examined the use of hand washing versus alcohol in an NICU and found the bacteria levels to be the same.

5.2.3 Private rooms

5.2.3.1 PICU private versus shared rooms

Several convincing studies suggest that private rooms reduce the frequency of HAI. However, Rose and Blythe (2008) conducted an extensive literature review on private versus shared pediatric rooms and, while normally supporting the use of private rooms, suggested cohorting as an alternative response in some cases due to the psychological importance of not being alone. Similarly, Morgan (2010) examined standard versus private pediatric patient room arrangements through a literature review, as well as surveys of professionals, children, and young people, and concluded that shared rooms should not be completely excluded.

This need for companionship may not be salient for PICUs as children in these units are frequently sedated and unable to interact with others. Based on the literature on adult rooms, most of the evidence for PICUs is that these should be private.

Recent research by Laura Poltronieri and colleagues set about exploring the impact of PICU private rooms on family behavior, staff patterns, and quality/safety measures. They found that with private rooms, the number of visitors and the durations of their visits were higher, nursing presence was higher, lengths of stay were shorter, and adverse events were fewer (Poltronieri and Schleien, 2010). This study is described in detail in the guest essay.

How PICU design impacts visitor behaviors, staff patterns, and quality/safety measures

Laura Poltronieri, AIA

The pediatric critical care unit is an extremely high-stress area in any children's hospital. New physical models of care, specifically private patient/family rooms, are being designed to address issues of family-focused care, patient/family visual and acoustic privacy, decreasing lengths of stay, and infection control. These emerging private room models often pose challenges to clinical staff who are used to working in more open environments.

Clinical staff members frequently express concerns that private rooms may compromise care or endanger their pediatric patients because of their perception of reduced staff visibility and greater distances to patients. Some staff members have suggested that design of these new family-focused units may lead to increases in unplanned extubation rates. Staff members also frequently express the opinion that open-cubicle curtained bays are the safest physical model in which to provide pediatric critical care, because they believe that staff members have greater visualization and awareness throughout the unit and can be at the bedside quicker when an emergency occurs. This research study set out to determine if these ideas about the relative safety of various physical models of PICU design were in fact true.

Study approach

Phase 1 of this study attempted to examine whether staff concerns for patient safety in private room models are warranted. This IRB approved research study systematically examined three pediatric intensive care units, all within the Morgan Stanley Children's Hospital of New York. The fact that all three PICUs, each with its distinct physical configuration, occur within one floor level of three interconnected buildings afforded a unique opportunity to compare safety data as well as visitor and nursing activity across all three models.

The specific research questions posed by the study included the following:

- Patient outcomes and unit safety
  - Do self-extubation rates differ between the three units?
  - Do medical errors and adverse event rates differ between the three units?
- Patient length of stay
  - Does acuity adjusted length of stay differ between the three units?
- Staffing patterns
  - Does percentage of nursing time at the bedside vary between the units?
- Family presence
  - Does the amount of on-unit and in-room family presence differ between the three units?

The three different physical configurations observed included the following:

1. 14-bed open unit with cubicle curtained bays; each bay approximately 155 NSF.
2. 13-bed unit with sliding glass fronts and glazed side walls with inter-connecting glass doors; each bay approximately 230 NSF.
3. 14-bed unit with sliding glass fronts and solid (opaque) side walls; each bay approximately 270 NSF.

A sample total of 8,416 on-site observation events, conducted during the course of seven days and four nights, included detailed activity mapping of patients, families, and staff on all three PICUs. The aggregate data generated from this environmental mapping process underwent thorough statistical analysis by an academic statistician.

Study subjects

The study subjects involved were 137 pediatric inpatients who were observed in their hospital rooms during 11 observation periods on seven calendar days in spring 2010. Their median age was 24 months with 32 percent under 12 months, an additional 31 percent aged 12–71 months, 20 percent aged 72–179 months, and 17 percent 180 months and older; 48 percent were female. In each of these observation periods, data was collected every 20 minutes, with a mean of 27.8 observations per child over multiple periods.

Since most subjects were observed for more than one period ($M = 2.30$ periods), the mean across all observations was calculated for each subject, and these means were used in all subsequent analyses. All variables were screened for violations of assumptions for GLM.

Almost every variable showed substantial skewness and/or kurtosis. We therefore used non-parametric statistics to analyze all variables. The age variable showed particularly severe skew, so subjects were divided into the four age bands described above; this variable was used in all subsequent analyses. A series of independent-samples median tests (the non-parametric equivalent to a one-way ANOVA) showed significant differences between PICU units on virtually all variables.

Additional study process and protocols

In addition, this in-depth research project used numerous multivariable research protocols in combination with one another to generate a comprehensive understanding of the impact which various PICU design features have on patients, family members, and staff. Phases 2 and 3 of the study included the following:

- Analysis of five-year historical patient outcome data, including lengths of stay, adverse medical event reporting systems data, and unplanned extubation rates.
- Thirty-one nursing questionnaire responses provided by nursing staff from the three units under observation.
- Eighty-two additional nursing questionnaires distributed among PICU nursing staff of three other children's hospitals.

Data analysis

Some of the most interesting findings from the study include the following:

- Family and visitor presence was significantly higher on the two units with private rooms versus the open-bay unit with cubicle curtains. This increased visitor presence included greater total number of visitors, greater number of visitors present at one time, as well as visitors present for longer periods of time. There were also fewer instances of patients with no visitors in these two private room units.
- Nursing presence at the bedside was greater in both private room models than in the open bay unit.
- The private room PICU with solid side walls had lower ALOS, accidental extubation rates, and adverse medical events reported than the other two units.
- Nursing presence at bedside was greater in both private room models than in the open-bay unit, with by far the greatest nursing presence occurring in the unit equipped with inroom charting computers. Nurses reported that with inroom computers family members often complain that they cannot readily find their nurse when they are charting in another patient room on the unit.
- In the private room unit with glass side walls, the interconnecting glass doors and side cubicle curtains were closed and drawn during 100 percent of all observations, which called into question the necessity and additional cost of these component items.
- Cubicle curtains were most likely to be open in the private room models, and more likely to be fully drawn in the open-bay unit. This finding challenges nursing staff's belief that patient visibility is greater in the open-bay unit.
- Nurses from all four children's hospitals reported that it is more important to see patients' monitors than to see the patients themselves.

- When away from the bedside nurses reported that it is more important to visualize their co-workers than it is to visualize their patients or patient monitors.
- Based on observation, during code events, team rounding, and end-of-life care as many as 20 people may be present at the bedside. The private room unit with 270 NSF per bed was the only one with room size that allowed for the entire rounding team to be present at the bedside at one time.
- ICU patients occupying rooms with window seats were more likely to get out of bed.
- According to questionnaire responses, "views to outdoors" and "quality of natural light" were highly ranked by nurses as "contributing to the quality of care."
- Other key unit attributes that nurses felt affected quality of patient care include the following:
  - Convenient location of hand hygiene stations.
  - Soothing interior ambience.
  - Size of patient care area around the bed.
  - Amount of storage space at bedside for supplies and equipment.
  - Charting medical record order entry system.
  - Relationship of nurse charting station to patients.
  - Relationship of additional nurse work areas to patients.
  - Distance from shared supply and equipment areas to patients.
  - Amount of proximal on-unit storage space for supplies and equipment.

Collaboration acknowledgment

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5.2.3.2 NICU single family versus open-bay rooms

Of all the topics that have been studied and discussed over the past decade regarding NICU design, the impact of single family rooms (SFRs) is undoubtedly the most common. One of the primary motivators behind these studies has been to encourage parental presence in the NICU, and researchers have shown that parents who stay on the unit are more involved with their children's care than those who stay elsewhere (Wigert, 2010).

Parental involvement improves NICU patient outcomes. For example, sleep is critical to the NICU baby's health (Colombo and De Bon, 2011), and Morgan et al. (2011) found a 176 percent increase in autonomic activity and an 86 percent decrease in quiet sleep when mother and child were separated, as opposed to engaging in skin-to-skin contact. Parent speech also impacts the occurrence and number of vocalizations in preterm infants (Caskey et al., 2011). Multiple authors have discussed the positive impact of single family versus open-bay NICU designs on parental interaction (e.g. Bowie et al., 2003; Brown and Taquino, 2001; McGrath, 2005; White, 2003, 2004, 2011).

Rather than describing in detail the content of each of the SFR versus open-bay studies, Figure 5.2 summarizes a representative sample. In addition, the comments of Dr. Robert White (see guest essay) provide a clear description of the status of this topic. Most research supports the use of SFRs with the exception of Pineda et al. (2013), who noted potential negative neurodevelopmental outcomes for SFR babies. However, the outcomes may be the result of leaving babies alone in private rooms rather than the SFRs themselves.

Figure 5.2: *Examples of research on NICU single family rooms*

Citation	*Outcome measures*	*Conclusions*
Carter, Carter, & Bennett (2008)	Length of stay, environmental stimuli, access to caregivers, access to information, personal privacy	The SFR is perceived by parents to offer an improved spacious environment that is less overstimulating for the infant and themselves. Access to staff, information, and overall support appears to be improved in spite of a larger overall floor area.
DiFiori & Schirripa (2013)	Infection, parental outcomes, parental satisfaction patient outcomes	SR mothers more likely to breast feed; parents visited longer and were more satisfied. Infection frequency unchanged.
Domanico, Davis, Coleman, & Davis (2011)	PEMR, mortality and nosocomial events, discharge weight, lengths and head circumferences, respiratory and nutritional parameters, breastfeeding success, noise level, illumination, air quality	Infants in the SFR unit had fewer apneic events, reduced nosocomial infections, and mortality. More mothers sustained mature milk lactation, and more infants were discharged breastfeeding.
Greer & Black (2013)	Length of stay, costs, walking behavior, parent satisfaction, family overnight, visitors	Families in SFR NICUs were more satisfied.
Harris, Shepley, White, Kolberg, & Harrell (2006)	Space allocations, construction costs, staff preferences and perceptions, and occupant behaviors	SFR NICU design provides solutions for increasing parent privacy and presence, supporting Health Insurance Portability and Accountability Act compliance, minimizing the number of undesirable beds, increasing staff satisfaction and reducing staff stress.
Oelrich (2003)	Patient outcomes, ALOS, communication, staffing, infection	Good communication was found in the SFR. There was an increase in nosocomial infections at one site which may have been due to carpet or increased acuity.

Citation	Outcome measures	Conclusions
Pineda et al. (2013)	Hemispheric asymmetry, cerebral maturation, language development	Infants in SFRs had a diminution of normal hemispheric asymmetry, lower amplitude EEG maturation, and lower language scores at 2 years.
Rosenblum (2005)	Weight, days requiring TPN, infections	The SFR demonstrated higher weight gain, fewer days before parental nutrition, and fewer HAIs.
Shepley, Harris, & White (2008)	Job Satisfaction Scale, Nurse Stress Scale, Satisfaction and perception of physical environment	SFR NICU design may increase staff satisfaction and reduce staff stress.
Shepley, Harris, White, & Steinberg (2008)	Behavioral observation of families	More frequent interactions were found in open-bay units, but longer interactions in SFRs. Recommended that open-bay units provide spaces for longer encounters, and that SFRs provide spaces that allow for spontaneous encounters.
Smith, Schoenbeck, & Clayton (2009)	staff perceptions and performance	Rankings of overall physical environment, patient care, job, technology, and off-the-job quality significantly improved in the SFR, but evaluations of patient care team interaction significantly declined. No meaningful changes from results were found up to 22 months afterwards.
Smithgall (2010)	HRV (heart rate variability), cardiac interbeat intervals, continuous electrocardiogram	The single private room encourages parental access to infants but does not impact maternal stress.
Stevens, Helseth, Khan, Munson, & Smith (2010)	Quality of employment, quality of work environment, quality of patient care, job quality in NICU, health and safety, safety and security, interaction with NICU team, interaction with technology, off-job quality of life, overall satisfaction	Staff perceptions of workplace quality were significantly higher in the SFR than the open-bay NICU. Exceptions were some aspects of health and safety, nature of interaction with NICU teams, and off-job quality of life.
Swanson, Peters & Lee (2012)	Teamwork, communication, development, facility, safety, and privacy	Advanced practitioners reported higher teamwork, but nurses did not. Nurse satisfaction initially higher in SFR, but declined.
Walsh, McCullough, & White (2006)	Observations of the nurses guided by a questionnaire identifying benefits, risks, and patient safety concerns	SFR is thought to be more effective for patient care and parent satisfaction compared to open bay. However, nurses believe success depends on sufficient staff, due to decreased patient visibility and longer distances. Large units present quality improvement, communication, and staff training challenges.

how might we increase feelings of teamwork among nurses working in SFRs?

Securing the benefits of single family rooms

Robert White, MD

The transition to private rooms (perhaps more appropriately termed single family rooms) in the NICU has taken longer than in other areas of the hospital, for a variety of reasons. Administrators have been reluctant to give large expanses of real estate to a discipline formerly housed in a much smaller area, clinicians were reluctant to surrender the ability to have all their patients and colleagues within visual range, and valid questions lingered about the safety and value of private rooms in the NICU, where proven adult benefits such as a reduction in falls and improvement in patient satisfaction might not apply. To be sure, there are significant pros and cons to private rooms in the NICU. Proven benefits include increased family participation (Carter et al., 2008), presence (Carter et al., 2008; Pineda et al., 2012), and satisfaction (Stevens et al., 2011) with a concomitant improvement in infant length of stay (Ortenstrand et al., 2010), chronic lung disease (Orstenstrand et al., 2010), and apnea (Domanico et al., 2011). Babies may also benefit from a reduction in noise and risk of infection (Domanico et al., 2011). Caregivers generally consider private rooms beneficial to babies, families, and themselves (Smith et al., 2009; Stevens et al., 2010). Privacy for families is clearly improved, but this can be a double-edged sword, as both families (Pineda et al., 2012) and caregivers (Smith et al., 2009) can experience a sense of isolation and stress. This may even be true for babies, whose verbal development may be delayed in a private room setting if the family is not present most of the day.

Securing the benefits of private rooms while avoiding the hazards is both a design and operational challenge, one that has been successfully achieved in a number of pioneering NICUs. Two key elements of the design strategy are outlined below.

Design places and programs that encourage families and staff to gather

Collaboration is difficult in a NICU with private rooms arranged on either side of a long hallway with no central gathering area for staff or families (Smith et al., 2009). Identifying a small area at the end of the hallway with a window, comfortable seating, and liquid refreshments will allow families to meet casually near their babies' rooms without having to leave the unit. Perhaps they need to leave the room while the baby is having a procedure, but want to come right back when it is done. Or perhaps the baby is sleeping but they want to be nearby when he or she wakes up, or if the doctor comes by on rounds. Leaving the area to go to a family lounge or waiting room isn't nearly as attractive as having a place very near their baby's room.

For staff, "fly-by" or decentralized stations outside the rooms are convenient, but miss the fact that NICU nurses depend on team work – starting an IV, retaping an ET tube, orienting a new staff member – and the need for collaboration is an important medical need, and we learn from the social sciences an important psychological need as well. Ideally, private rooms would be arranged in clusters, or neighborhoods, that have "homes" (private rooms) for babies, "places of business" (nursing stations) for staff, and "parks" (general gathering areas) for both. For staffing purposes, these neighborhoods should be no fewer than eight beds, and preferably 10 to 12 beds so that a single nurse

won't be responsible for the entire cluster when one of her colleagues has to leave the area (Walsh et al., 2006).

Provide options

Private rooms are not ideal for everyone. A family with twins or higher order multiples whose parents would like them to be in the same room is an obvious example. Babies whose parents rarely visit may be another example, especially when they are in cribs and could hear human voices from elsewhere in a multi-bed room but would be isolated with little verbal stimulus in a private room. Nils Bergman also points out that in many parts of Africa, being placed in a private room is the equivalent of solitary confinement – culturally, privacy is not always valued as highly as being part of a community, even during breast-feeding or similar activities that many Westerners would prefer to do in private.

The ideal unit design, then, provides options. Does the family prefer to stay in a private room with their baby(s)? There should be enough private and twin rooms with family space that supports their presence 24/7 to accommodate this. Likewise, there should be shared space for babies whose parents visit rarely and don't stay long when they do come, or babies whose parents would prefer to be in a room with a few other babies and families. Operationalizing this depends somewhat on the total bed number and on the configuration of the space available. In a hypothetical 40-bed unit, one might design two four-bed rooms for unrelated babies and the occasional higher order multiples, four twin rooms (this number will be very dependent on the unit's experience with twins – more in hospitals with an active infertility program, fewer in free-standing children's hospitals), and the remainder as private rooms.

One final option that should be considered, if permitted by the state's codes and certificate of need process, is to design some or all of the private rooms with enough space and headwall capacity for one critically ill infant which could also serve two intermediate infants in an overflow situation.

It is vitally important to recognize that private rooms by themselves are not the source of good neonatal outcomes. Extended, intimate human contact, especially with the parents and most especially with the mother, is crucial to optimal neonatal outcomes (White, 2011). Babies in a unit that is well designed, but where staff fail to fully encourage parental participation in care, will not experience their full potential.

References

Carter, B.S., Carter, A., and Bennett, S. (2008). Families' views upon experiencing change in the neonatal intensive care unit environment from the "baby barn" to the private room. *Journal of Perinatology, 28*, 827–829.

Domanico, R., Davis, D.K., Coleman, F., and Davies, B.O. (2011). Documenting the NICU design dilemma: Comparative patient progress in open-ward and single family room units. *Journal of Perinatology, 31*, 281–288.

Ortenstrand, A., Westrup, B., Brostrom, E.B., et al. (2010). The Stockholm neonatal family-centered care study: Effects on length of stay and infant morbidity. *Pediatrics, 125*, e278–e285.

Pineda, R.G., Stransky, K.E., Rogers, C., et al. (2012). The single-patient room in the NICU: Maternal and family effects. *Journal of Perinatology, 32*, 545–551.