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**Architectural design, facilities and family participation in neonatal units in Spain: a multicentre study.**

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**Author statements.** LCR and CRPA had primary responsibility for protocol development and survey design. GSG, LCR, ACR, MTMP and CRPA contacted the participants and gathered the

data. GSG and LCR analyzed the data, GSG wrote the initial draft of the manuscript, that was critically reviewed and modified by LCR, SPB, ACR, MLM, MTMP and CRPA.

**List of abbreviations.**

NICU: neonatal intensive care unit

NIDCAP: Newborn Individualized Developmental Care and Assessment Program.

VLBW: Very low birth weight

SFR: single-family rooms.

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**Abstract (200 words).**

**Aim.** To evaluate the architectural design of neonatal units in Spain and its impact on the participation of parents in neonatal care.

**Methods.** Observational, multicentre study including level III Spanish neonatal units. A web-based survey was conducted, including questions about hospital and NICU data, architectural design, facilities and family participation.

**Results.** 63 neonatal units were included. Most units (55, 87%) had part or all the intensive care patients located in open bay units, while 34 units (54%) had at least one individual patient cubicle. Single-family rooms, defined as those including enough space and furniture for family members to stay with the infant without restrictions, were available in 8 units (13%). Eighteen units (29%) had a structured program of family education or parental courses. Units that had single-family rooms were more likely to have parental participation in rounds ( $p<0.01$ ), safety protocols ( $p=0.02$ ), FiO<sub>2</sub> management ( $p<0.01$ ) and nasogastric tube feeding ( $p=0.02$ ), as well as to allow siblings to participate in kangaroo care ( $p<0.01$ ).

**Conclusion.** Widely variable architectural designs and policies can be found in Spanish neonatal units, with most units not offering single-family rooms. The presence of single-family rooms may impact the participation of parents in neonatal care.

**Keywords:** NICU design, evidence-based design, developmental care, family integrated care.

**Key Notes.** The architectural of neonatal units plays a key role in the success of these developmental strategies. In this survey based study, most Spanish neonatal units were found to lack an optimal structure for parents to stay in the unit without restrictions. This, according to our data, may impact the participation of families in neonatal care.

## Introduction

Prematurity remains the leading global cause of death and long-term disability in children,<sup>1</sup> and despite the increase in survival over the last decades, preterm infants are still at high risk of neurodevelopmental challenges.<sup>2</sup> In extremely preterm newborns, admission to neonatal intensive care units (NICUs) extends for their first months, during which a key phase of brain development takes place,<sup>3</sup> and disturbances in this period, mediated by clinical instability but also a suboptimal environment, have long-term adverse consequences.<sup>4,5</sup>

Developmental strategies have been shown to be effective in improving cognitive and motor outcomes in preterm populations<sup>6</sup> and have gained importance in the NICUs in recent decades. The participation of families in neonatal intensive care has important neurodevelopmental and nutritional benefits for infants, and also improves parental stress and anxiety<sup>7,8</sup>, but the implementation of these practices can be challenging and presents training, staffing and architectural barriers.<sup>9,10</sup>

The design and architecture of neonatal units plays a key role in the implementation and success of these developmental strategies. Room sizes are important for the facilitation of bonding and family experience<sup>11</sup> and noise and light levels can impact infant wellbeing and neurodevelopment<sup>12</sup>. Single-family rooms, defined as those including enough space and furniture for family members to stay and live with the infant without restrictions during the admission, promote communication with families, infection control and adequate sleep, with a direct impact on cognition and speech outcomes<sup>13</sup>. However, the structural design of neonatal units is frequently outdated and rarely responds to developmental practices. There is little evidence about the architectural design of European NICUs and about the impact of this design on the participation of families in preterm care.

The aim of this study was to assess the architectural design of neonatal units in Spain and to evaluate the impact of this design on the participation of parents in neonatal care.

## Methods

This was an observational and multi-centre study based on a national survey examining the architectural principles of neonatal unit designs. Given the design and lack of patient involvement, the study was waived of approval by the Research Ethics Review Board of Hospital Universitario 12 de Octubre (Madrid, Spain).

The survey was sent on February 2023 to all Spanish level III NICUs, defined as those belonging to the Spanish public healthcare system and admitting preterm newborns of at least 28 weeks (IIIA 28 or more weeks, IIIB less than 28 weeks and neonatal surgery, IIIC less than 28 weeks, neonatal and cardiac surgery, ECMO, pediatric transplant), as per official data provided by the Spanish Ministry of Health. All level III Spanish NICUs are perinatal hospitals, all of them are university hospitals, and all of them admit both preterm and term infants, although in different proportions depending on their level of care.

The survey consisted of a web-based form, with 48 questions organized in 4 sections: general hospital and NICU data, NICU architectural design, facilities and practices, and family participation in neonatal care. The questions included information about the hospital setting and volume of patients, construction dates and renovation; information about the unit and levels of care, design of the unit and rooms including intensive care and intermediate care, kitchen, restroom – shower, rest and sleep areas for staff and families, and extended family / sibling access to the unit. The survey included multiple-choice and open-ended questions. The questionnaire was designed jointly by a neonatologist trained in developmental care and an architect specialist in neonatal unit architecture.

A link with the survey was sent via email to all the directors of the participating units. Email reminders were sent twice to all units that did not give a response, and data were collected from February to September 2023. The answers to the survey were self-reported by the

receiving physicians, and quality of responses was assessed by the survey designers, with additional clarifications requested to the participating hospitals if needed.

A descriptive analysis of the data was performed summarizing the individual responses, using proportions and percentages for categorical variables, and means and standard deviations for quantitative variables. Comparison between different units were made for outcomes regarding participation of parents in neonatal care, using bivariate analysis with Pearson's chi square.

Statistical analysis was performed with SPSS (IBM SPSS Statistics, Chicago, IL, USA, v23.0).

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## Results

Sixty-three neonatal units responded to the web based survey (response rate 63/78, 81%). All 17 Spanish regions with level III units were included in the survey. All included units were considered level III, among which 17 (27%) were IIIA, 35 (56%) were IIIB, and 11 (17%) were IIIC. Response rates were 74% for IIIA, 80% for IIIB, and 100% for IIIC, respectively. The delivery volume and number of admissions are summarized in Table 1. Figure 1 shows the year of initial building and renovations of the 61 units from which information was available.

Regarding the architectural environment and organization of the unit, only 15 units (24%) were part of a separated children-maternity hospital, while the remaining 76% were part of a general hospital. Individual patient cubicles, defined as those individual spaces separated by fixed architectural structures, were available in neonatal intensive care in 34 units (54%), but only 7 units (11%) had 3 or more of them. Single-family rooms were available in neonatal intensive care in 8 units (13%), of which 5 were IIIC hospitals. In 55 units (87%) most patients admitted to the NICU were located in open bay areas with multiple patients. Families had a specific common room for having meals in 36 units (57%) and in 35 units (56%), there was a shower available for parents in the parental washrooms. Only in 8 units (13%) there was a parental sleep room available in the hospital, while 9 units (14%) offered a hotel or out of hospital accommodation for families. Up to 25 units (40%) provided meals for at least one of the parents while the infant is admitted in the unit.

Only 18 units (29%) stated that they had a structured program of family education or parental courses. Table 2 summarizes the specific responses regarding different kind of participation in neonatal care and educational resources.

When asked about a hypothetical new design for their units, 24 respondents (38%) stated that they would choose a unit with all individual cubicles, all single-family rooms or a combination of both, while 38 (60%) said they would prefer a mix of individual cubicles, single-family rooms

and open bay rooms with multiple patients. Some of the reasons stated to choose designs with single-family rooms, individual cubicles or a combination of both were to better integrate families, to individualize care and improve parents and professionals' satisfaction, to improve bonding and breastfeeding, to reduce pre discharge parental anxiety, to give parents more privacy and more autonomy when caring for their infant, to reduce neonatal pain and discomfort, and to humanize the neonatal intensive care.

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## Discussion

Our study described the architectural designs of Spanish NICUs. The survey results showed that their layouts are variable, and that the majority of NICUs have not had the opportunity to be refurbished to promote developmental and family-centered care. Most of the units do not have individual cubicles or single-family rooms, and support for families is suboptimal. The results of the survey suggest that this could have an impact on the participation of parents in neonatal care.

The importance of NICU architectural designs has been increasingly recognized in the literature over the last years. A systematic review of the literature, including mostly observational studies, was published by O'Callaghan et al in 2019,<sup>14</sup> suggesting single-family room design as optimal for neonatal units. These rooms, according to a study by Domenico et al,<sup>15</sup> can lead to improved breastfeeding rates, better infection and noise control, reduced lengths of stay and even improved neonatal morbidity and mortality. Single-family room designs were also reported to improve parental satisfaction and facilitate developmental and family-centered care.<sup>16</sup>

In our country, this is the first study to describe the architectural designs of neonatal units on a national level. A previous single-centre study described the implementation of a family-integrated care model in Madrid<sup>17</sup> and how the unfavorable architectural design of the unit at the time, without single-family rooms, was one of the barriers to this implementation.

Regarding the Newborn Individualized Developmental Care and Assessment Program (NIDCAP), a prior multi-center survey-based study in Spain<sup>18</sup> showed that 78% of NICU professionals who participated believed that modifying the architectural space was crucial for the successful implementation of NIDCAP. Unfortunately, our findings suggest that most of these structural modifications have not taken place, which may be preventing NICUs from providing optimal developmental care. As stated in the results of this survey, family participation in newborn care

is also suboptimal, and the units with individual cubicles or single-family rooms are the ones with higher rates of parental participation in NICU care.

In other European countries, some studies have also described architectural practices and structural barriers to the implementation of developmental programs. A qualitative study with interviews conducted in Norway, Sweden and Netherlands, three of the European countries with longer tradition of neonatal developmental practices, described that the physical environment and facilities in the ward had an important role in family-centered practices, stressing the perceived importance for families of having a private bathroom, a kitchen or a place to sleep in the hospital<sup>19</sup>, which as shown in our results is uncommon in the Spanish setting. An observational study<sup>20</sup> focusing on a survey to Swedish NICUs published in 2019 showed that, similarly to what we have described, most of the units did not provide meals nor opportunities for other family members to visit, and only around half units provided a bed/room to stay for parents. Another international study<sup>21</sup>, including mostly European NICUs and focused on facilitators and barriers for parent-infant closeness, described similar findings, with single-family rooms, kitchen, bathroom or comfortable chairs mentioned as key facilitators, but most units not having single-family rooms, and parents unfrequently participating on rounds and mother-infant separation being very common.

One of the advantages of modifying the architectural spaces is to facilitate parental presence and participation, which has been shown to improve outcomes. Lester et al<sup>22</sup> demonstrated in a quasi-experimental study that single-family room designs improved medical and neurobehavioral outcomes, mediated by increased maternal involvement and developmental support. In a previous study by our group<sup>23</sup> it was described that the admission of patients in single-family rooms was associated with parents spending more hours per day with them and recognizing signs of infant stress and pain faster. We also found that units with this kind of

architectural designs had increased parental involvement and support, but we did not have access to outcome data to confirm whether this results in better neonatal outcomes.

Our study has some limitations that must be acknowledge. First, our survey was aimed only at Spanish hospitals, and the conclusions may not be applicable to other countries and healthcare systems. Second, the survey was self-reported, so there could be some inaccuracies in the collected data. Third, we did not have information about institutional culture, staff training or patient ratios, and we did not include parental perspectives, all of which would have given us a different and important insight to the topic. Fourth, the questions about family involvement in care were not very extensive or detailed, and the association between this and architectural variables does not guarantee causality. Moreover, the statistical associations made between architectural layouts and parental participation do not necessarily indicate causality, and it is possible that hospitals that have had possibilities and funding to renovate their architecture and build single-family rooms might also had more opportunities to develop family and developmentally oriented practices. More studies are needed about structural and architectural design of neonatal units, and more clear guidelines should be developed by neonatal institutions to improve the standards applied to the design of these units.

We can conclude that Spanish neonatal units have widely variable architectural designs and policies, and most units do not provide single-family rooms. The facilities for families and possibilities to stay at the hospital are suboptimal in most units. The presence of architectural features such as single-family rooms may impact the participation of parents in neonatal care.

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Characteristics		Frequency (%)
Number of deliveries	<1500	15 (24%)
	1500-3000	33 (52%)
	3001-4500	10 (16%)
	4500-5000	5 (8%)
Admissions, total	<500	39 (62%)
	501-1000	14 (22%)
	>1000	8 (13%)
Admissions, intensive care	<200	36 (57%)
	200-400	19 (30%)
	401-600	3 (5%)
	>600	1 (2%)
Admissions, VLBW infants (<1500g)	<10	4 (6%)
	11-30	26 (41%)
	31-50	10 (16%)
	51-70	8 (13%)
	>70	12 (19%)

Table 1. Total deliveries and admissions in included units. VLBW: Very low birth weight.

<b>Family participation or education, survey items</b>	<b>Results, overall</b>	<b>SFR</b>	<b>No SFR</b>	<b>p-value</b>
Parents may participate in daily rounds.	13/63 (21%)	5/8 (63%)	8/55 (15%)	<0.01
Parents may participate in diaper changes.	51/63 (81%)	8/8 (100%)	43/55 (78%)	0.14
Parents may dress their infant with own clothes in NICU.	31/63 (49%)	6/8 (75%)	25/55 (46%)	0.12
Parents may participate in patient safety protocols.	24/63 (38%)	6/8 (75%)	18/55 (33%)	0.02
Parents may participate in nosocomial sepsis prevention protocols.	35/63 (56%)	7/8 (88%)	28/55 (51%)	0.05
Parents may participate in pain prevention and treatment.	34/63 (54%)	6/8 (75%)	28/55 (51%)	0.20
Parents receive education in kangaroo care in order for them to be autonomous and transfer the infant to kangaroo.	28/63 (44%)	6/8 (75%)	22/55 (40%)	0.06
Parents may participate in FiO2 management.	8/63 (13%)	4/8 (50%)	4/55 (7%)	<0.01
Parents may feed their infants through NG tube.	24/63 (38%)	6/8 (75%)	18/55 (33%)	0.02
Siblings may participate in kangaroo care (consented by parents).	10/63 (16%)	4/8 (50%)	6/55 (11%)	<0.01
Grandparents and other family members may participate in kangaroo care (consented by parents).	28/63 (44%)	5/8 (63%)	23/55 (42%)	0.27

Table 2. Responses to parental participation and education in different areas of care. P-value for univariate analysis comparing units with and without any single-family rooms (SFR)

**Figure 1.** Cronobuilding® of Spanish level III NICUs, including opening and renovations . Colours refer to the year of building (yellow, prior to 1965; green, 1966-1985; purple, 1986-2001; blue, 2002-2022). The abbreviation n.a. refers to not available data.

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