Designing Nursing Robots with Empathy: A User-Centered, Qualitative Research Approach

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***Abstract*—Pediatric intravenous (IV) self-removal is a common and disruptive problem that can lead to treatment delays and increased workload for nurses. To inform the design of empathetic nursing robots and lay the foundation for a creativity generation system, this qualitative study explored nurses' experiences with pediatric IV self-removal. Semi-structured interviews were conducted with five pediatric nurses and analyzed using the Modified Grounded Theory Approach. Key findings included factors contributing to IV self-removal, nurses' coping strategies and challenges, and differences between medical and nursing approaches. User experience (UX) and customer journey mapping visualized the patient experience and opportunities for robot interventions. Building on prior research in design thinking and collaborative creativity, this study highlights the value of a patient-centered, empathy-driven approach and proposes strategies for integrating user insights and fostering interdisciplinary creativity in developing nursing robots. The results provide a framework for advancing nursing robotics through user-centered design and promoting more holistic, innovative solutions to complex healthcare challenges.**

Keywords — design thinking, co-creation, team creativity, UX-based workshop, prototyping

I. Introduction

Pediatric IV self-removal is a prevalent and challenging problem in hospital care, leading to treatment interruptions, increased risk of complications, and added workload for nurses. As nursing robots are increasingly explored as potential solutions to support nursing care, it is crucial to understand the unique needs and experiences of pediatric patients and nurses in this context. However, current nursing robot development often faces challenges in effectively incorporating user perspectives and fostering creative, patient-centered solutions.[1][2]

The authors have previously conducted research on cognitive sharing and creative ideation in product development projects. The "KADEN Project" (Kasamatsu & Ainoya, 2015) [3][4] employed a design process that emphasized the use of image sketches and collages to share mental models and foster creativity among design and engineering students. Another study (Ainoya, 2014) [5] proposed a hierarchical model of concept for creative conflict resolution in manufacturing, highlighting the importance of understanding and sharing the cognitive characteristics of individual team members. These studies suggest that visualizing ideas through sketches based on imagination and mental imagery can facilitate effective communication and creative problem-solving in multidisciplinary teams.

Building upon these insights, the current study aims to address the challenges of pediatric IV self-removal by conducting a qualitative investigation of nurses' experiences and perspectives and applying the principles of cognitive sharing and creative ideation to the design of empathetic nursing robots. Additionally, this research introduces the novel approach of UX mapping to capture and integrate user perspectives throughout the design process. By combining these strategies, we seek to contribute new knowledge and methodologies for fostering innovation and collaboration in the development of user-centered healthcare technologies. The main objectives of this study are:

1. To explore pediatric nurses' experiences, challenges, and coping strategies related to IV self-removal incidents.

2. To identify key factors contributing to IV self-removal and opportunities for nursing robot interventions through UX mapping and customer journey mapping.

3. To examine the differences between medical and nursing approaches to IV management and highlight the importance of an empathy-driven, patient-centered approach in nursing robot design.

4. To lay the foundation for a creativity generation and sharing system that integrates user insights, interdisciplinary collaboration, and creative ideation techniques to foster innovation in nursing robotics.

II. Background

Pediatric IV self-removal and its impact

Intravenous (IV) therapy is a common and essential part of pediatric medical care. However, the self-removal of IV lines by pediatric patients is a frequent and significant problem in clinical settings. This not only disrupts the treatment process but also poses risks such as bleeding, infection, and damage to blood vessels. Moreover, it increases the workload of nurses who need to re-insert the IV lines and closely monitor the patients.

Current state and challenges in nursing robot development

Robotics technology has been increasingly explored as a potential solution to various challenges in nursing care, including reducing nurses' physical burden, enhancing efficiency, and improving patient outcomes. However, the development of nursing robots faces several obstacles. One major challenge is the lack of effective communication and shared understanding among the diverse stakeholders involved, such as nurses, patients, engineers, and designers. This often results in a mismatch between the developed robots and the actual needs and preferences of end-users.

Prior research on creativity generation and sharing systems.

To address the challenges mentioned above, there has been growing interest in the development of creativity generation and sharing systems in various fields, including healthcare. These systems aim to facilitate the creative process by providing tools and platforms for ideation, collaboration, and knowledge sharing among diverse participants. In the context of nursing robot development, such systems could potentially enable nurses, patients, and other stakeholders to actively contribute their insights and ideas, leading to more user-centered and innovative solutions. However, research on the application of creativity generation and sharing systems in nursing robotics is still limited, highlighting the need for further exploration.

III. METHODS（FIG.1）

Nursing Staff Interviews

We conducted semi-structured interviews with pediatric nurses to gain insights into their experiences and challenges in managing IV therapy for children, particularly focusing on the issue of IV self-removal.

Participant Selection and Sample Size:

Participants were recruited based on the following criteria:

- Registered nurses with current or recent experience working in pediatric wards
- Experience in managing IV therapy for pediatric patients
- Willingness to share their experiences and insights

A total of five nurses were interviewed, which was determined to be sufficient for reaching theoretical saturation.

Semi-structured Interview Process:

The interviews were conducted by a main interviewer, with two observers present. Each interview lasted approximately 30 minutes and was conducted either face-to-face (for 2 participants) or online via Zoom (for 3 participants). The interviews were recorded using a voice recorder and video camera (for face-to-face interviews) or Zoom's recording function (for online interviews).

The semi-structured interview guide included the following key questions:

1. Challenges and difficulties faced in managing IV therapy for pediatric patients
2. Successful strategies or techniques used in managing IV therapy for pediatric patients
3. Communication approaches used when explaining and setting up IV therapy for children
4. Children's reactions and responses to IV therapy
5. Experiences with children who could tolerate IV therapy
6. Experiences with children who could not tolerate IV therapy

Qualitative Data Analysis using M-GTA

The interview data was analyzed using the Modified Grounded Theory Approach (M-GTA), a qualitative data analysis method that aims to generate a substantive theory grounded in the data.

Transcription and Coding:

The recorded interviews were transcribed verbatim and imported into the qualitative data analysis software MAXQDA. The data was then coded by the researchers, focusing on identifying the situations and experiences described by the participants in relation to the three main stakeholders (nurses, patients, and doctors) and the timeline of IV management tasks. (**Error! Reference source not found.**).

Constant Comparative Analysis and Category Generation:

Through a process of constant comparative analysis, the coded data was organized into categories and subcategories. This involved comparing the coded data, identifying patterns and relationships, and refining the categories until a coherent and comprehensive understanding of the phenomenon was achieved.

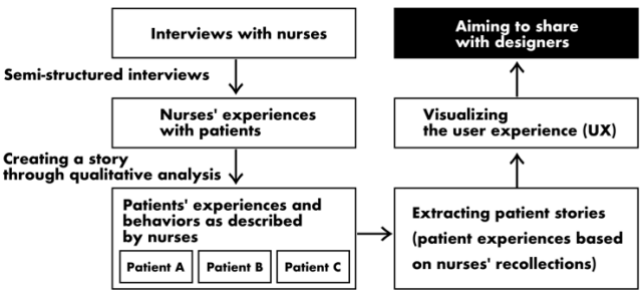

Fig.1 Conceptual diagram of the study

IV. Results

Key Findings from Nursing Staff Interviews

Factors and Impacts of Pediatric IV Self-Removal:

The interviews revealed that children's developmental level and individual characteristics significantly influence their understanding of and response to IV therapy, which in turn affects nurses' approach to managing IV self-removal.

Several common factors were identified:

- If children understand what an IV is, they are less likely to deliberately remove it or show resistance

- When children are aware of the IV but still attempt to remove it or show concern, there may be some underlying issues with the IV that require nursing intervention

- Some children may touch or attempt to remove the IV out of curiosity or discomfort, even if they understand its purpose

- When children lack understanding of the IV's meaning, they may touch or attempt to remove it due to curiosity, discomfort, or pain

- Children who don't understand the IV's purpose may also have emotional reactions and attempt to remove it, in which case mild restraints may need to be considered

(fig.2)

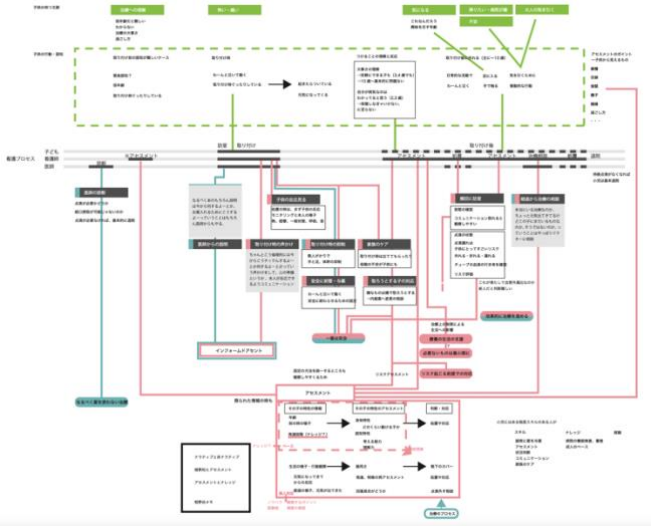

Fig 2. Patient UX from interviews with nursing staff

Nurses' Coping Strategies and Challenges:

Nurses' interventions for managing IV self-removal are typically directed by physicians' orders. However, if physicians were more aware of patients' characteristics, cognition, and reactions, they could select interventions that better account for these factors. Currently, interventions are often chosen based on the medical objective and available hospital supplies, making it difficult for nurses to contribute to the selection process.

In addition to the child's medical condition, nurses must also consider the child's developmental level and conscious state when determining the appropriate intervention. This significantly expands the scope of the assessment domain.

Nurses' choice of intervention is heavily influenced by their previous experiences. There is a growing need to explore ways to convert these experiences into shareable knowledge.

Application of Previous Research Insights:

The findings of this study align with the principles of cognitive sharing and creative ideation explored in the authors' previous research (Kasamatsu & Ainoya, 2015; Ainoya, 2014). The use of UX mapping and customer journey mapping to visualize and share user experiences and perspectives reflects the importance of creating a shared understanding among team members with diverse expertise[6]. The rich qualitative data gathered from nurse interviews serves as a valuable resource for stimulating imagination and creative problem-solving, similar to the role of image sketches and collages in the "KADEN Project."

Furthermore, the emphasis on understanding the cognitive characteristics and concerns of different stakeholders (patients, nurses, doctors) in the IV self-removal context mirrors the hierarchical model of concept proposed by Ainoya (2014). By recognizing and integrating these diverse perspectives, the current study lays the groundwork for more effective collaboration and creative conflict resolution in the development of nursing robots. (fig. 3)

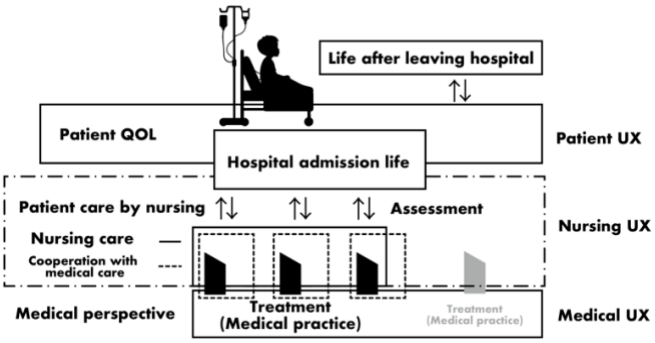

Fig 3. Stakeholders and their respective UX in nursing

V. Discussion

Implications for Nursing Robot Design

Essential Functions and Characteristics of Nursing Robots Derived from IV Self-Removal Cases:

- Need for real-time monitoring and early detection of patient discomfort or distress

- Importance of providing timely and appropriate interventions to prevent self-removal attempts

- Potential for robots to offer personalized distraction and comfort measures based on individual patient preferences and characteristics

- Necessity of clear and age-appropriate communication capabilities to educate and reassure patients about IV therapy

Importance of Empathetic Robot Design

and Specific Strategies:

- Incorporating features that convey empathy, such as soft and comforting voice tones, gentle movements, and soothing visual displays

- Designing robots with a friendly and non-threatening appearance to reduce patient anxiety and promote trust

- Enabling robots to recognize and respond appropriately to patient emotions through advanced sensing and AI technologies

- Involving nurses, patients, and families in the design process to ensure that robots align with their needs and preferences

Foundation for Building a Creativity Generation

and Sharing System

Importance of Diverse Perspectives and Insights Gained from Interview Results:

- Highlighting the value of incorporating multiple viewpoints, including those of nurses, patients, and families, in the development of nursing robots

- Emphasizing the need for a holistic understanding of the patient experience, beyond just the technical aspects of IV management

- Recognizing the potential for qualitative research to uncover unique insights and drive innovative robot design

Potential for Creativity Generation through Collaboration among Nurses, Engineers, and Designers:

- Discussing the benefits of interdisciplinary collaboration in fostering creative solutions to complex healthcare challenges

- Proposing a framework for facilitating effective communication and knowledge sharing among team members with diverse backgrounds

- Investigate projects to develop nursing robots using interdisciplinary collaboration.

Plans for Future Ideation Workshops:

- Outlining the objectives and expected outcomes of the proposed workshops, such as generating novel robot design concepts and identifying key research priorities

- Describing the planned participants, format, and activities of the workshops, with a focus on promoting creativity and collaboration

- Plan workshop participants, formats, and activities with a focus on promoting creativity and collaboration

Limitations and Future Directions

Limitations of the Current Study:

- Acknowledging the small sample size and limited diversity of participants, which may affect the generalizability of findings

- Recognizing the focus on a specific patient population and care setting, which may limit the applicability of insights to other contexts

- Discussing potential biases or limitations associated with the qualitative research methods employed, such as the influence of researcher subjectivity

Future Research Plans:

- Proposing future studies that build upon the current findings and address the identified limitations, such as conducting larger-scale and more diverse investigations

- Exploring opportunities to apply the research methodology and insights to other nursing care scenarios beyond IV management

- Outlining plans for the development and testing of a creativity generation and sharing system based on the lessons learned from this study

Contribution to Nursing Robotics Research:

This study makes several notable contributions to the field of nursing robotics research. First, it provides a detailed qualitative exploration of the challenges and opportunities surrounding pediatric IV self-removal, an area that has received limited attention in the context of nursing robot development. Second, it introduces the application of UX mapping and customer journey mapping techniques to the design of nursing robots, demonstrating how these tools can help to capture and integrate user perspectives throughout the design process. Third, by building upon previous research on cognitive sharing and creative ideation in product development, this study offers new insights and strategies for fostering interdisciplinary collaboration and innovation in nursing robot design. The proposed methodology, which combines user-centered design principles, creative ideation techniques, and cognitive sharing strategies, represents a novel and promising approach to addressing the complex challenges of developing empathetic and effective nursing robots.（fig.4）

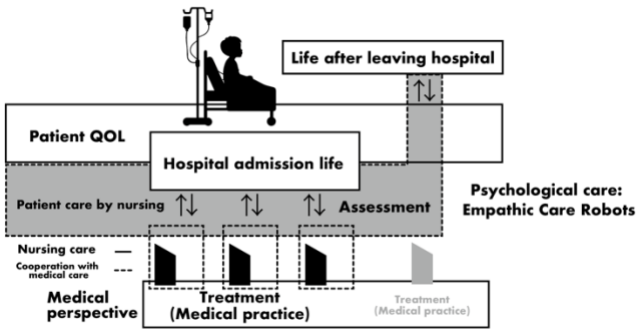

Fig 4. The potential of empathic caregiving robots through psychological care

Finally, by emphasizing the importance of a patient-centered, empathy-driven approach and highlighting the differences between medical and nursing perspectives, this study contributes to a broader shift in nursing robotics research towards more holistic, user-centered solutions. The findings and methodological framework presented here can inform future research and development efforts aimed at creating nursing robots that truly meet the needs and preferences of patients and healthcare providers.

VI. Conclusion

Summary of Main Findings and Contributions:

This study provides valuable insights into the challenges and opportunities associated with pediatric IV self-removal, as well as the potential for nursing robots to address this issue. Through qualitative interviews with experienced nurses and the development of a comprehensive UX map and customer journey map, we have identified key factors contributing to IV self-removal, the impact of this problem on patients and healthcare providers, and the essential functions and characteristics that nursing robots should possess to effectively prevent and manage these incidents.

Moreover, our research highlights the importance of empathetic design in nursing robotics and proposes specific strategies for incorporating empathy-driven features and interaction modalities. By adopting a user-centered approach, grounded in the real-world experiences and perspectives of nurses and patients, we have laid the foundation for developing nursing robots that are not only functionally effective but also emotionally attuned to the needs of their users.

Importance of Patient-Centered Approach and Creativity in Nursing Robot Development:

A central theme emerging from this study is the critical role of patient-centered design in the development of successful nursing robots. By leveraging UX mapping and customer journey mapping techniques, we have demonstrated how these tools can help to capture the rich and nuanced aspects of the patient experience and translate these insights into actionable design requirements and innovation opportunities.

Furthermore, our findings underscore the significance of creativity and interdisciplinary collaboration in the nursing robot development process. By bringing together the diverse perspectives and expertise of nurses, engineers, designers, and other stakeholders, we can foster a more holistic and innovative approach to problem-solving and generate novel solutions that transcend the limitations of traditional, technology-driven design paradigms.

Future Directions for Research on Creativity Generation and Sharing System:

Building upon the insights and methodologies developed in this study, we propose several directions for future research aimed at promoting creativity and knowledge sharing in nursing robot design. These include:

1.Conducting larger-scale, multi-site studies to validate and

extend the findings of the current investigation, and to explore

the generalizability of the UX mapping and customer journey mapping approaches to other healthcare contexts and user populations.

2. Developing and testing a formalized creativity generation and sharing system that integrates the principles and techniques of user-centered design, interdisciplinary collaboration, and participatory innovation. This system could include tools, platforms, and processes for capturing and analyzing user insights, facilitating creative ideation, and supporting the co-creation of nursing robot solutions.

3. Evaluating the impact of the creativity generation and sharing system on the quality, acceptability, and effectiveness of nursing robot designs, as well as on the satisfaction and well-being of patients, nurses, and other healthcare stakeholders.

By pursuing these research directions, we can continue to advance the field of nursing robotics and contribute to the development of more user-centered, empathetic, and innovative technologies that enhance the quality and safety of patient care.

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