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A Broad Study to Develop Maternity Units Design Knowledge Combining Spatial Analysis and Mothers' and Midwives' Perception of the Birth Environment

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Abstract

Objectives: This article investigates how the physical birth environment is perceived by the users (women and midwives) in different settings, a midwife-led unit and an obstetric-led unit, placed in Italy. **Background:** In the field of birth architecture research, there is a gap in the description of the spatial and physical characteristics of birth environments that impact users' health, specifically for what concerns the perception by women. **Methods:** The study focuses on multi-centered mixed methods design, employing both quantitative and qualitative research methods (questionnaire, spatial analysis) and covering different disciplines (architecture, environmental psychology, and midwifery). **Results:** The results revealed significant differences between the two settings and some associations between perceived and spatial data concerning: calm atmosphere, greater intimacy, spacious birth room, clarity of service points, clarity in finding midwives, sufficient space for labor, noise, privacy, and the birth room adaptability. **Conclusions:** The findings confirm the importance of the spatial layout and indicate documented knowledge as an input to consider when designing birth spaces in order to promote user well-being.

Keywords

labor and delivery units, qualitative research, research tools, space syntax, healthcare design, spatial analysis, midwife-led unit, obstetric-led unit, birth space, built environment

It is widely recognized, mainly by researchers, that the physical environment can influence health outcomes by affecting the behavior, physiological processes, experiences, and interactions of its users (Andrade et al., 2016; Del Nord, 2006; Nickl-Weller & Nickl, 2013; Ulrich et al., 2008). This relevance of the environment has been increasingly discussed also in relation to childbirth. Indeed, the configuration of birth

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spaces, at both unit and birth room scale, appears to play an important role in maternity cases, though at times it is underestimated in practice (Folmer et al., 2019; Foureur et al., 2010; Nilsson et al., 2020; Shaa & Setola, 2019).

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Many studies show the importance of considering the birth environment as one of the elements impacting users' health, especially women's health, in the short term and long term (Foureur & Harte, 2017; Nielsen & Overgaard, 2020; Setola et al., 2018; Skogström et al., 2022). Literature considers the health of mothers and newborns in its all-embracing definition of state of complete physical, mental, and social well-being (Engel, 1977; WHO, 1948). In particular, perinatal well-being has been conceptualized as a dynamic, complex, and multidimensional process (Wadephul et al., 2020).

Users' health issues concern many aspects that contribute to the all-embracing definition of health and well-being: They range from measuring unnecessary intervention rates in childbirth (WHO, 2018a) and epigenetic studies (Uvnäs-Moberg et al., 2020) to the evaluation of women's birth experiences (Nilvér et al., 2017) and gathering information on women's needs (Migliorini et al., 2019; Slomian et al., 2017). In each of these fields, the physical environment can play a positive or negative role in supporting the physiological process of birth and women's experiences. The spatial–functional and psycho-sensory characteristics of the birth spaces are therefore capable of influencing health outcomes, that is, they are able to encourage or inhibit physiological birth by limiting intervention rates (Aburas et al., 2017, Foureur et al., 2010b).

The spatial–functional and psycho-sensory characteristics of the birth spaces are therefore capable of influencing health outcomes.

The user's perception of the space is part of their experience. Several studies underline the need to investigate the perceptions and attitudes of users of healthcare environments in order to plan future environmental interventions by capitalizing on what users wish to see in the environment and also to determine the success of a hospital design that might satisfy users' needs (Andrade et al., 2012; Douglas & Douglas, 2004).

As stated by the World Health Organization (WHO), while much is known about the clinical management of labor and childbirth, less attention is paid to what, beyond clinical interventions, needs to be done to make women feel safe, comfortable, and positive about their birth experience (WHO, 2018b). Meeting women's psychological and emotional needs should be as important a goal of the care provided as ensuring optimal clinical outcomes. As a consequence of a woman-centered philosophy, women have the right to choose from many care options and birth settings which have been shown to positively impact on women's experience of childbirth (Migliorini et al., 2019; Overgaard et al., 2012).

In many European countries such as Italy, the place of research, or Australia, a variety of birth settings reflect the healthcare and organizational model. Women can choose to give birth in the obstetric-led unit (OLU) inside the hospital, in the midwife-led unit (MLU) also called the birth center, run by midwives which can be situated inside and outside the hospital, or at home and in maternity homes (Stark et al., 2016). The options depend on women's needs, risks, and choices (Henshall et al., 2016; Hodnett et al., 2012).

Moreover, the last WHO guidelines (WHO, 2018b) emphasize the importance of favoring the physiological process of childbirth in all settings. Architecture can contribute to the implementation of physiology by creating spaces that promote activities encouraging healthy and physiological behaviors, such as moving around freely during labor (Hammond, 2015; Lepori, 1994), assuming different positions (Lawrence et al., 2013), personalizing the room configuration (Hammond et al., 2017), relaxing (Foureur et al., 2011; Hauck et al., 2008), regulating indoor comfort (Igarashi et al., 2014), and finding a protected and intimate space (Carolan-Olah et al., 2015; Fahy & Parratt, 2006).

In the field of childbirth architecture research, more studies on the physical characteristics of

birth environments that impact users' health are needed (Setola et al., 2019). In particular, studies on users' perceptions and interdisciplinary research focused on the architectural design of the birth environment are needed to enrich the knowledge and evidence of this topic.

Another key point relates to the lack of tools capable of supporting professionals, from healthcare managers to architects and designers, in the planning, organizing, and designing of birth spaces. There are some country-specific official guidelines (AusHFG, 2017; Department of Health, 2013; FGI, 2018), but they do not take into account certain characteristics of the built environment which are proven to influence the birth experience for stakeholders (Joyce, 2021).

This work is part of a broader study investigating how the spatial and physical characteristics of the birth environment are perceived by key users (women and midwives) in two different settings in order to identify the best physical birth environment that foster the well-being and experience of mothers. The data of midwives have been collected to better understand mothers' experience from midwives' point of view. The research sought to identify some items of the built environment which are experienced as crucial in different settings as they affect the physiological process of birth and women's experience. The items derive from the "building spaces" of the scoping review concerning Western countries by Setola et al. (2019) which are (Figure 1):

- the presence of a filter between the birth room and the other spaces, which can promote intimacy and privacy;
- the size, shape, and configuration of the birth room, which assist with movement and different positions during labor;
- the position of the midwives' desk, which supports care and safety;
- the configuration of the unit, which can foster a calm atmosphere and facilitate orientation for users; and
- the presence and role of social spaces in the unit.

The physical interpretation of these building spaces, through the analysis of spatial and physical characteristics, partially fill the gap in architectural knowledge regarding tools for professionals able to support the childbirth experience from the design perspective.

Method

Study Design

This study is part of a broader research project on the users' perception of birth environment. The present work involves different disciplines that join and interweave different methods and analyses to provide an understanding of the complexity of this experience. The interdisciplinary approach combines quantitative data (derived from self report questionnaire and geometrical and configurational analysis) and qualitative data (derived from open-ended questions and field observations) from the fields of Architecture and Environmental Psychology, with the support of Midwifery and Health Sciences scholars in an advisory role.

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A multi-centered mixed methods design was chosen for this research to enable an in-depth exploration of the relationship between the users' perception of the environment and the spatial and physical characteristics of the birthplace.

According to multiple case study approaches (Stake, 2005; Yin, 2014), each environment was conceptualized as a "case" providing multiple sources of evidence (Proverbs & Gameson, 2008). Case studies are particularly helpful in understanding the internal dynamics of a context, and including multiple cases might enable an exploration of how a specific environment could influence the users' perception.

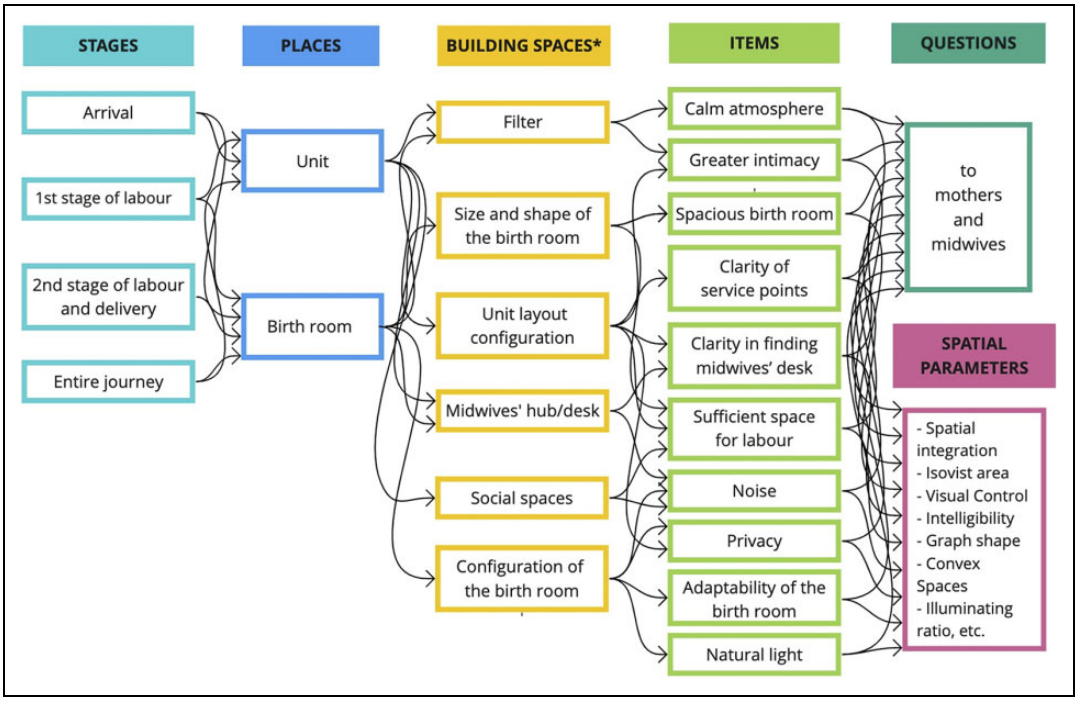

Figure 1. The logic behind the construction of the Birth Environment Spatial Perception Questionnaire. [a] The term "building space" refers to single functional spatial units, their spatial relations (visibility, proximity, accessibility, and permeability), and the physical environment characteristic that define them (dimension, shape, topology, envelope walls, auditory, and lighting environmental surroundings; Setola et al., 2019).

Furthermore, according to the idea that the multiple key informant data collection improves the validity of research projects (Wagner et al., 2010), we collected data on both women's and professionals' perceptions of the birth environment to better understand mothers' experience.

Interdisciplinarity regarding methods, data, analyses, and languages is certainly a relevant feature of the research process because it promotes integration and a more complex understanding of social issues (Szostak, 2002). The integration started at the beginning of the study, with the joint drafting of the questionnaire, and continued up to the findings, which were displayed and discussed together with midwifery scholars to integrate the perceptive and spatial analyses.

Figure 2 shows the main steps of the research and its interdisciplinary nature: identification of the spatial parameters and the joint drafting of the questionnaire on spatial perception, administration of the *Birth Environment Spatial Perception (BESP) Questionnaire* in parallel with spatial data collection, the perceptive and spatial analyses, and finally the comparison and interpretation of data carried out together.

Settings

The study was carried out in two birthplaces in two teaching hospitals located in Italy, reflecting diverse healthcare and organizational models and with significantly different spatial layouts and physical characteristics of the environment.

The first unit type, representing the Case 1 setting, was an OLU where care is provided by a team of midwives and doctors to high- or low-risk women. The labor and birth ward is situated inside the hospital, on the second floor, next to the postnatal ward and operating theaters. The labor ward is characterized by the standardized load-bearing structure of pillars which imposes a rectangular

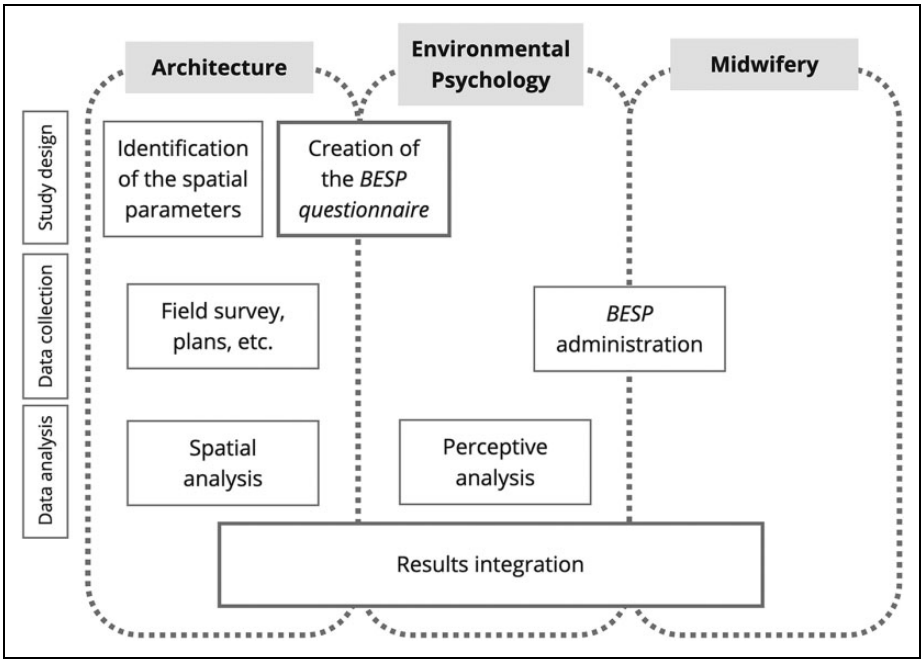

Figure 2. Interdisciplinarity in research steps.

layout and a long corridor with rooms on each side hosting the main flow of traffic. The midwives' station is situated in one of these rooms, quite central to the entire unit, and supported by dedicated areas, such as a monitoring area, visiting room, triage, neonatal room, restroom for staff, storage rooms, and so on. The six Labor, Delivery, and Recovery (LDR) rooms, from which mothers are moved into a separate postpartum room following the birth, are typically rectangular and centered around the bed, surrounded by the necessary equipment, and have an en suite bathroom and resuscitation room on the side. The rooms, which are quite spacious, have a window overlooking the outside and two of them have a birthing pool. For the plan, see Figure 8.

The Case 2 setting is an alongside MLU, where midwives are responsible for ante, intra, and postpartum care. It offers care to women with straightforward pregnancies who decide to give birth physiologically. It is situated on the first floor of an independent two-floor round building, linked to the maternity building by a corridor directly connected to the OLU, Neonatal Unit and Caesarean Section theater in case women or babies need to be transferred. The circular system of the layout expands from a central space where the midwives desk is located and around which there are five Labor, Delivery, Recovery, and Postpartum (LDRP) rooms where mothers spend their entire stay, and various other functions, such as a kitchen for families and staff, a neonatal room, a restroom for staff, a triage room, so on. The five rooms have a home-like feel, with an en suite bathroom, double bed, birthing pool, furnishings that foster physiologic birth and emergency equipment hidden within the furniture and skylights, which guarantee limited access to natural light. The third and outer ring of the birth center is a wide, bright corridor with large windows overlooking the landscape outside. This represents the flow for visitors who can enter the rooms directly from a secondary entrance, but also a social space where they can wait, walk, and exchange experiences. For the plan, see Figure 8.

Participants

One hundred twelve individuals (66 low-risk women, 46 midwives) participated in the

quantitative study; they were selected from the MLU (50) and the OLU (62). The initial research design also included the involvement of the partners/supporters in the collection of data on perception. However, scarce completed questionnaires by partners/supporters did not allow sufficient data to be included in the study, and this category of user is excluded from the results. The team chose to collect data of the key users; however, the midwives' (and partners') point of view was included to better understand mothers' experience that is the focus of the paper.

Only women whose pregnancy was identified as straightforward were selected, according to local protocols at the time of entry into the chosen facility (MLU or OLU). Exclusion criteria have been considered: lack of knowledge of the Italian language, lack of access to means to compile online questionnaires, under 18 years of age or over 43 years. The mothers had an average age of 35.1 years and 48% were primiparous. The midwives had an average age of 42.5 years and had worked on average for 17.2 years.

Data Collection

This research used the online survey method for quantitative data collection.

The objectives and the voluntary nature of the study were explained to the midwives during a meeting and to mothers during their stay after birth. After informed consent was obtained, a link to fill out the questionnaire online was provided to those (mothers and midwives) who joined the research.

The mothers had to complete the questionnaire within 3 months of the birth. This period was chosen because in literature, it represents a particularly delicate time in which the woman is focused on her child and on the definition of her new identity as a mother (Perun, 2020). In addition, the accuracy of the memory of an event tends to decrease after this time interval (Mazzoni, 2011).

The midwives were advised to choose a suitable moment when they were free to fill in the questionnaire that would not interfere with the care and needs of the mothers in the postnatal periods.

The study was conducted after obtaining the approval of both the local hospital Ethics Committees. The data collection procedure was in line with the Research Ethical Code of the Italian Association of Psychology and the ethical recommendations of the Declaration of Helsinki, as well as the American Psychological Association standards for the treatment of human volunteers.

The tool used in this work (*BESP Questionnaire*) is part of a broader survey that collects different measures related to the affective quality attributed to environment (Russel et al., 1981), spatial humanization (Fornara et al., 2006), and delivery experience (Fenaroli & Saita, 2013). The survey consisted of online self-report questionnaires comprising several constructs with various items and was designed by using the application "survio.com." Completing the questionnaire by participants took an average of 30 minutes.

In this article, we present only the results of the *BESP*, the questionnaire created specifically by the research team to explore the connection between the built environment and the users' experience in different birth settings to guide maternity design.

Furthermore, for the spatial data collection, plans of the two units were collected and various field surveys were undertaken in the two contexts, with photos, observations, and additional metric surveys.

BESP Questionnaire

The creation of a specific—ad hoc—questionnaire arises from the need to investigate specific items of the built environment connected to specific behaviors, feelings, and emotions related to the physiology of childbirth (Olza et al., 2018). In the absence of an appropriate existing tool capable of detecting some particular spatial and physical characteristics of the maternity environment, the research team decided to design an ad hoc questionnaire as the most suitable tool for its research purposes.

As a consequence, the research team chose to deepen these spatial and physical characteristics through targeted questions in the questionnaire. The *BESP* was built by both Architecture and

Environmental Psychology researchers to satisfy the assumptions and objectives of the research.

Figure 1 explains the logic behind the construction of the *BESP Questionnaire*. Each question derives from an organized framework of items set up by the researchers to better formulate the question for the two categories of users and focus their attention on the perception of specific environmental issues.

First of all, the questionnaire presents the questions following the stages of the stay, from arrival to the first and second labor stages, and on to the entire journey. Furthermore, each question specifies the place it refers to the entire unit or the birth room in which the mothers delivered. The "building spaces," taken from a study of the literature (Setola et al., 2019), represent the macro area of the birth setting identified by the study as crucial for the design of the birth environment and in need of better investigation. To do so, various items were identified according to the time, place, and physical interpretation of the "building spaces." The 10 items, quantifiable thanks to the identification of the spatial parameters, were then translated into appropriate questions, which were slightly different for mothers and midwives in order to see if the specific items could have a correspondence in perception.

The *BESP Questionnaire* (mothers' version and midwives' version) included the 10 items on a Likert-type scale and two open questions. The first open question was common to the two categories of respondents and asked which elements of the built environment they would change; the second was different for the two categories of respondents and asked mothers about their movement during labor and midwives about the birth room configuration to understand mother experience from midwives' point of view.

Spatial Parameters

The construction of the study design, aimed at finding correspondence between the perception and spatial and physical characteristics of the built environment, cannot disregard the identification of spatial parameters tailored to each item through spatial analysis.

The researchers identified some strategies to objectively detect the items to be investigated in the questionnaire in order to know in advance if they had a spatial correspondence and consequently seek associations with the perception of users.

The spatial analysis is possible, thanks to the use of one or more spatial parameters that vary from a simple metric measurement (distance, surface, dimension, etc.) to Space Syntax variables suggested by the literature (Al-Sayed et al., 2014; spatial integration, Isovist area, visual control, intelligibility, graph shape, convex space) and finally binary questions (presence/absence, inside/outside).

Data Analysis

Analysis of perception. For the statistical data analysis, the Jamovi Statistical Software for Social Science was used. All significance tests were two-sided with a Type I error rate of 5%. This means that we accept a 5% chance that we are wrong when we reject the null hypothesis (equality between groups).

Descriptive statistics (means and standard deviations) were used to characterize the study variables.

Differences between the mothers and midwives and between the MLU and OLU in perception of the spaces were tested using independent sample Student *t*-tests. This test, comparing means, aims to provide statistical evidence that the population are different.

The open answers were categorized by researchers to allow a comparison between the two groups.

An exploratory factor analysis was conducted to examine the factor structure of the *BESP*. According to the factor analytic methodology, some items are related because they are determined in part by common but hidden influences. The main aim of factor analysis is to define the number of essential influences underlying a group of items.

Spatial analysis. The spatial analyses regarded various parameters of the space that could be detected by a field survey (environmental

Table 1. Means, Standard Deviation, and Student *t*-Test in the Midwife-Led Unit (MLU) and Obstetric-Led Unit (OLU).

Item	Setting	*N*	Mean	St. dev.	*t*	*df*	*p*
Calm atmosphere	MLU	50	4.88	0.52	7.424	110	.000*
	OLU	62	3.52	1.21			
Greater intimacy	MLU	50	4.84	0.51	4.791	110	.000*
	OLU	62	4.16	0.89			
Spacious birth room	MLU	50	4.82	0.56	7.041	110	.000*
	OLU	62	3.39	1.35			
Clarity of service points	MLU	50	4.58	0.76	4.626	110	.000*
	OLU	62	3.66	1.23			
Clarity in finding midwives	MLU	50	4.86	0.50	8.023	110	.000*
	OLU	62	3.55	1.07			
Sufficient space for labor	MLU	50	4.76	0.56	7.662	110	.000*
	OLU	62	3.26	1.29			
Noise	MLU	50	1.32	0.71	−7.307	110	.000*
	OLU	62	2.98	1.48			
Privacy	MLU	50	4.84	0.42	6.147	110	.000*
	OLU	62	3.69	1.26			
Adaptability of the birth room	MLU	50	4.62	0.72	6.54	110	.000*
	OLU	62	3.38	1.17			
Natural light	MLU	50	3.50	1.39	0.194	110	.847
	OLU	62	3.45	1.25			

Note. N = sample size; St. dev. = standard deviation; t = student t-test value; df = degrees of freedom.
*$p < .001$.

quality), a geometrical reading of the layout (e.g., size, distance, surfaces), and a configurational study through the use of spatial analysis softwares, such as DepthmapX (Turner, 2001). These parameters highlight some quantitative properties of the spatial layout to be used for a comparison of the two different configurations of the units.

Therefore, some spatial and physical characteristics could be measured directly on the unit plans provided by the health management of the two settings or through onsite observation and data collection. Conversely, for the configurational analysis, the researchers used Space Syntax software, a theory and an analysis technique developed by Bill Hillier of The Bartlett, UCL from the late 1970s with the aim of investigating the relationship between space and social behavior (Hillier & Hanson, 1984). Through a scientific approach, the theory makes explicit the relationship between forms of space and social, behavioral, functional, and movement factors (Hillier, 2007). The analytical systems of Space Syntax were a significant support tool for the categorization and study of the two configurations, for example, using DepthmapX, a multiplatform software that performs a set of spatial network analyses designed to understand social processes within the built environment (Turner, 2001), from which variables are derived, such as integration, visual control, and intelligibility, which may have experiential significance (Al-Sayed et al., 2014).

Results

Perception of the Spaces Results

Examining the user perceptions of the different settings, Table 1 sets out the means and standard deviation in all items of *BESP* in the MLU and OLU. The Student t-test revealed a statistically significant difference between the two settings. The MLU has a significantly higher mean in Calm atmosphere ($t = 7.42$, $p < .000$), greater intimacy ($t = 4.79$, $p < .000$), spacious birth room ($t = 7.04$, $p < .000$), clarity of service points ($t = 4.63$, $p < .000$), clarity in finding midwives/mothers

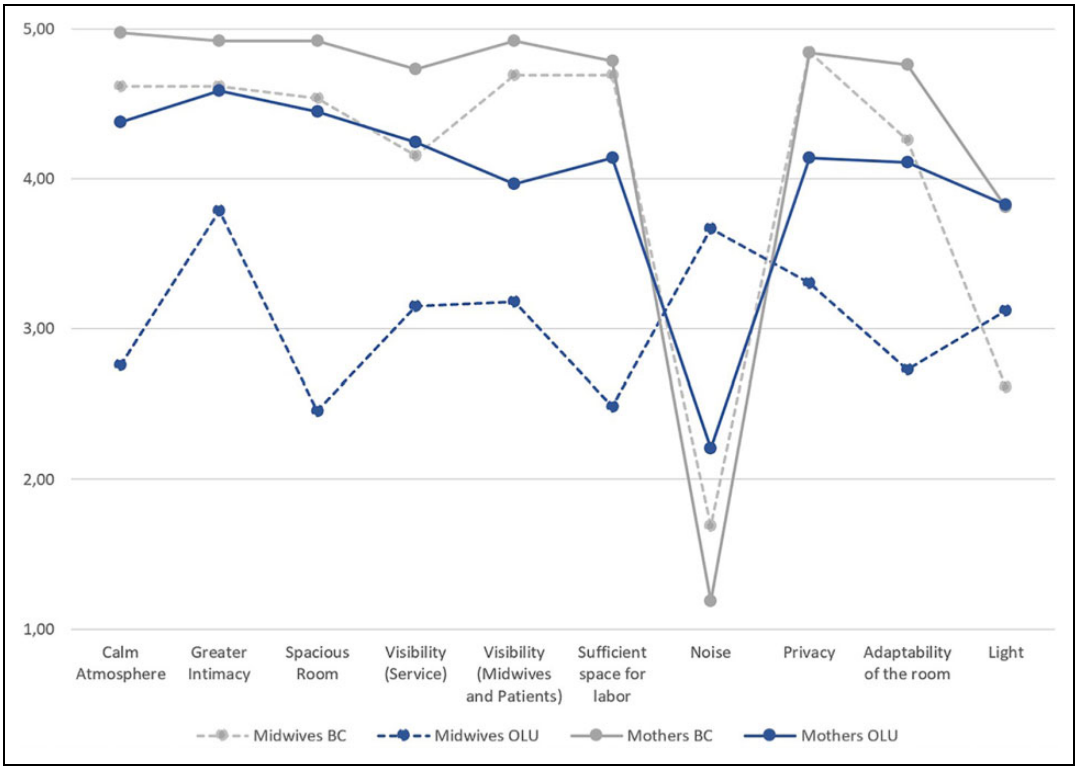

Figure 3. Mothers and midwives means in different birth settings.

($t = 8.02$, $p < .000$), sufficient space for labor ($t = 7.66$, $p < .000$), privacy ($t = 6.15$, $p < .000$), and adaptability of the birth room ($t = 6.54$, $p < .000$). On the contrary, the noise item has a significantly lower score in the MLU than in the OLU ($t = 7.30$, $p < .000$).

Among the two settings, there is no difference in the natural light perception.

In order to assess the differences between the perceptions of the mothers and midwives, we used independent sample *t*-tests. Mothers and midwives significantly differ in all the dimensions investigated: Mothers report higher means in Calm atmosphere (Mmothers = 4.71, $t = 7.81$, $p < .000$), greater intimacy (Mmothers = 4.77, $t = 5.36$, $p < .000$), spacious birth room (Mmothers = 4.71, $t = 8.79$, $p < .000$), clarity of service points (Mmothers = 4.52, $t = 5.58$, $p < .000$), clarity in finding midwives (Mmothers = 4.50, $t = 4.69$, $p < .000$), sufficient space for labor (Mmothers = 4.50, $t = 6.74$, $p < .000$), privacy (Mmothers = 4.53, $t = 3.83$, $p < .000$), adaptability of the birth room (Mmothers = 4.48, $t = 6.54$, $p < .000$), and natural light (Mmothers = 3.82, $t = 3.51$, $p < .001$). The noise perception item has a significantly higher score for midwives than mothers (Mmidwives = 3.11, $t = 7.30$, $p < .000$); in particular, midwives in the OLU reported significantly lower scores in all spatial parameters compared to midwives in MLU and to mothers in both settings.

Despite these differences, Figure 3 shows the similar trend in the *BESP* items.

Open answers. Table 2 shows category percentages for the desired changes suggested by mothers and midwives responding to the first Open Answer (OA1) in the two settings.

In the MLU, a shower inside the birth room was suggested by both mothers (33%) and midwives (27%). Furthermore, women and midwives also expressed their need for more natural light (33% of mothers, 27% of midwives) and for the

Table 2. OA1, Desired Changes Suggested by Mother and Midwives.

	Mothers (32)				Midwives (42)			
Desired Changes Suggested	MLU (21)		OLU (11)		MLU (11)		OLU (31)	
Shower inside the birth room	7	33%	0	0%	3	27%	0	0%
More natural light, bigger windows	7	33%	0	0%	3	27%	1	3%
More functional furniture and equipment	3	14%[a]	2	18%	1	9%	9	29%
Control of indoor quality (ventilation, temperature, and light)	5	24%	1	9%	3	27%	5	16%
More privacy	0	0%	1	9%	0	0%	1	3%
Position of the bath	1	5%	0	0%	2	18%	2	7%
Bath in the birth room	0	0%	1	9%	0	0%	4	13%
Bigger birth room	0	0%	1	9%	0	0%	14	45%
Less noise	0	0%	2	18%	0	0%	4	13%
Warmer atmosphere	0	0%	3	27%	1	9%	5	16%
Colors	0	0%	1	9%	1	18%	6	13%
Introduce music or aromatherapy	0	0%	1	9%	2	9%	4	19%
Position of the bed					0	0%	4	13%
Layout					2	18%	3	10%
Common spaces					0	0%	2	7%

Note. MLU = midwife-led unit; OLU = obstetric-led unit.

possibility to control the quality of the indoor environment, that is, the windows and roller shutter, adjust the light, ventilation, and climate control (24% of mothers and 27% of midwives).

In the OLU, the highest percentage was midwives who want a bigger birth room (45%), followed by those (29%) who want more functional furniture and equipment including shelves, mattresses and pillows, pulling ropes, a bigger and more adequate bed, a closet, and space for partners. About 19% of midwives in the OLU suggested the introduction of music and aromatherapy, and 16% proposed hiding the medical supplies, a welcoming space, reducing the feeling of being hospitalized, and photos and pictures to create a warmer atmosphere.

Moreover, a higher percentage of mothers in the OLU (27%) desired a warmer atmosphere, followed by those (18%) who wished for more functional furniture, for example, more space in the closet, and those (18%) who asked for less noise.

As described above, the second Open Answer (OA2) aimed to analyze whether women had left the room and where they had gone during labor.

The results show that in the MLU, 46% of mothers left the birth room mainly to walk in the central space and the corridor. On the other hand, in the OLU, just one mother said she had left the birth room during labor.

The question for midwives asked if, supporting mothers, they usually move any of the furniture from the initial configuration, and if so which pieces. Twenty-one percent of midwives working at the MLU stated that they had done so (mainly chairs) and 87% of midwives in the OLU said they had changed the initial configuration of the birth room, mainly by moving the bed, chairs, and medical equipment.

Exploratory factor analysis (EFA). We based these analyses on a total of 112 participants. In the EFA, all nine items were subjected to a varimax rotation. The Kaiser–Meyer–Olkin value was 0.90 and Bartlett's test of sphericity was significant, 745 (36), $p < .001$, supporting a rationale for performing the EFA. The number of factors to be extracted was based on a screen plot test. The two factors extracted accounted for 35.2% and 32% of the total variance.

As seen in Table 3, the factor loadings of the nine items ranged between 0.47 and 0.85, suggesting that each item substantially contributes to the factor at fair and excellent levels (Tabachnick & Fidell, 2007).

Table 3. Factor Loadings.

Item	Factor 1	Factor 2	Uniqueness
Calm atmosphere	.617		.367
Greater intimacy	.726		.361
Noise	−.707		.376
Privacy	.677		.381
Spacious birth room		.844	.129
Clarity of service points		.477	.552
Clarity in finding midwives		.639	.437
Sufficient space for labor		.840	.118
Adaptability of the birth room		.681	.237

Note. Varimax" rotation was used.

Spatial Analysis Results

The results of the analysis of the built environment are summarized in Table 4 and concern both the identification of items of the built environment and the use of spatial parameters to orient maternity units design. The table reflects the structure of the *BESP Questionnaire* in which every item is measured in relation to the space it refers to, that is, the entire unit or the birth room. The spatial parameters, shown in the third column, differ in nature: the presence or absence of building elements, surfaces, dimensions and distances, percentages, or space syntax indicators. Before giving the results of the two settings in the last column, the explanation provides the meaning of the spatial analysis and helps us to understand its use and interpretation by the researchers.

The choice of the spatial parameters from the Space Syntax theory derives from previous research and studies where they were used in healthcare design as a support and guidance for projects (Sadek & Shepley, 2016), well documented by Haq and Zimring (2003), Haq and Luo (2012), and Setola and Borgianni (2016). In particular, we refer to:

- intelligibility, as a parameter indicating the cognitive understanding of the space and its ability to orient;
- visual integration (HH) as a spatial property supporting the relationship between users, for example, the nurses' workstation and patient room;
- spatial integration (HH) as a measure related to the likelihood of people concentration and their access, and, on the contrary, users' privacy preferences;
- the Isovist technique, as a measure related to the specific target from an observation point;
- the graph analysis of convex maps representing the quality of the path spaces; and
- the practice of analyzing a plan by dividing the space (the birth room in this study) into Convex Spaces (the squares or rectangles of which it is composed) to measure the degree of adaptability of the room.

The results show that the spatial parameters revealed a quantifiable difference in the two settings, with the exception of:

- intelligibility, used to detect the clarity of service points, which gave practically identical results in both settings;
- visual integration (HH), used to detect privacy in the birth rooms according to Alalouch and Aspinall (2007), which did not reveal the degree of privacy in the birth rooms; and
- the window/floor illuminating ratio, which complied with the Italian regulations in both settings and was quite similar with no significant difference.

Comparison of Perceptive and Spatial Results

The research identified eight associations by comparing the perceptive and spatial results. In fact, the results obtained from both disciplines,

Table 4. Analysis of the Built Environment.

Item	Space	Spatial Parameter	Explanation	Setting	Results
Calm atmosphere	Unit	Isolation from flows	The calm atmosphere inside the unit is favored by its position compared to the other health flows of the hospital (mixed use, entrance, ease of orientation, etc.). The more isolated the location of the unit, the more likely a calm atmosphere will prevail.	MLU OLU	Yes, independent building No, part of the hospital maternity ward
Greater intimacy	Birth room	Presence of interface btw BR and other spaces	The interface space indicates the filter space at the entrance which determines a gradual outside–inside transition. The presence of an interface between the birth room and other spaces promotes greater intimacy.	MLU OLU	Yes, presence No, absence
Spacious birth room	Birth room	M^2 of free surface	The more space free of furniture or medical equipment there is in the room, the more space there is for activities/users.	MLU OLU	Area: 23 m^2 Area: 14 m^2
Clarity of service points	Unit	Intelligibility	The intelligibility *R* of the unit indicates if what can be seen of a space represents a good guide for what we cannot see of the entire system, that is, it indicates how much a person recognizes the layout and is able to orient themselves within it. It varies from 0 (min.) to 1 (max.). The higher the *R*, the clearer the location of the service points.	MLU OLU	R^2: .727 R^2: .714
Clarity in finding midwives	Unit	1. Visual integration (HH) 2. Isovist, percentage of visible unit area from the desk 3. Mean distance desk-rooms	1. Visual integration (HH) measures the visibility of a space by considering the entire unit, that is, how much space is visible from all the other locations in the system. The HH value is measured at the midwife's position. The higher the HH, the clearer the midwives' location. 2. The Isovist technique considers the visible area seen from an observation point. It is calculated as the percentage of area visible from the midwives' desk in relation to the area of the entire unit. The higher the percentage, the clearer the midwives' location. 3. The average distance between the midwives' station and the entrance doors of the rooms is calculated. The shorter the distance, the clearer is the midwives' location.	MLU OLU	1. HH: 9.2 2. 30% of area 3. Mean distance: 9.0 m 1. HH: 5.3 2. 7% of area 3. Mean distance: 14.5 m
Sufficient space for labor	Unit	1. Graph analysis of the convex map 2. Available surface area	1. The graph represents the quality of the path spaces: if the graph is tree-like, the spaces are placed in sequence and the path is fixed; a ring-shaped graph permits various path options and corresponds to more possibilities of choosing spaces to move around in during labor. 2. The free surface in which a woman can walk during labor is calculated. The more surface available, the more space for labor.	MLU OLU	1. Ring-like graph 2. Area: 300 m^2 1. Tree-like graph 2. Area: 120 m^2
Noise	Unit	Spatial integration (HH)[a]	Spatial integration (HH) measures the accessibility of a space within the unit. A high HH value is usually related to more movement and activity of people in that space. The HH of the spaces outside the BR doors, that is, the corridors, is calculated. The higher the HH, the higher the noise.	MLU OLU	HH: 4.6, average HH: 9.4

(continued)

Table 4. (continued)

Item	Space	Spatial Parameter	Explanation	Setting	Results
Privacy	Birth room	1. Visual Integration (HH) 2. Visual control 3. Isovist, percentage of visible BR area from the corridor 4. Dimension and opening of the BR door	1. The lower the HH, the higher the privacy. 2. Visual control indicates the ability to control a space visually. The lower the visual control of the bed, the higher the privacy. 3. The Isovist technique considers the visible area from an observation point. The percentage of room visible to a hypothetical user walking down the corridor is calculated. The lower the percentage, the higher the privacy. 4. The width of the door, its opening (toward the room or the corridor) and if it is directed to the bed or the places designated for labor and childbirth affect the perception of privacy. A door that opens outward and not toward the most active area of the room guarantees a higher level of privacy.	MLU OLU	1. HH: 5.8 2. Visual control: 0.3 3. 50% of area 4. Door: 0.65 m (or 1.20 m). Outward opening, not toward the bed 1. HH: 5.5 2. Visual control: 1.0 3. 85% of area 4. Door: 1.20 m. Inward opening, toward the bed
Adaptability of the birth room	Birth room	Number of convex spaces	Dividing the room into convex spaces (the squares or rectangles of which it is composed) allows us to perceive the degree of adaptability of the room because their presence reflects the possibility of creating different spatial environments and configurations within the same environment. The higher the number of convex spaces, the more the room fits the needs.	MLU OLU	3 Convex spaces 1 Convex space
Natural light	Birth room	1. Window to floor area ratio 2. Position and presence of external obstacles	1. The illuminating ratio indicates how much light can enter the room by comparing the window surface to the floor surface. The higher the illuminating ratio, the more natural light. 2. If the position of the window is too low or high, the input is reduced. The presence of any external overhangs can affect the amount of direct radiation.	MLU OLU	1. W/F > ⅛ [b] 2. h. 2.70 m, external overhang 1. W/F >⅛ [b] 2. h. 1.10 m, no external overhang

Note. BR = birth room; h = height; MLU = midwife-led unit; OLU = obstetric-led unit.

[a]HH stands for Hillier and Hanson, it represents how the measure appears in the DepthmapX software. [b]Minimum value according to Italian legislation.

architecture and environmental psychology, have the same trend. The statistically significant differences between the two settings for each item have a correspondence in the spatial analysis, except for the clarity in finding midwives, which has no spatial measurement correspondence (the intelligibility value reveals no difference in contrast to perception) and the absence of a difference in the natural light perception between the two settings has no significant measurement able to identify the desired or appropriate quantity of it.

Figures 4–13 illustrate the associations between the perceptive and spatial data by showing their similar trends.

The statistically significant differences in the perception of the space by users in the two settings are synthesized by the arrows, showing their differences by direction and color (up green arrow for a more positive perception, down red arrow for a more negative perception) and the gray equal sign indicates no significant difference. Similarly, the analysis of the built environment conducted by the researchers for each item is symbolized by the arrows, and the equal sign indicates spatial results that are not significantly different. This graphical simplification has been done to immediately show if the results for each item follow the same trend in the two settings.

The comparison of the perceptive and spatial results shows that many of the spatial parameters identified can represent valuable tools to develop knowledge about the design of the birth setting.

Discussion

The Differences Between the Two Settings in Terms of Perception and Environment

The findings suggest that the differences in the perception of the two settings, revealed by both sets of participants, can have a spatial correspondence.

The two settings analyzed in the paper (MLU and OLU) at first glance appear to be very different from an architectural point of view in terms of the layout and quality of the spaces (furniture, lighting, materials, etc.). This difference is confirmed by both the perceptive and spatial parameters. The results obtained clearly show how the perception of the key users (women and midwives) of the environment is different depending on the setting in which the birth took place: a significant difference was in fact found for nine of the 10 items examined. Below, we will see in detail the items differently perceived in the two settings and if the chosen spatial parameters (Table 4) can be used to describe them.

Calm atmosphere. A calm atmosphere in birth settings, which reduces stress and enables relaxation, is important because it facilitates normal birth and produces physiological benefits (Foureur et al., 2011; Hauck et al., 2008).

The two case studies analyzed reveal a difference in terms of isolation and separation from external flows (Figure 4) in that the MLU is an independent building connected to the central maternity building by two corridors, while the OLU is included within a triple rectangular block in which the corridor that connects the birth rooms also acts as a connection to the other neighboring functional areas. This spatial difference is reflected in the how differently the birth space environment is perceived by mothers and midwives who, despite assessing both settings as positive, perceived greater calm in the MLU. This result confirms the hypothesis that a calm atmosphere in the birth unit is favored by the configuration of the unit (Setola et al., 2019), that is, its position compared to the other health users flows of the hospital. The more isolated the unit's location, the more likely a calm atmosphere will be perceived, by avoiding mixed uses, having dedicated entrances, and promoting ease of orientation, and so on.

In the spatial assessment of the two environments, it can be presumed that other environmental quality factors also influence a calm atmosphere, such as the amount of natural light, the quality of sight, the presence and/or a view of green spaces, the quality of the furniture, noise pollution, and so on as we will see at the end of these discussions. These qualitative assessments of the space are confirmed by the responses collected in the open questions (Table 2). They highlight the need felt above all in the OLU by mothers (27%) and midwives (16%) to create a calmer atmosphere, associated with the warmth, hospitality, and domesticity of

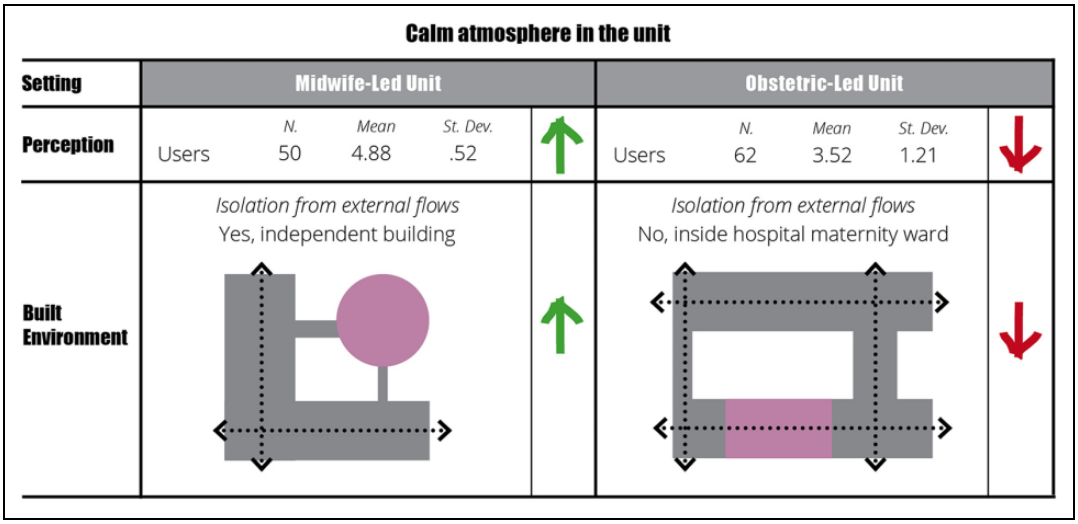

Figure 4. Comparison of the spatial and perceptive data for the calm atmosphere item.

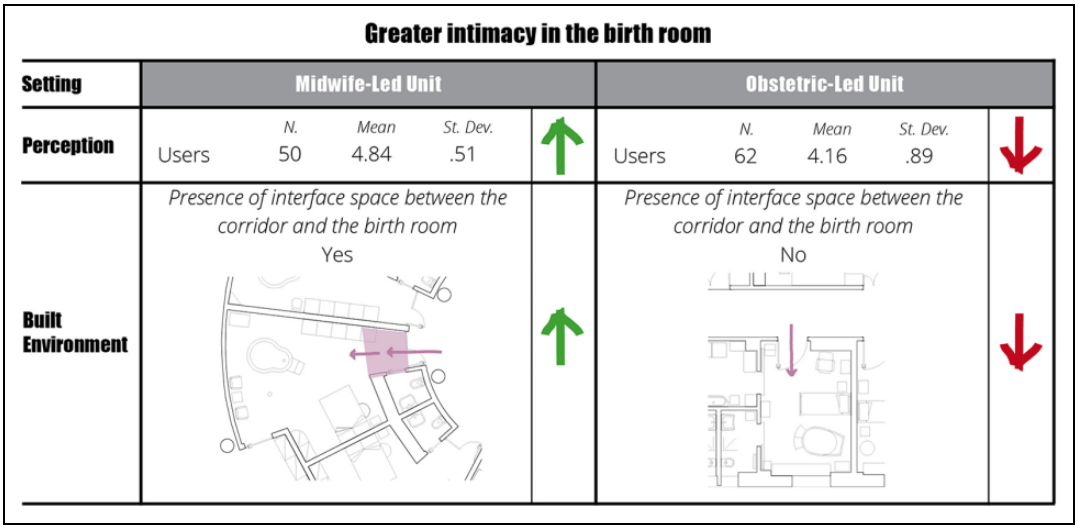

Figure 5. Comparison of the spatial and perceptive data for the greater intimacy item.

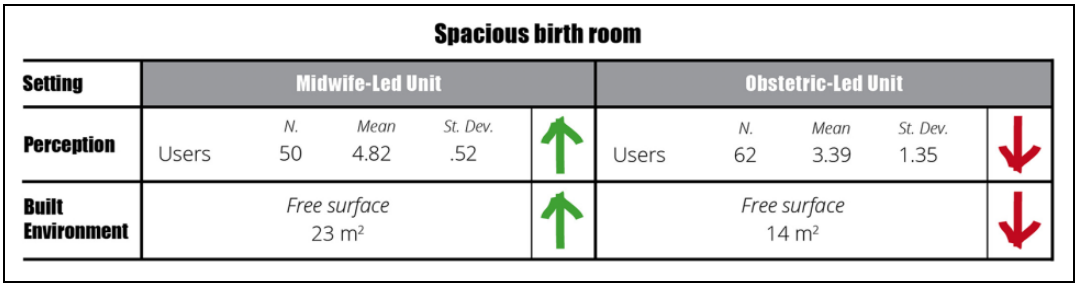

Figure 6. Comparison of the spatial and perceptive data for the spacious birth room item.

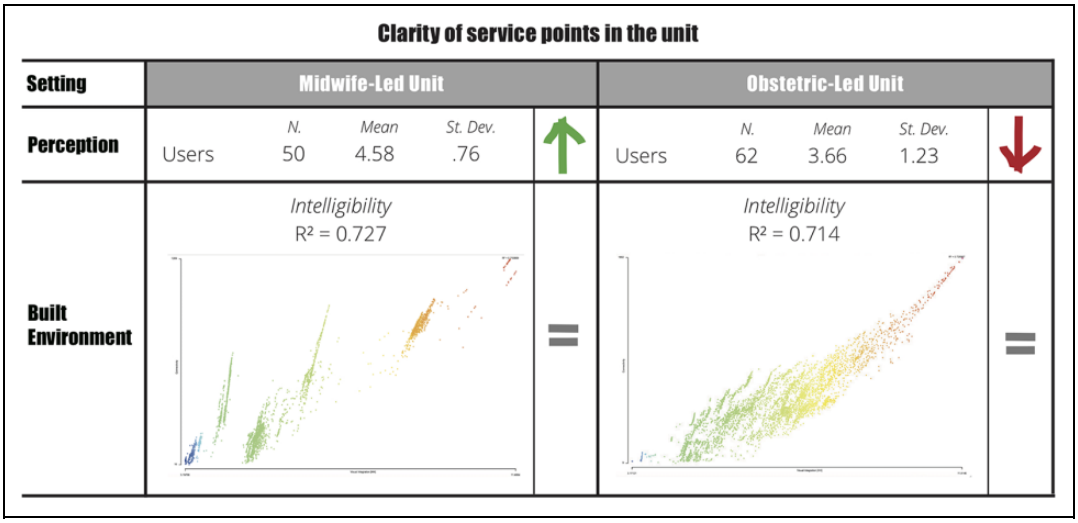

Figure 7. Comparison of the spatial and perceptive data for the clarity of service points item.

the spaces (calm settings, welcoming spaces, reduced feeling of being hospitalized), by hiding medical supplies and using art and ornaments on the walls (photographs and pictures), as well as introducing the use of music, colors, and aromatherapy.

Greater intimacy. The sense of intimacy and privacy in the birth room and the perception felt when entering it influences the users' emotional sphere. Our results show that the intimacy in the birth room can be fostered by a filter space that separates the room from the corridor. This interface space indicates a gradual transition from the outside to the inside. The hypothesis that the presence of an interface space promotes greater intimacy was confirmed by the perception of women and midwives and is higher in the MLU. In fact, in the MLU the room layout, thanks to the bathroom positioned at the entrance, creates a filter space between the central connection where the midwives are and the birth room, while in the OLU there is no filter space between the room and the corridor that connects all the functions of the childbirth block (Figure 5). The results confirm that the mother's capacity for autonomy and control, together with her perception of safety, which support the physiology of childbirth (Carolan-Olah et al., 2015; Fahy & Parratt, 2006; Lothian, 2004), can be strengthened by the perceptive impact created when moving from the corridor to the room.

Spacious birth room. It is important for the birth room to be of a suitable size so that all the activities can be carried out safely (Department of Health, 2013), but space that remains free of furniture and medical equipment is just as important as it encourages the movement of the woman during labor (Lepori, 1994).

The difference in square meters between the free surface areas in the two settings is 9 m^2; this difference is also perceived by users as shown in Figure 6. In the open answers to the questionnaire, almost half of the midwives (45%) of the OLU remarked on the need for a larger room. These results confirm the hypothesis that the more space free of furniture and medical equipment there is in the room, the more the space can be used for activities (e.g., moving) by users.

Clarity of service points. Having access to and knowing where to find the refreshment areas, such as the bar, vending machines, kitchenettes, and bathrooms, is an important requirement for women and their partners, above all during labor and postpartum (Foureur & Hastie, 2008; Harte et al., 2016; Walsh, 2006). The intelligibility of the unit's configuration could support this understanding and orientation. The two settings both show medium

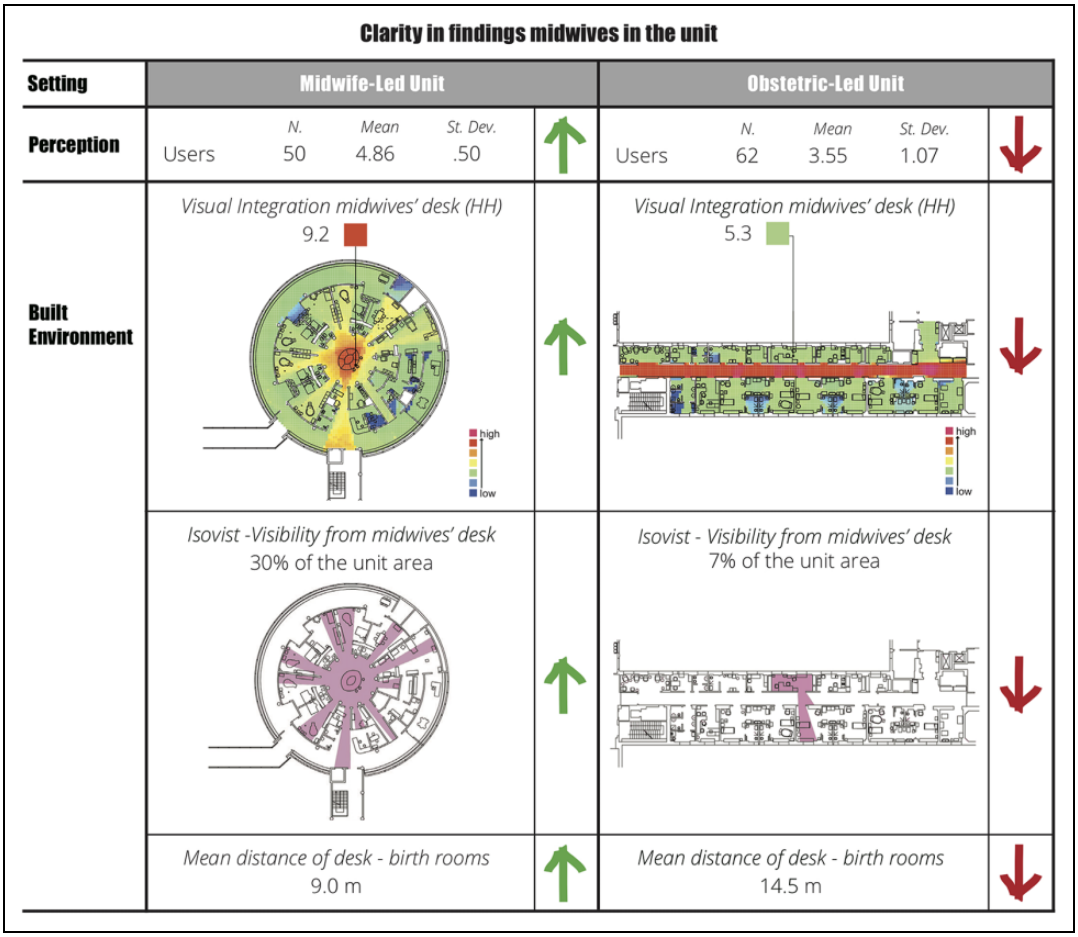

Figure 8. Comparison of the spatial and perceptive data for the clarity in finding midwives item.

to high intelligibility, even though a significant difference emerged in the perception of the two settings, resulting higher in the MLU. The intelligibility *R* of the unit indicates if what can be seen of a space represents a good guide for what we cannot see of the entire system, that is, how much a person recognizes the layout and is able to orient themselves within it. The higher the *R*, the clearer the location of the service points is likely to be.

The results suggest that perhaps intelligibility is not the most appropriate parameter to measure the clarity of the layout based on the services it houses as well as the degree of familiarity the users may have with the facility.

Clarity in finding midwives. Clarity in finding midwives is related to where the midwives' desk hub is positioned in the layout with respect to the birth room, which is important for increasing the women's sense of safety, that is, knowing where they can find the midwives if they need them or knowing that they are in any case "monitored" by the staff and for midwives who can ensure prompt assistance through proximity or a direct view of the doors to the rooms (Symon et al., 2008b; Tavakoli, et al., 2020).

The spatial measurement hypothesis of this item, which includes the visual integration (HH) of the desk, the percentage of the area visible from the midwives' desk in relation to the area of the entire unit calculated using the Isovist technique, and the average distance between the midwives' station and the entrance doors of the rooms, seems to be confirmed by the perception

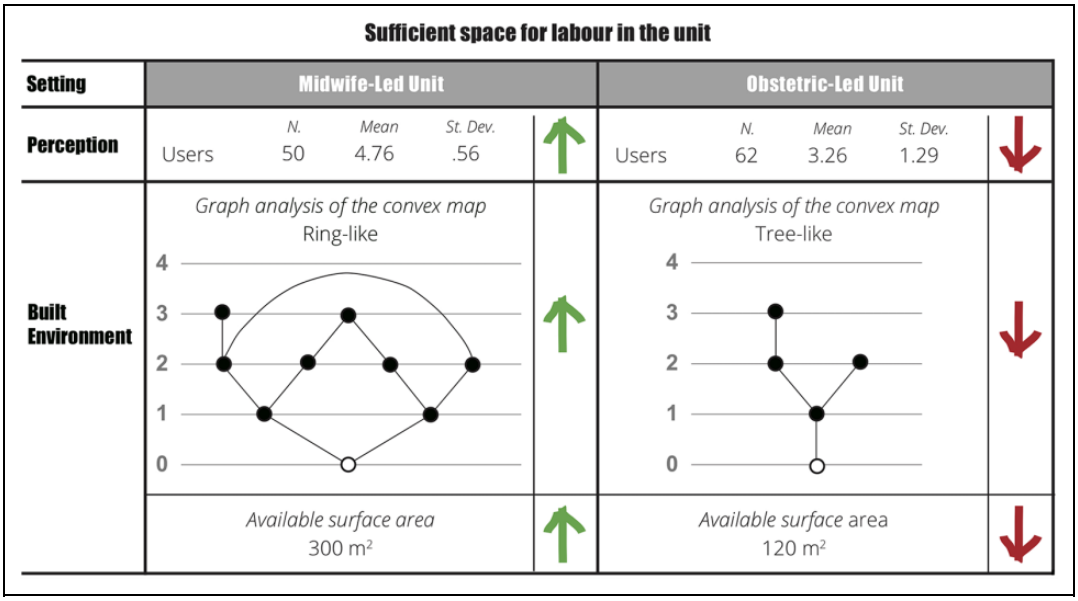

Figure 9. Comparison of the spatial and perceptive data for the sufficient space for labor item.

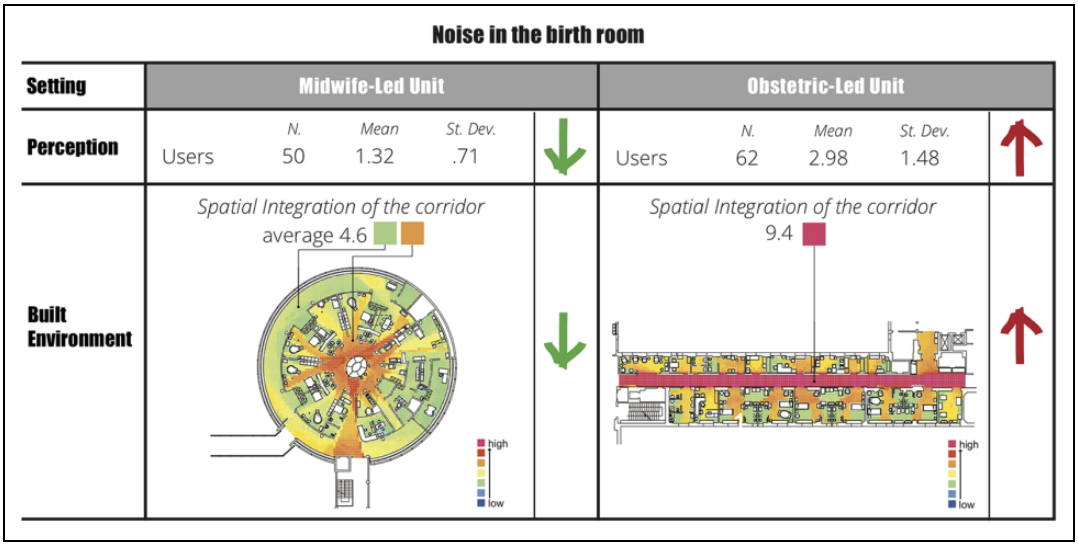

Figure 10. Comparison of the spatial and perceptive data for the noise item.

of both midwives and women. In fact, the statistically significant difference in detecting the perception of the clarity of finding midwives, which is greater in the MLU than in the OLU, can be explained by looking at the maps (Figure 8). The midwives' desk in the OLU is situated in one of the rooms facing onto the corridor, while in the MLU it occupies the central space, which is easy to identify and which the birth rooms branch off. From this space, the percentage of the visible area is higher than in the OLU, where only the door of one room can be seen. Moreover, the linear layout of the OLU, despite the desk being located centrally within the unit, makes the average distance

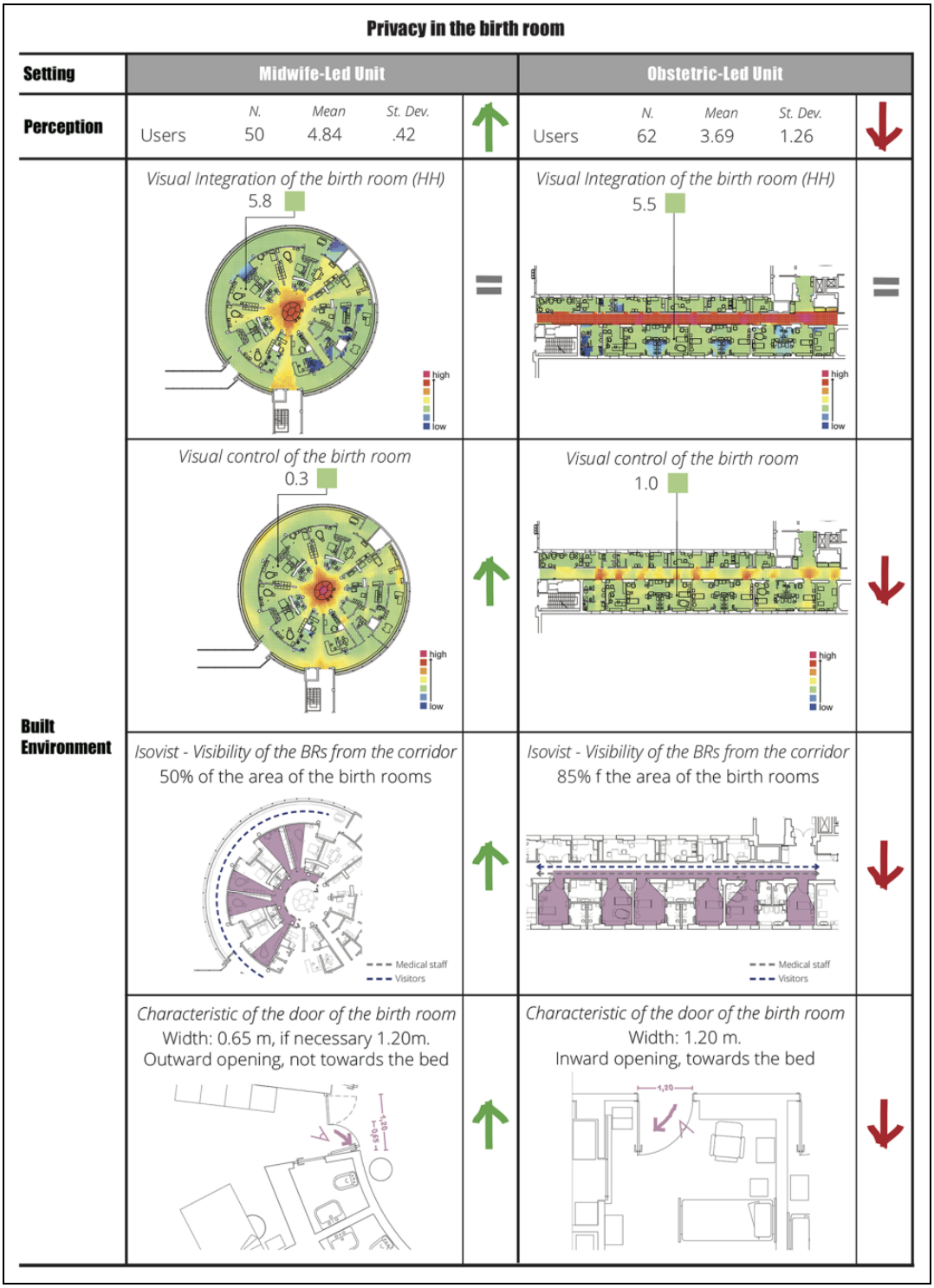

Figure 11. Comparison of the spatial and perceptive data for the privacy item.

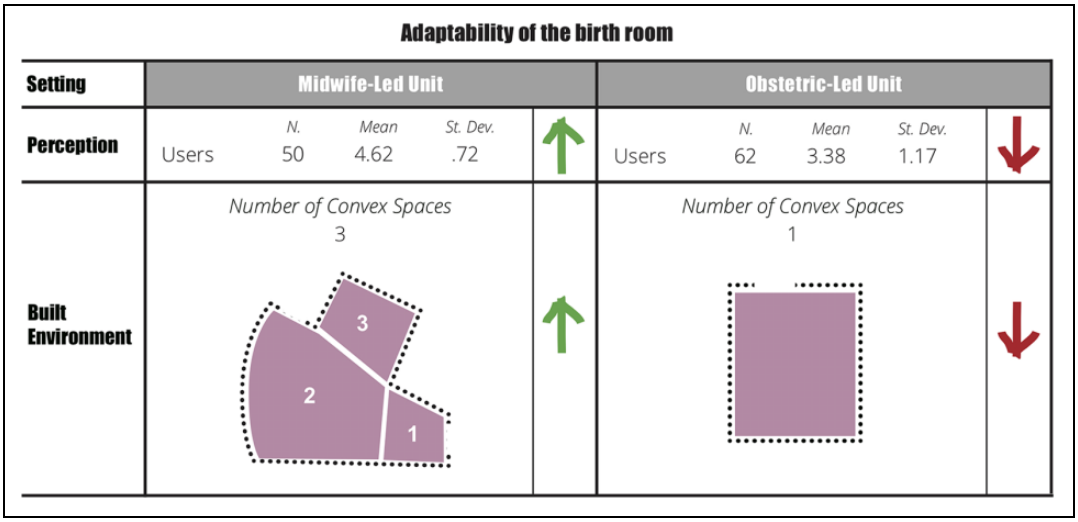

Figure 12. Comparison of the spatial and perceptive data for the adaptability of the birth room item.

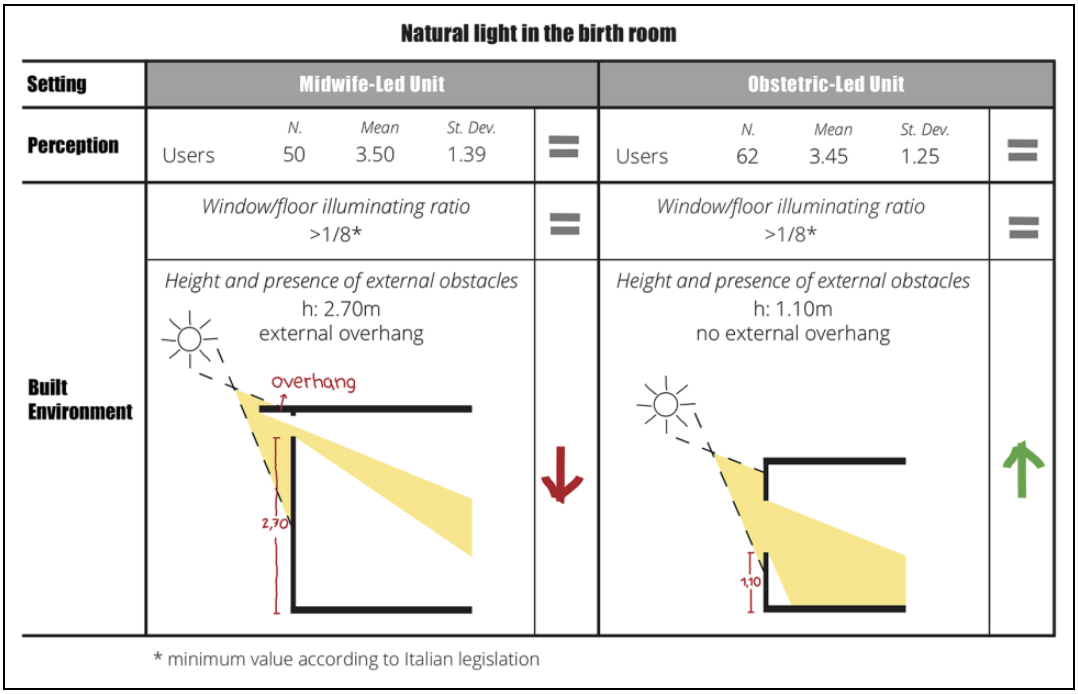

Figure 13. Comparison of the spatial and perceptive data for the natural light item.

to the rooms longer. The layout of the OLU, which is linear with the rooms in a battery arrangement, also means that some of the rooms are further away and therefore more difficult for the midwives to monitor (and equally this alters the mothers' sense of safety). As a result, not all the rooms have the same visual and spatial relationship with the midwives' operating station. Instead, the desk in the MLU is central with respect to all the rooms, which provides not only

immediate visual control of all the rooms, but it is also the same distance away from all five of them.

Observations regarding the midwives' position in relation to the birth rooms are confirmed by the open responses of the midwives in the OLU (three midwives) as seen in Table 3.

Moreover, the spatial properties chosen to analyze the birth setting expand the overview of studies involving nursing and staff working in different care spaces (Lu & Zimring, 2012).

Sufficient space for labor. The possibility for women to move around during labor helps the physiological process of childbirth (Hammond, 2015; Lepori, 1994). The built environment can encourage the movement of users by making free, accessible, and quality spaces available for women to walk around in.

The hypothesis that the more available free surface there is, the more space there is to walk around during labor is confirmed by the perception of the women and midwives, which is different in the two settings (Figure 9). In the MLU, there are more available spaces (300 m^2 of free surface area vs. 120 m^2) in that there is a large corridor surrounding the rooms and directly accessible from them, with benches, light, and adequate room to move around. In addition, the quality of the paths that a woman can take is represented by graphs indicating the degree of possible choice between the paths: in the OLU, the graph is tree-like, the spaces are placed in sequence and the path is fixed, up and down the corridor; in the MLU, a ring-shaped graph permits various path options and corresponds to more possibilities of choosing spaces to move around in during labor. Moreover, the open questions revealed that in the MLU during labor, women left the room and went into the central space, external corridor, and common kitchen. In the OLU, only one person left their room, probably also due to the absence of pleasant spaces to go to.

Noise. The presence of noise (people coming and going, people talking, trolleys/materials and equipment) in the proximity of the birth room can become a source of stress, compromising women's ability to relax and their privacy and control during labor (Ban et al., 2021; Hammond, 2015; Symon et al., 2008a). Among the spatial measures, a high spatial integration (HH) value is usually related to greater movement of people and activities in that space as it measures the accessibility of a space within the unit.

The HH of the spaces outside the doors of the birth room, that is, the corridors, has been calculated in both settings (Figure 10). The hypothesis that the higher the HH, the higher the noise seems to be confirmed by the association with mothers' and midwives' answers about their perception of noise, which are significantly different for the two settings: in fact, the corridor in the OLU connects to other activities (neonatal resuscitation, induction space, operating theaters), and it likely has a greater flow of people and equipment, while the MLU room is surrounded by a space which only the two midwives on duty have access to, and an external corridor for relatives designed so that no one can stop and talk in front of the birth room, whose opening is managed completely independently by the woman.

A relevant factor here is not only if the source of the noise is close to the door of the birth rooms (and therefore where the storerooms and depositories are located) but also the type of user that can be found near it, as well as the behavior of the professionals.

The open questions revealed that 18% of midwives in the MLU and 13% in the OLU, versus 0% of mothers in both settings, mentioned noise as a disturbance, and this shows there is a difference in the specific needs of the user or that staff have a different awareness of the impact of noise on the physiology of childbirth as they complain about the need to ensure greater soundproofing in the rooms. This difference in the mothers' and midwives' perception of noise is confirmed by the trend of the answers which can be seen in Figure 3, which show that the midwives, above all in the OLU, have a more negative perception of the amount of noise inside the room.

These observations raise the question of why mothers feel differently to the midwives about the issue of noise and require further in-depth analysis.

Privacy. A sense of privacy inside the room is essential for the physiology of childbirth

(Lothian, 2004; Sheehy et al., 2011; Stenglin & Foureur, 2013). It translates as the visibility of the same, so it is assumed that the activities carried out inside the room must not be seen from the external corridor (Shin et al., 2004).

Privacy is understood in this study as elements of the room that facilitate visual protection from the external environments as operators enter and exit it; therefore, it is understood in relation to the strategic placement of furniture with respect to the entrance and the use of solutions and additional devices to reduce the room's exposure. Three parameters were chosen to describe this property in spatial terms and they were differently confirmed by the analysis.

The first two spatial parameters, visual integration and control, have been shown to relate to privacy in multi-bed wards (Alalouch & Aspinall, 2007). The first measure, visual integration (HH) did not reveal a significant difference in the two settings and therefore needs to be studied further, both as regards the different layouts and based on the type of ward (the studies named were not in fact on birth spaces and no single-bed rooms were considered).

The other three spatial analyses on the other hand were consistent with the users' perception of privacy, creating associations between perception and spatial measures. In fact, the visual control of the bed location, which identifies the best positions for controlling the largest area possible, is lower as the perception of privacy increases (MLU).

The visible area from an observation point, that is, the percentage of a room visible to a hypothetical user walking down the corridor (the lower the percentage of the visible area from the corridor, the higher the privacy), was greater in the OLU where it must be pointed out that the sense of privacy is reduced by both medical staff and visitors passing in front of the birth rooms, unlike the MLU where the door through which visitors enter can be independently managed by the mothers and the door for assistance opens onto a private area reserved for the midwives.

Lastly, it was useful to consider the width of the door, the direction in which it opens (toward the room or the corridor) and if it is directed at the bed or places designated for labor and childbirth. In fact, the tighter door of the MLU that opens to the outside and not toward the most active area of the room guarantees a higher degree of privacy.

Adaptability of the birth room. During labor, it is important that the room can easily be adapted/customized to suit the needs of the woman at various times, so that she can adjust the lights, use different furniture, change the space, and move around (Hammond et al., 2014; Jenkinson et al., 2014). The prerogative is to ensure as much freedom of movement as possible and a flexible environment to guarantee the maximum emotional and physical freedom of the woman who requires different situations in the different phases of labor and childbirth.

Dividing the room into convex spaces (the squares or rectangles it is made up of) allows us to perceive the room's degree of flexibility because they reflect the possibility of creating different spatial environments within the same environment. The hypothesis that the higher the number of Convex Spaces, the more the room fits the needs seems to be confirmed in both settings. In fact, the morphology of the OLU is that of a unique convex space, whereas the MLU can be broken down into three convex spaces; the MLU setting is perceived by mothers and midwives as more adaptable than the OLU. In addition, OA1 reveals that the OLU midwives wish to have more functional furniture and equipment. Another factor that emerged from the open questions is the request for greater control over the indoor quality of the room (ventilation, temperature, and light) in the MLU made by both mothers and midwives. Our results confirm that the adaptability of the birth room is then connected to its ability to assume different spatial configurations related to the possibility of arranging the furniture in different ways. This characteristic lies both in the mobility of the furnishings and how the room can accommodate them to suit different requirements.

Natural light. The presence of windows and natural light in the birth room is an important requirement for the well-being of women both during labor and postpartum (Balabanoff, 2016; Hammond et al., 2017) and also the ability to adjust it (Canazei et al., 2019). There are various factors

that interpret the quality of the natural light: the illuminating ratio, which indicates how much light can enter the room by comparing the window surface to the floor surface; the position of the window in the wall; the presence of any external overhangs affecting the amount of direct radiation; and the placement of the room in the building (i.e., the floor for the presence of possible shadows cast by nearby buildings and the orientation).

The perceptive analysis of this item did not reveal any significant differences between the two settings, nevertheless, Figure 3 allows us to make some additional assessments. In both settings, the average score is lower than that of other items, with a minimum in the MLU, but the mothers were more satisfied than the midwives.

The measurements taken show that the measurement of the aero-illuminating ratio is only indicative, in fact, in both settings although the ratio is not high it complies with legislation and no significant differences emerged in this dimension. This could be interpreted considering that many factors can come into play when considering the quality of the natural light in the room. First and foremost, leaving aside the aero-illuminating factor, there are other architectural characteristics that can have an impact on the quality and quantity of natural light in a room. These, as can be seen in Figure 13, can be identified for example in the height of the window in the room and therefore its capacity for direct radiation, or the presence of overhangs or external obstacles that can reduce the luminosity and have a negative impact on the MLU.

It is also good to consider another determining factor for the investigation regarding the quantity of natural light, which emerges above all in the open questions. Although the findings on the perception of natural light during childbirth resulting from the *BESP Questionnaire* did not reveal significant differences, the open questions contained requests for more natural light and bigger windows in the MLU by both mothers (33%) and midwives (27%), and this element, in addition to being partly confirmed in the findings described above, may also be influenced by the fact that in the MLU mothers stay in the same room after they have given birth unlike those in the OLU who are transferred to another ward (LDR vs. LDRP). During childbirth, the necessary light is soft, while after birth, it becomes more important to have more and brighter light. This could lead to the search for modular façade components according to the needs.

Other topics. Open Answer 1, which asked users what they would like to change in the spaces, confirms some of the points already demonstrated in literature, such as the need for a private bathroom with a shower, a bath in the room, the possibility of controlling the indoor comfort (possibility of ventilation, control of temperature and light), introducing music or aromatherapy, and lastly more functional furniture and equipment (accessories for labor, coat rack, closet, shelves, mattresses and pillows, pulling ropes, snf space for partners).

About the role of the social spaces in the unit, we can refer to Open Answer 2 demonstrating that only one woman exited the birth room during labor in the OLU—in fact, social spaces were lacking—whereas in the MLU, women left the room to go into the corridor and central spaces which are calm spaces where users walk and interact. Moreover, Table 2 shows how among the spatial changes suggested by midwives, two midwives in the OLU mention a common space as no such place exists there (unlike in the MLU), the need for a space in which to relax with vending machines, and common spaces reserved for mothers.

Quantitative Spatial Parameters to Support the Design of the Birth Environment

The results obtained through the associations between perceptive data and spatial data have in some way confirmed the hypothesis of the significance of having found quantitative and measurable spatial parameters in the architecture design. The study expands the use and application of geometrical and configurational analysis to the design of birth spaces according to the uses of spatial parameters listed in the Table 4.

Some of them worked better, in fact associations with the perceptive data in eight items emerged; others show how difficult it is to reduce

the assessment to a single physical parameter (natural light, for example); or how it is necessary to further analyze the spatial parameter examined (e.g., intelligibility *R* in order to understand the unit) in that it is not fully explained in the description of the item; or some of them were not confirmed with respect to the existing literature and therefore further studies would be necessary (e.g., integration HH for privacy). Moreover, in several cases, more than one parameter was chosen to describe an item, therefore a qualitative evaluation of them is always required.

The identified spatial parameters and connected measures, in the presence of an association with perceptions, could be used for the design evaluation and to better understand the role of the built environment in maternity settings and therefore orient the implementation of existing birth spaces or the creation of new ones.

The spatial parameters in fact have a descriptive value for architecture design; some characteristics of the layout come to light which are not directly visible to the naked eye and can support architects who design spaces for childbirth, so that they can create spaces that are perceived positively by people and that foster a social, psychological, physiological, and healthy experience of birth.

Birth Setting Characteristics: Calm Environment and Flexible Environment

In the exploratory factor analysis (Table 3), all the items in each group help to explain the two factors that emerged. In particular, Factor 1 is described by the items that concern the presence of a calm atmosphere in the unit, also fostered by the lack of noise, privacy, and the intimacy of the birth room; Factor 2 is described by those items that concern the spatial and physical characteristics of the layout, such as clarity in identifying the position of the services and people, and the characteristics of the birth room, such as the surface area available for activities and moving around in and the capacity of the space to adapt to different layouts.

The two factors therefore lead to the identification of two homogeneous groups in both settings: we could define Factor 1 as Calm Environment and Factor 2 as Flexible and Intelligible Environment. These factors summarize the characteristics that all birth environments should have in order to contribute to the physiological process of birth and consequently a better experience.

Limitations

The findings of this study have to be seen in light of some limitations. The first is the absence of partners' point of view, which could have corroborated and added richness to women's experiences.

The second limitation concerns the impossibility to include the standard birth outcome data for women from each unit to create a more explicit connection between the physical environment and actual birth experiences.

Concerning the fact that midwives were involved to give further insights into women's perception, it would be important to also consider midwives' experience and well-being to broaden the knowledge about the impact of the birth environment on these users and better inform the design process. In doing so, future studies should acknowledge that the well-being and experience of mothers and midwives may be materially different and need different physical and spatial characteristics.

In addition, the different trends in OLU midwives' perception compared to other participants open a reflection about the different meanings that the users attribute to the same space. Even if midwives' perception was oriented to mother experience, their point of view as a worker might influence their answers. This aspect should be deepened in future studies.

In addition, regarding the spatial analysis, some physical and spatial characteristics connected to the items of the built environment could be developed more thanks to additional qualitative data (deriving from in-person interviews and focus groups which would help in analyzing, describing, and better understanding the phenomena).

Future studies could focus on different feelings of mothers and midwives, especially about the issue of noise, the clarity of service points, and the presence and role of the social spaces in the unit, which have been explored in this study but need further work.

Finally, more studies are needed to develop the use and correctness of the use of spatial parameters to evaluate design projects.

Conclusion

The study broadens the knowledge about the users' perception of the birth physical environment and develops maternity spaces design knowledge. Spatial and physical characteristics of the built environment have been identified as important for mothers' experience and well-being. In particular, the findings confirm the importance of the spatial layout qualities and indicate documented knowledge as an input to consider in the design process.

Items of the built environment and the spatial parameters to measure them have been identified to better understand the role of the built environment in maternity settings and inform the practice of designers, helping to verify the spatial layout choices throughout the design process. The spatial parameters identified and detailed in the study refer to calm atmosphere, greater intimacy, spacious birth room, clarity of service points, clarity in finding midwives, sufficient space for labor, noise, privacy, and the birth room adaptability.

The findings partially bridge the gap in tools for designers and increase architects' awareness in the design of birth spaces which support the physiology and the experience of the users. The study is useful for the future identification of design guidelines referred to specific environments (units, midwife stations, common areas, and birth rooms) and at the same time provides the spatial parameters that can be used to assess and set such guidelines.

This study also extends our understanding of the importance of the interdisciplinarity process in research on the environment. The use of a mixed method design resulted in a more integrated understanding of the relationship between users' perception and spatial characteristics.

Implications for Practice

- The article confirms the importance of the spatial layout to the user's perception in the birth environment.
- It describes the spatial and physical characteristics related to items of the built environment experienced as crucial in woman's experience.
- It informs the practitioner about items of the built environment to consider when designing birth spaces: calm atmosphere, greater intimacy, spacious birth room, clarity of service points, clarity in finding midwives, sufficient space for labor, noise, privacy, and the birth room adaptability.
- It identifies the spatial parameters to measure the items of the built environment, to orient the design of maternity settings, or to inform the implementation of existing ones, such as visual integration, main distances, layout relations, and convex spaces.
- The items and spatial parameters represent a documented knowledge to develop design guidelines to fill the gap in architectural research and practice.

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Ethics Approval

The research was approved by the Ethical Committee of the Department of Educational Sciences at the University of Genoa (April 23, 2018), by the Ethical Committee of the Area Vasta Emilia Nord (May 24, 2018), and by the Ethical Committee of the AOU Careggi (June 1, 2018).

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