



# Impacts of the Design of a Neonatal Intensive Care Unit (Single-Family Room Care and Open-Ward Care) on Clinical and Environmental Outcomes

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## Abstract

Preterm birth has been increased over the last two decades, thus leading to higher admissions of preterm infants to the neonatal intensive care units (NICUs). The design of NICUs may have several consequences for the health of infants, parents, and staff. In addition, it has gone through numerous changes in recent years, including the single-family room (SFR). The purpose of this study was to investigate the effects of using SFRs in the NICUs on the environmental (outcomes related to NICU environmental features) and clinical outcomes of the infants. Further, the present systematic review study was based on English papers about utilizing SFRs in the NICUs published during 2012-17. The papers were collected by searching the keywords “neonatal intensive care unit”, “single-family room”, “preterm infants”, “parents’ perspective”, “staff’s perspective”, “infant outcomes”, and “open-ward care unit” in ISI, Scopus, PubMed, Science Direct, Google Scholar, Magiran, and OVID database. The findings showed that applying SFRs improves clinical and environmental outcomes and that the staff and parents have a positive attitude toward this method. Besides, it costs the same as or even in some models less than the open-ward method and is considered a cost-effective method. Although a consensus may not be achieved on some issues such as maternal stress, language and motor development, intellectual maturation, and to some extent nurses’ satisfaction, in general, using the SFR in the NICUs enhances clinical and environmental outcomes and there is a positive attitude towards this method.

**Keywords:** Open-ward care unit, Parents’ perspective, Preterm infants, Single-family room

## Introduction

Low-birth weight and preterm birth, as major health problems, are among the most important causes of mortality over the world. Approximately 9.6% or 12.9 million births in the world are considered preterm (1). These preterm infants face various problems including respiratory problems, low-weight, feeding difficulties, neurological disorders, and the like. In addition, around 50% of the infants weighing less than 1 kg suffer long-term neurological problems and serious health issues (2). Further, preterm birth has increased over the last two decades because of issues such as gestational stress, lifestyle, addiction, alcohol consumption, work pressure, the consumption of prohibited medications during pregnancy, and the like (1,3-6).

A preterm infant is a baby who has not completed 37 weeks of the gestation period (6-9). The approximate number of Iranian preterm infants is reported at 9%-11.8% (1) and many of these infants are admitted to the neonatal

intensive care units (NICUs). Because of the sensitive nature of the provided services, these units benefit advanced technologies and mostly cost a lot (1,8,9). On the other hand, the reduction of neonatal mortality is one of the most essential goals of the healthcare system.

Various studies show that a service provision of this unit greatly affects neonatal health outcomes. Neonatal care units are extensively changed and different models are proposed for neonatal-perinatal care such as couplet care, family-integrated care, specialized care, and group-care (10). According to some studies (1,8), NICUs are currently designed in an open ward or single-family room (SFR).

An open ward comprises four large rooms (75-128 m<sup>2</sup>) with 8-12 beds in each room and is lighted with fluorescent lamps. The standard distance between the beds is around two meters. Furthermore, the environmental measures to reduce the stimulants include low-light lamps, incubator cover, noise reduction, minimizing loud noises in the unit,

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and parental education on the need in order to reduce the sensitivity (11).

Similarly, family rooms are private places that provide the conditions for both parents to take care of their preterm infants (12). These rooms were first used in 1994 and gradually became more common up to 2003 when around one-third of newly established NICUs used such rooms. This went up to near ½ of the units from 2011 to 2014. Recent studies suggest that using SFRs improves the quality of the services while reducing the complications following the preterm birth (8).

The present study reviewed the published papers (2012-2017) on the implementation of SFRs in the NICUs.

## Methods

The current comparative review study evaluated the papers published between 2012 and 2017. In comparative research, the paradigms under the study are identified and the state, experiences, and characteristics under the study are assessed and extracted accordingly. Since no study has investigated the use of the SFR care in providing preterm infants with intensive care in Iran and given the need to investigate the empirical experiences of other countries, the contraceptive method was used for the in-depth review of the paradigms under study.

In this retrospective research, sixteen papers, published from 2012 onwards on SFR care and improvement in preterm infants admitted to the NICUs, were collected by searching the keywords such as “neonatal intensive care unit”, “single-family room”, “preterm infants”, “parents’ perspective”, “staff perspective”, “infant outcomes”, and “open-ward care unit” in ISI, Scopus, PubMed, Science Direct, OVID, Google Scholar, and Magiran databases.

The papers related to the implementation and use of SFRs in the NICUs addressed different aspects of the effects of this unit that can be generally divided into 2 categories as follows.

*Category I:* The relationship between SFR care model and clinical outcomes such as improvement in maternal and neonatal health outcomes, including neonatal weight gain, reduced hospital-acquired infection, the need for medical procedures, pain level, stress and tranquility in such conditions, as well as environmental outcomes like noise and light control following the introduction of SFRs to the NICUs.

*Category II:* The perspective of the staff or parents or both on the use of SFR model.

In this study, 80 papers were found in the above-mentioned databases. After eliminating the duplicates and irrelevant papers, the remaining 16 papers were analyzed and classified according to the above categories. The results of the studies were then compared in each category and the similarities and differences were pointed as well. A summary of these results is presented in comparative tables.

These tables were used to analyze and compare the data

following the categorization of papers and the extraction of their results. In other words, such tables compare the dimensions which were obtained from these studies.

## Results

The database search yielded 80 papers on the NICUs and 75 papers remained by eliminating the duplicates. Fifty papers were not related to the SFR and 9 papers out of the remaining 25 papers were excluded on the account of not reporting the effects of using SFR (Figure 1). Finally, 16 papers were selected, the contents of which were related to reports regarding the effects of using SFR. These papers included 5 cohort, 5 review, and 5 questionnaire-based studies, along with 1 quasi-experimental study. In addition, they addressed the effects of using SFRs in the NICUs at two major levels as follows.

*Category I:* The relationship between this care model and maternal and neonatal health outcomes (i.e., neonatal development outcomes) including neonatal weight gain, reduced hospital-acquired infection, the need for medical procedures, pain level, stress, and tranquility in such conditions.

Ten papers were reviewed in this category (Table 1), which addressed the clinical outcomes following the use of SFR regarding taking care of preterm infants in the NICUs (Table 2).

In a paper entitled “*Single-family room care and neurobehavioral and medical outcomes in preterm infants*”, Lester et al examined the factors related to the improvement in the clinical and neurological outcomes of preterm infants who were admitted to the SFR. This a prospective cohort study investigated the clinical and neurological outcomes of preterm infants weighing less than 1.5 kg from 2008-2012. They studied 151 and 252 preterm infants in open wards and SFRs, respectively, and found that service providers in the SFR improved

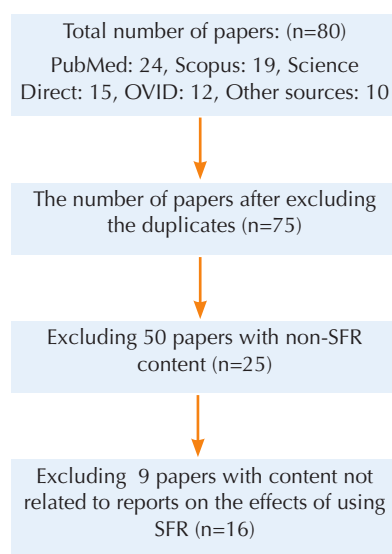


Figure 1. Database Search Strategy and Results.

**Table 1.** The Studies Reviewed in the First Category

Design	Country	Author/Date
Cohort	USA	Barry M. Lester/2014
Quasi-experimental	USA	RG Pineda/2012
Cohort	USA	Dennis C. Stevens/2012
Review	USA	Dennis C. Stevens/ 2015
Cohort	USA	RG Pineda/2014
Cohort	USA	Barry M. Lester/2016
Review	Iran	Marzieh Shahheidari/2012
Review	USA	Michael S. Dunn/2016
Review	USA	MM Shepley/2014
Cohort	USA	RH Pickler/2017

**Table 2.** Outcomes Investigated in the Reviewed Literature

Clinical outcomes:
Chance of autism
Language score
Motor score
Cerebral maturation
Cerebral injuries
Need for medical procedures
Intravenous hemorrhage
Maternal tranquility
Length of stay
Weight gain
Improved oral feeding
Sepsis
Hospital-acquired infections
Environmental outcomes:
Lighting
Noise
Staff and parents' perspective:
Parental satisfaction
Staff satisfaction
Parental privacy

the neurological and clinical outcomes of preterm infants such that those admitted to the SFR had a better weight when discharged. Other related outcomes were less need for medical procedures, better weight gain, less sepsis, less physiological stress, low hypertonicity, greater tranquility, and a lower level of pain. The findings suggested that the cause of difference lies in the need for medical procedures, stress, pain, the mother's presence, and greater attention to infants during the treatment procedure. Nurses were also reported to have a positive attitude towards the environment and working conditions in this method (2).

Pineda et al compared neonatal and maternal outcomes in open wards and SFRs. They studied 81 preterm infants in open wards (n=39) and SFRs (n=42) and observed no significant differences between the 2 groups respecting the prevalence of brain injuries, initial medical severity, an hour of intubation, the presence of sepsis, patent ductus

arteriosus, and necrotizing enterocolitis. In addition, the stress level of mothers with infants in the SFR was higher compared to those with infants in the open ward although the only positive point about the SFR in this study was increased parent visitations (13).

Likewise, Stevens et al evaluated the state of the practice of SFRs and open wards at this hospital. Two open wards and 45 SFRs were studied and the results indicated that the noise level was lower in the SFR than the open ward, the lighting reduced in the SFR and nursing workrooms. Further, the staff and parents were more satisfied with the working environment and care, respectively (14).

In another review study, Stevens et al assessed the state of the practice of this ward at Sanford Children's Hospital. According to this paper, the use of SFRs at this hospital provided better and more suitable services than the open ward. Moreover, sound pollution was lower in these rooms, parents were more satisfied, and the staff had better attitudes towards the ward apart from the sense of isolation. However, no significant difference was found between the open ward and the SFR in terms of clinical outcomes such as the time of discharge, the prevalence of pulmonary infection, or intravenous hemorrhage. The only improved outcome in the SFR group was the increased sleeping hours of the neonates (9).

Pineda et al in their study investigated the differences in the clinical outcomes of preterm infants hospitalized in the NICUs (open ward and SFR). This prospective cohort study was conducted on 136 infants (<30 weeks gestation) during 2000-2010. Two types of outcomes were examined, including the condition of the infants at two years of age by Bayley Scales of Infant and Toddler Development as the primary outcome, followed by the secondary outcomes encompassing clinical factors during hospitalization, as well as neurological and cerebral injuries. Furthermore, less normal hemispheric asymmetry and lower cerebral maturation scores were recorded for the infants of the same age at the SFR. At the age of two, infants who were in the SFR had lower and motor scores (15).

Moreover, Lester et al examined the clinical outcomes of 18-month-old infants (123 and 93 infants in SFR and open ward, respectively) while focusing on maternal involvement. They were divided in terms of low/high maternal involvement, breast/bottle feeding, and maternal care. Additionally, the infants in the low/high maternal involvement were evaluated based on language and motor scores, as well as Bayley cognitive scale and autism screen. Based on their findings, infants in the SFR benefited higher maternal involvement and had higher language and Bayley scores compared to those with lower maternal involvement. Similarly, the length of stay was shorter with higher maternal involvement and the chance of infants with the symptoms of autism was higher in the open ward with lower maternal involvement. In general, the findings of this study demonstrated improvements in neurodevelopmental outcomes in infants benefiting

higher maternal involvement (16).

In a review paper Shahheidari et al. addressed neonatal clinical outcomes and the attitudes of families and staff. This review study encompassed publications from 2001-2011 and compared SFR and open-ward NICUs in 12 studies. Factors related to the improvement of clinical outcomes increased privacy and parental involvement in patient care. These would improve the outcomes such as infection control, noise control, improved sleep, the reduced length of stay, and reduced rehospitalization. However, nurses represented no positive attitude towards SFRs because of the increased workload (17).

In addition, Dunn et al investigated this treatment method. Based on their findings, this method decreased hospital-acquired infections while increasing parental and neonatal comfort and privacy. Parents and the staff also had a positive attitude towards this method in most of the centers adopting this method (18). Further, Shepley et al indicated that SFR improves the outcomes and parental privacy and costs extremely less than the open wards (19). In another study Pickler et al examined 87 preterm infants. Their data included 5111 and 5809 feedings in the open ward and the SFR, respectively, and the findings suggested that light and noise levels in the SFR were significantly lower compared to the open ward. Feedings were performed 3 times a day at 9 AM, 12 PM, and 3 PM. The improvement of feeding levels was directly related to higher levels of light and noise, and as a result, feeding improved more significantly in the open wards (20).

*Category II: Staff and parents' perspective on SFR service provision.* Six papers were reviewed in this section. These studies were mostly conducted as a survey or questionnaire-based studies one month before introducing SFR in the NICUs and 6-8 months after its implementation (Table 3).

Stichler addressed the history of NICUs from the parents and nurses' viewpoints about SFRs in a paper entitled. Accordingly, some of the nurses showed no positive attitude toward this type of caring method and believed that it puts the infants at risk because they cannot monitor the infants in SFRs similar to the open wards. Other nurses indicated that stress and tension were lower for both parents and nurses by using this method. They also declared that infants in the open wards are isolated by the covers in the open wards and nurses should rely on the monitoring alarms. As a whole, there was no

consensus among the nurses on this issue. As for the parents' views, all the reports suggested that the increased parental involvement in caring for their babies, as well as the increased privacy created a positive attitude towards the SFR among the parents (21).

Hogan et al assessed the views of NICU nurses before and after the establishment of the SFR-NICU through interviews and surveys among the nursing staff. Their results showed an increase in workload and isolation. On the other hand, given the improved conditions for both infants and parents and the positive impact of SFR on patient outcomes, the nurses were satisfied with this method thus this could mitigate the negative impact of nursing workload and isolation (22).

In addition, Swanson et al examined parents and staffs' perception of SFR care. They surveyed the parents and staff 6 months before and 1-8 months after SFR implementation. The questionnaires measured five categories including "teamwork, communication, development, safety, and privacy" with scores ranging from 0 to 10. In the open ward, both parents and staff were satisfied with the teamwork. Further, the specialist doctors had higher scores in relation to teamwork one month after the implementation while nurses reported low scores regarding teamwork and safety whereas showing higher scores in other categories. However, the specialists' scores represented no change after the implementation. On the other hand, nurses were satisfied with the SFR 1 month after its implementation while this diminished 8 months later. Generally speaking, parents were more satisfied compared to the staff. The researchers argued that parental satisfaction was mainly focused on their infants than the facilities, and the nurses' lower satisfaction with the SFR care was probably due to the decreased communication with their colleagues (3).

In their paper entitled "*Improvements in staff quality of work life and family satisfaction following the move to single-family room NICU design*", Watson et al investigated parents and staff's views about SFR care. They measured parental satisfaction and the quality of work life of the staff prior to and two times following the implementation of SFR care. Accordingly, the quality of the staff's working life and parental satisfaction improved at both times after the implementation (23).

Bosch et al evaluated the views of staff on the SFR in their study. Based on their results, from their perspectives, these private rooms improved the quality of the work environment for the staff, along with the quality of the treatment environment and safety for parents. They also reduced workplace stress for the staff while increased parental and neonatal privacy (24).

In a short note, Stevens et al asserted that new evidence suggests improved noise and light control, as well as staff and parental satisfaction in the SFR-NICU. The cost of SFR is lower compared to the open wards and this method has not so far shown unwanted consequences (25).

**Table 3.** The Studies Reviewed in the Second Category

Design	Country	Author/Date
Questionnaire-based	USA	Stichler 2012
Questionnaire-based	USA	Christy Hogan/2016
Questionnaire-based	USA	JR Swanson/2014
Questionnaire-based	USA	Jo Watson/ 2012
Questionnaire-based	USA	Sheila Bosch/2014
Review	USA	Dennis C. Stevens/2014



The current discussion is summarized in Tables 4-6.

## Conclusions

Overall, the present study reviewed 16 papers (10 papers on clinical and environmental outcomes and 6 papers on staff and parents' perspective). Considering the data in Tables 4, 5, and 6, it can be concluded that although no consensus may be built about some cases (e.g., maternal stress, language, and motor scores, intellectual maturation, and even nurses' satisfaction), using SFR-NICUs undoubtedly improves clinical and environmental outcomes.

Regarding other clinical and environmental outcomes in addition to staff and parents' perspectives, the attitude toward the SFR is considered positive. On the other hand, the SFR costs the same as or even in some models less than the open ward method (9,25,26). However, further research is required in this field because of the ambiguities about the impacts of using SFR-NICUs on the above-mentioned indices.

**Table 4.** Clinical Outcomes (Category I)

Clinical Outcomes	Number of Papers Reporting Increased Impacts of Clinical Outcomes	Number of Papers Reporting Decreased Impacts of Clinical Outcomes
Pain		1
Maternal stress	1	1
Sleep	2	
Chance of autism		1
Language score	1	1
Motor score	1	1
Cerebral maturation	1	1
Cerebral injuries		1
Need for medical procedures		1
Intravenous hemorrhage		1
Maternal tranquility	1	
Length of stay		1
Weight gain	1	
Improved oral feeding	1	
Sepsis		1
Hospital-acquired infections		2

**Table 5.** Environmental Outcomes (Category I)

Environmental Outcomes	Increase	Decrease
Noise	2	
Light	2	

**Table 6.** Staff and Parents' Perspective (Category II)

Relevant Factors	Increase	Decrease
Parental satisfaction	5	
Staff satisfaction	3	2, relative decrease
Parental privacy	3	

## Conflict of Interests

Authors have no conflict of interests.

## Ethical Issues

The study was approved under the ethical code of IR.USWR.REC.1396.252 and IRCT20180125038502N1.

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