Scenarios, personas and user stories from design ethnography: Evidence-based design representations of communicable disease investigations

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Abstract

Purpose—Despite years of effort and millions of dollars spent to create a unified electronic communicable disease reporting systems, the goal remains elusive. A major barrier has been a lack of understanding by system designers of communicable disease (CD) work and the public health workers who perform this work. This study reports on the application of User Center Design representations, traditionally used for improving interface design, to translate the complex CD work identified through ethnographic studies to guide designers and developers of CD systems. The purpose of this work is to: (1) better understand public health practitioners and their information workflow with respect to communicable disease (CD) monitoring and control at a local health department, and (2) to develop evidence-based design representations that model this CD work to inform the design of future disease surveillance systems.

Methods—We performed extensive onsite semi-structured interviews, targeted work shadowing and a focus group to characterize local health department communicable disease workflow. Informed by principles of design ethnography and user-centered design (UCD) we created persona, scenarios and user stories to accurately represent the user to system designers.

Results—We sought to convey to designers the key findings from ethnographic studies: 1) that public health CD work is mobile and episodic, in contrast to current CD reporting systems, which are stationary and fixed 2) health department efforts are focused on CD investigation and response rather than reporting and 3) current CD information systems must conform to PH workflow to ensure their usefulness. In an effort to illustrate our findings to designers, we developed three contemporary design-support representations: persona, scenario, and user story.

Conclusions—Through application of user centered design principles, we were able to create design representations that illustrate complex public health communicable disease workflow and key user characteristics to inform the design of CD information systems for public health.

Keywords

Human centered design; public health informatics; communicable disease reporting; information workflow; personas

1. INTRODUCTION

Despite years of effort and millions of dollars spent to create a unified electronic communicable disease reporting systems, the goal remains elusive. The timely monitoring and control of communicable infectious diseases is critical to maintaining the health of communities and is a primary activity of local health departments (LHD)[1]. Post 9/11 the application of information technology (IT) to support disease monitoring efforts at public health agencies has been a high priority[2]. However, efforts to implement communicable disease (CD) information systems into public health practice have been slow and with costly mistakes[3]. Independent implementations of in-house and commercial-off-the-shelf (COTS) technology have resulted in great variability in purpose, function and capacity of these CD information systems[4, 5]. As a result, effective and efficient surveillance systems that support CD work remain a goal of the future.

Research into the factors that influence the adoption of IT in clinical healthcare suggests that adoption is hindered by economic barriers, contextual barriers, lack of training, user resistance, policy constraints, and legal constraints[6–9]. System design and usability are important to the adoption of health IT. A systematic review of usability methods used in health informatics found that the majority of studies failed to report an explicit qualitative design approach, focused only on a single aspect of the work environment, and rarely used task and/or workflow analysis to contextualize the fit of users, tasks, systems and work environments in the early stages of design[10]. To reduce barriers introduced at the early stages of system design, design approaches that address these oversights are necessary.

Over the last several years, we have seen increased efforts to improve interoperability and electronic data exchange between public health and clinical systems[11]. However, budget cuts and resource constraints[12] have limited the ability of staff to dedicate time to provide input into the design of information systems used in their work. As a result, despite recent state-level improvements in disease surveillance capacity enabled by information systems, tools and representations to assist system designers in understanding CD work at the local level are needed.

Recent research that characterized barriers to the work of disease surveillance recommended further study of public health information work and inclusion of public health practitioners in the early stages of system design[13]. Scenario-based design has been used to explore interface design for public health services during emergencies[14], to develop tools that visualize simulated outbreaks for disease detection and control training[15] and to create research tools for data mining and visualizations of health data [16]. However, these studies focused primarily on applying user-centered design for improving functionality of interphase design of an existing system. They do not address the need for a more complete understanding of disease surveillance case investigation workflow nor do they demonstrate how user-centered design methodology can be used to produce verified design artifacts that illustrate to designer the users, tasks and context of public health work early in the system design process. Therefore, this study was conducted to fill the gap in knowledge regarding communicable disease investigation and reporting information workflow and apply user-centered design to inform system designers about users of CD systems.

1.1. Aims of the Study

To address this problem our studies had two aims:

1. Describe the work processes, influences and environment of CD monitoring and control at an LHD

2. Based on the data produced by the first goal, develop both traditional and novel evidence-based design representations that model CD monitoring and control as references for system designers to inform design of future disease surveillance systems

To achieve our first aim, we conducted a workplace ethnographic study to produce *workflow diagrams* and *descriptions of themes* that influence work. To achieve our second aim we employed methods of design ethnography and user-centered design (UCD) to produce *personas*, *scenarios of use* and *user stories* to convey key findings based on the workflow analysis. We describe here the initial ethnographic studies of CD information workflow at a Washington State LHD and the application of UCD as a novel way to represent these findings to designers.

1.2. Workflow and Design

The *workflow diagram* is a common representation from traditional task analysis[17–19] that schematically presents structures and relationships of work tasks in a flowchart. Workflow studies can include people[20], groups[21, 22], context of work[23], and human values and beliefs[24]. The use of ethnographic methods and thematic analysis can complement workflow diagrams with *descriptions of themes* of work[23]. *Design ethnography* is a research practice that draws on traditional ethnography and focuses on common patterns that are important to the design of information systems[25]. A form of action research, design ethnography focuses closely on discovering opportunities for design interventions in the situation under study. To make research findings as vivid as possible to designers, UCD offers alternative forms of representation for user and workflow data. Three common representations of user/task data in forms that are useful to designers are

personas[14, 26], *scenarios*[14, 27–29], and, more recently, *user stories*[30, 31] (see Table 1 for definitions). These representations have been used primarily to describe user behavior for improving internet interface design. These representations have not heretofore been used in public health informatics research to represent users and complex workflow to designers early in the process of developing CD systems.

2. METHODS

In this section we discuss the study setting, participants, data collection, and data analysis.

2.1. Setting

Kitsap County Health District (KCHD) is one of thirty-five LHDs in the State of Washington. It is located in Bremerton, Washington on the Kitsap Peninsula in the western part of Washington State. Kitsap County has a population of approximately 250,000 and is characterized by a mixture of urban and rural areas, with a large naval population and two Northwest Indian tribes. KCHD has 124 FTE and is classified as a medium-sized LHD (size classification is defined in terms of population served; medium = 50,000–499,999[32]). KCHD provides the following major community services: parent-child health services; clinical services; communicable disease and HIV/AIDS services; environmental health services; health promotion and health education programs; and community assessment. At the time of primary data collection, KCHD had recently adopted a new statewide information system to support CD activities.

2.2. Participants

Eleven participants were recruited from LHD personnel based on their job roles in CD programs, including the sexually transmitted disease (STD) program, the AIDS/HIV program, and Environmental Health. Participants provided data through a variety of methods including initial informant interviews, semi-structured interviews, selected work shadow observations, and a focus group. Table 2 shows participants by job role and the data collection methods with which they were engaged.

2.3. Data Collection

A mixed methods approach to data collection was used in order to triangulate our understanding of CD activities at the LHD. Interview data were collected over a three-month period in the autumn of 2006. Selected work shadow observations and a focus group were used to triangulate and validate our interview findings. Principle members of the research team have maintained a relationship with participants at the study setting since that time. All study instruments and protocols were approved by the Institutional Review Board (IRB) of the University of Washington. Informed consent was obtained from all participants prior to conducting interviews, observations and the focus group.

2.3.1. Preliminary Interviews—We began the study with two preliminary interviews to rapidly collect data about the study setting, familiarize ourselves with the organizational context of the LHD and identify key informants[33].

2.3.2. Primary Data Collection: Semi-Structured Interviews—An interview guide was developed by two researchers based on prior health department research studies[34] and information obtained from the two initial interviews. Questions were designed to explore tasks involved in CD activities including CD data collected; modes of data transfer; forms and technologies used; information resources; and people involved in carrying out CD activities.

Researchers working as a team conducted onsite, hour-long, individual semi-structured interviews with nine LHD employees involved in CD activities. Each interview was recorded using a Sony digital audio recorder. Researchers took field notes, photographed participant work spaces and collected artifacts such as forms, notes and guidelines used to carry out CD reporting activities.

2.3.3. Work Shadow Sessions—To document activities and gather more detailed data about specific tasks described in the interviews, two researchers engaged in two half-day work shadow observations[35] with the primary CD nurse epidemiologist and the main switchboard operator. Participants were chosen for shadowing based on the pivotal roles they play in CD work processes. Researchers used cameras and collected detailed notes during the observations. Because CD reporting activities were episodic, yet involved repetitive tasks, we observed participants on two afternoons that we had been informed would include those activities.

2.4. Data Analysis

Interviews were transcribed by a professional transcriptionist and yielded 462 pages of transcripts. Photos taken during the work shadow sessions were printed. Interview transcripts and photos were reviewed and discussed by three researchers to identify key workflow processes and to develop an initial coding scheme. The interview transcripts were then coded, and key themes related to CD work were identified.

2.4.1. Preliminary Workflow Analysis—Three researchers conducted a preliminary workflow analysis of interview transcripts, field notes, photos, and documents. The resulting workflow diagram identified "triggers" (initiations of contacts with the public health agency), actors, modes of information transfer, and business processes. An initial workflow diagram of CD monitoring and control was created and outstanding questions were identified.

2.4.2. Thematic Analysis—Building on the results of the workflow analysis, two researchers conducted iterative content analysis of interview transcripts to identify common themes that influenced CD work using the coding scheme that was developed during the workflow analysis (see section 2.4). Key tasks, values, barriers and facilitators to CD work were identified. Photos and field notes were reviewed in the context of emerging themes [38]. Discrepancies between the two coders were resolved through consensus [38, 39].

2.4.3. Workflow Validation—In keeping with CDC recommendations to gather stakeholder feedback during evaluations of surveillance systems[36], two researchers conducted a follow-up focus group[37] with four participants to perform member checks

(validation of findings through participant feedback) of the initial workflow diagram and validate our understanding of the characteristic themes related to CD monitoring and control. The focus group lasted two hours and took place at the study setting. The session was recorded using a digital audio recorder. The focus group included two participants who had participated in individual interviews and two additional employees (see Table 1). Participants were asked to think about CD information workflow at the beginning of the session. They were then shown a projection of the initial CD information workflow diagram and asked to provide oral feedback regarding it. Participants were also provided with individual print copies of the initial workflow diagram and asked to make written modifications to their print copies where pertinent. Based on the focus group feedback, only minimal changes to the workflow diagram were needed. The identified characteristics and themes of CD work were described and participant responses were noted. The final diagrams (see Figures 1–4) were constructed in the University of Washington Laboratory for Usability Testing and Evaluation (LUTE) in the Department of Human Centered Design & Engineering.

2.4.4. Data Representations for Design Process—The activities from Aim 1 produced a workflow diagram and descriptions of themes that influenced work. However, these abstract representations of CD tasks failed to illustrate the values and context of the users in the "designer-friendly" formats currently being discussed in UCD. To augment the workflow diagrams and descriptions of themes, we applied design ethnography and UCD principles to create a persona, scenario and user stories. Design ethnography relies on field observation that produces qualitative data, which are increasingly used in public health research[38]. However, design ethnography goes beyond the aims of traditional ethnography to focus on discovering design opportunities and to represent people and work in ways that serve as a foundation for the planning and design of information systems. These design representations are constructed from the same data sources as workflow diagrams and descriptive themes resulting from thematic analysis but aim to humanize work processes with concrete descriptions of people, activities and context. The goal is to be immediately useful during the design process to envision the impacts of tradeoffs in design decisions.

Creating persona, scenario and user story: Based on the results of our ethnographic studies, the research team identified key characteristics, practices, motivations and needs of CD nurse investigators that should to be taken into consideration by designers developing CD reporting systems. Using a persona template similar to those described for technical design we created the CD nurse epidemiologist persona based on characteristics and tasks identified from the coded interview transcripts. The scenario was created as a composite of activities described, photographed, and observed through reading the transcripts and notes taken during observation. The user stories were derived from the same data using the user-story models provided by Cohn[31]. Representations were reviewed by all study researchers to ensure accuracy and clarity. They were then reviewed by interview participants for feedback and validation.

3. Results

We present the results of our investigation below, organized by our two aims.

3.1. Aim 1: Description of practitioners, processes, influences and environment

The results for Aim 1 include final workflow diagrams and description of themes that influence work.

3.1.1. Final Workflow Diagrams—CD workflow was divided into four main phases: *notification*, *investigation*, *response*, and *reporting*. A "notifiable condition" is an infectious disease that must by law be reported to the State Department of Health (DOH). Characteristics of tasks and data collection performed by a CD nurse epidemiologist (CD nurse) during each phase are described below. A list of potential activities is given in the task box where several alternatives for a given task exist (ex. Figure 2).

3.1.1.1. Notification: Notification refers to the process whereby LHDs were informed by community health care providers, hospitals, clinical laboratories, and, occasionally, community members of the occurrence of a CD of potential public health importance (see Figure 1). Cases were reported by phone, fax and the DOH online notification system, *PHRED* (*Public Health Reporting of Electronic Data*)[39]. Once notified of a potentially significant CD, nurses determined whether the case was within their local jurisdiction and if it was a notifiable condition. Cases outside the jurisdiction were rerouted to the appropriate authority. If the case involved a notifiable condition, the LHD followed a formal process of investigation and reporting. Any case with an unknown etiology required further investigation to identify the infectious agent. In cases where the infectious etiology remained unknown or involved a non-notifiable condition, an investigation may have been conducted but the formal, state-mandated process of investigation and reporting was not required. Participants estimated that only 10% of reported cases regarding infectious diseases involved notifiable conditions. Once it was determined that the case involved a notifiable condition, the specific form required for reporting the condition was retrieved and printed from the DOH website. During the investigation phase, this form served as a working document for data collection.

3.1.1.2. Investigation: Investigation involved gathering the details of the case from providers, labs, and the patient and family (see Figure 2). Before contacting the client, the CD nurse confirmed the case with the provider and made sure the patient was aware of the diagnosis. The CD nurse collected information from the provider and patient regarding patient contact information, the timing of symptoms, exposure, potential contacts, lab results, and risk factors related to the occurrence of the infection. This process, which often took place over a matter of days, required numerous phone calls to multiple individuals and agencies. Information regarding the case was gathered, generally by phone or fax, from the community provider, clinical laboratories, hospitals, patients, and their families. Data were entered on the printed notifiable condition form as they were collected.

3.1.1.3. Response: Response was closely tied temporally to the investigation phase (see Figure 3). Response involved informing patient(s) about disease management and exposure concerns, referring them to the appropriate health care provider, and consulting with the physician to ensure appropriate treatment of the patient and possible contacts. If the investigation uncovered additional cases it would require the initiation of new case

investigations. Response could include notifying schools and work places of potential exposures, informing the media, or conducting community educational activities. The CD nurse may have consulted with state infectious disease experts, the district health officer, or other resources to learn more about appropriate treatment and exposure management. Data collected about the case continued to be recorded on the print copy of the notifiable conditions form. Handwritten notes were made in the margins and on sticky notes attached to the form. The working form was handed off to the covering CD nurse if the primary CD nurse had a day off or was on vacation.

3.1.1.4. Reporting: Reporting consisted of completing the notifiable conditions form and sending the results of the case investigation to the DOH for aggregation and analysis (see Figure 4). The reporting process could involve following up with the media, schools, and involved workplaces. Once the data were entered and a follow-up had occurred, a copy of the case was printed, and the paper forms, working documents, and notes gathered about the case were filed manually. At this point, the case was considered closed.

Traditionally, the completed form was mailed or faxed. New technology meant the data for many notifiable conditions were being manually entered from the print form into a new online reporting system called *PHIMS* (*Public Health Information Management System*) [40]. At the time of this study, all notifiable conditions except sexually transmitted diseases, HIV, and tuberculosis were being reported through PHIMS. The others were still reported by fax or mail.

3.1.2. Descriptions of Themes that Influence Work—Four themes that influenced CD work at the LHD were identified: *communication with stakeholders* and the influence of unwritten policies on communication; the *mobile, episodic nature of work*; public health personnel *focus on investigation and response* phases over reporting; and the *role and response to IT* on CD monitoring and control. Table 3 shows illustrative quotes for factors of each theme.

3.1.2.1. Communication with Stakeholders: Effective CD monitoring and control required ongoing communication between LHD personnel and stakeholders such as health care providers, health laboratories, and members of the public. The nature of such communication was influenced by stakeholder role. Communication within the LHD was also shaped by two unwritten policies: *taking steps to facilitate person-to-person communication* and *respect for how clients tell their stories*.

Although required by law to report notifiable conditions, participants speculated that health care providers may view notifying the LHD or returning follow-up calls during the investigation phase as low priority if they are busy with patient care or other tasks. Health laboratories are also required to report positive results of tests for notifiable conditions. Participants observed that compliance with reporting requirements was generally much higher for health laboratories than for providers. Members of the public also called to report problems or events. The more common role played by members of the public is that of *client*, someone who may have contracted a reportable CD. A substantial portion of CD nurse communication occurred with clients during the investigation and response phases.

The first unwritten policy was that CD nurses were always available during the day to receive case reports by phone from providers and laboratories or calls from members of the public. Calls from community health providers were routed by an operator through the health department switchboard or taken through direct phone contact. If the primary CD nurse was unable to take the call, the switchboard operator located another available CD nurse. The second unwritten policy was that of respect for how people choose to tell their stories, especially during the investigation and response phases. CD nurses did not like to interrupt the flow of conversation with clients, both out of consideration for the speaker and because of the perception that information was communicated more freely without interruption.

3.1.2.2. Mobile, episodic nature of work: The emphasis on direct communication meant that when a call came in, the call was answered. Inevitably, these work interruptions imparted a "drop everything" quality to the enacted work of CD monitoring and control. During any single day CD nurses could receive dozens of phone calls, while at the same time performing home visits, administering clinic treatments, and taking samples to the state laboratory.

A working document in the form of a printed notifiable conditions form was important during the investigation and response phases of CD workflow. CD nurses relied on having a mobile, easily portable, updateable, and transferable way of storing and conveying information. The paper working document allowed the CD nurses to make notes wherever they happened to be and was used to convey information from the point of collection to a secure computer at the LHD. CD nurses used the working document both as a personal memory aid and as a way to hand off information to other CD personnel for follow-up. It was also used to keep notes about processes during the investigation phase, such as the number of times calls were attempted, not just the final outcome.

3.1.2.3. Focus on investigation and response: CD workflow at the LHD was shaped by a fundamental difference between the views of the local and state health department about the perceived mission and goal of LHDs with regard to CD monitoring and control. In the case of the LHD, department personnel placed greater emphasis on the investigation and response phases over the reporting phase. Reporting was seen as "after the fact," and not perceived as urgent. When new notifications come in, they were assigned a higher priority than reporting resolved cases. This resulted in a backlog of reporting to the state.

3.1.2.4. Role and response to IT: Technology influenced how communicable work was done. LHD personnel relied heavily on telephony through various systems including the health department switchboard, landlines and mobile phones. In addition, health department personnel accessed many different information systems using personal computers. Two of these systems were PHRED[39], the DOH online laboratory notification system undergoing a pilot test, and PHIMS[40], the recently adopted DOH online CD reporting system. However, there were issues with DOH systems related to integration, data entry and designs that did not support local workflow for CD monitoring and control. For example, reporting forms differed for each notifiable condition and, therefore, online reporting processes were

correspondingly different. Lack of standardization was perceived as a persistent problem in public health systems design.

The primary barrier was that PHRED and PHIMS were separate systems without data exchange capability. Health department personnel were forced to do duplicate data entry because laboratory results did not feed from PHRED into PHIMS. The concept of a working document was not supported in PHIMS. As previously noted, CD nurses downloaded and printed the specific notifiable conditions form, once it is established that it was a reportable notifiable condition, This paper copy was used it through the reporting phase. A driver for retaining the working document is that DOH information systems did not support remote login for security reasons. As reported previously[34], before the introduction of PHIMS, CD nurses mailed or faxed printed notifiable conditions forms to the DOH. As a result, PHIMS had shifted the task of data entry for reporting from the state DOH to LHDs. CD nurses preferred to have a case completed and "all the ducks in a row" before providing data to another agency; this desire also led them to postpone entering *any* data until they had *all* of it, in its final form. Because of technical difficulties in using the system, they felt they needed quiet uninterrupted time for computer data entry – a challenge given the interrupted nature of their work.

3.2. Aim 2: Development of design representations

This study was undertaken as an effort to address the gap in knowledge about case investigation workflow and the need to engage disease surveillance professionals in the design of systems that support their work. Aim 2 builds on descriptions of CD workflow from Aim 1. We employed UCD, design principles often used to represent users for interface design, to create three additional renderings of workflow data in the form of a persona, scenario and user story. The contribution of Aim 2 is the demonstration of methods to understand disease surveillance workflow in context and provision of example outputs of those methods.

The persona was created based on characteristics and tasks identified from the coded interview transcripts[26]. The example of a scenario of use was developed in accordance with the principles of scenario-based design [27, 28]. The scenario itself was selected to conform to two requirements: first, it had to involve several different dimensions of the work—in this case, enacted values, informal individual work strategies, and steps required by law or policy; and second, the level of complexity of the work process had to be low so that it could be represented briefly. The user story was developed in accordance with the principles and templates described in [31], especially with regard to the syntactic format of the elements to be included. In this case, the rules for the representation itself insisted on brevity; in addition, the story had to be told from the first-person point of view of a specific user group and had to cover only a single unified activity.

3.2.1. Persona—The following persona (Figure 5) is a composite drawn from the data collected about several CD nurse epidemiologists at the LHD.

3.2.2. Scenario—The following scenario of use (Figure 6) describes a call from a health care provider to report a notifiable condition. The call is handled by the switchboard operator at the LHD.

3.2.3. User Stories—In the following two examples of "Agile" user stories (Figure 7), note that each story is told in the first person with the relevant type of user specified, one unified user activity accompanied by minimally sufficient information about the key user values and contextual details.

3.2.4. Validation of Design Representations—The persona, scenario and user stories were validated with the primary CD nurse at the study setting in June 2012. An inquiry about the status of processes and technology made at this time revealed that while no major changes in workflow or systems had been made since our last project update, most lab results now arrived electronically through PHRED, rather than by fax[40]. However, the PHRED system does not feed into the electronic reporting system (PHIMS) and remote access to PHIMS was still not possible.

4. Limitations of the Study

While using a case study design provided a detailed description of the tasks and processes involved in CD activities, the results may not be generalizable to other public health settings[41]. A limitation with ethnographic studies can be researcher bias in the analysis and interpretation of results. To minimize bias, the transcripts were reviewed and coded by more than one researcher. In addition we validated our results through performing member checks and selected work shadow observations.

5. Discussion

This study was undertaken to fill the gap in knowledge with regard to disease surveillance case investigation workflow and to demonstrate methods to design case investigation information systems. Towards that end, we implemented workflow and task analysis, thematic analysis, design ethnography, and user-centered design (UCD) to understand work processes and to construct evidence-based design representations of communicable disease workflow in a medium-sized local health department. The novel contributions of this study are an increased understanding of case investigation workflow and demonstration of the design methods to support it, which were created by engaging disease surveillance professionals in the design process. Given the resource constraints of public health, there is a critical need for approaches that ensure the successful adoption of information systems into public health practice. The evidence-based design representations reported in this study were developed as example references for system designers and public health informaticians for use in these efforts.

The long-term goal of this work is to encourage the creation of information systems based on UCD and design ethnography to ultimately improve health outcomes through more efficient use of public health information technologies. This goal has not been met in the past. For instance, the automated systems already in use in the setting we studied (PHIMS and PHRED) were designed to improve the efficiency of notifiable condition reporting, and

in particular, to overcome inefficiencies in information transfer and delays in reporting. However, these efficiencies were not realized, in part because of the failure of the systems designers to align the system properly with actual CD work. For example, the lack of interoperability between PHRED and PHIMS and the transfer of responsibility for data entry from the state (based on paper documents received from the LHD) to the local health departments (done online) led to new inefficiencies in the system. Furthermore, because data entry had to be done only on specific desktop computers, the added task of data entry required several hours of uninterrupted computer time. Given the mobile and disparate nature of CD work, this resulted in delays in reporting of days or even of weeks.

We believe that the approach and methods demonstrated in this study can be useful to understand public health work and illustrate to designers key characteristics that must be taken into consideration in system design. More specifically, the findings from our studies suggest the following:

a.   Washington State DOH online notification systems should be linked to online case reporting systems to minimize manual data entry.

b.   Current mobile technologies should be used for reporting because they better complement the mobile and episodic nature of CD work.

c.   The system user interface should offer a "working" document that can be easily updated and shared among CD investigators. It should also allow for multiple cases to be open at once.

To avoid introducing unnecessary user problems during design, user representations should vividly illustrate for system designers the requirements and constraints of CD work. During our data analysis process, we encountered the problem of building a model of the work at a sufficiently high level to show its overall structure, while at the same time preserving the details of the enacted work that influenced decisions about the use of information technologies. The five representations of the data derived from our study (workflow diagram, thematic analysis, persona, scenario, and user stories) allowed us both to provide a high-level model of the work as well as to preserve sufficient detail so that design decisions could reflect the true requirements of the enacted work. The three representations derived from the UCD literature (persona, scenario, and user story) focus especially on conveying a vivid sense of the realities of work as experienced by the workers themselves. These representations provide the essential missing bridge between researchers and designers to help us achieve the goal of successful evidence-based tool design that has too often eluded us. The design representations that result from the approach demonstrated in this study can convey contextual understanding to system designers and developers. Future research to demonstrate the usefulness of these methods in a laboratory setting should include: 1) a comparison of system designers' satisfaction after performing design tasks for public health workflow using flowchart-narrative and persona-scenario-user-story techniques and 2) heuristic evaluation by experts of the designs resulting from these design tasks[42].

References

1. Silk BJ, Berkelman RL. A review of strategies for enhancing the completeness of notifiable disease reporting. Journal of public health management and practice : JPHMP. 2005:11.

2. Gerberding, JL. Advancing the Nation's Health: A Guide to Public Health Research Needs, 2006–2015. Atlanta, GA: U.S. Department Of Health And Human Services, Centers for Disease Control and Prevention; 2006.

3. Eban K. Biosense or Biononsense? Scientist. 2007; 21:32.

4. Centers for Disease Control and Prevention. Status of state electronic disease surveillance systems--United States, 2007. MMWR Morbidity and mortality weekly report. 2009; 58:804–7. [PubMed: 19644441]

5. Centers for Disease Control and Prevention. State electronic disease surveillance systems --- United States, 2007 and 2010. MMWR Morbidity and mortality weekly report. 2011; 60:1421–3. [PubMed: 22012115]

6. Ash JS, Bates DW. Factors and forces affecting EHR system adoption: report of a 2004 ACMI discussion. Journal of the American Medical Informatics Association. 2005; 12:8–12. [PubMed: 15492027]

7. Gandhi TK, Poon EG, Sequist TD, Johnson R, Pizziferri L, Karson AS, et al. Primary care clinician attitudes towards ambulatory computerized physician order entry. AMIA Annu Symp Proc. 2005; 961:961. [PubMed: 16779248]

8. Johnson KB. Barriers that impede the adoption of pediatric information technology. Arch Pediatr Adolesc Med. 2001; 155:1374–9. [PubMed: 11732959]

9. Anderson, JG.; Aydin, CE.; Jay, SJ. Evaluating health care information systems: methods and applications. Thousand Oaks: Sage Publications, Inc; 1993.

10. Yen PY, Bakken S. Review of health information technology usability study methodologies. Journal of the American Medical Informatics Association. 2011

11. Office of the National Coordinator for Health Information Technology. Health IT Strategic Framework: Strategic Themes, Principles, Objectives, and Strategies. Washington, DC: 2010. April 1, 2010 ed

12. Meyer, J.; Weiselberg, L. Health Management Associates, A Report for the Robert Wood Johnson Foundation and the National Association of County & City Health Officials. 2009. County and City Health Departments: The Need for Sustainable Funding and the Potential Effect of Health Care Reform on their Operations.

13. Reeder B, Revere D, Hills RA, Baseman JG, Lober WB. Public Health Practice within a Health Information Exchange: Needs and Barriers to Disease Surveillance. Online Journal of Public Health Informatics. 2012:4.

14. Reeder B, Turner AM. Scenario-based design: A method for connecting information system design with public health operations and emergency management. Journal of Biomedical Informatics. 2011; 44:978–88. [PubMed: 21807120]

15. Livnat, Y.; Gesteland, P.; Benuzillo, J.; Pettey, W.; Bolton, D.; Drews, F., et al. Epinome-a novel workbench for epidemic investigation and analysis of search strategies in public health practice. AMIA Annual Symposium Proceedings: American Medical Informatics Association; 2010. p. 647

16. Sutcliffe A, de O, Thew S, Buchan I, Jarvis P, McNaught J, et al. Developing Visualization-based Decision Support Tools for Epidemiology. Information Visualization. 2012

17. Taylor, FW. The principles of scientific management. New York: Harper; 1911.

18. Kirwan, BE.; Ainsworth, LK. A guide to task analysis. London: Taylor & Francis; 1992.

19. Vicente, KJ. Cognitive work analysis: Toward safe, productive, and healthy computer-based work. Mahwah, NJ: Lawrence Erlbaum; 1999.

20. Grudin, J.; Pruitt, J. Personas, Participatory Design and Product Development: An Infrastructure for Engagement. Proceedings of the Participatory Design Conference; 2002. p. 144-61.

21. Bardram, JE. Plans as situated action: an activity theory approach to workflow systems. Proceedings of the 5th European Conference on Computer-Supported Cooperative Work; Lancaster, UK: Kluwer Academic Publishers; 1997. p. 17-32.

22. Bowers, J.; Button, G.; Sharrock, W. Workflow from within and without. Proceedings of the 4th European Conference on Computer-Supported Cooperative work; Stockholm, Sweden: Kluwer Academic Publishers; 1995. p. 309-24.

23. Beyer, H.; Holtzblatt, K. Contextual design: defining customer-centered systems. San Francisco: Morgan Kaufmann Publishers; 1997.

24. Friedman, B.; Kahn, J.; PH; Borning, A. Value Sensitive Design and Information Systems. In: Zhang, P.; Galletta, D., editors. Human-computer interaction and management information systems: Foundations. Armonk: ME Sharpe Inc; 2006. p. 348-72.

25. Salvador T, Bell G, Anderson K. Design ethnography. Design Management Journal (Former Series). 1999; 10:35–41.

26. Pruitt, J.; Adlin, T. The persona lifecycle: keeping people in mind throughout product design. Morgan Kaufmann; 2006.

27. Carroll, JM. Scenario-based Design: Envisioning Work and Technology in System Development. NY: Wiley; 1995.

28. Rosson, MB.; Carroll, JM. Usability engineering : scenario-based development of human-computer interaction. San Fancisco: Academic Press; 2002.

29. Reeder B, Demiris G. Building the PHARAOH Framework Using Scenario-Based Design: A Set of Pandemic Decision-Making Scenarios for Continuity of Operations in a Large Municipal Public Health Agency. Journal of Medical Systems. 2010:34.

30. Beyer H. User-centered agile methods. Synthesis Lectures on Human-Centered Informatics. 2010; 3:1–71.

31. Cohn, M. Addison-Wesley Professional. 2009. Succeeding with agile: software development using Scrum.

32. NACCHO. The Status of Local Health Department Informatics. 2010.

33. Marshall M. The key informant technique. Family Practice. 1996; 13:92–7. [PubMed: 8671109]

34. Turner AM, Stavri Z, Revere D, Altamore R. From the ground up: information needs of nurses in a rural public health department in Oregon. Journal of the Medical Library Association : JMLA. 2008; 96:335–42. [PubMed: 18974810]

35. McDonald S. Studying actions in context: a qualitative shadowing method for organizational research. Qualitative Research. 2005; 5:455–73.

36. German. Updated Guidelines for Evaluating Public Health Surveillance Systems. MMWR. 2001; 50(RR13):1–3. [PubMed: 18634202]

37. Krueger, RA.; Casey, MA. Focus groups : a practical guide for applied research. Thousand Oaks, Calif: Sage Publications; 2000.

38. Devers KJ. How will we know "good" qualitative research when we see it? Beginning the dialogue in health services research. Health Services Research. 1999; 34:1153. [PubMed: 10591278]

39. Washington State Department of Health. Public Health Reporting of Electronic Data (PHRED). Washington State Department of Health; 2011. http://www.doh.wa.gov/EHSPHL/Informatics/phred_labs.htm

40. Turner, AM.; Ramey, J.; Lee, ES. Connecting public health IT systems with enacted work: report of an ethnographic study. American Medical Informatics Association; 2008. p. 737

41. Reeder B, Hills R, Demiris G, Revere D, Pina J. Reusable design: A proposed approach to Public Health Informatics system design. BMC Public Health. 2011; 11:116. [PubMed: 21333000]

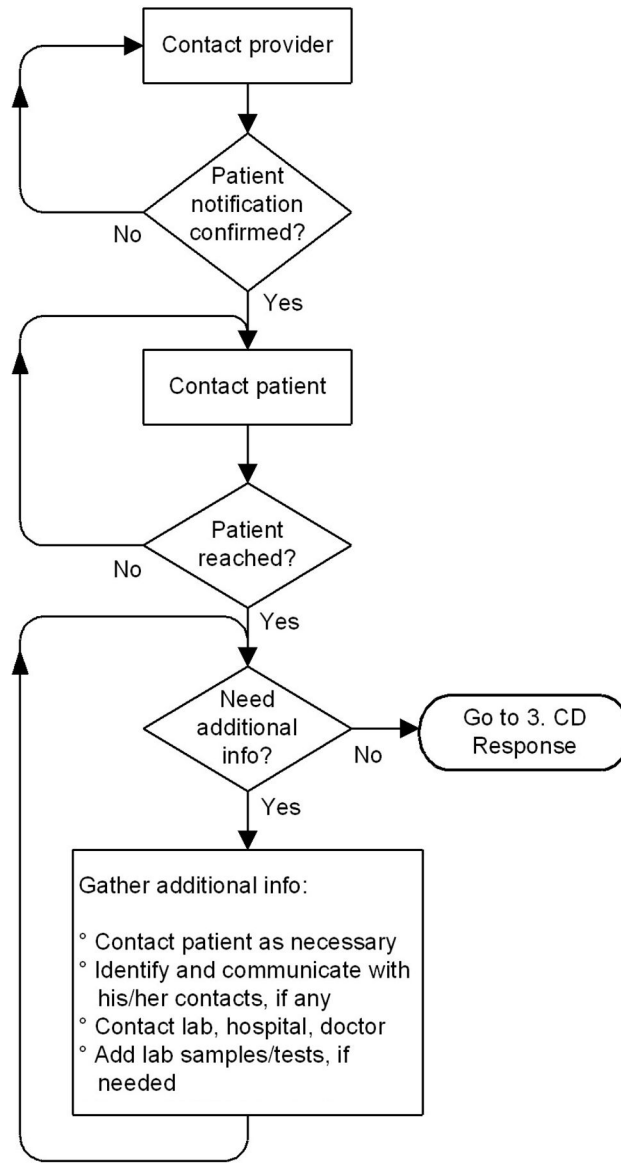42. Nielsen, J. Usability engineering. Morgan Kaufmann; 1994.

Highlights

- We modeled communicable disease (CD) workflow at health department using user-centered design.

- Public health CD work is mobile and episodic yet CD reporting systems are stationary and fixed.

- Health department efforts are focused on CD investigation and response rather than reporting.

- Current CD information systems do not conform to PH workflow thus affecting their usefulness.

- Personas, scenarios and user stories provide evidence-based representations for designers.
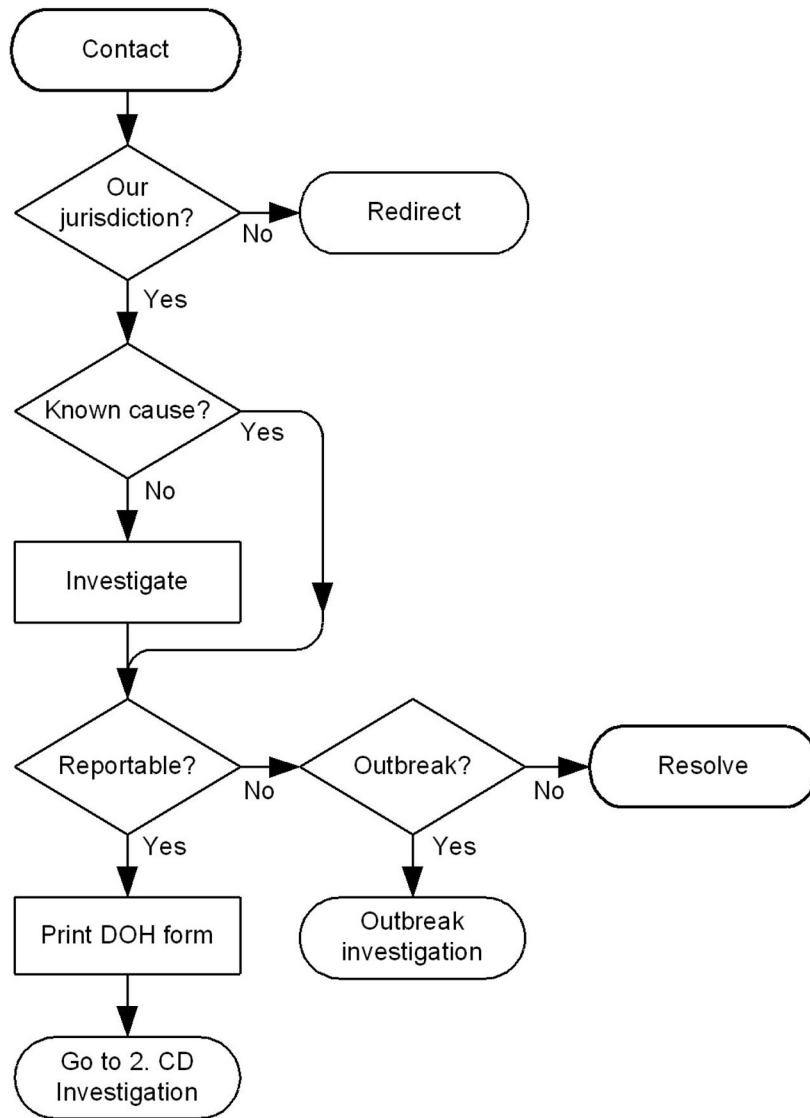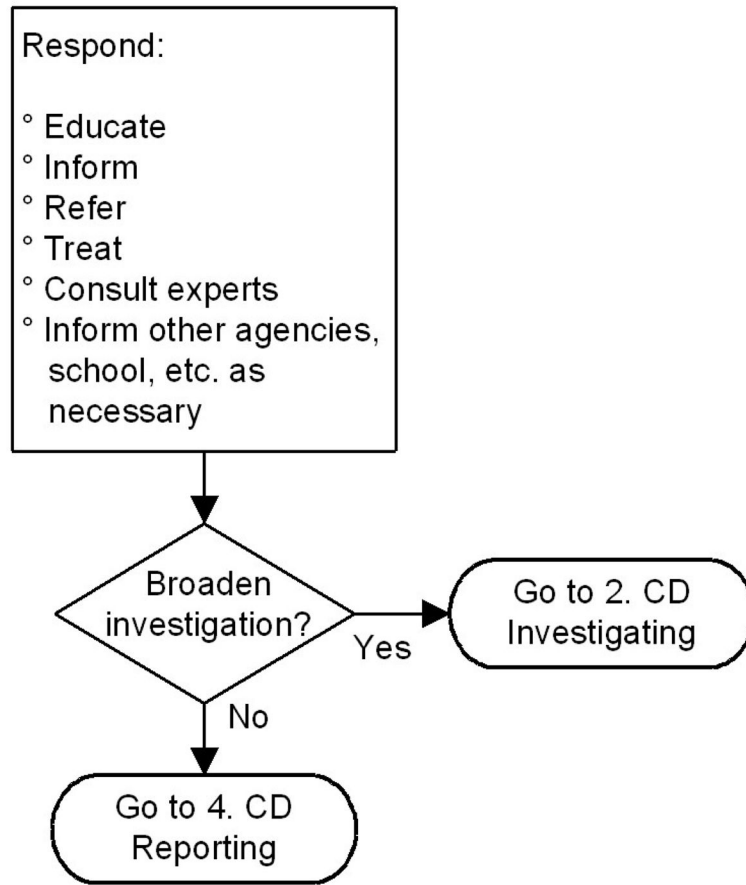
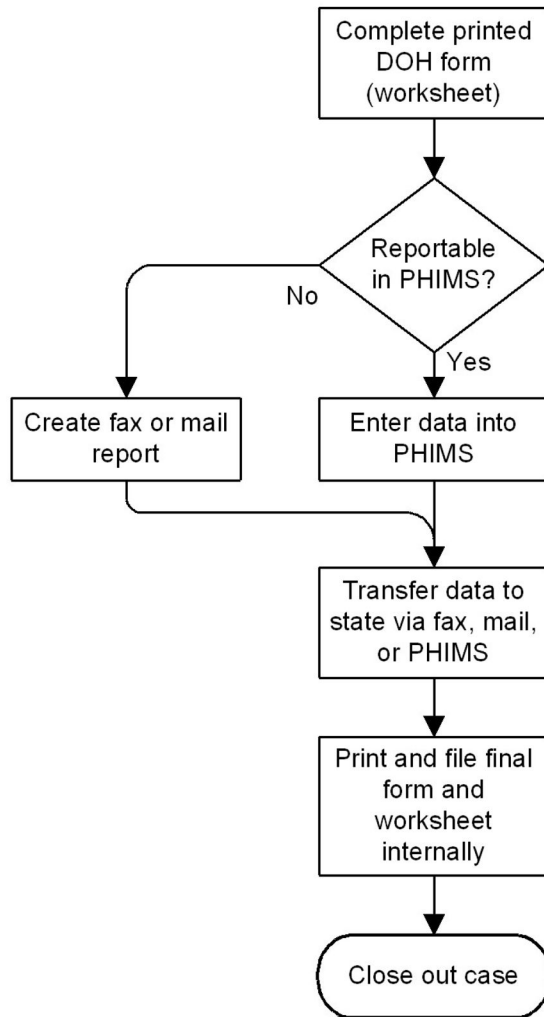**Figure 1.**
Notification Phase

Figure 2.
Investigation Phase

Figure 3.
Response Phase

Figure 4.
Reporting Phase

Persona	
	Cindy, Nurse Epidemiologist
Job title	Communicable disease nurse epidemiologist
Gender	Female
Age	45-59 years
Description	Has worked with the health department for more than 15 years. Her job requires her to be on the move all over the county, collecting information from people as investigations unfold, following up with treatment, and educating citizens and agencies about prevention of communicable diseases. Well connected with the community; very client-oriented. Enjoys her job and takes pride in it.
IT experience	Years of on the job training with legacy systems. Prides herself on her technological expertise; active member of the user group to advise and pilot state-developed automated system for disease reporting.
Tasks	Receives case notifications from providers and laboratories, contacts others to gather data regarding case, conducts field investigations, takes lab specimens to state laboratory, directs observation therapy, does case management, completes state reporting requirements. Shares information with other divisions including environmental health and epidemiology
Values	Highly respectful of clients; puts a high value on service to both community and local agencies. Focus on improving health.
Work Style	Active, hardworking, multi-tasking; on the go; pragmatic.

Figure 5.
Persona of a Nurse Epidemiologist

Donna, the switchboard operator, receives a call from a health care provider about a possible case of TB. Donna puts the caller on hold and quickly checks today's list of the nurse epidemiologists in the office. Since Cindy is at the top of the list, she tries to put the call through to her, but it reverts to voicemail. So she leaves a quick message for Cindy and looks for someone else to take the call. As she does, she gets another call, so she makes a note about it on a yellow sticky for follow-up. She then sees Janet, another CD nurse, come in. (She always leaves her door open so that she can see everybody coming and going.) She is relieved when Janet picks up the phone so that she can connect the callers to a "live" person.

Wearing her switchboard headphone, Donna then continues to go through the faxes from labs that have come in to the secure fax machine in her office since the end of the previous day. She sorts them into stacks for the appropriate CD program—HIV/AIDS, STD, etc. As calls come in, she alternates between the work on getting the faxes ready to go out to the right offices and the work of directing callers to "live" responders. If there is a break between calls and faxes, she sorts and files the local hard copies of investigation reports.

Figure 6.
Scenario of a Notifiable Condition Report to Switchboard Operator

User Story 1:
As the switchboard operator, I need to track the routing of up to five overlapping in-coming calls so that I can quickly connect every caller with a "live" person.

User Story 2:
As a CD nurse epidemiologist away from the office conducting a client visit, I need access offsite to the CD reporting forms, so that I can enter data as it is reported to me.

Figure 7.
Example User Stories

Table 1

Definitions of design representations

Design Representation	Description
Persona	A persona is a detailed data-driven description of an imaginary person that focuses on the motivating values, judgment processes, pressures, and tradeoffs of workers. The goal is to share understanding of users among designers during the design process and to support design decision-making.
Scenario of use	A scenario of use focuses on bringing the context and actions of the user into the design process. A scenario of use is a story with a plot about people and their activities including actions, events and settings.
User story	A user story is an extremely brief narrative from Agile Development that describes a specific work activity of a single worker and situation. User stories generally conform to the following format: "*As a <type of user>, I want <some goal> so that <some reason>*"[31].

Table 2

Study participants and data collection methods

Participant	Job Role	PRIMARY DATA COLLECTION			VALIDATION
		Initial Informant Interview	Semi-structured Interview	Work Shadow Observation	Workflow Diagram Focus Group
Participant 1	Epidemiologist	✓	✓	-	-
Participant 2	Senior Administrator	✓	✓	-	✓
Participant 3	Nurse Epidemiologist	-	✓	✓	✓
Participant 4	Nurse Epidemiologist	-	✓	✓	-
Participant 5	Env Health Specialist	-	✓	-	-
Participant 6	Operator	-	✓	-	-
Participant 7	Nurse Epidemiologist	-	✓	-	-
Participant 8	Program Manager	-	✓	-	-
Participant 9	Epidemiologist	-	✓	-	-
Participant 10	Epidemiologist	-	-	-	✓
Participant 11	Program Manager	-	-	-	✓

Table 3

Illustrative Quotes for Themes that Influence Communicable Disease Work

Theme	Factor	Illustrative Quote
Communication with Stakeholders	Priority of Reporting	*"Clinicians aren't maybe motivated to 'waste their time'… I've certainly been on the phone where I'm trying to pull this information out of busy clinicians who just don't want to take the time to report it."* -Senior Administrator
	Person-to- person Communication	*"The point is that all calls get operator answered immediately and that you don't get answering machines and get that frustration."* -Senior Administrator
Mobile, Episodic Nature of Work	Variable Workflow	*"I've been to people's houses, I've met them at McDonald's, I send them letters, I call them. I was very fortunate, the Health District gave me a cell phone number so that people can call me later in the day, … and I've had a lot of good luck getting hold of people at 7 o'clock in the morning and then later in the evening."* - CD Nurse Epidemiologist #4
	Paper-based Documentation	*"Having something to at least write notes on is good, because it does take sometimes several hours or sometimes even days to get back."* - CD Nurse epidemiologist #1
Focus on Investigation and Response	Prevention	*"Yes, counting the numbers is important at the end of the day, but the goal is to prevent further outbreaks."* - Senior Administrator
	Treatment	*"My main focus is to contact people, make sure they're getting treated and getting their partners treated."* - CD Nurse epidemiologist #4
Effects of Information Technology	Poor Interaction Design	*"The ideal would be to just put it in*[data into the computer] *as you are going and not be duplicating, because that is what we are trying to get away from. But, you know interviewing people, I can't say, oh well, wait I'm going to get to that*[later] *because it is not in the order of my form."* - CD Nurse Epidemiologist #2
	Lack of Standards and Integration	*"If you've got TB, it's one reporting system. If you've got Salmonella it's another reporting system. If you've got AIDS it's another reporting system. And God forbid you have STD's, it's another reporting system."* - Senior Administrator