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Single-Family Room Design in the Neonatal Intensive Care Unit—Challenges and Opportunities

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The trend toward single-family room (SFR) design in the neonatal intensive care unit (NICU) has been driven by a growing understanding of the developmental needs of preterm infants, a desire to provide environments that support and encourage family participation, and infection control considerations. SFR design offers many potential benefits, but also requires substantial change in the NICU culture, as well as additional space and technology when compared to an open ward. The advantages and drawbacks of the SFR design are reviewed, and strategies are offered to assist those who are considering construction or renovation of an NICU.

Keywords: NICU design; NICU environment; Single-family room NICU; Family-centered care

The open ward concept has been preserved in the neonatal intensive care unit (NICU) long after it was abandoned in other inpatient areas of the hospital. There are many good reasons for this, some of which remain valid, but most can no longer be invoked. In this article, we will explore the reasons single-family rooms (SFR) are growing in popularity as new NICUs are being built and discuss how the desirable features of the open ward can be incorporated into SFR design in order to maximize benefits to babies, families, and caregivers alike.

Why Change?

Benefit to Babies

The most compelling evidence that has driven the interest in SFR design is the increasing awareness of how important the sensory environment is to the premature newborn who is in a critical stage of brain growth and development.^{1,2} During the third trimester, the infant's brain increases in mass by 400%, comparable to the 400% growth seen in the entire period from term to adulthood. Most neurons are formed by the end of the second trimester, but only limited dendritic connections are present. These proliferate during the third trimester in all areas of the brain but especially in the auditory cortex, where learning of phonemes and voice inflection is already taking place.^{3,4} The fetus is primed to receive multisensory input from the mother—

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smell, taste, tactile, pain, movement, temperature change, light, and auditory input are all detected and elicit a response in the fetus, and in the preterm infant as well. In the open ward setting, even when the baby is in an incubator, many of these sensory stimuli are different in character, timing, and context than they are in utero. To some extent this is unavoidable, but the presence of the infant in an open ward, where shielding from activity in the adjacent bed space with its attendant noise and lights is incomplete at best, is now understood to be less than optimal from a developmental standpoint.

A second benefit to babies offered by SFR design is increased access to their parents, especially for intimate contact including skin-to-skin care. Although it is possible to facilitate skin-to-skin care in an open ward, both space and privacy issues limit many parents from taking full advantage of this technique. SFR designs have been shown to enhance parental interaction with the baby⁵ and caregivers.⁶ It is not difficult to imagine how uncomfortable some parents (especially fathers) might be to sing a lullaby, read a children's story, or discuss sensitive matters with the medical staff in an open ward, or how much more likely this would be to occur in the SFR setting. Evidence for the value of skin-to-skin care in particular is now growing rapidly,⁷⁻⁹ and it is also intuitive to understand how much more suitable the mother's arms would be than the incubator or warming bed with regard to all the desired sensory stimuli.¹⁰

Finally, SFR design offers significant potential value to infants for infection control. Hospital-acquired infections remain a major cause of death, disability, and cost in premature babies. The initial all-private room NICU was constructed in the 1980s in Brest, France, for infection control purposes and recent pandemics of severe acute respiratory syndrome and influenza, as well as local outbreaks of methicillin-resistant *Staphylococcus aureus* and multiple-resistant Gram-negative bacteria, have emphasized the importance of considering this an important issue in NICU design. Hospital-acquired infection has been reduced in the adult setting through the use of private

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rooms,¹¹ and since it is now clear that the incubator is an insufficient barrier to acquisition of nosocomial organisms, the SFR is an attractive way to address this problem.

Benefits to Families

The interest in SFR design has also been driven to a large extent by the evidence that families benefit from this environment in comparison to the open ward. Increased parental satisfaction in a SFR is clear, but families have also been found to participate more actively in medical discussions^{5,6} and become more comfortable and competent in the care of their infants. Clinical experience has shown that families feel more welcome in the SFR setting, and they perceive that their babies receive better care. Although families can certainly individualize the bedside area to some extent in an open ward, the SFR setting greatly enhances this tendency, with families embracing the opportunity to make the room home-like and personalized.

Single-family rooms also address the difficult issue of privacy that has always been an ethical responsibility but has now also become a legal responsibility since the introduction of Health Insurance Portability and Accountability Act regulations. Although privacy can be protected to some extent in open ward NICUs, there are still sometimes unavoidable breaches that would not occur if the family was in a private room.

Benefits to Caregivers

While SFR design has potential drawbacks for staff (which we will discuss in greater detail in the next section), it presents benefits as well if designed properly. With good design, nurses and other caregivers are provided a space where their needs for a supportive sensory environment-which are quite different from those of the baby-can be met. While they are at the bedside, of course, the sensory environment must be first of all suitable to the needs of the baby, but increasingly many elements of care (eg, charting, preparation of medications and feedings, team report) can and in many cases should be performed away from the bedside. In these areas, lighting (especially daylight and access to nature), sound (eg, conversation, music), and other stimuli that would not be appropriate at the bedside can be allowed and even encouraged to the extent that it improves the well-being and performance of caregivers. Like families, caregivers appreciate and will readily take advantage of the opportunity to personalize their work environments.

Challenges Presented by SFR Design

Communication/Safety

Open-ward NICU design was essential in the era before central monitors and wireless technology became available. The ability to hear monitor alarms, visualize babies easily and continuously, and communicate readily with colleagues were vital to proper neonatal care. Although technology is now available to assist in these needs, it is not yet optimal.

"Baby-to-nurse" communication refers to transmission of alarms from monitors that track physiological parameters in the baby, as well as alarms from medical equipment such as ventilators, IV pumps, incubators, and more. Monitor information can now be sent from a baby's bedside to a monitor at any other bedside, to a central monitor, as well as to a wireless communication device carried by caregivers. These devices can be programmed to also send monitor information to other caregivers in the NICU if the primary caregiver is unable to immediately respond. Currently, though, most medical devices cannot be networked with the monitor alarms, so an "infusion complete" or "occlusion" alarm from an IV pump, or alarms of similar importance from ventilators and incubators are readily transmitted only by auditory means. Although this situation would rarely endanger an infant (if an infant was in immediate danger, parameters from the monitor such as heart rate or oxygen saturation would also go into alarm mode), it does create significant anxiety for caregivers and family members and noxious auditory stimulus to the infant if the alarms are not immediately recognized.

"Nurse-to-nurse" communication is taken for granted in an open ward NICU-it happens naturally and almost continually, and of course includes respiratory therapists, physicians, and other medical professionals. It even goes beyond verbal communication; visual cues allow us to tell when a colleague needs assistance, or even information as simple as who is working with us at the moment. In the SFR, this level of constant communication is necessarily impaired, to what extent, is a function of design and will be discussed more extensively in the next section, but it is always an issue. Wireless technology now allows us to be in immediate contact with everyone else on the medical team and even tells us where they are located. It can actually enhance some aspects of team communication, such as that between staff and management, from one shift to another, and with other departments in the hospital.

"Family-to-nurse" communication is also very easy on a superficial level in an open ward, but more extensive, personal conversations are clearly enhanced by the SFR setting.⁵ A challenge in either setting is the appropriate venue for teaching rounds. While work rounds that may include only a few members of the medical team and the family are facilitated by the SFR,⁶ bedside rounds that involve large numbers of the medical team have drawbacks in both the SFR and open ward settings. One approach utilized successfully in many adult, child, and neonatal units is to separate the direct care planning and teaching functions, holding the latter rounds away from the bedside. This is less intimidating to families, less likely to detract from the baby's environment, and allows teaching points to be made that might be inappropriate at the bedside.

"Family-to-family" communication occurs with less frequency but greater intensity in the SFR NICU than it does in the open ward.⁵ Good design and family support programs such as those offered by the March of Dimes can assure that these opportunities are productive, but require active involvement of someone with the responsibility for family support to insure that they occur.

To some extent, all of these communication issues have an impact on patient safety, which relies both on good alarms as well as good communication amongst the medical team and between the medical team and the family. Visibility is a particular challenge with SFR design, as are the inherently increased distances between beds and from beds to unit support areas.

Cost

Construction costs of SFR NICUs have been estimated to be 5% greater than comparable open ward designed NICUs. Usually more space is designated at the bedside for family support and storage of frequently-used supplies and less space elsewhere in the NICU for these functions than in an open ward. Of equal or greater concern is the question of whether ongoing costs, especially for labor, are higher in the SFR NICU; this question is less easy to quantify. Most SFR NICUs built in the United States in the last 10 years have not changed their nurse–baby ratios, although a few have required an increase in nurse staffing, and a few have also needed an increase in support staff. On the other hand, if SFR design can reduce hospitalacquired infection, increase family participation, facilitating earlier discharge in some cases, and improve neurodevelopment of the infant, SFR might actually reduce health care costs.

Design and Operational Strategies to Maximize Benefits of the SFR NICU

Layout

The most critical feature to successful SFR design is to carefully identify central gathering areas for staff and families that have easy visual and physical access to clusters of at least 8 and preferably 12 or more rooms, as well as ready access to daylight and support areas. This is very difficult to accomplish with gross square footage (total floor space, including support areas, divided by the number of beds) of less than 500 square feet per bed or in a structure which is relatively long and narrow. Optimal square footage to avoid undesirable compromises to some aspects of care is usually around 750 gross square feet per bed; this could be somewhat more or less depending on the services housed and the flexibility of the building footprint.

Design of the SFR itself typically includes a family area at the rear of the room, a patient care space in the center of the room, and an area for handwashing, charting, supplies, waste containers, and other support materials at the front of the room. This layout provides privacy for the family, maximizes space available for care of the infant, and allows for easy stocking and removal of materials without disturbing those in the room. Whereas typical floor plans of NICUs show only an infant bed in each care area, good design requires that the care area be designed to facilitate the ongoing presence of the family at the bedside, ideally in skin-to-skin contact with all but the most unstable infants. When this is anticipated in the floor plan and in mockups, implications for the location of outlets, supplies, and lighting will be evident.

The family area should be a place where one or both parents can sleep, rest, relax, and work comfortably. The provision of a bathroom in each SFR is controversial; so is the availability of a TV or DVD player, although these devices have great potential for education, relaxation, and allowing families to stay in touch with the outside world, and can be used with headphones to avoid an adverse impact on the infant.

The front portion of the room also deserves careful attention. Is the sink large enough to permit good scrubbing, without counters or items nearby that could be contaminated by splashing?^{12,13} Can supplies be stocked and trash and soiled linens be removed easily and quietly? Is it easy to see what is going on in the room from a central point but also possible to provide visual privacy when needed?

There are a number of other design features, both of the SFR and the NICU as a whole that should be planned carefully,¹³⁻¹⁵ but those are not unique to the SFR design and are beyond the scope of this paper.

Communication/Safety

As noted earlier, technology is now available to support good communication where physical and visual access are limited. Several problems remain, though, that require careful planning. Because of the need to hear non-networked alarms, rooms should be designed so that this sound can be transmitted to the central nursing area when the SFR door is open without other barriers or competing noise that could interfere with the ability of the nurse to hear the alarm. In some situations, though, (e.g., an infant in an open crib or skin-to-skin without medical devices, hospice care, or 1:1 nursing), closing the door could be acceptable and even desirable. The "nurse call" button should be easily accessible both to parents who may be holding the baby at the bedside and to caregivers at any point of care; this might require two such buttons in some settings.

Personal communication devices used by nurses should be easy to use in a hands-free mode both for convenience and for infection control purposes, and should not themselves be a source of noise. With convergence of technology, it is also feasible that these devices could soon provide visual access to the SFR and the infant bedside.

Operational Strategies

SFR design facilitates extensive family presence and involvement in care, and also requires recognition of aspects of collaborative nursing care that were common but often not formalized in open ward designs. Anticipating the need for policies that support family involvement and collaborative nursing care then, becomes part of the planning for SFR design and can even benefit from some level of implementation long before the new NICU is built. For example, the elements of collaborative nursing as currently practiced should be reviewed, compared with a vision of what would be optimal, and then steps taken to move in that direction. If caregivers typically help one another during an IV start, when weighing an infant, or when performing respiratory care, how can that teamwork be formalized in a way that provides the least stress for the infant, and the greatest efficiency for the staff? Is there a role for families to help in such cases? If responding quickly to saturation alarms is important to limit complications of oxygen toxicity or deprivation, how can caregivers best assist one another, and empower parents to become a part of the care team in this regard? Further consideration of these topics is beyond the scope of this paper but presents fertile ground for future discussion and clinical research.

Does It Really Matter?

Clear evidence that SFR design improves the outcomes for babies is still lacking. Surveys done in SFR units show that the great majority of families prefer the SFR and that most nurses believe it is the best environment of care for the infant.¹⁶ A comprehensive study is underway at Women & Infants Hospital of Rhode Island to evaluate the long-term impact on infants cared for in an SFR compared to those treated in an open ward. In the meantime, the best evidence currently available comes from Sweden, where a randomized controlled trial of 365 families showed that preterm infants cared for in a setting where the family was present and providing skin-toskin care on an almost continuous basis required approximately 5 days less of intensive care, on average, and were discharged home 5 days earlier than those who were cared for in an area where parents were welcome at all times but their overnight stay was quite limited. Skin-to-skin care was instituted in both groups but particularly facilitated in the group that had continuous access for the parents.¹⁷ This group is planning to obtain long-term follow-up of these infants, but even the short-term data would indicate that significant costsavings can be derived by designing and operating a NICU where the environment of the baby and parents is more nurturing than the open ward design would allow. This may be an important step to the era where parents are accepted as full partners in the medical team.

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