

The published version of this paper is available at DOI: <https://doi.org/10.1177/1937586719826058>

Health Environments Research & Design Journal

The Impact of the Physical Environment on Intrapartum Maternity Care. Identification of Eight Crucial Building Spaces

Journal:	<i>Health Environments Research & Design Journal</i>
Manuscript ID	HERD-18-0064.R2
Manuscript Type:	Literature Review
Keywords:	Labor and delivery units, Literature search, Maternity units, Salutogenic design, Architecture, Spatial layout, Birth outcomes
Abstract:	<p>Objectives This paper investigates whether the physical environment in which childbirth occurs impacts the intrapartum intervention rates and how this might happen. The study explores the spatial physical characteristics that can support the design of spaces to promote the health and wellbeing of women, supporters and maternity care professionals.</p> <p>Background Medical interventions during childbirth have consequences for the health of women and babies in the immediate and long-term. The increase in interventions is multifactorial and may be influenced by the care model, the relationships between caregivers and the organizational culture, which is made up of many factors, including the built environment. In the field of birth architecture research there is a gap in the description of the physical characteristics of birth environments that impact users' health.</p> <p>Method A scoping review was performed to seek to understand the direct and indirect impacts of the physical environment on interventions.</p> <p>Results The findings are organized into three tables reporting the influence that the physical characteristics of a space might have on people's behaviors, experiences, practices and birth health outcomes. Eight building spaces that require further investigation were highlighted: Unit layout configuration, Midwives' hub/desk, Social room, Birth philosophy vectors, Configuration of the birth room, Size and shape of the birth room, Filter and Sensory elements.</p> <p>Conclusions The research shows the importance of considering the physical environment in maternity care and that further interdisciplinary studies focused on architectural design are needed to enrich the knowledge on this topic and to develop accurate recommendations for designers</p>

The Impact of the Physical Environment on Intrapartum Maternity Care.
Identification of Eight Crucial Building Spaces

There is widespread concern about the increase in intrapartum intervention rates, in particular as regards caesarean sections, and recent research and discussions have focused on the need for the appropriate use of medically-indicated interventions (Miller et al., 2016; Shaw et al., 2016). Medical interventions during birth have consequences for the health of the mother and child, in both the immediate and long-term (as shown in the latest studies on epigenetics).

In this paper, the authors define intrapartum interventions as all interventions occurring from the onset of labor up to and including the expulsion of the placenta and membranes. Intrapartum interventions include, but are not limited to, the induction of labor, the use of intravenous oxytocin, artificial rupture of the amniotic membranes, epidural anesthesia, electronic fetal health rate monitoring, episiotomy, caesarean section, etc.

The reasons for the **increase in intervention rates are multifactorial** and in many circumstances unexplainable, as evidenced by the variation in rates within and between countries (EURO-PERISTAT, 2013). **The rates may be influenced by the model of care adopted, the relationships between caregivers and the organizational culture, which is made up of many factors including the built environment.**

The activities and relationships among users (a woman in labor, her supporter) and maternity healthcare providers (clinicians and staff) in the labor ward in hospital settings or during home births are contained within walls, and therefore within spaces of

a certain shape, characterized by precise levels of illumination and the objects and equipment they contain.

The knowledge base informing the built environment in healthcare facilities has grown rapidly in recent decades. The research findings demonstrate that the physical environment impacts users' health outcomes and wellbeing, both positively and negatively, in different fields such as mental health care (Connellan et al., 2013), dementia care (Marquardt, Beueter & Motzek, 2014) and pediatric care (Del Nord, 2006), and in different functional units of the hospital such as operating rooms (Joseph, Bayramzadeh, Zamani & Rostenberg, 2017), intensive care units (Denham, Bushehri & Lim, 2018) and wards (Rashid, 2015).

The evidence indicates that well-designed hospitals are safer and promote healing in patients, and are better for staff (Ulrich et al., 2008). The corollary of this is that poorly-designed spaces are less safe, may cause harm or morbidity for users, and may be worse workplaces for staff.

The term *environment* has different meanings in different disciplines and different research fields. In the context of environmental sociology (Catton & Dunlap, 1978), environmental psychology (Bonnes, Bonaiuto & Lee, 2004) and environmental design (Lauria, 2017), the term points to the physical environment and its relationship to a person and their needs and feelings, and to the social relationships among people. The term immediately poses an interdisciplinary and inter-scalar problem that has been accentuated over time by the complexity of the investigated phenomena. This has led to the inclusion in the concept of environment of every area of the anthropized environment and connoting aspects that cannot accurately be defined as physical (technologies, health status, wellness conditions, etc.).

This paper focuses, from an architectural perspective, on the physical environment as the built physical space where women undergo labor and birth. The authors specify the physical environment by using the term “building spaces” (Delany, 2015) which refers to single functional spatial units, their spatial relations (visibility, proximity, accessibility, permeability), and the physical environmental characteristics that define them (dimensions, shape, topology, envelope walls, auditory and lighting environmental surroundings).

This paper reviews the literature to determine whether the architectural factors and design features of the birth environment have an impact on intrapartum interventions, and if so, how this occurs.

Method

A scoping review of the topic was firstly conducted within the Scopus databases, Avery Index to Architectural Periodicals (EBSCO), and SAGE Journals in December 2017. The search strategy included the following keywords: ("Birth Environment" OR "Birth Space" OR "Birth Design" OR "Birth Architecture") OR ("Maternity Environment" OR "Maternity Space" OR "Maternity Design" OR "Maternity Architecture") OR ("Midwifery Space" OR "Midwifery Design" OR "Midwifery Architecture") OR ("Obstetric Environment") AND ("Caesarean Section" OR "Intervention rates" OR "Birth Outcomes"). The search was limited to studies in the English or Italian language.

Initially, 80 studies were found, 12 papers were further screened by title and abstract, and 4 were finally identified as relevant by reading the full text. The inclusion criteria adopted while reading the full text were: (a) the paper must provide a clear

description of the building spaces; and (b) the text must describe whether the physical environment influences intervention rates or birth outcomes.

Numerous articles referring to certain environmental qualities such as home-like, clinical, intimate, private, calm, and related psychological and functional effects were discarded as they did not meet criteria (a), that is they did not provide a clear description of the building spaces, and this acted as important filter. *Home-like* is the term chosen to illustrate the following logic: if the authors specified or explained the spatial quality, for example by saying “‘homelike’ decorative features including soft lighting, colored bedspread, floral curtains, carefully designed wooden furniture, a wooden rocking chair and artwork on the walls” (Bowden, Sheehan & Foureur, 2016, p.74), the paper was included. If instead the term was attributed to a space but the authors did not state which specific element was able to confer this spatial quality, by providing a materially identifiable explanation, the paper was excluded.

The dearth of literature retrieved from the search, the authors’ knowledge of healthcare architecture research, a review of the references of the included articles, and many of the papers that were discarded due to the absence of a direct connection between building spaces and intervention rates, suggested the importance of looking for different kind of impacts, which finally led to the development of a broader perspective.

The search then moved from seeking to understand the direct impacts of the physical environment on birth intervention rates to looking at how the physical characteristics of space might influence people’s behavior, experience or practice. The rationale was that the physical environment of birthplaces has the potential to influence intrapartum interventions both directly (A) and indirectly (B) by influencing women’s and staff’s behaviors, experiences and practices, which act as intermediate impacts. (See Figure 1).

[Place Figure 1 approximately here]

The figure illustrates that the indirect impact (B) is made up of the succession of two direct effects, both supported by the literature. The first effect is confirmed by studies on **social and health care architecture. It is known that in these kinds of buildings the physical environment plays an important role in determining stress levels, behaviors and the care experience, and** sometimes even the healing of patients (Codinhoto, Tzortzopoulos, Kagioglou, Aouad & Cooper, 2008; Nickl-Weller & Nickl, 2013; Peponis, Zimring & Choi, 1990; Ulrich, Berry, Quan & Parish, 2010). The second direct effect has been reported in midwifery and obstetrics where users' behavior, experiences and practices have a direct impact on intrapartum intervention rates because they affect the physiological birth process. It is widely recognized that stress-related factors interfere with the physiological hormonal processes of women in labor (Buckley, 2005; Stenglin & Foureur, 2013) and consequently their experiences. Behaviors such as movement and the ability to adopt upright birth positions can reduce the duration of labor, the risk of caesarean section and the need for epidural anesthesia (Lawrence, Lewis, Hofmeyr, Dowswell & Styles, 2013; Priddis, Dahlen & Schmied, 2012). Moreover, midwives' good practices foster the physiological progress of labor which leads to fewer interventions for women (Iannuzzi, 2016; Simkin & Ancheta, 2011; Walsh, 2012).

In reviewing the literature in light of these considerations, the research identified the physical elements of the birth environment that affect behavior, experience and practice, that is those direct impacts that could function as mediators, namely factors that later influence birth interventions and outcomes.. Consequently the new search strategy incorporated the use of the keywords "behavior", "experience" and "practice" in the search matrix instead of the previous terms related to intervention rates. Database

findings were screened by adopting the same procedures previously illustrated and the following inclusion criteria: the paper must provide a clear description of the building spaces and describe the influence of the physical environment on behavior, experience or practice. Initially, 247 studies were found, 56 papers were then further screened by title and abstract, and 8 were finally identified as relevant by reading the full text. The systematic keyword search was supplemented with additional manual searches of the references given in the included articles and related material identified through the active research network on the topic. A total of 37 studies (30 scientific articles, 3 book chapters, 2 research reports, 1 doctoral thesis and 1 interview) met the criteria and were read and analyzed in depth.

Results

The findings were organized into three tables. Tables 1 and 2 report 32 of the selected studies, and Table 3 the remaining 5. Table 1 shows the main characteristics of the selected studies and the building spaces that emerged as influential. These studies were mostly conducted in Western countries and employed quantitative, qualitative and mixed design research methods. Table 2 illustrates in-depth description of the building spaces mentioned in the previous table and their impacts on behaviors, experiences, practices and interventions. As shown in the last column, the main impacts were on women (28), midwives or staff (8), and less frequently on those supporting women in labor (6).

[Place Table 1 and Table 2 approximately here]

Table 3 outlines elements of building spaces that were shown to have an impact in documents setting out building design principles and recommendations.

The five key architectural publications analyzed were:

- a) “Key design concepts” (Foureur & Hastie, 2008), written in collaboration with the architect Bianca Lepori, considers all the sensory modalities that could have a positive impact on physiological birth processes. The architect’s comparison of home and hospital birth spaces conducted by closely observing how women behaved in each place led to her to develop “Mindbodyspirit architecture” for birth theory (Lepori, 2008) drawing on an experiential approach to design. The framework of the theory can be identified in design principles based on the fact that all individuals experience space with at least three bodies: the moving, the feeling and the dreaming one.
- b) “Birthing Unit Design Guidelines” (Forbes, Foureur, Leap & Homer, 2008), which proposes “optimal birth spaces” derived from a review of the literature, insights from surveys of women and in-depth interviews with midwives and architects in health facility practices.
- c) “Budset Design Principles” (Foureur, Leap, Davis, Forbes & Homer, 2011), developed using a qualitative study including a literature review, interviews with key informants (architects, midwives and researchers), and consultation with an expert panel.
- d) “Evidence-based guide to birth environment design” (Jenkinson, Josey & Kruske, 2014), a report proposing a Birth Space guide based on findings from literature reviews.
- e) “La Casa di Maternità” (Felli & Lauria, 2006), a book presenting guidelines for the design of Maternity Home facilities.

Based on these sources, the physical components included in Table 3 were mostly identified for their performance rather than morphological-descriptive characteristics. The BUDSET Tool (Foureur et al., 2011) was used as a framework to organize and categorize the identified characteristics of the building spaces.

[Place Table 3 approximately here]

Different information can be gleaned from Tables 1, 2 and 3: firstly, they provide some interesting data on the building spaces, they then differentiate between the type of impact these spaces produce, and finally a salutogenic approach emerges in many papers.

The Building Spaces

Tables 1 and 2 show that data on building spaces is limited and lacking in detailed descriptions, including the relative architectural plans. The design principles presented in Table 3 give a detailed description of the building spaces providing important clues for our investigation, although some important design aspects are not covered.

However, despite these limitations, some physical elements are fully demonstrated and recur repeatedly. One example is the presence of a medical bed in the birth room which does not help the physiological process, or a bed that occupies the central space in the room (Bowden et al., 2016; Fahy & Parratt, 2006; Forbes et al., 2008; Foureur et al., 2011; Jenkinson et al., 2014; Lepori, 1994; McCourt, Rayment, Rance & Sandall, 2016; Mondy, Fenwick, Leap & Foureur, 2016; Walsh, 2006), or one that is visible (Hodnett, Stremmler, Weston & McKeever, 2009). Moreover, the bed is seen as being majorly responsible for layout inflexibility, thereby preventing midwives from finding the space to carry out tasks (Hammond, Foureur & Homer, 2014).

The literature included in this review and the architectural knowledge and experience of the authors led to the identification of eight building spaces that require further investigation: 1) *Unit layout configuration*; 2) *Midwives' hub/desk*; 3) *Social room*; 4) *Birth philosophy vectors*; 5) *Configuration of the birth room*; 6) *Dimension and shape of the birth room*; 7) *Filter*; 8) *Sensory elements*.

The relevance of building spaces is based on several factors. Some are currently unsupported by evidence (e.g., the position of the desk), some are found in the literature but their impacts are not proven (e.g., the Unit layout configuration), and others recur repeatedly in papers but lack a clear description of their physical characteristics (e.g., the Filter). Although the building spaces are analyzed and presented individually, some are closely related and interact with each other.

The first three building spaces are related to the unit configuration, i.e., the set of spatial relationships (permeability, accessibility and visibility) between the rooms in a layout. For example, it is crucial to consider the birth room as a set of reciprocal relationships regulated by the distance, dimension, position and connection of the room with respect to other spaces in the layout (corridors, social spaces, storages, midwife desks and hubs).

Unit layout configuration. The first building space that impacts how people live within the environment is the layout configuration. It dictates how the spaces are connected, their permeability, the number of doors between them and the visibility between rooms, and how these elements affect people's movements and how they enter and exit the birth room and move within the unit. People's movements within the unit are governed by different purposes: women need to walk during labor, midwives move between their work hub and the birth room, and the women's supporters may require access to refreshments and to be able to rest in different areas.

In order for women to identify their own place, the architect Bianca Lepori (2008) has underlined the importance of planned pathways, partitions and sequences of spaces, while Longo and Setola (2009) have discussed the importance of space morphology (dimensions and layout) providing several uses for users. Symon, Paul, Butchart, Carr and Dugard (2008b) identified that the perceived spaciousness of the ward layout was directly related to increased user satisfaction and quality of care, and Symon et al. (2008d) showed that the spatial layout enabled staff to perform their duties and promoted interaction among them. Ariadne Labs and MASS (2017) conducted a pioneering study showing how design elements influence clinical decision-making and identified quantitative layout data associated with the caesarean section rates of the analyzed case studies. Some of these design elements depend on the layout configuration. The analysis showed that the maximum distance between the various Labor Delivery Rooms (LDRs) and the average distance of the nurse stations from the birth rooms are positively associated with the number of caesarean sections performed, the greater the distances the higher the cesarean rate. The measure of this last distance is linked to the compactness of the layout and the proximity of the elements within it. In short, it is a configuration problem because the distance decreases if the rooms are grouped into clusters thus assuming a central rather than longitudinal conformation. Even the percentage of the unit circulation area accessible to users, another factor that Ariadne Labs and MASS (2017) suggest could be linked to the extent of medical treatments performed during labor and delivery, is a configuration aspect: it makes a difference to a woman in labor if she is invited to walk along a corridor or can choose from alternative circular routes.

These studies reiterate the importance of the layout but no specific or in-depth studies have been carried out on the most suitable morphology of the layout (e.g., circular or elongated) in relation to the care model, nor on the position that different

rooms should occupy within the layout to facilitate optimal movements for users.

Furthermore, no studies have yet been carried out in LD units on how the careful design of the configuration in the environment allows for greater appropriation by the users who inhabit them (Penn, 2005).

Layout configuration is important not only because it influences movement but also because it affects social interaction among people (Setola & Borgianni, 2016), a relational aspect of immense importance in labor and birth.

Intelligibility is the property of a layout that can be understood and therefore easily navigated by people. In the guidelines, the configuration aspect comes into play at the level of the unit's intelligibility with respect to the point of arrival in the hospital (Forbes et al., 2008; Foureur et al., 2011).

[Place Figure 2 approximately here]

Midwives' hub/desk. The strategic position of spaces like the midwives' hub and desk may favor the relationship between women and midwives and among midwives themselves, as well as decrease stress and misconceptions in communication and practice among colleagues. For example, Berridge, Mackintosh and Freeth (2010) talk about how the location of the midwives' hub, in particular as regards its proximity to labor rooms, can affect communication and collaboration among staff. The authors have raised the question, without reaching definitive conclusions, of whether the hub and desk are better located in the same place or not. Conversely, Foureur et al. (2010) highlighted that a central desk facilitates positive communication, enabling the concepts of risk and safety to be explored. Symon et al. (2008d) state that positioning the desk in the corridor does not help the staff as it leaves them exposed to noise and interruptions by users. When the desk is positioned close to the rooms the distance between midwives and women is

reduced, but staff interactions can be noisy and disruptive for the women (Foureur & Hastie, 2008).

In summary, **the best place to position the midwives' hub and desk has been under-explored** and is poorly understood. Further aspects need to be examined, for instance the ideal number of them, **whether the midwives' desk and hub are considered to be two different places or the same** (this very much depends on the care model), **and their optimum location in the spatial layout in order to foster relationships and preserve the privacy of all users.**

[Place Figure 3 approximately here]

Social room. The presence and location of social spaces such as kitchens and/or a living room is a matter for further investigation. These spaces are perceived very positively by people and seem to have two main functions: **facilitating relations between midwives, women and supporters** (Longo & Setola, 2009; Walsh, 2006), and providing a welcoming shared space, for instance a “family room” (Forbes et al., 2008; Foureur et al., 2011), to accommodate supporters, thereby encouraging exchanges of experiences and providing them with a place of rest and support (Foureur & Hastie, 2008; Harte, Sheehan, Stewart & Foureur, 2016; Jenkinson et al., 2014) in their positive role of assisting women during the labor and birth process. Therefore, the real role of this kind of space, the people who use them, the number of them and their location in the spatial layout require further exploration.

[Place Figure 4 approximately here]

Birth philosophy vectors. In this paper, *vectors* are defined as those elements designed to communicate information, such as posters, works of art, and images and writing on the walls of the unit and the birth room that convey a specific educational

meaning related to childbirth and help to create an emotional atmosphere in the environment.

This communication takes place on several levels. Harte, Sheehan, Stewart and Foureur (2016) have shown that posters and brochures showing birth and physiological labor and birth support activities influence the instrumental and emotional needs of supporters. McCourt, Rayment, Rance and Sandall (2016) describe how decorative changes in the environment can change the midwives' practice, and Mondy, Fenwick, Leap and Foureur (2016) present a large pin-up board with photos and event notices as a shared space between women, their families and midwives. In the guidelines (Foureur & Hastie, 2008; Foureur et al., 2011) use of the feminine archetype is suggested in artworks and symbols of beauty, wholeness and harmony as they help to reduce women's stress. Each vector conveys a meaning aimed to support the mood and wishes of the person who needs it at that moment. These vectors should be placed at strategic points for the users and integrated into the design of the unit.

[Place Figure 5 approximately here]

In addition to the previous four building spaces, another four concern the characteristics of the birth room, a space inhabited by mothers, midwives and supporters.

Configuration of the birth room. The birth room is a place where different activities occur at different times. It is used by women, their supporters and midwives before, during and after birth so the same environment must be capable of transforming itself accordingly. The solution the birth room should offer stakeholders does not just relate to the physical activities occurring during the intrapartum care process but it also concerns users' experiences, an awareness of "flexible definitions of normality" and "recognition of the 'unique normality' of each woman" (Downe & McCourt, 2008, p.23).

The birth room should be as flexible as possible and suited to different purposes. First of all, it should support the woman's changing needs as she progresses through the different stages of labor and requires different atmospheres and settings to foster relaxation, distraction from the pain and to create a more intimate birth space. Flexibility in the birth room configuration can contribute to a feeling of privacy and safety which, together with the ability to move around, are essential for women in labor (Franck & Lepori, 2007; Hammond, Homer & Foureur, 2017; Igarashi, Wakita, Miyazaki & Nakayama, 2014; Lawrence et al., 2013; Lepori, 1994; Stenglin & Foureur, 2013; Walsh, 2006) to support the physiological birth process.

Flexibility within the room could be provided by the types of fixtures and modular furniture. For example, minimal fixed items and a movable bed allow individual women to express themselves (Jenkinson et al., 2014; Foureur et al., 2011). Creating ancillary spaces to store equipment near the room allows for flexibility in the use of different support materials (Forbes et al., 2008). The use of mobile furniture means the space can be configured differently and this has an impact on the women and supporter's sense of control (Harte et al., 2016). An inflexible and impractical layout also has a negative effect on midwives (Hammond et al., 2014) who as a result may not be able to support the women adequately.

However, a number of unanswered questions remain and include the essential requirements of the furniture, the size and appearance of the intimate birth space and, importantly, how to achieve such a level of flexibility within sometimes rigid hospital environments.

[Place Figure 6 approximately here]

Size and shape of the birth room. A very important element linked to the configuration of the birth room is the room size. Having an empty space or an empty and

protected area in the room allows for freedom of movement and different birth positions and activities during labor and birth (Lepori, 1994). Being able to move freely during labor is important for positive birth outcomes (Forbes et al., 2008; Foureur & Hastie, 2008; Foureur et al., 2011; Hammond, 2015; Mondy et al., 2016; Rados, Kovács & Mészáros, 2015; Singh & Newburn, 2006). The room should be big enough to host supporters as well as the belongings of both the women and supporters (Jenkinson et al., 2014; Symon, Paul, Butchart, Carr & Dugard, 2008b) as this provides a welcoming feeling and the possibility of transforming the space into a familiar environment (Harte et al., 2016).

In relation to birth room size, standards in some countries indicate that the minimum size should be 24 square meters (m²) or 258 square feet (ft²) without a pool and 34.5 m² (371 ft²) with a pool in the UK; 28 m² (301 ft²) in Australia; 30 m² (323 ft²) in the USA; between 25 m² (269 ft²) and 30 m² (323 ft²) in Italy (AusHFG, 2016; Department of Health, 2013; FGI, 2018; Ipsel Guidelines, 2007). However, it is not known if this space is sufficient to facilitate women walking around and to allow for different configurations of furnishings.

It is also essential for the birth room area to have the most suitable shape. A narrow, long room would not be appropriate to achieve flexibility whereas a room with a more square shape probably would.

Furthermore, **the shape, favoring flexibility, also makes it possible to obtain the more intimate space** many authors speak of, **which is essential for childbirth**. This space should evoke the concept of a *nest*, a cozy and protected space in the room where the woman feels undisturbed, safe and focused on the changes taking place as the birth progresses, and therefore the space allows the physiological process to proceed through “good hormone orchestration” (Foureur et al., 2011; Hammond, 2015; Jenkinson et al.,

2014; Lothian, 2004; Odent, 2003; Stenglin & Foureur, 2013). For example, the morphology of a room with more convex angles naturally creates different and intimate spaces. However, it may be less flexible than a square room where the space can be altered and spatial situations created according to individual preferences (See Figure 6).

In summary, the size of the room should be sufficient to facilitate women's free movements and the shape of the room should offer maximum flexibility to facilitate individual women in reshaping *their* space. However, further investigation is needed to determine whether this intimate space represents the whole birth room and/or a specific space, a corner, or a hidden and more private space within the same room.

[Place Figure 7 approximately here]

Filter. The interface between the birth room and the corridor is an important spatial filter that marks the transition between two different inhabited spaces, one more public and the other more private. It is important to fully understand this physical element as it helps to favor a calm atmosphere and the concept of privacy (Forbes et al., 2008; Foureur & Hastie, 2008; Foureur et al., 2011; Jenkinson et al., 2014). In their study on birth room design elements, Shin, Maxwell and Eshelman (2004) investigated the entrance transition to the room and found that this space, depending on how it is designed, relates to a feeling of hominess, a preference for using the space and women's perception of personal control.

The position of the door with respect to the internal configuration of the furnishings, such as a pool or bed, becomes an important element to check what can be seen from the inside and outside, and provides users with an adequate level of privacy (Forbes et al., 2008; Foureur & Hastie, 2008; Foureur et al., 2011; Sheehy, Foureur, Catling-Paull & Homer, 2011). This level of privacy can be obtained by taking simple precautions, for example closing a curtain to obstruct the view of what happens in the

room from the corridor. The filter, however, seems to encompass many more purposes: the transition from a corridor to a more calm and personal atmosphere, separation from all that is external, and proximity to points of contact with the midwives. In the literature, there are no descriptions of these aspects.

The filter space could be of different dimensions and achieved in many ways, with furniture, fixed elements such as low walls, and even with the space that changes in itself creating indentations or small entrances, with lighting, etc., depending on what level of permeability with external spaces is required and why.

[Place Figure 8 approximately here]

Sensory elements. All the sensory elements embedded in the space are important to create a calm and relaxing atmosphere in the unit and especially in the birth room: from the possibility of having natural and artificial dimmer lights, to the colors of the walls and different touchable textural surfaces. According to many authors, the elements that affect our senses, such as light, noise, visual art, a view of nature, temperature control, warm colors, smells and surface textures, all promote a relaxing atmosphere that reduces anxiety and stress and in turn facilitates normal birth and produces physiological benefits (Aburas, Pati, Casanova & Adams, 2017; Balabanoff, 2016; Bowden et al., 2016; Carolan-Olah, Kruger & Garvey-Graham, 2015; Duncan, 2011; Felli & Lauria, 2006; Forbes et al., 2008; Foureur & Hastie, 2008; Foureur et al., 2011; Igarashi et al., 2014; Jenkinson et al., 2014; McCourt et al. 2016; Mondy et al., 2016; Stenglin & Foureur, 2013; Symon et al., 2008c).

Two studies detailed the characteristics of sensory environments. Hauck, Rivers and Doherty (2008) found that the use of a *snoezelen room* during labor provided women with distraction, relaxation, comfort, control, and the choice of complementary therapy. Hodnett, Stremmler, Weston and McKeever (2009) compared an *ambient room* (a room

with radical modification) with a normal labor room and found that there were positive childbirth outcomes for women who labored in the ambient room: they had a shorter labor and were less likely to need oxytocin infusions. A more recent experimental study conducted in Herning Hospital in Denmark investigated the use of a room with a 3D projection on three walls designed to create an immersive environment, though the findings have not yet been published.

In summary, although we understand the beneficial effect of this last group of elements on the birth process, little is known about which if any specific element has more impact and in what context. For example, it is not known if the dominant focus should be on projection, music, aromas, and moreover, the possibility of integrating them into birth room designs, from a cost competitiveness and technological perspective, remains poorly understood.

[Place Figure 9 approximately here]

The Impacts

The impacts column of Tables 2 and 3 describes the physical, psychological and physiological effects of the building spaces which can be organized into three categories: impacts on interventions, on users' experiences and behaviors and on staff practices.

Impacts on interventions. This category includes papers that investigated how some building spaces are correlated to intervention rates in childbirth: for example, less frequently required epidural analgesia (Duncan, 2011), the likelihood of using artificial oxytocin and shorter labor times (Hodnett et al., 2009), and the likelihood of having an emergency caesarean section (Singh & Newburn, 2006).

This category also includes studies highlighting building spaces that facilitated normal birth (Carolan-Olah et al., 2015; Newburn & Singh, 2003; Symon et al., 2008c),

the physiological benefits (Fahy & Parrat, 2006; Foureur et al., 2011; Jenkinson et al., 2014; Sheehy et al., 2011) and promoted the physiologic hormone process (Lothian, 2004).

Impacts on users' experiences and behavior. The majority of studies analyzed reveal impacts on the experiences of women, midwives and supporters. These include women's sense of self (Fahy & Parrat, 2006; Stenglin & Foureur, 2013); the perception of personal control (Shin, Maxwell & Eshelman, 2004); women's distraction and relaxation (Aburas et al., 2017; Foureur et al., 2011; Hauck, Rivers & Doherty, 2008; Igarashi et al., 2014; Lepori, 2008); women's perception of comfort and sense of wellbeing (Bowden et al., 2016; McCourt et al., 2016); lower levels of stress and anxiety in both staff and women (Forbes et al., 2008; Foureur et al., 2011; Hammond et al., 2017; Jenkinson et al., 2014; Rados et al., 2015; Stenglin & Foureur, 2013; Symon et al., 2008c); midwives' positive feelings (Hammond et al., 2014), supporters feeling welcome, privacy and social interactions (Harte et al., 2016). Furthermore, other elements impact women's behavior such as free movement, assuming different labor and birth positions and accomplishing different activities (Igarashi et al., 2014; Jenkinson et al., 2014; Lepori, 1994; Mondy et al., 2016; Walsh, 2006).

Impact on staff practices. Some studies highlighted the influence of the physical environment on midwives' practices through the impact on intra-professional communication (Berridge, Mackintosh & Freeth, 2010; Foureur et al., 2010) and on the ability to perform tasks comfortably and responsively (Hammond et al., 2014; Hammond et al., 2017; Symon et al., 2008d).

A Salutogenic Approach

The approach suggested by some of the analyzed papers reveals a health-orientation that aims to identify positive and negative impacts in order to create a path that favors physiological labor and birth. This argument refers to the Salutogenesis concept, a theory originally developed by the medical sociologist Aaron Antonovsky in the late 1970s which is concerned with understanding what generates and maintains health and wellbeing (Perez-Botella, Downe, Meier-Magistretti, Lindstrom & Berg, 2015).

From this positive health perspective, understanding which spatial determinants maximize health and wellbeing for women, supporters and staff offers architecture the potential of contributing to the understanding of pregnancy and childbirth as a health-producing processes (Downe, 2010).

Thus, the challenge is to focus on space as an intrinsically positive resource for wellbeing and to find ways to develop assets for maternity, where the space forms an important contributing factor and, along with other factors, holds the key to a positive change in outcomes for women.

Conclusions

The research investigated the impacts of birth space characteristics on intrapartum maternity care, arriving at the definition of a conceptual model to better understand the direct and indirect influences of the physical environment. The effects of the physical environment can be found not only by studying intervention rates, which represented the initial purpose of the study, but also all the transitional/intermediate impacts (behavior, experience and practice) elicited by the space which later influence intrapartum interventions.

The reviewed articles, limited to circumscribed and different birth contexts (mainly European, Australian and American), have highlighted aspects that are desirable to stakeholders but that should be contextualized in the care model, culture and health of every single woman.

The complexity and versatility of the building spaces identified should be further understood through the contribution of several disciplines, including architecture, midwifery and anthropology to enhance the meaning of each building space, provide knowledge about its nature and stimulate the creativity of architects to find the most appropriate architectural solutions.

The research shows the importance of considering environment design in maternity care and that even some existing studies not focused on this topic provide evidence of specific building spaces. The extrapolation of that data presents the existing studies in a manageable way to address specific research focused on architectural design in order to enrich our knowledge of what works well for women in childbirth, their supporters and caregivers. It also helps to expand on the evidence to prove the effect that the physical environment design has on birth outcomes and finally to develop accurate recommendations for designers.

References

- Aburas, R., Pati, D., Casanova, R., & Adams, N. G. (2017). The Influence of Nature Stimulus in Enhancing the Birth Experience. *Health Environments Research & Design Journal*, 10(2), 81-100.
- Ariadne Lab, & MASS (2017). Designing Capacity for High Value Healthcare: The Impact of Design on Clinical Care in Childbirth. Retrieved from <https://www.ariadnelabs.org/>

- AusHFG (2016). Part B. Health Facility Briefing and Planning HPU 510 Maternity Unit, Revision 7.0, 18 May 2017. *Australasian Health Facility Guidelines*. Retrieved from <https://www.healthfacilityguidelines.com.au/health-planning-units>
- Balabanoff, D. (2016). Light in the Reimagined Birth Environment. (Doctoral dissertation). Retrieved from <https://indd.adobe.com/view/3a35bb36-7f43-4e94-b79f-7ce4b989f452>
- Berridge, E. J., Mackintosh, N. J., & Freeth, D. S. (2010). Supporting patient safety: Examining communication within delivery suite teams through contrasting approaches to research observation. *Midwifery*, *26*, 512–519.
- Bonnes, M., Bonaiuto, M., & Lee, T. (2004). *Teorie in pratica per la psicologia ambientale*. Milano, Italy: Raffaello Cortina Editore.
- Bowden, C., Sheehan, A., & Foureur, M. (2016). Birth room images: What they tell us about childbirth. A discourse analysis of birth rooms in developed countries. *Midwifery*, *35*, 71–77.
- Buckley, S. J. (2005). *Gentle Birth, Gentle Mothering: the wisdom and science of gentle choices in pregnancy, birth, and parenting*. One moon press, Brisbane.
- Carolan-Olah, M., Kruger, G., & Garvey-Graham, A. (2015). Midwives' experiences of the factors that facilitate normal birth among low risk women at a public hospital in Australia. *Midwifery*, *31*, 112-121.
- Catton, W. R. Jr., & Dunlap, R.E. (1978). Environmental sociology: a new paradigm. *The American Sociologist*, *13*, 41-49.
- Connellan, K., Gaardboe, M., Riggs, D., Due, C., Reinschmidt, A., & Mustillo, L. (2013). Stressed spaces: mental health and architecture. *Health Environments Research & Design Journal*, *6*(4), 127-68.
- Codinhoto, R., Tzortzopoulos, P., Kagioglou, M., Aouad, G., & Cooper, R., (2009). The impacts of the built environment on health outcomes. *Facilities*, *27*(3/4), 138-151.
- Delany, S. (2015). Uniclass Classification Scheme, last updated 31st January 2018. Retrieved from <https://toolkit.thenbs.com/articles/classification#classificationtables>.

- Del Nord, R. (2006). Environmental stress prevention in Children's Hospital Design. Milano, Italy: Motta Editore.
- Denham, M. E., Bushehri, Y., & Lim, L. (2018). Through the Eyes of the User: Evaluating Neonatal Intensive Care Unit Design. *Health Environments Research & Design Journal*, (11)3, 49-65.
- Department of Health (2013). Health Building Note 09-02: Maternity care facilities. Retrieved from <https://www.gov.uk/government/publications/>
- Downe, S. (2010). Towards Salutogenic Birth in the 21st Century. In Denis Walsh and Soo Downe (Eds) Essential Midwifery Practice: Intrapartum Care. Blackwell Publishing.
- Downe, S., & McCourt, C. (2008). "From being to becoming: reconstructing childbirth knowledges". In Downe, Soo (Ed). Normal Childbirth. Evidence and Debate, p.3-28. Churchill Livingstone Elsevier.
- Duncan, J. (2011). The effect of colour and design in labour and delivery: A scientific approach. *Optics & Laser Technology*, 43, 420-424.
- EURO-PERISTAT (2013). EURO-PERISTAT Project with SCPE and EUROCAT. European Perinatal Health Report. Health and care of pregnant women and babies in Europe in 2010. May 2013. Retrieved from www.europeristat.com
- Fahy, K. M., & Parratt, J.A. (2006). Birth Territory: A theory for midwifery practice. *Women and Birth*, 19, 45-50.
- Felli P., & Lauria A. (2006). La casa di maternità: una struttura sociale per il parto fisiologico. Linee guida per la progettazione. Pisa: Edizioni ETS.
- FGI (2018). Guidelines for Design and Construction of Hospitals. Retrieved from <http://www.madcad.com/store/subscription/FGI-Guidelines-Hospital-2018/>.
- Forbes, I., Foureur, M., Leap, N., & Homer, C. S. E. (2008). Birthing Unit Design: Researching New Principles. World Health Design Magazine. January, 47-53. Retrieved from <http://www.worldhealthdesign.com/birthing-unit-design-researching-new-principles.aspx>

- Foureur, M., Davis, D., Fenwick, J., Leap N., Iedema, R., Forbes, I., & Homer, C. S. E. (2010). The relationship between birth unit design and safe, satisfying birth: Developing a hypothetical model. *Midwifery*, 26, 520–525.
- Foureur, M., & Hastie, C. (2008). “Putting the principle into practice”. In: Birth Territory and Midwifery Guardianship. Edited by Fahy K., Foureur M., Hastie C. Butterworth Heinemann Elsevier. pp.101-112.
- Foureur, M., Leap, N., Davis, D. L., Forbes, I. F., & Homer, C. S. E. (2011). Testing the Birth Unit Design Spatial Evaluation Tool (BUDSET) in Australia: A Pilot Study. *Health Environments Research & Design Journal*, 4(2), 36-60.
- Franck, K., & Lepori, B. (2007). Architecture inside out. Wiley Edition London.
- Hammond, A. (2015). A Space of Possibilities: The importance of birth unit design. *Australian Midwifery News*, 15(3), 28-31.
- Hammond, A., Foureur, M., & Homer, C.S.E. (2014). The hardware and software implications of hospital birth room design: A midwifery perspective. *Midwifery*, 30, 825–830.
- Hammond, A., Homer, C. S. E., & Foureur, M. (2017). Friendliness, functionality and freedom: Design characteristics that support midwifery practice in the hospital setting. *Midwifery*, 50, 133-138.
- Harte, J. D., Sheehan A., Stewart, S. C., & Foureur, M. (2016). Childbirth Supporters’ Experiences in a Built Hospital Birth Environment: Exploring Inhibiting and Facilitating Factors in Negotiating the Supporter Role. *Health Environments Research & Design Journal*, 9(3), 135-161.
- Hauck, Y., Rivers, C., & Doherty, K. (2008). Women’s experiences of using a Snoezelen room during labour in Western Australia. *Midwifery*, 24, 460–470.
- Hodnett, E.D., Stremmler, R., Weston, J.A., & McKeever, P. (2009). Re-Conceptualizing the Hospital Labor Room: The PLACE (Pregnant and Laboring in an Ambient Clinical Environment) Pilot Trial. *BIRTH*, 36(2), 159-166.

- Iannuzzi L. (2016). An exploration of midwives' approaches to slow progress of labour in birth centres, using case study methodology. (Doctoral dissertation). Retrieved from <http://eprints.nottingham.ac.uk/>
- Igarashi, T., Wakita, M., Miyazaki, K., & Nakayama, T. (2014). Birth environment facilitation by midwives assisting in non-hospital births: A qualitative interview study. *Midwifery*, 30, 877-884.
- Ipsel Guidelines (2007). Linee guida per gli interventi di prevenzione relativi alla sicurezza e all'igiene del lavoro nel blocco parto. Istituto superiore per la prevenzione e la sicurezza del lavoro. Retrieved from <https://appsricercascientifica.inail.it/>
- Jenkinson, B., Josey, N., & Kruske, S. (2014). BirthSpace: An evidence-based guide to birth environment design. (Research Report of the Queensland Centre for Mothers & Babies, The University of Queensland). Retrieved from <https://espace.library.uq.edu.au/>
- Joseph, A., Bayramzadeh, S., Zamani, Z., & Rostenberg, B. (2017). Safety, Performance, and Satisfaction Outcomes in the Operating Room: A Literature Review. *Health Environments Research & Design Journal*, 11(2), 137-150.
- Lauria, A. (2017). Environmental design & accessibility: notes on the person environment relationship and on design strategies. *Techne Journal*, 13, 55-62.
- Lawrence, A., Lewis L., Hofmeyr, G. J., & Dowswell, T., Styles, C. (2013). Maternal positions and mobility during first stage labour. *Cochrane Database Syst Rev*. Aug 20 (8), CD003934.
- Lepori, B. (1994). Freedom of Movement in Birth Places. *Children's Environments*, 11(2), 1-12.
- Lepori, B. (2008). "The moving, feeling and dreaming body guides architectural design". In: *Birth Territory and Midwifery Guardianship*. Edited by Fahy K., Foureur M., Hastie C. Butterworth Heinemann Elsevier. pp. 96-101.
- Longo, E., & Setola, N. (2009). Towards a spatial dimension of social rights. New perspectives in architecture and law studies. *Interdisciplinary Themes Journal*, 1, 1-10.

- Lothian, J. A. (2004). Do Not Disturb: The Importance of Privacy in Labor. *The Journal of Perinatal Education*, 13(3), 4-6.
- Marquardt, G., Bueter, K., & Motzek, T. (2014). Impact of the design of the built environment on people with dementia: an evidence-based review. *Health Environments Research & Design Journal*, 8(1), 127-57.
- McCourt, C., Rayment, J., Rance, S., & Sandall, J. (2016). Place of Birth and Concepts of Wellbeing An Analysis from Two Ethnographic Studies of Midwifery Units in England. *Anthropology in Action*, 23(3), 17-29.
- Miller, S., Abalos, E., Chamillard, M., Ciapponi, A., Colaci, D., Comandé, D., ... Althabe, F. (2016). Beyond too little, too late and too much, too soon: a pathway towards evidence-based, respectful maternity care worldwide. *Lancet*, 388 North American Edition (10056), 2176-2192.
- Mondy, T., Fenwick, J., Leap N., & Foureur, M. (2016). How domesticity dictates behaviour in the birth space: Lessons for designing birth environments in institutions wanting to promote a positive experience of birth. *Midwifery*, 43, 37-47.
- Newburn, M., & Singh, D. (2003). Creating a Better Birth Environment. Women's views about the design and facilities in maternity units: a national survey. National Childbirth Trust, London.
- Nickl-Weller, C., & Nickl, H. (2013). Healing Architecture. Schweiz: Braun Publishing AG.
- Odent, M. (2003). Birth and Breastfeeding: Rediscovering the Needs of Women During Pregnancy and Childbirth. Clairview.
- Peponis, J., Zimring, C., & Choi, K. (1990). Finding the building in wayfinding. *Environment and Behavior*, 22(5), 555-590.
- Penn, A. (2005). The system-user paradox: do we need models or should we grow ecologies? In ACM International Conference Proceeding Series, Proceedings of the 4th international

- workshop on Task models and diagrams. 1–8. Gdansk Poland and New York USA: ACM Press.
- Perez-Botella, M., Downe, S., Meier-Magistretti, C., Lindstrom, B., & Berg, M. (2015). The use of salutogenesis theory in empirical studies of maternity care for healthy mothers and babies. *Sexual & Reproductive Healthcare*, 6, 33–39.
- Priddis, H., Dahlen, H., & Schmied, V. (2012). What are the facilitators, inhibitors, and implications of birth positioning? A review of the literature. *Women and Birth*, 25, 100-106.
- Rados, M., Kovács, E., & Mészáros, J. (2015). Intimacy and privacy during childbirth. a pilot-study testing a new self developed questionnaire: the childbirth intimacy and privacy scale (CIPS). *New Medicine*, 19(1), 16-24.
- Rashid, M. (2015). Research on nursing unit layouts: an integrative review. *Facilities*, 33(9/10), 631-695.
- Setola N., & Borgianni S. (2016). *Designing Public Spaces in Hospitals*. NY: Routledge.
- Sheehy, A., Foureur, M., Catling-Paull, C., & Homer, C. S. E. (2011). Examining the Content Validity of the Birthing Unit Design Spatial Evaluation Tool Within a Woman-Centered Framework. *Journal of Midwifery & Women's Health*, 56(5), 494-502.
- Shin J.-H., Maxwell L. E., & Eshelman P. (2004). Hospital Birthing Room Design: A Study Of Mothers' Perception Of Hominess. *Journal of Interior Design*, 30(2), 23-36.
- Shaw, D., Guise, J.-M., Shah, N., Gemzell-Danielsson, K., Joseph, K. S., Levy, B., Wong, F., Woodd, S., & Main, E. K. (2016). Drivers of maternity care in high-income countries: can health systems support woman-centred care? *Lancet*, 388North American Edition (10057),2282-2295.
- Simkin, P., & Ancheta, R. (2011). *The labor progress handbook: early interventions to prevent and treat dystocia*. John Wiley and Sons.
- Singh, D., & Newburn, M. (2006). Feathering the nest: what women want from the birth environment. *RCM Midwives*, 9(7), 266-269.

- Symon A., Paul J., Butchart M., Carr V., & Dugard P. (2008a). Maternity unit design study part 1: background to multi-site study in England. *British Journal of Midwifery*, 16(1), 29-33.
- Symon, A., Paul J., Butchart, M., Carr, V., & Dugard, P. (2008b). Maternity unit design study part 2: perceptions of space and layout. *British Journal of Midwifery*, 16(2), 110-114.
- Symon, A., Paul, J., Butchart, M., Carr, V., & Dugard, P. (2008c). Maternity unit design study part 3: environmental comfort and control. *British Journal of Midwifery*, 16(3), 167-171.
- Symon, A., Paul J., Butchart, M., Carr, V., & Dugard, P. (2008d). Maternity unit design study part 4: midwives' perceptions of staff facilities. *British Journal of Midwifery*, 16(4), 228-231
- Stenglin, M., & Foureur, M. (2013). Designing out the Fear Cascade to increase the likelihood of normal birth. *Midwifery*, 29,819–825.
- Ulrich, R.S., Zimring C., Zhu X., DuBose J., Seo H., Choi Y., Quan X., & Joseph A. (2008). A Review of the Research Literature on Evidence-Based Healthcare Design. *Health Environments Research & Design Journal*, 1(3), 61–125.
- Ulrich, R.S., Berry, L.L., Quan, X., & Parish, J. T. (2010). A conceptual framework for the domain of evidence-based design. *Health Environments Research & Design Journal*, 4(1), 95-114.
- Walsh, D.J. (2006). 'Nesting' and 'Matrescence' as distinctive features of a free-standing birth centre in the UK. *Midwifery*, 22, 228–239.
- Walsh, D. (2012). Evidence and skills for normal labour and birth. A guide for midwives. 2nd ed. Routledge.

Author and year	Design and method	Sample and location	Aim	Building spaces
Aburas et al. (2017)	Experimental design T-test, ANOVA, Pearson's Correlations	50 women (26 control, 24 study group) 8 LDR (4 control, 4 study group) USA	To examine the clinical and behavioral impacts of visual nature stimuli on women during labor and delivery	Visual nature images
Ariadne Labs and MASS (2017)	Research report. Exploratory study Delpny, descriptive analysis, association, Pressure-Tank Model	3 BC, 9 hospitals USA	To understand how design impacts clinical processes, decisions and outcomes during childbirth	Unit layout
Balabanoff (2016)	Doctoral research report		To re-imagine birth space, using architectural means and expertise, in order to connect sensory experience with consciousness, meaning, intimacy and cosmicity	Light and color
Berridge et al. (2010)	Longitudinal study Ethnographic methods Observations, IPA framework	Staff 4 DS UK	To explore the nature of intra- and interprofessional communication on delivery suites, with a particular focus on patient safety	Midwives' hub / desk Resource room / rest room
Bowden et al. (2016)	Qualitative study Kress and Van Leeuwen's social semiotic theoretical framework	40 images of birth rooms (26 OLU, 6 AMU, 8 FMU)	To examine images of birth rooms in developed countries and analyze the messages and visual discourse being communicated through images	Technological birth room Homelike birth room
Carolan-Olah et al. (2015)	Qualitative study IPA approach, interviews, Smith and Osborn's approach	22 midwives 1 maternity setting AU	To explore midwives' experiences and views of the factors that facilitate or impede normal birth	Intimate birth room
Duncan (2011)	Research project Quantitative collection, statistical analysis	58 women (32 control, 26 study group) UK	To explore whether visual and performing arts have any measurable effect on physiological, psychological and biological outcomes of clinical significance on patient recovery	Visual and performing art
Fahy and Parratt (2006)	Theory derived from reflections upon empirical experiences as midwives and researchers		To present a timely and succinct overview of the theory of Birth Territory so that it can be discussed, critiqued, refined and further developed for testing via research	"Sanctum", homely birth room "Surveillance room", clinical birth room
Foureur et al. (2010)	Conceptual model based on literature review and cross- disciplinary studies		To describe the development of a conceptual model based on literature and understandings of design, communication, stress and model of care	Midwives' desk Tea room, office and corridors
Hammond et al.	Video ethnographic study	6 women + supporters, 8	To explore the impacts of physical and aesthetic design	Birth room layout

1						
2	(2014)	Video-reflexing interviews, field notes	midwives 7 LW, 1 BC AU	of hospital birth rooms on midwives	Colors, light, surfaces, artwork Equipment	
3						
4						
5	Hammond (2015)	Interview to Professor M. Foureur			Enveloping space Flexibility of birth room Open space of possibilities	
6						
7						
8						
9						
10	Hammond et al. (2017)	Qualitative explorative descriptive method In depth, face-to-face photo-elicitation interviews, thematic analysis	16 midwives 7 DS, 9 BC AU	To identify and describe the design characteristics of hospital birth rooms that support midwives and their practice	Friendly birth rooms Functional birth rooms Freedom	
11						
12						
13						
14						
15						
16	Harte et al. (2016)	Exploratory video ethnographic, field notes, video-cued interviews	1 family Maternity unit AU	To explore inhibiting and facilitating design factors influencing childbirth supporters' experiences	Spaciousness Family alcove Options to facilitate personal choice	
17						
18						
19						
20						
21	Hauck et al. (2008)	Qualitative exploratory design In depth interviews, comparison method modified from the grounded theory	16 women Snoezelen room AU	To explore women's experience of using a Snoezelen room during their labor	Snoezelen room	
22						
23						
24						
25	Hodnett et al. (2009)	Pilot randomized controlled trial Questionnaires, SAS, tests for differences, coding	62 women, 39 nurses, 30 physicians 1 labor room, 1 ambient room CA	To test the feasibility of a randomized trial and the acceptability of the modified labor room to women and their care providers	Ambient room	
26						
27						
28						
29						
30	Igarashi et al. (2014)	Semi-structured qualitative interview study Constant comparative analysis	20 midwives (14 midwifery home, 6 home) JP	To understand the organization of the perinatal environment considered important by independent midwives in non-hospital settings and to clarify the processes involved	Light and temperature Modifiable spatial organization	
31						
32						
33						
34						
35	Lepori (1994)	Interviews, reports	Women, midwives IT	To discuss the conflict between the humanization of the hospital birth environment and the spatial requirements imposed by a pathological definition of birth	Empty center and protected area Visual and tactile continuity Flexibility of birth room	
36						
37						
38						
39	Lepori (2008)	Experiential approach to design		To share how, starting from the birthing room, awareness has been brought to architectural practice in general as well as to the way birthing rooms are	Patterns of organization Pathways Personal territory	
40						
41						
42						
43						
44						
45						
46						

				designed	
3					
4	Longo and Setola (2009)	Experiential approach Narrative observation and description	1 BC IT	To investigate places in the buildings where social rights embed in	Spaces of sociality Spaces morphology
5					
6					
7					
8	Lothian (2004)	Opinion paper		To discuss the importance of providing labor support that respects the woman's privacy, protects her from unnecessary interventions, insures her safety, and allows her to trust her inherent ability to give birth normally	Protected space
9					
10					
11					
12					
13					
14	McCourt et al. (2016)	Ethnographic design Interviews, documentary analysis, observations	Staff, women, supporters AMU UK	To investigate the role of midwifery units in promoting a sense of wellbeing and to re-normalize concepts of birth	Home-like birth room Décor, furnishing, equipment, bed
15					
16					
17					
18	Mondy et al. (2016)	Qualitative approach Video ethnography and reflexive interviewing	6 women 5 hospital + 1 BC AU	To explore, describe and compare birth spaces with different domestic characteristics and subsequently, how laboring women worked within these spaces during the labor process	Conventional setting Domestic setting
19					
20					
21					
22					
23	Rados et al. (2015)	Questionnaires	88 women 2 OLU HU	To explore what role privacy and intimacy play during labor and delivery and to discover whether perceived stress is related to privacy and intimacy experienced by mothers	Birth room's characteristics
24					
25					
26					
27					
28	Sheehy et al. (2011)	In-depth interviews	10 women, 2 midwives AU	To establish the content validity of the BUDSET from the perspective of women and midwives	Technological design setting
29					
30	Shin et al. (2004)	Likert-type ratings of line-drawings Questionnaires, interviews General Linear Model, ANOVA, Correlation Coefficient	35 women 49 drawings USA	To examine a select set of interior design elements for their contribution to the perception of hominess in a birthing environment	Sitting areas Entrance transition space Personal display area Windows Openness toward Outside
31					
32					
33					
34					
35					
36	Singh and Newburn (2006)	Self-completion survey	2620 women (2% home, 16% MLU/BC, 87% hospital) UK	To explore whether the environment in which women give birth matters to them and whether it makes a difference to the type of birth they have	Important elements of physical environment
37					
38					
39					
40	Stenglin and Foureur (2013)	Expanding current understanding of the theory of birth territory by		To explore how the design and use of existing spaces can be maximized to create safe, sanctum-like	Bound, unbound space Light
41					
42					
43					
44					
45					
46					

	applying Binding, a theoretical tool drawn from social semiotics		environments that meet the changing needs of women as their labor unfolds	Natural materials
5 6 7 8 9 10	Symon et al. (2008a), (2008b), (2008c), (2008d) Multi-method study Questionnaires, focus groups, interviews NHS AEDET, Excel and SPSS	559 women, 521 partners, 227 staff 3 OLU, 6 MLU UK	To examine the impact of maternity unit design on satisfaction levels, and staff perceptions of work performance	Spaciousness of the unit Environmental variables Ward and room layouts Staff offices, work stations and facilities
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46	Walsh (2006) Ethnography design Interviews, observations, recordings	30 women, 15 midwives, 10 MCAs UK	To explore the culture, beliefs, values, customs and practices around the birth process within a free-standing birth center	Staff room Flexible space

Author and year	Building spaces	Impacts	Who
Aburas et al. (2017)	Visual nature stimulus: set of nature images on a TV	Improves clinical and behavioral outcomes: higher satisfaction, lower heart rates	W
Ariadne Labs and MASS (2017)	Maximum distance between LDRs, average distance from nurse station; percentage unit circulation space available to patients	Associated with more caesarean sections	W
Balabanoff (2016)	Varying lightness, darkness and colour, coloured light projected, refracted and reflected, an intricate play of shadow and light on surfaces	Ameliorate pain, enhance consciousness of cosmos, provide opening to sky/garden and enclosing comfort of privacy, make daylight visible and vivid	W
Berridge et al. (2010)	Midwives' hub / desk Resource room / rest room	Affect patterns of intra and interprofessional communication: collaboration, teamwork, case discussion, note-writing	St
Bowden et al. (2016)	Technological images: bed centered, stark, cold-colored, white, pale blue or green walls, bright lighting, plastic or stainless material, shiny smooth surfaces, counter tops and linoleum/vinyl floor; focus on labor bed and medical equipment	Inform and persuade that childbirth is potentially risky and requires medical assistance → Women will lie down and assume a passive pose	W, Sp, St
Carolan-Olah et al. (2015)	Homelike images: double bed, bath and soft lighting, relaxing warm colored walls (red, pink, orange), homelike furniture and décor (wood grain cupboards, artworks, soft lighting, curtains), colored/wood grain floor, labor supports (birth stool, mat, ball etc.), views of nature, everyday objects (plant, cups)	Induce the concept of childbirth as physiologically normal and active process → Sense of comfort, relaxation and well-being	W, Sp, St
Duncan (2011)	Intimate and supporting birth room environment (dim lighting, quiet space and limiting the amount of traffic in the room)	Facilitate normal birth → Number of physiological benefits	W
Fahy and Parratt (2006)	Visual and performing abstract art: a screen hiding medical equipment and acting as focal point of attention and distraction	Shortens the duration of labor, reduces the requirement for epidural analgesia	W
Fourreur et al.	“Sanctum”. Homely environment that optimizes privacy, ease, control and comfort of the woman: there is easy access to a toilet, a deep bath and the outdoors “Surveillance room”. Clinical environment that facilitates surveillance and optimizes the ease and comfort of the staff: clinical-looking, equipment on display, dominated by the bed, no easy access to bath, toilet or outdoor	Enhances confidence and embodied sense of self → Optimal physiological function and emotional wellbeing Causes fear and reduces embodied sense of self → Inhibited physiological functioning, reduced emotional wellbeing and emotional distress	W
	Central desk where midwives congregate to share real-time and	Influences positive communication enabling concept of risk and safety	W, Sp,

1					
2	(2010)	remembered narratives (Williams, 2003)	to be explored and management plans for women to be refined	MW	
3		Tea room, office and corridors (Hunt and Symonds, 1995)	Generate opportune communication		
4					
5	Hammond et al. (2014)	Usability of space. Congestion and clutter: inflexible and impractical layout (bed-centered), inadequate storage for woman's belonging	Produce less comfort and a lack of space to undertake tasks. Midwives less likely to stay with women		
6		Earthy colors, adjustable lighting, soft surfaces, natural light, artwork and personal objects	Positively affect feelings	MW	
7		Impractical equipment	Produce noise and loss of time		
8					
9					
10					
11					
12					
13	Hammond (2015)	Enveloping space: quite, dimly lit, warm	Provides comfort and the possibility to focus inward		
14		Flexibility of birth room	Supports women's changing needs		
15					
16		Open space of possibilities: women free to move, moveable furniture, bed can be put to one side, opportunity for water immersion, for lighting, heating and cooling controlled, equipment not on display, presence of cozy corner, quiet secluded space - a little nook to move into	Provides ideal emotional, psychological, physiological and neurobiological responses → More conducive to active birth	W	
17					
18					
19					
20					
21	Hammond et al. (2017)	Friendly birth rooms: use color, lighting and texture to create warmth, minimize clinical aesthetic incorporating clinical features in a way that reduce the dominance of these objects through thoughtful placement or concealment and the provision of alternate foci	Reduce stress and support positive experience	W	
22			Increase feelings of safety and support the practice	MW	
23					
24					
25					
26		Functional birth rooms, not prescriptive in design and layout: baby resus doesn't open out onto the end of the bed, no big equipment that occupy the whole corner, adequate storage, de-centralized bed, adaptable and flexible objects and equipment	Facilitate active labor and birth	W	
27			Enable choice and provide options to better meet the women's need	MW	
28					
29					
30					
31		Freedom, spacious, uncluttered, private, comfortable and free from distraction birth rooms: windows provide fresh air, curtains create ambience, plenty of move-ability around.	Provide possibilities	W	
32		Space of possibilities: a place that allows freedom has ample unstructured space and engender a sense of multiple possibilities	Allow for flexible, spontaneous and responsive practice	MW	
33					
34					
35					
36	Harte et al. (2016)	Spacious space, easily accessible storage, aesthetically pleasing colors and images	Make feeling welcome and give the possibility to personalize and create a familiar space	Sp	
37		Family alcove near entrance to birth room	Promotes privacy		
38					
39					
40					
41					
42					
43					
44					
45					
46					

1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
	softened. Medical equipment and waste out of view		
	Large pin up board filled with photos of women, babies and their families + notices for community members	Provide a sharing space between women, their families and midwives	W, Sp
	Rados et al. (2015) Be on sight through a door or a window, being able to move around and choose position freely, see immediately who is entering the room, closed door, could hear voices, and sigh or scream freely, private bathroom	Influence intimacy and privacy → Level of stress	W
	Sheehy et al. (2011) Lack of privacy: people walking in and out, anyone able to hear or see women, busy places	Create a Foreign Space, sense of unfamiliarity → Fear Cascade *	
	Technological design: medical equipment visible	Produce insecurity, stress and anxiety → Fear Cascade *	W
	Sterile / clinical aesthetic: bright lights, white paint, white sheets, vinyl floors and metallic surfaces	Intimidates → Fear and anxiety → Fear Cascade *	
	Shin et al. (2004) Sitting areas in alcoves and window areas		
	Entrance transition space		
	Sitting area for family near the bed. Additional seating away	Contribute to the perception of Hominess and Controllability (perception of Personal control) and the Preference (likeliness of using the setting)	W
	Adequate display area for personal mementos and gifts		
	No interior windows to the corridors		
	Openness toward Outside: Access to natural views and daylight and adequate windows treatments for light and privacy control		
	Singh and Newburn (2006) Important elements of physical environment such as: Not to be in sight of or overlooked by others; Able to walk around; Able to control who comes into the room; Bean bags, pillow and mats to use; Unable to hear other women...	Women who had access to a good range of these facilities were less likely to have an emergency caesarean section	W
	Stenglin and Foureur (2013) Flexibility in Banding scale: a. Bound space: through enclosure such as corners, nook and crannies; blinds over windows ensuring visual privacy, small office with soft furnishing; dimly ambient lighting and warm colors for the admission space; visual images of bound view of nature: cloistered space in the natural environment. b. Too bound space c. Unbound space: high ceiling, lofty spaces by soaring overhead, domestic	Evokes feelings of comfort, safety and security a. Induces protection, privacy, safety → Dissipate anxiety and enables women to quiet and focus inward b. Make feel constrained, suffocated, smothered c. Produce loss of enclosure around occupant, feeling of openness and freedom, rest and relaxation	W

For Peer Review

	Building spaces	Impacts	Who
1			
2			
3	Entrance to the maternity unit easily identified: dedicated entry area	Reduces anxiety and gives confidence for a safe arrival	W, Sp
4	Public arrival area as a transition space	Transfer emotionally from being an "outside person" to an "inside person"	W, Sp
5	Easy way-finding and welcoming environment, familiar corridors	Reduce anxiety and stress	W, Sp
6	possibly with external windows		
7			
8	Long corridors and distances	Can be frightening, cause anxiety and perception of extreme workload	W, Sp
9			
10	Arrival		
11	Corridors without windows or evidence that other people and staff are nearby	Can cause anxiety and interrupt the progress of the labor	W
12			
13	Glass doors from the outside door to unit entrance	Provide an easy route where staff and support can be readily seen	W, Sp
14			
15	Not automatic double doors or airlocks	Can be difficult to maneuver and put roadblocks in the way of hurrying or anxious people	W, Sp
16			
17	Airlock spaces	Can make laboring woman claustrophobic and increase anxiety	W
18			
19	Access to nature: moving easily into gardens and courtyards	Reduces stress levels (Biophilia Hypothesis)	W, Sp, Mw
20			
21	Outside		
22	Access to an outside area: moving to another environment	Can reduce fear and restore the production of oxytocin	W
23	View of nature	Induces psychological and physiological benefits	W
24			
25	Reception		
26	High and not attractive staff desks and reception counters	Form intimidating barriers	W, Sp
27	Birth room in the ground floor	Favors way-finding, easy access to some outdoor areas or natural relaxing surrounds → Restore oxytocin production and a more effective labor process	W
28			
29			
30	Space large enough to walk around and assume different positions	Supports normal birth → Less emergency caesarean sections	W
31	Birth room		
32	Flexible space: minimize fixed items	Supports mobility → Assists the descent of the fetus and shortens labor	W
33			
34	Having different spaces	Allow to retreat and maintain privacy, withdraw undisturbed and focus inward	W
35			
36	Bed out of the way (moveable or retractable): empty space in center of room	Permits the balance of the room to be left for multiples activities that suit the woman → more control, freedom of movement and assuming different positions → Support physiology	W
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			

	covered built-in benches, bars on walls	supporters rest on	
	Various equipment: mattresses, birth stool, exercise balls, pulling ropes, beanbag...	Support more frequent position changes	W
	Access to a suitable bath or pool	Reduces pain during labor and facilitates birth. Water immersion associated with reduced use of epidural/spinal analgesia and a decreased duration of labor	W
Birthing bath	Bath in a protected corner /on the side wall of the room	Occupant not on display → Sense of privacy and soothing, relax and support	W
	Bath with approach sides and grab rails	Is more practical and safe, allows supporters or midwives to sit and assist without discomfort	W, Sp, Mw
	Bath not deep enough	Forces women to recline → Counterproductive to the physiology	W
En suite bathroom facilities	Private bathroom with toilet, hand basin and shower	Enables to maintain privacy and remain relaxed	W
	Private access to shower (large enough for 2 or more people) and acting as secluded space	Reduces pain, can assist the release of oxytocin, support an active role	W
	Natural light → Window large enough to allow natural indirect light, minimizing glare	Aids in healing process and supports the biorhythms of the body and day-night orientation	W
	Bright artificial light	Stimulates the neocortex → Release of adrenalin → Inhibited physiology of birth	W
Light	Soft/lower light	Create a more restful mood and greater sense of privacy	W
	Strong/brighter light	Active mood/encourage activity	W
	Centrally located overhead lights	Likely to increase anxiety	W
	Adjustable, dimmable lights controlled by woman	Offer opportunities to change the mood	W
Colour	Brighter colors	Stimulate the neocortex	W
	Warm tones more subdued in color	Provide restful psychological responses	W
	Whites and creams colors	Contribute to a stark, clinical feel	W
Texture	Naturally occurring fibers: hard-edged manmade textures	Stimulate left-brain activity → Increased catecholamine production → Fear Cascade*	W

	Natural materials (wood, tiles) or wood-effect materials	Provide a domestic appearance and enhance the connection with nature → Less stress inducing	W
	Soft and yielding textural objects	Provide comfort	W
	Nonslip wet areas floors	Help safety	W, Sp, Mw
	Washable, sterilizable and smooth surfaces	Create a clinical appearance	W
	Décor as visual focal points (artworks, light projection system)	Provides distraction from pain during labor and can help to focus	
	Decoration with natural objects (fountains, aquariums, plants, rivers stone, shells), and images of nature (paintings or projected images)	Enhance stress reduction and reduce likelihood of Fear Cascade*	W
	Bed focal point of the room	Induces immobility sense of surveillance → Left- brain activity → Anxiety → Fear Cascade*	W
Indoor environment	Calming and relaxing design: multi colored lights, projected light displays	Produce a less clinical environment and therapeutic distraction	W
Airflow	Adjustable temperature, access to natural and cross-ventilation, windows screened	Provide comfort	W
Smell	Presence of equipment to use aromatherapy → Pleasing aromas	Lower anxiety and pain perception. Useful in managing intrapartum and post CS nausea	W
	Antiseptic and sterile smells	Provoke anxiety, fear and stress	W
	Curves: rounded corners and edges to walls and furniture	Provide a softer environment reminiscent of caves that enhance safety, sense of privacy and less sense of surveillance	W
Feminine symbols	Feminine archetype in artworks (curved objects, roundness and soft feminine images), symbols of beauty, wholeness and harmony	Favor calmness and reduce stress	W
	Access to food and drink and to separate public toilet and shower	Encourage the presence of supporters and make them feel welcome →	Sp
Accommodation for companions and birth attendants	Birth room sufficiently spacious and well-furnished to comfortably accommodate supporters	Women with continuous support have better outcomes: lower rates of caesarean section and instrumental birth, less use of pharmacological pain relief, shorter labors	Sp
	Presence of a "family room": welcoming shared space/ Large room and well-furnished to accommodate support people	Provide a comfortable wait to supporters and possibility for women to share experience and give each other support	W, Sp

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

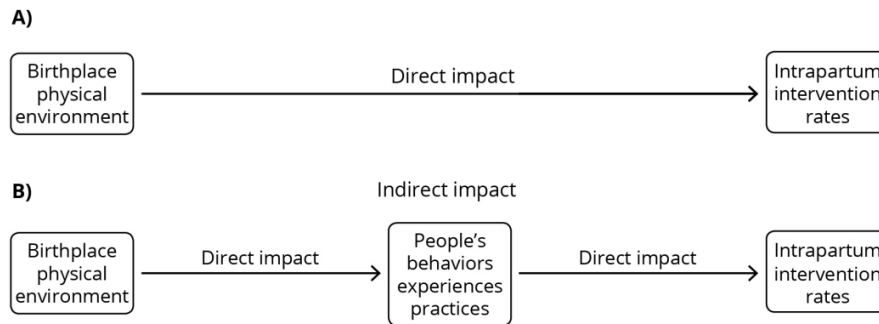


Figure 1. Conceptual model of direct (A) and indirect (B) influence of physical environment of birthplaces on intrapartum intervention rates

172x65mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

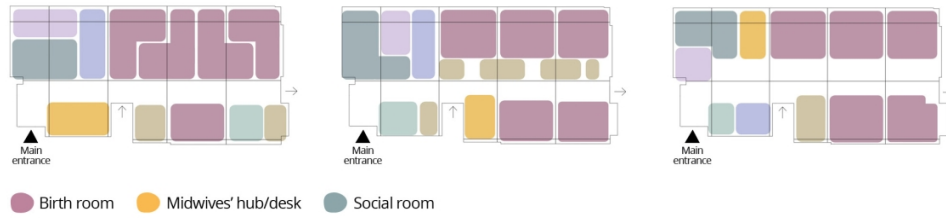


Figure 2. Different solutions of birth unit layout configuration

172x45mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

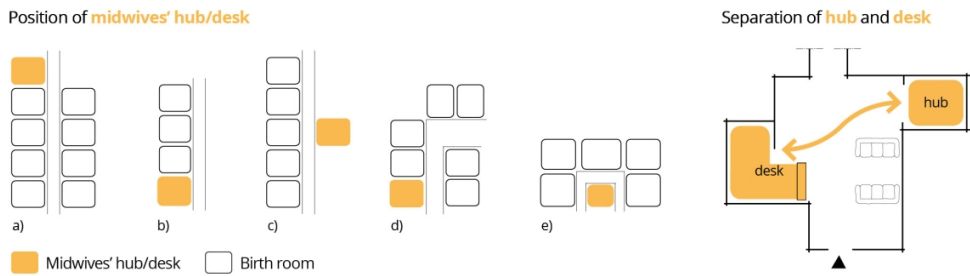


Figure 3. Different positions of the midwives' hub/desk and the birth rooms in the unit layout and a possible separation of hub and desk

171x54mm (300 x 300 DPI)

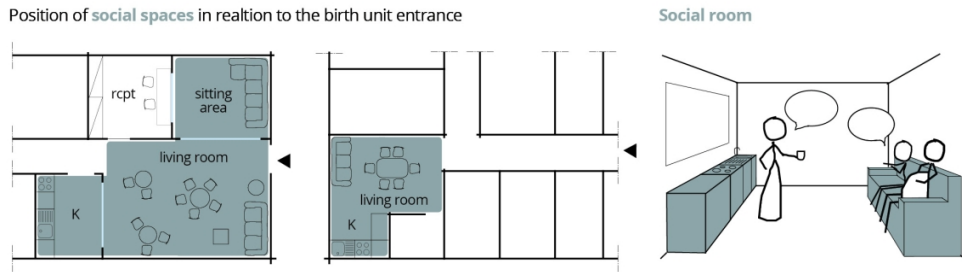


Figure 4. Possible positions of social spaces in the layout in relation to the birth unit entrance

172x52mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

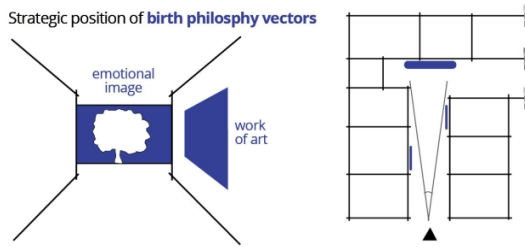


Figure 5. Different type of birth philosophy vectors and their strategic position in the birth unit layout

172x46mm (300 x 300 DPI)

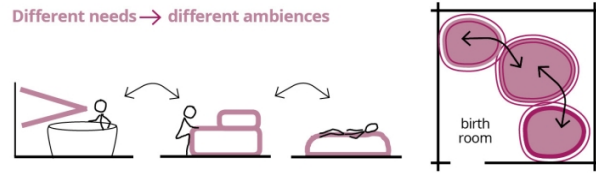


Figure 6. Different ambiances in the same birth room

172x34mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

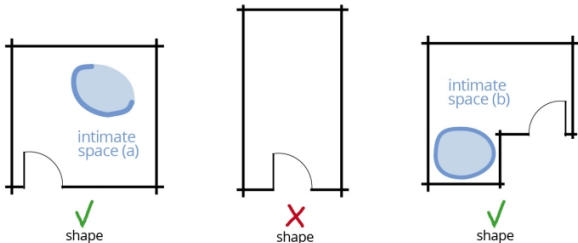


Figure 7. Different shapes of the birth room and the presence of intimate spaces created by a mobile furniture (a), or identified with the corner (b) of a room with a particular shape

172x48mm (300 x 300 DPI)

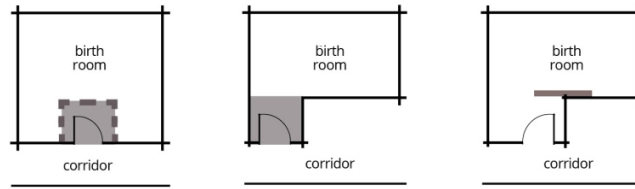


Figure 8. Different type of interface (filter) between the birth room and the corridor

172x37mm (300 x 300 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

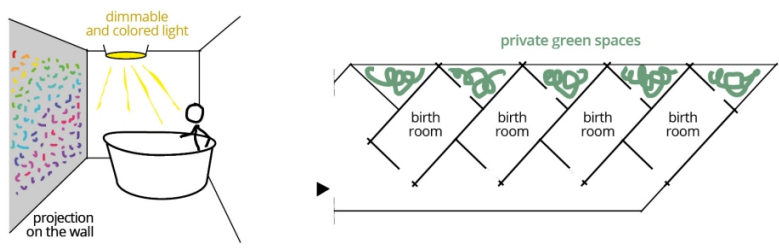


Figure 9. Different sensory elements creating a calm and relaxing atmosphere in the birth room

172x50mm (300 x 300 DPI)