



Faculty of Design

2023

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Suggested citation:

Balabanoff, Doreen (2023) Color, light, and birth space design: An integrative review. Color Research & Application. ISSN 0361-2317 Available at <https://openresearch.ocadu.ca/id/eprint/3982/>

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REVIEW

Color, light, and birth space design: An integrative review

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Funding information

Social Sciences and Humanities Research
Council of Canada, Grant/Award
Numbers: 430-2020-01104, 890-2021-0079

Abstract

This integrative review sought knowledge across a broad spectrum of literature concerning the role of color and light in maternity environments. Today it is acknowledged that the clinical nature of birth spaces is detrimental to maintaining normal physiological birth rates. Significantly, “clinical” spaces are often described as white, pale, monochromatic, and/or overlit. Attempts to make maternity settings more “home-like” have promoted use of “warm” or “soft” colors. Ambience or spatial atmosphere is known to impact birth hormones, affecting labor commencement and progress. Today, efforts to improve birth spaces include “sensory rooms” (offering pain distraction via dark spaces and illuminated color elements); programmable colored light installations; and immersive image projections. Yet, as this paper shows, there is little specific study of the physical and psychological impact of color and light within birth settings. However, there are significant findings on colored light’s impact upon birth processes, including the contraindication of bright blue light. And there is valuable knowledge embedded in old and new literature from diverse disciplines. This review thus exposes the strong need for further research and literature focused directly on how color and light in birth environment design impact birth experience for all involved. It is clear that environmental color and light need to be taken seriously as potent interrelated environmental factors that are directly implicated in the health and wellness of mothers and their infants during labor and birth. Thus, it is crucial to bring deeper awareness and comprehensive knowledge into use by designers, developers and managers of birth spaces.

KEYWORDS

color, light, birth environment, maternity, design, architecture, ambience

1 | INTRODUCTION

Today, designers, midwives and researchers are seeking ways to create less clinical birth settings that support

women's capacities and desires for giving birth without major medical interventions. Economical solutions would be valuable, particularly within low resource settings, and color can contribute greatly to enhancing birth spaces at

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low cost. The need for cultural and contextual belonging is another factor that suggests color as a fundamental and desirable element in a new paradigm for birth space.

Given this context, designers require more knowledge about birth, labor and birth care in order to meet the above-stated needs and desires. This review is part of an effort to build design awareness and knowledge about the import of a paradigm shift for birth spaces across the globe. It is one of the outcomes of a transdisciplinary research project, *Transformational Change for Birth Environment Design*, funded by the Social Sciences and Humanities Research Council of Canada (SSHRC). The interest in developing more salutogenic birth environment design is growing, but design approaches that support normal physiological birth processes and emotionally satisfying birth experiences are not prevalent today. Midwifery practice and research are challenging the overmedicalization of birth. Founding members of the Global Birth Environment Design Network (<https://www.gbedn.org/>) leading this project are Nicoletta Setola (University of Florence), Davis Harte (Boston Architectural College), Elizabeth Newnham (University of Newcastle) and author of this paper, Doreen Balabanoff (OCAD University). The aim is to create a wide-ranging knowledge mobilization platform to inspire and inform architects, designers and healthcare providers about optimization of birth space design.

Arising out of a larger integrative review concerning birth environment design, this paper sought to provide a first review of literature that specifically considered, tested, or studied color and light within maternity spaces. The author sought to assess what is currently known about the use of color in birth space design, and what dissemination of information and further research is needed in this area. Light and color (and their inseparable partners darkness, shade and shadow) are intricately interwoven aspects of interior architectural experience. They overtly *and* subliminally impact what we see and how we feel in a spatial setting. The study of color in birth environments includes both natural light and artificial lighting as important aspects of perceived spatiality.

This review confirms the existence of important current knowledge concerning the mind-body impact of color and light on birth processes that designers of birth spaces need to know and utilize. Particular attention to light levels, spectral composition of light, and lighting controls is crucial to enabling (or impeding) labor processes. Awareness of how color and light can contribute to creation of salutogenic birth environments is important for designers *and* commissioners of birth spaces. It should be noted that this paper does not review the broader field of knowledge concerning psychophysiological impact of environmental color, unless it is referenced in papers focused specifically on birth environment. Certainly, bringing this broader body of evidence concerning

environmental color into birth environment design research and practice is important as a next step, and for future research development.

1.1 | Background

Hessam Ghamari and Cherif Amor, in their comprehensive overview of the literature on color as an environmental constituent of healthcare settings, concluded that (1) understanding of color use in healthcare settings is not yet supported by strong evidence; (2) color, light, lighting and surface materials must be studied together, and (3) further studies are needed and should include “the interaction and inclusion of persons and environment simultaneously.”¹

Over the past 15 years, midwives have been increasingly considering the role of maternity care settings in supporting normal physiological birth, and have noted that the current paradigm, the biomedical model of birth care, ignores the personal and emotional experience of birth.^{2,3} In 2008, midwives Kathleen Fahy, Maralyn Foureur and Carolyn Hastie published their Birth Territory theory, positing that the birth environment itself can play a crucial role in facilitating and supporting normal birth⁴ and that the clinical nature of birth spaces can have a negative impact on birth processes and thus birth outcomes. They noted that stimulation of the stress hormone (epinephrine/adrenaline) is oppositional (and thus suppressive) to oxytocin, the hormone that induces and sustains labor. The hospitalization of birth has contributed to rising caesarean section rates—above 30% in many countries—far from the World Health Organization’s longstanding recommendation of 10-15%.⁵ Design of the birth environment itself, Fahy, Foureur and Hastie argued, can support or undermine normal physiological birth, understood as vital to improved health and wellbeing of mothers and infants.

In landmark studies (2003 and 2005), Debra Singh and Mary Newburn surveyed new mothers about the birth spaces they had recently occupied, and found that women felt strongly that the environment could impact how difficult or easy it was to give birth. Aspects of the spatial design, for example, whether there was a space to walk, impacted outcomes including caesarean section rates.^{6,7} Research on birth environment impact has continued since then. A recent multidisciplinary literature review focused on how the physical birth environment affects behavior, experience and practice, and found thirty-seven papers meeting the search criteria. The authors, Setola et al, identified and discussed eight key spatial elements that have impact, directly and indirectly, on intrapartum maternity care. These were articulated as: (1) unit layout configuration; (2) midwives’ hub/desk; (3) social room; (4) birth philosophy vectors

(images/spatial locations); (5) configuration of the birth room; (6) dimension and shape of the birth room; (7) filter (privacy screening); and (8) sensory elements.⁸

Designers commissioned to create maternity spaces generally work from guidelines, briefs and interviews with medical professionals and staff that utilize and build upon the currently prevalent medical paradigm for birth practices. There is usually little time for research and analysis on seemingly non-crucial topics such as color choice. In any case there have been minimal conclusive research outcomes available in this area. Hard evidence about impacts of environmental color and light in healthcare environments is difficult to obtain—controlled clinical trials within healthcare settings are challenging, and can have many confounding factors limiting their usefulness as “evidence” of specific impact. Color may seem like a trivial pursuit to some, and in any case, it is not a simple element that one directive in a guideline can cover. What designers and healthcare administrators do not know, but need to know, is whether and how their choices and use of specific colors and materials (as influenced by both natural light and artificial lighting) impact the minds, bodies, birth behaviors, experiences, practices and outcomes of those who use their designed birth spaces. The need for this knowledge is grounded in the possibility that color and light might be used proactively to facilitate salutogenic (health and wellness creating) births—a goal that goes beyond designing for the current medicalized model of birth. But it also is important to note that color use has potential for negative impact.

Phenomenological understandings of architecture have taken up the emotionality and moodedness inherent in spatial experience, involving the ecological complexity of interrelationship between the mind-body and one's surrounding environment.^{9,10} Ghamari and Amor's aforementioned review specifically notes the import of this approach. As Maurice Merleau-Ponty has described vividly, qualities of light, air, atmosphere, sound and smell are significant in human experience of place—perception is grounded in our mind-body integration with surrounding environment (including other inhabitants/actors).¹¹ James J. Gibson's ecological psychology theory also highlighted the inseparableness of all creatures and their surrounding environment. He posited that our perceptual systems are made for perception-in-motion, and informed by opportunities and motivations. Thus meaningful environments can instill and support agency of the actor(s) in a particular environment.¹² The field of “neuroarchitecture,” empowered by brain imaging capacities, has highlighted the role architecture can play in influencing occupants' behaviors, comfort, and wellbeing.¹³ Beauty as an architectural experience has also been explored as a spiritual dimension of built space and place, and understood as important in

providing human experience that is emotive, memorable and meaningful.¹⁴ The field of epigenetics also now corroborates mind-body-environment interconnectivity as it scientifically verifies the dynamic response of gene expression to environmental factors.¹⁵

Across time, cultures, and geographies, birth is a fundamentally spiritual experience connecting humans to the regenerative capacity of all species, and to the mysterious arrival of deep love and joy that comes with a new being entering into earthly life. Within our growing awareness of the environmental interconnectivity of everything, it should be clear that the design of birth spaces is not to be taken lightly. Birth environment can have significant impact on birthing women and their infants, and also on caregivers and companions who are part of the environment and are thus influenced *and influencing*. And it is without doubt that color and light can be utilized for provision of beauty, comfort, lowered stress levels, feelings of intimacy, and memorable personal, emotional and spiritual experience. It is time to treat color and light seriously in the design of birth spaces, and to this end, specific knowledge and evidence are important.

1.2 | Methods

This review has been limited to sources that specifically mention/discuss light and color in birth spaces or maternity units, or that discuss light and/or color as related to physiological birth processes or psychological implications for birth experience. It was purposely integrative—including journal articles, excerpts from books, news items, guidelines, and dissertations from any field or practice. In this way it aimed to include the widest possible gamut of perspectives considering color research and knowledge that might have implications for best practices in birth environment design.

The search occurred in the context of the aforementioned larger transdisciplinary project, in which a search by the research team, through diverse literature, led to the creation of a group Zotero library containing over 2000 items that were understood by the team to hold relevance for birth environment design.

The more specific search reported in this paper utilized the terms light, lighting, color, color, birth, birth environment, maternity, maternity unit, birth space...and produced over 70 peer-reviewed articles, subsequently canvassed by the author for meaningful content. The review did not exclude unpublished dissertations, published books, and other sources if they contained relevant discussion and insights related to color and light in birth settings.

Four papers, discussed below in Section 2, were found that *specifically focused on light and color* in birth

environments. A further perusal of collected documents concerning birth showed that there is some significant existing information about the role color and light can play, positively or negatively, in relation to birth experience, birth physiology and birth processes. It is also clear that further pertinent knowledge exists or will exist in the near future, *arising in diverse fields*, and thus a trans-disciplinary approach is important as the literature develops in this architectural arena.

It is important to state here that it was beyond the scope of this review to include the large body of research on environment color that was not specifically related to birth or birth environment. *A future paper bringing relevant knowledge from broader environmental color and light research into focus for birth environment design would be valuable.*

The three framing perspectives that follow offer an introductory insight into the reviewer's viewpoints that might have influenced findings and conclusions.

1.3 | Three key perspectives

Three perspectives are briefly introduced below, as they have fundamentally informed the author's interest and viewpoints on color and birth environment design: (1) Bianca Lepori's architectural perspective on the import of light and color in birth spaces¹⁶; (2) Maurice Merleau-Ponty and James J. Gibson's phenomenological and ecological understandings of perception, including color and light, as inseparable aspects of embodied spatial experience^{11,12,17}; (3) Florence Nightingale's clear and fundamental observation that color and light have impact on health/wellbeing.¹⁸

These three perspectives point to the crucial notion that spatial color and light are part of a dynamic mind-body-environment synergy that co-creates our complex experiences of the world. This notion is at the heart of the author's approach to this literature review on color and birth environment design.

1.3.1 | Architectural meaning: The import of light and color in birth space design

Italian architect Bianca Lepori offered an architectural understanding of birth environment with focus on *the birthing woman's experience of her spatial setting*, grounded in her observations of home births.¹⁶ Here, she speaks of the role of environmental light in the birth setting:

The sense of the open, and that of the closed is suggested to us by light and dark, by

*luminosity and darkness or shadow. As much as light allows the eyes to see, too much light creates environments where we are no longer able to see [...] due to the privileging of the undifferentiated which is counter to creating areas of intimacy [...] and] the visioning of one's own existential landscapes.*¹⁶ (p. 129)

Lepori was the first voice from the field of architecture to highlight birth environment design as an important *architectural* project of our era. Her comments on light and color in birth spaces began not as a prescription, but as an antidote to the medical model of birthing rooms:

It is impossible to define the "correct" color for a place of birth, just as it is not possible to provide a standardized model of this space.

Perhaps the discourse should work in reverse, that is, eliminating those colors that evoke medicalization, asepticity, "surgery."¹⁶ (p. 127)

Lepori further noted that combinations of materials and colors could be calming as well as "strengthening," as a vivid color could add life, inspire determination or movement, or a pastel color could soften rigid surfaces.

Her work set forth a challenge that this author has taken up: to focus on this important space, and to intuitively and imaginatively work towards architectural settings for birth that offered a *more primal and personally empowering birth experience*.

1.3.2 | Phenomenological awareness: Color and light as inseparable elements of an ecological and embodied spatial experience

A second orientation is the phenomenological and ecological understanding that color and light are not truly separable elements in our perception of the built environment. They are fundamentally complex and entwined perceptually, as mind-body-environment are also inseparable in our spatial experience. Maurice Merleau-Ponty and James J. Gibson were early proponents of these insights, now at the heart of embodiment theories^{11,12,17} (pp. 64–115).

Karen Fridell Anter, Ulf Klarén and Harald Arnkil have noted that much research about light has been concerned with technical applications, and that the often industry-led research about color has tended to focus on color measurement and reproduction technologies with limited relevance to design of spatial settings. They have

identified, in the discourse on light and color, three major approaches: (1) psycho-physics; (2) biology/neurology; and (3) perception/cognition. Further, they have articulated the difficulties in using these approaches for applied work in architectural design, due to the *dynamic and interrelational nature of spatial perception and experience*¹⁹ (p. 240).

1.3.3 | Salutogenic approach: Effects of color and light on health/wellbeing

In the 19th century, Florence Nightingale, recognized today for her clear research methods and data collection that provided informed healthcare knowledge, spoke of the spirit-enhancing potency of color eloquently,¹⁸ anticipating Antonovski's valuable salutogenic theory driving new approaches to environmental design.²⁰ Nightingale wrote:

The effect...of brilliancy of color is hardly at all appreciated [...] I shall never forget the rapture of fever patients over a bunch of bright-colored flowers...Little as we know about the way in which we are affected by form, by color, and light, we do know this, that they have an actual physical effect. Variety of form and brilliancy of color in the objects presented to patients are actual means of recovery.¹⁸ (n.p.)

Nightingale's observations about the "actual physical effect" of color on patients' wellbeing are valuable in reminding us that *color and light have real impact on the mind-body*, and that *variety* and *brilliancy* are factors in their impact. They are related to her interest in natural light in designing healthy birth spaces and to her keen awareness of both clinical rigor and human needs in a hospital environment.²¹

2 | FIRST RESULTS AND DISCUSSION: COLOR IN BIRTH SPACES—FOUR PAPERS

Four papers met the review criteria of specifically studying color impact in birth spaces. Listed in chronological order, they are: (1) *The Effect of Color and Design in Labour and Delivery: A Scientific Approach*, which clinically tested a visual art addition to the birth space to determine if "color and design" had impact on labor length and pain²²; (2) *Light and Embodied Experience in the Reimagined Birth Environment*, a practice-based dissertation/exploration of the role of light and color in creating an architecture for birth enhancing embodied birth experience and supporting physiological birth processes¹⁷; (3) *Color Analysis of Birth Space Ambiances*, a study of

stress responses in relation to maternity spaces, with a focus on spatial color affect and effect²³; and (4) *Illuminating Bodily Presence in Midwifery Practice*, which presented an ethnographic study mapping behavior and experience in a "sensory delivery room" (ambient colored light in the labor room as enhancing embodied experience) as compared with a "conventional" delivery room.²⁴

These four papers are discussed below. Section 3 will then follow with an expanded review of further studies related to birth physiology or psychology, and color (not specifically focused on the birth environment).

2.1 | Paper 1: The effect of color and design in labor and delivery: A scientific approach

This 2003 study by Jane Duncan, *The Effect of Colour and Design in Labour and Delivery: A Scientific Approach*, sought evidence concerning visual art as useful in birth rooms. It questioned whether color and design inserted into labor rooms could create significant physiological changes in women's labor, potentially contributing to maternity care economics.²² Measures used were (1) length of labor; and (2) frequency of requirement for analgesia (pain relief). A "positive visual stimulus" was hypothesized as useful for altering the clinical nature of the room. An artwork was designed to this end—specifically addressing two goals: (1) reducing women's anxieties and fears thus diminishing requirements for analgesia, and (2) acting as a focal point of attention and distraction during labor.

"Warm" and "cool" color palettes were devised as options for the two sides of the art screen. The study reported a 2-h difference in length of labor between modified room and standard room, analyzed as statistically significant. Further, a 7% decrease in analgesia requests was charted, but was not statistically significant (due to sample size). Limitations of the study included the non-randomized approach and methodological specificity. The research did not include interviews or commentary by subjects or caregivers. No specific data on subject's color choices or impressions was included. Hence the study results may have been more indicative of the value of hiding the medical equipment and providing options for a distracting and attractive artwork to focus upon during labor. No conclusion about the warm or cool color use or preferences of users was reached.

While the study highlighted the possibility of creating interesting visual art distractions in a birth environment, it did not focus on or provide adequate evidence for definitive repeatable color use concepts. A positive aspect of the intervention was the choice offered to laboring

women of a two-sided screen with different color options. Certainly, this study points to the possibility and potential value of undertaking a similar study with more a rigorous methodology.

2.2 | Paper 2: Light and embodied experience in the reimagined birth environment

This doctoral project (by the author of this review), entitled *Light and Embodied Experience in the Reimagined Birth Environment*, was a practice-based exploration intending to contribute to the development of a new architectural paradigm for birth environment—supporting the emotional resonance and personal agency needed for normal physiological birth.¹⁷ The dissertation provided a thematic transdisciplinary review of birth environment literature; compared the writings of Maurice Merleau-Ponty and James J. Gibson on environmental perception of light, color and darkness; analyzed the author's previous artistic practice thematically as related to her own practice-based light-color spatial knowledge; developed and presented studio explorations; and concluded with distilled visual and textual outcomes.

The studio-based studies were photographed, and presented in thematic groupings. They evidenced the potential for meaningful use of light, color and darkness within spatial settings for birth. Themes emerging from the exploratory studio work were articulated with images and correlated textual discussion. Theme 3, “Richly Resonant Color-Light-Darkness” (pp. 238–240) and Theme 4, “Noticing Light: Surface, Substance and Ether” (pp. 241–243) were particularly focused on color, both physical and ephemeral. The theme “Venustas: Intricate Physicality, Ephemerality and Sensuality” (pp. 302 and 303) captured the complexity and relevance of esthetic architectural elements that cannot be reduced to one “tested” form or item, that is, represented in stasis or given as having only one attribute not influenced by others, or devoid of cultural, social and living environmental contexts. Privacy and intimacy were highlighted as concepts that strongly related to darkness, light, and deep and resonant color. Aliveness was an emergent concept with strong relationship to color and vividness.

The conclusion offered six points (and articulated discussion of these) for reimagining birth space using light (light-color-darkness) as key affordances for normal birth and embodied birth experience: (1) Facilitate awareness of cosmos using lateral and zenithal openings for light; (2) Enhance the phenomenological interplay between light and surface; (3) Make the threshold between inside and outside experientially rich; (4) Develop modulation

and gradation of light for sensual flow; (5) Use color to create vividness and depth; and (6) Develop spatial aliveness through use of light¹⁷ (pp. 309–318).

2.3 | Paper 3: Color analysis of birth space ambiances

Color Analysis of Birth Space Ambiances, by Ichraf Aroua and Faten Hussein, addressed color use in birth spaces seeking to discover “situations of stress” correlated with spatial color that was not controllable by subjects.²³ The mixed methods included a strong variety of both qualitative and quantitative elements.

The authors used several diverse birth settings in France and one in Tunisia, which brought consideration of the role of culture and place to the discussion. They noted the subjectivity of spatial color perception, understood as cultural difference. For example, while they made the more general statement that “the white color and bright light characterizing the hospital birth environment increased anxiety and fear for birthing women,” they also noted that “In the case of the Tunisian maternity, women disapproved the use of white. For them it was cold and unpleasant, while a French woman perceived it as a symbol of hygienic and aseptic ambiance.”

Stress levels were biometrically measured. Visual representation of stress levels was correlated to different areas/rooms in the maternity unit and matched to women's experiential descriptions: “Despite the presence of the pink, it feels white and pale. I cannot forget that I am in a hospital”; or “For me, the corridor is more pleasant by the faience colored blue which makes me feel at home.” Lowering of light was noted as impacting feelings of privacy, and control over lighting as offering opportunity to change mood as desired. The researchers stated: “[...] brighter light can encourage activity and lower lighting can create a greater sense of privacy.” A respondent said: “White color makes me feel cold and its neutral aspect is not cheerful; it is unpleasant.” The comment was correlated to a peak in her stress level (shown in a graph).

The authors stated that monochromatic schemes were not positively received; they argued that effects of color are generally associated with there being a harmony of several colors in the same space. An interviewed French architect sought to use varied color to maximize the spatial sense of security and tranquility. Another interviewed woman enjoyed this space: “I found the maximum of privacy in this room; it is warm and colorful.” The authors concluded, based on their correlation of space occupancy with stress level measurements, that “every color creates a particular ambiance in a birth environment. It has a

significant role in shaping the mood of women: stimulating or calming.” They noted that stress situations “can be caused not only by colors but also by other components such as sounds and smells, which may contribute to creating an uncomfortable ambiance.”

The authors commendably provided color swatches under each of the many images shown. Yet, more detail would be helpful. How were the color samples selected, for example, digital color picker, matched color sample in situ? Often, photographic images of architectural spaces have limitations for color representation—and a set of swatches may not adequately capture the richness of the color in a spatial setting. It would be valuable to include even more visual references along with the textual discussion, as color terms are generally lacking in precision, and color affect/effect is very nuanced. It would be helpful to discuss proportional use of each color in the space, and to include information about lighting.

It should be noted the authors provided a valuable overview of relevant healthcare color studies as an introduction to their own research discussion. Their mixed methods approach was effective in putting together physiological response and narratives of experience. They successfully presented awareness that other sensory elements are woven together with color perception. It is clear that developing further similar color studies in birth spaces would provide useful knowledge for practitioners to utilize for optimizing birth spaces.

This study exemplified the complexity of environmental color research: color, light, material, cultural knowledge, professional and practice-based knowledge, personal feelings—these are ever-present variables that can confound spatial analysis. The key take-aways are that color use in birth environments can ameliorate stress, contribute to sense of security, and alter mood and ambient energy. Further, color meaning in birth space is linked to cultural expectation and experience.

2.4 | Paper 4: Illuminating bodily presence in midwifery practice

In *Illuminating Bodily Presence in Midwifery Practice*, Stine Louring Nielsen, Mikkel Bille and Ann Berlin Barfoed presented a sensory ethnographic study of birth environments that employed colored illumination to aid in creating embodied and emotionally resonant spatial experience.²⁴ Their focus was on “the emotional tinging of spaces whereby they become perceptible in a bodily-sensuous way,” with reference to Gernot Böhme’s architectural/esthetic philosophy of spatial atmospheres.²⁵ They noted that sensory technologies are now being utilized in delivery rooms across the world, and

that in Denmark alone, five birth maternity wards have incorporated a “Sensory Delivery Room” (SDR)—based on knowledge that strategic use of light and sound can mitigate stress, and stress-reduction is important for successful labor and delivery. In SDR’s, midwives could “set the scene of delivery using multi-colored light and various soothing sounds,” with the intent of improving the birth experience for all involved (women, partners, staff).

The researchers studied 67 births in two rooms, “conventional” and “sensory” using 500 mappings of colored light settings showing related midwifery practices, bodily positions and flows of the delivery room. Interviews with the midwives described their use of the various color/light settings through the labor and delivery experience. The analysis revealed four themes: (1) The Potency of Brightness and Dimness; (2) Changing the Energies; (3) Handling Dynamics and Dissonances; and (4) Attuning Bodily States of Being. The authors stated:

Our analysis showed how midwives generally shared a sensory awareness of how light not only shapes atmospheres in the delivery room, but also how these atmospheres attune practices and gestures of human bodies, by their “bodily gripping powers.”²⁴ (p. 7)

The conclusion called for moving beyond studies of sensory elements and their effects on medical outcomes and patient safety issues. The authors posited that “atmospheric” framing of midwifery practices and maternity spaces offered a way to understand the social and felt nature of the architectural setting. They concluded that further attention should be focused on the “atmospheric interstices of technology and professional practices” and how atmospheric spatial design in birth environments can contribute to an all-important attuned sense of “being present” (pp. 7 and 8).

3 | FURTHER REVIEW OF STUDIES: IMPACT OF COLOR AND LIGHT ON BIRTH

Given the limited dedicated studies on light and color in birth spaces, the review shifted to finding mention of the impact of color and light *on birth physiology, processes and experiences*. Discussion of significant points from the papers found is thematically organized below. Within these studies, a *highly significant finding* emerged, related to the impact of strong *blue light* on labor processes.

The sections below highlight key areas of focus in the literature: Section 3.1 Amelioration of fear and stress; Section 3.2 Hormones supporting or hindering physiological birth including two subthemes Sensuality and comfort (3.2.1) and Blue light avoidance (3.2.2); Section 3.3 Ambient spatiality and mood; Section 3.4 Felt esthetics; and Section 3.5 Spiritual experience.

3.1 | Amelioration of fear and stress

In their 2013 paper, “Designing out the Fear Cascade to increase the likelihood of normal birth,” Maree Stenglin and Maralyn Foureur discussed the fear that arises as women in labor enter the hospital setting.²⁶ They suggested the conceptual duo of “Bound” space and “Unbound” space as a way of understanding the spatial needs of birthing women. (Note: “Bound” and “Unbound” are capitalized in their text.) They identified three crucial points in the woman’s journey: (1) admission to hospital; (2) early labor; and (3) moment of birth. Key points include (1) comforting, private “Bound” spaces are valuable at admission; (2) “Unbound” spaces are desirable during early labor; and (3) securely “Bound” spaces are needed for the intensely vulnerable time of late labor and giving birth. They suggested use of *warm* incandescent lighting and noted *temperature* as another strong comfort factor. *Bound spaces with warmth of color and comfortable texture* were advocated for the first spaces women enter and wait. It is worth mentioning that this concept can now be understood as backed up by scientific studies concerning impact of light on labor processes, as discussed below (in Section 3.2.2).³⁴

In 2008, Fahy, Foureur and Hastie had provided and discussed the term “Fear Cascade.” It names a situated cycle of events, a series of hormonal responses and medical interventions that typically follow the first embodied fear response *triggered and sustained by environmental factors*.⁴ (see Section 3.2.1 for discussion of oxytocin as a crucial hormone supporting labor and birth, easily undermined by environmental stressors.)

In a recent book chapter, Balabanoff elaborated a sense of the “inappropriate birthing body”—as a woman loses confidence in herself, and in her capacities to give birth—as created by the stressful hospital environment. Contributing factors include the *red emergency sign* at nighttime entry; the *bright hallway lighting*; a waiting room without privacy or *sensitive lighting/materiality*; the often *largely white, beige, or grey* maternity spaces; *lack of natural light* or view; the *glare of glossy floors*; the sounds and smells of the hospital environment.²⁷ Fear is now understood as a trigger that can make the birth

experience feel emotionally and physically *risky*, and thus potentially traumatic, for all involved. Light and color are involved as they have potential to be negative triggers or positive influences.

Aroua and Hussein’s study (as discussed above) showed that specific moments of uncertainty or unfamiliarity created stress peaks for a birthing woman. Color meanings were associated by birthing women with the spatial impressions these spikes documented, for example, white = medical = stress²³ (pp. 44 and 45). Lepori’s note (see¹⁶ and Section 1.3.1 above) to avoid colors that evoke medicalization, asepticity, and “surgery” are here corroborated, as a woman spoke of her stress in the blank/white corridor space, of not being able to forget she was in a hospital, and then of other colored spatial elements (blue and white tiles) that reminded her of home and calmed her.²³

The BUDSET tool for evaluating birth spaces, created and tested by Foureur et al, uses a checklist divided into thematic sections, which can be filled in by individual post-occupancy analysts to effectively document and score the birth unit.²⁸ BUDSET places light and color in an esthetics category, rather than the Fear Cascade section. But given ongoing research developments, it might be valuable to also include color and light in the Fear Cascade area (where plants, flowers and views to gardens or nature settings are included as elements offsetting fear and stress).

A study by Calida Bowden, Athena Sheehan and Maralyn Foureur utilizing visual semiotics considered the color of walls and the meanings given by position, size, and color of elements in birth room images. The authors noted that warm and cool colored walls, highly colored objects, and highlighted areas or features can contribute to perception of birth environments as either “technological,” “homelike,” or “hybrid,” and argued that these subliminal perceptions will have impact on physiological processes (production or suppression of birth hormones).²⁹

Ethnographic case studies of midwifery units in the United Kingdom that were trying to make a “different” kind of space from the stressful hospital setting, intending to create an atmosphere of calmness, showed use of wood and described a “balance of warm and cool accent colors,” paintings with pastoral scenes, and windows with views of nature. Images were provided, though no specific color analysis or verbal description of affect/effect was offered.³⁰

Recent studies also have explored the use of sensory enrichment as distraction useful to ameliorating stress and pain. Snoezelen rooms—multisensory rooms originally devised to increase enjoyment and sensory experience for those with intellectual disabilities—have been

experimentally used as labor rooms, testing their potential to distract women from pain and fear during labor. These spaces typically engage a variety of furnishings, sensory experiences, and colorful moving elements (rhythmic lights, aquarium fish, filmic images). One study from Australia noted the positive outcome that whatever birth results were, women were satisfied with their experience of handling their labor process in the Snoezelen room.³¹ Women's descriptions were vivid and offered impressions of the rhythms of light and the colored elements: "The fiber optics were there and in between contraction I was like 'oh wow that's pretty cool, I'll put them around me' so I had them over my belly, the contraction are like a wave and the colors were like a wave." "The fish were so peaceful, just like blobbing along like nothing was wrong, it kind of mesmerized me a bit cause I wasn't relaxed and looking at something so relaxed helped me to relax." "The fish tank and there [... were] colored lights on the wall as well, they were on, and there was a disco light as well. It was very, very calming." The authors identified six key themes highlighting what the Snoezelen environment could offer: (1) distraction; (2) relaxation; (3) comfort; (4) environmental control; (5) choice of complementary therapies; and (6) safety in a non-clinical atmosphere³¹ (p. 464).

Two randomized trials in Iran have been conducted on Snoezelen use in labor spaces. One trial studied length of labor and ratings of pain intensity in first-time mothers using a Snoezelen room. The researchers found that both labor length and pain were significantly and positively impacted by laboring in the Snoezelen space. They concluded that the study corroborated other studies that had shown that multi-sensory rooms provided fear and pain amelioration, as impacted by endorphin production (relaxation).³² In another recent study, findings showed that fear, anxiety and satisfaction were impacted positively and significantly by labor and birth in Snoezelen Rooms.³³

It is clear that fear amelioration is a significant aspect of birth environment design, related to creating calming and distracting spatial settings. In these studies, color and light have been shown to be quite effective in entry spaces as well as labor room settings in ameliorating fear and anxiety.

3.2 | Hormones supporting or hindering physiological birth

Two sub-themes below discuss color and light as supporting or hindering the hormones that trigger and sustain normal labor processes: (1) Sensuality and Comfort; and (2) Blue Light Avoidance.

3.2.1 | Hormones: Subtheme 1: Sensuality and comfort

Support for normal physiological birth has been at the core of the discourse about creating better birth environments for many years. The neurohormone oxytocin, secreted by the endocrine system and related to love, sex, intimacy, comfort, comforting, connection, and bonding, has been often invoked. Michel Odent³⁴ and Kerstin and Uvnäs-Moberg^{35,36} have spoken of oxytocin as the "hormone of love," as all from sperm/egg connection to sexual stimulation are within its realm of influence.

The antidote to oxytocin, adrenalin, is known as the stress hormone, the "fight or flight" hormone. Sarah Buckley's executive summary of hormonal activities during labor and birth has stated³⁷: (n.p.) [emphasis added]

When the body produces adrenalin, oxytocin production shuts down, and labor slows or stops. In labor, anxiety or situations in which the woman does not feel private, safe, and undisturbed may provoke epinephrine-norepinephrine elevations, which may slow or stall labor and reduce fetal blood supply via epinephrine-norepinephrine effects. Stress may also slow labor by reducing pulsatile oxytocin and/or by increasing beta-endorphins.

Further, she notes:

Laboring women may experience excessive stress in relation to their maternity care providers and birth environments (e.g., if not familiar, calm, and private), which may increase beta-endorphins to supraphysiologic levels and slow labor.

Buckley states that high quality studies are needed "in relation to physiologic aspects of labor stress, and methods for ameliorating this." She suggests "attention to emotional well-being may promote labor progress" (p. 151). Significant cues for birth space design are confirmed in her summary by the specific mention of environments and care that support low-stress, privacy and undisturbed labor, and feelings of safety, familiarity, and calm. Yet the focus here is solely on the body and the woman's emotions, without linking them to environmental influence.

Uvnäs-Moberg (and Uvnäs-Moberg et al) by contrast, have discussed that oxytocin production can be stimulated by *warm low lighting*, for example, *candlelight*; sensual and sexual touch and pleasure; *ambient and physical*

sensations of warmth and softness; natural materials; relaxing views of nature, water, sky; calming music/sounds and aromas; pleasant mental experiences.^{35,36} It is worth noting that all of the italicized elements (my emphasis) are recognizably related to color, that is, we mentally associate them with color images and sensations created by light and materiality.

An early proponent of understanding oxytocin as related to birth environment, Odent³⁴ called attention to studies by Newton et al³⁸ documenting the negative impact of environmental stressors on birthing mice and their pups. Researchers tested fouling nests with cat urine, disturbing and moving mice mid-birth, and setting laboring mice in *brightly lit glass bowls*—all causing delayed and troubled labor and poor birth outcomes.

Odent has highlighted the need for *darkness* as an aspect of privacy/security, linked to feelings of safety: “one does not feel so observed in the dark. Most female mammals try to find a dim corner...”³⁴ (p. 17). He offered strong notes about the role of environmental light and darkness for birth hormones and processes:

Light, too, is a well-known stimulus to the neocortex. The sense of sight is the most intellectual of our senses. From this one can deduce the special importance of darkness during human labor [...]. Since human beings are characterized by the huge development of their neocortex – the part of the brain that inhibits the instinctive, involuntary processes – we can begin to understand that darkness is probably even more important for the birth of humans than it is for the birth of other mammals. It is precisely this development of the neocortex that makes all instinctive human behavior so fragile, so dependent on environment. Of course, many people don't need a long explanation to convince them that closing the curtains tends to reinforce the feeling of privacy.³⁴ (p. 18)

Odent described the clinic he created in Pithiviers as moving toward a darker, more homely, non-clinical environment, one more conducive to undisturbed physiological birth³⁹ (pp. 1 and 2). Foureur and Stenglin (see Section 3.1 above concerning their fear amelioration concepts) provided notes on spatial sense and light levels that are relevant to this discussion:

High levels of illumination are likely to make an enclosed space feel more expansive or Unbound as light enhances our ability to perceive color, texture, pattern, depth, space,

and volume (Gardiner and Moloney, 2001) whereas dim lights create spaces that feel more contracted and Bound.²⁶ (p. 823)

As Buckley has articulated, there are other hormones including beta-endorphins that work in complex interactivity during pregnancy, labor and birth.³⁷ Further high-quality studies concerning color and light in birth spaces and as influential to hormone production would be valuable contributions to knowledge about birth environment impact.

3.2.2 | Hormones: Subtheme 2: Blue light avoidance

This review of the literature brought the hormone *melatonin* into focus as crucial to understanding how the *color of light* in birth environment design might impact birth physiology and thus birth experience. Melatonin has not yet appeared much within the birth hormone and birth environment discourse, but researchers are now seriously considering the role of *blue light*, which affects melatonin production, *as highly significant for labor and birth*.

This key finding from this literature review has arisen within pineal gland research.⁴⁰ Evidence from animal studies and human studies that *exposure to high intensity blue light will shut down labor contractions* exists, but is not widely shared. To clarify, it has been known and discussed for some time that nighttime melatonin production in humans (and other mammals) is affected by bright light, and particularly by short wave (blue and blue/green) light, which cuts off the melatonin production needed for sleep. Thus, most of us know that bluish screen light at night is problematic for our circadian system, impacting our overall wellbeing. But in the context of *birth*, study of melatonin has yielded scientific findings that have not yet been widely disseminated and yet are highly significant for design of labor and birth spaces.⁴¹ It is oxytocin, not melatonin, that has been typically discussed in relation to birth environment, that is, shutting down oxytocin will slow/stop labor. But studies indicate that melatonin *may itself be the birth trigger*, working in concert with oxytocin to start and sustain birth processes. Further, the presence of melatonin increases the efficacy of oxytocin significantly at the cellular level.⁴²

In a 2018 review of the literature on melatonin, the authors noted that melatonin is useful in counteracting pain and can reduce the dosage needed in anesthetic preparations. But even more significantly, the authors provided multiple sources for evidence that “bright lighting at nighttime peak melatonin secretion is suppressed, and this hinders the development of regular uterine

contractions”⁴³ (p. 207). Further, they note “...in connection with the use of artificial light at night, especially in hospitals, there is a tendency to reduce the frequency of births in the night, and the development of ...weakness of labor”⁴³ (p. 207). Thus, they state, the interest of researchers in this area over the last decade has increased:

...the physiological role of melatonin in the reproductive function has given sufficient evidence not only [of] chronotropic activity, but also a number of other pharmacologically valuable properties that determine the optimal course of pregnancy and childbirth, making a promising development of new approaches to its use in obstetrics. At the same time, existing data indicate the need for special attention to keeping in obstetric hospitals light conditions needed for the endogenous production of melatonin, as well as restrictions on the use of its suppressive drugs.”⁴³ (p. 207) [emphasis added]

This news is important for maternity unit design, as it highlights what birth environment design discussions have already flagged—that we need to address and reimagine the lighting in birth spaces—including all entry spaces and reception or waiting rooms/areas. Significantly, this information *runs counter to the widely held understanding that blues and greens should be utilized in birth spaces due to their calming effect*. To clarify, with low (warm) lighting on at night, a blue or green wall would not likely pose a threat to labor progress. But thinking of the trend towards colored LED lights and screen-based image projection as options within spatial design, one can easily imagine how these might provide the opposite of their desired impact—by actually *slowing down* or stopping birth processes. Pale green walls warmed by the sun might provide a positive feeling in a birth room, but ubiquitous or eye-level use of blue LED lighting (in the range of 450–480 nm) or high illuminance bluish white light (e.g., 10,000 lux) at night, in the birth space, or enroute to it, would specifically undermine physiological birth processes.

A recent Danish study⁴⁴ took up the question of impact of colored light, with apparent awareness of melatonin's impact on birth processes (discussed in the paper). The study used specific wavelength options for intentional effect. The five pre-set sensory programs were: arrival (red), relaxation (red-blue), breathing (blue), atmospheric (red-yellow), and white light. Users could slightly change the wavelength distribution among the available color sets. It should be noted that the use of

blue in the “breathing phase” was surprising considering the authors' citations of melatonin studies by Olcese et al and Olcese and Beesley.^{41,42} The researchers set the average irradiance and illuminance level in the standard delivery room much higher than in the sensory delivery rooms: “standard room” (260 lx); “sensory delivery room” (83 lx). The study found that the caesarean delivery rate was significantly lower in a “sensory” room (6.4%) than in the standard room (10.7%). The authors noted that they did not see a difference in duration of labor, perhaps because they “did not record which light program was chosen, and for how long the sensory programs were applied during labor. Moreover, if the sensory programs were shut down for a period of time, or what time of day the birth took place – if it was night or day.” They noted that women and staff preferred the two sensory rooms.⁴⁴ (n.p.)

In a randomized trial Lorentzen et al⁴⁵ found little difference in clinical outcomes in a “sensory” room versus a “standard” room (here spectral levels were not specifically reported). They found that birthing in the specially designed physical birth environment did not lower augmentation of labor rates. Nor did it show significant difference in duration of labor, use of pharmacological pain relief, and chance of birthing without complications. But the authors stated that the “standard” room was already at a high standard, and suggested a randomized comparison of more disparate spaces would be valuable.

One further study related to melatonin and light showed that the concept of lighting impact during maternity care is growing. The research was post-natal, involving only mothers and infants with pre-planned caesarean section births, set in a hospital in Austria. A “dynamic lighting system” was tested to explore “non-visual” effects of fixed bright light levels in the morning, followed by personally adjustable lighting throughout the rest of the day. Implications for mothers and infants' cortical, endocrine, and circadian bodily systems were of interest, including potential impact for mood, alertness, and sleep. While some effect on the morning activity of infants was noted, the study did not have conclusive findings concerning impact on mothers, and the authors discussion of complicating variables confirmed the difficulty of studying spatial light and its psychophysiological effects.⁴⁶

Further studies with attention to methodologies that capture both scientific data and women's impressions/feelings are important to develop. As birthing rooms lean into the notion of “ambience” they evoke the trends toward new responsive, even circadian, lighting approaches, and towards “atmospheric” architecture/design, focused on how a space is “felt” and “understood”

by the mind, body and spirit, and how hormonal and physiological responses can be manipulated.

3.3 | Ambient spatiality and mood

Anthropologist Sheila Kitzinger's descriptions of traditional settings and homebirth experiences have highlighted the connection, during home birth, to familiar places and traditions. She has noted the temporal rhythm of life that is lost in the hospital setting: "...the rising and setting of the sun, changes in the weather, light streaming into the birth room, clouds gathering, frost and moonlight..."⁴⁷

Margaret McDonald's anthropological dissertation about midwives' cultural construction of nature in Ontario, Canada also offered many references to color and spatial desires, and impressions and feelings women utilized and remembered as part of their home birth experiences.⁴⁸ One interviewee said: "I used to say 'birth is not a pastel experience' because I hate this pastel idea of motherhood you know? It's purple and red and throbbing! It's very primal." And another stated:

Our shower curtain is a field of purple irises and that's what I kept thinking about...that image of them opening...I think it made me manage the pain better. It gave me something to think about. I'm a very visual person and I like purple and it gave me something to focus on...⁴⁸ (p. 268)

Mood is a key concept for supporting physiological processes of birth—and it is dynamic rather than static in relation to the time frame and phases of labor. Stenglin and Foureur stated that lighting is "critically important" and that light should be dimmable and changeable as needed for restful or more active moods.²⁶ They noted that color could support mood by stimulating with brighter colors or providing restfulness with subdued warmer tones. Closed or open spaces, smaller and larger spaces—these can be comforting or liberating at different times during the birth journey. Light, color, and darkness, and the capacity to control them, can impact sense of space and privacy, and are implicated in the moodedness of spatial settings.

As noted above, Balabanoff has gathered and compared the writings of Gibson and Merleau-Ponty on light, color and darkness as experienced by the mind-body¹⁷ (pp. 64–117). Merleau-Ponty noted that the sky, was not "'over there' but rather in me [...] I am this sky...my consciousness is saturated by this unlimited blue"¹¹ (p. 222). Gibson noted that colors are inseparable from surface

texture, and color-texture provides information about the composition of substance, important for survival, safety and wellbeing¹² (p. 131).

It seems clear that color, light and darkness have much to do with the moodedness or atmosphere of a space, whether it feels safe, friendly, threatening or calming. Atmosphere can support the birthing body by several means, including: (1) influencing hormones; (2) creating "sanctum space"; (3) suggesting flow, movement, energy; (4) offering empowerment, sensitivity, emotionality; (5) privileging intimacy and sensuality; or (6) opening us to or connecting us to the energy and poetics of our surroundings.

As noted earlier, Brandon Ro and Julio Bermudez,¹⁴ Gernot Böhme,¹⁰ Juhani Pallasmaa⁹ and Sarah Robinson and Pallasmaa¹³ are among authors who have discussed the ambient and embodied aspects of experience that architectural and spatial settings can evoke through diverse esthetic choices.

In a recent trial of an alternative birthing room in Sweden,⁴⁹ researchers found the three most strongly appreciated elements were: (1) the bathtub; (2) projected nature images on the walls; and (3) dimmable lighting. One participant said:

I think it [the room] made me a lot stronger during birth. It maybe sounds strange, but you are dependent on the surrounding environment. It influences you and the feeling of strength and safety (Participant 6). (p. 8)

The most requested missing physical feature was a window, providing access to fresh air, daylight and nature views outside the room. The ability to modify the room, including projected images, music, and lighting, was highly appreciated. The authors concluded:

The overall impression of the environment seems to be more important than individual physical features in birthing rooms, since the different physical features can reinforce one another and achieve a synergetic effect improving the women's experience of giving birth. (p. 12)

One is reminded of obstetrician Frédérick Leboyer's call for an overall mood of respectful quiet in the room, with lowered lighting, gentle skin-to-skin contact and a slowing down of our rhythms to attune ourselves to the infant's experience. This sensitive and quiet ambience within the birth room offered the newborn a peaceful, even blissful, entry and post-entry time of adjustment to its new world.⁵⁰

3.4 | Felt esthetics

Esthetics of the birth room are not simply cosmetic; they are deeply felt, influencing all who are within the space, nuanced by personal and social factors.

Newburn and Singh found that women felt that the environment could make it easier or more difficult to give birth.^{6,7}

Aburas et al studied the impact of screening nature images on a (small) television screen in the birth room but found little change in outcomes—perhaps due to scale and presentation issues.⁵¹ It is important to include users of these spaces in further analysis of color choices, needs, and desires, and such research projects are building this awareness.

Symon et al surveyed mothers and partners about their impressions of the environment. There were no specific inquiries on “esthetics,” though questions were ostensibly focused on the environment. Women scoring higher on “comfort questions” were more likely to have had a normal birth. “Comfort” can be understood as a felt condition, and is complex—more information about whether materials and colors were involved, and if and how they contributed to comfort would be useful. Partners were more negative about the environment, including temperature and smells. “Homelike” aspects were not described with any specific physical or atmospheric characteristics.⁵²

Harte et al’s video-ethnographic case study explored midwives’ experiences and feelings within an Australian hospital birth environment, using ethnographic and symbolic interactionist frameworks to thematically analyze gathered data.⁵³ Findings showed “sparse understanding or accommodation of supporters’ needs” in the built environment creating experience of “an unbelonging paradox”—of being needed, yet uncertain and “in the way” during “tenuous nest building” activities (pp. 136 and 141). The researchers noted that esthetics in the setting “strongly overlapped with occupants’ perception of ‘lack of control’ over the space” (p. 19). Supporters could not alter the setting to create a sense of belonging. The authors stated: “the capacity a space has “to be made familiar” or “to be personalised” emerged as an important criterion in the development of design guidelines [...]” (p. 12).

Interviewees spoke of the need for more esthetically pleasing colors in the room, pleasant images, positive distracters, adjustable light, windows, control of daylight, and more lighting choices, along with dimmers for comfort. Lack of art was deemed to contribute to unappealing esthetics and a clinical feel. A supporter interpreted the space as cold:

It’s the colour, that grey or white, it’s so cold. Maybe some murals or something...paintings...or pictures of a baby on the wall...a beautiful piece of sketching or something of a baby...or stars or the moon, or nature, that sort of thing [would make the space more appealing].⁵³ (p. 148)

A midwife described her feelings about the unappealing esthetics:

The white walls and the grey furniture...now I’m so used to it, I don’t think about it but I’m sure the women [and presumably the supporters] get that sense [of discomfort] as soon as they walk in. (p. 248)

A supporter noted: “I prefer it dim...sometimes the lighting is really harsh...that was harsh, that spotlight.” (p. 22) Another also spoke of the harsh light:

A dimmer in the bathroom would have been good...because you couldn’t have the light on. It was too uncomfortable. You just had to rely on the light from the window or from the other room.⁵³ (p. 148)

These gathered insights from birth supporters clearly show that color and light are esthetic elements in the birth environment that noticeably and directly influence how one feels. It is worth noting that the absence of positive elements created its own deeply felt emotional response.

Bowden, Sheehan and Foureur gathered images of birth spaces, analyzed visual semiotics, and described how colors and surface textures in these images conveyed *meanings*, for example, “hygienic, easy to clean, medically functional.”²⁹ Only 27.5% of images offered *desirable* “notions of domesticity and naturalness of birth” (the example showed a double bed to one side, and *soft lighting, warm-colored walls, wood grain*)²⁹ (p. 74). Their study reminds us that within flat pictorial images we can still *feel* the qualities of spatial settings through the forms, materials, colors and textures that convey messages to the mind-body. We can feel their absence as well as their presence.

Nicoletta Setola et al provided a comprehensive review of diverse aspects of birth environments seeking to report how they impacted rates of medical intervention.⁸ The authors noted:

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. (p. 69)

Thus, the search moved to exploring how characteristics of the space *influence inhabitants' behaviors, experiences, practices*:

[...T]he 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. (p. 69)

Their extensive chart provided details of how various architectural characteristics have influence. Many comments on color and light were included, for example: white and brighter colors stimulate the neocortex *inhibiting birth physiology*; white, cream, pale blue and green colors contribute to a *clinical feeling and promote passivity (lying down on bed)*; warm tones of more subdued hue, and soft light create a *restful relaxing mood*; natural materials and soft textures *feel more domestic; friendly* birth rooms use color, lighting and texture to create *warmth*. [my italics]⁸ (pp. 76–82).

In another study, Setola et al explored how key concepts in Antonovsky's Salutogenesis theory—manageability, comprehensibility and meaningfulness—could be translated into practical application in birth spaces. A description of the first hospital environment in Italy to utilize a colorful environment was given:

[...]“Homelike maternity centres” started in 1984 with the creation of “the natural birth room” in the small remote hospital of Poggibonsi in Tuscany [offering] for the first time in a hospital an intimate, comfortable and colorful environment with a double bed, pillows and a small pool. In this room the woman could give birth and then stay together with the newborn and family. This model was groundbreaking for the time.⁵⁴ (p. 698)

The researchers noted that the contemporary hospital labor ward layout has been habitually laid out in a rectangular grid, and thus has had little access to natural daylight, and the impact on staff is now being noticed. Among the factors noted in the two case study examples were connection to garden, green space, nature, natural light, skylights, intimacy, and private ambience. All of

these are felt esthetic elements of the surrounding environment, evoking sensations of color, light and darkness in our mind's eye and our bodies.⁵⁴

In 2006, a study of color design and lighting in twenty general hospitals across England was published.⁵⁵ The authors noted the value of color and appropriate light, ranging from: wayfinding; recovery rates; improvement of overall experience and wellbeing of patients, staff and visitors; and “powerful tools for coding, navigation and wayfinding” (p. 344). While this may still be the most comprehensive and useful inventory and explanation of actual and potential color and light design in hospital settings, there was, in this paper, a dearth of information on color for maternity units. One comment noted that some specific rules were in place due to “clinical requirements”: “...yellow for example is not recommended for premature baby units as the nurses need to detect early signs of jaundice” (p. 352). This was an interesting observation, but could be a questionable directive, as *any* strong color would potentially be problematic, and lighting composition including color rendering index would likely be the most important factor. Thus, the literature on color, if providing too simple a directive, can create lasting statements which require revisiting and new analysis.

In this review, an image showing a high intensity orange in a hallway was captioned in this way:

Orange was considered to be a suitably powerful and energetic color for this maternity unit; successfully used here with a contrasting harmony of purple. An overpowering hue such as this may be difficult to endure for any length of time.⁵⁵ (p. 353)

Mention of “energetic” color in maternity wards was repeated in this paper, but there was no mention of privacy and intimacy. Indeed, the lack of attention to privacy and intimacy is noticeable not only in the literature, but in the paradigm and reality of most designed birth settings across the globe. And yet as Gibson and Odent have particularly noted, privacy is strongly related to spatial darkness, and to feelings of protection and security (seeing the world outside, but not being seen).

In a 2016 study, on “domesticity” and birth experience, the researchers state:

Consciously or unconsciously, we respond or react to every space we encounter through our emotions, translated into a complex array of neuro-hormones that flood our brain and body, altering our physiology and influencing behaviour; women, their

supporters and health care providers alike.⁵⁶ (p. 45)

In regard to a photo of a room with soft furnishings, color and wood effects applied to the feature wall and cupboards, they comment:

The overall effect, when arranged like this, could be described as relatively pleasant or benign. However once a woman was occupying the space the soft furnishing seemed to disappear or be overwhelmed by the use of [medical] equipment.⁵⁶ (p. 40)

In the five hospital birth spaces they analyzed, “none of the rooms had dimmable lights, lighting was fluorescent, and none had air-conditioning controls,” and there was a “large number of electrical “red” PowerPoints and access points for medical gases.” Contributing to the clinical nature of the space were room numbering, large clocks, white hard cold surfaces in bathrooms, no privacy screen for toilet. “The use of white, chrome, plastic and bin liners created a sterile looking space that was quite devoid of any sense of the personal or intimate nature of birth”⁵⁶ (p. 40).

Interviewing woman who had given birth in an alternative delivery room “inspired by the principles of healing architecture and Snoezelen” researchers noted that ultimately individuals used and perceived the esthetic elements in their own ways⁵⁷ (p. 41).

In general, the warm, dimmed light in the room contributed to the women’s sense of comfort and being in a safe environment. Overall, they used and perceived the light and the distractions very differently.

Thus, we can see that there is extensive awareness that environmental esthetics are not purely visual, they are an interwoven layering of felt perceptions, made up of associations and meanings that materials, forms, colors, and light induce in us—creating feelings as complex as “belonging” and “home” and “safe” and as hostile as “sterile” and “lack of the personal or intimate.”

3.5 | Spiritual experience

The spiritual nature of birth experience is a less discussed topic, and yet as Lepori’s comments (see Section 1.3.1), remind us, the existential nature of birth—the powerful human experience of bringing a new life into the world—is profoundly meaningful, and can be addressed

and augmented through architectural expression.¹⁶ The clinical nature of birth spaces holds its focus on risk and medical practices, leaving emotion and spirituality out of the equation. Nightingale’s comments (see Section 1.3.3) about color so positively influencing the spirit of patients remind us of the inherent value of color in salutogenic architecture, but also of the spiritual dimension of wellbeing.¹⁸

Susan Crowther and Jenny Hall have discussed the contemporary discomfort with the term “spirituality” in discussion of birth, and note that definitions of spirituality related to birth often have focused on cognitive and psychological meanings, neglecting an embodied and spatial view.⁵⁸

It is self-evident within the history of architecture that in places with a spiritual atmosphere, color, light and darkness play a powerful role. Mindfulness, an approach to self-awareness and attunement that has recently provided a link between spiritual ways of knowing and the fields of neuroscience and architecture, has been taken up in birth discourse. A chapter on mindful birth space by co-authors Balabanoff and Foureur discusses the influence of birth spaces on the mind, body and spirit, and the embodied experience of birth.⁵⁹ “Each space and place of birth has not only a particular physicality composed of volumes, voids, materials, but its own ethereal resonance – made up of areas or vistas of light, colour, darkness, and of sounds and smells. Each space affords or inhibits movement; connects to or denies sunlight, vistas, and outside air. A mindful birth environment curates and balances the complexities of its environment to allow a focus on being in the moment, deeply aware of the power and beauty of birth.”

In a study considering the role of the birth environment, Japanese midwives spoke of warm room temperature as supporting labor progress. They point to the absence of traditional knowledge concerning mind/body balance in medical approaches, and thus the necessity of “validation” that may stand in the way of its use.

It has been suggested that the origin of this thinking may lie in the yin and yang of Chinese–Japanese medicine. Currently, midwives in Japan study midwifery and nursing based on Western medicine. However, midwifery homes that cannot use medication or medical technology sometimes use Chinese medicine concepts of maintaining the whole body balance for health (Sun et al., 2013) and various types of folk remedies. As evidence for complementary and alternative medicine including “warmth” is often

lacking, validation of its effects is necessary.⁶⁰ (p 882)

As traditional knowledge that takes a more holistic understanding of the relationships between inner and outer being may be dismissed in the medical model of birth, so approaches to the environment that offer poetic and emotive embodied experiences of birth are also undervalued.

In a paper discussing an international cooperative inquiry on spirituality and birth (led by Crowther and Hall) the participants concurred that “[a] sanctuary space is important for spiritual experience”⁶¹ (p. e143). They commented: “So much has been written about how women need to “go inside themselves” [...] a cold, clinical environment is not conducive to that”; (p. e138) “[...]birth spaces that empower holistic care support the physical, emotional and spiritual experience of birth, offering women feelings of deep safety and rightness” (p. e143). In discussing the moodedness and atmosphere of birth space, a co-researcher commented:

I am reminded yet again how shapes, images, colours, sounds and lights of birthing spaces can invite calm and bring us to a feeling of “rightness” or conversely bring feelings of being agitated, fearful and “harshness.” (p. e143)

The development of “birth territory” theory and practice included architect Bianca Lepori’s aforementioned concepts of birth spaces that spoke of accommodating the “moving, feeling and dreaming body”⁴ (pp. 96–101). Lepori’s architectural ideas showed a strong interest in how the spatial setting connects with the birthing woman’s deeply personal spirituality. The ancient Vedic Chakras, which comprise a color-coded system for understanding the energy and synergy of the mind-body, was mentioned in the concluding guidelines section of the Birth Territory text. “Careful coloring” of walls, furniture and linens was suggested, with reference to a Chakras chart.⁴

Ancient spiritual knowledge and ways of knowing are understood as valuable within transdisciplinary approaches that seek working across and beyond the disciplines. Indigenous and other cultural traditions of light and color use in birth spaces would be valuable additions to this knowledge base.

The notion of the architectural setting as a “grounding” for spiritual experience of birth seems important, as it points to an architecture that is something more than a “relaxing” space. Across the ages architecture from all cultures has provided special places that evoke awe,

wonder, beauty, depth, and contemplative being. MacDonald recounted a story told by an interviewed midwife of a woman who wanted to move to a different home location to give birth, and who was struggling with a breech position baby:

...when we walk in the door I say to myself “I would really love to have a baby in this room too.” The view overlooked all of Penatanguishene Harbour and this huge willow tree and the sun was coming up and I thought “This is why. It’s the light. It’s the feeling of the room.” And she promptly turned that baby as soon as she got into that room. And she got really moving with the rhythm [of her contractions]. So it was the room. There was something... “That would turn a baby?” I ask. That would turn a baby! It worked for her. She had been working on that posterior baby and as soon as she got over to that room she just went: ahhhhhhh.⁴⁸ (p. 251)

This narrative points to the importance of architecture that connects us to the awe and power of nature, and brings us to a deeper sense of belonging and meaning. Color and light are involved in these feelings that influence our minds and bodies as felt immersive and soulful experience.

Ro and Bermudez, investigating how beauty and esthetics of architecture can be scientifically studied and explained, asked survey participants if they remembered any “extraordinary architectural experiences” (EAE) occurring at some time in their life.¹⁴ They analyzed results of the narrative responses, and noted:

As a whole, “emotional” responses (i.e., feelings, moods, and strong body reactions due to emotion) and “physical” experiences (i.e., sensations and impressions) are present in a large majority of the written narratives. Unsurprising, a chi-square test revealed a statistically significant association between stories with “emotional” content and those with “physical” sensations... nearly three-fourths (74%) of the authors reporting sensual/perceptual/physical qualities as the most important characteristic of EAE’s.¹⁴ (p. 26)

87% described their EAE as “introspective and/or silent.” 92.7% said they experienced a “higher level of awareness than normal.” The adjectives “intense,”

“profound,” and “vivid” all were rated at over 80%. EAE's also were strongly vivid in memory (63.5%). The study had a strong methodology focused on replicability/reliability, and offers a striking model for testing environmental/architectural affect/effect.

Related to spirituality, the 718 respondents reported... that their EAE resulted in insight (55.7%), beauty (47.0%), joy (43.2%), peace (40.7%), and knowledge (31.9%), arguably all components of a spiritual experience of architecture that transforms human understanding...¹⁴ (p. 26)

Though not specifically about birth environment or color, this research project by Ro and Bermudez demonstrated that we can effectively develop evidence about the ways in which architecture engages us emotively and spiritually. Color and light are not specifically described here, but they are certainly two environmental factors well-known to contribute to our emotionality and spirituality in both interior and exterior spaces.

Aroua and Faten, *who provided the most direct and specific color study on birth environments found by this review* (see Section 2.3), pointed to these existentially meaningful qualities. A woman in their study said: “Yellow is a brilliant and happier color, the color of the sun, of joy; it makes the room shine.” Another woman said: “The spaces are good enough...apart from the delivery room. It is grey and austere. It depressed my husband too.” One could interpret these comments as psychological, but they were also indicative of a spiritual sense of being and feeling that is important to consider as designers, and that too often is unspoken, or not valued within contemporary modes of evidence-based research and practice²³ (p. 42).

Balabanoff (2016) wrote:

...the design approaches we choose to utilise for reimagining birthspace should be concerned with both deeply felt orientation and sensitive empowerment of action...and light can play an important role in providing these. Movement, situated agency, a sense of belonging, temporal experience, the body, and sense of place and light are inseparably interwoven⁶² (p. 19)

Balabanoff previously mentioned doctoral work (2017) showed, through use of many images, that the architectural experience of color and light can provide the embodied emotional resonance that sensitive and empowering birth spaces could and should offer (see esp. pp. 130–168 and 184–227).¹⁷ In a 2019 paper delivered to

the Architecture, Culture, and Spirituality Forum (ACSF) Balabanoff wrote:

Light thus emerged through my studies as an aspect of birth environment design that was not yet adequately valued, though it seems obvious. Whether seeing sunrise or sunset, a blue sky or a cloudy or stormy one, there is a connection to cosmos that is given by natural light and its constancy but ever-changingness. But there is also an emotional resonance given by the tremendous range of light-color-darkness, both physical and ephemeral. Providing a view out returns one to the universal – sky, garden, birds, clouds, and the cyclical nature of life – seasons, storms, blossomings, water flowing, the world quickening in spring, the ripeness of summer fruit, the austere beauty of winter. Everywhere, these associations are different, but similar. The threshold between inside and out can mediate and make manifest the aliveness caused by the passage of the sun or moon through the day or night. Thus a window is more than a view, it lets light in all its powers engage our embodied senses. Birth centers and birth rooms could and should provide these affordances for pleasure, sensuality, flow, exhilaration, joy, aliveness.⁶³ (p. 4)

As noted earlier, in anthropologist Sheila Kitzinger's writings on birth, color, light, beauty and spiritual energy were often present. Many examples were given of diverse cultures' birth rituals and practices with descriptions of their connection to aliveness, cosmos and color. Kitzinger noted that Indigenous women's birth practices have traditionally been situated in their surrounding environments, which are sometimes purpose-built. Phrases from her text are evocative: “constructing her own hut,” “women's bath house,” “a familiar place,” “grandmother's hut,” “the safest place,” “special hut,” “a hole in the roof,” “focus on a bit of the sky,” “counting the stars,” “dim light,” “the coming of the soul,” “darkness,” “spiritual energy,” “hut where the waves met the seashore,” “decorated with beautiful objects and wood carvings,” “maintaining contact with the heavens,” “what the baby first sees must be beautiful,” and “cormorant feathers for thatch”⁴⁷ (pp. 170–172).

4 | CONCLUSIONS

The literature shows that *we do know* that the *esthetic resonance of the birth environment is important to birthing*

women, and to birth processes, but is undervalued in the medicalized approach to birth. It is clear that color decisions and influences will impact caregivers and supporters, and thus affect the quality of care within a birth setting. Light and lighting have a major role to play concerning supporting or undermining birth processes. Warmth and softness rather than coldness and starkness are understood as desired qualities of birth spaces and experiences. The *quality* of what we know concerning the impact of the birth environment on birth itself is growing. Diverse ways of verifying desired and valuable attributes are developing. But it is clear that further research on environmental color and light related to maternity needs must now be carefully designed to offer insight which is neither too prescriptive nor too vague. Case studies showcasing details concerning color and lighting design and collecting data on user experience are needed, to aid those who require further evidence on why we should include various elements in birth environment design.

A key finding of this review is the negative impact on labor progress from use of blue light and high illumination levels. It should be noted that while scientific knowledge is growing, dissemination of vital information across disciplinary boundaries is problematic and inadequate. Many who are knowledgeable about birth have not yet heard of the impact that bright and/or strong blue light has in shutting down melatonin, thus seriously and negatively impacting labor contractions. This is a strong example of the need for deeper study of the potency of color, light and darkness within birth environment design, and the need for linking relevant new knowledge across the disciplines to maternity facilities managers, designers, and care practitioners, as well as to birthing women and their families.

This review was limited initially to seeking published research with a focus on birth environment *and* color. Further inclusion of research related to birth physiology and birth experience yielded additional studies with relevance to birth environment design. Future additions to this basic gathering of knowledge could seek more general studies on the psychophysiological impact of environmental color, searching for existing knowledge relevant for maternity spaces.

In particular:

- Mixed methods *combining physiological response correlated closely with user insights* could provide valuable new corroboration/evidence concerning color/light in birth spaces.
- Future research acknowledging indigenous and traditional cultural knowledges can provide needed attention to how the birth environment can embody

cultural and spiritual traditions, and how it could better foster respect and dignity for all involved.

- Color and light need to be studied together, for development of articulate guidance for birth environment design that can foster better birth processes, experience and outcomes.

More work on this important topic area is not only useful, but is crucial, considering the sheer numbers of human beings it can influence positively, across all continents and levels of socioeconomic development.

AUTHOR CONTRIBUTION

Doreen Balabanoff: Investigation, Writing, Reviewing, Editing.

ACKNOWLEDGMENTS

The author wishes to acknowledge the Social Sciences and Humanities Research Council of Canada for two grants supporting Transformational Change for Birth Environment Design, the overarching research project within which this review belongs. The author thanks research colleagues J. Davis Harte, Elizabeth Newnham, and Nicoletta Setola for their ongoing dedication to this work, and their great collaborative spirit and capacity. And I am very grateful to the Study Group on Environmental Color Design (ECD) of the International Color Association (AIC), for continuing to remind me that environmental color is a topic that has been—and continues to be—explored, studied, discussed amongst a global coterie of dedicated observers, scholars, designers, and artists. I also wish to particularly thank long-time ECD chair Verena M. Schindler for her deep commitment to sharing environmental color knowledge, and her editorial skills in helping to shape not only this article, but I'm sure many others' contributions to this field. With her leadership and guidance, many have learned that they can contribute to knowledge and understanding about the meaning and value color provides to us, in both built and natural environments.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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How to cite this article: Balabanoff D. Color, light, and birth space design: An integrative review. *Color Res Appl.* 2023;1-20. doi:10.1002/col.22842