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Patient Acuity and Hospital Rooming: Initial Assessment of Acuity-Based Placement on a Medical Surgical Unit

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Abstract

At a tertiary care academic medical center, a transdisciplinary team is developing future hospital plans through an Innovation Design Unit (IDU). This 17-bed IDU recently opened to medical surgical patients to evaluate the i built environment. Staff indicated visibility to the patient and placing high acuity patients close to the nurse station were important. The team compared patient room placement and acuity data for 7.5 weeks on the IDU and two traditional medical surgical units to determine if placement is related to acuity. The number of patients placed in each room ranged from 1 to 18 (450 room placements total across all 57 rooms). Patient acuity ranged from 45.6-321.6 with mean (SD) of 99.1 (34.1) for IDU and 104.7 (42.6) for traditional. The Kruskal Wallis test indicated no statistically significant differences in the acuity scores for patients by room or by unit type (alpha=0.05). The Pearson correlation coefficient calculated resulted in a statistically significant positive correlation ($p < 0.001$), there was moderate correlation ($r=0.46$). This initial investigation indicates that rooming patients based on acuity is not a current practice. The design of the hospital requires the application of human factors design principles to enable effective care delivery and manageable staff workload.

Keywords
Built Environment, Layout, Care Delivery, Workflow and Nursing Care.

1. Introduction
The built environment can influence care delivery throughout the hospital. The design of an inpatient unit includes patient room location, centralized versus decentralized nursing stations, proximity to supply rooms, and many other

factors that influence workflow for clinical staff, care delivery processes, patient experience, and safety. Investment in a new building is intended to provide a space for care delivery lasting decades. While future renovations are expected, the overall structure should provide a space and layout to meet the needs of expanding and evolving healthcare delivery processes

At a tertiary care academic medical center, a transdisciplinary team of nurses, therapists, physicians, engineers, designers, and scientists is developing future hospital plans through an Innovation Design Unit (IDU). This 17-bed unit, recently opened to care for medical surgical patients, is equipped to evaluate the workflow and effectiveness of innovative designs throughout the built environment and inform future hospital designs. The design team is preparing the floor layout for acute care patient floors in the future hospital tower plans. Through a feedback session, the staff indicated visibility to the patient and placing high acuity patients close to the nurse station were important factors for workflow and patient care. A subset of the IDU team including an ergonomist, senior healthcare data scientist, and nurse implementation scientist, pursued this work to provide a foundation for decisions about hospital floor design principles.

1.1 Objectives

The goal of this paper was to analyze the relationship between patient acuity levels and room placement within the IDU. By examining patient locations, acuity scores, and nursing time allocation patterns, this study will help the team understand more about current practices and determine future work to evaluate how the hospital floor design and layout will impact patient care needs, nurse workflow, and the rooming process.

2. Literature Review

Clinician workflow and movement have been studied in the hospital setting to inform unit layout and room orientation across levels of care (Zheng et al 2011; Tang et al 2007; Kramer et al 2023; Han et al 2020). Much of this research explores how the physical layout—including nursing station location and patient room placement—affects workflow, efficiency, and patient assignments. Furthermore, existing research has focused predominantly on static layout optimization rather than developing adaptable design principles that can accommodate evolving care delivery models. These studies have consistently overlooked patient acuity as a primary factor in spatial design decisions, creating a significant gap in evidence-based room placement strategies.

Within the nursing literature, the layout of nursing workstations is a well-covered topic. Much of the research focuses on comparing centralized vs. decentralized nursing stations. There are differing perspectives on the layout of these workstations. Even examples of centralized nursing stations often have various stations throughout a unit depending on the size of the unit and the overall floor layout. In one article by Real et al. (2017), the researchers described the impact floor layout has on communication and patient outcomes. Similarly, Hua et al. (2012) focused their research on the influence of the physical environment on team communication and safety. However, these studies provide limited guidance on how patient acuity should influence room placement decisions within these different station configurations.

Another area covered in the literature is patient visibility from the nurse station or from other spaces outside the patient room. This visibility is influenced by design and the hospital floor layout. Design features that influence visibility include corridor width and the overall shape of the unit (Hadi and Zimring 2016; Johanes and Atmodiwirjo 2015). The visibility of the patient has been studied for impact on efficiency (Xuan and Chen 2020), patient experience (Bosch and Apple 2016) and ICU mortality (Lu and Ossmann 2014). In some of these studies, visibility included indirect visibility with virtual monitoring; however, direct patient viewing from outside the room is often a standard design in the acute patient care setting. In addition to safety, layout has been shown to influence efficiency, particularly in terms of staff movement and time spent traveling between patients and equipment (Ibrahim and Sherif 2022). Yet these visibility studies rarely consider how patient acuity levels might inform optimal room placement to maximize both visual oversight and workflow efficiency

While the physical layout impacts workflow, hospitals also work hard to support nursing workload through patient assignments. Admitting patients to floors that align with patient acuity and can provide the care the patient requires, is part of ensuring staff have a manageable patient load. This room placement process is especially challenging in rural hospitals (Bartlett and Vanhoundt 2023); however, the process of bed management and patient assignment can be challenging at all hospitals. There are many factors that can be included in the decision support for bed allocation

including patient acuity (Walczak and Pofahl 2003). There are many tools for assessing acuity (Al-Dweik & Ahmad, 2020) and ensuring appropriate nurse assignment (Eastman & Kernan , 2022). Despite this extensive work on acuity assessment, there remains limited research connecting patient acuity data to spatial design decisions for optimal room placement

For this analysis, the research team is utilizing the Systems Engineering Initiative for Patient Safety (SEIPS; Carayon and Hundt 2006) and SEIPS 2.0 (Holden and Caryon 2013) as guiding models. Based on how clinicians interact within the work system (tools & technologies, internal environment, tasks, and organizational conditions) the team identified workflow expectations for staff and various means to measure this work. All these interactions are centered around the person or people involved in carrying out the work, which is essential in a sociotechnical system such as a hospital This study highlights the integration of human factors and systems thinking in evaluating layout and workflow, with a focus on the built environment and opportunities for technologies to be further studied or implemented as mitigating strategies to other work system barriers.

The literature reveals a clear gap in understanding how patient acuity should inform room placement decisions within hospital unit design. While workflow optimization and acuity management have been studied separately, limited research has examined the relationship between patient acuity patterns and optimal room placement. The Innovation Design Unit provides a unique opportunity to address this gap by analyzing these relationships within a real-world care environment, thereby contributing foundational evidence for future hospital design decisions.

3. Methods

In this analysis, the team compared patient room placement and acuity data for 7.5 weeks on the IDU and two traditional medical surgical units to determine if placement is related to acuity. The data was collected retrospectively for adult patients admitted to Nebraska Medicine main campus from January 7, 2025, through April 30, 2025.Age-based exclusion criteria omitted pediatric patients from the study. This study was exempt from review by the institutional review board.

4. Data Collection

Data were collected from the electronic health record (EHR) where patient acuity is scored and tracked during patient hospital stays. These data were associated with patient rooms on the IDU and traditional medical surgical units under investigation in this research. In the first phase of data collection, patient acuity was collected directly before and after transfers to the unit from January 1, 2025, through February 28, 2025. Only the initial transfer to the unit was captured. Additionally, Real Time Location System (RTLS) data were gathered for the IDU to capture time staff spend in the patient room. Time calculations were from the entry and exit events collected through the RTLS system. These events were tracked from January 7, 2025, through April 30, 2025, and included analysis of all patient acuity documentation for each day in the room. In the IDU, one room had to be excluded from review for time in patient room due to an RTLS system malfunction. Any measurements for time in a room that exceeded a 24-hr period were also excluded.

Table 1. Data Definitions: Variables extracted from EHR and RTLS systems

Variable	System	Definition
Location	EHR	Location details including department, room, and bed were collected at the time of transfer.
Patient Workload Acuity	EHR	Patient Workload Acuity is calculated based on a customized patient rule scoring process to generate a total score comprising eight main indicators; ADLs, admissions/transfers, assessments, discharges, LDAs, medications, orders, wounds, and risks. The scores and weights were determined by a team of clinical and technical experts and continue to be reviewed and modified, as needed. Scores between 0-170 are considered low, while 170-220 are medium, and 220+ are classified as high.
Patient Workload Acuity: ADLs	EHR	Evaluates the need for support with daily activities such as dressing, grooming, feeding, and more. Encompasses ten rules.

Patient Workload Acuity: Admissions/transfers	EHR	Evaluates admission documentation, admission orders, and transfer orders. Encompasses three rules.
Patient Workload Acuity: Assessments	EHR	Evaluates documentations within defined limits (WDL) rows, vitals, pain, intake and output, and assessment checks. Encompasses thirteen rules.
Patient Workload Acuity: Discharges	EHR	Evaluates the complexity of discharge needs such as education, belongings, and medication. Encompasses ten rules.
Patient Workload Acuity: LDAs	EHR	Evaluates line, drain, and airway cares by type and level of complexity. Encompasses twenty-seven rules.
Patient Workload Acuity: Medications	EHR	Evaluates medications administrations for route, dual sign documentation, and titrations. Encompasses twelve rules.
Patient Workload Acuity: Orders	EHR	Evaluates orders for isolation, labs, procedures, and diet. Encompasses twenty-six rules.
Patient Workload Acuity: Wounds	EHR	Evaluates wound documentation for stage, dressing changes, and therapies. Encompasses eight rules.
Patient Workload Acuity: Risks	EHR	Evaluates fall risk, call light usage, feeding assistance, and psychosocial behaviors for patient, family, and visitors. Encompasses sixteen rules.
# Encounters	EHR	The unique number of encounters, which translates to unique patients, per location, per day.
Acuity Count	EHR	The unique number of entries on the patient workload acuity flowsheet for the day. This is an automated process that typically occurs every hour the patient is in the room.
Time in Room	RTLS	Enter and leave events per staff, per room, are used to calculate the time in the room and are attributed to the date on which the leave event occurred. Any calculated time in a room exceeding 24hrs was removed.
# Leave Events	RTLS	The unique number of leave events recorded in a room throughout the day.

5. Results and Discussion

The number of patients placed in each room ranged from 1 to 18 (450 room placements total across all 57 rooms). There were 11,371 leave events from the patient rooms and 20,290 distinct acuity entries for the 16 included beds on the IDU.

5.1 Numerical Results

The range for the average acuity score for patients by department is displayed in Table 2. Patient acuity ranged from 45.6-321.6 with mean(SD) of 99.1(34.1) for IDU and 104.7(42.6) for traditional. For these medical surgical units, it was expected that acuity was not high. On these units, nurses are able to care for multiple patients.

Table 2. Analysis Variable: Average Acuity Score for Patients by Department

Department	Mean	Std Dev	Std Error	Median	Minimum	Maximum	Quartile Range
NM 6USW	104.7	42.6	3.5	95.9	49.3	321.6	41.1
NMC 5USE	95.1	30.3	2.6	90.4	50.0	209.6	37.9
NMC 5USW	102.1	36.7	2.8	93.9	45.6	295.3	40.1

For the time staff spent in the patient rooms, patients on the 17-bed IDU averaged 189.0 minutes per patient with a standard deviation of 113.0 minutes. This included an average of 12(+/-2) Leave Events and 21(+/-4) Activity Counts.

5.2 Graphical Results

There was no statistical difference in the average patient acuity across the different units as demonstrated in Figure 1. Here we can see the average for each unit has average patient acuity below 100. There are outliers on each unit, but the acuity is fairly low. Since these are medical surgical units, that is an expected acuity. The factors leading to higher acuity are all nurse workload factors. Across these units, the staff works to ensure nursing distribution for patient assignments is equitable based on this acuity and expected workload as described in the literature (Eastman & and Kernan, 2022).

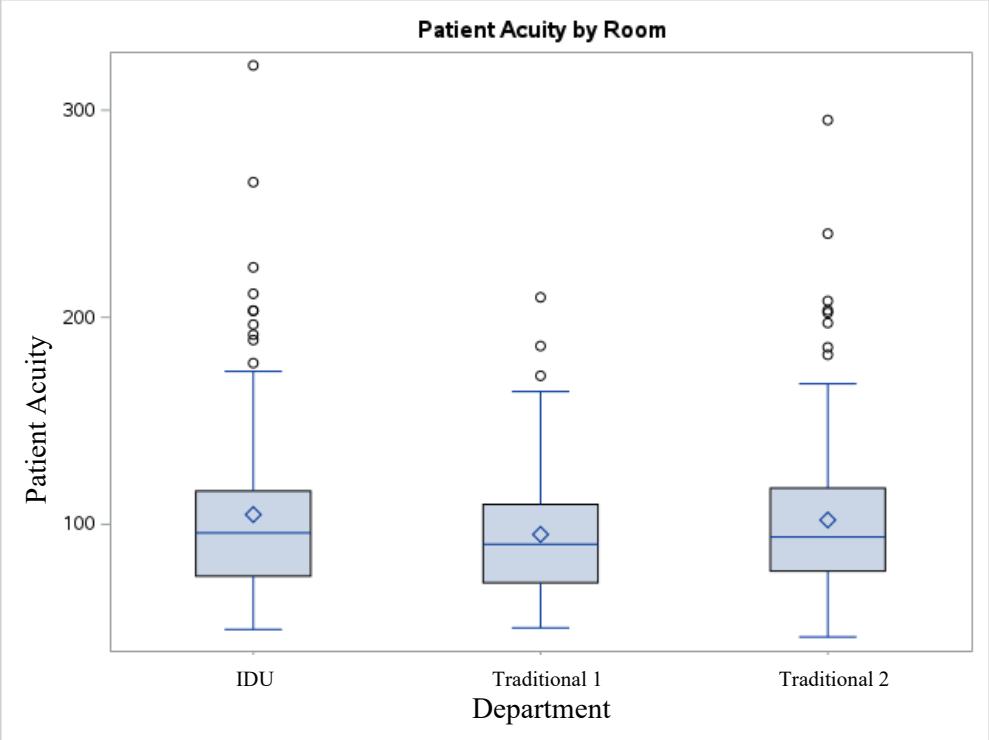

Figure 1. Patient Average Acuity by Department.

In Figure 2, below, there is a display of the distribution of time spent in patient rooms versus the patient acuity. The trendline is added to show a positive relationship. However, the model only has a moderate fit. There was statistical significance for this correlation between time in room and acuity with a moderate Pearson Correlation Coefficient (0.46). Similarly, the number of in/out activities was significantly correlated with patient acuity with a moderate Pearson Correlation Coefficient (0.33). Since the acuity is used as a measure of nursing workload, this positive correlation was expected. As demonstrated below, this acuity calculation might not account for some patient conditions or situations that could require more time for the nurses to spend in the patient room. As the hospital continues to design and operate with a focus on bed management and nursing workflow, these are opportunities to further explore measures of acuity.

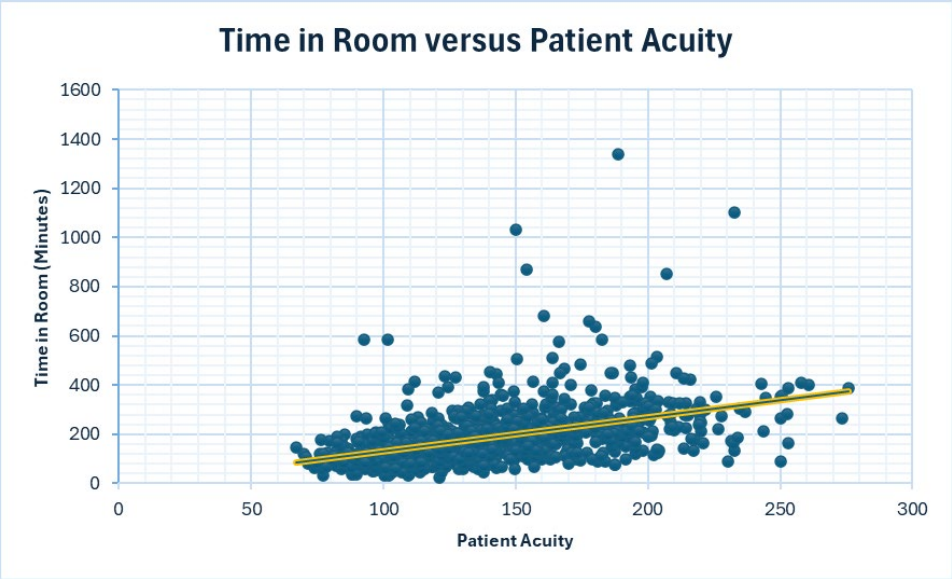

Figure 2. Time in Patient Room versus Patient Acuity

Across the patient rooms, there was not a statistically significant difference in patient acuity. Figure 3 demonstrates the average patient acuity across the IDU. While some rooms have higher average acuity, there was no statistical significance for this sample. Among the rooms that tended to have slightly higher acuity such as room 9 had the highest average across encounters. This room was right next to the Hub. Room 4 had a few high acuity outliers and is located in the corner of the unit as one of the furthest from the nurse station.

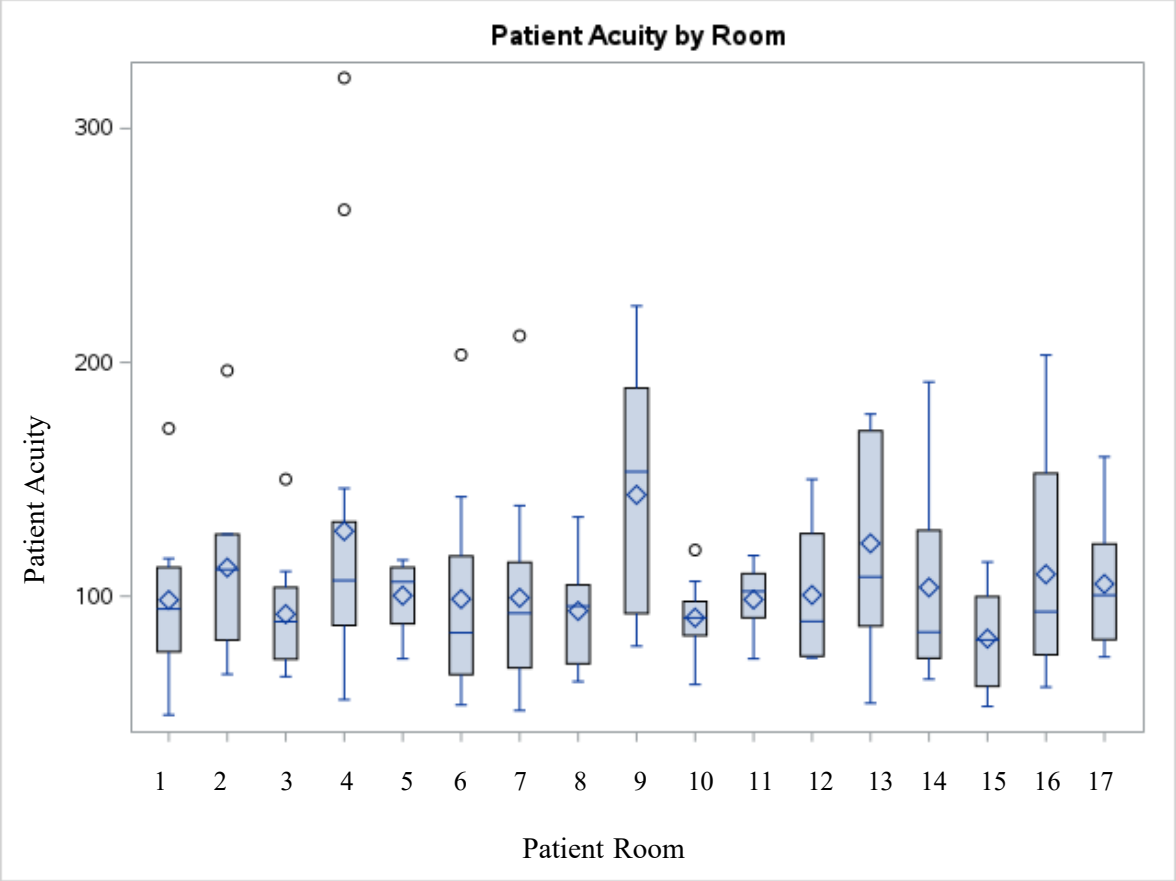

Figure 3. Patient Acuity by Room

5.3 Proposed Improvements

On the IDU, the innovation team is approaching problems with a "bail early" philosophy and is aiming to test proposed solutions to problems. Therefore, there is a desire to make improvements upon this process. Based on these findings, it is likely that patient room placement is not directly determined by patient acuity. This could be due to the variability of patient room turnover and the difference between acuity for patients being assigned a room versus patients already roomed. Future research into the optimization of rooming and the mitigation of barriers associated with rooming, floor layout, and clinician workflow are planned.

5.4 Validation

This research resulted in no statistical significance with the Kruskal-Wallis Test for patient acuity comparisons across rooms on the IDU ($p=0.60$) or on the other unit ($p=0.36$). A Pearson correlation coefficient was calculated to determine the relationship between patient acuity and time in the patient room. While there was a statistically significant positive correlation ($p <0.001$), there was only moderate correlation ($r=0.46$). It is anticipated that the small sample size could have contributed to this. However, it is also likely that the proxy measures for patient care (time spent in room) are not fully representative of the complexity of patient care interactions.

The goal was to determine if patients are assigned a bed based on acuity. The answer to this question seems to be that there is no data supporting this relationship. While nurses often express the desire to place patients who need more care closer to the nurse station, it is likely that either there is significant variability in the acuity or type of care patients need and how they are placed or there is not room availability at the time of placement. Additionally, when we compare the acuity to the time spent in the room, there is not a clear correlation between the two. This indicates that the acuity measure might not be the right measure to understand the amount of time nurses spend in the room. Additional work will be needed to better understand these care conditions and factors influencing time spent in patient rooms given this low correlation.

There are several limitations to this analysis. This research was only conducted on patient units with a lower acuity (medical/surgical) and on a general unit instead of a specialty care unit. There was a limited dataset with only these two units (and only one unit for the study of time in room). The unit has only been open for a few months, which further limits the data. Finally, the investigation did not include in the analysis changes in acuity throughout the patient hospitalization.

6. Conclusion

Based on the findings from studying patient acuity and rooming in this new IDU, there is no statistical significance in the relationship between patient rooming location and patient acuity. For the patients with higher acuity, staff spent significantly more time in the patient room and experienced more in/out activities. Patient rooming on the IDU or traditional units does not seem to be influenced by patient acuity based on the documented acuity scores. Patient rooming and the physical layout of the hospital require the application of human factors design principles to enable effective care delivery.

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Biographies

Bethany R. Lowndes is currently an Associate Professor at the University of Nebraska Medical Center in the Department of Neurological Sciences. She obtained her BS in Biological Systems Engineering and Ph.D. in Engineering (with an emphasis in Biomedical Engineering and significant coursework/training in Industrial Engineering) in 2010 and 2015, respectively. Additionally, Dr. Lowndes received her masters in public health for public practice in 2017. She completed her post-doctoral fellowship at Mayo Clinic in the Center for the Science of Health Care Delivery with a research emphasis on human factors and ergonomics applications for improve surgical safety and effectiveness. Her research interests include the applications of human factors and ergonomics principles to advance health and safety of patients and clinicians. As a team scientist, she has led and collaborated on projects funded through NIOSH, AHRQ, NIH, and industry. Dr. Lowndes is currently interested in measuring and improving the interactions between healthcare providers, patients, caregivers, technology and the environment in order to advance health across different levels of care. As an active member of the Human Factors and Ergonomics Society, she is committed to long-term efforts of incorporating human factors design principles and systems approaches for the promotion of worker wellbeing and patient safety.

Breanna Hetland is an Associate Professor at the University of Nebraska Medical Center College of Nursing and Nurse Scientist at Nebraska Medicine. This includes her role as an Implementation Scientist in the Innovation Design Unit. Her novel program of research focuses on merging technology with nonpharmacological healing approaches to positively engage patients and family caregivers during the critical illness experience. She graduated summa cum laude from Southern Illinois University Edwardsville College of Nursing. Her clinical experiences include a study abroad medical trip to China and Tibet, a summer externship in the medical intensive care unit at the Mayo Clinic, and 5 years as a critical care nurse. She obtained her PhD in Nursing with a minor in Integrative Therapies and Healing Practices from the University of Minnesota. Her work has been federally supported by the National Institute of Nursing Research through a Ruth L. Kirschstein F31 Predoctoral Fellowship as well as a T32 Postdoctoral Fellowship in Symptom Management and Palliative Care Research in Adults with Advanced Disease, which she completed at the Frances Payne Bolton School of Nursing at Case Western Reserve University. In her most recent study, Dr. Hetland and her team developed The Family Room mobile app, a digital platform to promote patient and family involvement in care during acute hospitalization. She has authored numerous peer-reviewed publications and her nationally recognized expertise in critical care nursing science and clinical practice has resulted in invited consultations, keynote presentations, and expert commentary.

Meghan Mendick is a Senior Healthcare Data Scientist at Nebraska Medicine in the Innovation Design Unit.
She holds a Bachelor of Science in Biotechnology from the University of Nebraska Omaha, where she developed a strong foundation in biological sciences and laboratory techniques. This was further enriched by a Master of Science in Cancer Research at the University of Nebraska Omaha, where she honed her skills in experimental design, data analysis, and scientific research. Recognizing the importance of integrating business acumen with scientific expertise,

she pursued an MBA from the University of Omaha, which equipped her with strategic thinking, financial analysis, and management skills. This unique combination of qualifications has enabled her to excel in various roles, including Analytics Senior Developer, Informatics Project Manager, and Applications Senior Analyst. Currently, as a Senior Healthcare Data Scientist, she leverages advanced analytical techniques and data visualization to extract actionable insights from complex datasets. Through collaboration with cross-functional teams to develop innovative solutions that drive data-driven decision-making and improve patient outcomes, she is committed to continuous learning and staying at the forefront of technological advancements in data science and healthcare.