiological tools such as Epi-X	Provide a secure forum in which public health officials can share documents, data, and comments on emerging issues and practices	Provide a secure communication mechanism so that involved public health officials can com-municate with each other based on roles and need
2. Diagnose and investigate health problems and health hazards in the community	Confidentially report cases, syndromes, risk factors, and survey data	Find all cases of a disease or a risk factor in a particular geo-graphic area	Broaden or narrow the selection of cases or survey responses to form a new data set	Track incidence and prevalence over time using public health practice tools	Enhance the use of forums such as Grand Rounds, case confirmation, discussion of risk factors and causality. (http://www. publichealth grandrounds. unc.edu/)	Inform public health partners via secure pathways

	A. Contribute	B. Find	C. Select	D. Analyze	E. Collaborate	F. Communicate
3. Inform, educate, and empower people about health issues	Contribute recommendations, lessons learned, promising practices via an agreed-upon process	Find recommendations, lessons learned, promising practices, on a particular health topic	Select all recommendations within particular parameters (e.g., all treatment options for prostate cancer)	Evaluate relevance and usability of health materials	Work with media and academia to disseminate health messages	Provide content for consumers in different languages and different cultural emphases
4. Mobilize community partnerships to identify and solve health problems	Identify and provide locations of services that would benefit from collaboration	Search for and identify community resources (e.g., satellite facilities, schools)	Extract a list of facilities within a certain radius of a given population requiring services	Allow the building of real-time community, membership, validation services	Provide secure communication networks for disseminating information	Communicate with emergency response partners
5. Develop policies and plans that support individual and community health efforts	Describe effective policies and why they have worked in various contexts and make accessible via the Web	Be able to find the laws and legal precedence for public health issues within a jurisdiction	Identify all laws or policies relating to a disease or risk factor	Assess the effectiveness of specific policies through performance measures	Discuss pending policies	Inform agencies of changes in policies
6. Enforce laws and regulations that protect health and ensure safety	Publish restaurant ratings, environmental inspection reports	Find applicable laws; Find previous reports (e.g., restaurant ratings, well inspection reports)	Compile laws pertaining to a specific population	Track legal precedent	Provide forum for discussion and prioritizing	Provide policy reminders
7. Link people to needed personal health services and assure the provision of health care	Contribute addresses, credentials, and services of local health care providers	Find the local and state services for which an individual or family with specific requirements is eligible	Select favorite providers	Establish on-line tools to assist clients with managing and transfer medical records and assessing health status	Collaborate with providers, HMOs, and hospitals to capture appropriate surveillance information	Establish means to communicate with local media to reach necessary populations
8. Assure a competent public and personal health care workforce	Publish position descriptions, list of competencies, and needs to a community bulletin board	Find potential employees	Select appropriate candidates based on established criteria	Establish and test benchmarks for competencies	Provide online training, mentoring and co-authoring support	Communicate agency goals to the workforce

	A. Contribute	B. Find	C. Select	D. Analyze	E. Collaborate	F. Communicate
9. Evaluate effectiveness, accessibility, and quality of personal and population-based health services	Contribute evaluation plans and protocols	Search for effective performance monitoring tools	Select a monitoring tool that is appropriate for the agency characteristics	Track outcomes of services	Discuss results of evaluation/ monitoring with other agencies	Allow online user feedback on service satisfaction
10. Research new insights and innovative solutions to health problems	Publish journal articles	Share journal subscription access over the Web; be able to mark articles as to their public health utility	Combine data from different sources	Conduct assessment of the relationship between the environment and health	Facilitate remote co-authorship	Provide alternative means to disseminate results of research

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The U.S. Government's Knowledge Management Web site can be found at: http://www.km.gov.

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