

## Single-Room Neonatal Intensive Care: State of the Practice

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### Abstract

Of the many challenges facing professionals who practice in neonatal intensive care in the United States, the question of what type of facility is optimal has been debated for more than a decade. We have attempted to explore this question at Sanford Children's Hospital in Sioux Falls, SD. The purpose of this article is to briefly summarize our work and other significant research findings regarding neonatal intensive care unit (NICU) room design. At this time, the single-room NICU is comparable, and possibly superior, to the open-bay NICU with the caveat that the on-going developmental needs of the neonate must be continuously assessed and appropriate interventions applied in their on-going NICU care.

**Keywords:** Evidence-based NICU design; Single-family room NICU

### Background

Since 1980, the new methods of care, technology and surgical techniques have resulted in dramatic improvement in survival, particularly for tiny neonates and those with surgical disorders. The approximate margin of viability has dropped from 1 kg and 28 weeks gestation to less than 0.5 kg and 22-23 weeks gestation. The introduction of artificial surfactant in the late 1980s had a great impact upon supporting tiny neonates with respiratory distress syndrome [1]. The subsequent approval of inhaled nitric oxide for the treatment of pulmonary hypertension of the neonate was another method of support which dramatically reduced the use of extracorporeal membrane oxygenation and has enhanced survival [2].

As survival improved, concern regarding the long-term neurologic development of neonatal intensive care unit graduates has heightened. In the 1980s, researchers [3,4] described the synactive theory of care, in which assessment of the neonate's behavioral state is used to determine how care could be provided in a manner to diminish physiologic stress. Subsequently, a number of investigators focused on the potential adverse impact of environmental factors upon the developing neonate. Prominent in this list were exposure to intense and constant illumination [5,6] and the associated inability to develop a normal circadian rhythm [7] in an environment that never had night. Further, exposure to both intermittent and continuous noise was felt harmful to the developing neonate [8]. Additional adverse factors include painful tactile stimulation, odor and known issues with temperature regulation. Control of all of these factors was deemed important while continuing to support family involvement with family-centered care [9].

Because most of the early publications were anecdotal, or descriptive in nature, our group undertook the opportunity to conduct research on the NICU environment in conjunction with the construction of a state of the art 27,000 ft<sup>2</sup> 58 bedded single-family room (SFR) NICU between 2003 and 2006. We incorporated the most recent recommendations and standards for NICU design [10,11] into planning. The planning process was extensive and multidisciplinary, involving all levels of care providers (physicians, nurses, therapists), administrators, technical personnel, architects, contractors, vendors, and parents of NICU babies. This process allowed us the unique opportunity to conduct an investigation of cohorts of neonates, parents and staff members who received and provided care in the traditional open-bay (OBY) and in the new SFR NICU.

### Summary of the Recent Literature

Our initial findings indicated that with the SFR design we were able to reduce the ambient illumination and noise levels to those recommended [12]. The noise level in the vacant rooms met the criteria of <45 dBA (decibels on the A-weighted scale which best estimates human hearing), which approximates the noise in a residence. However, the level of noise in the functioning NICU was not reduced, primarily due to the constant noise of respiratory equipment operating at levels of 45 to 65 dBA, which is roughly the level of conversational speech.

We demonstrated significantly improved parental satisfaction with care in the SFR NICU compared with the OBY NICU using a commercially available parent satisfaction survey [13]. The perceptions of all NICU staff members (physicians, nurses, therapists) in regard to care and working conditions were significantly better in the SFR NICU [14]. One exception was that the sense of isolation expressed by

nursing staff in the SFR NICU was greater than in the OBY NICU. This finding has been affirmed by other investigators [15]. For nursing staff, the number of neonates assigned per shift and the total acuity of care per shift remained the same in the two facilities; however, additional staff were required in the SFR NICU to assist with the management of equipment and stocking of supplies in individual rooms [16].

In a detailed analysis of over 3000 NICU admissions to the two facilities, no significant differences in adverse outcomes of care (death, severe intraventricular hemorrhage, chronic lung disease, retinopathy of prematurity requiring laser ablation surgery) were found when the analysis was controlled for a variety of clinical characteristics [17]. Finally, in a very detailed analysis, the average cost of care in the SFR NICU was less than the OBY NICU [18]. Shepley et al. developed a business plan for a hypothetical SFR NICU based on the decreased length of hospitalization reported by Ortenstrand et al. [19] in Sweden and our data reported above [18] and projected that the increased cost of building a SFR NICU could be recuperated within the first year of operation [20].

We were unable to demonstrate significant differences in clinical outcomes of care, such as length of hospitalization, incidence of chronic lung disease or rate of intraventricular hemorrhage, between the two facilities. One exception was that in a very small cohort of neonates, sleep time was significantly increased by as much as 2.5 hours per day in the SFR NICU [16]. It is important to note that aggressive developmental care practices were in place in both of our units. Both NICUs had a full time developmental therapist and a number of trained nurses who made recommendations for developmentally appropriate care and positioning. These interventions likely impaired our ability to measure potential differences in many outcome comparisons.

Ortenstrand et al. [19] was able to demonstrate a significant reduction in the length of hospitalization in neonates of <30 weeks gestation in a unit with family-centered care and single-room design. Lester et al. [21] demonstrated improved outcomes of care in a SFR NICU; however, the improvements were related to enhanced maternal interaction and enhanced developmental support for the neonates rather than the environment.

All of the findings regarding the SFR NICU have not been as positive. Pineda, et al. [22] reported the potential for increased stress in mothers in the SFR. This group also reported the finding of lower verbal developmental scores at two years of age in neonates in the SFR [23]. The authors acknowledge that visitation by parents in the SFR environment was limited, possibly biasing the results.

### Summary of Recommendations for NICU Design

In the United States today, it appears that there is much information supporting the use of the SFR NICU for care of the small preterm neonate. The literature supports its effectiveness, safety and that is not more costly. Patient outcomes are equivalent to those of the OBY NICU with the caveat that ongoing parental involvement and a program of developmental support with trained staff and therapists is in place. In instances where active parental involvement is not possible, a multiple-bed setting may be developmentally preferable, especially for stable neonates. A change to SFR NICU care is a major undertaking which must involve detailed multidisciplinary input and the facility must be customized for the local care practices, staffing patterns, finances and space available.

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