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Health Technol. (2016) 6:125–136
DOI 10.1007/s12553-015-0123-1

ORIGINAL PAPER

A conceptual model for the role of storytelling in design: leveraging narrative inquiry in user-centered design (UCD)

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Received: 20 July 2015 / Accepted: 11 December 2015 / Published online: 6 January 2016

Abstract The Prevention through Design (PtD) initiative identifies the design stage as an opportunity to "design out" hazards and risks. An early emphasis on safety enables the reduction of opportunities for error and misuse in healthcare technology, and the corresponding safety and well-being of patients and providers. A pre-condition for preventive design is a deep understanding of users' characteristics, goals, needs, and contexts of use. Standards recommend a user-centered design process coupled with ethnographic methods (e.g., self-report, observation) to gain this knowledge. However, current human factors methods may not provide an efficient means to explore the problem space during the concept stage. On-site observations require identification of an appropriate observation site, stakeholder buy-in, and IRB approval with adherence to HIPAA regulations. Off-site simulations require task scope, which limits design exploration before it has been initiated. Recommended self-report methods (e.g., interviews, focus groups) also have limitations. In previous work we found that the elicitation of experiences through "storytelling" resulted in the identification of significantly more context of use information than semi-structured interviews. The overall goal of this work is to present storytelling as a method rooted in narrative inquiry that aids designers' understanding of usability requirements. We present a conceptual model for the role of storytelling in design informed by a synthesis of narrative and design research and apply the model to healthcare technology. We present the Design+Storytelling framework as a means for healthcare designers to operationalize storytelling in their work.

Keywords Narrative inquiry · Requirements · Storytelling · User-centered design

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1 Introduction

The Institute of Industrial Engineers (IIE) Council of Fellows [1] identifies the re-engineering of healthcare delivery as a "grand challenge". The increased use of technology within healthcare, and the corresponding need for usable technologies that support patient care, demands a focus on usability during design. Although the importance of medical device usability has been well established since the formation of the Human Engineering Committee within the Association for the Advancement of Medical Instrumentation (AAMI) [2], a review of devices reveals that "a disturbing proportion of new devices still have significant shortcomings" in the user interface [3]. This finding suggests an opportunity to explore human factors methods that facilitate the creation of usable technology. To inform this exploration we consider the (a) meaning and

impact of usability within healthcare, (b) strengths and limitations of User-Centered Design (UCD) as a means to support usability and prevent healthcare errors, and (c) opportunity to leverage narrative inquiry within a UCD process. We then present our conceptual model for the role of storytelling in design and apply this model to healthcare technology.

1.1 What is usability and how does it impact healthcare?

Usability is historically defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" [4]. However, recent design standards have expanded this definition to include concepts such as learnability [5, 6]. For example, the usability of an infusion pump during medication administration may be evaluated in terms of practitioners' (a) required training time, (b) accuracy and speed in entering medication orders, and (c) perceptions of the pump's ability to support work goals, such as the provision of safe care.

Due to the impact of usability on practitioner and patient safety, the National Occupational Research Agenda (NORA) [7] identifies the design of medical device interfaces as a Prevention through Design (PtD) research gap. As device interactions involve both practitioners and patients, a poorly designed user interface has the potential to harm practitioners who deliver treatment as well as patients who receive care. From this perspective, patients are considered device users; although a patient may not directly control the device, s/he is directly impacted by its use. For example, a poorly designed infusion pump interface may facilitate a spill of medication during chemotherapy administration due to an incorrect bag connection. In this scenario, the practitioner is exposed to potentially harmful chemicals while the patient's therapeutic treatment is delayed. Considering the potential for poor usability to negatively impact the safety and health of practitioners and patients, usability is an Occupational Safety and Health Administration (OSHA) issue as well as a patient safety concern. Even in cases in which only the patient is harmed, practitioners may become "second victims" of patient injury due to the emotional and professional consequences [8].

1.2 User-centered design (UCD) as a prevention through design (PtD) process to improve usability and reduce error

The overall goal of the PtD initiative is to reduce hazards and risks through improved design [9]. A human factors strategy to reduce medical error is to "design out" device characteristics that contribute to error [10]. Standards recommend a user-centered design (UCD) process as a means to improve usability and reduce error opportunities within the design [5, 6]. Although the term Human Centered Design (HCD) is used interchangeably with UCD in the literature, we use UCD to remain consistent with medical device standards.

UCD is an iterative design framework that identifies four non-linear and interdependent activities that promote user experience during design: (a) understand and specify the context of use, (b) specify the user requirements, (c) produce design solutions, and (d) evaluate solution against the requirements [11]. A UCD cycle is complete when the design solution encapsulates all of the identified requirements for the given cycle. Context of use is defined as "user characteristics, tasks, equipment, and a physical and social environment in which a product is used" [12]. Context of use is critical for design understanding as varied contexts result in varied usability requirements.

Consider the context of use for medication administration within the emergency department (ED) of a mid-sized city hospital. The potential users within the ED include doctors, nurses, pharmacists, lab technicians, and patients. Patients may be passive users who receive treatment through a device. Patients may also be active users who directly control the treatment, as in the self-administration of pain medication via a patient controlled analgesia (PCA) pump. These diverse user characteristics must be considered during design, as the usability requirements for a PCA pump are different for a patient without any medical knowledge than for a pharmacist with years of medical training and expertise. Tasks and equipment used during medication administration may include (a) retrieving and interpreting a medication order from an electronic health record (EHR) system, (b) obtaining the dosage from the pharmacy or a medication management system, (c) verifying the patient's identity and dosage via wristband barcode scanning and (d) programming the delivery of the medication via an infusion pump. Users' ability to utilize the equipment to complete tasks is also affected by the physical and social environment of the ED. The architecture of the ED may impact the appropriateness of a design solution. For example, a centralized nurses' station located in the center of a U-shaped ward facilitates the monitoring of patients within close proximity to the station while hindering the monitoring of patients located at a greater distance. In this scenario, an auditory warning system is more appropriate and more usable than a visual display. Aspects of the social environment also impact the appropriateness of a design solution. For example, an EHR system may be considered unusable if it does not adequately support the flow of patient records from the ED to other wards as patients are admitted.

The medication administration scenario within the ED exemplifies the impact of context of use on the appropriateness of a design solution. This finding is reiterated in the IEC 62366 warning to designers that "the context of use can have a significant impact on usability of the medical device user interface" [5]. However, exploration of the context of use within healthcare is challenging due to domain specific barriers, such as institutional review board (IRB) and health

insurance portability and accountability act (HIPAA) constraints, which affect the appropriateness of methods traditionally used by designers [13–15]. Standards recommend the use of ethnographic methods, such as observation and interviews, to facilitate exploration of user needs and contexts of use. However, these methods have additional limitations and overhead when applied in a healthcare setting. Hospital IRB applications and processes are notoriously complex as the forms typically assume a medical intervention and not a qualitative study. In previous work [16], we encountered hospital IRB approval boards that met once every 6 months, which resulted in an unexpected project delay. After IRB approval, designers may require additional approvals to complete UCD activities, as observation of practitioners' delivery of patient care by definition requires observation of the patient. Although this permission can be obtained, the request disrupts the provider-patient interaction and may unintentionally alter the context of use, affecting the quality of the data collected. There are also scenarios in which permission cannot be obtained and interactions cannot be observed. For example, it would be inappropriate to disrupt a cardiac arrest patient entering the ED to request consent as the interruption may delay care during a life- and time-critical situation. Designers are also unable to observe scenarios in which patients are admitted to the ED while unconscious and unable to provide consent.

The medical device industry relies on simulation centers to conduct observations when in situ observations are not possible, but Sharples et al. [17] note that "it can be difficult to conduct realistic simulated or naturalistic observation of the use of a medical device due to the range of actors and contexts of use". In lieu of direct observations, designers may elicit user needs and contexts using self-report methods, such as interviews. However, these methods may fail to elicit contextual information since the practitioner is removed from the work environment. The inability to observe practitioners coupled with the limitations of self-report methods traditionally used in design impede understanding of the contexts in which the device is to be used.

1.3 Leveraging narrative inquiry in design

Considering the criticality of understanding the contexts of use, designers require a knowledge elicitation method that elicits contextual information. Historically, designers have adapted ethnographic methods (e.g., observation, structured interview, unstructured interview, group interview) for use during design tasks (Fig. 1). This adaptation is appropriate due to the similarities between designers' and qualitative researchers' goals. For example, a phenomenological researcher aims to understand the *lived experiences* of a population while a designer aims to understand the *user experience*.

Although designers have adapted structured, unstructured, and group interviews during design, standards [5, 6] do not reference the potential benefits of narrative interviews. This omission of narrative inquiry (i.e., the eliCitation of personal experiences) as a potential method is surprising considering its prominence within qualitative research [18–21] and its use to understand the experiences of healthcare workers [22, 23].

In previous work [24] we explored the elicitation of personal experiences during requirements analysis for medical devices. This work was motivated by Garmer et al's [25] call for methods that facilitate understanding of the context-of-use in a healthcare environment. We referred to our approach as "storytelling" due to the prevalence of "story" over "narrative" in design research literature. In this work we compared the usability requirements gathered from infusion pump nurses from two methods: (a) focus groups followed by individual interviews — FG&I and (b) focus groups followed by individual storytelling sessions — FG&S. FG&S participants contributed significantly more distinct context of use information, with an emphasis on the social context. These findings suggest that storytelling as a method aids designers' understanding of usability requirements. Storytelling's ability to aid understanding of the social context provides necessary design guidance considering NORA's contention that "the successful design and implementation of new products, materials, and work procedures involves a social process, as well as a technical one" [7].

Based on these initial findings, we present storytelling as a method that may be utilized by designers following a user centered design process (Fig. 2). At the time of this writing, FDA's [26] draft guidance for the optimization of medical device design identifies interviews as one method to explore use-related hazards. As a variation of the interview technique, storytelling fosters analysis of hazards through the elicitation of personal narratives that capture hazardous tasks, equipment, and contexts. Storytelling artifacts, which include tasks, critical incidents, and scenarios, also facilitate formative and summative evaluations of designs required to obtain FDA approval. Similar to [27], we acknowledge how scenarios may benefit both a user-centered design process and the regulatory framework required by the FDA. We propose storytelling as a means to elicit scenarios of use.

PtD contributions of this previous work include a protocol for conducting a storytelling session and a framework for defining usability requirements within the healthcare domain. The opportunity to provide additional PtD contributions through the application of storytelling in design motivated this work. The goals of this project were to create:

(1) a conceptual model for the role of storytelling in design based on a synthesis of narrative and design research
(2) the Design+Storytelling framework, which guides designers' use of storytelling

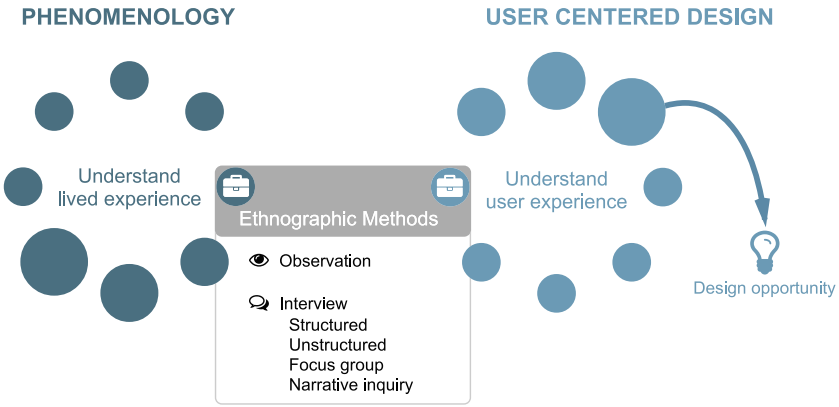

Fig. 1 UCD leverages ethnographic methods to understand user experience and potential design opportunities

(3) practical design guidance informed by empirical findings from the framework's application within healthcare

This paper presents the first two goals of the project. First, the conceptual model for the role of storytelling in design is presented with an example specific to healthcare technology. Next, the paper details the steps of the Design+Storytelling framework for practitioners interested in utilizing storytelling during the design of healthcare systems, services, and improvement projects.

2 Conceptual model for the role of storytelling in design

A review of design literature reveals an increased interest in stories as a means to alleviate communication problems between designers and stakeholders. Misunderstandings may derail a project and are noted as a contributing factor towards ultimate design failure [28]. The call to action, "perhaps it's not requirements that we should ask for, but rather a good story" [29] provides motivation for the

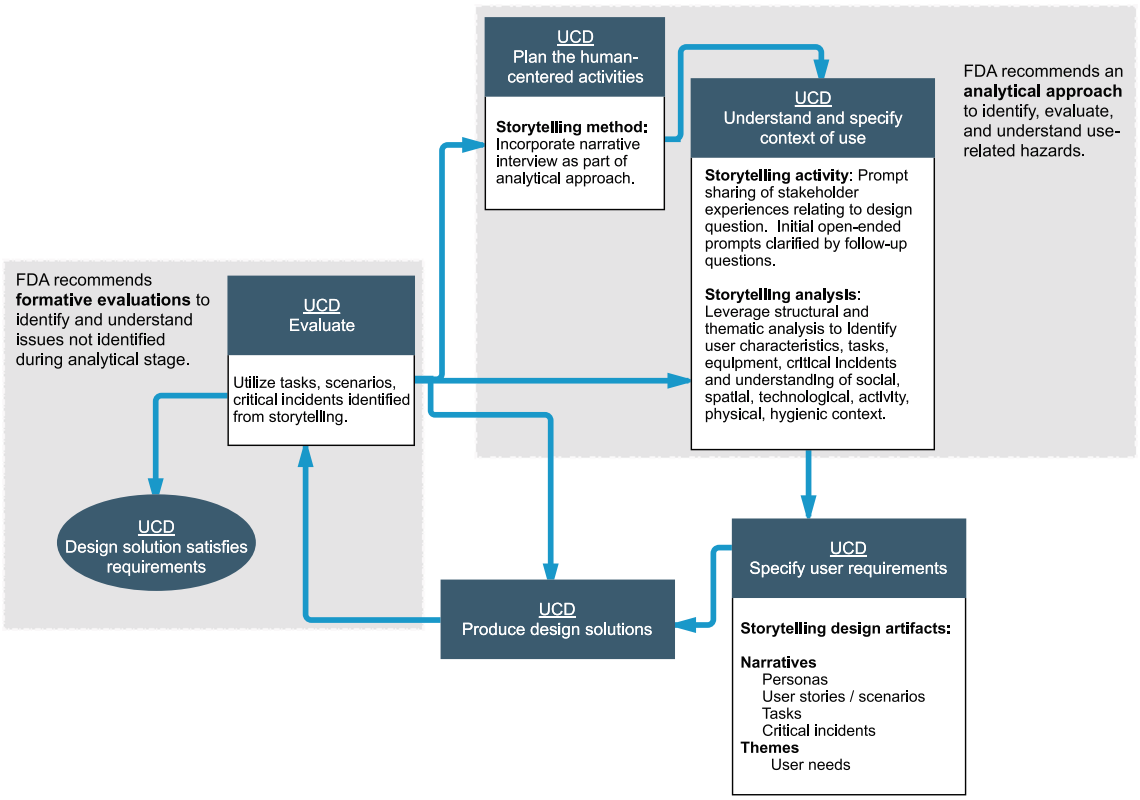

Fig. 2 Storytelling, as a method option within a user-centered design process [11], supports FDA [26] requirements for an analytical and evaluative approach to design

exploration of storytelling as a means to avoid communication issues. Yet, this deceptively simple statement begs several questions. *What is a "good story" ? How does a one "ask for" a story? How may designers utilize the information collected in stories to inform design and creation of deliverables?* We provide the conceptual model for the role of storytelling in design as a first step towards answering these questions.

Our conceptual model prescribes how designers elicit and analyze stakeholder stories – skills that are "increasingly recognized as crucial" [30]. In response to the lack of guidance for these skills in the current literature, our conceptual model (Fig. 3) highlights two distinct processes for the collection and analysis of stories. The first process within our storytelling method is the storytelling activity in which stakeholder experiences are collected. This section of the model explores how designers "ask for" stories. The second process, storytelling analysis, explores how designers find meaning in stakeholder stories. This section of the model explores how designers utilize stories to inform design and the creation of deliverables. The analysis phase is an information discovery process in which user needs are explored and design opportunities are identified. The model leverages qualitative research methods (i.e., structural and thematic analysis) as a means to focus the activity towards information that is helpful to designers. This ensures that the analysis is purposeful and will ultimately aid in the creation of design deliverables, such as a formal requirements specification. As a checkpoint, the designer may cross-reference the information discovered with the information requirements dictated by design standards. This allows designers to differentiate between "design relevant" and "design irrelevant" stakeholder stories and prompts designers to solicit further stakeholder information. In this respect, the conceptual model provides an internal checkpoint to prevent the communication problems between stakeholders and designers that are often cited in the literature.

2.1 Storytelling method composed of two processes that support the transition from problem space to solution space

Design may be viewed as a transition between two spaces: the problem space and the solution space [31]. Stakeholder knowledge defines the problem space and designer knowledge constitutes the solution space (Fig. 4). Designers aim to identify a design opportunity that addresses stakeholders' needs. This successful transition from user needs (i.e., problem space) to design opportunity (i.e., solution space) requires successful communication between stakeholders and designers.

Although on the surface this appears to be an easy endeavor, it has its challenges. In the early stages of design in particular, it is necessary to elicit user's tacit knowledge — information that is difficult to express or explain [32]— in order to understand users' needs. Although standard interviews may not adequately elicit tacit knowledge [33], narrative interviews do not demonstrate this deficit [34, 35]. Considering the potential for narrative interviews to elicit valuable user knowledge necessary for UCD, we leverage narrative inquiry as the theoretical foundation for our conceptual model. Narrative inquiry is a qualitative research method that involves the elicitation and analysis of personal experiences. In its simplest definition, a narrative is a personal account of experience; however, a universally accepted definition is lacking in the

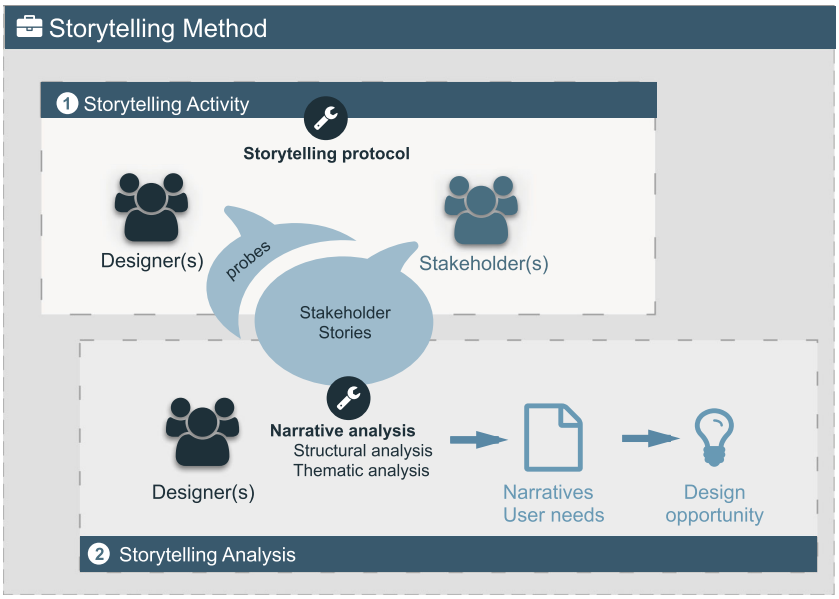

Fig. 3 Conceptual model for the role of storytelling in design

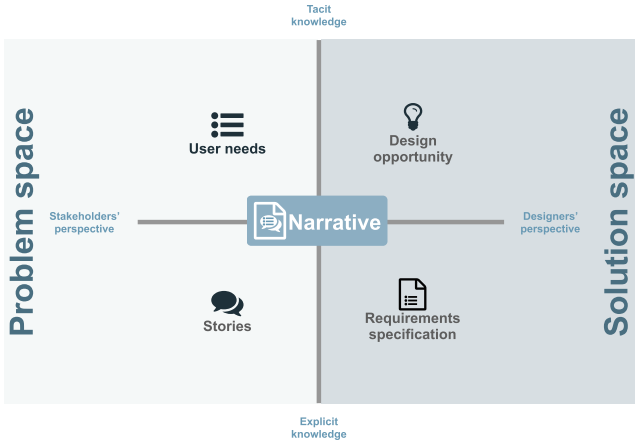

Fig. 4 Collection and analysis of stakeholder narratives facilitate transition from the problem space to the solution space

literature. Narrative may be defined as a sequential ordering of events with a specific structure [19], a representation of experience [21], a joint production of storyteller and listener [20], or as a cognitive schema used to organize and understand experience [36]. Story is primarily used to represent the storyteller's perspective of the retold experience while narrative references the researcher's interpretation of the story. As stories represent the stakeholder's perspective, we view stories as representations of the problem space. We view narratives as design artifacts that facilitate designers' transition from the problem space to the solution space due to narrative's evaluative component that includes the designer's interpretation of the story.

Based on this review of narrative theory literature, we operationally define narrative as "a representation of personal experience (i.e., a story) formed by content and structure". In the storytelling method, stories are elicited during the storytelling activity and are transformed into narratives as a result of storytelling analysis.

The motivation for this work was to facilitate stakeholders' communication of user needs more effectively and efficiently to designers. Just as designers utilize prototypes to explicitly communicate a solution for stakeholder review, stakeholders may share stories to communicate user needs to designers. The goal of the storytelling method is to facilitate the transition from problem to solution space through the: (1) elicitation and understanding of stakeholders' needs, (2) identification of a design opportunity to address the needs, and (3) specification of system requirements that define the proposed solution to the identified design opportunity.

2.1.1 The storytelling activity: elicitation of design relevant information from stakeholders

The storytelling activity represented in our conceptual model leverages best practices from the narrative interview – a method used within narrative inquiry to elicit personal experiences. As in a narrative interview, the success of the storytelling activity is defined by its ability to elicit desired information. Since the overall goal of the storytelling method is to identify a design opportunity, the goal of the storytelling activity is to elicit information relevant to design. This includes users' characteristics, tasks, goals, and context of use, which define users' needs. The conceptual model uses the term "stakeholders" instead of "users" to encourage broad participation in the activity as valuable design information may be elicited from stakeholders who may not be traditionally viewed as users. For example, a chief nursing officer (CNO) may be unable to provide information about daily patient care and device use due to limited direct interaction with patients, but may provide valuable insight into the administrative goals and challenges of the organization.

The conceptual model highlights the impact of context on the storytelling activity where session context is defined by the (a) composition of the stakeholders and (b) questions posed within the activity. Stakeholder composition affects the quality and type of information elicited since storytelling with one participant is fundamentally different than storytelling with two or more participants. In a group activity, hierarchical differences may discourage participants from divulging negative information, such as errors, in the presence of a superior due to fear of professional consequences. Group storytelling may facilitate designers' quest for design relevant information, as storytellers tend to provide more detail-rich stories in the presence of other attentive listeners [37]. Conversely, storytellers tend to provide less detailed stories in the presence of inattentive listeners. Due the potential negative impact of inattentive listeners on activity success, designers are cautioned to carefully recruit stakeholders when scheduling group sessions.

The storytelling protocol, which defines the scope of the activity through questions posed to stakeholders, impacts the information elicited. In contrast to standard interview protocols, which promote a question-and-answer discourse, the storytelling activity utilizes a modified interview protocol that encourages participants to share stories [21]. Designers use open-ended prompts, such as "Please tell me your story about [x] in as much detail as possible" [22] to shift the control of the elicitation session from the designer back to the stakeholder. The use of open-ended questions addresses the criticism that specific questions frame the session from the interviewer's perspective [38] and encourage stakeholders to share information important to the designer, but not necessarily to the stakeholder.

The protocol leverages the use of probing questions, as the purpose of the storytelling activity is not only to elicit personal experiences, but also to elicit information relevant to design. Since stories are co-constructed by storyteller and listener [20], designers may use probes to influence the stakeholder to (a) alter the focus of the story and (b) include additional story detail. For example, the probing question, "How did

your working relationship with the attending doctor change after the medication error?" encourages the nurse to re-focus the story to highlight the social structure within the hospital. This question strategy allows designers to purposefully elicit valuable contextual information relevant to design.

As in narrative interviews, designers may alter the context of the storytelling activity based on the goals of the activity. Consider a designer tasked with the identification of a design opportunity within ED security. The designer may choose to conduct a group storytelling activity to elicit detail-rich stories, yet decide to separate groups by work roles in an effort to reduce any potential issues due to hierarchical differences between nurses, doctors, and lab technicians. Open-ended questions, such as "Please share an experience that you had where you felt that ED security was an issue", allow stakeholders to identify a broad range of potential security issues, ranging from needs for information technology (IT) security to the reduction of violent outbursts in the ED. Designers may utilize additional probes within the protocol, such as "Please describe how your work is affected by issues with IT security", when the elicitation of task relevant information is demanded by the design problem.

2.1.2 Storytelling analysis: systematic management of user research data, creation of design artifacts, & identification of design opportunities

The storytelling method prescribes a process for the analysis of stories collected during storytelling activities. In this respect, stakeholder stories are the output of the storytelling activity and the input to storytelling analyses. According to our conceptual model, designers leverage methods used within narrative inquiry — structural and thematic analysis — to analyze stakeholders' stories for information relevant to design.

Designers initially employ structural analysis [19], a method prevalent within narrative inquiry, to organize the information collected during the storytelling activities. This structural approach encourages designers to form practitioner's stories into concise narratives that contain important statements of interest. For example, the structural approach can reduce a practitioner's lengthy story into a succinctly organized narrative that maintains the integrity of the story. These concise narratives provide several benefits within UCD as narratives act as design artifacts that (a) maintain the stakeholders' voice and perspective, (b) facilitate communication and discussion within design meetings and (c) may be used as storytelling prompts within later UCD iterations to further explore topics of interest.

Structural analysis guides designers' management of data contained within stakeholders' stories. In structural analysis, designers organize stakeholders' statements by structural components, which are defined as: complicating action, abstract, orientation, resolution, evaluation, and coda (Table 1). Although only the complicating action — a temporal sequence of statements that provides the narrative's plot — is necessary for the creation of a narrative, all remaining components except for coda are also relevant to design. For example, the abstract is a brief statement that summarizes the narrative, and may be used by designers during meetings to quickly focus the discussion on that particular event. For example, the inclusion of the abstract in the question "how does that requirement address *My Worst Day Ever in the ER*?" (a) provides a cognitive aid to the design team to facilitate recall of the stakeholder's experience, and (b) encourages discussion of the experience without the need for designers to spend valuable work time to retelling the story.

After structural analysis, designers employ another prevalent method within narrative inquiry —thematic analysis —to analyze narratives for content, specifically the identification of functional and usability needs. Thematic analysis aids designers' management of data elicited during the storytelling activity as it provides a structured process for this identification of user needs. Thematic analysis is used within qualitative inquiry to identify themes of interest to a research question. Similarly, designers use thematic analysis to identify user needs of interest to a design problem. Designers utilize a coding scheme within this phase of storytelling analysis to facilitate the identification of user needs. For example, a coding scheme that contains the categories effectiveness, efficiency, satisfaction, and context of use, encourages the identification of usability needs. Designers may alter the coding scheme depending on the design problem or domain. For example, designers of healthcare technology may include a separate category for safety, given the life-critical nature of the domain.

The identified user needs provide several benefits within UCD, as user needs act as design artifacts that facilitate designers' (a) exploration of the problem space, and (b) transition to the solution space through the identification of a design opportunity.

3 The Design+Storytelling framework applied to healthcare

As president of the Institute for Healthcare Improvement (IHI), Dr. Donald Berwick lamented an inefficient healthcare system in which "we lose the ideas of the workforce by not inviting them to join invention" [39]. We present our Design+Storytelling framework (Fig. 6) in an effort to address the communication problems cited by Dr. Berwick and others [7, 40].

The Design+Storytelling framework (Fig. 5) operationalizes the ideas within the conceptual model and provides guidance for the implementation of the storytelling methodology. The framework helps designers identify and

Table 1 Example statements for structural components of a narrative and the design relevance of each component

Structural component	Design relevance	Example narrative statement	Required?
Abstract	Provides a summary of the story, which designers' may use to quickly reference the event during design meetings.	My more successful patient infusion	No
Orientation	Describes the story's characters and setting, which provides user characteristics and contextual information	Trust me, I was really, like, shaking because this is a chemo.	No
Complicating action	Temporal sequence of events, which reveals stakeholders' goals, tasks, and potential barriers	She was, like, really – I would say crashing. Put her on nitrogen. Five milligrams didn't do good.	Yes
Resolution	Describes how the problem described within the complicating action was resolved, which reveals the scope of the problem's impact as well as currently used process "work arounds" to mitigate the problem.	The patient ended up in the unit because her blood pressure – that's when she started going down too.	No
Evaluation	Reinforces the stakeholder's perspective and the purpose of the story, which encourages designer's exploration of the problem space from the user's perspective.	So the infusion pump is kind of – it's one of the tools that we use for patient safety.	No
Coda	A closing statement, which signifies the end of a story. Coda is the only structural component not relevant to design.	So that is what happened that day.	No

refine a design opportunity that meets business goals and objectives. First, designers define the initial project scope, which may be as broad as "improve quality care within the emergency department". An initial broad project scope may be refined to an actionable and viable design opportunity through iterations of the initial stages of the UCD process: (1) plan the human-centered activities and (2) understand and specify the context of use. The results of storytelling analysis are used as a checkpoint to determine if subsequent iterations are necessary or if the design process can continue to the next UCD stage in which designers document user requirements for the refined design opportunity (Fig. 6).

An overview of the six phases (i.e., define project scope, identify stakeholder groups, document context for storytelling activity, finalize analysis plan, conduct storytelling activity, conduct storytelling analysis) follows. As all analytical approaches harbor some limitations, we provide mitigation strategies to reduce the potential negative impact at each stage (e.g., storytelling participant bias impacting the information elicited during the storytelling activity).

3.1 Define project scope

The initial stage in the framework is the definition of the project scope. Designers may determine project scope based on which areas or systems improvements are most needed. Project scope may also be framed by the potential to create a new product or service. The initial project scope may be broad (e.g., reduce sentinel events at all locations within a corporate hospital) or narrow (e.g., reduce blood culture contaminations within one hospital's ED).

The framework acknowledges the dynamicity of project scopes and provides a checkpoint for refinement during the analysis stage. After initial stakeholder stories have been collected and analyzed, designers may reframe the scope to focus on the problems with the most reported negative impact or to choose a design opportunity that aligns best with the business goals and objectives. For example, the original goal to improve quality care in ED may be refined to the reduction dosage miscalculations through assistive technology. If refinement of the project scope is required, the framework guides designers back to the Define Project Scope stage for another full iteration of the framework.

3.2 Plan for storytelling method

Project scope drives the plan for the storytelling method. A plan facilitates efficient and directed knowledge elicitation from stakeholders who have the knowledge necessary to further explore or refine the project scope. Data collection and analysis protocols reduce the potential for designers to skew the results of the storytelling method. For example, a storytelling protocol reduces the risk of designers asking inappropriate or off-topic questions. The creation of a storytelling protocol requires the development of questions, probes and the selection of session settings that maximize information discovery. The development of an analysis plan to identify design relevant information (e.g., users, goals, tasks, context, etc.…) also frames the goals of the analysis and limits opportunities for designers to misinterpret the collected information.

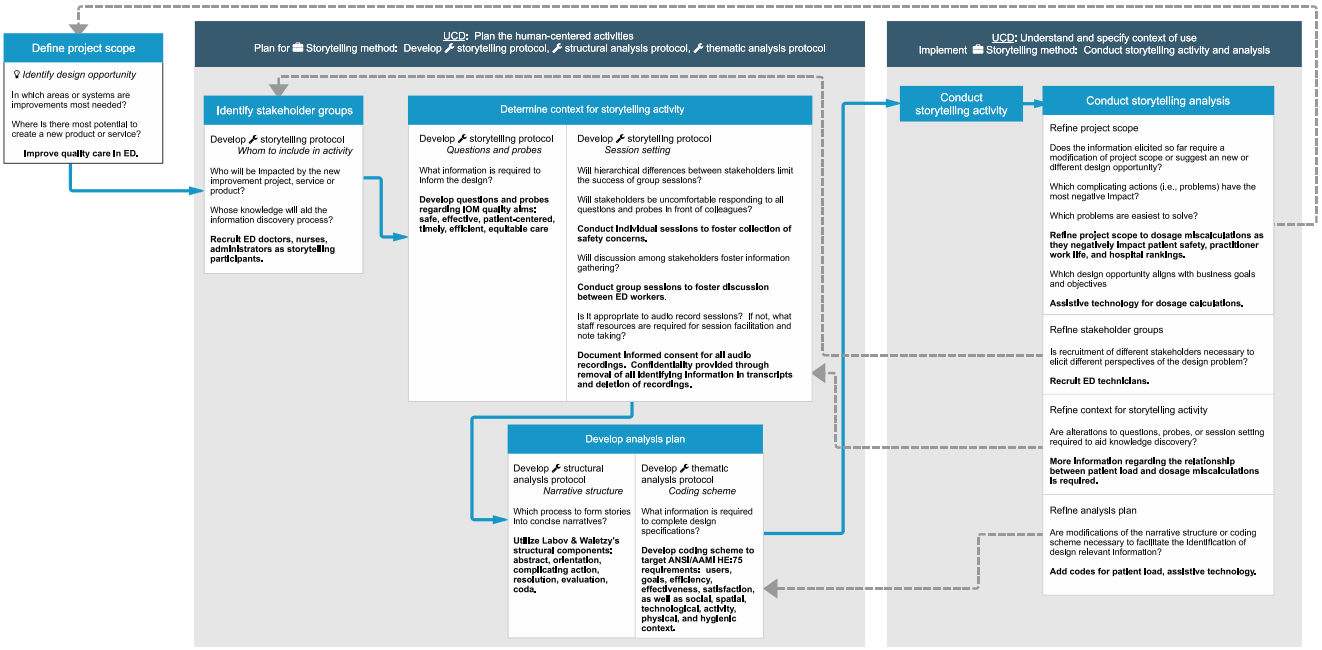

Fig. 5 The Design+Storytelling Framework applied to healthcare

3.2.1 Identify stakeholder groups

Identification of stakeholder groups is critical due to the need to understand their particular and unique needs. Initial stakeholders should include those whose knowledge will aid in the information discovery process as well as those who will be impacted by the product or system created. Consideration of the project scope (e.g., Improve quality care in ED) also helps designers target stakeholder groups (e.g., ED doctors, ED nurses, hospital administrators).

We advise the inclusion of the open-ended question *Is there anyone else I should be talking to?* in the storytelling protocol to mitigate the risk of excluding stakeholder groups. The analysis stage also provides another opportunity to check and refine stakeholders. In light of the analysis results so far, designers determine that recruitment of additional stakeholders is

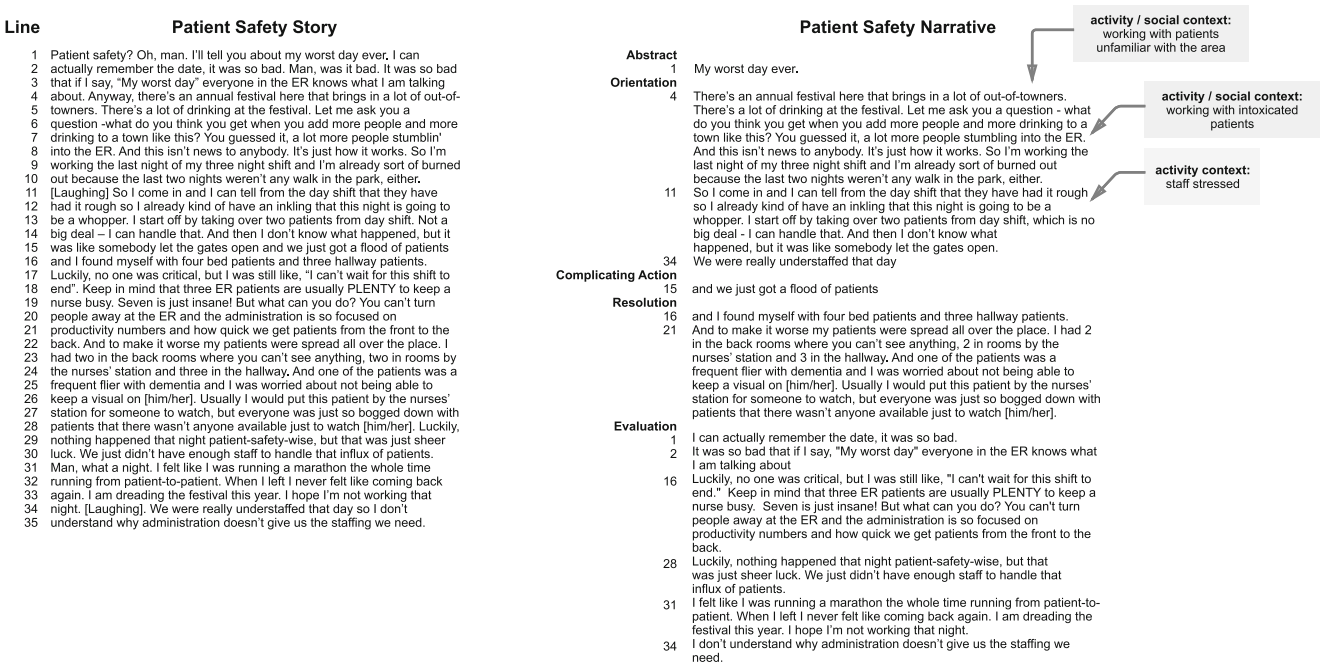

Fig. 6 Structural analysis forms stakeholder stories into narratives. Thematic analysis facilitates the identification of user needs

necessary to elicit different perspectives of the design problem. In this case, another iteration of the framework is required, starting at the Identify Stakeholder Group stage. When new stakeholder groups are added, the design team must also consider if new or adapted protocols for storytelling and analysis are required. For example, ED technicians may be prompted with, *Tell me a story about an experience that you had where a malfunctioning device was returned for repair* to further understanding of ways to improve quality care in the ED.

The complexity of requirements gathering prevents a recommendation for an exact number of stakeholders to include in the process. In their work with a medical device company, Martin et. al. [41] interviewed 47 healthcare workers to help identify requirements for a novel medical device, which suggests that participation from dozens of stakeholders may be required.

3.2.2 Determine context for storytelling activity

Next, designers consider how stakeholder characteristics may necessitate the selection of different contexts for the storytelling activity. The questions, probes, and setting defined in the protocol set the context for the storytelling activity. Designers are advised to consider potential interaction effects between questions and setting that may negatively impact the ability to elicit information. For example, in the quest to improve quality care in ED, designers may develop storytelling prompts around the IOM quality aims of safe, effective, patient-centered, timely, efficient, and equitable care. This approach would result in a prompts, such as, *Please tell me about an experience that you had where patient safety was an issue* and *Please tell me about an experience that you had where practitioner safety was an issue*. As participants may be reluctant to share freely in fear of personal or professional consequences, designers may consider conducting individual sessions to foster the collection of safety concerns.

During development of storytelling prompts and probes, designers should consider strategies to reduce participant bias. For example, if the storytelling probes include negative (e.g., ineffective care) and positive (e.g., effective care) themes, designers may alternate starting with the a positive/negative theme across participants in an effort to reduce potential priming of participant responses.

Another consideration at this stage is the potential for hierarchical differences between participants to limit the success of group sessions. For example, an ED nurse may not be willing to share stories of ED inefficiencies in a group session that includes his superior, the Chief Nursing Officer. When choosing the session setting designers should also consider potential negative reactions to an audio recorder. For example, if the focus of the storytelling session is sentinel events, it may not be appropriate to audio record due to the sensitive (and possibly legal) nature of the stories shared.

The iterative nature of the framework encourages designers to refine the context of the storytelling activity. At the analysis stage checkpoint, designers question if alterations to the questions, probes, or session setting are required to aid knowledge discovery. If yes, designers are guided back to the Determine Context for Storytelling Activity stage for another iteration through the framework.

Due to the influence of storytelling context on successful elicitation of information relevant to design, future work will explore how alterations to the storytelling context affect the information collected during storytelling sessions.

3.2.3 Develop analysis plan

Once the process for collecting stories has been determined, a plan is required to analyze the stories for design relevant information. The first step within the analysis stage is structural analysis – a means to transform stakeholder stories to concise narratives. The framework recommends the use of Labov & Waletzy's [19] structural components (e.g., abstract, orientation, complicating action, resolution, evaluation, coda) as it forms stories into a narrative framework that facilitates analysis of design relevant information. For example, designers may focus on the "evaluation" section of a narrative to extract user needs relating to satisfaction. Similarly, designers may refer to the "orientation" section to further understand the social and technological context surrounding the participant's reported experience.

The next step of the analysis plan is to develop a coding scheme. As medical device design requires documentation of design specifications, the coding scheme should focus on the identification of information required by design standards, such as ANSI/AAMI HE:75 [6].

The analysis plan should include strategies to reduce coding bias. The use of two independent coders who must form agreement during structural and thematic analyses mitigates this risk. The use of the grounded theory technique of constant comparisons [42] also helps to ensure analytic rigor across all data collected.

The analysis plan may be refined when designers determine that modifications are of the narrative structure or coding scheme are necessary to facilitate the identification of design relevant information. For example, as the project scope narrows from *Improve quality care in ED* to *Develop assistive technology for dosage calculations*, designers may add codes for *patient load* and *assistive technology* to provide additional focus.

3.3 Implement storytelling method

Now that stakeholders have been identified and a plan has been created for the collection and analysis of stories, designers may implement the storytelling method. First,

designers conduct storytelling activities with recruited stakeholders by following the previously determined protocol. Next, designers utilize structural analysis to form transcribed stories into narratives (Fig. 6), which helps streamline subsequent thematic analysis. In the patient safety narrative example, thematic analysis of the orientation section reveals several activity and social contexts related to patient safety (e.g., working with patients unfamiliar with the area, working with intoxicated patients, and working while stressed) that should be considered during the design for use within an ED, including during summative and formative evaluations of the design solution.

The framework encourages a rigorous approach to analysis, which provides designers opportunities for reflection and refinement of the method. For example, after the discovery of the prevalence of intoxicated patients in the ED, designers may refocus the design of a PCA pump, which is typically patient controlled, to include a lock-out feature for confused or intoxicated patients.

4 Future work

The conceptual model for the role of storytelling in design and the Design+Storytelling framework represent the first two goals of our overall research project. In future work we plan to explore the impact of the storytelling context (e.g., questions, session setting) on the success of the method. Based on these findings we plan to provide practical design guidance informed by empirical findings from the Design+Storytelling's framework's application within healthcare.

Acknowledgments This work was supported by Grant Number T01OH008613 from CDC-NIOSH.

Compliance with ethical standards

Conflict of interest Dr. Kim Gausepohl declares that she has no conflict of interest. Dr. Woodrow Winchester declares that he has no conflict of interest. Dr. Tonya Smith-Jackson declares that she has no conflict of interest. Dr. Brian Kleiner declares that he has no conflict of interest. Dr. James D. Arthur declares that he has no conflict of interest.

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