

12/9/2011

CORNELL
UNIVERSITY

CAYUGA MEDICAL CENTER:
NEONATAL INTENSIVE CARE UNIT
PROJECT REPORT

DEA 4530 Planning and Managing the Workplace

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What is a Neonatal Intensive Care Unit?

Neonatal Intensive Care Units, or NICUs, are a critical aspect in maintaining the health and wellbeing of infant patients in a hospital. Neonatal units are focused specifically on the health of newborns and the “care for medically unstable or critically ill newborns requiring constant nursing, complicated surgical procedures, continual respiratory support, or other intensive interventions” (White, 2007). The spaces that support the newborns include delivery rooms, nurseries, and other spaces where high-risk infants are monitored and given both extensive and intermediate care. Different levels of care are needed in all of these spaces because each infant requires a different level of support given their condition. According to the Recommended Standards for Newborn ICU Design, there is a need for recommendations about the design of NICUs. A consistent set of standards is needed so that health care professionals, architects, interior designers and health care regulators can have a base for the critical design of current and future neonatal intensive care units.

Importance of NICU Design

The design of neonatal intensive care units plays a large role in patient safety, clinical outcomes. Design contributes to the type and quality of care given for all people involved in neonatal spaces, including newborns, parents, other family members, friends and hospital workers. Being transferred from the mother’s womb to the intensity of a neonatal unit can be overwhelming for an infant, especially one who is premature and has not fully developed yet. Lighting and acoustical quality are of particular importance, as are basic design principles such as layout and location and family and visitor comfort. Above all else, the way NICUs are laid out affects the health of the infants who are in the unit. The infants are often some of the most vulnerable patients in the hospital; therefore the design of the wards needs to allow them to conserve their energy and make it as easy as possible for caregivers and health professionals to help the infant in whatever way is needed. According to Mardelle Shepley (2005), “conscientious architects are becoming increasingly aware of the impact of design decisions on the sensory environment of the neonatal intensive care unit.” Design strategies for NICUs need to address emotional, physical, developmental, medical and social needs for infants, families and

hospital workers. The following environmental conditions directly relate to patient safety, health and comfort.

NICU Design and Health: Lighting Levels

Environmental conditions in NICUs are of the utmost importance considering the relationship they have with health and development. The impact of light on health and wellbeing has been a major focus of study for many researchers in the field of neonatal studies. According to Anjali Joseph (2006), “light impacts human health and performance by enabling performance of visual tasks, controlling the body’s circadian system, affecting mood and perception, and by enabling critical chemical reactions in the body.” While light exposure has many positive effects for patients of all ages, including reduced depression and pain, shorter lengths of stay in the hospital, and improved sleep, the effect that lighting levels have on newborns is very specific. Cycled lighting, where lighting levels are raised and lowered according to the natural lighting levels of the outdoor environment and time of day, can be used in NICUs to help preterm infants recover more quickly. In a study performed on infants in cycled and non cycled lighting conditions, infants in the cycled lighting condition gained weight more quickly, could be fed orally sooner, spent less time on a ventilator and/or phototherapy and had enhanced motor coordination. This suggests that earth’s natural rhythm can have a huge effect on health and regulation of the body. Because neonatal infants have thinner eyelids, this decreased exposure to light during nighttime also helps the infants slowly adjust to light exposure and lowers the chance of retinal damage. Unfortunately, a fairly common practice in many NICUs is to keep lighting at a constant, often high level, exposing infants to unnecessary amounts of light (Joseph, 2006).

Light exposure can also be used to treat neonatal hyperbilirubinaemia, a condition known less formally as neonatal jaundice. Neonatal jaundice is common in premature infants because they have not yet fully developed the ability to metabolize the product of the decomposition of hemoglobin in red blood cells. Light therapy can help the infant by bleaching this product into a form that can be processed (Joseph, 2006).

In summary, adequate light exposure, both in amount and type of light is imperative in increasing the wellbeing of patients in healthcare settings. Natural light should always be incorporated, but it is the combination of natural light and electric light that meets the needs of people regardless of the outdoor environmental conditions. Planning for and controlling lighting in neonatal settings is an inexpensive way to improve quality of care and patient experience. In NICUs specifically, cycled lighting techniques can be used to help pre term infants.

In terms of mitigating issues with lighting, single-family rooms are favorable over open bay models, for similar reasons. Parents prefer having greater control over the infant's immediate environment, and infants are not affected by the care of other babies like they might be in a single ward. Admittedly, shielding a neonate from activity in adjacent bed space, including noise and light is incomplete at best (White, 2010). Taken together with the sound reduction information, there also seems to be a substantial number of developmental benefits suggested, including sleep patterns, brain development, weight gain, attention span, and vision maturity (Shepley, 2004).

NICU Design and Health: Noise Levels

The impact of noise on patient health in NICUs has also been a focus of research in the field. Hospital settings have very high noise levels due to the types of activity and amount of traffic flow that occurs, especially in neonatal wards where the level of activity is high and the infants can get upset easily. More specifically, “the NICU is often characterised by loud, unpredictable noise from extraneous sources such as alarms, ventilators, phones and staff conversation to which preterm infants are especially vulnerable” (Wachman & Lahav, 2010). Sleep loss and increased blood pressure are some of the most common side effects of high noise levels. In addition, high sound levels cause communication problems between staff members and between staff members and patients, leading to increased stress and increased chances of miscommunication. “A well-designed acoustical environment is critical in addressing these problems related to noise and communication of information” (Joseph & Ulrich, 2007).

In neonatal care units, quiet time is very important because loud noise levels contribute to infants' ability, or lack of ability, to absorb oxygen. If infants are unable to absorb oxygen, they

have increased blood pressure and heart and respiration rates, often requiring more oxygen support therapy (Joseph & Ulrich, 2007). Because ambient noise in NICUs often exceeds levels recommended for patient health and wellbeing, infants and mothers in the spaces are faced with negative health consequences. As discussed above, high noise levels have negative effects on infants' cardiovascular systems and there is new research that suggests that these effects can carry through to school age, when neurodevelopmental problems become apparent. Unstable cardiovascular systems cause the body to decrease perfusion of critical brain tissues, in turn affecting development. The recommended sound level of NICUs, as set by the American Academy of Pediatrics in 1997, cannot exceed 45 decibels (Wachman & Lahav, 2010). A quiet hour when sound levels are relatively low helps infants sleep, which is critical for brain development. While decreasing noise such as unwanted sound helps with infant healing time, increasing sounds in the form of music can be healing. Music helps lower cortisone levels, the hormone linked to high levels of stress (Shepley, 2005).

Regarding noise levels, single-family rooms are much preferred overall compared with open bay or alternative layouts. Increased noise can exacerbate stress levels on all parties, but single-family rooms aid in noise reduction through structural means. Families can also exercise greater control over the environment of their child, minimizing stimuli that may adversely affect him or her, and promoting sleep. Finally, single-family rooms provide a quiet atmosphere for private conversations among families, as well as nurses and physicians, encouraging communication and parental involvement (Stevens et. al, 2010).

The National Perinatal Association has looked at types of flooring that can be used to reduce noise and provide aesthetic qualities. According to Ulrich et al (2008), The National Perinatal Association suggests that a combination of carpeting, which dramatically reduces noise, and medical grade rubber or linoleum sheet flooring, which is resilient to constant wear and tear, is the best flooring option in neonatal units.

NICU Design and Health: Layout of the NICU

The layout of the NICU can make a significant difference in the care that the infant receives. This is the facet of NICU design that was addressed at CMC, and therefore is the focus of this report. The traditional model of NICUs consists of a single ward, or ‘open bay’ where all infants are cared for together to enhance visibility and access. This model is very similar to early adult wards with many beds in one large room, containing no walls or boundaries between one infant and another. The available space per infant was generally large enough to contain the various equipment and monitors needed, allow appropriate access for staff and possibly a chair for a parent (Ritzel). There is little room for intimacy, and no ability to individualize the environment. Whereas hospitals have eagerly renovated adult units to provide semi-private, and more recently private rooms for patients, NICUs have largely remained the single ward model (Brown and Taquino, 2001).

Now, with the growing trend of “patient and family centered care”, hospitals are beginning to apply the same reasoning to NICU design. Private adult rooms enhance patient privacy and satisfaction, reduce risk of infection, and improve clinical outcomes; do results compare when neonates and their families are provided a single-family room? Typical single family rooms provide ample space for the infant and any necessary medical equipment, with separate ‘zones’ for the family and staff. The family area might include seating that is convertible for sleeping, a desk with internet access, and some storage. The staff area may include ample charting space, a hand washing station and supplies. The single room provides privacy for the family, while maximizing space and access to the infant for medical care (White, 2007).

Alternative models that seek to compromise between the two extremes are also abundant. Some are designed as multiple “pods”, with two to six babies sharing each pod as in the single-ward model. This combines the convenience and visibility of the open bay layout within the pods with the increased intimacy of having fewer infants and their families sharing one space (Laing et. al, 2004). Others may be designed as an open bay model with a select few private rooms. One concern with this layout is developing an appropriate policy for who gets placed in

the private rooms, the healthiest or sickest neonates (Shepley, Harris and White, 2008). These alternatives may also include different spaces for parents; some have even provided a separate room for the parents adjacent to the infant, complete with a bathroom, bed, dresser, desk, and television (Johnson, Abraham and Parrish, 2004)(Johnson, Abraham and Parrish).

Looking beyond the direct effects that environmental conditions have on patients and families in NICUs, many studies seek to outline basic design guidelines for neonatal units. The location and layout of NICUs both within a hospital and within the unit itself are key to the success of a unit in terms of clinical outcomes and satisfaction of the patients and staff. Currently, it is recommended that neonatal units have a distinct and separate area in the hospital to minimize the spread of disease and to help control privacy. The unit should also be well connected to other areas of the hospital so it can be easily accessed and it should have effective circulation within it to help with navigation. The waiting room for patients and families should be clearly identifiable and should have hand-washing areas, telephones areas, ample seating, lactation support and storage space for visitors (White, 2007).

Room layout is another dimension of design related to how the unit functions as a whole. It is suggested that the width of aisles in patient rooms and nurseries be wide enough to allow for the movement of large medical equipment such as infant respiratory devices. Electrical and gas units should be located in an easily accessible area and all equipment should permit flexibility in where and how it can be moved (White, 2007).

Other design recommendations include: locating alarms, phones and sinks away from infants' heads, locating central stations such as nurse and check in areas away from patient rooms and using special vibration pads around loud equipment that is required in infant rooms. In addition, sink areas should be equipped with noise reducing faucets that are capable of producing warm water instantly so that the sinks don't have to run for a long time to get the water to the desired temperature. In terms of room adjacencies, locate louder rooms, such as employee break rooms, away from patient rooms and mitigate noise further by using sound absorbing ceiling panels. These panels should have an average Noise Reduction Coefficient (NRC) of .85 across the entire ceiling. Noise from air handling units and other building systems

should also be considered; it is best to locate mechanical, plumbing and electrical systems away from infant rooms and select HVAC systems that are insulated and quiet (Acoustics in Healthcare Environment, 2010).

In terms of the NICU in relation to healthcare staff comfort, the NICU can be a very stressful environment. Therefore, the layout of the space should support, not hinder, their activities (Shepley, 2002). Nurses spend an incredible amount of time walking back and forth from the NICU and other main hubs such as the nurse's station, increasing the time that it takes for them to perform tasks and decreasing their comfort and productivity at work. By reducing stress for staff members and physicians in NICUs through improved physical environment, hospital workers can better care for the infants and their families. More specifically, reducing the time that nurses spend searching for supplies and gathering them can help in turn reduce stress and nurses can then spend more time caring for patients (Shepley, 2005).

One study by Shepley, Harris and White (2008) noted that two hospitals with differing NICU models found no significant difference in distance traveled by nurses, while a different study indicates that nurses in private rooms NICUs walk one half mile per shift more than those working in open bay NICUs (Stevens et.al, 2010). Despite the contradicting research, it is indisputable that stress among staff is increased when their time with patients is decreased due to other, less meaningful activities. Therefore, careful thought must be put into unit and space configuration decisions to minimize activities like searching for supplies, and therefore maximize nurses' time to engage with patients and families (Shepley, 2005).

Specific Issues at the Cayuga Medical Center Neonatal Intensive Care Unit

Generally, Neonatal Intensive Care Units are defined into three levels: Level 1 for full term newborns from 37 weeks to 42 weeks old, Level 2 for pre-term newborns from 32 to 37 weeks old and Level 3 for newborns 23 to 32 weeks old. Level 1, basic care, is a hospital nursery that basically can perform neonatal resuscitation, evaluate and provide care of healthy newborn infants and near-term infants, and stabilize newborn infants born before 35 weeks until transfer to nursery that can provide higher levels of neonatal care. Level 2, specialty care, is a special

care nursery that can provide care to infants born at more than 32 weeks. These neonates are moderately ill with problems that are expected to resolve quickly and are not anticipated to need intensive care on a very urgent basis. Level 3, subspecialty care, is a hospital NICU that can provide continuous life support and comprehensive care for high risk, critically ill newborn infants (Hardy, 2005). Cayuga Medical Center NICU is a Level 2 facility. The nearest Level 3 NICUs are in Syracuse, New York and Rochester, New York.

Inside the NICU, because time is a very important factor, time management is the most essential problem related to the importance of redesign for the NICU. The NICU in CMC can be split up into acute problems, including respiratory and cardiovascular procedures, and non-acute problems. Therefore, the layout of materials in the space should be related to the types of emergencies and should be divided into acute supplies and non-acute supplies. However, before we started our study, Dr. SriSatish Devapatla observed that there were no guidelines for material arrangement and all the supplies were stored in chaos. The layout and placement of materials within the space are very important factors related to the time it takes for nurses and physicians to complete tasks to save babies. The main target for our project was to reduce the time for nurses and physicians to perform such tasks. As noted above, the space layout in NICU needs to support nurse's and physician's activities, not add to the stressful nature of the situation. It is important to note that before the project began, the emergency procedures went well, however, there were still concerns caused by inappropriate layout. Our goal was to create consistent and standard times for emergency procedures regardless of the experience of the physicians and nurses, the acuity of the baby, and the time of day.

The main problem being addressed is related to the layout and the placement of the materials within the workplace. Using concepts from LEAN processes aiming at increasing efficiency and decreasing waste, we assessed the current layout at Cayuga Medical Center in order to eliminate two kinds of "wastes". The first kind of waste is due to Motion (Operations), i.e. the time for walking without working, specifically the time it takes to walk away from the main workstation, searching for tools or materials, and unnecessary motion due to poor workplace layout. Another kind of waste we want to eliminate is waste due to Inventory, since the materials in NICU are sometimes over stored or obsolete, and low efficiency can be due to

poor material layout within drawers and cabinets.

Some specific problems before we started our interventions are stated below. The organization in cabinets and drawers are not well arranged and can compromise the activities of nurses. Particularly, some important supplies or materials of a specific size were missing and there were redundancies in storage of some rarely used materials. Some materials that should not be used are still available in drawers and were placed in very prominent places (e.g. one specific type of chest tubes which cannot be used on neonates).

For the original layout in the NICU, the left side was generally kept for non-acute activities, and the right side was for acute and important activities. But the supplies were all mixed together and not well arranged as they were supposed to be. Originally, there was no relation between different sets of cabinets. Also, the drawers were disorganized and some materials were randomly placed in two drawers (eg. BP cuffs). Another problem was concerning the MedCart. It should be locked but not every nurse in NICU has keys to the MedCart (though they are always supposed to). So if there is an emergency, the nurses cannot have access to the materials inside the MedCart without getting assistance from outside the NICU.

In addition, the labeling placed on drawers and cabinets were inaccurate and often missing for important materials, such as the PediCap. In the original design, there were abbreviations for some supplies but not for others, and the abbreviations were often inconsistent or unclear. The admission supplies drawer in particular was disorganized, with many materials missing labels or clear descriptions of the supplies. To mitigate some of these problems, the labeling design needed to be streamlined and well-organized.

Some materials are placed in inappropriate cabinets and shelves, and several nurses have trouble reaching these cabinets without a step stool. Some materials were left in boxes on the counter top, decreasing the amount of flat workspace the nurses can use for clinical care. It is not because there is not enough room in drawers and cabinets, but because all the materials were not well organized and the space was not used properly. Another problem with supply storage is that the NICU is the main storage area for all the supplies on the unit, which greatly increases traffic

in and out, which can be detrimental to the neonates wellbeing.

In the CMC NICU, there are currently 36 nurses and eight nurses' aides in total. Sixteen of the nurses are special care certified and there are two aides in training. Ten of the sixteen nurses work in the daytime, plus two aides, and six of them work at night. But generally, there will be least one nurse who is in special care at all times. Usually, there will be two special care nurses.

Methodology

Throughout the semester, our methodology followed a typical progression of observation, interviews and brainstorming, and small scale experiments to test the effectiveness of certain changes. As mentioned above, we used the concepts of LEAN processes to drive the development of our proposed solutions. It is also important to note that improvement is not complete; our solutions are not meant to be static, but continually improved upon as more information and feedback is collected.

In order to delve into CMC's issues with the current NICU space, it was imperative to make some initial observations. Over the course of a week (about four hours total), Dr. SriSatish Devapatla, the resident Neonatologist, oriented each team member to the commonly used equipment, all the materials that are stocked for emergency procedures, and necessary terminology. Inventory lists were provided by Denise Salmi in Materials Management, which included all supplies used in the department, as well as their par levels and average usage. These introductory visits also allowed for initial brainstorming and a narrowing of our focus. Dr. Devapatla explained that the vast majority of neonatal emergencies required at least one of four procedures: endotracheal intubation, peripheral line placement and blood draw, umbilical (central) line placement, and chest tube placement. By eliminating human and environmental factors, the goal was to assemble materials for these procedures as quickly as possible. Consistency was also important; the time required to collect the materials should not depend on who is working, when the emergency occurs, or the acuity of the ill newborn. We believed tackling this specific question would make the largest impact in a short amount of time.

Our next step was to interview the nurses on the unit working in the current NICU. Primarily, the goal was to obtain useful feedback and ideas to incorporate into our solutions for the space. Since these special care nurses were the ones who actually use the space, they understood the current organization better than anyone else, and can speak to its advantages and disadvantages. This knowledge was essential to tap into, especially because of our limited knowledge of the clinical information and CMC's policies and procedures. Secondly, by taking the time to talk with the nurses, and fully understand their day-to-day issues with the space, we hoped to increase their buy-in into the project. Their inclusion and support helped our modifications succeed in the long run.

The interviews consisted of five questions:

- What do you like best about the current NICU?
- What do you like least about the current NICU?
- What is the biggest challenge concerning workflow, room design, or materials during a NICU emergency?
- Describe a “wish list” to make the current NICU an ideal space.
- How does working with other neonatologists change your experience during a NICU emergency?

Through these questions, we aimed to glean what they disliked about the NICU, how *they* might fix the situation if they were given the opportunity, and also their impressions working with neonatologists other than Dr. Devapatla. This last concern is relevant because the nurses are used to Dr. Devapatla; they know his preferences and understand his expectations. The changes we present should help mitigate any issues nurses have with “guest” neonatologists who have different expectations, supporting the goal of consistency discussed above.

Over two weeks the interviews were conducted, and using the responses from fifteen subjects, a fishbone diagram was developed. In order to pick the “low hanging fruit”, a Pareto analysis was performed to identify the 20% of factors that cause 80% of the problems (Figure 1).

It was established that searching multiple drawers for supplies, redundancies in drawers and cabinets, using countertops for storage space, and the spatial separation between warmers and supplies are the biggest drivers of added time when obtaining supplies. Keeping in mind the LEAN principle of eliminating all kinds of waste, we categorized two types of waste to address: motion and inventory. Motion waste in the current NICU included having to walk away from the workstation (therefore walking without working), searching for materials, and any other unnecessary movement due to poor workplace layout. In regards to inventory waste, we addressed materials with inaccurate par levels according to their usage, as well as poor layout of supplies in drawers and cabinets.

Two solutions to test were proposed, one to eliminate human factors, and the second to eliminate environmental factors in the current NICU. In order to eliminate human factors, we decided to develop “pick lists” for each procedure that the nurse can use as a guide while gathering supplies. These lists would name everything that is typically needed in a particular emergency scenario so the nurse is not relying on memory or waiting for the neonatologist to tell her every single material they will need. The second solution was a systematic organization of all the supplies based on procedures. For example, if all the supplies necessary for endotracheal intubation were located in the same place, any unnecessary movement from searching or walking to different cabinets would be removed from the process. Other changes related to the organization included dividers to arrange the drawers properly, placement of most-used materials at the front of each drawer, and clear labels for all items and drawers.

Our experimental design consisted of three trials, each run with four subjects. In order to account for different levels of experience, we chose two experienced nurses and two inexperienced nurses on the unit. This allowed us to observe how significant the learning curve is in the NICU, as well as stratify our data in another way to glean new information. We timed the four emergency procedures discussed above: endotracheal intubation, chest tube placement, peripheral line placement and blood draw, and umbilical line placement. All tests were completed in the current NICU at Cayuga Medical Center.

The first trial included both human and environmental factors, and was designed to

duplicate the current scenario. While being timed, Dr. Devapatla asked each nurse to retrieve supplies one by one, based on the pick list we developed. The organization of the room was not changed, and the nurses did not have access to the pick list before or during the trial. To eliminate human factors in the second trial, the nurse was given the pick list to use, instead of Dr. Devapatla orating. The material organization was unchanged again. Based on this trial, we redesigned the pick lists, color coding each procedure and including the location of each supply to eliminate any searching or confusion. The third trial included both the revised pick lists and a newly organized space, including clear labels and color coding that corresponded with each pick list. Theoretically, both human and environmental factors are accounted for in the final trial. We concluded by revising the pick lists again based on observation and suggestions from the subjects. Supplies were reordered and readability was streamlined. The progression of pick lists can be seen in the Appendix (Figures 2, 3, 4).

Results and Discussion

We collected run trial times from four of the unit nurses. Two of the nurses were fairly experienced in the NICU, while the other two nurses were generally new to and inexperienced in the NICU. The data collected from the four individual nurses can be seen in the Appendix (Figures 5, 6, 7, 8). During the data collection, the nurse participants were each tested separately and generally did not observe each other during the trials. They were not told their run times any time during the data collection phase and they were not provided with the target times to compare themselves to. Limitations of the experiment were the small sample size of four nurses used in the trials and that more than one new nurse was used in the role of 'New Nurse 2' due to unforeseen and unavoidable scheduling conflicts. However, the nurses used for the position had respectively similar knowledge and skill levels in the NICU. It was also difficult to instill a consistent sense of urgency during each of the trials and for each of the nurses. This is specifically a limitation because with the mood of the environment during the trials is expected to greatly affect the individual nurse's run times.

To begin analyzing the data, we chose to average the nurses' run times together for each trial. We then compared these times to a target time for each of the procedures (Figure 9). This

target time was collected from timing Dr. Devapatla in the Trial 3 conditions. His run times were chosen as the target for the nurses because he was the most skilled with the layout and organization of the supplies in the NICU. It is predicted that there will be an initial learning curve for any hospital staff that use the reorganized NICU to gather the materials for the pick lists procedures. Looking at this data, it can be seen that with each subsequent trial, the nurses run times dramatically decreased with most of the Trial 3 times under half of the Trial 1 times. Also, on average the chest tube placement procedure saw the greatest reduction in run times going from 5 minutes, 47 seconds down to 1 minute, 49 seconds. With each subsequent trial, the nurses' times became increasingly consistent with each other as well. The decreasing standard deviations between the run times for each procedure during each trial indicates that the spread of the run times became increasingly smaller, which is in line with our original goal of consistency (Figure 10).

Delving deeper into the data, it can be seen that the experienced nurse averages and the new nurse averages had differences in their run times and their ability to adapt to the different trial conditions, which was an expected result. For the experienced nurses, the Trial 1 run times were generally not as high as those of the new nurses. Going from Trial 1 to Trial 2 of the umbilical lines placement for the experienced nurses shows an odd increase in the average run times (Figure 11). This can most likely be attributed to the aforementioned experiment limitation related to the inability to sustain an urgent pace during all of the trials. As for the new nurses' averages, their overall improvement in run times from Trial 1 through Trial 3 is explicitly noticeable (Figure 12). When it comes to the nurses' averages for Trial 3, they are similar to those of the experienced nurses, showing that with continued limitation of the human and environmental factors affecting the nurses there will be more consistent performance outcomes between them.

Future Recommendations

Based on our project, there are several recommendations that can be made to CMC and HOLT Architects about the NICU design in CMC. Our observations and data analysis lead us to believe that by implementing the use of pick lists, better materials and supplies organization, and color-coding allow for increased hospital staff efficiency. These changes are also expected to be

financially valuable to the hospital. By extensively decreasing the amount of inventory waste that the NICU had, the project created cost savings associated with fewer unnecessary supply ordering. This is achieved because the materials managers have a better ability to monitor the par and trigger levels of the supplies. Before, because of the clutter, disorganization, and redundancy of the supplies, the material managers could mistakenly order supplies that appeared to be below their trigger levels, when in fact the supplies were just in the wrong location. We believe that with these tangible outcomes, many of the procedures implemented in the NICU in regards to this project can be replicated in other areas of the hospital.

The location of the med cart key is a very specific design issue that we encountered over the course of our research. The med cart key is currently located in a locked drawer across the room from the med cart, which increases the time it takes to prepare materials during emergencies because nurses and staff must walk across the room and unlocked the drawer before walking back to the med cart and unlocking it. One possible solution to this issue of increased walking time is to place the key to the med cart in a small, lockable key box that would be secured to the top of the med cart. Hypothetically, the nurses would enter in a number code for the lockable key box and get out the key when needed and then replace it when done. This would decrease the time that it takes to complete emergency procedures and further support our goal of keeping walking time at a minimum. In addition, the Pyxis, where nurses go to retrieve medicine and other supplies that must be locked, should be moved closer to the NICU in order to reduce walking time.

Other recommendations include increasing the nurse work station space so that nurses have enough room for storage and paperwork, and placing another printer outside of the NICU so that the printer in the NICU is not being used for anything besides emergency or NICU related reasons. The printer solution specifically addresses the issues of excess noise in the NICU and hopefully the addition of another printer outside of the NICU but still in the unit would reduce printer use in the NICU and consequently reduce noise levels. The current NICU is used for treating infants but also used as the main storage space for all supplies in the department. This means that there is constantly extra noise and movement of people in and out of the space as they gather materials they need. This creates excess noise and distractions and creates a more stressful

environment in the NICU. As a result, we suggest that only supplies needed for the NICU babies be kept in the NICU and other supplies should be kept in a separate storage location in the unit. To reduce excess stress further, we recommend that an ante washroom be added outside of the NICU. Parents, visitors, physicians, nurses and other staff members would be able to wash their hands before entering, therefore reducing the chance of spreading infections to the newborns in the NICU. All of these recommendations would help maintain the health and safety of everyone in the NICU, whether they are patients, staff, physicians or families, and would help address the wide array of issues in NICU environments, including noise, health, safety and comfort. Similar to what many pieces of literature on this topic suggest, minimizing external factors in the NICU environment, whether it be walking distances, noise, or lighting. In terms of our research, our findings support Shepley's (2005) concept that reducing stress for staff members and physicians in the NICU can be achieved by improving the physical environment. As a result, hospital workers can better care for infants, and in the case of emergency procedures, can complete material gathering tasks at a much faster rate. Reducing the time that nurses spend on gathering tasks will in turn give them more time to care for their patients and will increase their productivity and comfort while working at in hospital settings.

In conclusion, the results of our study indicate that it is possible to reduce the time it takes to prepare for emergency procedures in the NICU environment by creating a system that eliminates waste while supporting organization. A similar process could be applied to additional emergency procedures in the NICU as well as additional emergency procedures that occur in other units in a hospital. By enabling nurses and physicians to do their tasks more efficiently and in a shorter period of time, they will experience increased productivity and comfort and in turn, patients will receive better care in emergency situations.

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APPENDIX

Figure 1. Fishbone Diagram.

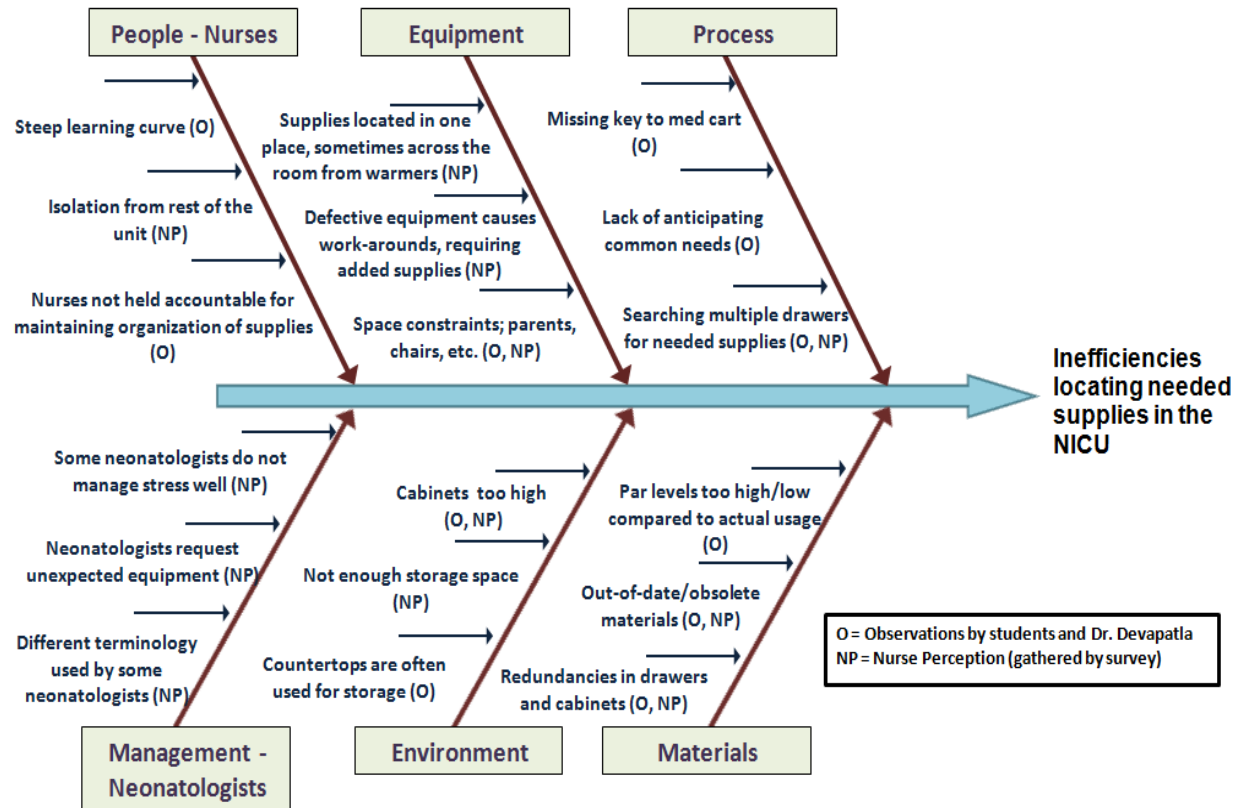


Figure 2. Pick List #1.

CHEST TUBE PLACEMENT	
S.No	Material
1	Chest tube insertion tray
2	Pleuravac
3	Betadine
4	Lidocaine
5	Tuberculin syringe with 25 G needle
6	Normal saline ampoule
7	Scalpel
8	Chest tube
9	Shoulder role
10	Xerofoam
11	Tegaderm (big size)
12	3-0 black silk suture
13	1/2" x 4" tape for chevron
14	Astromorph
15	Gown / Face mask / Cap
16	Sterile gloves

Figure 3. Pick List #2.

CHEST TUBE PLACEMENT	
Material	Location
Wedge roll	Black Drawer 1
Chest tube catheter	Black Drawer 1
Xeroform	Black Drawer 1
1/2" x 4" cloth tape for chevron	Black Drawer 1
Tegaderm (big size)	Black Drawer 1
Chest tube insertion tray	Black Drawer 2
Chest tube drainage system	Black Drawer 2
3 ml syringe with 25 G needle	Cart Drawer 1
Normal saline vial	Cart Drawer 1
1% Lidocaine	Cart Drawer 1
Scalpel	Cart Drawer 3
3-0 black silk suture	Cart Drawer 3
Betadine	Cart Drawer 3
Gown / Face mask / Cap	Cabinet 2
Sterile gloves	Counter top
Astromorph (Neonatal morphine)	Pyxis

Figure 4. Pick List #3.

CHEST TUBE PLACEMENT	
Material	Location
Astromorph (Neo. morphine): Ask your assist to get it.	Pyxis
Wedge roll	Black Drawer 1
Chest tube catheter	
Xeroform	
1/2" x 4" cloth tape for chevron	
Tegaderm (big size)	
Chest tube insertion tray	Black Drawer 2
Chest tube drainage system	
3 ml syringe with 25 G needle	Cart Drawer 1
Normal saline vial	
1% Lidocaine	
Scalpel	Cart Drawer 3
3-0 black silk suture	
Betadine	
Gown / Face mask / Cap	Cabinet 2
Sterile gloves	Counter top

Figure 5. Experienced Nurse 1's individual run times for each trial and procedure.

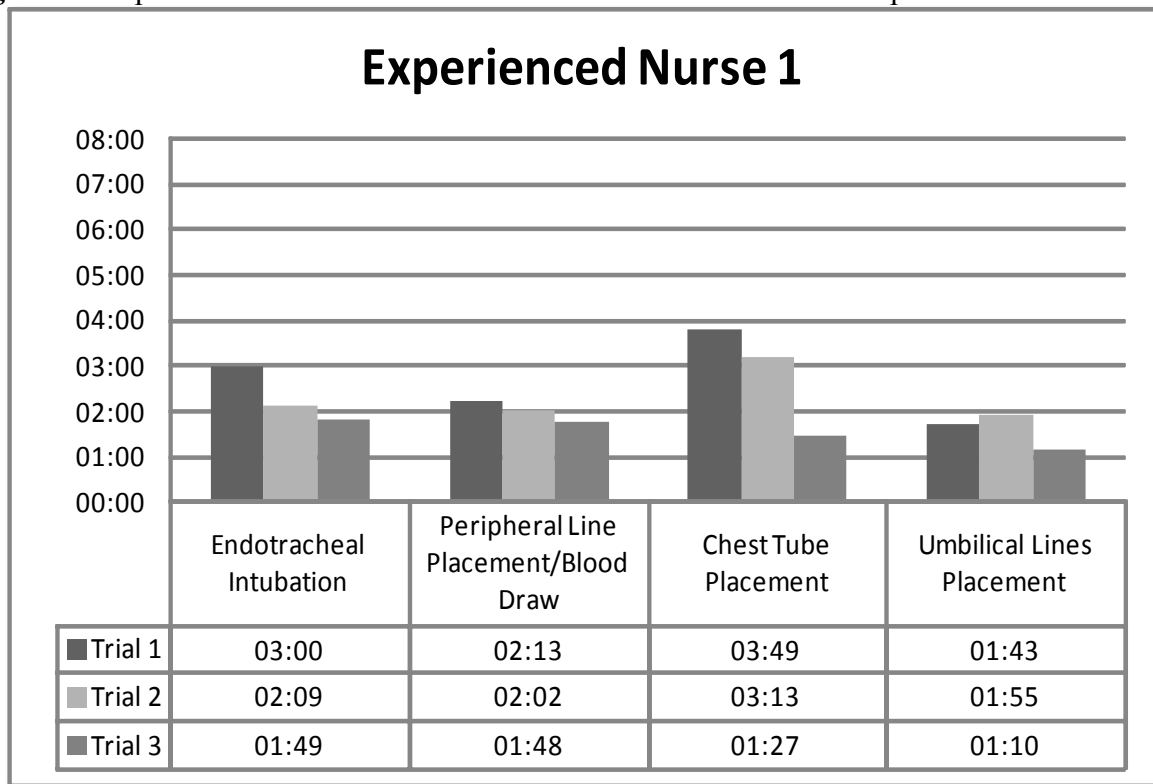


Figure 6. Experienced Nurse 2's individual run times for each trial and procedure.

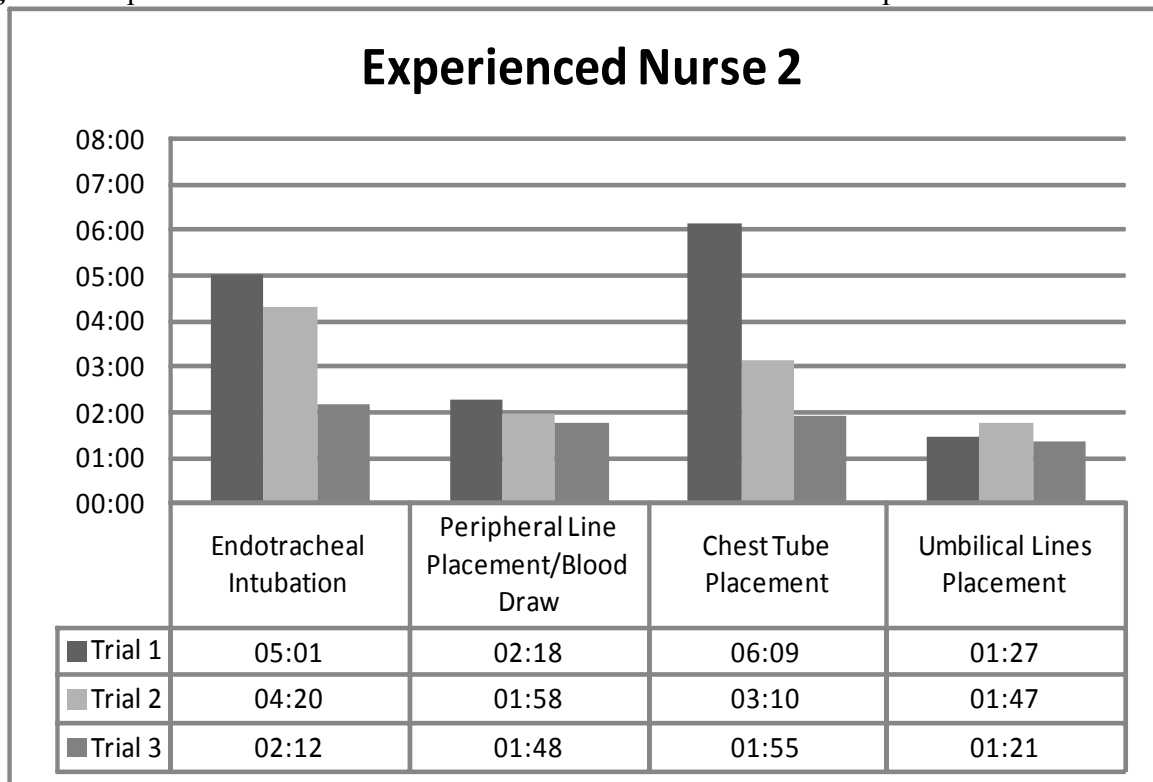


Figure 7. New Nurse 1's individual run times for each trial and procedure.

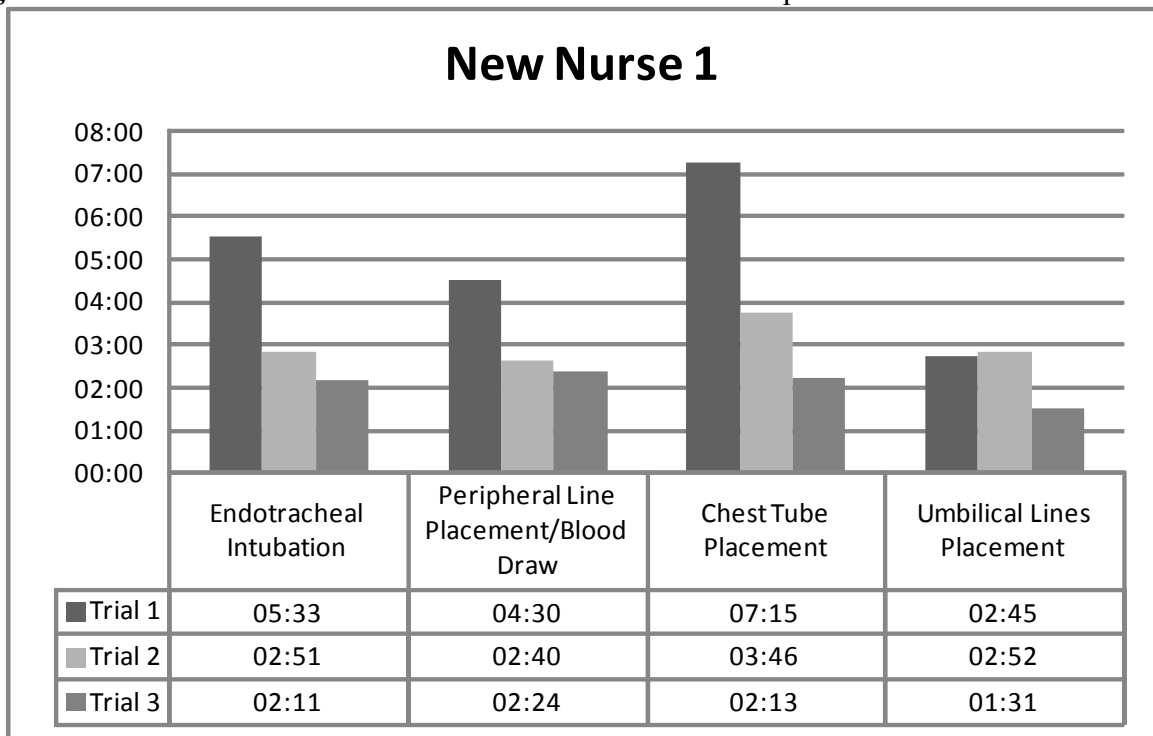
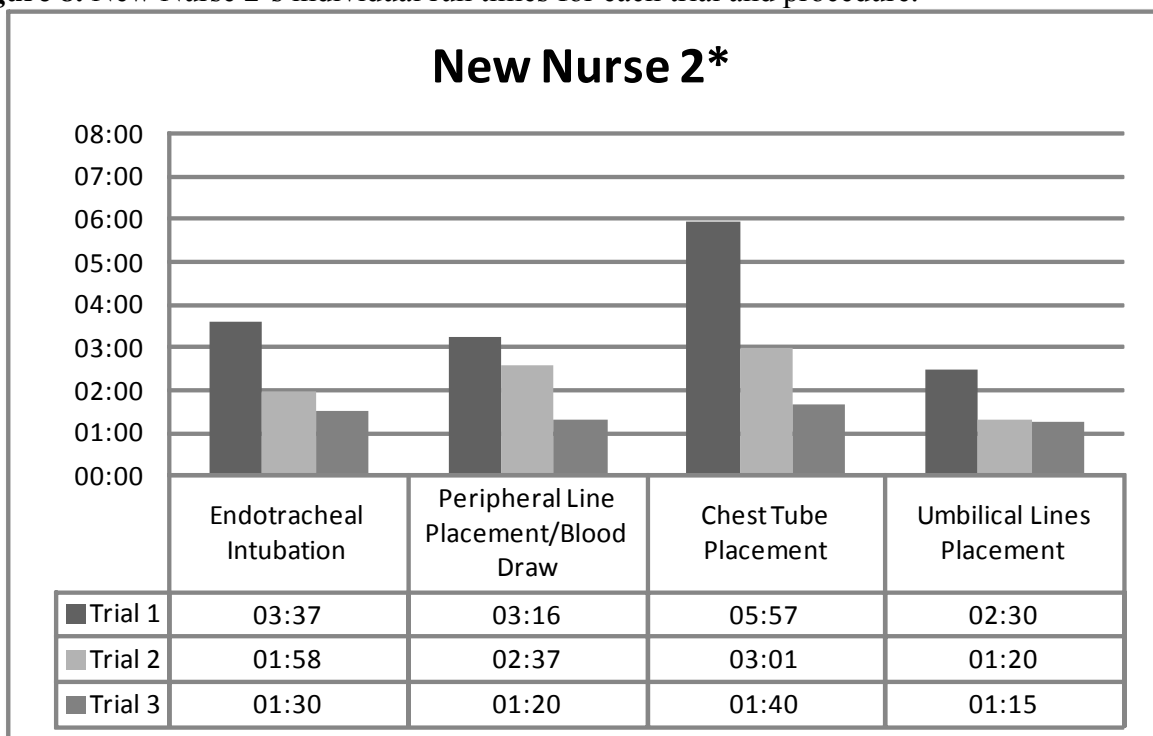


Figure 8. New Nurse 2's individual run times for each trial and procedure.



*Trials 1 and 2 were completed by one new nurse. However, due to scheduling conflicts, this nurse could not complete Trial 3. Dr. Devapatla chose another new nurse as a replacement that had comparable skills and experiences.

Figure 9. Overall nurse averages for each trial compared to the procedure trial times.

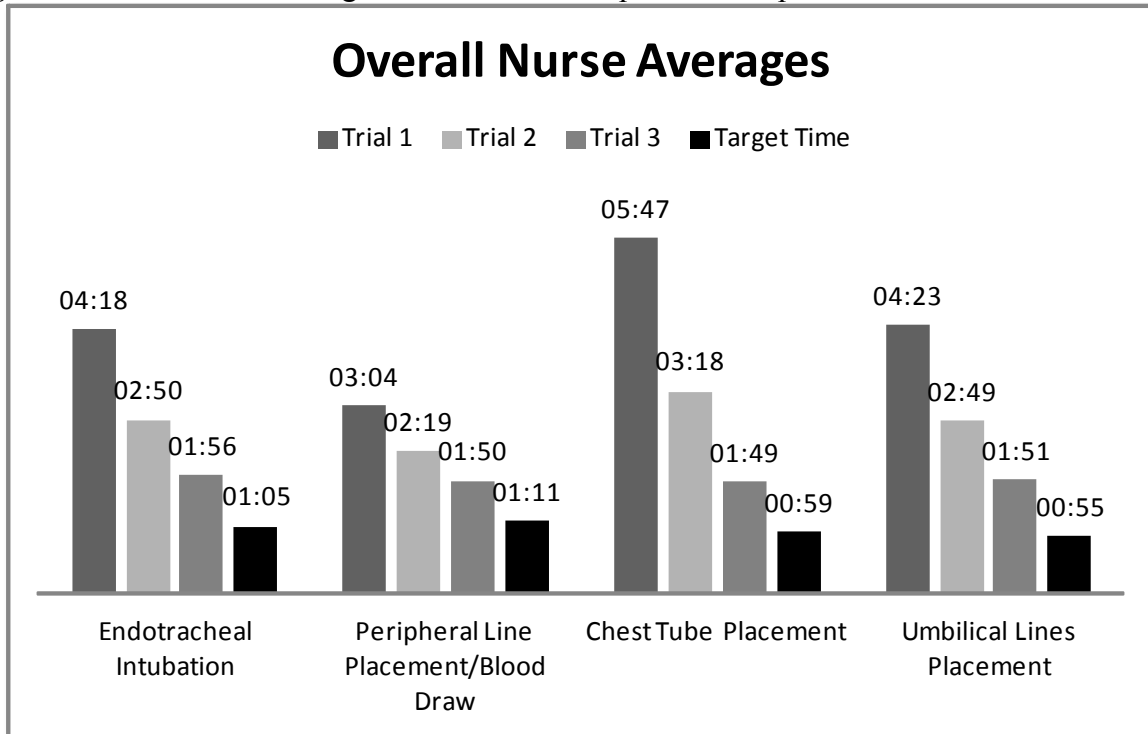


Figure 10. Standard deviation for the run times of each procedure during each trial.

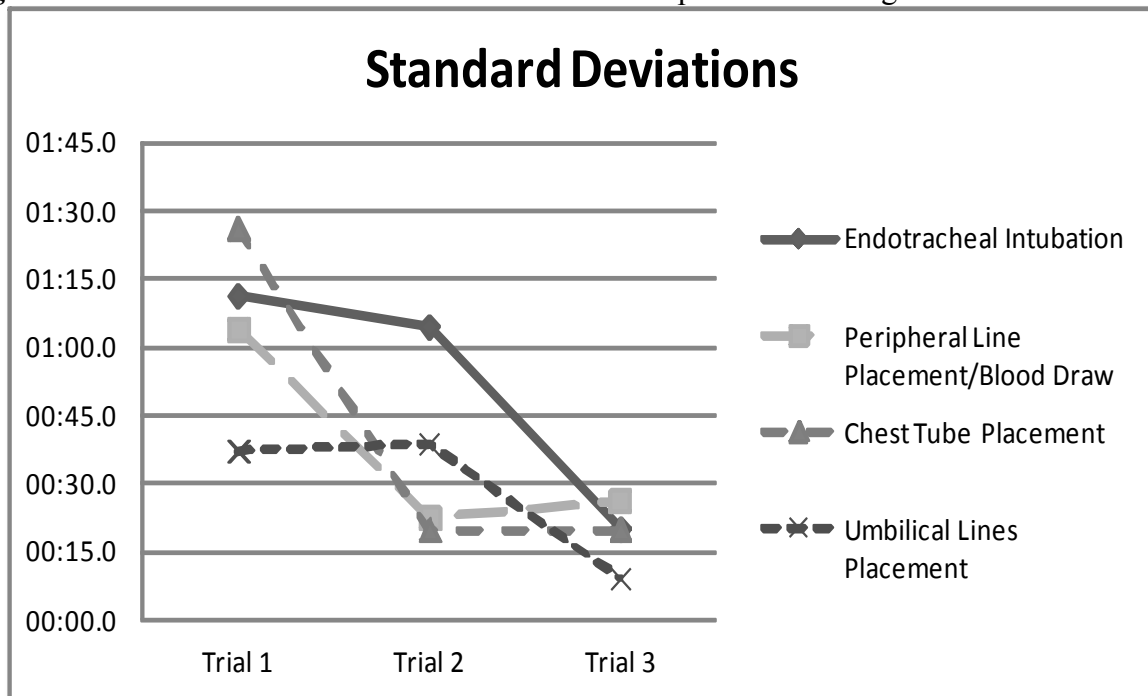


Figure 11. Experience nurse averages for trials of each procedure.

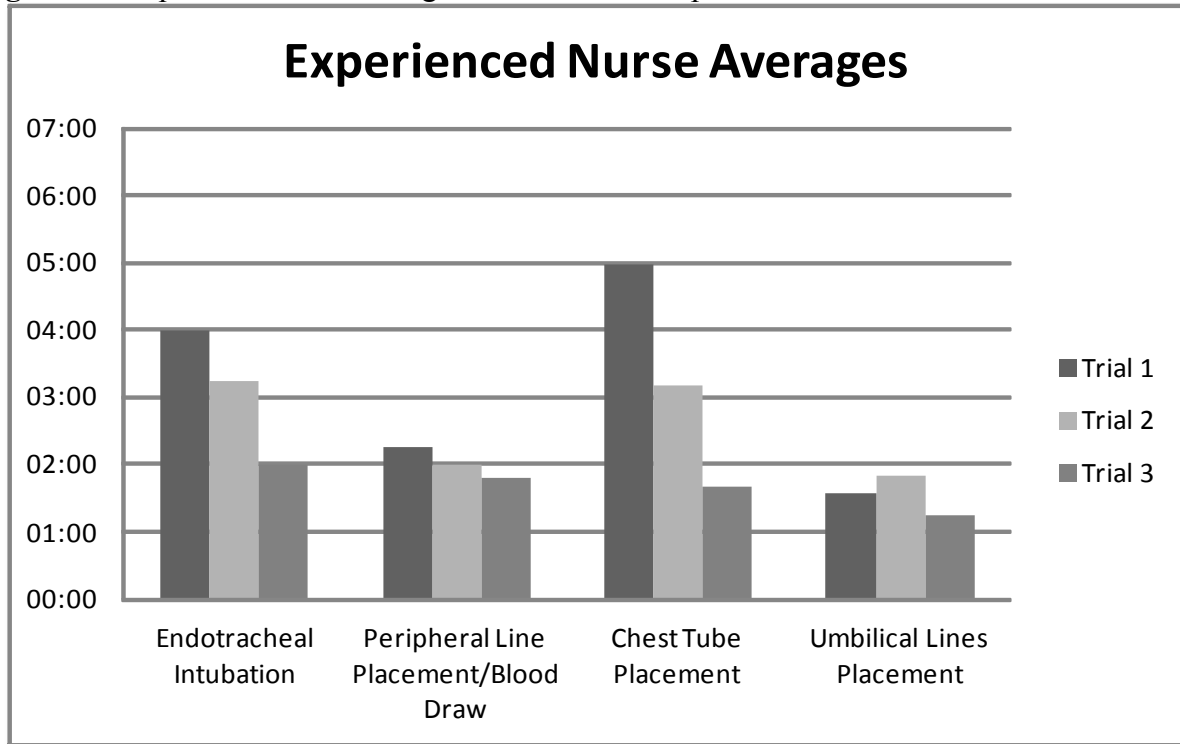


Figure 12. New nurse averages for trials of each procedure.

