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Developing an immersive virtual reality medication administration scenario using the nominal group technique

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ABSTRACT

Aim: This paper aims to describe how the Nominal Group Technique was applied to obtain focused content to develop medication administration error scenarios for future use to educate practicing RNs with immersive virtual reality simulation.

Background: In the United States, medication errors account for up to $46 million in daily loss to hospital operational budgets. Each phase of prescribing, dispensing, administration, monitoring, and reconciliation is crucial in reducing potentially life-threatening outcomes associated with medication errors. Registered Nurses are responsible for safely administering diverse classifications of medications to patients in various healthcare settings. However, human and system factors can contribute to the exposure of hospitalized patients to a medication error. Virtual reality simulation-based education can be a methodology to educate practicing Registered Nurses on safe medication practices.

Design: A Nominal Group Technique process was used to generate consensus from participating Registered Nurses on human and system factors that can contribute to medication administration errors.

Methods: The process consisted of (a) preparation, (b) running the group with an introduction of the subject, (c) generation of ideas, (d) listing of ideas, (e) discussion of ideas, (f) ranking of top ideas, (g) voting on top ideas, (h) discussion of the vote outcome, and (i) re-ranking and rating the top items. Human and system factor idea items encompassed medication errors during ordering, prescribing, or administering medications. Both novice and experienced Registered Nurses rank-ordered these factors as those most likely to encounter or which would most likely occur during one working shift.

Results: Descriptive statistics of frequencies and percentages were used to analyze the findings when grouped by human and system factor categories. Non-parametric testing with a Kruskal-Wallis test was conducted to compare the human and system factors by categories and years of Registered Nurse experience. Findings revealed that the factors of *Time Management: getting behind, hurried, urgent* (KW-H 11.2, *df* 4, p = .025) and *Right Medication*: medications have similar look and sound-alike names (KW-H 11.1, *df* 4, p = .025) impacted safe medication administration for both the novice and experienced nurse.

Conclusion: The NGT process identified human and system factors contributing to errors and impacting safe medication administration practices. Findings will support the creation of medication administration scenarios for use with immersive virtual reality simulation.

In the United States, medication errors account for up to $46 million in daily loss to hospital operational budgets, increasing patient care costs by 16% (Zimmerman and House, 2017). Globally, these errors contribute approximately $42 billion in annual healthcare expenditures (World Health Organization, 2017). Around 5% of all hospital inpatients have experienced harmful effects from medication administration errors (Agency for Healthcare Research and Quality (AHRQ), 2019). Such errors can contribute to adverse drug events (ADEs), which have increased the length of stay for hospitalized patients. It is alarming that these ADEs make up one-third of the total adverse events within hospital systems (U.

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S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion, 2014). Each phase of prescribing, dispensing, administration, monitoring, and reconciliation is crucial in reducing potentially life-threatening outcomes associated with medication errors (Tariq et al., 2021).

As primary licensed caregivers within hospitals, Registered Nurses (RNs) are responsible for safely administering diverse classifications of medications to patients in various healthcare settings. However, human and system factors can contribute to the exposure of hospitalized patients to a medication error. Research indicates that unexpected interruptions, distractions, use of high-risk medications, and other human factors related to stress, lack of sleep, and education level interfere with the medication administration process, potentially resulting in an adverse patient safety event (Bucknall et al., 2019; Flynn et al., 2016; Kavanagh and Donnelly, 2020; Millichamp and Johnston, 2020; Reed et al., 2018). Despite extensive prelicensure education and post-licensure competency assessments in the practice setting, RNs can make medication administration errors which lead to ADEs. Moreover, system errors such as medication barcode scanners not reading correctly or misprinted medication labels can impact safe medication administration (Institute for Safe Medication Practices (ISMP), 2021a, 2021b). Therefore, it is imperative that RNs receive medication administration training that is impactful in adhering to medication administration safety standards.

To speak to the critical and unresolved problem of medication errors, these investigators are developing an immersive virtual reality experiential simulation environment to train nursing professionals in safe medication administration. The first step to accomplish this aim involves creating accurate and realistic simulation scenarios for use in the VRS. This article describes how the Nominal Group Technique (NGT) process was applied to obtain focused content from which to develop medication administration error scenarios for future use to educate practicing RNs with immersive virtual reality simulation.

1. Background

A medication administration error has been defined as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer" (National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP), 2021, para. 1). Patient safety initiatives designed to reduce medication administration errors directly related to human actions or healthcare industry procedural processes remain recognized as priorities by multiple healthcare agencies (AHRQ, 2019; Centers for Disease Control and Prevention (CDC), 2016; Institute for Healthcare Improvement (IHI), 2012; ISMP, 2015). The Joint Commission (2021), an accrediting organization focused on quality healthcare initiatives, provides standards of practice for use by healthcare organizations. The 2021 patient safety goals for hospitals affirm the continued importance of medication administration to patient safety practices. Additionally, recommendations continue to promote the labeling all medications and medication containers, verification of all medication and solutions both verbally and visually by two qualified individuals, and proper review of medications by entering and exiting staff during shift changes. Unfortunately, failure to follow institutional or manufacturer policies and acts of omission remain a prevalent cause for medication administration errors (Oliveros et al., 2017). Moreover, crucial medication administration tenets involving procedures for the route, dose, type, and time are not consistently followed, especially with administration of intravenous medications, checking doses of anticoagulants or analgesics, completing drug calculations, and noticing allergic responses (Cochran et al., 2016; Harkanen et al., 2019; Van der Veen et al., 2018).

In the United States, individual states provide overarching legislation outlining the autonomous scope of practice for RNs for administering medications. In addition, the American Nurses Association (2015) articulates how RNs are ethically bound to create a culture of safety that encompasses following policies to reduce errors and report error events related to such actions as the administration of medications. Also, the National Council of State Boards of Nursing (2018) provides detailed professional licensure requirements and guidelines related to safe medication administration practice. Despite these resources, traditional didactic theory education and skill competency assessments about safe medication administration, operating medication dispense technology, and drug calculations for both prelicensure students and practicing nurses ineffectively replicate the challenges encountered in the practice setting (Kavanagh and Donnelly, 2020). This is especially true with interruptions and distractions commonly encountered in a nurse's daily practice (Leufer and Cleary-Holdforth, 2013; Orbaek et al., 2015; Williams and Davis, 2016). Additionally, reduced exposure to the medication administration process, math anxiety, and deviations to standards observed in the clinical setting infringe upon the traditionally recognized five rights of safe medication administration practices: (a) ordering medications, (b) preparing medications, (c) administering medications, (d) right patient, (e) right medication, (f) right dose, (e) right route, and (f) right time, taught in prelicensure nursing programs (Adhikari et al., 2014; Orbaek et al., 2015).

While systemic safety mechanisms inherent in electronic medication administration records and barcode scanners exist, diverse education delivery formats and inconsistent formats for verification of maintained medication administration competencies among practicing RNs increase the risk of a medication error (Jheeta and Franklin, 2017; Sessions et al., 2019; Van der Veen et al., 2020). Furthermore, scheduling training time and cost can impact the capacity of hospital institutions to offer continued medication administration safety and competency education (Leufer and Cleary-Holdforth, 2013). Virtual reality simulation-based education can be the methodology to educate practicing RNs on safe medication practices.

The incorporation of immersive virtual reality simulation (VRS) into prelicensure nursing education has grown exponentially. VRS exemplifies how health care, gaming, and engineering industries are uniting to positively impact patient safety with innovative teaching strategies. VRS immerses a learner in a virtual realm where the learner can actively engage and interact within a realistic environment (Farra et al., 2013). A review by Baniasadi et al. (2020) spoke about how using virtual reality in medical education can be costly, misused, or cause side-effects like motion sickness, and needs to be validated before incorporating as an education modality. Alternately, VRS provides a immersive experience which allows for a level of interactivity and provides the user feedback. Research supports how nursing students are satisfied, gain self-confidence, and positively accept the use of VRS to train (Verkuyl and Hughes, 2019; Lange et al., 2020). Moreover, the presence of virtual in academia is aligned with teaching such areas as health assessment, mental health concepts, procedural skill proficiency, empathy, psychomotor skills, and emergency response situations (Bryant et al., 2015; Huber et al., 2017; Plotzky et al., 2021; Verkuyl and Hughes, 2019).

As an underexplored technology, immersive VRS provides the capacity to educate healthcare professionals in a manner that can be consistently reproduced (Faber et al., 2012; Garrett et al., 2014). One proof-of-concept study discussed the feasibility of 3-D VRS to reliably replicate the process of withdrawing medication from an automated medication dispensing system (Vottero, 2014). During the simulated experience, participants made errors related to dosage and time without knowing that a mistake had occurred. Thus, lending support for virtual platforms to train RNs on safe medication administration behaviors. Emerging from the literature is how VRS is being used to educate nurses on psychomotor skills like endotracheal suctioning and emergency response training (Plotzky et al., 2021). Unfortunately, despite significant advances in technology, the integration of immersive VRS into the healthcare setting to educate practicing RNs is profoundly absent (Leufer and Cleary-Holdforth, 2013; Lange et al., 2020). Systematic and scoping reviews note the scarcity of high-quality research on immersive

VRS within midwifery and nursing education as a whole (Fealy et al., 2019; Plotzky et al., 2021). Encouragement for educators to conceptualize, design, integrate, and research VRS within nursing education exists.

2. Design

Since the initial development in the latter part of the 1960s as a consensus generating method, the NGT is commonly accepted in healthcare within medical-surgical practices as a means for the sharing of viewpoints, encouraging the formation of ideas, establishing priorities, and solving problems within a group setting (Gallagher et al., 1993; Shaw et al., 2018; Pucher et al., 2015). By securing diverse perspectives on factors influencing medication administration, the NGT allows for transforming qualitative responses into quantifiable statements, which can be ranked by priority. Supported for use within nursing clinical practice and education, the NGT provides both a methodological template and a psychologically safe process to gain consensus from practicing RNs regarding medication safety practices (Cooper et al., 2020; Gallagher et al., 1993; Foth et al., 2016; Harvey and Holmes, 2012). This approach can be a consideration for nursing administrators and educators who focus on institutional and unit-specific safety goals related to medication administration. Overarching steps of an NGT described by Gallagher and colleagues (1993) were followed. The steps incorporated (a) preparation, (b) running the group with an introduction of the subject, (c) generation of ideas, (d) listing of ideas, (e) discussion of ideas, (f) ranking of top ideas, (g) voting on top ideas, (h) discussion of the vote outcome, and (i) re-ranking and rating the top items. Subsequent sections describe the application of the NGT to select three medication administration error topics for the development of the simulation scenarios.

3. Methods

3.1. Preparation and running the group

Collaboration occurred with leadership within the study site who selected one medical-surgical unit with both novices and experienced RNs to obtain a convenience sample optimally representing similar practice units. Novice RNs were recognized as newly licensed RNs enrolled in a nurse residence program or with less than 3 years of practice experience within their current field of practice. Experienced RNs were identified as having greater than 3 years of experience within their current area of practice or recognized in the institution as clinical preceptors. Preparation also encompassed introducing the NGT purpose and process to RNs, touring the designated practice unit to view medication administration processes, shadowing an RN during medication administration, and determining a schedule with an action plan for completing the NGT process. Multiple group interview sessions were scheduled on the selected medical-surgical practice unit to maintain rigor with following during the NGT process and gain consensus from as many RNs as possible.

3.2. Generation, listing, and discussion of ideas

NGT interview sessions occurred over four consecutive days, with three back-to-back sessions, which lasted approximately 30 min each session. Each NGT session included an investigator developed template focused on identifying human and system factors which could contribute to errors of safe medication administration practices. The human and system factor categories encompassed: (a) *ordering medications*, (b) *preparing medications*, (c) *administering medications*, (d) *right patient*, (e) *right medication*, (f) *right dose,* (e) *right route*, and (f) *right time*. The investigators also captured descriptive data relating to years of experience to align with preset definitions of novice and experienced nurses. During each NGT session, RNs silently wrote comments related to the template's predetermined human and system factor categories. Once all RNs in the session completed their silent contribution, all ideas were shared and discussed. During the discussion, the investigator acknowledged thoughts and clarified any existing or new ideas arising from the conversations. Tables 1 and 2 present a compiled and overarching synopsis of human and system factor items which could contribute to medication administration errors as identified and written by the participating RNs.

3.3. Initial ranking and voting on ideas

When the investigators typed out a verbatim list of ideas generated from the interviews, a new rank of ideas template was created with the same overarching categories related to human and system factors that could impact safe medication administration. The generated ideas were entered under each corresponding category with similar idea items combined as one item or theme. RNs rank-ordered the idea items based on the chance of encountering or the chance of the idea item occurring during a scheduled shift. Each category included at least one and up to ten idea items. Directions for the templated were to prioritize the items in numerical order from 1 (most likely to encounter/occur) up to 10 (least likely to encounter/occur). This template also included a column

Table 1
A synopsis of potential errors during ordering, preparing, and administering medications.

Ordering medications	Preparing medications	Administering medications
Entering verbal orders; using the verbal readback technique; misunderstanding the provider; placing telephone order in the computer system when unsure what the provider ordered	Errors form the side of the pharmacy	Patient wristband issues with scanning of medications; not completing identification checks; receiving phone calls while scanning disrupt the medication administration process
Not writing down the orders; easy to click the wrong medication/dose/route in the electronic health record	Not double checking the dosage for intravenous medications; wrong amount drawn; preparing medications without training	Administering partial doses incorrectly
Orders for the same medications with a different name; Duplicate medications are ordered	Not paying attention to the number of pills ordered; calculating partial dose correctly; drug calculations	Distraction by talking to the patient; not focusing on the administration of pump rates;
Not discontinuing an old order	Time constraints; Distractions in the preparation room	Urgency; time constraint with double-checking orders
Sound alike and look alike medications are ordered incorrectly	Failing to complete the 5 rights or trust the electronic MAR	Lack of knowledge regarding medication being administered or parameters for administration
Medication ordered on the wrong patient	Reconstitution of medications with inappropriate diluent	Medication incompatibility: Mixing incorrectly
Linked Orders	Pulling wrong medication from dispense system; pulling wrong antibiotic from patient room bin; pulling some other patient's medication	Not completing medication checks for correct dose; administering medications prior to scanning
Medications remain on the orders in the EHR when "stopped" not certain why the medication is ordered	Piggyback of medications incorrectly into the primary line.	Administering a medication at an incorrect rate or route; verifying route: IV or SQ Sliding scale insulin: making certain does entered in EHR is correct

Table 2
A synopsis of potential errors during the five rights of safe medication administration.

Right patient	Right medication	Right dose	Right route	Right time
Barcode issues when scanning medications and patient identification; Not using patient identification checks (no scanning)	Incorrect medication pulled for a look alike or sound alike medication; grabbing the wrong medication from the medication dispense system	Dose amount is greater than ordered dose; Not confirming dosage prior to administration	Medication is ordered sublingual, but given oral; Administration of capsule medications incorrectly	Missing Window as some medications are 1 h and some 30 min; medications not on unit
Multiple patients have the same last name	Administering medications inappropriate for the patient	Calculating partial doses; partial dose package; drug calculation errors; setting pump incorrectly	Medication is ordered sublingual, but given oral	Doses not given on time; getting behind; Patient or family member rushing nurse to give the dose; urgent
Patient not oriented/no one in room to verify patient identification	Wrong medications in patient bin; took wrong medication from bin	Failing to check or relying on already pre-set stops in computer charting system	Order changed as the last minute	Scheduled early or too close by pharmacy; medications may interact
Medication reconciliation process not followed	Patient does not know home medications or side effects	Different doses for antibiotics; wrong dose entered in pump	Medications are ordered PO, but given via a PEG or NGT or incorrect to order this route	Verification of correct time when administering PRN medications
Make sure patient's armband is correct	Not checking allergies; not scanning medications	Not completing second medication check at the bedside prior to administration	Intravenous vs. subcutaneous for administering insulin	Administering medications longer than ordered
Not labeling syringes with patient or medication name				Label on the medication is different from the order in the computer

for nurses to indicate years of experience. Over a 2-week timespan, RNs had opportunities to ask questions and complete the rank of ideas template. This timespan allowed for consensus input from all RNs working weekday/weekend shifts. Ranked idea items were analyzed using descriptive statistics for each category and by years of experience. The ranked item ideas were further reduced for a final discussion and re-ranking by the RNs.

3.4. Discussion and re-ranking of top ideas

RNs viewed the final updated version of the rank of ideas template. This version remained with idea items listed under the same human and system factors categories; reduced to include at least one to six idea items. The re-ranking of ideas continued with the same scoring of 1 (most likely to encounter/occur) to 6 (least likely to encounter/occur). RNs completed the re-ranking of the top ideas over 1 week. During the re-ranking process, the RNs could discuss or ask questions about the idea item categories.

3.5. Ethical considerations

The institutional review board (IRB) of the study site (Baylor Research Institute) approved all processes of the NGT involving human subjects via an expedited review. RNs working on the selected medical-surgical unit were recruited to participate via face-to-face contact with the investigators. The RNs were provided study information at each interview or rank of ideas visit. The information included how this was a voluntary process that would not impact their employment status, that no identities would be collected, and that participants could stop participation at any point during the NGT process. Consent was provided by the participants completing the interviews and rank-order of ideas template.

4. Results

Descriptive statistics of frequencies and percentages were used to analyze the demographic data related to the participating RNs' years of experience. The original NGT interviews resulted in 22 RNs sharing comments and ideas, which became foundational to developing a rank of ideas template. This group of RNs represented novice (n = 12, 54%) and experienced (n = 10, 45%) nurses. A total of 12 RNs [novice (n = 6, 50%); experienced (n = 5, 42%); and one unanswered response] completed the initial NGT ranking of ideas template to further refine and reduce the ideas collected during the interviews. The final NGT process was conducted with 23 RNs completing the second (final) rendition of the rank of ideas template [novice (n = 11, 47.8%); experienced (n = 9, 39.2%); and unanswered responses noted (n = 3,13%)].

Descriptive statistics of frequencies and measures of central tendency were used to analyze the rank of ideas template to determine the factors an RN would most likely encounter or which would most likely occur during a shift. These factor categories were extrapolated from the original NGT interviews and organized based on best alignment with

Table 3
Nominal group technique: final outcomes for rank order idea items for human factors.

Category item	Rank mean (SD) scores
Ordering medications	
Order Entry: Orders entered are the same with different name; ordered on wrong patient	2.57 (66)
Preparing medications	
Time Constraints; Distractions	2.21 (1.6)
Calculating partial doses	2.96 (1.4)
No label placed on syringes	3.35 (2.0)
Administering medications	
Distractions while in the patient's room	2.61 (1.4)
Right medication	
Retrieved wrong medication from medication dispense system in medication preparation room	3.13 (1.5)
**Retrieved wrong and/or wrong medication in patient room bin in medication preparation room; look alike or sound alike medication	3.30 (1.2–1.4)
Right dose	
Calculation Error: Partial doses of pills/partial doses which require split of a pill	2.78 (1.3)
Relying non already pre-set medication stops without investigating	2.96 (1.4)
Right route	
Medications are ordered PO, but administered via PEG or NGT	1.74 (0.69)
Medications administered incorrectly via a PEG or NGT	2.48 (0.90)
Right time	
Time Management: Getting behind; hurried; urgent	2.00 (1.0)
Missing window as some medications are 1 h and some are 30 min	2.52 (1.3)

*Note: The lowest numerical ratings are the "most likely to encounter" and the higher ratings are the "least likely to encounter" by an RN during safe medication administration. Presented by top three re-ranked idea items.
** Items with similar Mean (SD) values

either a human or system factor. Tables 3 and 4 represent the three top-ranked consensus items for each category.

When exploring data collected from the NGT process, Gallaher and colleagues (1993) encourage going beyond individual levels of analysis to a within-group level of analysis. Thus, the investigators explored the human and system factor categories to determine differences in findings by years of RN experience. The categorized idea items were kept in rank order and classified as ordinal levels of measurement. Secondary to the sample size, testing with the Kruskal-Wallis test was conducted (Pallant, 2010). A Kruskal-Wallis Test is recognized as the nonparametric test alternative to the one-way analysis of variance to compare three or more groups. The investigators identified that an alpha/p-value of < 0.05 would indicate relevant differences among the groups for this data. When exploring the data, relevance was noted in the human and system factor items of (a) *Time Management* idea item "Time management: getting behind, hurried, urgent" (KW-H 11.2, *df* 4, p = .025) and (b) *Right Medication* idea item of "medications have similar look and sound-alike names" (KW-H 11.1, *df* 4, p = .025). Post-hoc testing was conducted with a two-tailed Mann-Whitney *U* test to identify which RN groups (novice or experienced) ranked these specific idea items as the chance of encountering or the possibility of the statement occurring during a scheduled workday (Pallant, 2010). Results demonstrated no relevance between being a novice or experienced RN with these specific *Time Management* (U = 35.50, z = - 1.11, p = .26) and *Right Medication* (U = 36.00, z = −1.07, p = .28) idea items.

The investigators also considered the potential relevance of the following idea items from human factors: (a) *Preparing Medications* idea item of "pulling wrong medication from the medication dispense system or patient room bin" in the medication preparation room (KW-H 8.4, *df* 4, p = .077) and (b) *Right Medication* idea item of "retrieved wrong medication from the patient bin in the medication preparation room" (KW-H 8.4, *df* 4, p = .079). Additional testing with the Mann-Whitney U was completed with the RNs distributed into the novice or experienced RN groups. Any unanswered responses were noted as missing items for these grouping variables. Results demonstrated the human factors idea item of *Ordering Medications* "Order Entry: Orders entered are the same medication with a different name; ordered on wrong patient" as p = .046. No other potentially relevant ranked idea items were identified.

Table 4
Nominal group technique: final outcomes for rank order idea items for system factors.

Category item	Rank mean (SD) scores
Ordering medications	
Order Entry: Orders are "stopped", but appear in the electronic health record	1.73 (0.86)
Verbal Orders; look alike or sound alike medications	1.91 (0.79)
Administering medications	
Scanning: Patient armband or medications; barcode issues; receiving a phone call when scanning	2.43 (1.5)
Sliding scale dosage: Making certain dose entered into electronic health record is correct.	3.17 (1.3)
Right patient	
Scanning: Patient armband or medications; barcode issues	2.74 (1.6)
No label of patient name on syringes filled with medications	3.00 (1.7)
Scanning: Partial medications not scanned	3.04 (1.5)
Right medication	
Patient does not know home medications or side effects of medications	1.78 (1.4)
Right dose	
Patient does not know own home dose	1.78 (1.3)
Right route	
Patient has a PEG or NGT and has medications ordered for oral route	1.57 (0.66)
Right time	
Medications are not on the unit at the due time to administer	1.26 (0.45)

*Note: The lowest numerical ratings are the "most likely to encounter" and the higher ratings are the "least likely to encounter" by an RN during safe medication administration. Presented by top three re-ranked idea items. **Category items with similar Mean (SD) values.

5. Discussion

The NGT process allowed for determining factors that significantly impact safe medication practices among novice and experienced nurses. The rank order human factor items within (a) *Preparing Medications* of "Time Constraints; Distractions" (M 2.21, SD 1.6); (b) *Administering Medications* of "Distractions while in patient's room" (M 2.61, SD 1.4), and (c) *Time Management* with "getting behind, hurried, urgent" (KW-H 11.2, df 4, p = .025) were of interest after both descriptive and inferential statistics. These category items align with literature indicating how distractions, interruptions, and following medication administration tenets involving the right time contribute to adverse drug events (Kavanagh and Donnelly, 2020; Van der Veen et al., 2018). While RNs participate in education and skill competency assessments related to safe medication practice, the dynamic challenges faced in a busy practice setting can impact behaviors (Kavanagh and Donnelly, 2020). RNs who face challenges of time and distractions will need to continue to advocate for working with their scope of practice and should have available support during such instances. Taking the necessary time to complete each step of the five rights and identifying practice situations that contribute to interruptions or distractions can reduce errors and prevent ADEs (Tariq et al., 2021).

Similarly, the rank order items (a) *Ordering Medications* of "Order Entry" (M 1.7, SD.86); (b) "Verbal Orders" (M 1.91, SD.79); (c) *Administering Medications* of "Scanning" (M 2.43, SD 1.5); (d) *Right Patient* of "Scanning" (M 2.74, SD 1.6); (d) *Right Time* of "medications are not on the unit at the due time to administer" (M 1.26, SD.45); and (e) *Right Medication* with "medications have similar look and sound-alike names" (KW-H 11.1, df 4, p = .025) demonstrated the prevalence of system factors that could contribute to medication administration errors. Healthcare organizations also have the accountability to create working environments where RNs can depend upon the technology offered within the facility. System errors related to order entry in an electronic health record or scanning devices should be reviewed and prioritized. When implementing new technology devices, such as medication scanners, both educational and technical support should be available for instances when these tools fail to function correctly or accurately (ISMP, 2021a, 2021b). Having an increased awareness of quality healthcare initiatives and standards with place importance on patient safety during any phase of the medication administration process is of value (AHRQ, 2019; The Joint Commission, 2021). Additionally quality improvement initiatives such as monitoring and reporting numbers of medication errors can isolate system factors negatively affecting medication safety practices (NCCMERP, 2021).

Another area of interest covering human and system factors was when a patient had a feeding or gastric tube. RNs expressed that a patient not knowing home medications (M 1.78, SD 1.4) or the dose (M 1.78, SD 1.3) was an item encountered during daily medication administration practices. Patients having a nasogastric or feeding tube had medications ordered for an oral route (M 1.57, SD.66), ordered orally, but administered via the tube (M 1.74, SD.69), or the medications were administered incorrectly (M 2.48, SD.90). Such data provides insight into the potential for additional education on administering medicines to patients with nasogastric or feeding tubes. Findings are also in accord with the literature noting how deviations from a prescriber's order or institutional policies, education level, and reduced exposure to medication administration might impact this category item (Tariq et al., 2021; Young et al., 2015).

After exploring all NGT data outcomes, RNs rank-ordered the idea items based on the chance of encountering or the chance of the idea item occurring during a scheduled shift. Findings revealed that system factors were most frequently ranked as "most likely to encounter or occur". While the total number of idea items with the human factors category

was more extensive than those of system factors, the human factors were more frequently rated as "least likely to encounter" by RNs during safe medication administration. All information gained from the NGT will contribute to producing medication administration scenarios to educate practicing RNs with immersive VRS.

5.1. Limitations

This NGT was developed in alignment with current literature and conducted at one university medical center with a population of RNs from one medical-surgical unit. Thus, limiting the generalizability of the findings. During the NGT process, participants were provided instructions for completing the rank of ideas template. However, some participants entered the same number twice or left some line items without a numeric response. The investigators counted blank items as missing and reached a consensus on deleting or accepting multiple numeric entries. The NGT also occurred after implementing and training a new electronic health record that incorporated a new scanning device. The investigators acknowledge that familiarity with the device could have influenced the results related to the scanning of medications.

6. Conclusion

The NGT process identified human and system factors that could contribute to errors and impact safe medication administration practices. Development of a combined and hierarchical list of the most encountered factors contributing to medication administration errors by novice and experienced practicing RNs emerged. This list will set the foundation for creating simulation scenarios that will accurately represent the most encountered obstacles present during medication administration for the population of RNs participating in this process. Registered Nursing and other healthcare professionals seeking to identify educational solutions for practice and patient safety matters can consider using the NGT. Findings also promote the need to further investigate how technology designed to ensure optimal medication administration safety such as electronic health records, barcodes, and scanners has the potential to contribute to medication errors.

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Conflict of Interest

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