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Article

Sensory Design in the Birth Environment: Learning from Existing Case Studies

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Abstract: Studies have shown how built environments for hospitals can influence psychological and physiological conditions and status for childbearing women. Sensory attributes of birth spaces can enhance comfort, feelings of wellbeing, and, to some extent, clinical outcomes. Recently, some case studies of multisensory rooms for the birth environment have been developed based on, e.g., Snoezelen room examples. The aim of this research is to develop an overview of how sensory aspects for birth environments are designed, used, and tested in current and recent studies. Case studies were selected according to sensory aspect significance, observing space factors, and relationship with the experience and comfort of users (women, partners, midwives). All case studies were analysed to collect information about the design and validation process. The collected data were organised in categories and compared for the selected case studies. Main findings were summarised in tables with the aim of underlining how sensory design processes and projects can positively influence comfort for birthing. Conclusions about how to bring forward the issue of sensory design so that it can be used and applied to support childbearing women is discussed.

Keywords: environmental comfort; Snoezelen room; multisensory room; impact evaluation; design process



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1. Introduction

Sensory environments represent spaces where sensory stimulations such as light, sound, colours, etc., can be controlled to affect experiences, e.g., stress in patients and staff [1–4]. These stimulations are important aspects in contributing to the environmental comfort in healthcare spaces [1,5–7] and have been found to support health and wellbeing outcomes in clinical settings [1]. Sensory environments can benefit and stimulate relaxation, self-regulation, positive emotions, and the reduction of chronic pain [1,2,7–9]. Emotions and feelings play a central role in behaviour regulation and decision making [10]. Specifically, in the birthing environment, spatial, psychological, and sensory features of the birth spaces can influence health outcomes and affect physiological birth by limiting interventions [11–13]. A calm atmosphere can reduce stress and enable relaxation, which can support normal birth and increase physiological benefits [7,11,14]. Environmental comfort and wellbeing could affect women’s (and partners’) behaviours and has an important role in their individual and collective experiences [6,7,15–18]. It can also support midwives’ work and their relationship with patients [4,19].

Limited research exists that investigates how to design multisensory environments or how different design features impact wellbeing and health outcomes [1,20]. This paper aims at learning from existing case studies to define a framework of requirements to design sensory spaces for birthing in healthcare settings and to support architects and professionals.

The literature about sensory design for birth environments is quite diverse, yet there are not many existing examples of sensory rooms in maternity settings. We are going

to present an analysis of the existing examples to identify sensory design solutions and sensory requirements for the birthing environment and their impact on users.

Findings from the literature and design solutions have been compared to understand the state of the art in terms of sensory design for birth. Are the design solutions proposed by the case studies able to meet the requirements shown by the literature?

We have focused on case studies where the impact of sensory stimulations on women were analysed, to understand whether there was a correspondence between requirements, design solutions, and women's wellbeing. Impact evaluation methods have also been analysed and discussed in relation to issues concerning how to measure the impact of design solutions on users.

Finally, design processes have been analysed to investigate methods developed for the sensory design of delivery and birth rooms, especially referring to women's involvement in the design phases, that we consider essential in the conceptual as well as the actual design phases relevant to the design of birthing rooms.

1.1. Importance and Influence of the Physical Environment in Birthing Settings

Hospital physical environments have been shown to impact users' health outcomes and wellbeing, both positively and negatively. Spatial and formal characteristics of spaces can enhance feelings of wellbeing as well as clinical outcomes in different functional units of the hospital such as operating rooms [21], intensive care units [22], and wards [23]. Favourable physical features for wellbeing and comfort are good ventilation, windows, views or access to nature, real or artificial, and design that promote orientation and distraction, as well as comfortable and ergonomic furnishings [24,25]. Furthermore, in a built environment for healthcare, the physical environment plays an important role in affecting stress levels, governing behaviours, and contributing to the care experience [26–29].

This is particularly true for birth space environments, where it is known that the environment is related to supporting or hindering physiological processes, thus influencing the birthing body [12,30–34]. Indeed, labour and birth are highly sensitive physiological processes dependent on the release of oxytocin to support the induction of contractions. The release of particular neurohormones can easily be affected by external environmental and psychosocial factors [35], especially if the environment is highly stressful [36]. Stress-related factors interfere with labouring and birthing women's hormonal physiological systems [37,38] and consequently with their care experiences. An environment perceived as controllable, comfortable, and safe will reduce stress and facilitate the release of endogenous oxytocin [39], supporting the physiological progress of the labour and birth process.

Research suggests that birth environment design is strongly related to increased medical interventions [40], as environmental stressors impede labour, increasing the risk of clinical interventions, including induction or augmentation of labour and operative birth [37,41,42]. During the birth, women can be supported both by high-quality care to minimise risks of complications and a familiar, calm, safe, and secure environment to make the hormonal system function optimally [42].

1.2. The Role of Environmental Comfort in Maternity Settings

Maternity facilities and birthing spaces are required to respond to women's desires for more salutogenic and satisfying birth experiences [43,44], including their need for a comfortable environment in birthing settings. Shifting from birthing in the home environment to the hospital environment in most high- and middle-income countries, the design of delivery and birth rooms has been generally dominated by a medical paradigm [45]. Such an environment for birth has been considered to be difficult to adapt to women's physical and psychological needs [46]. Women's perceptions of comfort and sense of wellbeing impacts the birth experience [47,48] and consequently the birth outcomes. In the last decades, many alternative maternity-care settings have been designed to stimulate more positive birth experiences and to meet the comfort needs of women and supporters. This includes the careful design of physical aspects of the built environment that affect

women and supporters' comfort and control, such as indoor parameters, e.g., temperature, humidity, air quality, and airflow, and personal parameters, e.g., lighting levels, noise levels, birth equipment, and home-like environment, depending highly on personal preference and personalities [49–52].

1.3. Sensory Design for Maternity Settings and its Significance for Women's Comfort

To improve the quality of maternity care in hospital settings, the physical environment needs therefore to reduce stress levels and to be based on women's personal preferences, enhancing women's comfort and sense of control. Towards this goal, a sensory-perceptive integrated design approach could further enhance the value of maternity settings, engaging sensory features of the birth environment and exploring how sensory input can affect experience and support outcomes on wellbeing and behaviour [10]. Indeed, information received through our senses shapes our perceptions of the environment and affects our emotions, thoughts, and behaviours [53,54].

Multisensory environments were first developed in the 1970s [55] to both stimulate and to help self-regulate all the senses, with the aim of generating positive sensations and emotions, reducing stress, promoting relaxation and sense of choice and control acquisition or recovery [1,2]. This aim has particular meaning to fragile or sensitive users, as environmental flexibility and customisation allows users to self-regulate and rebalance according to their sensory preferences. Flexibility and customisation can be provided not only through the design of the environment and its components but also by automation technology, allowing a simplified stimulations control [20].

Multisensory environments are usually equipped with sensory devices that provide users playing and regulating sensory stimulation such as sight, hearing, touch, smell, proprioception, and taste. Sensory interventions are indeed based on two types of stimuli: external ones derived from the relationship of the organs of sight, touch, smell, hearing, and taste with the outside world, giving information on the surrounding context and on one's own safety; the somatic senses, such as pressure on the skin, awareness of one's own body (proprioception), and of space and balance (vestibular), that instead communicate a sense of internal security. Both types of stimuli can be conveyed by different birth room physical characteristics or equipment and they constitute a sort of "sensory microcosmos" around the childbearing woman (Figure 1).

Across the literature, multisensory rooms are known as "comfort rooms" [56], "sensory rooms" [8,57], and "Snoezelen rooms" [58–60].

Multisensory rooms were originally designed to support intellectual disabilities [61]. Today, their use has expanded to different user groups in health and educational settings [55,56,62]. In general, these rooms have been used in situations that impact a person's emotional perception, sensory sensibility, behaviour, and relationships in places where sensory regulation provision can promote a sense of personal control, security, stability, and calm [4,9], including labour moments for childbearing women. Furthermore, sensory rooms facilitate communication and relationships, in particular with health professionals, thus supporting users' self-awareness and self-control [4].

As we can see from the examples mentioned above, the use of sensory rooms assumes particular relevance related to healthcare settings, where policies have over the last years been oriented towards humanisation of hospital environments and a strong focus on patient-centred care. Recently, some examples emerged of sensory rooms related to the birthing environment that will be described in more detail in this paper. The concept of Snoezelen for birth spaces refers to indoor environments that provide childbearing women distraction, relaxation, comfort, and environmental control within the safety of a hospital environment [6,7]. Distracting senses in the Snoezelen room during labour and birth moments decreases women's pain intensity in the second stage of labour [6] and incidence of c-section [63], making labour and birth experiences more pleasant for women [64]. Many studies have shown that sensory stimuli such as light, noise, visual art, a view of nature, temperature control, warm colours, smells, and surface textures

throughout the promotion of a relaxing atmosphere reduce anxiety and stress and produce physiological benefits [12,14,37,40,47,48,52,65–73]. Furthermore, features of familiarity, as well as the possibility for the woman to move around, have been associated with a shorter length of labour and a decreased intensity of labour pain [64].

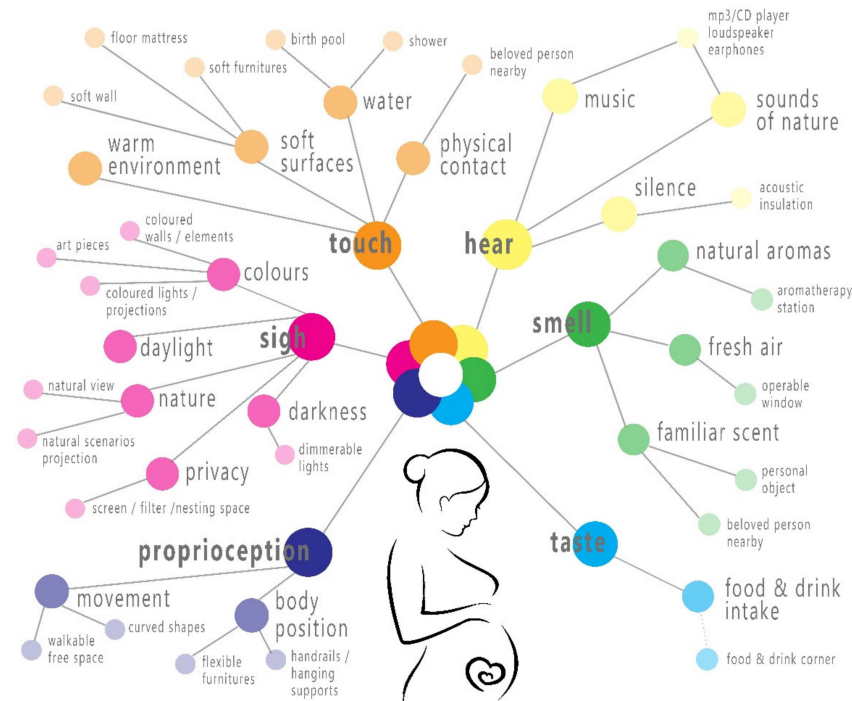


Figure 1. Diagram that represents the “sensory microcosmos” around the childbearing woman.

1.4. Design for Sensory Delivery and Birth Rooms

From the scientific literature, we can understand that both properties of the spaces and the sensory elements can affect the sensory perception. Analysing the literature in this field we were able to identify birth space and sensory requirements for sensory delivery and birth rooms (Figure 2).

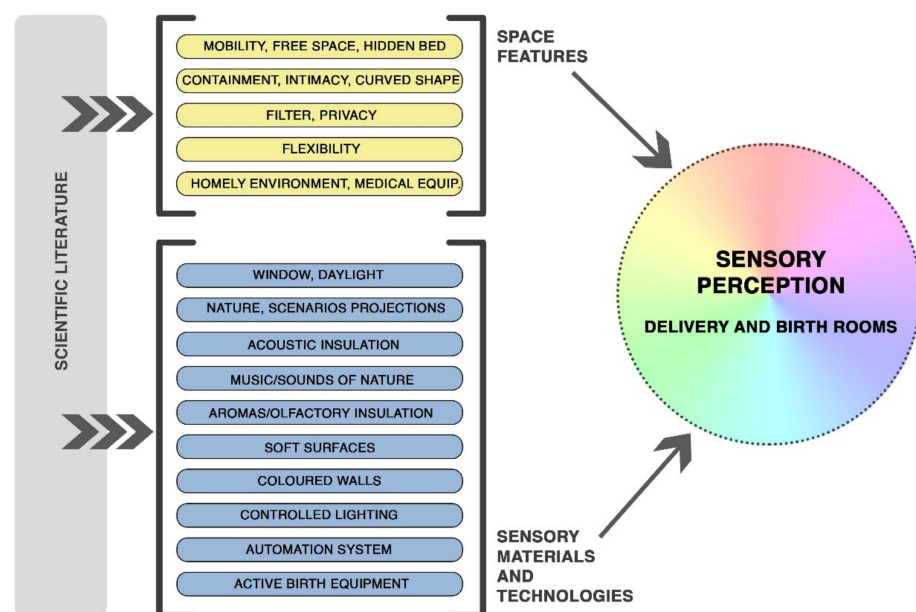


Figure 2. Space features and sensory materials and technologies that can affect the sensory perception in the sensory delivery and birth rooms.

We refer to Setola et al.'s review [40] to focus on the birth space requirements, considering the properties and the characters of the space and the configuration of the birth room that may affect the sensory perception. The shape, the size, the layout, and the configuration of the room in terms of objects, structures, furniture, and facilities contribute to the creation of a welcoming atmosphere. The concept of atmosphere unites the creative, social, and clinical disciplines in a shared embodied "language" of sensory experience [18] that can promote the sense of agency, safety, and satisfaction [55] and can create affective moods that influence wellbeing. For example, an intimate space can promote a calm environment and support the relationship with the partner and the ability to work together; the room's adaptability can facilitate women's sense of control and improve their comfort, changing the environment and the sensory stimulations depending on their specific needs and sensory preferences and regulation. Many design aspects can contribute to the creation of a calm atmosphere: the configuration of the birth unit, the quality of natural and artificial light, the access to views and greenery, the quality of furniture, the opportunity to hide medical supplies, and the use of art and colours in the room or on the walls, as well as reproducing music and providing aromatherapy to make the spaces warm, hospital, and domestic [11].

Perception, action, and meaning are closely related, as women are engaged directly in the meaning of events in the environment [74]. In this way, women are active agents in the atmosphere [56], as they not only perceive the world through the atmosphere but they also truly engage with the atmosphere in a dynamic process that starts from the senses.

The sensory perception of the environment has an impact on women's (and partners' and midwives') behaviours and their related experiences. The room is considered a sensory instrument to support the act of care [18].

Birth sensory requirements are defined, referring to sensory elements that can affect women's comfort and wellbeing during the childbirth experience. All the sensory elements embedded in the space are important to create a calm and relaxing atmosphere in the delivery and birth room [40]. The sensorial experience represents an existential bridge to a new version of oneself through bodily experience [18].

In the next paragraphs, the role of each spatial and sensory feature on the improvement of the birth space/experience will be described, referring to the literature.

1.4.1. Birth Space Requirements

Mobility, Free Space, Pull-Out/Hidden Bed

Qualitative research on a Snoezelen room for labour indicated that having free space in the room without the prominence of the central bed allows flexibility of movement, fostering comfort sensations for labouring women [7]. Mothers' perceptions of spaciousness were strongly associated with overall satisfaction with surroundings and facilities, as well as with care received [51]. The built environment can improve women's free movements and encourage them to walk around by offering free, accessible, and quality spaces [11] to guarantee the maximum emotional and physical freedom.

Containment, Intimate Space, Curved Shapes

The perception of intimacy and privacy upon entering the birth room influences the users' emotional sphere [11]. A quiet dimly lit warm space where they feel much more enveloped can help women go inside themselves to proceed with the hard part of labour [75]. Design strategies such as dimming lights (see also Section 1.4.2: Controlled Lighting: Dim and Colours) and a small hallway to hinder direct view from the corridor (see also next paragraph: Filter, Privacy) can promote the feeling of containment and intimate space. Curved shapes, including convex and concave surfaces, can provide a positive visual stimulus in the labour and delivery room, producing beneficial psychological and physiological changes in women's behaviours and in clinical outcomes [67]. Dividing the room into convex spaces can also improve the perception of flexibility by supporting the creation of different spatial zones within the same environment [11].

Filter, Privacy

When labour is most intense, the mother is likely to experience the greatest sense of security in a very strongly bound space with physical, visual, and acoustic privacy and control, providing a physical and emotional sense of well-being [37]. A filter at the entrance of the room to mark the transition between the corridor and the birth room helps to favour a calm atmosphere and the sense of privacy [14,32,69,71].

Flexibility

A flexible birth room can support the adaptation of the environment to a woman's changing needs during the different stages of labour, in which different atmospheres and settings are required to promote relaxation, to reduce pain, and to create a more intimate birth space [40]. For this reason, flexibility of the birth room can support the feeling of privacy and safety [75,76], can affect the women's and supporters' sense of control [77] and the midwives [78] in supporting women adequately. Modifying the room's features, including hiding/making available medical equipment if needed [16] and the mobility of adaptable furnishings [11], contributes to women's feeling of comfort [7] and creates an environment more conducive to active birth [75].

Homely Environment, Medical Equipment

Hiding medical equipment and designing a homely environment to optimise privacy and comfort helps reduce women's anxieties and fears [32,63]. A homelike environment can also give the couple a feeling of respect and control [79], enable the partner to feel able to engage in securing a familiar and safe space for the birthing woman, and provide a place to rest and sleep [77].

The use of warm incandescent lighting, which sheds a warm yellow light is more resonant of home lighting than bright stark fluorescent lights typically associated with hospital environments [37]. Asking women to bring familiar domestic objects into the hospital environment is a way to enable the personal scents and smells associated with home to permeate the space [37].

1.4.2. Birth Sensory Requirements

Window, Daylight

Interior windows decrease the sense of privacy, intimacy, and perception of personal control in hospital birthing settings [80], while windows opened towards the outside represent a source of natural light, views, and ventilation [81]. Natural light and ventilation support women to maintain their natural circadian cycle, protecting the regulation of the human body clock [82]. Natural light affords women's senses of orientation and wellbeing [65]. Operable windows are preferable for providing fresh air [80] and give women a way to reduce stress when the room is too hot or too cold [82]. It is also very important to allow regulating the amount of light available, especially in the different stages of the labour. For example, during birth, a soft light is necessary, while after birth it is better to have a brighter light [11].

Nature, Scenarios Projections

Nature views can shorten hospital stays [82]. Scenario projections with beautiful, calming nature images—such as waterfalls or beaches—produce benefits to the labouring woman in promoting relaxation and calmness, in enabling free movement, and in promoting choices [83]. Snoezelen elements connected with nature, such as a fish tank with colourful tropical fishes, can bring peaceful and relaxing sensations [7].

Acoustic Insulation

Noise (produced by people moving and talking, as well as trolleys/materials and equipment) is an environmental variable that can adversely affect women and can produce stress, decreasing their ability to relax and their sense of privacy and control during

labour [11,52,75,84]. Noise insulation is required much more in the postnatal ward than in the labour ward, where women are bothered by other women in labour, crying babies, and talking staff [49–52]. On the other hand, acoustic insulation of the birth room contributes to women's perceptions of privacy as they do not feel inhibited from making noise [7].

Music/Sounds of Nature

Music, in combination with support, has been found to be a helpful coping strategy during labour [85]. Music can provide comfort, familiarity in an unknown and clinical environment, and a positive distraction from fear, pain, and anxiety [86,87]. As auditory stimuli, music and sounds of nature instead of usual hospital sounds are rated by labouring women as a positive element. Music selections can vary, corresponding to variations in pain intensity from early to late labour, playing pieces that evoke a variety of desirable emotional or cognitive states, including relaxation, increased energy, distraction, and concentration [83].

Aromas/Olfactory Insulation

Because of the strong relationship between smell and emotion [88], bringing familiar domestic objects into hospitals enables the personal scents and smells associated with home to permeate the space, enhancing emotions of familiarity and security [37]. Olfactory insulation can create an “olfactive climate” favourable for labouring women and newborns [89], cutting out the sterile antiseptic smell of the hospital environment. Using aromatherapy in labour increases women's senses of relaxation and facilitates a sense of participation in their care [90]. For example, lavender essential oil can reduce the anxiety of childbirth by affecting pain perception at intrapartum [91].

Soft Surfaces

Soft mattresses for women and supporters and large pillows are rated as positive during active labour [83]. Also, Snoezelen elements such as chairs with wrap-around backrest and large soft rugs are perceived as relaxing by women [7]. Somatosensory stimulation based on soft surface touch is related to skin positive soft stimulation that can help oxytocin release [39].

Coloured Walls

Colour has been found to have a physical effect for short periods [92]; in particular, the use of “cool colours” such as blue and green promote calm and relaxation, while “warm colours” such as red, orange, and yellow are exciting and stimulating and promote physical and social activity [67,93]. Some colours can be associated with a more homely environment and can increase a sense of belonging [94,95].

Controlled Lighting: Dim and Colours

Dim lighting can create an intimate and supporting environment to make women feel comfortable and safe [15,66]. The possibility of adjusting lights to suit women's preferences contributes to environmental control perception and coloured lights promote relaxation and distraction [7]. Dynamic lighting and luminous coloured screens create more homelike and comfortable spaces and contribute to a positive impact on birth experiences, feelings of security, and experiences of pain [19].

Automation System

The possibility of personalization of the birth space enhances feelings of comfort, hominess, and privacy [80]. Interactive audio–visual systems—controlled by users with a touch panel and allowing them to design their own birth sensory setting and match it with the different stages of labour, according to hard work or relaxation, including turning everything off—promote feelings of relaxation and avoid stressful situations [15,96].

Active Birth Equipment

Active birth equipment promotes women's physical comfort and encourages active behaviour, to support women coping with labour, relaxation, and feeling in control [15]. Birth mats, bean bags, birthing balls, and similar allow for non-restrictive movement, enhancing relaxation and helping women to cope with labour [83]. Furthermore, active birth equipment supports uprights positions, providing more physical comfort during labour and birth [97].

2. Materials and Methods

This paper investigates how sensory elements and configuration of the birth room can influence users' comfort. Existing birth space case studies were used to identify sensory design aspects, observing space factors and relationships with experience, human rights, and comfort of users (women, partners, midwives).

The investigation was developed by the analysis of the different design solutions adopted and the evaluation of their impact on women, partners, and midwives. For this reason, we selected from the scientific literature sensory delivery rooms that were set up in the last 10 years and where scientific research was conducted to understand the impact of the design solutions on users.

The research was conducted within the Scopus databases, Avery Index to Architectural Periodicals (EBSCO), SAGE Journals, and the PubMed database in June 2022 and updated in December 2022. The search strategy included the following keywords: "sensory room AND birth"; "sensory room AND maternity"; "snoezelen AND birth"; "snoezelen AND maternity"; "sensory AND birthing environment"; "snoezelen AND birth environment"; "multisensory AND birthing environment"; "multisensory room AND birth"; "multisensory room AND maternity"; "sensory room AND labour"; "snoezelen AND labour"; "sensory AND birth room"; "multisensory AND birth room"; "snoezelen AND birth room"; "sensory AND maternity setting"; "multisensory AND maternity setting"; "snoezelen AND maternity setting"; "sensory AND delivery room"; "snoezelen AND delivery room"; "multisensory AND delivery room".

The results were filtered by including only papers in which were presented existing case studies of sensory delivery and birth rooms set up in the last 10 years. Reading the full text, the authors selected only case studies that were well described, especially referring to the space features and sensory materials and technologies, to be able to compare them in the research. Finally, the authors included only papers in which the impact on users was evaluated by quantitative or qualitative methods to show the relation between the environment and women's (partners'/midwives') comfort and wellbeing. The search was limited to studies in the English or Italian language. For this reason, only 12 papers were selected that related to 4 different case studies, reported in Table 1.

Table 1. List of case studies.

Case Studies	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Name	Birth place for the future	Room4Birth	Snoezelen birthing room	Sensory delivery room
Place	Hospital Unit West in Herning, Denmark	Sahlgrenska University Hospital (SUH), Gothenburg, Sweden	Iran University in Tehran	North Zealand Hospital, Hillerød, Denmark
Year of Construction	2015	2018	2012	2013
References	Lorentzen et al., 2019 [96] Lorentzen et al., 2021 [98] Hansen et al., 2022 [99] Nielsen and Overgaard, 2020 [15], Folmann, 2020 [74]	Berg et al., 2019 [17] Skogstrom et al., 2022 [16] Goldkuhl et al., 2022 [100] Goldkuhl et al., 2022a [101]	Manesh et al., 2015 [41]	Lundmark, 2014 [19] Wronning et al., 2019 [63]

The analysis of case studies was conducted by a list of categories related to sensory design as presented in the introduction. Birth Space (Section 1.4.1) and Sensory (Section 1.4.2) Requirements were identified in the literature about Snoezelen and sensory rooms related

to positive effects of sensory design in therapeutic spaces and in the literature about the birth environment.

Based on the studied literature and background (Section 1.4) and complemented by a description of the state of the art on sensory design in the birth environment, the occurrence of the different categories was investigated in each case study (Figure 3). First, we analysed the solutions that were developed and proposed for each category, both in Birth space requirements (Table 2) and Birth sensory requirements (Table 4). Then, each category was related to the impact generated on users and evaluated by the experimental research on case studies (Table 3 and Table 5) (Figure 3).

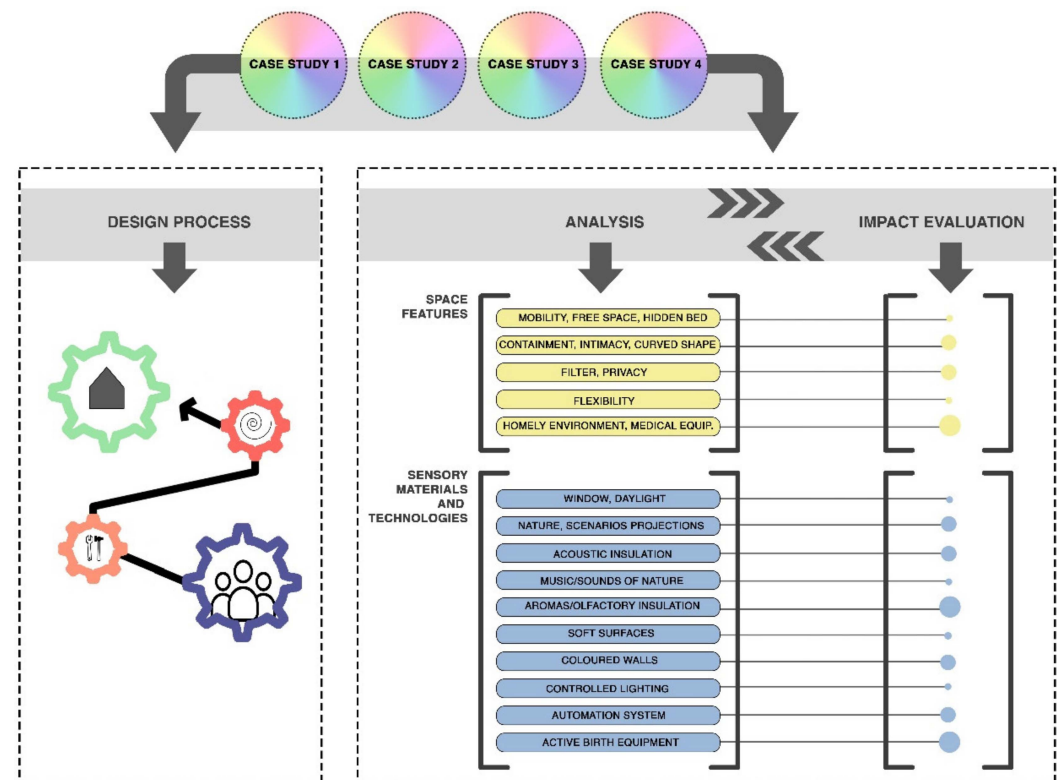


Figure 3. Methods for the analysis and the evaluation of case studies.

The authors also focused on the design process developed for each case study and analysed it (when reported) to understand the design approach, the methodology, the composition of the design team, the disciplines involved, the design or co-design tools, and the people involved (Figure 3).

3. Results and Discussion

The research and literature review on sensory design is quite broad, as described in the background. There are many studies that indicate the importance of the sensory environment on women's wellbeing and the improvement of childbirth experiences and outcomes. On the other hand, there are not many existing examples of sensory birth environments and the impact evaluation on users is often missing. In the case studies, it was not clear how the process of the generation of the idea of the sensory delivery room and the configuration of different features inside the room had been developed and executed. The lack of information about the design process and the generation of the projects makes it difficult to identify in the studied cases a common rigorous method to design the sensory delivery rooms.

In the majority of cases, the focus is on the evaluation of the overall satisfaction of women/couples, but it is difficult to find data on the impact of a specific feature, such as a property of the space of a sensory element. However, through the analysis of the selected

case studies and the literature referred, it was possible to identify solutions proposed (Tables 2 and 4) and to learn from them, looking at the impact found on users (Tables 3 and 5).

Table 2. Birth space requirements: solutions proposed.

Birth Space Requirements	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Mobility, free space, pull-out/hidden bed	Total of 39 square metres. Three different areas for wellness, activity, birth. The birth bed is located in the birth zone, covered with a blanket. A private space is offered to the couple.	Total of 23.8 square metres. There is sufficient floorspace to move around. The birth bed is located to the side of the room, covered with a green-coloured bedspread.	Women can move freely (walk, sit, or lie down).	
Containment, intimate space, curved shapes	A double sofa bed, covered by pillows. A nest for the woman.			
Filter, privacy	Three different areas for wellness, activity, birth. A private space is offered to the couple.	Three-square-metre entrance hall. A green-coloured curtain creates a filter from the hospital corridor. The bathtub is located in a corner.		
Flexibility	Flexible furniture: <ul style="list-style-type: none"> - A double sofa bed, adjustable in height, covered by pillows. - A bar stool at the side of the bed for the partner to support the woman staying close and in different positions (upright and high position) 	<ul style="list-style-type: none"> - Different physical features to be used by women and partners: - A special chair for the partner can be placed close to the woman during different stages of birth. - A sofa bed can be adapted for couple's needs. - Access to furniture that promotes upright positions. 	Women can move freely (walk, sit, or lie down).	
Homely environment, medical equipment	Home decor and materials such as wood. Non-clinical furniture such as modern tables, lamps, chairs, sofa bed. Resuscitation equipment next to the bed.	Familiar, homely, and private environment. Medical equipment hidden by a wood-panel wall that can be rolled up when necessary. Homely decor, furniture, and textiles.		

Table 3. Birth space requirements: data of impact evaluations.

Birth Space Requirements	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Mobility, free space, pull-out/hidden bed	Stimulation to move around freely. Promotion of another form of emotional support. Increase of women's confidence in their own abilities and sense of control.	Spatial mobility promotion.		
Containment, intimate space, curved shapes	Promotion of physical contact, intimacy and closeness with the partner and the idea of being equal. Relaxing effect, withdraw for rest when needed. Individual-controlled options for pain relief.			
Filter, privacy	Increase of women's confidence in their own abilities and sense of control.	Respect for the birth environment. Protection of the women's integrity by maintaining a private and calm atmosphere. Feeling of privacy. Low risk of being seen if the door opens.		
Flexibility	Promotion of physical contact, intimacy, and closeness with the partner and the idea of being equal. Individual-controlled options for pain relief. Different opportunities to relax individually without being in different places: women can feel the partner is close when needed.	Improvement of the women's mood. Integrity promotion. A comfortable place for the partner makes the woman relax and focus on herself and on giving birth. Promotion of spatial mobility.		
Homely environment, medical equipment	Feeling of being welcomed and being embraced. Emotional support, comfort, and reduction of stress. To support women's ability to adapt to the birth environment and to the transition from home to hospital. Promote safety, confidence, and the sense of self. Promote the interaction with the partner in a spontaneous everyday manner.	Feeling safe and calm. Welcoming feeling. Reminding of women's homes or previous experiences. Positive impression of the space. Improvement of the overall birth experience. Hiding elements that evoke a sense of danger and illness to create a calmer atmosphere. Stress reduction, feelings of the possibility for a pleasant labour. Knowing that medical equipment is close and available decreases feelings of stress and fear.		

Table 4. Birth sensory requirements: solutions proposed.

Birth Sensory Requirements	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Window, daylight	A window that is possible to hide by a curtain.	A window, hidden with curtains if media installation in use.		
Nature, scenario projections	Panoramic nature videos onto 3 walls of the room. Four natural scenes: forest in different seasons, such as winter, springtime, and autumn, and seaside and waves. Women and partners can match the scenarios to the different stages of labour, depending on their need, including turning them off.	Seven programmed audio-visual stimuli projections: stormy ocean, sunny beach, winter landscape, forest in spring, summer, or autumn, and nature at dawn. Installation on two walls, including the window.	Aquarium with fishes at a distance of 1.5 m from the mothers. A projector with green light alternately changes pictures. The luminous shapes glint to the wall.	A large Philips luminous textile screen on one wall and dynamic LED lighting with a touch control panel. Five optional sensory programs with different auditory and visual stimulation (coloured lighting and soundtracks). The lighting and screen pictures can shift colours: blue, green, yellow, red, and white.
Acoustic insulation		A 40-mm suspended sound absorber in the ceiling.		
Music, sounds of nature	Soothing music for relaxation from “MusiCure” and sounds from nature integrated in the scenarios. Possibility to bring one’s own music and play it during birth.	Sound effects and music integrated in the scenarios.	There was light music with rain sound.	Five optional sensory programs with different auditory and visual stimulation (coloured lighting and soundtracks).
Aromas/olfactory insulation	Massage oil.			
Soft surfaces	The double-sized mattress of the sofa bed is covered by pillows and textiles. The textile differs from clinical hospital furniture textiles.	Sofa, pillow, textiles.	Soil-coloured carpet in the entire room.	
Coloured walls				
Controlled lighting: dim and colours	Colour-controlled and dimmable lightings. Lights are integrated in nature scenarios.	Dimmable lighting.	A projector with green light alternately changes pictures. The luminous shapes glint to the wall.	Programmable calming lights with low irradiance, restful blurred pictures displayed on a wall-sized big screen, and sound effects. A large Philips luminous textile screen is installed on one wall and dynamic LED lighting with a touch control panel. The 5 pre-set sensory programs included: arrival (red), relaxation (red/blue), breathing (blue), atmospheric (red/yellow), and white light with no sound.

Table 4. Cont.

Birth Sensory Requirements	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Automation system	An innovative interactive digital projection system operated by an iPad that the couple can easily use without introduction. The woman and the birthing companion can customize the birth setting by creating a relaxing atmosphere with music, controlled lighting, and natural scenarios.	The automation system offers a choice of 7 programmed audio-visual stimuli projections on 2 of the walls (stormy ocean, sunny beach, winter landscape, forest in spring, summer or autumn, and nature at dawn) with integrated light, sound effects, or music.		Five sensory programs with different auditory and visual stimulation, coloured lighting, and soundtracks: 1/Welcome Program: scenes from a bonfire by a lake and selected MusiCure music. 2/Relaxation Program: various scenes from nature, incorporating blue, green, and warm colours and selected MusiCure music. 3/Breathing Program: images and sounds of lightly breaking foamy waves.
Active birth equipment	Birth pool, birthing ball, trolley walker, hot stones, massage oil.	Bathtub, birth ball, birth support rope.		3/Breathing Program: helps the woman maintain a beneficial breathing rhythm during contractions. This rhythm is established via images and sounds of lightly breaking foamy waves. The midwife can actively use the program to stimulate the woman's regular and smooth respiration.

Table 5. Birth sensory requirements: data of impact evaluations.

Birth Sensory Requirements	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Window, daylight		A window, fresh air, natural light, and nature view are the most requested physical features in the birth room. Feelings of being disoriented in time as the window is not visible and natural light is missing and they cannot easily determine whether it is day or night.		
Nature, scenario projections	Positive distractions: <ul style="list-style-type: none"> - Finding joy and relaxation; - Capturing women's attention during labour; - Promoting the sense of control. Association with important aspects of the couples' daily lives and positive emotions. Controlling the projected scenarios make women avoid stressful situations.	Positive personal memories evoked. Experience as entering another world, which reduces feelings of stress. Choosing scenarios according to women's preferences. Reminding of own home or previous experiences. Positive impression of the space and improvement of the overall birth experience.		

Table 5. Cont.

Birth Sensory Requirements	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Acoustic insulation		Making the room feel familiar.		
Music, sounds of nature	<p>Positive distraction:</p> <ul style="list-style-type: none"> - Finding joy and relaxation; - Capturing women's attention during labour; - Promoting the sense of control. <p>Controlling the sound according to women's needs avoids stressful situations.</p>	<p>Reminding of own home or previous experiences.</p> <p>Positive impression of the space and improvement of the overall birth experience.</p> <p>Area of improvement: having the opportunity to play one's own music according to nature scenario projections on the wall.</p>	<p>The first stage duration of labour in the intervention group was less than the control group and observed significant difference.</p>	
Aromas/olfactory insulation				
Soft surfaces	Chance of individual-controlled options for pain relief.	<p>Making the birthing room feel familiar.</p> <p>Area of improvement: having more textiles such as large pillows.</p>	The entire room is floored by soil-coloured carpet.	
Coloured walls				
Controlled lighting: dim and colours	<p>Controlled lighting has a positive effect on women. It was considered calming. It contributed to women's sense of comfort and safety. The control of the sound according to users' current needs avoids stressful situations.</p>	<p>The room light is in contrast to the bright lighting in other parts of the labour ward. It increases the familiarity of the room. It creates a cosy atmosphere.</p> <p>Reminding of own home or previous experiences.</p> <p>Positive impression of the space and improvement of the overall birth experience.</p>		<p>Most primary births commence at night or in the early morning hours when it is dark or when the light has less significant blue wavelength contributions. Thus, alteration of light could influence labour progression and outcome.</p>
Automation system	Controlling the sound, the lighting, and the scenarios projected according to women's needs reduces stressful situations.	<p>Strengthening the women to feel in control and as though they own the room. Feeling free to adapt the environment according to one's own needs.</p> <p>Feeling a sense of safety, integrity, and familiarity.</p> <p>A few women defined the technical panel to control light as too complex to use it by themselves. They needed staff support. It was suggested to write instructions to avoid this issue.</p>		
Active birth equipment		<p>Promoting upright positions.</p> <p>Promoting the use of the bath as their initial activity rather than a bedbound position. The bathtub was perceived as user friendly, comfortable, pain relieving, calming, cosy, and with clean water. It was easy to get in/out of it. A few found it too deep.</p> <p>The birth support rope was low ranked, but women were still pleased to have it. It was suggested to better explain how to use it.</p>		

3.1. Impact Evaluation Methods

In every case study, the impact of a sensory birth environment was evaluated by different methods, both quantitative and qualitative. In Table 6, these methods are summarised.

Table 6. Impact evaluation methods.

Methods	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Medical records	Primary outcome: use of oxytocin for dystocia. Secondary outcomes: length of labour, use of pain relief, uncomplicated birth.	Primary outcomes: vaginal non-instrumental birth, no oxytocin augmentation of labour, postpartum blood loss, childbirth experience. Secondary outcomes: the variables in the primary outcome analysed separately, plus use of epidural analgesia, vaginal laceration, neonatal intensive care admittance.		Primary outcomes: use of additional oxytocin, risk of caesarean delivery. Secondary outcomes: need for vacuum extraction, need for an episiotomy, rate of rupture of the anal sphincter, length of birth, parturition period, the rate of postpartum haemorrhage, and neonatal outcome.
Pain intensity measures			Pain was measured at entering the room, the first 3 h (every hour) and in the second stage (from full dilation to onset of foetal head crowning).	
Survey/ questionnaire	Woman's experience (6 weeks after birth). Partner's experience (1 week after birth). Breastfeeding duration (6 weeks after birth).	Women's experience		Women/couple's experience
Individual semi-structured interviews	Total of 14 women who had used the alternative delivery room; 12 interviews with Danish first-time fathers who participated in the birth of their first child.	Total of 19 women who had used the alternative delivery room.		Five women/couples who had experienced childbirth in SDR
Observation				Five women/couples, five midwives
Focus group				Five midwives

3.1.1. Medical Records

Medical records were studied in all case studies, except for Case Study 3. The outcomes measured for case studies are reported in Table 6.

The results of the medical outcomes did not present significant evidence in any case study. Even though the results were more positive in the sensory birth environment, they did not reach statistical significance. The only data that had statistical significance were measured in Case Study 4, where the caesarean delivery rate was significantly lower in the group of women giving birth in a sensory delivery room (6.4%) compared with the group giving birth in a standard delivery room (10.7%) [63].

It would be interesting to understand why there is no direct correspondence between medical outcomes and the high level of comfort and satisfaction measured in qualitative and ethnographic studies.

Probably, it would be necessary to include alternative qualitative methods in the clinical trials. A bridge between the world of treatment, efficiency, and utility with the world of feelings, emotions, and understanding becomes essential to approach the space from a multisensory and somatic position [18]. Furthermore, for this reason, medical outcomes

are likely not enough to understand women's (partners' and midwives') experiences. On the contrary, sensory-design approaches seem to be very important not only for users' satisfaction but also for their health.

Indeed, a negative birth experience can pose a risk for mothers, babies [102,103], and the entire family's health, resulting, for instance, in parental stress symptoms and a weakened parent–child relationship [104].

Studies suggest that between 9% and 50% of women have traumatic experiences during childbirth [102] and 5–30% of women perceive their births negatively [103]. Negative birth experiences can cause post-traumatic stress and depression in women and their families [85] or negative effects on breastfeeding and partner relationship [105]. It can also cause fear of birth [106] and unwillingness for to again experience pregnancy and birth [107].

It is also necessary to consider that the effects of sensory design might be evident in effects beyond the healthcare system, e.g., effects such as a more comfortable homecoming, stability around the birthing situation, less need for other medical attention, etc. This may impact partners' return to work life, efficiency of parental leave, etc.; effects that benefit society at large rather than a specific healthcare organisation.

3.1.2. Users' Experience Evaluation

The birthing experience was evaluated by quantitative methods in Case Study 1 and 2 by delivering questionnaires to women and their partners. Then, some of the women who had used the alternative delivery room and their partners were also involved in individual semi-structured interviews, to go further in depth about some of the topics of the questionnaires (Table 6). Results of the investigation in terms of impact on users will be discussed in the next paragraphs and they are summarised in Tables 3 and 5.

In Case Study 3, pain intensity was measured upon entering the room, the first 3 h (every hour), and in the second stage (from full dilation to onset of foetal head crowning) (Table 6). No significant difference was seen between the mean score of pain intensity in mothers when entering labour and during the first hour and the second hour, while significant difference was observed between the mean score of pain intensity in the third hour and in the second stage between the two groups. The intensity of pain in the intervention group increased less than that of the control group. This finding suggests that several factors are responsible for the relief of pain [6].

In Case Study 4, a survey was conducted to understand women's/couple's birth experiences. Then, observation of the participants, individual interviews with five women/couples who had experienced childbirth in a SDR, and a focus group interview with five midwives were conducted (Table 6). A total of 93% of the women reported that the sensory delivery room had a very positive impact on the birth experience. A total of 73.5% of women reported that the sensory delivery room had a very positive impact on their experience of pain during childbirth. A total of 96% of women reported that the sensory delivery room had a very positive impact on their feelings of security and well-being during childbirth. A total of 94% of the partners responded similarly [19]. Midwives reported that the SDR created an atmosphere that was much more subdued, calm, and reassuring than a typical delivery room, having positive effects on the labour/delivery experience. The expectant mothers were better able to relax, delivered their children more quickly, and managed their pain better, especially in the dilation phase of labour. The room also helped the women better regulate their breathing. It promoted relationships, building rapport and intimacy and improving the rapport (synergy) between the midwives, the patients, and their partners. It increased the midwife's professional satisfaction [19].

From all case study qualitative evaluations, we can observe that all users—women, partners, and midwives—reported a very positive impact of sensory design on the birth experience. In Case Study 2, for example, all women appreciated the possibility of giving birth in the new room (tested as a sensory delivery room). They felt welcomed by the room, defining it as “magic, wonderful, fantastic, clean, and luxurious” [16]. The delivery

room made them feel calm and relaxed to focus on their body and the birthing act [16]. The *personal room* (i.e., the new room considered as personal rather than institutional) was signified by the birthing women's active involvement and agency. "Agency was defined as the women's self-determination and ownership over the room, the birth process, embodied knowledge, and informed decisions" [100]. The *personal room* provided "a calm, equal, and trusting atmosphere based on the woman's individual needs and resources" that facilitated the involvement of a birth partner, as well as the women's adaptability, free movement, and sense of familiarity [100]. In Case Study 1, the women had a very positive experience in the new delivery and birth room. It represented a great example of a patient-centred care environment, where the physical environment adapted to many of the women's individual and psychological needs. It was useful, for example, to support the woman's transition to hospital and to reduce stress and anxiety [15]. The room also provided different chances for physical comfort and relaxation, to support women coping with birth and their sense of control. The women were also very satisfied by the ability of the alternative delivery room to support the birthing companions [15].

As we can see from the case study analyses, physical and sensory features that compose the space are strictly related to the properties of wellbeing and relaxation, having an important role in the improvement of the birth experience. In Case Study 2, for example, it is reported that 64.9% of women assessed the physical features in the birthing room to be meaningful to a very high extent, 28.7% to a high extent, 5.4% to a low extent, and 0.99% as not at all. The bathtub was identified as the most important (6.7 points), followed by the nature scenario projections in combination with light, sounds, and music (6.3 points) and the dimmable lighting (6.01 points) [16].

In the next paragraphs, the solutions proposed for each case study (Tables 2 and 4) will be discussed, referring to the related impact on users, as summarised in Tables 3 and 5.

3.2. Birth Space Solutions and Impact

Case Studies 1 and 2 presented solutions for all the birth space requirements: mobility, free space, pull-out/hidden bed; containment, intimate space, curved shapes; filter, privacy; flexibility; homely environment, medical equipment (Table 3) (Figure 4).

	CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
MOBILITY, FREE SPACE, HIDDEN BED	✓	✓	✓	✗
CONTAINMENT, INTIMACY, CURVED SHAPE	✓	✗	✗	✗
FILTER, PRIVACY	✓	✓	✗	✗
FLEXIBILITY	✓	✓	✓	✗
HOMELY ENVIRONMENT, MEDICAL EQUIP.	✓	✓	✗	✗

Figure 4. Diagram showing the presence of birth space solutions in case studies.

Both sensory birth rooms were quite large, especially in Case Study 1 where it was 39 square metres. In this way, the women and the birthing companions were stimulated to move freely within the room (Table 3). The dimension of the room and the physical facilities promoted the emotional support. Women's confidence in their own abilities and sense of control were also promoted by privacy [15]. Privacy and intimacy were promoted by organising the space in three different areas based on wellness, activity, and birth. This

made the space more flexible, including the location of the labour/birth in the more private birth zone and the possibility to cover it with a blanket until needed. In addition, in Case Study 2, the birth bed was located at the side of the room and was covered with a green-coloured bedspread (Figure 4). Here, privacy was also promoted by the provision of an entrance hall of about 3 square metres, separating the birthing area from the hospital paths by a green-coloured curtain (Table 3). Respect for the birth environment was promoted by a private and calm atmosphere, thanks to the filter created by closing the curtain in the hallway of the sensory birth room [100]. The position of the bathtub, that was located in a corner of the room, also reduced the risk of being seen if the door opened [16].

In both case studies, a familiar, homely, and private environment was provided (Figure 4) by home decor, use of materials such as wood, and non-clinical furniture such as modern tables, lamps, chairs, sofa bed, and textiles (Table 3). It made the women feel safe, calm, and welcomed [100] as if being embraced. This also made women experience emotional support and comfort and reduced stress. Women were able to adapt easily to the room and to the transition from home to hospital. Women felt more confident, promoting their physiological functioning and emotional wellbeing [15]. “The room reminds women’s home or of previous experiences. This contributes to a positive impression of the space and affects the overall birth experience positively” [16]. Women also highly appreciated the opportunities to interact with the birthing companion in a spontaneous everyday manner [15]. In Case Study 2, medical equipment was hidden behind wooden panels (Figure 4), which were rolled up when necessary, promoting a calmer atmosphere in the room. Additionally, in Case Study 1, the resuscitation equipment was close to the bed (Table 3). Being conscious that medical equipment was close and available reduced stress and fear [16].

In Case Study 2, spatial mobility was facilitated by the availability of furniture promoting upright positions. This feature was strictly related to flexibility (Table 3) (Figure 4). The chance to have different physical features was much appreciated. The design of the room positively affected women’s moods, maintaining their integrity and offering a place for partners. If the partners felt comfortable, “the woman could relax and focus on herself and on giving birth” [16]. In Case Study 1, the idea of flexibility was also developed by providing flexible furniture: a double sofa bed that was also adjustable in height and was covered by pillows and textiles; a bar stool on the other side of the bed, so that the partner could stay close to the woman, in different positions. The sofa bed also referred to the feature containment, intimate space, curved shapes that was developed only in Case Study 1 by an area/nest for the relaxation of the woman (Table 3). The sofa bed also promoted the physical contact between the woman and the birthing companion, strengthening the experience of intimacy and closeness; it maintained intimacy and the idea of being equal. The calming atmosphere allowed them to withdraw for rest when needed, offering a chance of individually controlled options for pain relief [15].

The intimate space is often mentioned in the literature as essential for childbirth [40], but it was not developed in the design process of the majority of case studies analysed (see Section 3.4) (Figure 4).

Case Study 3 described more the single features, focusing on the sensory elements. It did not refer to the characters of the space, even though we can understand that they were considered in the design process. For example, women could walk, sit, or lie down based on their wishes [6], expressing the properties of the space to be flexible, large, and free. Sensory elements present in the room promoted relaxation but were also able to promote intimacy and familiarity.

Case Study 4 presented a product, thus it cannot refer to the space. However, the sensory stimulations developed by the sensory product were able to change and adapt the environment, depending on users’ needs. This ability of adapting the environment was strictly related to the idea of flexibility. The sensory delivery room also helped to create a more homelike and comfortable space, which contributed to a feeling of security, sense

of control, identity, and sense of belonging. They also experienced the midwives as being more attentive to their needs [19].

3.3. Birth Sensory Solutions and Impact

Furthermore, there were some sensory solutions that were reported by the literature as essential for birth that were not developed in the case studies. We could not find examples for the use of aroma or olfactory insulation in the birth room and there was no information about coloured walls (Figure 5). There was also no experimentation on that data available about their impact on users. Acoustic insulation was only referenced in Case Study 2, where a 40-mm suspended sound absorber was set up in the ceiling (Figure 5), increasing familiarity [16].

	CASE STUDY 1	CASE STUDY 2	CASE STUDY 3	CASE STUDY 4
WINDOW, DAYLIGHT	✓	✓	✗	✗
NATURE, SCENARIOS PROJECTIONS	✓	✓	✓	✓
ACOUSTIC INSULATION	✗	✓	✗	✗
MUSIC/SOUNDS OF NATURE	✓	✓	✓	✓
AROMAS/OLFACTORY INSULATION	✓	✗	✗	✗
SOFT SURFACES	✓	✓	✓	✗
COLOURED WALLS	✗	✗	✗	✗
CONTROLLED LIGHTING	✓	✓	✓	✓
AUTOMATION SYSTEM	✓	✓	✗	✓
ACTIVE BIRTH EQUIPMENT	✓	✓	✗	✓

Figure 5. Diagram showing the presence of birth sensory solutions in case studies.

Of course, all the birth rooms had a window and provided daylight, but only in Case Study 1 and 2 was there a description of how the curtains worked to obscure the room and permit the projection (Table 5) (Figure 5). The study reported the window as the most requested physical feature in the birth room, to have ventilation, natural light, and a nature view [16]. When using the curtains for projections, the window was not always visible and the access to daylight was limited. This caused feelings of being disoriented, as they could not determine easily whether it was day or night [16]. This aspect was very important and could represent a development for the research in evaluating the relation between the natural projection and the availability of daylight, essential for the circadian rhythm.

Another feature that is well known to be very important but was not expressed in most of the case studies is the active birth equipment (Figure 5). In Case Study 1 and 2, it was mentioned that there were some elements to facilitate the birth, such as a birth pool, a birthing ball, hot stones, and massage oil in Case Study 1 and a bathtub, a birth ball, and a birth support rope in Case Study 2 (Table 5). The availability of furniture promoted upright positions, such as the birth ball and the trolley walker. The secluded position of the birth

bed made several of the women use the bath for water immersion as their initial activity rather than a bedbound position. The bathtub was ranked as the most appreciated physical feature in the birth room, even though not all the women used it. It was perceived as “user friendly, comfortable, pain relieving, calming, cosy, and with clean water because of the quick water refill” [16]. Women reported that it was easy to get in and out of it; only a few found it too deep [16]. The birth support rope was lowest ranked, but women were still pleased to have this opportunity. On the other hand, women suggested to explain better how to use the birth support rope to facilitate its use [16]. In Case Study 4, we can say that the sensory automation program had a role in active birth equipment. The system provided five optional sensory programs with different hearing and sight stimulations such as coloured lighting and soundtracks. The visuals were displayed on a large screen as blurred dynamic light that was reflected on the walls. The lighting and screen pictures could shift colours: blue, green, yellow, red, and white. One of the sensory programs, Program 3, called the “Breathing Program”, helped the woman maintain a beneficial breathing rhythm during contractions by the use of pictures and sounds of lightly breaking foamy waves. The midwife could actively use the program to stimulate the woman’s regular and smooth respiration [19]. It was an interesting example of an integrated use of technology and sensory stimulation to actively support women in the birth experience.

The features that were more appreciated and investigated in almost all case studies were: nature, scenario projections; music, sounds of nature; soft surfaces; controlled lighting, dim and colours; automation system (Table 5) (Figure 5).

In Case Studies 1, 2, and 4, a sensory automation system integrated different sensory stimulations, such as videos, coloured and dimmable lighting, music, or nature sounds (Table 5).

Case Study 1 provided panoramic nature videos onto three walls of the room. Women/couples could choose between four scenarios: forest winter landscape, beach with waves, forest springtime, forest autumn. Women and birthing companions could match the scenarios to the stages of labour, shifting between hard work or relaxation, including turning them off. The nature scenarios were developed on the Snoezelen principle [96]. The four scenarios integrated soothing music for relaxation from “MusiCure” (two scenarios) and sounds from nature (two other scenarios). There was also the opportunity to bring one’s own music and play it in the room. Colour-controlled and dimmable lights were also integrated in the nature scenarios (Table 5). The stimulation of sight and hearing captured attention to support women coping with labour and to maintain a sense of control [15]. In this way, nature scenarios represented a positive distraction to make women find joy and relaxation. Women associated pictures and videos with important aspects of the couples’ daily lives, promoting positive emotions. The effect of the warm and dimmed room lighting was considered calming and promoted a sense of comfort and safety. Controlling sensory stimulations such as sound, light, and projections also made the women avoid stressful situations. Audio and visual stimuli were perceived as calming and they offered the chance of small talk [15].

Case Study 2 offered seven programmed audio–visual stimuli projections (stormy ocean, sunny beach, winter landscape, forest in spring, summer or autumn, and nature at dawn) to choose natural scenarios with integrated dimmable lighting, sounds, and music. The projection covered two walls, including the window (Table 5). Nature scenario projections, integrated with lights, sounds, and music, were highly ranked. The different scenarios “evoked positive personal memories and were also experienced as entering another world, which in turn reduced feelings of stress” [16]. This contributed to a positive impression of the space and affected the overall birth experience positively. An area of improvement mentioned was to have the opportunity to play one’s own music according to the nature scenario projections [16]. The dimmable lighting also promoted familiarity, creating a cosy atmosphere. The flexibility of the room, according to women’s needs, promoted women’s sense of control. “The room was ‘their place’ during birth” [16]. A few women defined the technical panel for the control lights as too complex to use it

by themselves and they needed staff support; it was suggested to have better written instructions to avoid this issue [16].

Case Study 4 was represented by a large Philips luminous textile screen that was installed on one wall of the sensory delivery room and blurred dynamic LED lighting that was reflected on the walls, shifting colours by a touch control panel (Table 5). It provided the integration of programmable calming lights with low irradiance, restful blurred pictures displayed on the wall-sized big screen, and sound effects. The automation system offered five optional sensory programs with different auditory and visual stimulation regarding coloured lighting and soundtracks. The five pre-set sensory programs included: arrival (red), relaxation (red/blue), breathing (blue), atmospheric (red/yellow), and white light with no sound [19]. The programs provided were:

1. Welcome Program: a bonfire by a lake scenario with selected MusiCure music to provide a calm and welcoming atmosphere.
2. Relaxation Program: nature scenarios with blue, green, and warm colours. Visuals were integrated with selected MusiCure music to provide a sense of relaxation, comfort, and security.
3. Breathing Program: to maintain a beneficial breathing rhythm during contractions. This rhythm was established via pictures and sounds of lightly breaking foamy waves. The midwife could actively use the program to stimulate the woman's regular and smooth respiration [19].

About the data, it was reported [19] that the sensory delivery room had a very positive impact on the birth experience, as mentioned before, but a correlation between a specific feature and the impact evaluation was not expressed. Probably the general aim was the integration of the different sensory stimulations in a unique product, so the study did not focus on one single feature. The automation system gave the opportunity to customise the space and to adapt the environment, depending on the women's/couples' needs.

Case Study 3 did not provide the same integrated system, but it also focused on the same features. An aquarium with fish was placed in front of the women at a distance of 1.5 metres and a projector with green light alternately changed pictures on the wall. Light music and rain sounds were also reproduced (Table 5). "Findings indicate that the first stage duration of labour in the intervention group was less than the control group and observed significant difference" [6].

About the soft surfaces (Figure 5), both Case Study 1 and 2 provided a double-sized sofa bed covered by some pillows and textiles that differed from clinical hospital furniture textiles (Table 5). It represented an opportunity for individually controlled options for pain relief [15], as mentioned above, and made the birthing room feel familiar [16]. In Case Study 3, the entire room was floored with soil-coloured carpet (Table 5).

3.4. Design Process

The introduction of sensory rooms in hospitals is one of today's challenges in health-care, a challenge that strictly relates to dialogue and co-design processes in order to define new spaces and practices for users' integrated healthcare and wellbeing.

The few examples we could find and analyse as case studies represent a portion of research projects as trials on the impact of sensory stimulations/environments on users. None of the case studies described the design process, the methodology, the design or co-design tools, or the people involved. More information about the design process would be necessary to understand the development of users' requirement framework and the relation with the solutions proposed for these aims.

Which principles are driving the design process? What is the relationship between the architectural firm and the research? Which tools could support the design process? How is the research/project team able to define women's (and other users') requirements? How do they develop sensory solutions? How are they able to define the correlation between the different solutions and their impacts on users? The experimental research on this field could be developed a lot to be able to answer all these questions.

Case Study 1 dealt with designing and rebuilding one of the existing birth rooms of Hospital Unit West in Herning (Denmark). An interprofessional design team including midwives, a zookeeper, a design psychologist, a wellness expert, a game developer, an architect, and a theatre set designer were involved for two workshops to inspire and create new ideas for the design and décor of the sensory birth room. In the workshops some important principles were developed: the room should be home-like; nature should be brought into the room; the room design should promote the partner's active supporting role and the woman's mobility during labour; the room should be flexible to make the couple create and customise their own birth environment during the different stages (arrival, during labour, and during the birth) [96]. It was not clear whether women were involved in the design process of the delivery and birth room and how and whether they were involved only in the first stage of the research or also in the final development of the project.

The involvement of patients is considered very important, both in maternity services' co-production [108] and in shared decision making, when designing healthcare environments [109]; however, in the case studies it was only developed as the evaluation of women's (partners' and midwives') satisfaction when experiencing the delivery sensory room and not in the concept phase of the project.

Furthermore, as we highlight in the discussion, sometimes we did not find a correspondence between the literature results on birth space requirements and their development in the project of sensory rooms for birth. To develop design solutions that improve the birth experience, it would be necessary to involve the users—women, partners, midwives—during the design process and to take into account the local social and healthcare context and users' needs, especially referring to women sensory preferences. In designing and building birthing environments, the user's sensory needs are the guiding “compass” to be listened to from the beginning and to be followed to achieve women's physical and psychological comforts. Several questions still remain open: how can users be involved in the design process? Should they be involved in the improvement of the requirements' framework or in the validation of design solutions? Should it be an ongoing co-design process through all the conceptual, defining, prototyping, and testing phases?

In the North Denmark Regional Hospital in Hjørring, a sensory delivery room was designed by the involvement of women in the design process. The case study was not included in this research because it did not evaluate the impact of the sensory room on users; however, it is an interesting example of the co-design process based on a somaesthetic framework. From January 2020 to January 2021, the design process was conducted; it involved an interdisciplinary team composed of a midwife, obstetric surgeons, an architect, a composer, a painter, and a nature photographer. The main principle of the project was represented by the hypothesis of approaching the delivery room design as a somaesthetic instrument and moving familiar and local nature moods inside the delivery room as positive distractions, combined with home-like décor [18]. The main goals were to: reduce stress, help pain management, create more active partners, support the midwives' relational work, and in general “build better and more memorable environments for the midwives, birthing women, and their companions, without compromising safety” [18]. The process was developed in three phases: concept design, building an interactive instrument, and crafting atmospheres. Learning from the state of the art on birth sensory design and from the existing case studies, such as Case Study 1, the team decided to create a welcoming multisensory atmosphere that supported the existential situation and stimulated a strong sense of place and time by capturing meaningful and familiar local moods in nature. Patients were involved in the concept phase through the use of 30 semi-structured interviews that were conducted with local pregnant women to understand and capture the important situated atmospheres from nature that they considered calming and meaningful. Memories of positive calming nature experiences were able to stimulate a sense of belonging and “consequently trigger the women's conscious and subconscious somatic response systems to help them perform in the different phases of the birth. The embodied memories will help them support the feeling of belonging, safety, and pain management” [18]. Then,

during the period 2021–2022, the artistic team travelled the northern part of Denmark, chasing local moods described in the interviews. The 100+ hours of recordings were cut into four one-hour moods; each cut is played for a minimum of 5 min, stretching from morning to night. Different ambient moods were developed, such as *Drømme* (dreaming), *Ro* (peace), and *Hjem* (home), and birth moods to support breathing rhythms and pain management. Additionally, music and natural soundscapes were composed on the basis of the interviews to create a quiet ambience. The result was a welcoming delivery room, whose atmosphere could be changed and customised according to the situation by the multisensory and immersive experience. The atmosphere was shaped by the circadian rhythms. The natural moods represented a positive distraction but also an active birthing feature, supporting the woman's pain management and performance.

Art was used in this case to “present a rich alternative to the clinical environments”. The aim of this work was not “asking for a new golden standard for randomised clinical studies, or faster, and more efficient births, but using somaesthetic practice to support the act of human care” [18].

Case Study 2 also dealt with interdisciplinarity. It was initiated in the planning of new facilities and developed as a research activity conducted by the Institute of Health and Care Sciences at the Sahlgrenska Academy, University of Gothenburg. However, in the scientific literature available in the English language, the design process has not yet been described.

Case Study 3 was also part of a research project at the Iran University of Medical Sciences. The study was conducted in two birth rooms in one of the central state and educational hospitals affiliated with Iran University in Tehran, with approximately 600 monthly births.

Case Study 4 represented a different experience as a PPI project to develop a sensory product with the contribution of the labour ward in North Zealand Hospital (Hillerød, Denmark), with two private companies, Philips and Wavecare. The final result was represented by a large Philips luminous textile screen installed on one wall of the room and dynamic LED lighting at the entrance, along the walls, and around the delivery area that were controlled by a touch control panel. Philips is one of the world's leading suppliers of solutions and equipment to the healthcare sector and has worked for many years on improving the patient experience. In the sensory delivery rooms (SDR), Philips developed the hardware for the installation. Wavecare has developed, among other things, calming themes for Philips Healthcare for many years and specialises in producing solutions for relaxation during medical procedures for several areas of the healthcare sector. For SDR, they developed the sensory experience via its audio–visual themes. This case study was particularly interesting for developing a new idea for a sensory delivery room that is generated by a modular element that can be easily placed and set up in different contexts to reproduce what we called “sensory atmosphere”. This opens a new direction for the research, thinking about integrated and flexible products that can offer sensory environments even in the existing buildings where there could be lack of space and sources.

4. Conclusions

It is clear that we can learn from the existing case studies by studying the different solutions and how they are commented upon, analysed, and experienced based on a sensory birth environment perspective. There are, however, few sensory delivery rooms set up in maternity settings that provide a complete description of the physical and sensory space. Research would benefit from analyses of other case studies that at the moment are not presented in the literature, as often is the case in design projects.

A few case studies have evaluated the impact of sensory birth rooms and specific sensory features on users (women, partners, midwives). The studies in this field can be developed to improve the structured presentation of data and findings to support the development of evidence related to different design features. The evaluation methods were very different and therefore produced variations in results. Comfort, behaviour, and experience are complex parameters to evaluate what requires qualitative alternative methods to be improved and added to, to complement the data on medical outcomes to

better represent women's birthing experiences. As often is the case, design research, as well as much of the research on healthcare, is based on a high degree of qualitative data and methods that need to be developed to bridge between design and patient outcomes.

The design process to arrive at sensory delivery rooms was not self-evident; many approaches were used and often lacked documentation of design decisions and their basis/criteria. Processes were often not described or did not represent a structured or even rigorous method. It was not possible to identify a design protocol or a framework of requirements in the case studies analysed. The framework of requirements could support effective and efficient design solutions and could be used as a tool in the co-design phase. The case studies did not always present solutions for all the requirements we identified, even though they were reported as essential for the birth space in the literature. Reasons behind design strategies and why they have been chosen would be relevant to study further. A question is if there is a need for a design protocol to support professionals and what it should encompass.

Women were not involved in the design processes in the studied cases, but only in the evaluation phase of the sensory delivery room. We consider their contribution essential for the definition of the sensory design framework. Case Study 1 and Skouboe and Højlund's [18] co-design experience could support this concept. A further question is whether inclusion in the design should be per project or through a broader approach aiming for more general guidelines.

A conclusion, or perhaps more of a reflection, we can discuss is the development of modular solutions for sensory environments to meet flexibility requirements. Case Study 4 could represent an example of an adaptable solution able to recreate a sensory environment by the integration of sensory stimulation in a unique product. This makes it possible to easily set up sensory spaces in several different environments, even in existing buildings, and a possibility to use a sensory design approach for many other uses/healthcare sectors in the hospital.

Finally, we are humans and we experience the world as we see it; we understand our environment through our senses. It is important to have this understanding alongside briefs, definitions of functions, lists of requirements, and other facts to enable a more comprehensive approach to design for healthcare environments.

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