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With advancements in technology and practices in the medical field, there has been an upward trend toward outpatient services in the last decade. This shift has also been driven by the cost of services, patient preferences, and government incentives (*Growth in Outpatient Care,* 2018). A few types of outpatient facilities are, but are not limited to surgical centers, urgent care, imaging centers, general outpatient, and physical therapy centers.

Additionally, healthcare in the United States of America is one of the most lucrative industries within our great nation. According to the Centers for Medicare And Medicaid Services, 19.7 percent of the United States Gross Domestic Product (GDP) in 2020 and projected to represent 30 percent of the GDP by the year 2030 (REIS, 2023). Furthermore, investor-owned and for-profit healthcare organizations dominate this industry which has caused rapid growth in the last 20 years. With this being such a lucrative industry that is predominately for-profit, it has brought forth a new set of challenges, such as the overall interest, values, ideals, and practices of these organizations (Health Care & Gray, 1986).

The aim of this study is not to dismiss outpatient services but rather to investigate design flaws within outpatient surgical centers that may have been overlooked during the boom of this healthcare facility type. Outpatient services will continue to grow and evolve just as technology and research continue to advance. Therefore, the built environment that these services take place in should also continue to advance towards a more patient-centered environment that cultivates healing.

# EXPLORATION OF LIGHTING CONTROLLABILITY:

# USING DESIGN SIMULATION IN PRE-OPERATING AND POST-OPERATING ROOMS

by

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in Partial Fulfillment
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Approved by

______________________________

Professor Travis L. Hicks
Committee Chair

## DEDICATION

I would like to dedicate this thesis to my family. I love each of you more than words can express. To my grandparents, Fred and Elaine Schuermann, thank you for making this endeavor possible and urging me to the finish line. You both have supported and pushed each of your grandchildren to understand and value the importance of an excellent education. To my parents, Michael and Cheryl Prillaman, thank you for always giving me the space and support to grow, pursue my dreams, and be unapologetically myself. You instilled the importance of effort, determination, and ‘making memories’, all of which I will carry throughout my lifetime. Thank you all for your unconditional love which has never gone unnoticed.

# APPROVAL PAGE

This thesis written by Caylin A. Prillaman has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair ______________________________ Professor Travis L. Hicks

Committee Member ______________________________ Dr. Lucinda K. Havenhand

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Date of Acceptance by Committee

November 15, 2023
Date of Final Oral Examination

## ACKNOWLEDGEMENTS

To begin, I would like to express my immeasurable gratitude to soccer. This sport gave me teammates, coaches, and support staff that helped shape me into the woman I am today. Through every roadblock and serendipitous moment, soccer was there. I am eternally grateful for all aspects soccer gifted to me and the person it helped shape me into.

I would like to recognize the Interior Architecture program and all those who have taught and steered me toward the completion of this thesis. To Professor Travis L. Hicks, my thesis chair, for your unwavering support throughout this long-winded process. Without you, and every other professor I have had along the way, I would not have had a successful career or achieved this prestigious degree.

In addition, I would like to thank the rest of my family as follows: Shirley Fink, Raymond Turney, Ashton Overby, Jackson Prillaman, and Logan Prillaman. Without your constant prayers, words of encouragement, and love, this achievement would never have been imaginable. Your sacrifices and support throughout my life have meant more to me than you will ever comprehend.

Lastly, I would like to extend my appreciation to my friends, Allison Penner, Christina Gregory, Emily Keilen, Jamie Phelps, Lauren Lucas, and Lauren Robeck. Your ubiquitous support throughout all my soccer highs and surgery lows is held in the utmost regard. Furthermore, your love and support have been a constant in my life even after we retired from athletics. I will continue to treasure each of you, as we move into the next phases of our lives.

Each of you is the reason I can pursue my dreams. It is with the knowledge of your unshakeable support that I continue to push on and know I am capable of anything.

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# CHAPTER I: INTRODUCTION

Healthcare in the United States has shifted in the last decade from hospital inpatient stays to outpatient visits. Despite population growth, an increase in elderly, and a sicker population, inpatient care steadily declined 6.6 percent over a decade. However, between 2005 and 2015, outpatient visits increased by 14 percent. Even more astonishing, the revenue of the hospital's outpatient services grew 45 percent in just 5 years (*Growth in Outpatient Care*, 2018). Refer to Figure 1 and Figure 2 for a visual representation of those percentages. With such a large shift from inpatient stays to outpatient visits, it begs the question, what is driving the shift in hospital services? This shift was driven by multiple variables. Healthcare practices improving, technological advances, and outpatient services tend to cost less than inpatient care. Furthermore, the research shows that hospitals that have higher quality and value incentives have more outpatient visits and revenue. While the researchers believed they would find a higher use of outpatient care, they did not find a lower use of inpatient care (*Growth in Outpatient Care*, 2018).

**Figure 1. Growth in Outpatient Care**

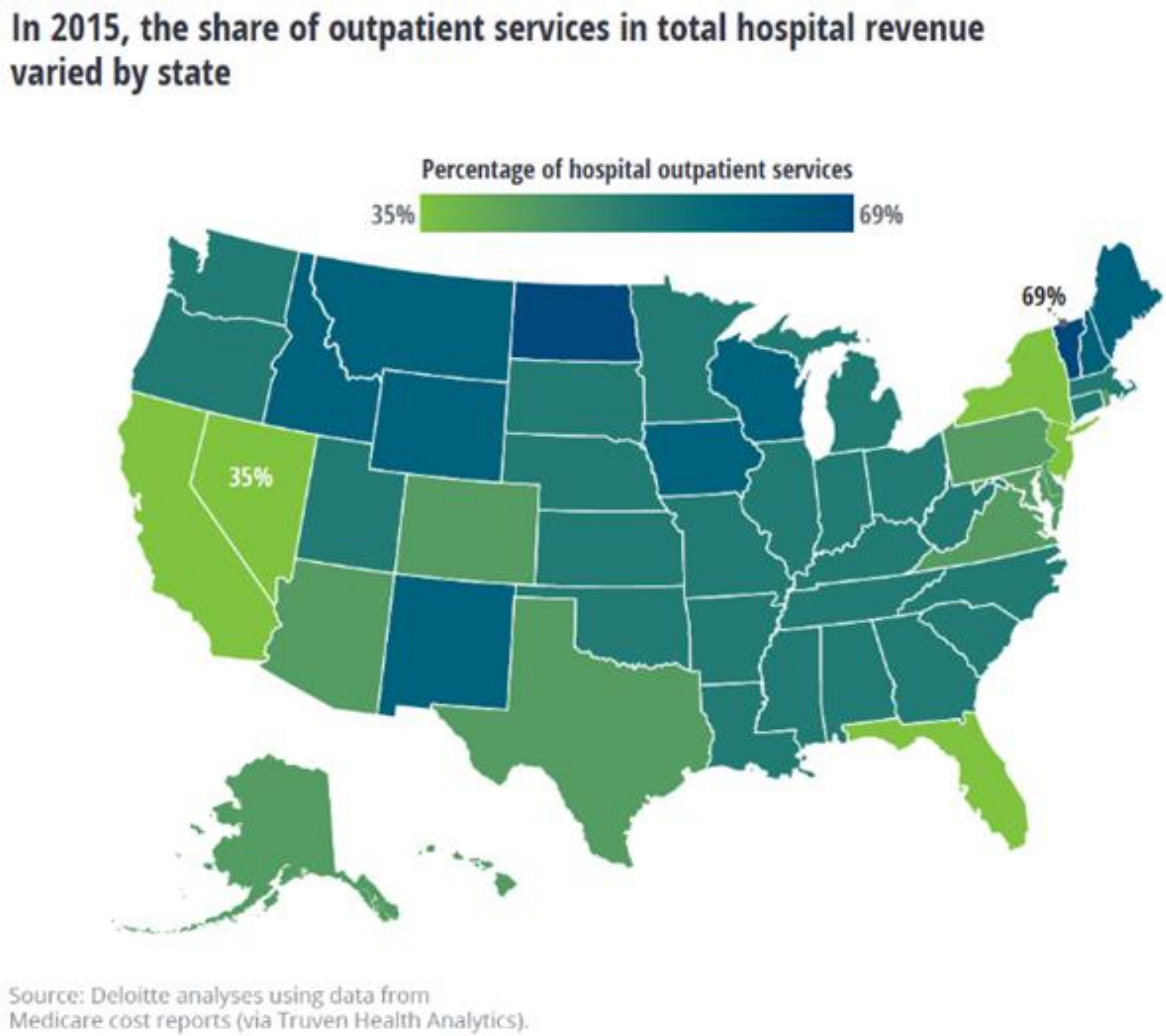
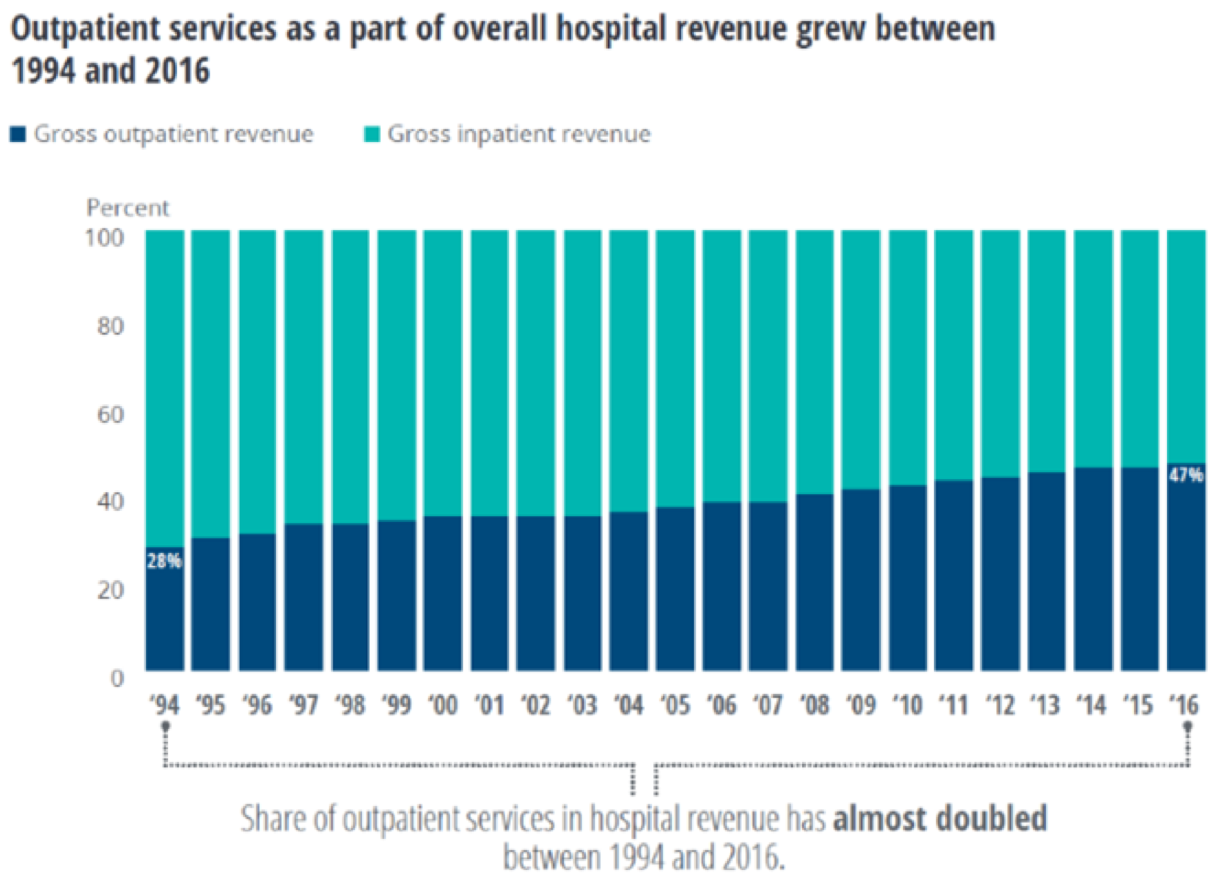


**Figure 2. Growth in Outpatient Care**



As the healthcare system continues to advance its practices and methods, it will continue to shift more and more of the services provided to outpatient facilities. When those procedures are only available in an outpatient setting, what will stop the healthcare system from slowly raising the rates to make a bigger profit? While one would imagine healthcare would have one goal, to do their best for the betterment of the patients, this is not always the case. Healthcare is a very lucrative industry. A lot of decisions and actions are for profit. In the past, the design of healthcare was focused on the workflows of physicians, with the patients viewed as individuals receiving care rather than active participants in their health and wellbeing. Since Roger Ulrich's "View through a Window" in 1984, the interest between design decisions and patient outcomes has grown. Presently, healthcare designers have continued to study this relationship and have begun designing patient-focused models (Guzzo Vickery et al., 2015). This is important because the healthcare industry tends to have a way of dehumanizing the environment.

**Outpatient Experience**

Auditory (hearing), kinesthetic (touch), visual (sight), gustatory (taste), and olfactory (smell) are the five basic human senses in which we as humans experience the world around us. While we use all five of these senses simultaneously, we as humans tend to rely heavily on one to register and take in the world around us, our vision. In outpatient surgical centers the direct downlighting in your eyes, the nurses and doctors, the medical equipment, and other patients anxiously awaiting their turn. Patients are in a chaotic situation with no control over their environment. The IES Lighting Handbook acknowledges that the main goal of the outpatient facility is the quality of care; however, the environment can be intimidating and daunting to patients. The patient room is of great interest when it comes to lighting and the tasks that must be performed in them. The light enhances the patient's experience in the space and should be planned to accommodate the variety of tasks that are required while also being efficient and comfortable. While a 2x4 indirect downlighting luminaire alone over the patient's bed could meet the illuminance criteria, this approach can feel institutional and dehumanizing (DiLaura et al., 2011). Furthermore, the lighting in patient and staff areas should provide a variety of lighting types and levels with the capability of individual control (*Guidelines for Design and Construction of Outpatient Facilities*, 2018).

Patients are submitting to the schedule of the healthcare facility. This feeling is addressed by Ahmed H. Sadek and Julie Willis as they see qualities that can improve ambulatory facilities and promote patient support. They acknowledge that when a patient is admitted to an outpatient facility, they often feel a sense of helplessness. Harnessing the environment and bringing in flexibility, can provide a sense of empowerment to the patients in what can be an uncontrollable situation (Sadek & Willis, 2020). Furthermore, Roger S. Ulrich says, "lack of control is a pervasive problem that increases stress and adversely affects wellness" (Ulrich, 1997, pg 100). With this empowerment in mind, where is there an opportunity to harness the built environment for the patients? Amid all the chaos there are only two spaces that a patient can call "their own" even for a short period, the pre-operative and post-operative room. There have been studies done on the controllability and flexibility of design elements in healthcare settings. However, the majority of research takes place in inpatient care and investigates the flexibility of furniture, lighting, and spatial layout. There have not been as many studies performed within the outpatient care environment. More specifically, those focused on lighting and other controllability within outpatient settings. While a well-lit space is important and necessary for doctors, nurses, and practitioners to perform their duties, it could have a negative effect on the patient's overall experience.

**Questions**

The purpose of this study was to take an existing outpatient surgical center and explore the possibilities of layering light and offering controllability to patients. The questions below were used as a framework for this study.

*How can the pre-operating and post-operating room be a more flexible environment that will not only empower patients but also enhance their experience through the controllability of lighting?*

*How would patients respond by having control over the lighting in their environment?*

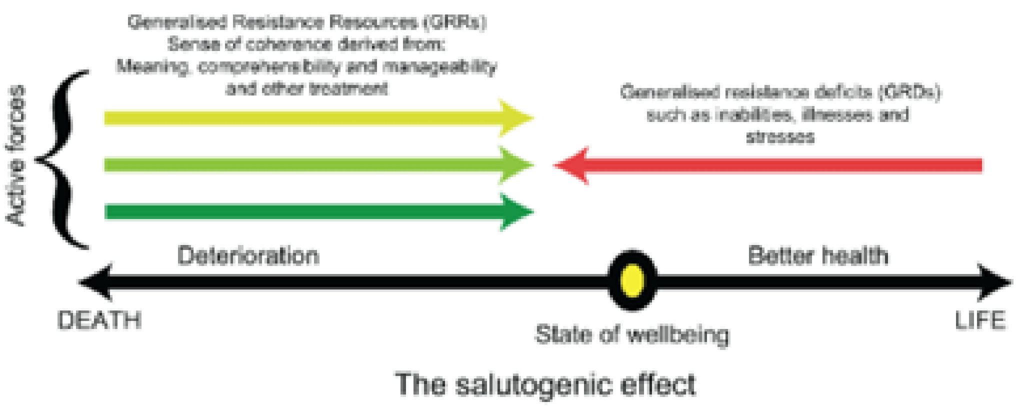
*What are some other design features that can be implemented to provide the patient with more control?*

CHAPTER II: RESEARCH

**Theory of Salutogenic Environments**

The salutogenic model was developed in 1977 by Aaron Antonovsky, as seen in Figure 3, who rejected the traditional notion that health and illness are separate things. Antonovsky saw health and illness as a continuous variable. He designed the salutogenic model to further "understanding of relationships between stressors, coping and health, with the aim of explaining how some individuals remain healthy despite stressors in their everyday life" (*Issues in Complementary and Alternative Medicine*, n.d.). Later, in 1995, Judith Heerwagen and others took the salutogenic model and turned it into the theory of salutogenesis and applied it to the work environment (Heerwagen et al., 1995). Similar to Ulrich's work, the Theory of Salutogenic Environments emphasizes not only social cohesion but also personal control and restoration relaxation in support of health and well-being (Sadek & Willis, 2020). This theory is used as an umbrella for the rest of my theoretical framework.

**Figure 3. The Salutogenic Effect**




**Note:** The concept that a state of health or wellbeing is a point on a continuum is central to salutogenic theory. Forces that support better health are called generalised resistance resources. They include treatment and a sense of coherence. Illnesses, inabilities and other generalised resistance deficits work the other way
**Sources:** Author; Newman (1996); Searles (1965)

**Supportive Design Theory**

Roger S. Ulrich is a very influential evidence-based healthcare design researcher and is probably one of the most cited researchers in the world (*HCD Mag*, n.d.). With multiple theories and other groundbreaking research in healthcare design, it was impossible not to use his work. Supportive design theory is the way a designer can utilize the built environment to not only reduce stress but also provide a sense of control over the physical environment. Within this theory, Ulrich specifies three components of supportive design which are: a sense of control, social support, and positive distractions in physical environments. Each of these has been identified as a way to cope with stress and promote wellness. His successive investigations of responses to natural scenes and urban scenes revealed that nature is vital in healthcare environments (Ulrich, 1984).

**Biophilic Design**

As mentioned in the previous theory, natural elements are important when promoting wellness and reducing stress in healthcare environments. There is a plethora of research that even dates back to 1839 when the Lexicon Medicum mentioned, "the healing powers of nature" (Totaforti, 2018). Later in 1984, Edward O. Wilson introduced the biophilia hypothesis. With this hypothesis, he suggests that humans have an innate urge to associate with other forms of life (*Biophilia Hypothesis | Description, Nature, & Human Behavior*, n.d.). While the idea of natural elements affecting the healing process has always been relevant, the ways designers have implemented the idea have changed over time. According to Stephen R. Kellert, biophilia is defined as "the inherent human inclination to affiliate with natural systems and processes, especially life and life-like features of the nonhuman environment" (Kellert, Heerwagen, & Mador, 2008, p. 3).

Furthermore, Kellert explains that there are two basic dimensions of biophilic design. These can then be related to six biophilic design elements: Environmental features, natural shapes and forms, natural patterns and processes, light, and space, place-based relationships, and evolved human-nature relationships. Within the light and space design element, there are twelve attributes identified. Seven of these are focused on the quality of light while the remainder are focused on spatial relationships. The seven design attributes of light are as follows: natural light, filtered and diffused light, light and shadow, reflected light, light pools, warm light, and light as shape and form. Natural lighting includes the effects that daylighting has on humans along with a full color spectrum of natural light. Filtered and diffused light mitigates the effects of glare and provides a connection between indoor and outdoor spaces. Light and shadow create curiosity, and mystery, and can produce satisfaction within both interior and exterior spaces. Lighting design can be enhanced with the use of reflected light. The way the light reflects off of light-colored interior spaces resembles the way light reflects off of bodies of water. There are functional benefits such as reducing glare, penetrating light throughout the space, and results in the ability to see objects at a distance. Pools of light often draw people in and promote movement and wayfinding. For example, pools of light in a forest help guide you along your way. They can also provoke a sense of security and protection. Warm light that is surrounded by dark spaces often fosters an inviting interior. Lastly, is the manipulation of light as a shape or form. This creates stimulating, imaginative, and dynamic spaces that allow for exploration and pleasing aesthetics (Kellert, Heerwagen, & Mador, 2008). While these design attributes focus on natural light, these attributes can be reciprocated with artificial light and will aid in the redesign of the pre-operative and post-operative unit. Note, that the use of natural light in the pre-operative and post-operative units is an existing design feature of this particular building.

**Illuminating Engineering Society- The Lighting Handbook: Reference and Application**

The Illuminating Engineering Society (IES) recognizes the importance of lighting in everyday life and strives to educate designers, professionals, and scholars. Within their health care chapter, IES acknowledges that the application of light often focuses more on the caregiver’s performance than on the patient's comfort. While this is an important acknowledgment, they go on to introduce general guidelines, technical application processes, and design ideas for lighting that not only benefit the caregiver but also the patient. Some of the general guidelines suggested to carry out through the design are color, quality of light, germ and dust management, lighting controls, systems coordination, hazardous materials, medication, and medical equipment. They suggest that all lamps should display CRIs ≥ 82. Furthermore, in patient areas, the range of illuminance should be 23-92 foot-candles. Within this range, patients will be able to read or relax while physicians can provide quality care. The color temperature should range between 3,000k-4,500k. This means the color temperature will be a neutral white to a cool white. Lastly, they take a look at lighting controls by saying,

> To provide less intimidating settings for patients and more flexible viewing conditions for caregivers, many ambulatory care facilities should be fitted with multi-level switching, if not dimming, systems. (DiLaura et al., 2011, p. 27.35)

While this control of lighting does depend on the room size, the ambient lighting can be set to a three-level switching or dimming system that will still meet the needs of caregivers while providing the patients with the flexibility and control they seek in this environment. Access to the controls should not interfere with the overall quality of care. Therefore, the controls should be easily accessed and simple to operate (DiLaura et al., 2011). The application of controls will be covered later in this study.

**Literature Summary**

By first looking at the Theory of Salutogenic, we see that social cohesion, personal control, and restoration relaxation all work together to support health and well-being while coping with stressors. Following that, we have Supportive Design Theory by Roger Ulrich. He identifies three components of a supportive environment: a sense of control, social support, and positive distractions in the built environment. These positive distractions Ulrich talks about are all connected with nature and biophilic elements. Biophilia is quite broad with numerous elements, attributes, and features defined. One that I focused on was the light and space design element. Within that element, there are seven design attributes of light defined by Stephen Kellert.

With this information, one can see that controllability could be important in the overall health and well-being of the patients. Patients are not just receiving care but should be viewed as active participants in their care. By relinquishing some control over the environment, healthcare designers may be able to positively attune patient's emotions. Furthermore, this may humanize the healthcare industry. Not by taking away from the healthcare professionals but rather adding to the overall health and wellness of the patients who are receiving care.

Lastly, The Facilities Guidelines Institute (FGI) and Illuminating Engineering Society's (IES) handbooks are not theories but rather design guidelines and application techniques. FGI's guidelines are written by a diverse group made up of professionals, scholars, and researchers across many fields. They focus on lighting, acoustics, and overall space of the built environment and how it affects the users of the space. The IES lighting handbook is filled with general guidelines, application processes, and design ideas directly related to lighting within healthcare spaces. These books are vital as we move into the study design and methods section.

# CHAPTER III: STUDY DESIGN AND METHODS

## Study Design and Methods

This study uses a prototyping and design simulation approach to investigate lighting and individual control in the pre-operative and post-operative spaces. While design exploration has not always been thought of as research, Linda Groat and David Wang write in Architectural Research Methods (2013)

> …we argue that design and research constitute neither polar opposites nor equivalent domains of activity. Rather, the relationship between the two is far more nuanced, complementary, and robust. (Groat & Wang, 2013 p. 21)

In this research study, a design simulation through perspective and panoramic renderings was created to show the existing pre-operative and post-operative spaces and then the proposed changes that could be made to enhance the built environment for patients.

## Project Site

For this study, three existing surgical centers were evaluated to be used for this investigation. Those were Moses Cone Hospital, The Surgical Center of Greensboro, and Duke Ambulatory Center. These three sites were not chosen at random, but rather three spaces where the researcher had personally had outpatient surgery. After comparing the three sites, The Surgical Center of Greensboro was chosen for this study due to it being the most recently built.

The spaces used for this study are the pre-operative and post-operative units of the Surgical Center of Greensboro located at 705 Green Valley Rd., Greensboro, NC 27408 as seen in Figure 4. The site plan was obtained using Google Earth and using Adobe Illustrator to highlight the site in red. The site was designed by CJMW Architecture and built by Landmark

Builders, located in Winston-Salem, NC. The completion of the Surgical Center of Greensboro was in 2017. The construction documents for the site were obtained by Landmark Builders in the summer of 2020. The plans provided were the Building Shell Package and Interior Upfit, both designed and produced by CJMW Architecture.

**Figure 4. Surgical Center of Greensboro Site Plan**

**Level One: Existing Pre-Operating**

The figures below illustrate the existing level one floor plan, reflected ceiling plan, and existing renderings of the space. The pre-operative unit, located on level one plan west, is highlighted by greying out the ‘not in scope’ areas of the plan as seen in Figure 5 and Figure 6.

Figure 7 and Figure 8 show an enlarged floor plan and reflected ceiling plan of the pre-operative unit. Figure 9 further enlarges the reflected ceiling plan of the pre-operative unit. Figure 10 is an enlarged reflected ceiling plan of a pre-operative private room. Additionally, an elevation and section detail has been provided to better understand the ceiling conditions in Figure 11 and Figure 12.

Utilize Figure 13, Figure 14, Figure 15, Figure 16, and Figure 17 to explore the existing space and conditions three-dimensionally. All materials are existing to the space and were provided in the Interior Plans from Kim Givens at Landmark Builders.

Within the pre-operative unit, there are two types of patient spaces. One is a private pre-operation room that may not have access to daylighting unless on the plan west exterior wall. Second, there is an open bay-style pre-operative space plan north that has access to daylighting. This will become more apparent in the design simulation portion.

**Figure 5. LVL 1 Furniture Plan - Existing**

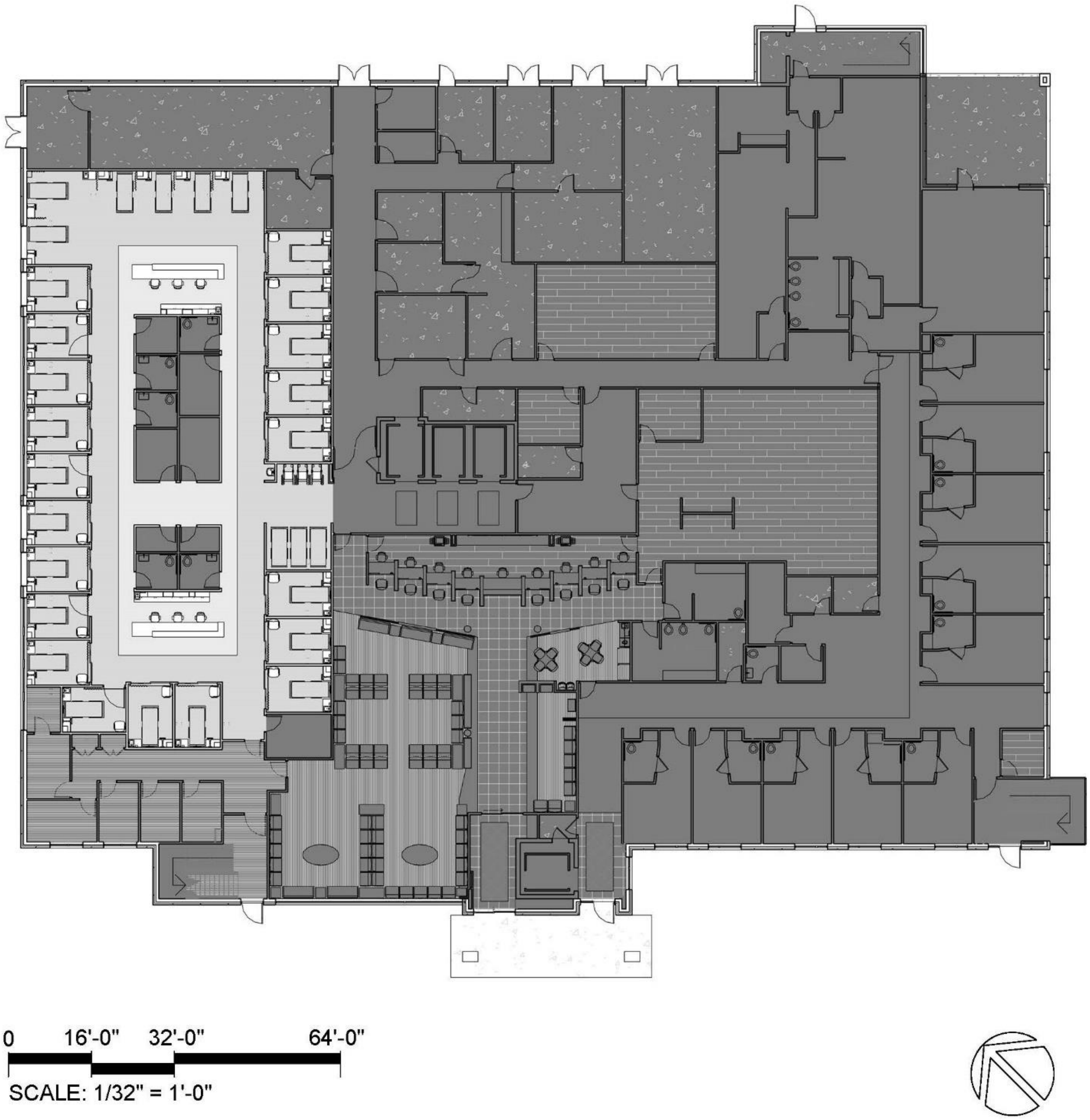


**Figure 6. LVL 1 Reflected Ceiling Plan - Existing**

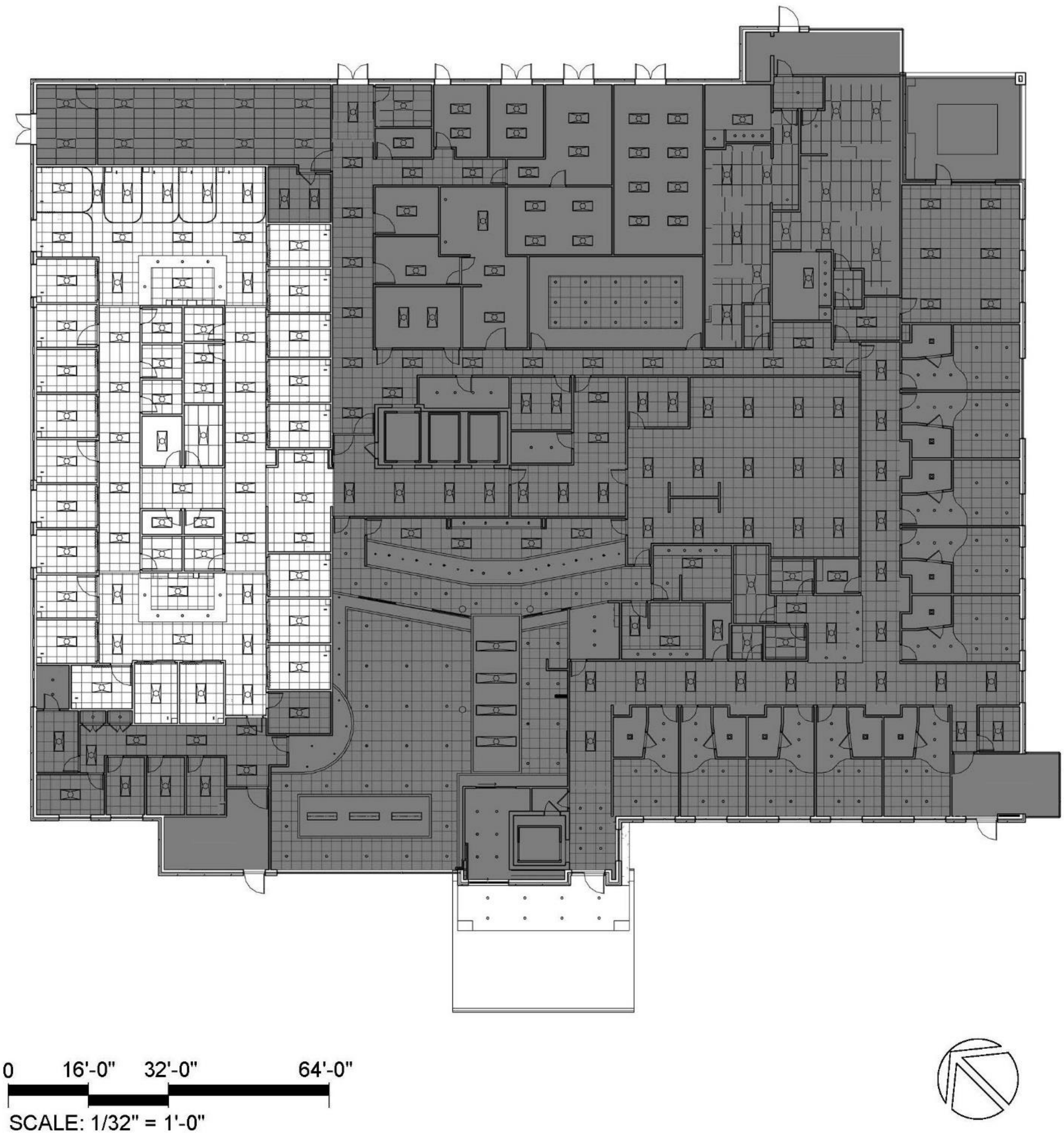


**Figure 7. LVL 1 Pre-Operation Furniture Plan - Enlarged - Existing**

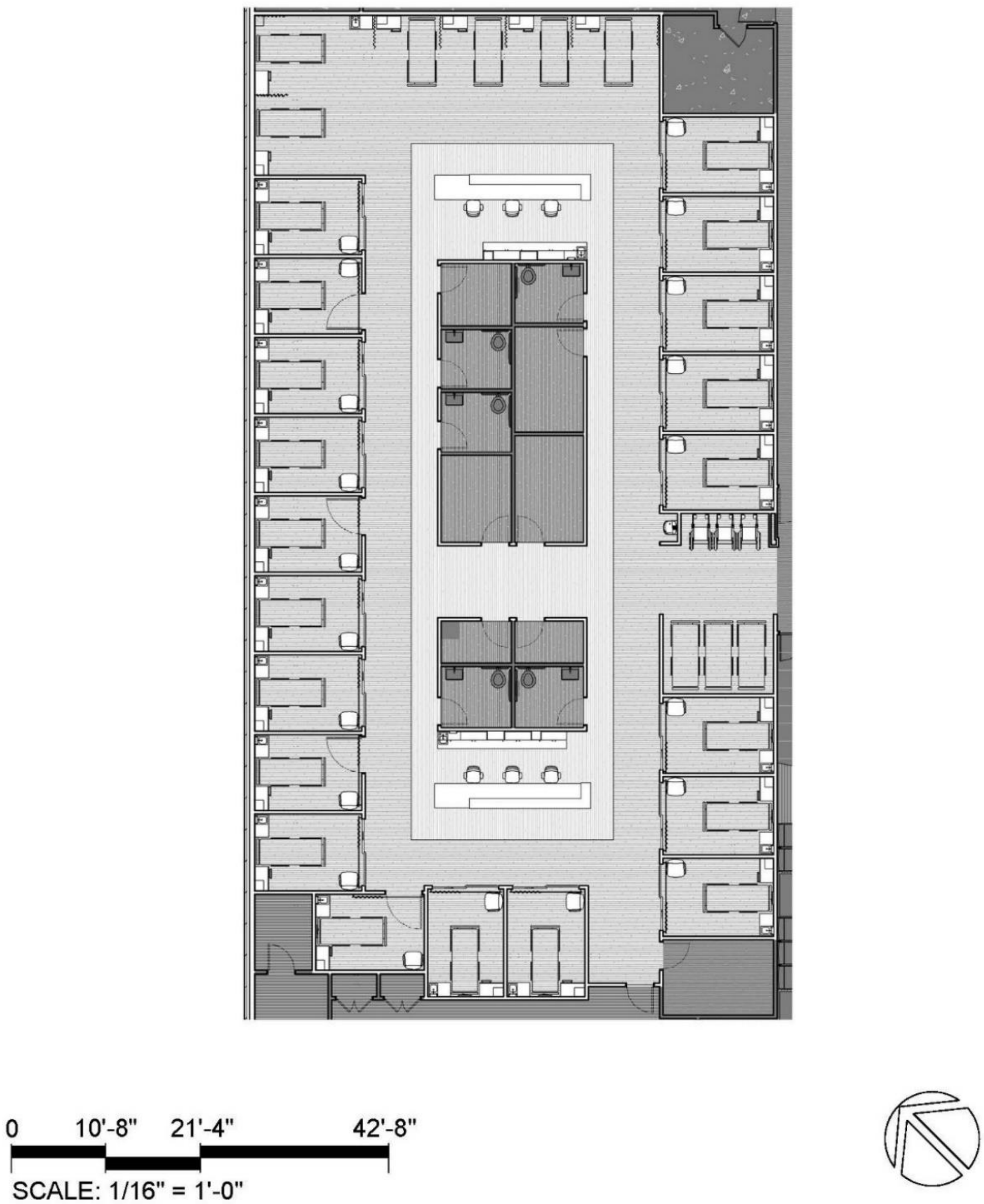


**Figure 8. LVL 1 Pre-Operation Unit RCP - Existing**

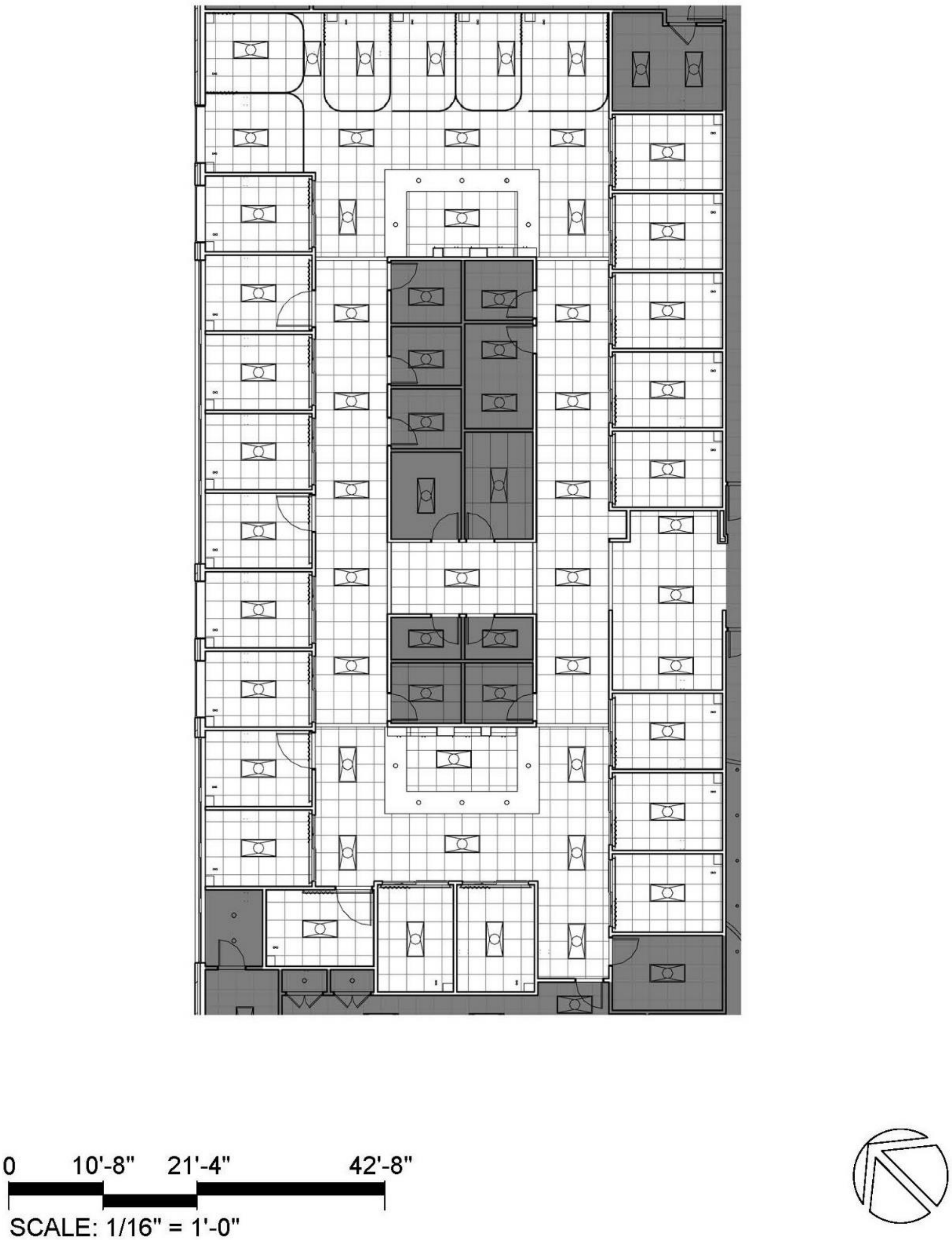


**Figure 9. LVL 1 Pre-Operation RCP - Enlarged Plan - Existing**

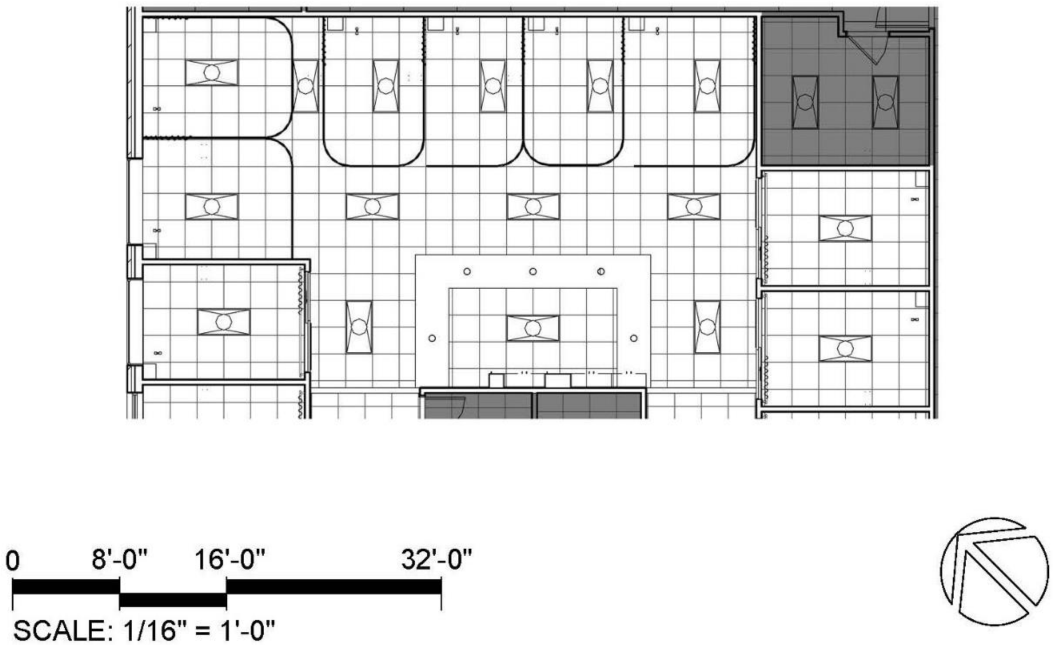


**Figure 10. LVL 1 Pre-Operation Room RCP Enlarged - Existing**

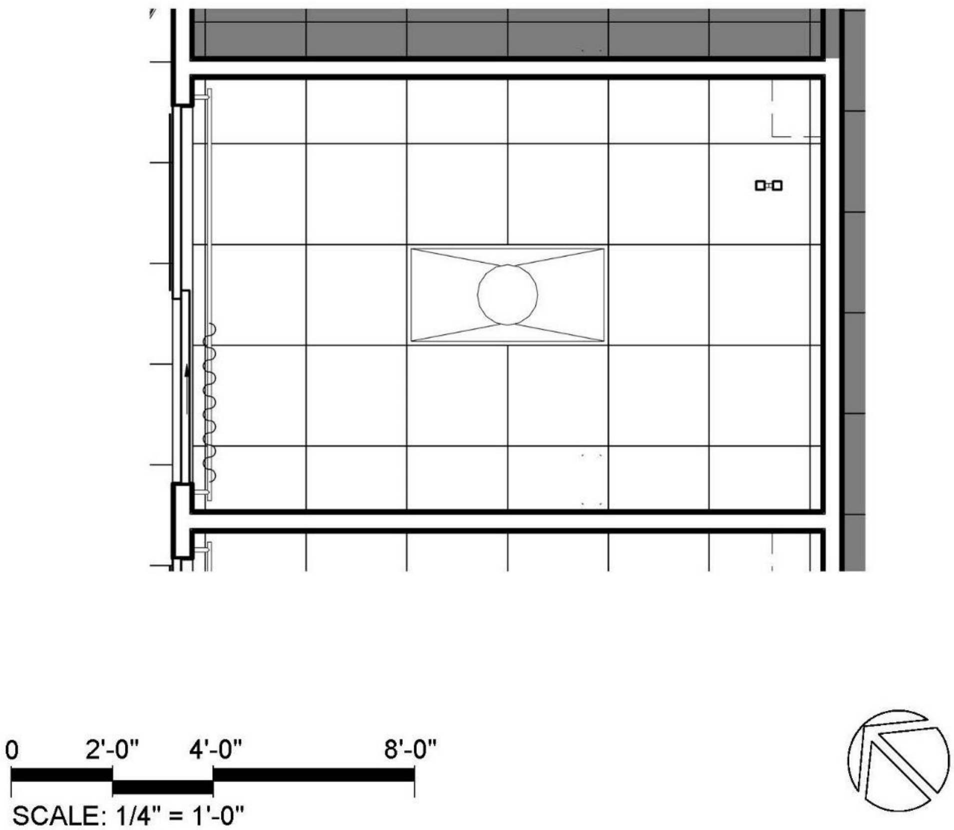


**Figure 11. Pre-Operation Room Elevation - Existing**

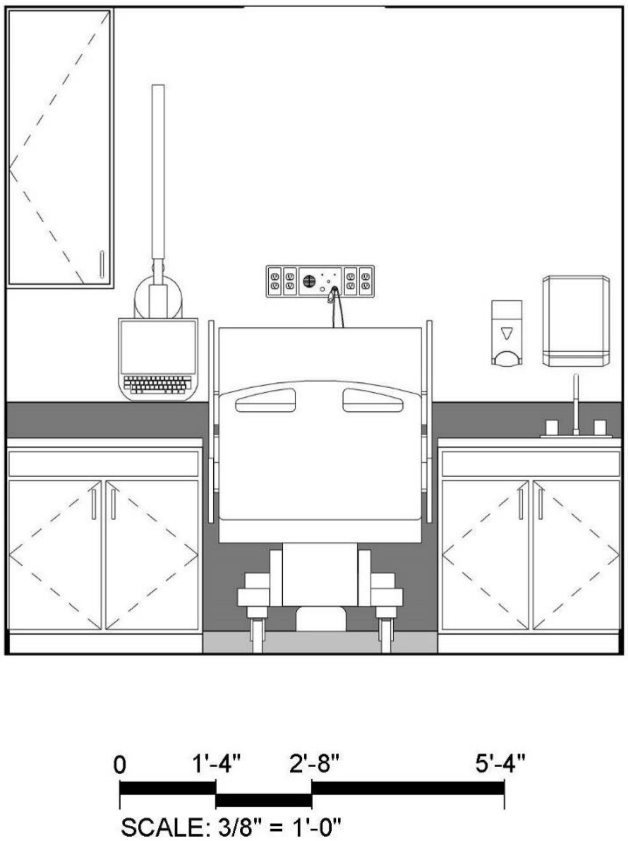


**Figure 12. Ceiling Detail - Existing**

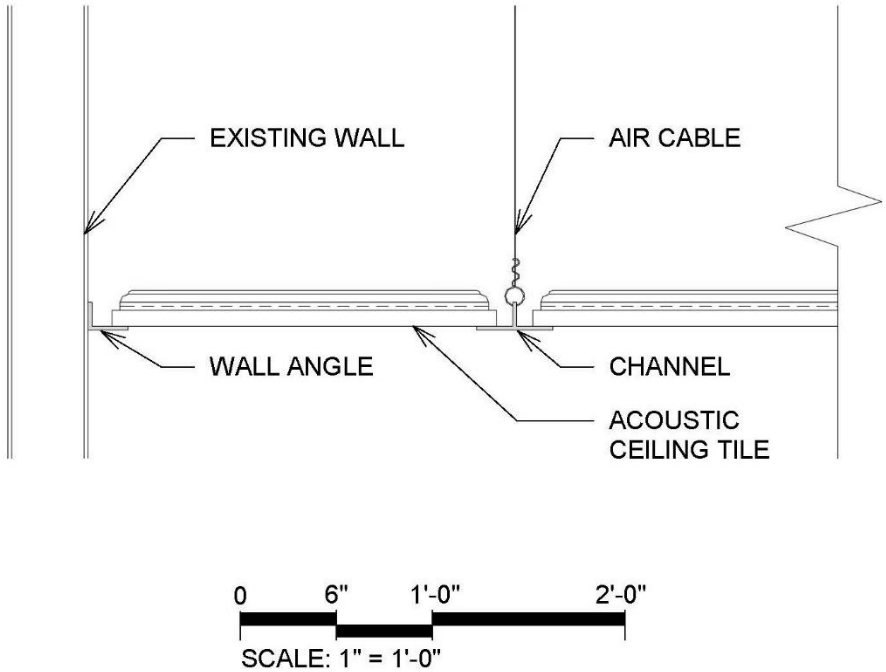



**Figure 13. Pre-Operation Existing Corridor – Rendering 1**

**Figure 14. Pre-Operation Existing Room – Rendering 2**

**Figure 15. Pre-Operation Existing Room – Rendering 3**

**Figure 16. Pre-Operation Existing Open Bay – Rendering 4**

**Figure 17. Pre-Operation Existing Open Bay – Rendering 5**

**Level Two: Existing Post-Operating**

The figures below illustrate the existing level two floor plan, reflected ceiling plan, and existing renderings of the space. The post-operative unit, located on level two plan southwest, is highlighted by greying out the ‘not in scope’ areas of the plan as seen in Figure 18 and Figure 19.

Similar to level one, Figure 20 and Figure 21 show an enlarged floor plan and reflected ceiling plan of the post-operative unit. Figure 22 further enlarges the reflected ceiling plan of the post-operative unit. Refer to Figure 12 for a section detail that has been provided to better understand the existing ceiling conditions within the level two post-operative unit.

Utilize Figure 23, Figure 24, Figure 25, Figure 26, and Figure 27 to explore the existing space and conditions three-dimensionally. All materials are existing to the space and were provided in the Interior Plans from Kim Givens at Landmark Builders.

Unlike level one, the level two post-operative unit is entirely open-bay style. Additionally, access to natural light is more prevalent and will be utilized in the design simulation.

**Figure 18. LVL 2 Furniture Plan - Existing**

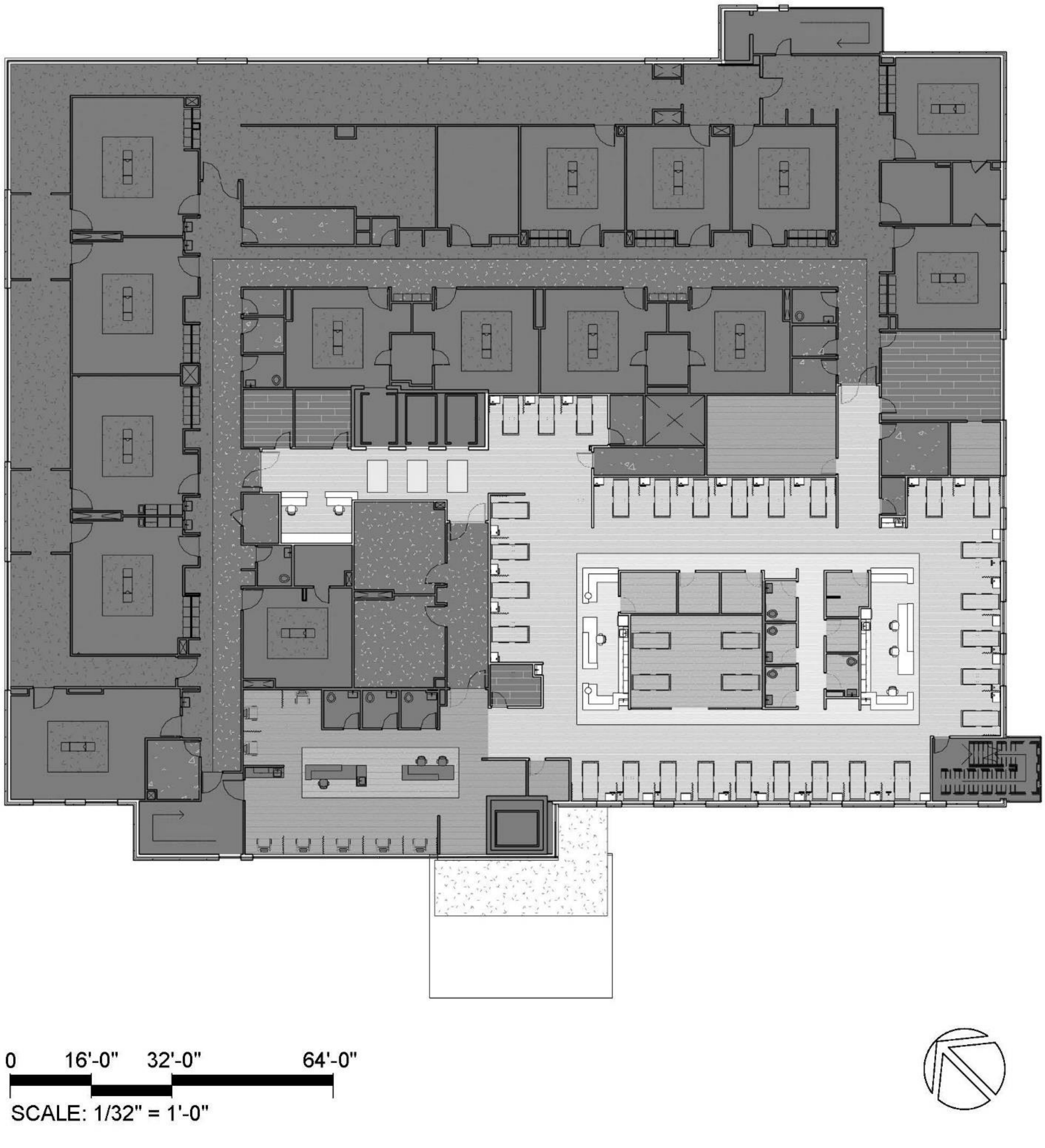


**Figure 19. LVL 2 Reflected Ceiling Plan - Existing**

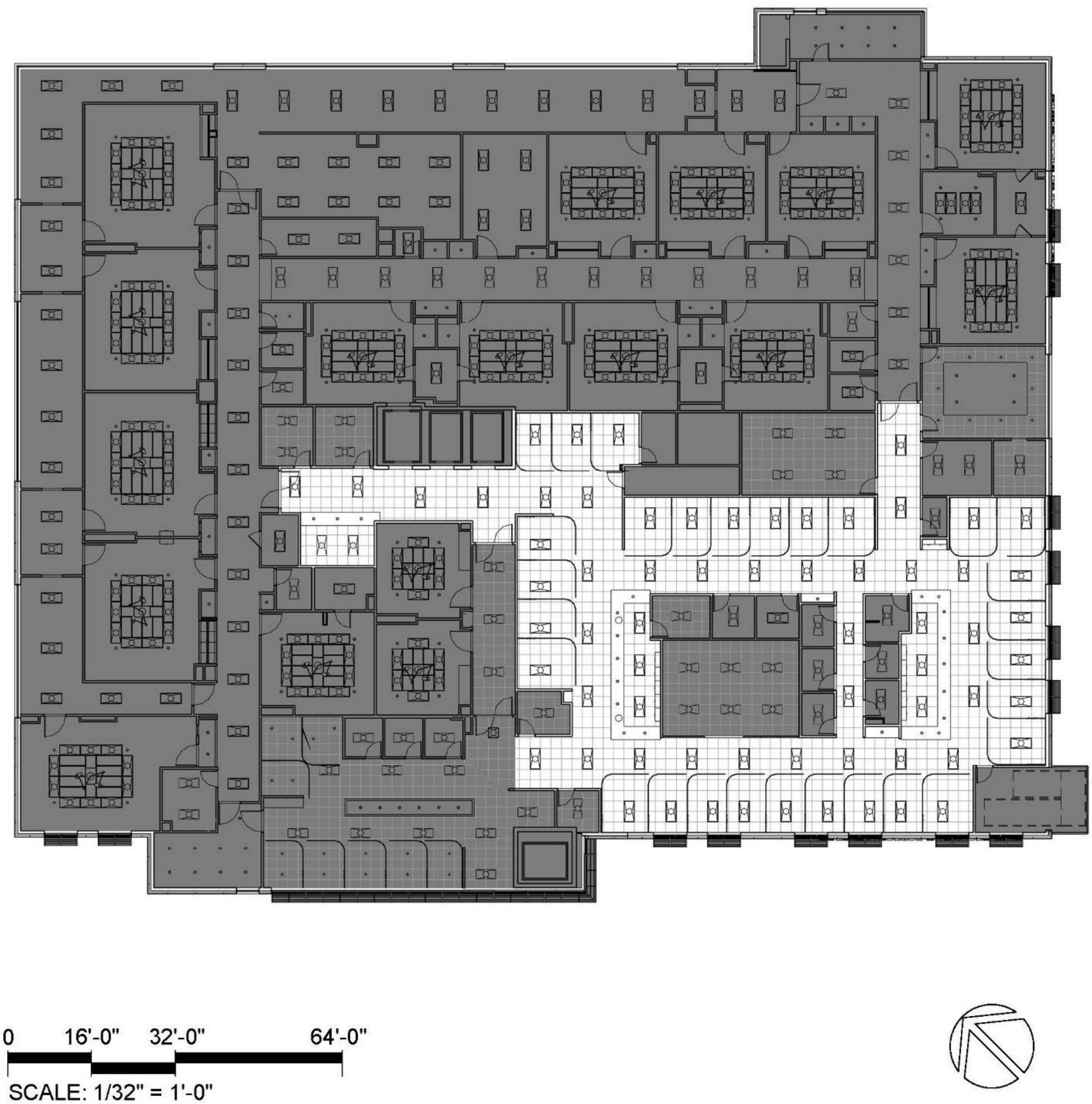


**Figure 20. LVL 2 Post-Operation Furniture Plan Enlarged - Existing**

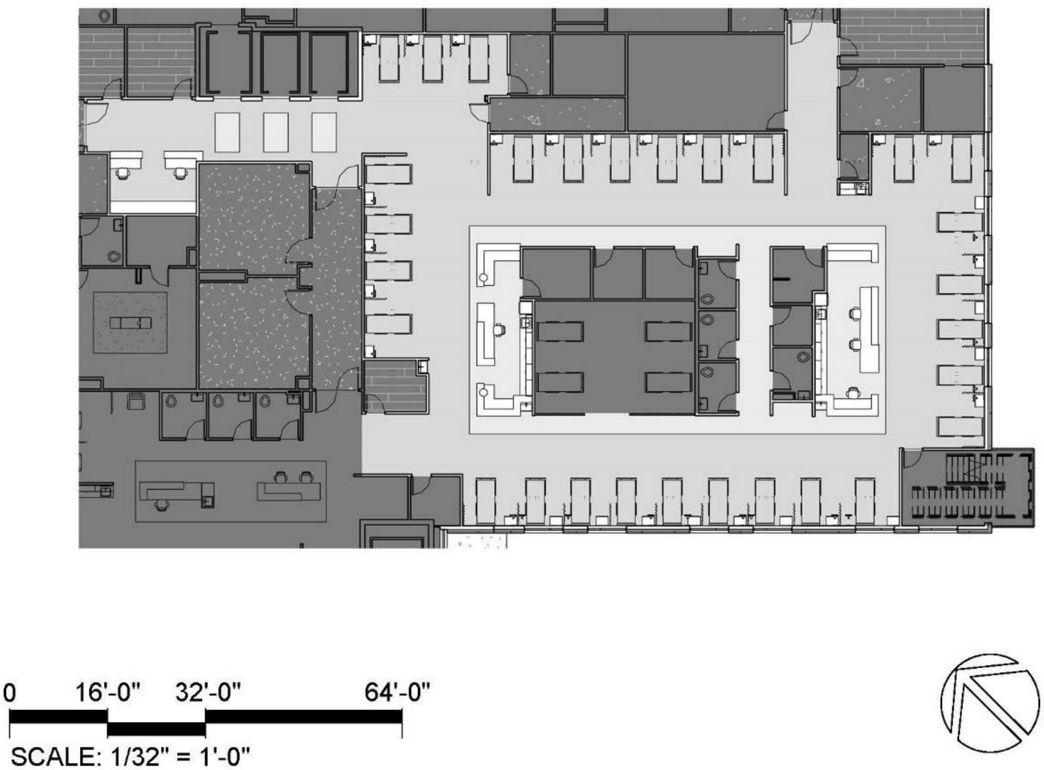


**Figure 21. LVL 2 Post-Operation Unit RCP Enlarged - Existing**

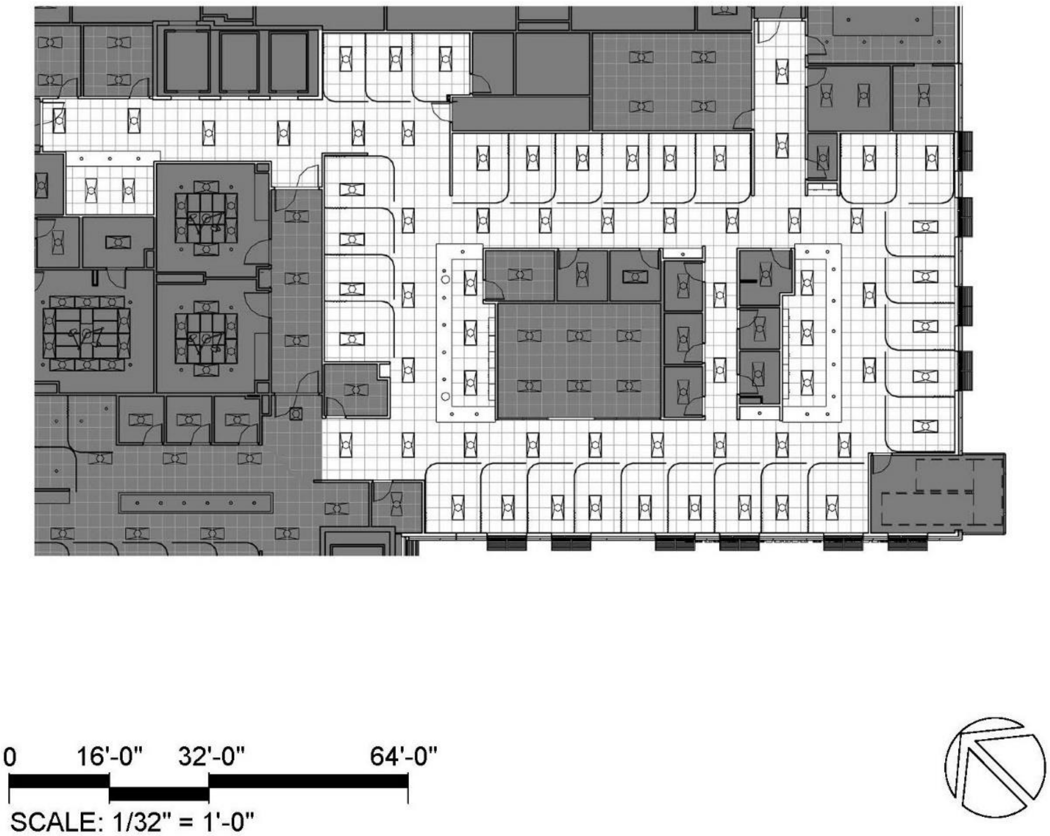


**Figure 22. Post-Operation Enlarged RCP - Existing**

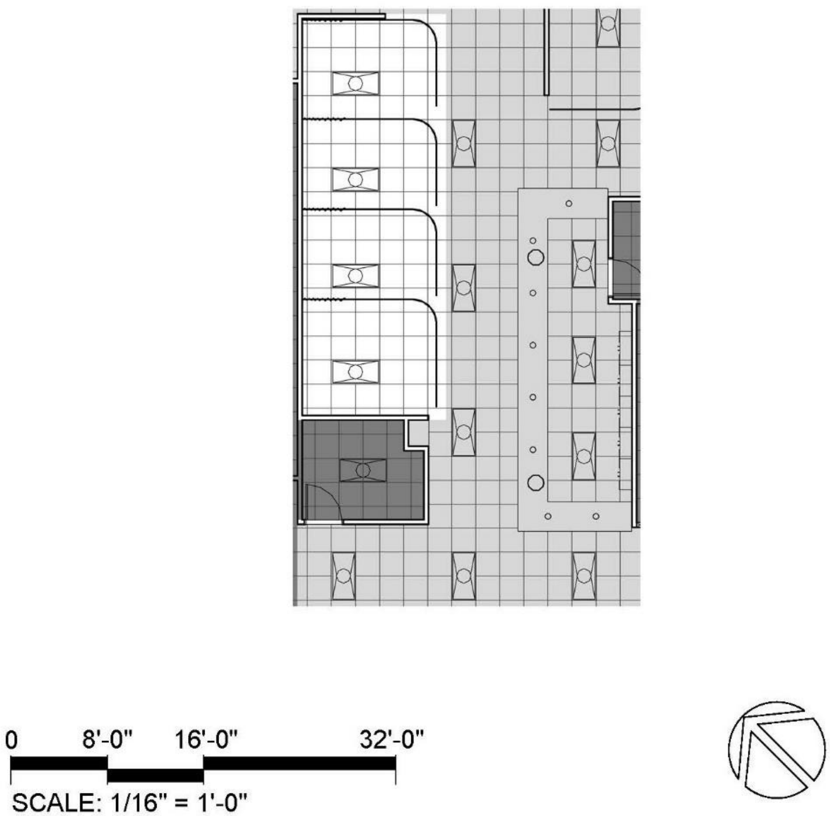


**Figure 23. Post-Operation Existing – Rendering 1**

**Figure 24. Post-Operation Existing – Rendering 2**

**Figure 25. Post-Operation Existing – Rendering 3**

**Figure 26. Post-Operation Existing – Rendering 4**

**Figure 27. Post-Operation Existing – Rendering 5**

# CHAPTER IV: PROCEDURES AND OUTCOMES

## Procedures

Once the existing plans of the space were obtained and researched, the combination of computer programs such as Autodesk Revit 2024, Lumion Student Version, and Adobe Photoshop 2024 were used to recreate the existing building floor plans, reflected ceiling plans, and produce perspective renderings of the existing space. Due to this being an existing building, accuracy was important in materials, lighting locations, and furniture placement throughout to reflect the existing site as closely as possible.

Subsequently, the next phase of this investigation was creating the prototypes of the pre-operative and post-operative units. This was achieved by using the combination of Autodesk Revit 2024, Lumion Student Version, and Adobe Photoshop 2024. The visualization products include updated reflected ceiling plans, perspective renderings, and panoramic views of the space. Within the pre-operative room and post-operative unit, there are additional lighting options such as cove lighting, under cabinet lighting, and indirect downlighting. The lighting implemented is informed by the biophilic light and space design element that was discussed earlier. Lighting changes were made from the original reflected ceiling plan. Collectively, these plans provide the layout for a typical “patient-owned” space that will be used in the simulation.

Lastly, an example of patient controls that could be utilized to manipulate these layers of light has been provided. See Figure 28 for Johnson Controls OpenBlue Patient Optimization Solution is a full patient room integration system. OpenBlue Patient Room Optimization is a completely configurable system that was designed for the patient but does not hinder healthcare staff from performing their duties.

Continue to the next section to find the updated floor plan, reflected ceiling plan, section details, and perspective renderings demonstrating the added layers of light in the pre-operative and post-operative units to represent the flexibility of lighting.

**Figure 28. Johnson Controls Example**


**Project Site – Level One: Pre-Operating Design Simulation**

The current location and confines of the pre-operating unit remain plan east and is highlighted by greying out the 'not in scope' areas of the plan as seen in Figure 29. A furniture plan has not been provided, as it will remain existing. Refer to Figure 5 and Figure 7 for existing level one furniture plans. Within the pre-operating space, specific layers of light were added to the existing reflected ceiling plan to provide flexibility for patients. These lighting details can be seen within the below-reflected ceiling plan, section details, and perspective renderings.

Figure 30 illustrates an enlarged reflected ceiling plan of the pre-operative unit where design changes may begin to appear subtly. Figure 31 and Figure 32 show enlarged reflected ceiling plans of the open bay and private room of the pre-operative unit. The ceiling changes should be more apparent. An elevation of the private pre-operation room is illustrated in Figure 33, and section details of the added layers of light are shown in Figure 34 and Figure 35.

Additional three-dimensional renderings have been provided to better showcase the design simulation changes. Within Figure 36, Figure 37, Figure 38, Figure 39, and Figure 40, all layers of light are shown as on, and may be hard to pinpoint exact light layers. See Figure 41 and Figure 42 for specific layers of light to be shown.

It is important to note, in Figure 42, that the presence of daylighting causes the additional layers of light to be even more subtle. When daylighting is present, it should be utilized and treated as a fourth layer of light.

**Figure 29. LVL 1 Reflected Ceiling Plan – Design Simulation**

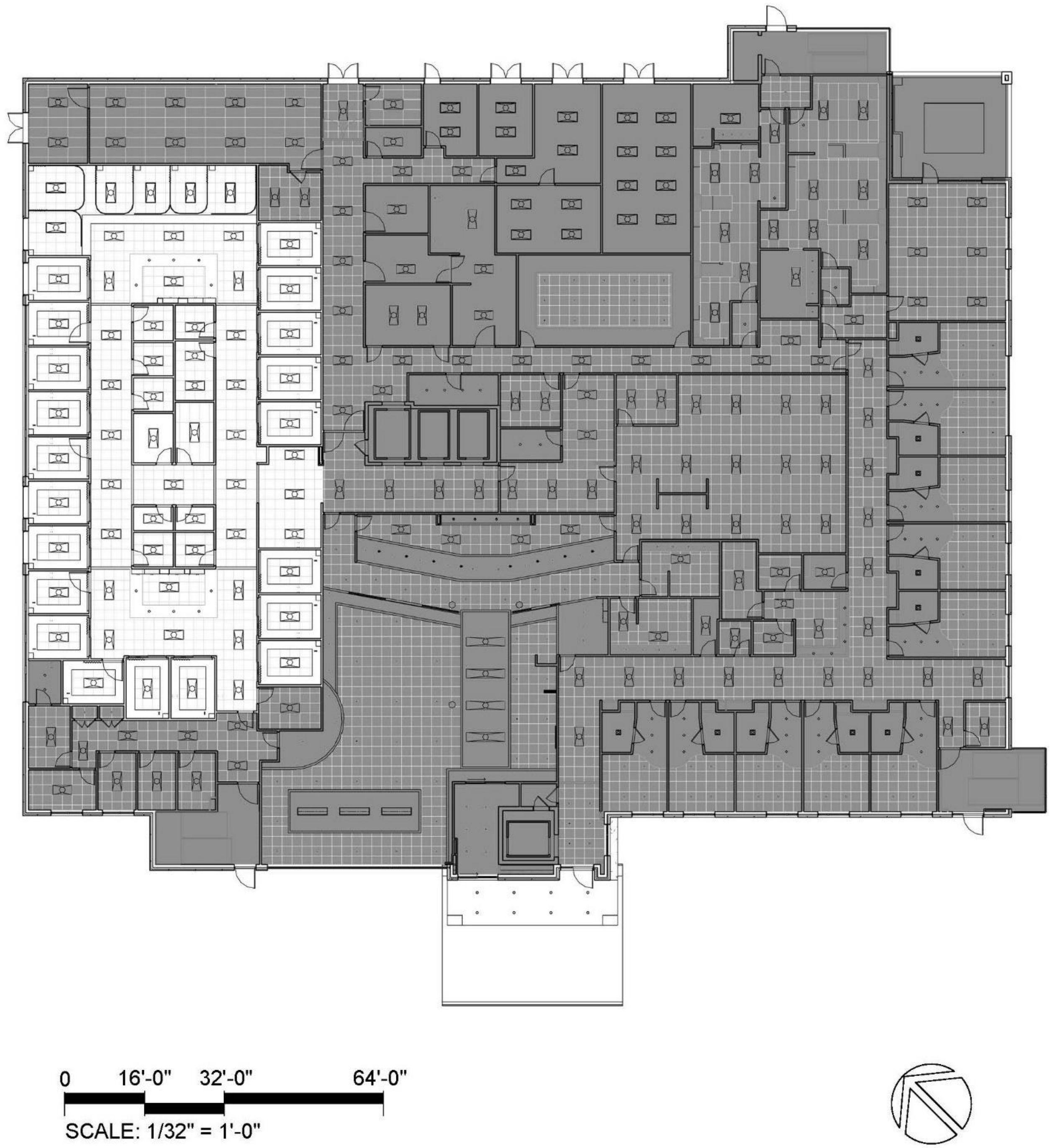


**Figure 30. LVL 1 Pre-Operation Unit Enlarged RCP – Design Simulation**

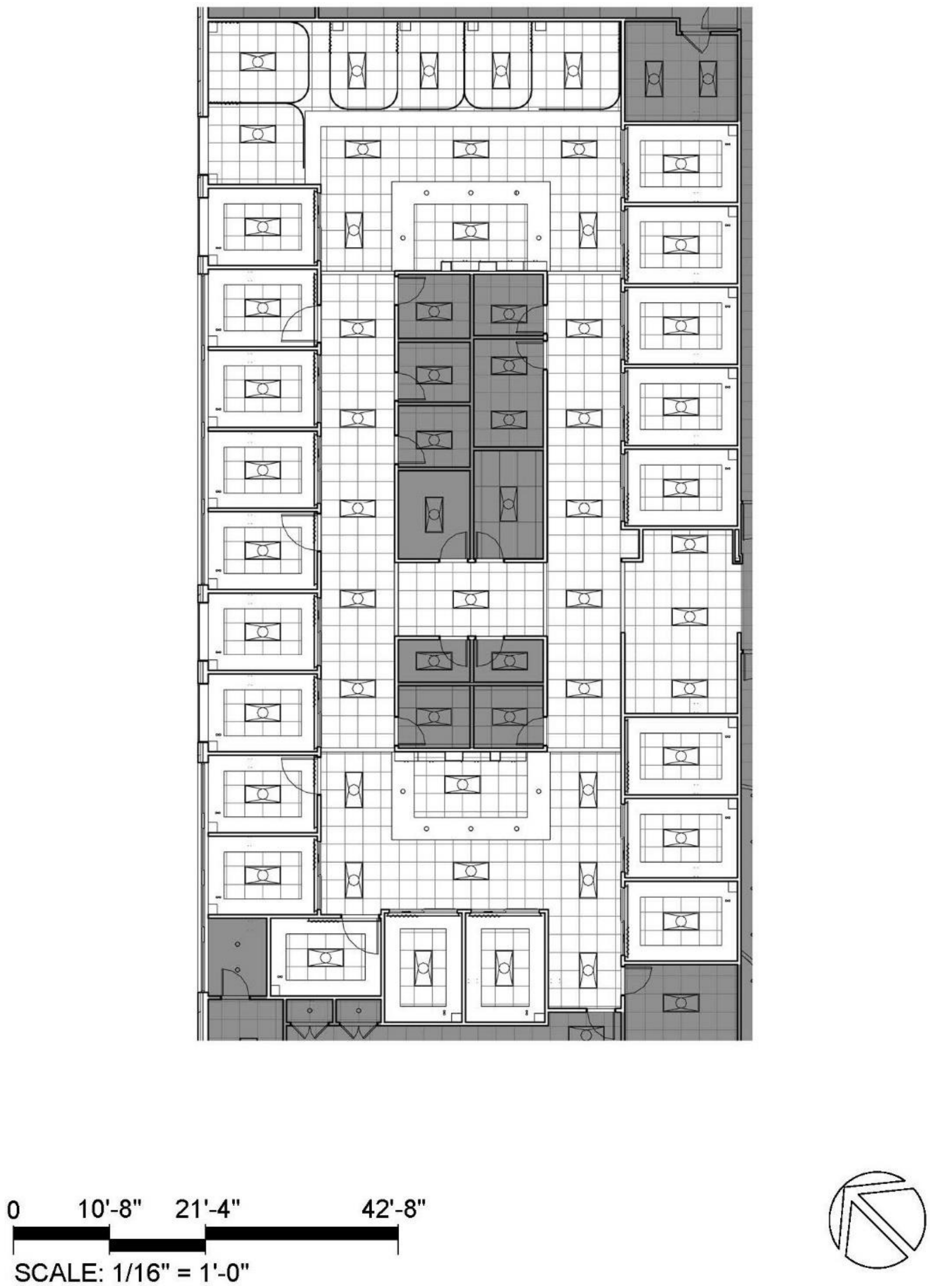


**Figure 31. Pre-Operation RCP Enlarged – Design Simulation**

**Figure 32. Pre-Operation Room Enlarged RCP – Design Simulation**

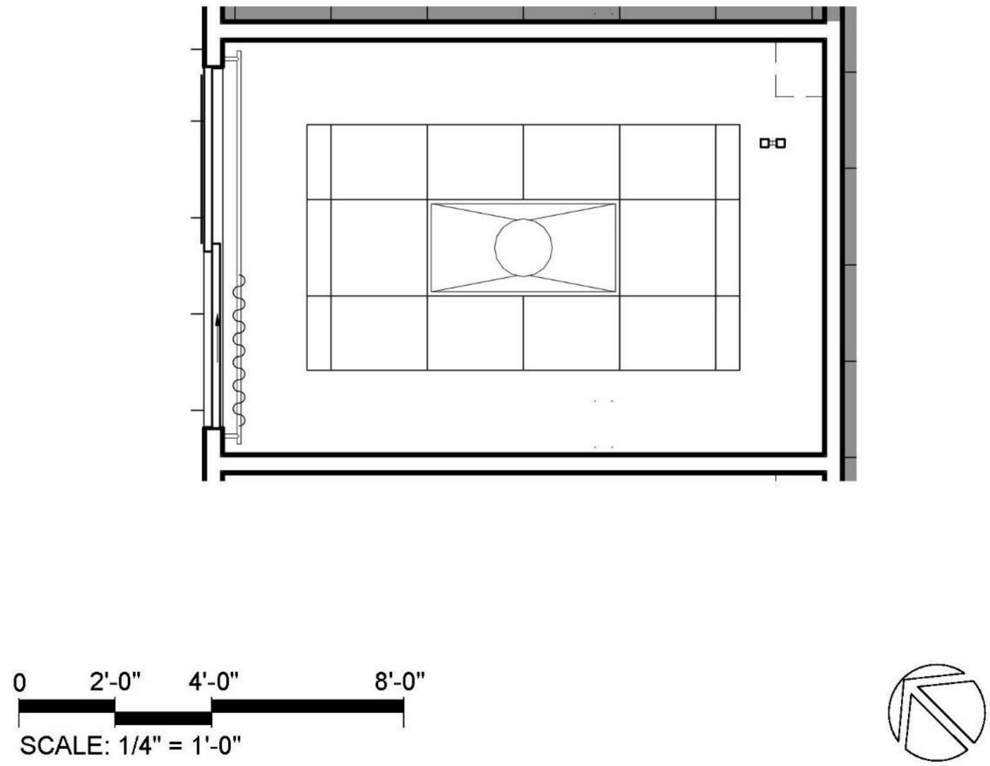


**Figure 33. Pre-Operative Room Elevation – Design Simulation**

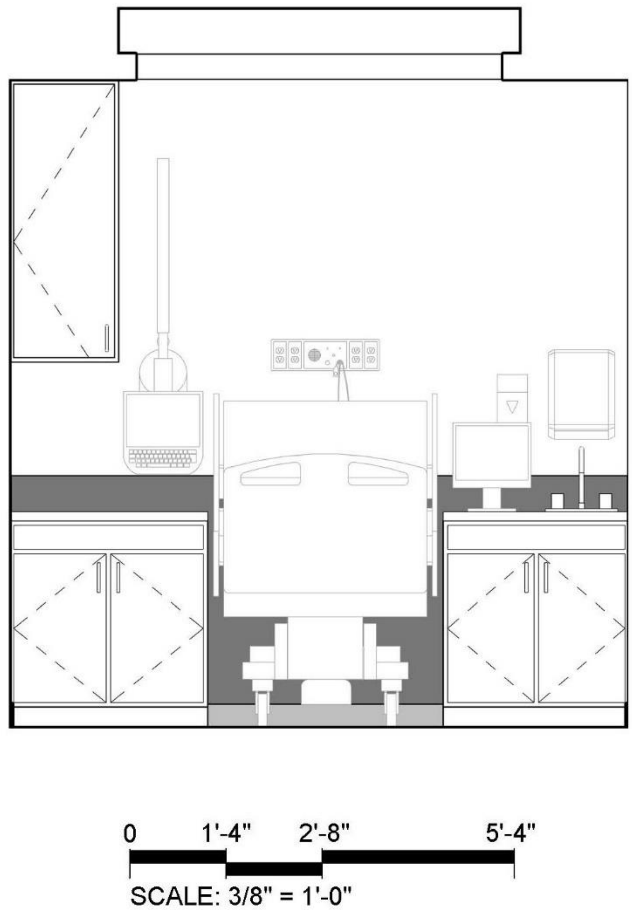


**Figure 34. Cove Light Detail – Design Simulation**

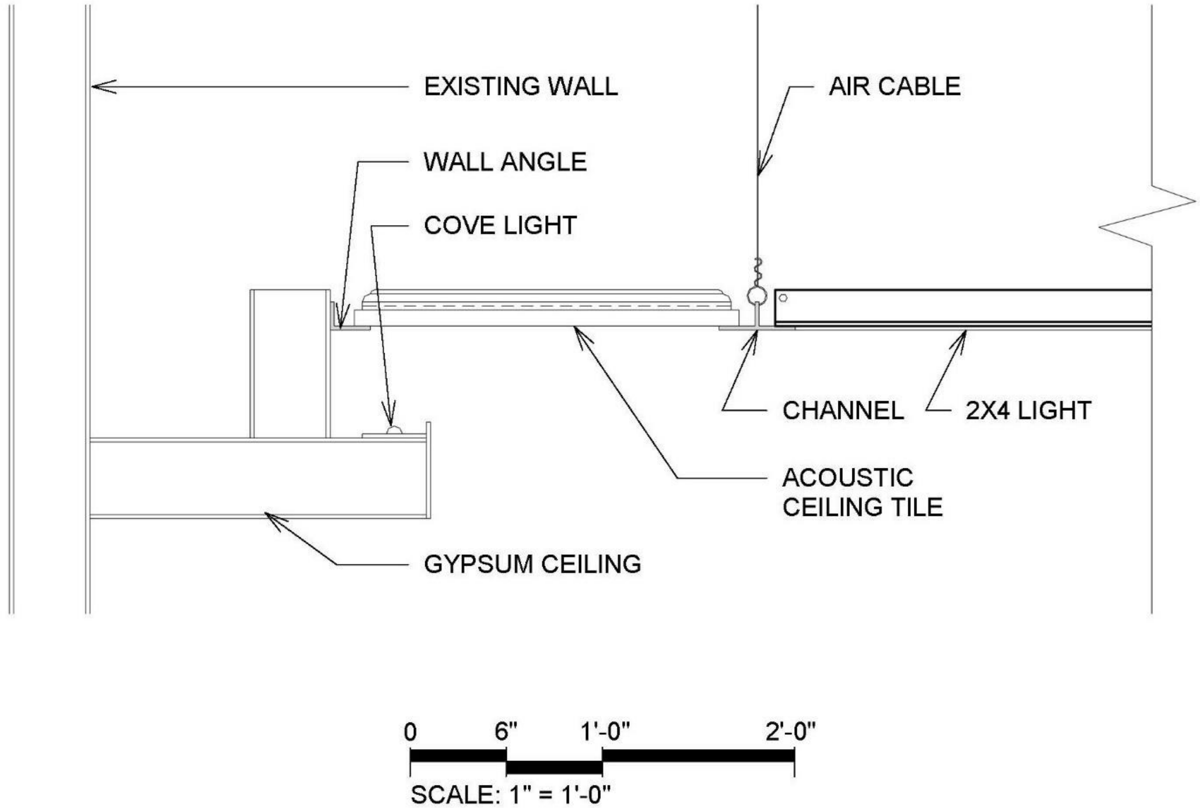


**Figure 35. Undercabinet Lighting Detail – Design Simulation**

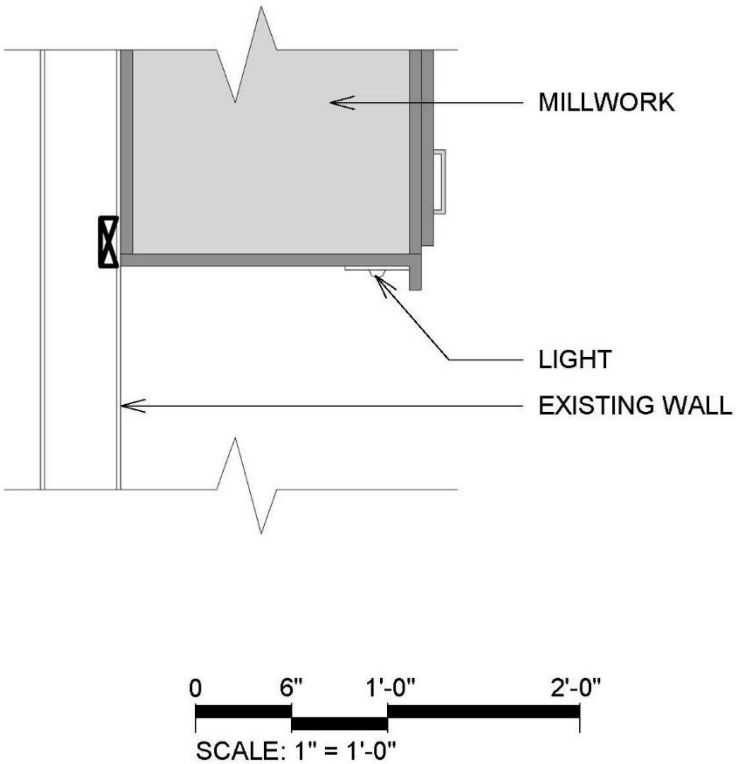


**Figure 36. Pre-Operation Design Simulation – Rendering 1**

**Figure 37. Pre-Operation Design Simulation – Rendering 2**

**Figure 38. Pre-Operative Design Simulation – Rendering 3**

**Figure 39. Pre-Operative Design Simulation – Rendering 4**

**Figure 40. Pre-Operative Design Simulation – Rendering 5**

**Figure 41. Pre-Operative Room Layers of Light – Existing vs Design Simulation**

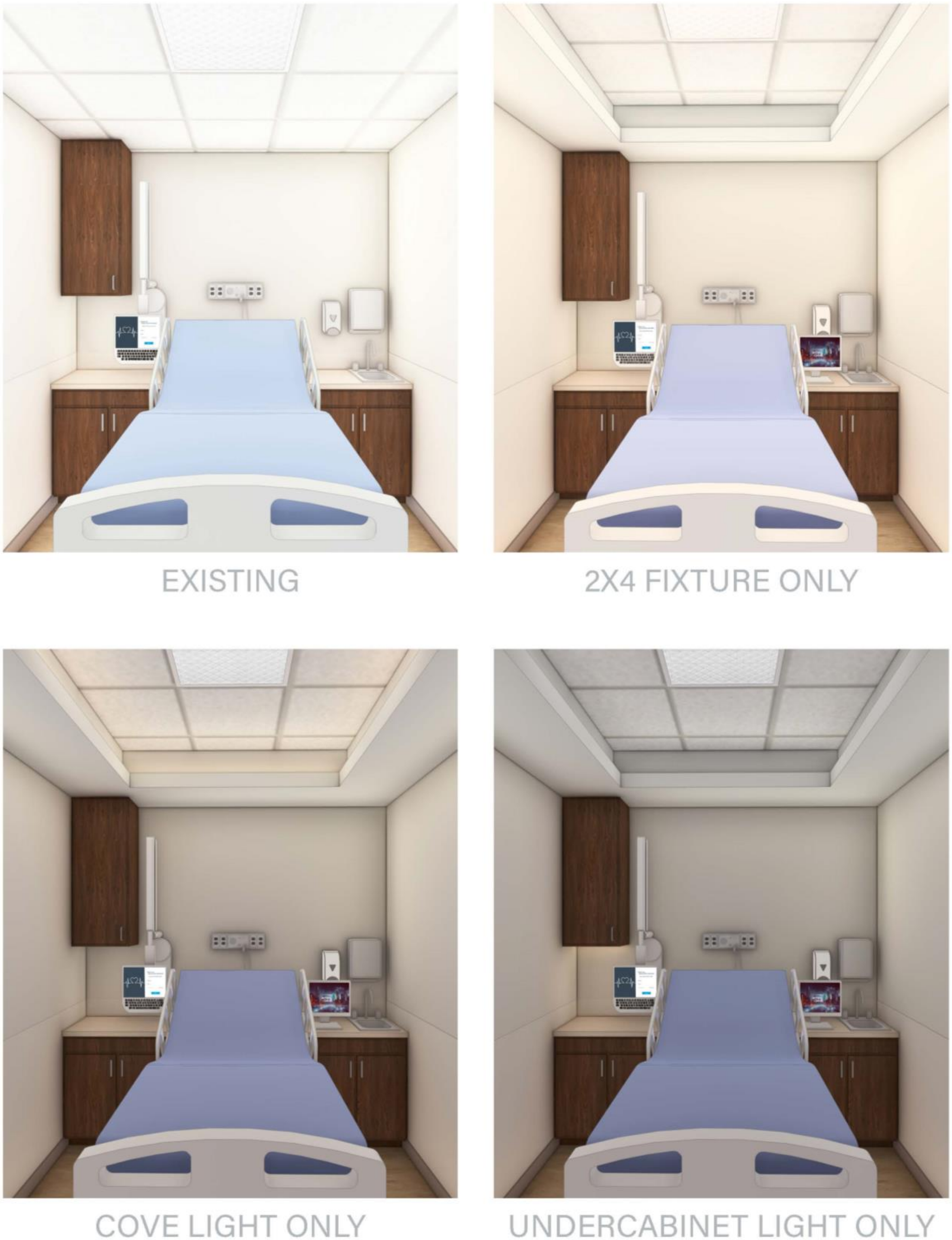


**Figure 42. Pre-Operative Open Bay Layers of Light – Existing vs Design Simulation**

**Project Site – Level Two: Post-Operating Design Simulation**

The current location and confines of the post-operating unit will remain plan southeast and is highlighted by greying out the 'not in scope' areas of the plan as seen in Figure 43. A furniture plan has not been provided, as it will remain existing. Refer to Figure 18 and Figure 20 for existing level two furniture plans. Within the post-operating space, specific layers of light were added to the existing reflected ceiling plan to provide flexibility for patients. These lighting details can be seen within the below-reflected ceiling plan, section details, and perspective renderings.

Figure 44 illustrates an enlarged reflected ceiling plan of the post-operative unit where design changes may begin to appear subtly. Figure 45 shows an enlarged reflected ceiling plan of the post-operative unit. The ceiling changes should be more apparent. Refer to Figure 34 for the cove light detail added in the post-operative unit. Additionally, a section detail of the soffit light added is shown in Figure 46.

Additional three-dimensional renderings have been provided to better showcase the design simulation changes. Within Figure 47, Figure 48, Figure 49, Figure 50, and Figure 51, all layers of light are shown as on, and may be hard to pinpoint exact light layers. See Figure 52 for specific layers of light to be highlighted.

It is important to note, in Figure 52, that the presence of daylighting in the post-operative unit causes the additional layers of light to be subtle. When daylighting is present, it should be utilized and treated as a fourth layer of light.

**Figure 43. LVL 2 Reflected Ceiling Plan – Design Simulation**

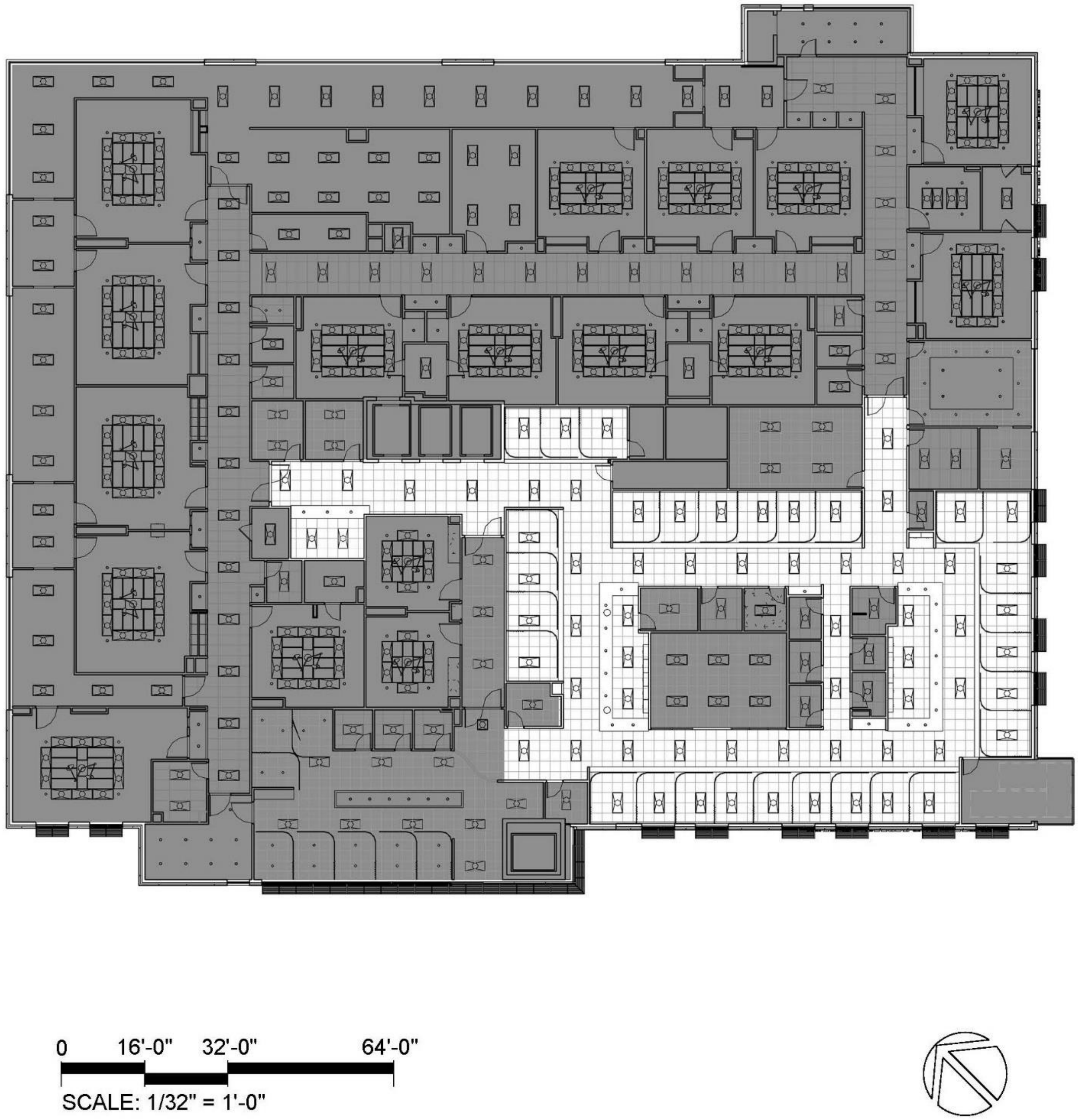


**Figure 44. LVL 2 Post-Operation Enlarged RCP – Design Simulation**

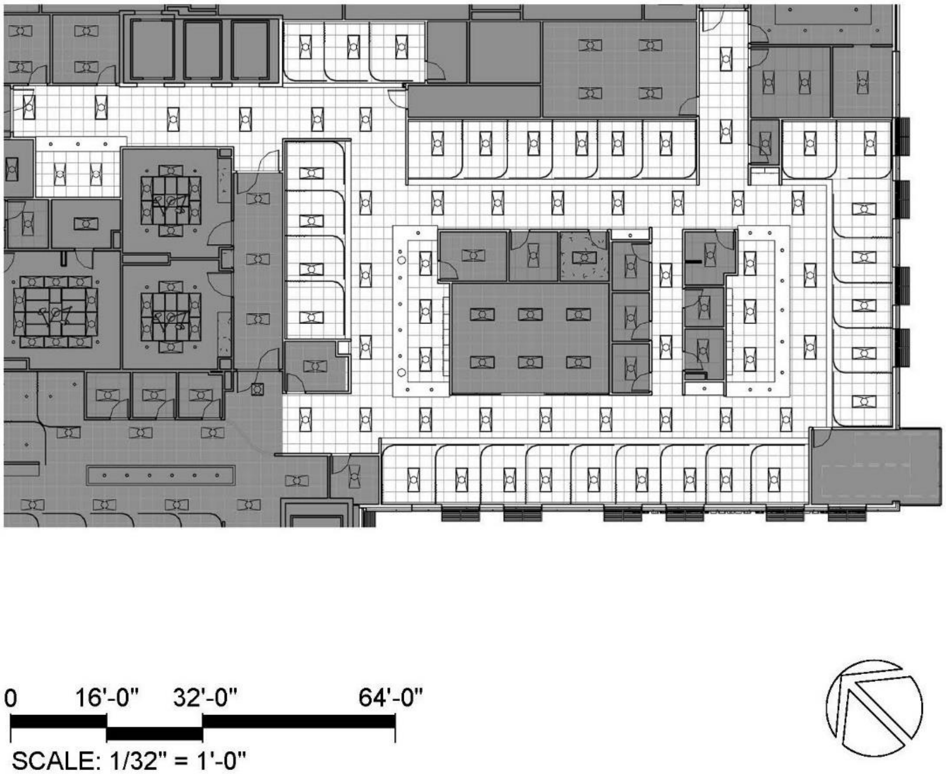


**Figure 45. Post-Operation Unit Enlarged RCP – Design Simulation**

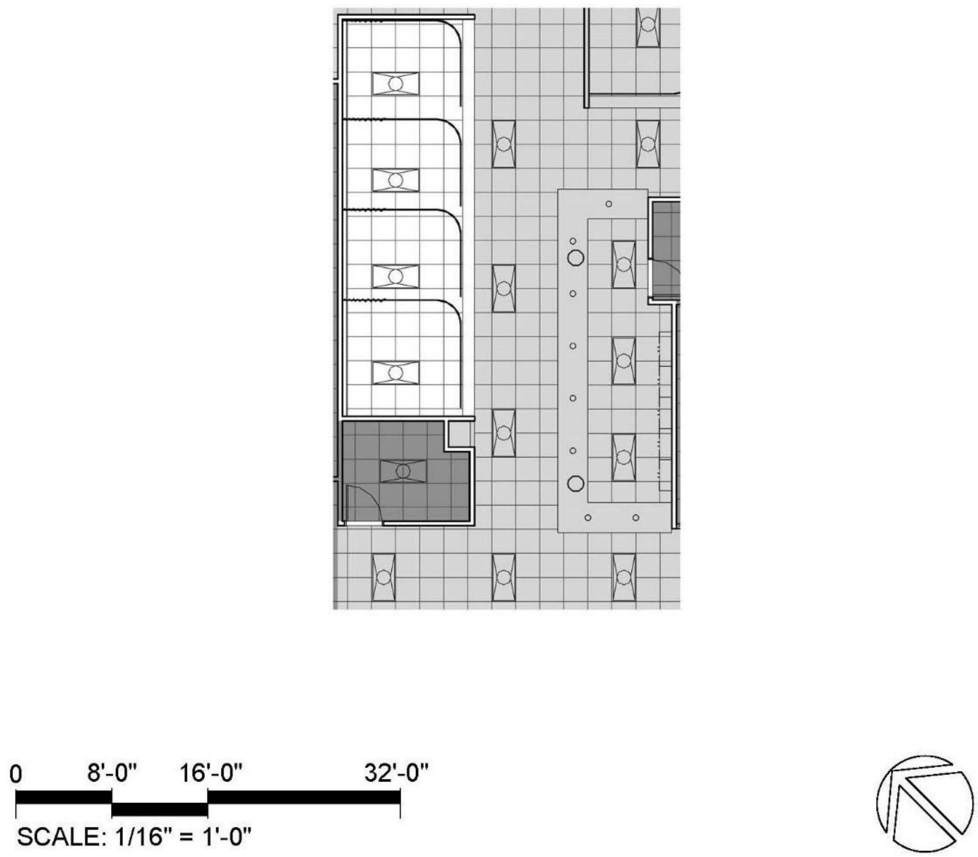


**Figure 46. Soffit Detail – Design Simulation**

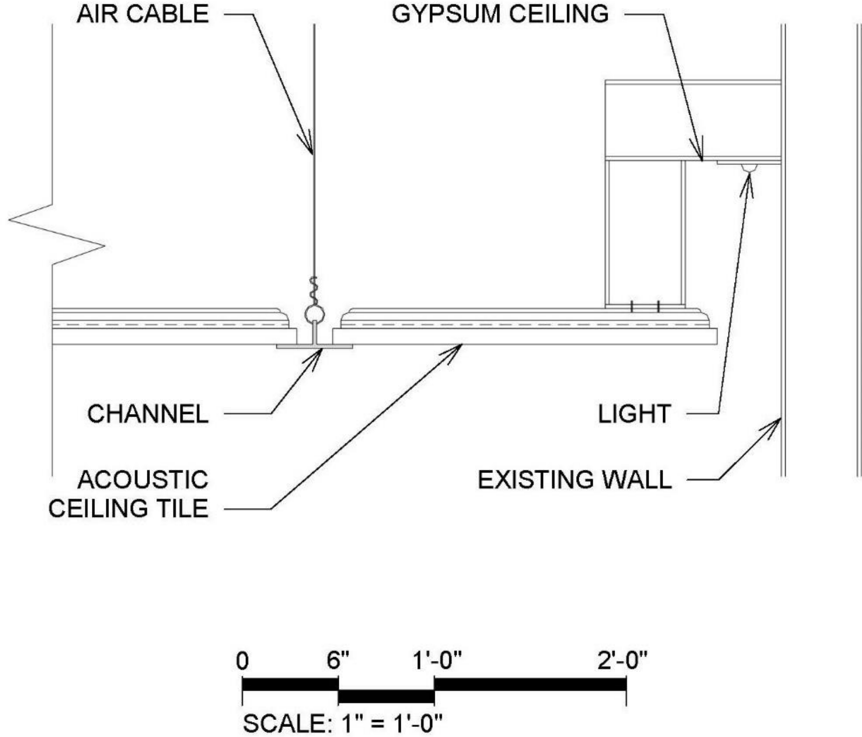


**Figure 47. Post-Operation Design Simulation Rendering – Rendering 1**

**Figure 48. Post-Operation Design Simulation Rendering – Rendering 2**

**Figure 49. Post-Operation Design Simulation Rendering – Rendering 3**

**Figure 50. Post-Operation Design Simulation Rendering – Rendering 4**

**Figure 51. Post-Operation Design Simulation Rendering – Rendering 5**

**Figure 52. Post-Operation Layers of Light – Existing vs Design Simulation**

**Patient Controls**

The addition of layers of light would not be complete without the use of controls for the patient and staff to operate them. The current technology for the controllability of lighting on the market is extraordinary. Multiple companies offer lighting controls that could be utilized for a patient-centered design. As previously stated, Johnson Controls offers a system called OpenBlue Patient Room Optimization. It supports not only the use of smart lighting but also, integrated adjustable thermostats, entertainment options, control for window shades, occupancy sensors for settings reset after each patient, and more. This system can be operated through a mobile device or with voice-activated controls such as Amazon Alexa. An advantage to utilizing a system like OpenBlue is the safety of the patient. Patients before and after surgery tend to be a “fall risk” and can cause harm to themselves by getting out of their bed. This control system allows patients the opportunity to feel comfortable and in control while also prioritizing their safety.

Another company called Leviton offers a distributed control system named the GreenMAX DRC that allows for easy installation and control capabilities for room controllers, occupancy sensors, touchscreen lighting, and LED controllers. Leviton’s devices can be wired into the lighting system and have multiple control options, like, wall-mounted and digital controls to be utilized by practitioners and patients alike.

Lastly, Intelligent Lighting Controls is on the verge of releasing a product called LightLEEDer ILC Pro. This soon-to-be-released product is programmed to control the LightLEEDer panel or EVO system that Intelligent Lighting Controls offers through a downloadable app. The free app allows for on/off control and dimming capability.

As previously stated, there are a multitude of lighting controls on the market that could be applicable and utilized when designing a patient-centered healthcare space.

## Outcome Summary

The objective of this investigation was to explore the flexibility of lighting in pre-operative and post-operative units by implementing layers of light while also providing patients controllability over the lighting within their space. This was achieved by taking the existing conditions of The Surgical Center of Greensboro and providing upfit options. The existing pre-operative and post-operative units' original layout and square footage did not change. Instead, by using the confines of the space, it was determined that upfitting the units would not produce a detriment to the space but rather enhance it towards a more patient-centered design.

## Limitations

While there are always limitations present in research, there were several within this research investigation. The first limitation present is HIPAA Laws, which are of course important and should be respected. However, they did hinder the ability to navigate the healthcare environment.

The main limitation of this research investigation was the impacts of COVID-19. The accessibility to healthcare facilities posed a problem as non-healthcare workers and healthcare guests were not admitted access to healthcare facilities. Only pre-tested essential healthcare workers and admitted patients were provided access to the facilities. By being prohibited from entering the Surgical Center of Greensboro the ability to obtain accurate existing light level readings was not possible. An additional limitation was the access to patients and healthcare professionals for informal interviews to collect quantifiable data. Due to the mandates of COVID-19, interviews and in-person site investigations were unobtainable. Ultimately, the COVID-19 pandemic forced the research to pivot from primary research methods to a project-based simulation.

Another limitation was the cause of using an existing building. The floor plans, materials, and overall circulation of the space did not change; therefore, the confines of the space were quite rigid. This limitation became apparent when adding layers of light and utilizing natural daylighting.

Additionally, daylighting was an issue in some areas. While the presence of natural light is important, the minimal amount of daylighting in the pre-operative unit was problematic while the abundance of natural light in the post-operative unit created difficult design decisions.

Even with the technological advancements of Autodesk Revit and Lumion rendering software, there are limitations within their capabilities. Revit has a feature in the properties tab that allows one to allocate a specific component to either an existing phase, demo phase, or new construction phase. This feature was initially utilized, however, once the phases were exported to Lumion, the materials, and phases were not registered within the rendering software. While this limitation was circumnavigated by duplicating the existing Revit and Lumion files to create the design simulation, it did take time and special attention to detail.

Lastly, within the 3D modeling and rendering software, there are limited healthcare-specific scale models and figures. Because of this, there are no scale figures present in the existing or design simulation renderings. However, the intention and focus of this study is on the patient experience. By adding scale figures there is the risk of the individual not envisioning themselves in the space which could cause negative results.

**Future Research**

Due to the limitations of this research investigation, there is room for others to expound upon the idea of controllability of lighting within outpatient surgical centers. This could be achieved in a variety of ways, such as primary research methods like interviews, questionnaires, or further investigating possibilities to give control of the space to the patients outside the idea of lighting.

In the case of pursuing interviews, the researcher could produce perspective and panoramic views that manipulate the layers of light or other elements of design, like the research investigation presented here. Then create a semi-structured interview with participants who have experienced outpatient surgery, within a reasonable timeframe, in a similar outpatient environment. The researcher should provide a variety of open-ended and close-ended questions that allow the participants to freely express opinions, feelings, and perceptions regarding the simulations that are produced. The combination of research, literature, and responses from the participants will ultimately form evidence of the patient's desire for controllability in outpatient surgical environments.

Regarding the pursuit of the questionnaire approach, the researcher should seek out participants who have recently had surgery within an outpatient surgical center. The questionnaire should consist of close-ended questions that can be converted into quantifiable data. The questions could range from yes or no to a scale from 1-10 for example. The goal of the questionnaire method is to evaluate the participant's responses and quantify the data. The data should create a firm position on the subject based on the participant's responses.

Another way to expand the body of knowledge is to further investigate design elements within the outpatient environment. This could be done by stimulating the remaining four basic human senses such as: auditory, kinesthetic, gustatory, and olfactory. Within this research, visual stimulation was the focus but that negates a part of the population that is visually impaired. Similar research models to the one produced here could be utilized to investigate the remaining four human senses.

Lastly, numerous types of healthcare environments fall under the outpatient umbrella. While this research only covered an outpatient surgical center, similar investigations and research could be done in other types of outpatient-built environments. Whether that be an urgent care, imaging center, general outpatient, or physical therapy center, the lighting and controllability within those spaces matter.

In conclusion, the use of outpatient facilities will continue to rise, and the design of those environments needs to be researched. The unfortunate reality is, that everyone will at some time, or another need medical care, and the goal when designing these environments should not only be the organization's bottom line, but the well-being of all those who enter the space.

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# APPENDIX A: THESIS PROGRESS TOOLS AND IMAGES

Within this appendix, there are process materials that include progress recruitment tools, process renderings, and additional layers of design. These procedures are no longer being utilized in this study. Refer to Figure A53, Figure A54, Figure A55, Figure A56, Figure A57, and Figure A58 for primary research method recruitment tools. These tools could be used as a framework for future researchers looking to expand the body of knowledge in the design of outpatient surgical centers.

## Figure A53. Progress Recruitment Tool

**APPENDIX A**

RECRUITMENT TOOL

<u>**Project Title:**</u> **Redesign of Outpatient Surgical Center: Controllability of Lighting in Pre-operating Rooms**

**What is the purpose of this study?**

This research study is an investigation of the controllability of lighting in an outpatient surgical center pre-operative room. Your participation is voluntary.

**Who can be a participant?**

I am looking for volunteers to participate in this study. To be eligible, you must have undergone outpatient surgery within the last 5 years. This is a voluntary study; therefore, there will be no compensation for participating. This is a minimal risk study. There is no anticipated harm to participants of this study.

**What happens?**

I will schedule 1-2 interviews with you that will take place over Zoom. The interview should last no longer than an hour. During the interview, I will ask a series of open-ended questions while you are experiencing a design simulation. This simulation is intended to allow you to be as descriptive and clear as you feel comfortable with. The information collected will be used to inform the overall redesign of the pre-operative room. Additionally, this information will contribute to the body of knowledge within healthcare design.

**What if I change my mind?**

This research study is voluntary. If at any time during the study you decide you no longer want to participate, you may withdraw from the study. There are no penalties for withdrawing from the study.

**How do I sign up?**

If you are interested in volunteering to participate in this study, please contact me.

Name: Caylin Prillaman

Email: caprilla@uncg.edu

This post is shareable. If you have anyone in mind that may be willing to participate, please pass this along.

**Figure A54. Consent Form (pg. 1)**

**APPENDIX B**

CONSENT FORM

**CONSENT TO ACT AS A HUMAN PARTICIPANT**

**Project Title: Redesign of Outpatient Surgical Center: Controllability of Lighting in Pre-operating Rooms**

**Principle Investigator:** Caylin Prillaman

**Phone:** [redacted]

**Email:** [redacted]

**Faculty Advisor:** Travis Hicks

**Phone:** [redacted]

**Email:** [redacted]

**Participant's Name:** ____________________________________________

**What are some general things you should know about research studies?**

You are being asked to take part in a research study. Your participation in the study is voluntary. You may choose not to join, or you may withdraw your consent to be in the study, for any reason, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. There may not be any direct benefit to you for being in the research study. There also may be risks to being in research studies. If you choose not to be in the study or leave the study before it is done, it will not affect your relationship with the researcher or the University of North Carolina at Greensboro. Details about this study are discussed in this consent form. It is important that you understand this information so that you can make an informed choice about being in this research study.

You will be given a copy of this consent form. If you have any questions about this study at any time, you should ask the researchers named in this consent form. Their contact information is above.

**What is the study about?**

This research study is an investigation of the controllability of lighting in an outpatient surgical center pre-operative room. Your participation is voluntary.

## Figure A55. Consent Form (pg. 2)

**Why are you asking me?**

You have been invited to participate in this study because you have experienced surgery in an outpatient setting.

**Research questions**

Due to the objectives of the study, these research questions will help to guide the study. More questions have been formulated but will not be asked until the interview.

How can the pre-operating room be a more flexible environment that will not only empower patients but also enhance their experience through the controllability of lighting?

1. How would patients respond by having control over the lighting in their environment?
2. What are some other design features that can be implemented to provide the patient more control?

**What will you ask me to do if I agree to be in the study?**

You will be asked to:

Answer all questions as clearly and to be as descriptive as possible.

**Study Time:** Participation in this study will require 1-2 interviews via Zoom. The interview should not last longer than an hour.

**Study Location:** All interviews will take place on Zoom. This interview will be recorded to be sure all the information you provide is accurate.

**Is there any audio/video recording?**

"Because your voice will be potentially identifiable by anyone who hears the recording, your confidentiality for things you say on the recording cannot be guaranteed although the researcher will try to limit access to the recording as described below."

**What are the risks to me?**

This study will be of minimal risk to you.

**What are the possible benefits for me or others?**

There will be no direct benefits to you for participating in this research study. The information collected could improve the outpatient environment for individuals in the future.

**How will the information you collect about me be shared, and protected?**

**Figure A56. Consent Form (pg. 3)**

Due to the nature of this study, your personal information is not needed. Your name will not appear on any transcripts. You will be assigned a participant number in order to keep the information collected organized. I will keep these recordings on a device that is not linked to the internet, is password protected, and will only be accessed by me. These recordings will be kept in a secure place for the entirety of the study. They will be erased at the conclusion of the study.

**Financial Information**

This study will be no cost to you. You will not be paid for participating in this study.

**What are my rights as a research participant?**

As a voluntary participant in this research study, you are not obligated to answer any of the questions that are asked. If at any time during the interview you choose not to answer a question, you may skip to the next one. For the questions you choose to answer, you should only provide as much information as you feel comfortable with. You are not obligated to finish the study. You are able to take a break, reschedule for a later date, or stop the study altogether. There will be no penalty for stopping the study at any time. If you choose to stop participating, I will get your consent to use the information collected to that point.

**What if I want to leave the study?**

"You have the right to refuse to participate or to withdraw at any time, without penalty. If you do withdraw, it will not affect you in any way. If you choose to withdraw, you may request that any of your data which has been collected be destroyed unless it is in a de-identifiable state. The investigators also have the right to stop your participation at any time. This could be because you have had an unexpected reaction, or have failed to follow instructions, or because the entire study has been stopped."

**What about new information/changes in the study?**

"If significant new information relating to the study becomes available which may relate to your willingness to continue to participate, this information will be provided to you."

**Who do I contact with questions or concerns pertaining to this research study?**

If you have questions or concerns at any point during this study, feel free to ask me now or at any time. You also have the option to contact my Faculty Advisor at the University of North Carolina at Greensboro using the information below.

1)Travis Hicks

**Figure A57. Consent Form (pg. 4)**

Associate Professor | Director of Center for Community-Engaged Design | Director of NC Main Street Program

Department of Interior Architecture | The University of North Carolina at Greensboro

527 Highland Avenue, Greensboro NC 27402

Phone: [redacted]

Email: [redacted]

2)Caylin Prillaman

MFA Candidate

Department of Interior Architecture | The University of North Carolina at Greensboro

Phone: [redacted]

Email: [redacted]

**Voluntary Consent by Participant:**

By signing this consent form this interview (used for an IRB-approved waiver of signature) you are agreeing that you read, or it has been read to you, and you fully understand the contents of this document and are openly willing consent to take part in this study. All of your questions concerning this study have been answered. By signing this form, you are agreeing that you are 18 years of age or older and are agreeing to participate, in this study described to you by Caylin Prillaman.

Signature:__________________________________________ Date:____________

## Figure A58. Interview Guide

**APPENDIX C**

INTERVIEW GUIDE

*Background Questions:*

1) How many years ago did you have surgery in an outpatient facility?
2) Do you remember much about the interior of the location in which you had surgery?
3) Do you remember more about the pre- or post-operative space?
4) Were there any design elements that you distinctly remember while in the pre-operative unit? (For example: lighting, acoustics, overall design)
5) How did you feel while in the pre-operative unit?
    a. Did you feel comfortable in this space?
6) Were you able to control aspects of the environment? (for instance: lighting, music, etc.)
    a. If so, what elements of the space were you able to control?
7) Did that impact your comfort in the space?

*Prototype Questions:*

8) What are your impressions of this environment?
9) How do you feel in this space?
10) What do you think about the design of this space?
11) What do you think about the lighting in this space?
12) How does this lighting compare to lighting in spaces that have left a positive impression on you?
13) Are there other elements of design you would like to see implemented?
14) Would you feel more comfortable if you have control over this environment?
15) Are there elements you would like to have control over?
    a. How would you like to have control? (ie: smart phone, ipad, remote?)
16) What suggestions would you have for people who design these spaces?

# APPENDIX B: PROCESS RENDERINGS

Due to the limitations of COVID-19, the researcher took time off and pursued a full-time career in interior architecture. This assisted in the development of skills in both Autodesk Revit and Lumion. Included within this appendix are process renderings from 2020 and 2021. The rendering program used was Autodesk Revit 2021 cloud rendering. Additionally, Adobe Photoshop 2021 was utilized for inserting control screens and 3D scale figures.

See Figures B59 and Figure B60 for the process pre-operation unit reflected ceiling plan and enlarged private pre-operation reflected ceiling plan. Next see Figure B61, Figure B62, and B63 for screenshots of process elevations and a standard private room. Additionally, see Figure B64, Figure B65, and Figure B66 for screenshots of the private room three-dimensionally.

Process renderings of the pre-operation unit, pre-operation private room, and open bay of the pre-operation unit are shown in Figure B67, Figure B68, Figure B69, Figure B70, Figure B71, Figure B72, and Figure B73.

Something to note, before taking time off, the researcher solely focused on the pre-operative unit. No figures are referencing the level two post-operative unit as that was brought into scope in 2023. Additionally, all plans referenced in Appendix B are not to scale and should not be referenced for future research.

However, one may notice there are different elements added for controllability not seen in this thesis. There was an exploration of the addition of a cove light in the pre-operative unit's private rooms which was kept in the research scope, but there was the addition of wall sconces instead of under cabinet lighting. Additionally, the researcher investigated other types of controllable elements such as a speaker, placed in the ceiling above the patient's bed and a television. Both would have the capability to be controlled by the patient. However, the focus shifted away from those elements once the level two post-operative unit was brought into scope.

The additional elements mentioned could have produced other design flaws through auditory or workflow disruption for the nurses and physicians. That is not to say, that those additional design elements could be used as a framework for future researchers. However, for this research investigation, they were eliminated from the scope.

**Figure B59. LVL 1 Pre-Op Unit RCP - Process**

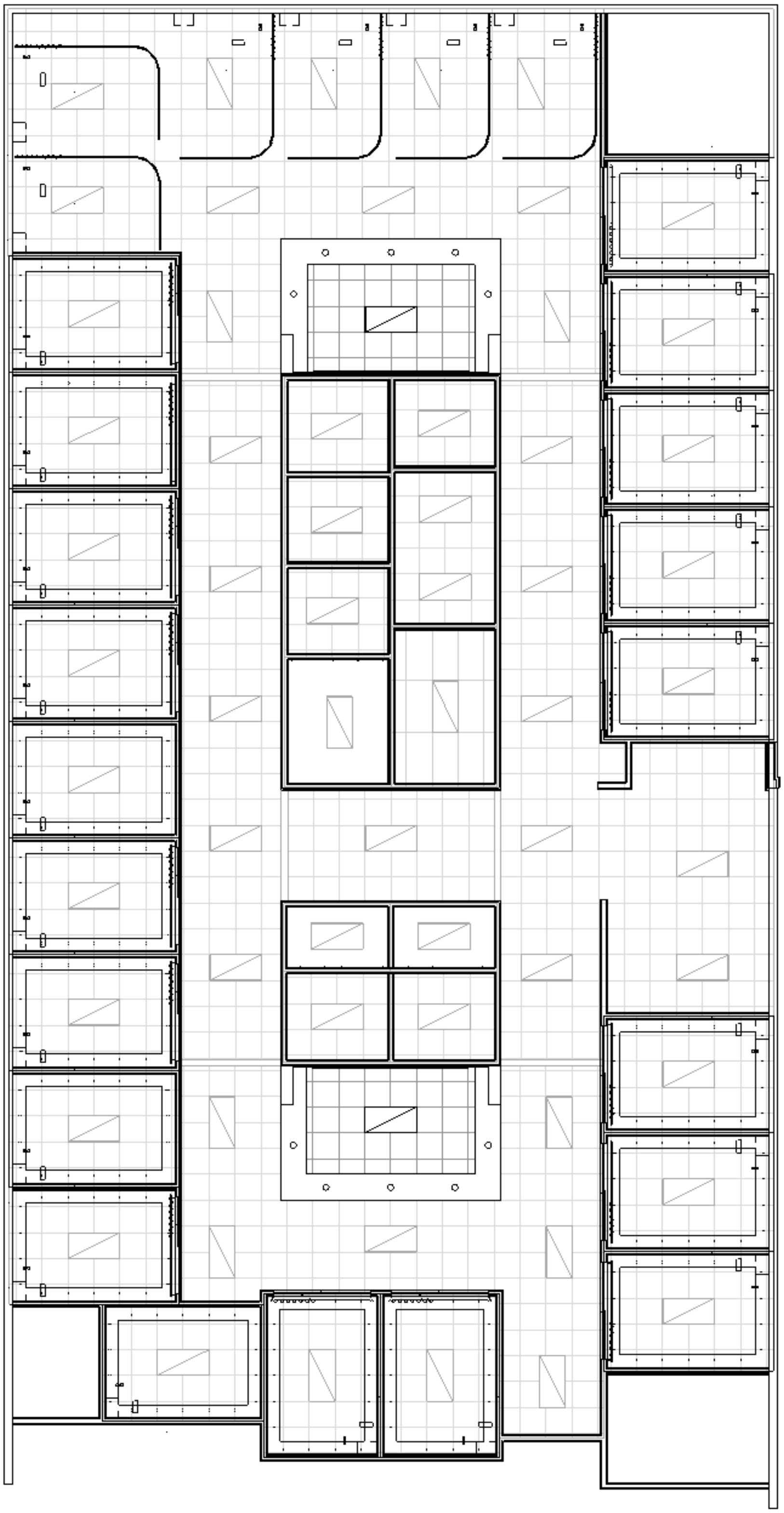


**Figure B60. LVL 1 Pre-Op Private Room RCP - Process**

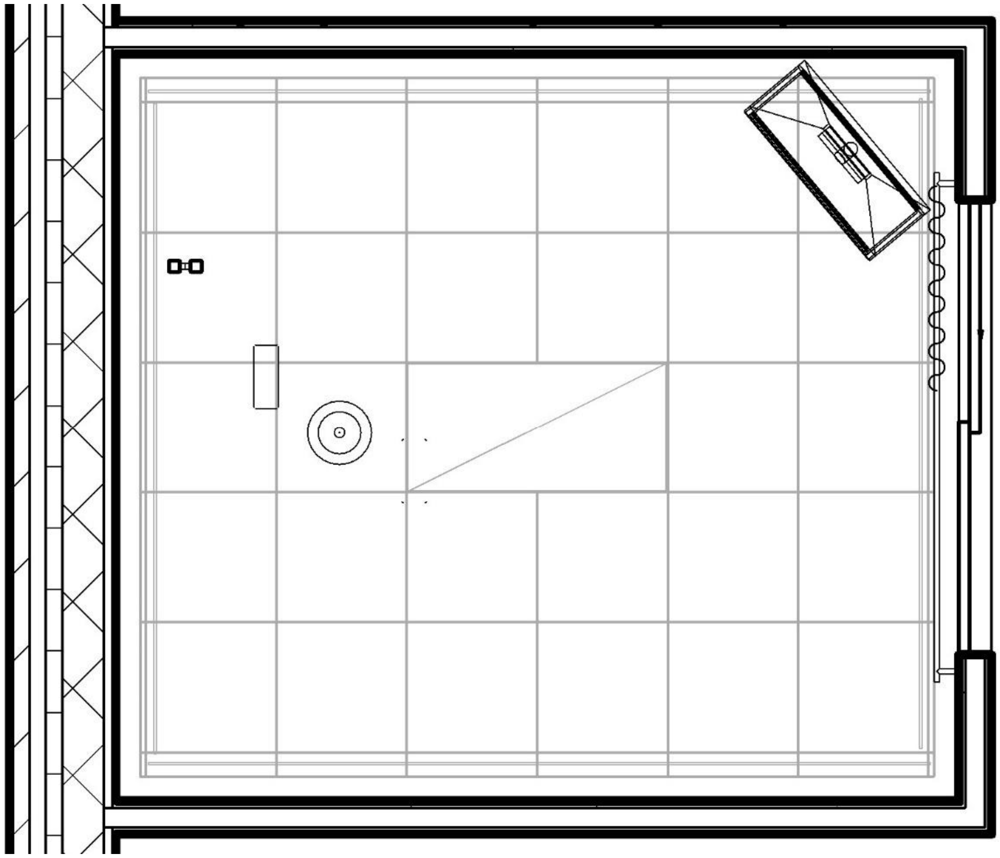


**Figure B61. LVL 1 Pre-Op Private Room Floor Plan Screenshot - Process**

**Figure B62. LVL 1 Pre-Op Room Existing Elevation Screenshot - Process**

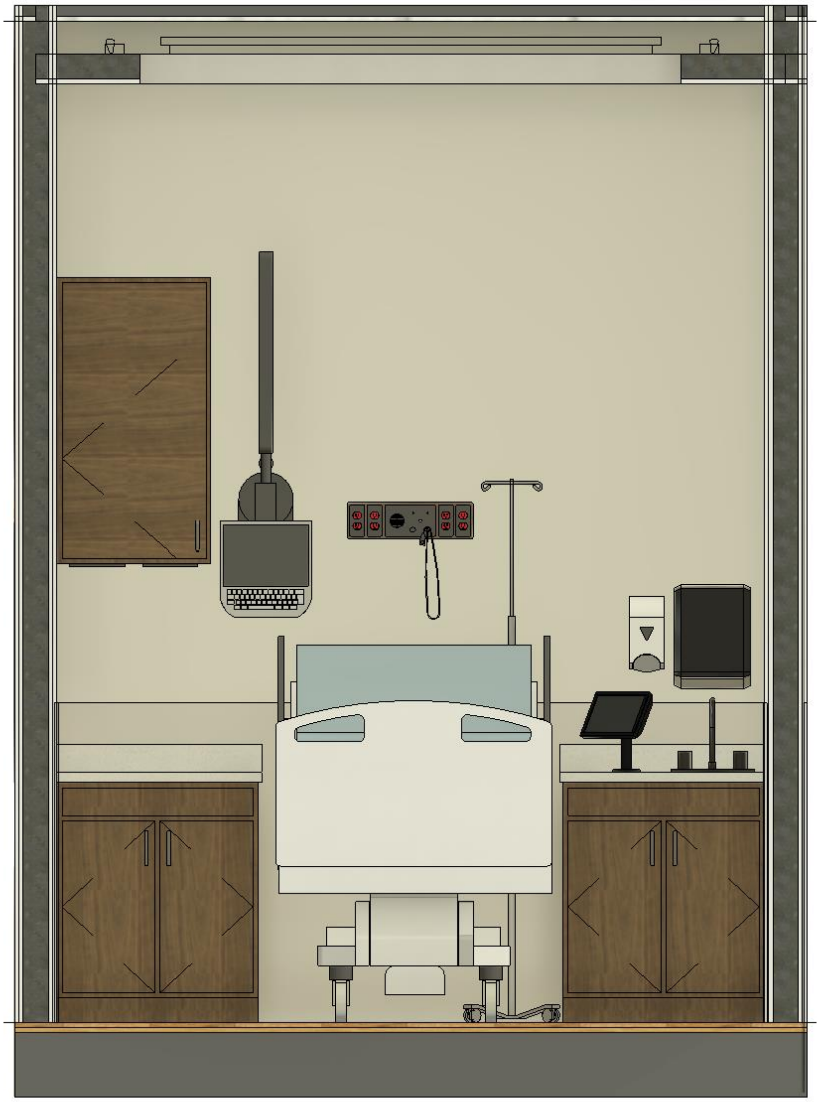


**Figure B63. LVL 1 Pre-Op Private Room Design Simulation Elevation - Process**

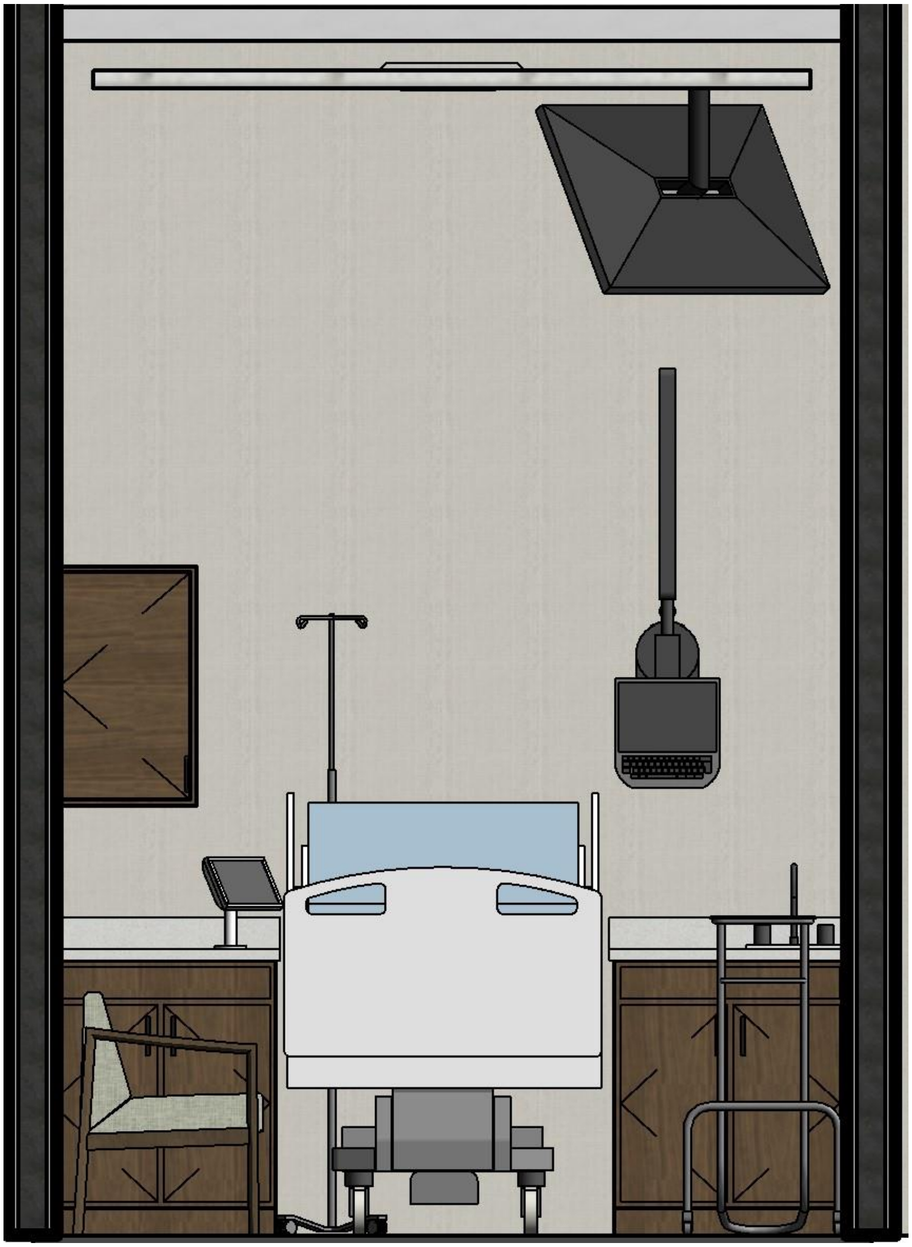


**Figure B64. LVL 1 Pre-Op 3D Rendering – Screenshot Process 1**

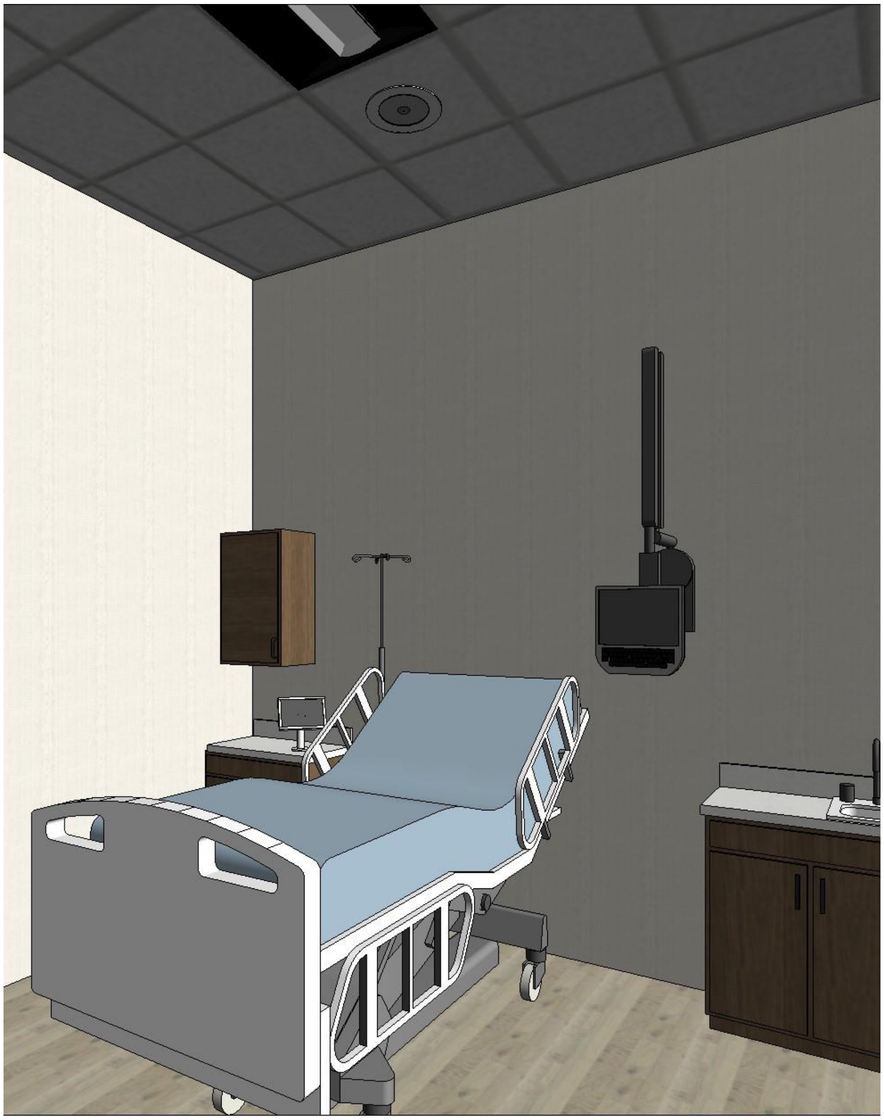


**Figure B65. LVL 1 Pre-Op 3D Rendering – Screenshot Process 2**

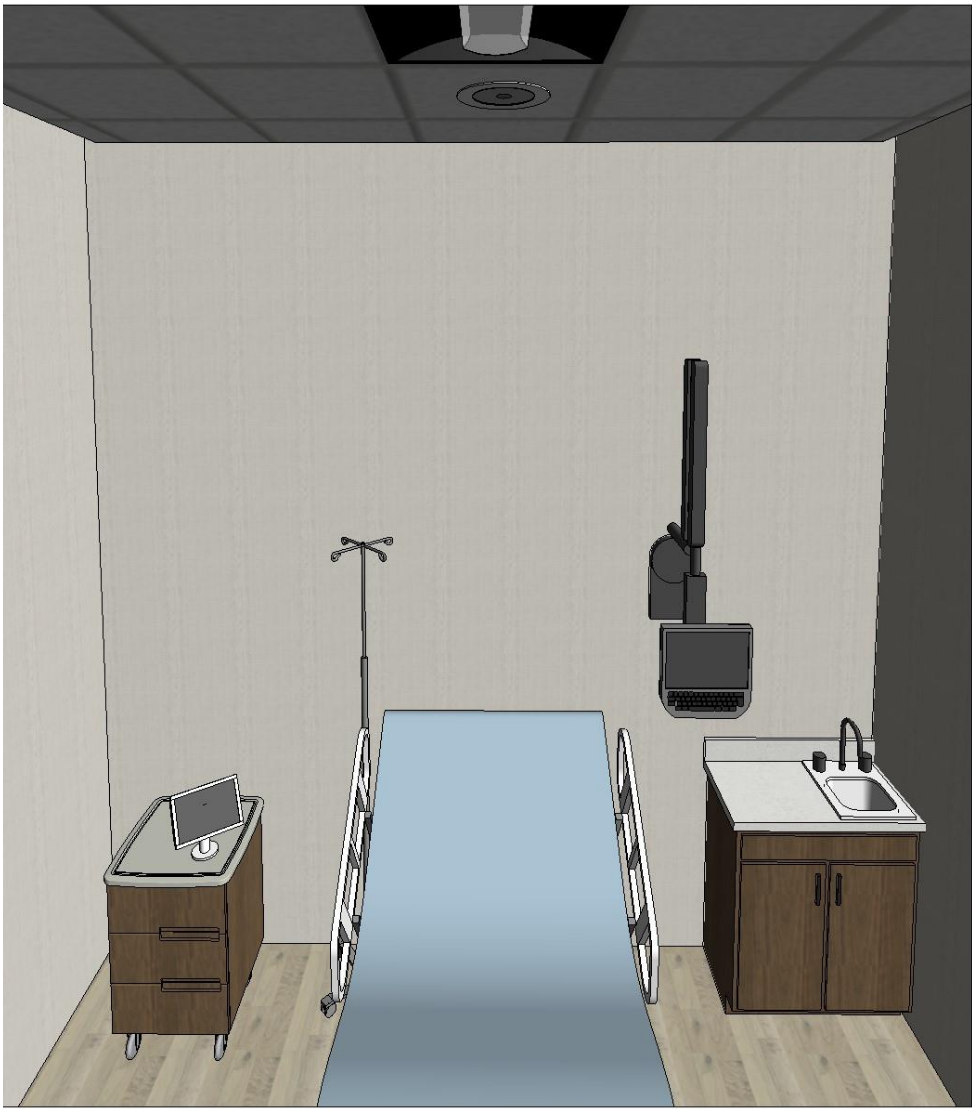


**Figure B66. LVL 1 Pre-Op 3D Rendering – Screenshot Process 3**

**Figure B67. LVL 1 Pre-Op Corridor Rendering - Process 1**

**Figure B68. LVL 1 Pre-Op Private Room Rendering - Process 2**

**Figure B69. LVL 1 Pre-Op Private Room Rendering - Process 3**

**Figure B70. LVL 1 Pre-Op Rendering - Process 4**

**Figure B71. LVL 1 Pre-Op Rendering - Process 5**

**Figure B72. LVL 1 Pre-Op Rendering - Process 6**

**Figure B73. LVL 1 Pre-Op Open Bay Rendering - Process 7**

APPENDIX C: EXPANSION OF THESIS WORK

The figures within this appendix include renderings of spaces outside the scope of research. These images include the check-in desk, waiting room lobby, and operating room. These are included to create a full scope of the patient experience within the outpatient surgical center's environment. There are no changes implemented in the figures listed below and reflect the existing project site. Refer to Figure C74, Figure C75, Figure C76, Figure C77, and Figure C78 for existing renderings of the Surgical Center of Greensboro.

**Figure C74. Waiting Room Rendering - Existing**

**Figure C75. Reception Rendering - Existing**

**Figure C76. Reception Rendering - Existing**

**Figure C77. Waiting Room Rendering - Existing**

**Figure C78. Operating Room - Existing**

# APPENDIX D: CUT SHEETS FOR LIGHTING CONTROLS

The figures within this appendix include the control system cut sheets proposed in this research investigation. The mentioned control systems are Johnson Controls, Leviton, and Intelligent Lighting Controls.

For this research investigation, Johnson Controls was the chosen system and utilized in the design simulation. However, additional cut sheets have been provided to aid future researchers investigating controllability options on the market.

For Johnson Controls OpenBlue Patient Room Optimization, reference Figure D79, Figure D80, and Figure D81 for additional information. For those interested in the capabilities of Leviton's GreenMAX DRC reference Figure D82, Figure, D83, Figure D84, Figure D85, Figure D86, Figure D87, Figure D88, Figure D89, and Figure D90. Lastly, for those looking for future controllability options that are being developed, reference Intelligent Lighting Control's cut sheets in Figure D91 and Figure D92.

**Figure D79. Johnson Controls Cut Sheet 1**

**Figure D80. Johnson Controls Cut Sheet 2**


# Introducing OpenBlue Patient Room Optimization

## Smart patient rooms are designed to bring greater comfort and convenience to hospital care – but their benefits extend far beyond the patient experience.

When patients can control their surroundings by voice or by app, they're more likely to do so safely from bed, decreasing the risk of falls, injury and wandering. And with adjustments to temperature, lighting and media in the patients' own hands, or their families', staff can stay focused on what matters most: the clinical aspects of care.

The results? For patients, a safer, more comfortable hospital stay. For facilities, greater efficiency and transparency; for clinicians, increased job satisfaction and a renewed sense that their work is rewarding.

Patients and their families arrive at the hospital with one priority: getting well. As they trust their care and safety to a team of clinicians and staff, they may feel they have little control over what happens next. The course of illness or injury is hard to predict. But the environment doesn't have to be.

Unfamiliar surroundings make it challenging for patients to relax and heal. Rooms may be too warm or cool for comfort. Window glare or dim lighting can make reading impossible. Staff making rounds can address these concerns, but it's not the best use of their time. While a nurse is closing the shades in one room, the patient next door may be waiting for help to the bathroom.

Intelligent controls in patient rooms can help ease the burden on clinical staff. Putting personal comfort in each patient's control, by voice or mobile app, means the patient can remain safely in bed, reducing fall risks and other dangers. OpenBlue Patient Room Optimization technologies can transform care settings alone or alongside other OpenBlue Bridge applications, such as the critical response platform OpenBlue Code Blue Optimization.

**An array of intelligent features**

Our OpenBlue Patient Room Optimization solutions are designed to work individually or in any combination with the technologies you already use.

These innovative options include:

- Pre-selection of patient room settings prior to hospital admission
- Safety-focused, voice-activated controls through a digital device like Amazon's Echo (Alexa)
- Integration with digital thermostats for adjustable room temperature
- Support for smart lighting systems
- Access to entertainment options, including preferred music streaming
- Controls for electronic window shades
- Custom patient meal ordering solutions
- Room occupancy alerts and settings reset between patients
- Compatibility with various mobile apps for streamlined digital solutions

2

**Figure D81. Johnson Controls Cut Sheet 3**



## Every hospital's needs and budgets are different

Our Patient Room Optimization offerings are completely configurable. You select the features that work for your staff, your facility, the patients you serve and the systems you already have in place. Whether you're building a new, cutting-edge hospital or campus or looking to modernize existing facilities, our solutions are designed to leverage your other technology investments and integrate seamlessly with all operations. Together, we'll design and build exactly what you need. And we'll keep innovating along the way to support you as those needs evolve.

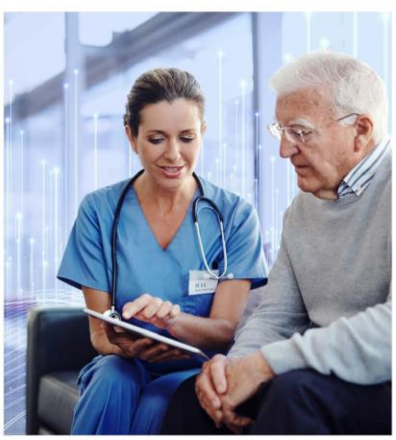
## OpenBlue Patient Room Optimization benefits all stakeholders

**For patients and their families:**
- Greater comfort and satisfaction
- A safer environment with reduced risk
- Reassurance and empowerment at a vulnerable time
- Better engagement and connection to care

**For clinicians and staff:**
- Improved safety from lower patient fall risk
- Reduced burden of non-clinical patient requests
- Greater focus on clinical aspects of patient care
- Increased clinical staff job satisfaction

**For facilities:**
- Remote access to room settings and functions
- Systems transparency, monitoring and alerts
- Improved operational efficiencies
- Optimized patient throughput and room turnover

**For IT:**
- Greater insights from systems integration and connectivity
- Compliance with stringent cybersecurity protocols
- Fully configurable for any infrastructure
- Seamless interoperability between business, building and clinical systems



## An investment in innovation

Investing in OpenBlue Patient Room Optimization technologies is a crucial step on the path to a higher standard of patient care. You can expect in return:

- Reduced risk of falls and injuries
- Better clinical outcomes
- Higher patient satisfaction ratings
- Improved clinical staff job satisfaction
- Greater operational efficiencies
- Streamlined facilities management
- Positive impact on hospital reputation

**Patient** priorities.

**Room** to innovate.

**Optimization** to enhance experiences.

**Figure D82. Leviton GreenMAX DRC App Cut Sheet 1**

Programming Guide
GreenMAX® DRC App

LEVITON

# GreenMAX® DRC App

## For System Commissioning and Control

### Commissioning Flow

- Create the project (internet connection required) and assign other users to the project if more than one person is commissioning
- All comissioning is done one room at a time from within the room
- Connect to the room controller over WiFi—system broadcasts as "GreenMAX DRC xxxxxx"—sticker with serial number is on the device
- Use identify to confirm you have the DRC you want
- Update firmware if required
- Connect to building access point if needed
- Add devices to this room controller, use identify and name devices. Remove devices that belong to other rooms
- Move to next room
- Sync to cloud

### Connectivity to Leviton Cloud Servers (Amazon)

- System does not require cloud connectivity for operation, however Leviton cloud services are used as a central point of authority for security
- Connectivity is required to create a new project and add/modify/remove users
- Periodic internet connectivity is required to update project access list, sync new rooms with the cloud during commissioning, and move access permissions between users
- During commissioning, rooms can be created without internet connectivity
- The GreenMAX DRC app communicates when changes need to be synchronized

### 1 Create a Project

- Projects are the base organizational structure for a system
- Projects should be named with organization/ company-centric terminology at levels appropriate for the system
- General building hierarchy is:
  - Project
    - Building
      - Floor
        - Area
          - Room
- NOTE: In the following examples, the project will not include an Area level

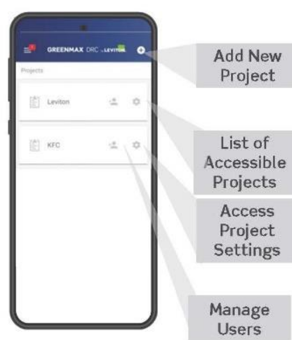
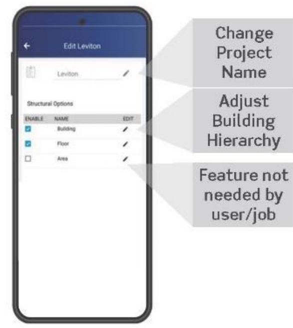


**Figure D83. Leviton Controls GreenMAX DRC App Cut Sheet 2**

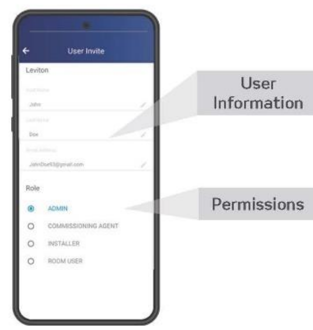
**2 Define Project Settings**

- General building hierarchy is:
  - Project
    - Building
      - Floor
        - ~~Area~~
          - Room
            - Group
- Projects and rooms are mandatory
- Building, floor and area are optional—de-select if not needed
- Building, floor and area can be re-named to terms that are more applicable to the application. For example, changing the term "Area" to "Wing", etc.
- NOTE: In the following examples, the project will not include an Area level




**3 Set Up User Permissions**

- User permissions can be assigned at any level of the building hierarchy
- All lower levels of the hierarchy inherit higher level permissions




**4 Create Buildings, Floors, Areas**

- Select project by clicking on the project name
- App will open the project and allow you to create buildings, floors, etc. as required—rooms are added last
- To add a room to an existing part of the hierarchy, navigate to the desired location and click the + button to add a room
- To connect to an existing room, navigate to it using the hierarchy


**Figure D84. Leviton Controls GreenMAX DRC App Cut Sheet 3**

5

**Creating a Room**

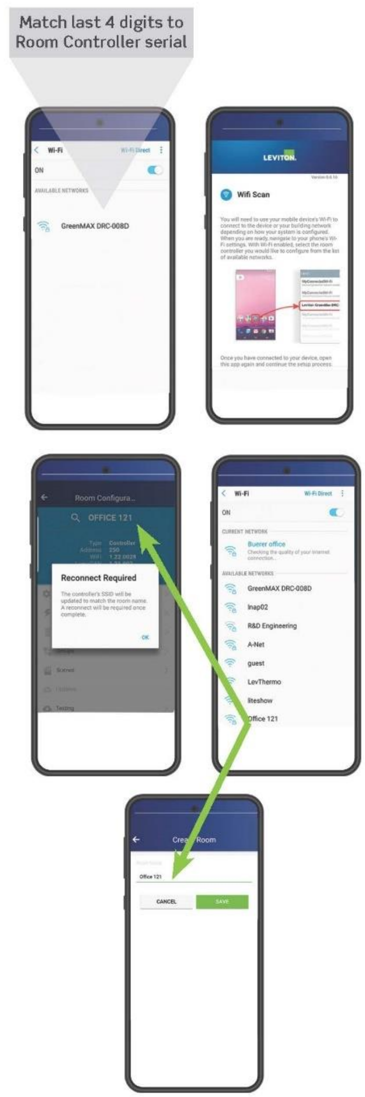
- Buildings, floors, areas, etc. are optional, but creating a room is required. Rooms are used to identify which Room Controller is secured and defined for all system level operations
- Room name should be unique within the building


6

**Connect to Room Controller**

- Connect to Room Controller AP through phone's WiFi menu
- Name will be “GreenMAX DRC xxxx”—”xxxx” are the last four digits of the unit's serial number
- Hit “Connect”
- Use password: leviton0000

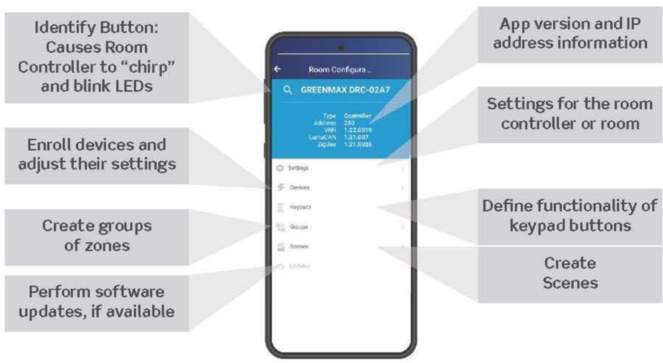

- DRC Controller AP name always matches room name
- Initial connection will initiate the following:
  - Add project security
  - Create room encryption keys
  - Rename SSID
  - Force reconnect to new SSID name




www.leviton.com/greenmaxdrc 3

**Figure D85. Leviton Controls GreenMAX DRC App Cut Sheet 4**

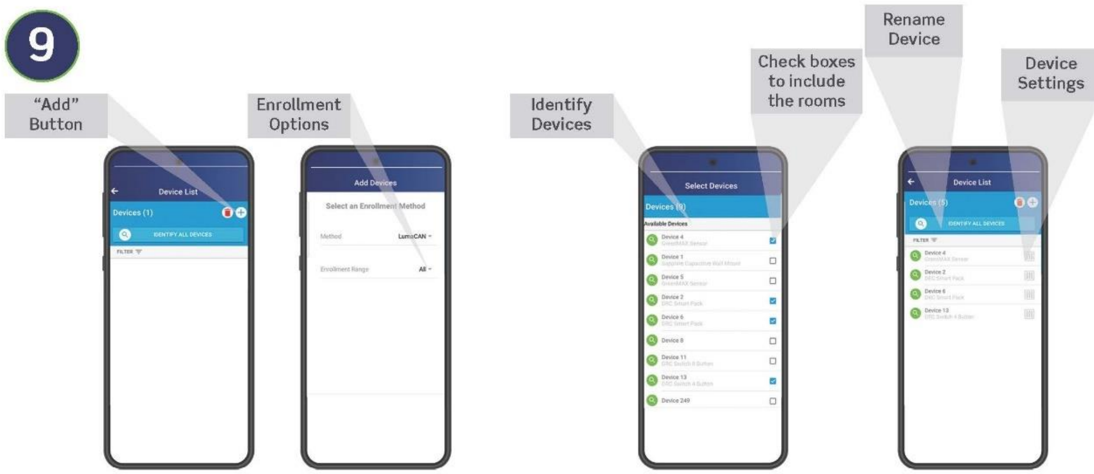
7 **Navigating the Main Configuration Screen**




8 **Connect to Building Access Point**

## Figure D86. Leviton Controls GreenMAX DRC App Cut Sheet 5

9



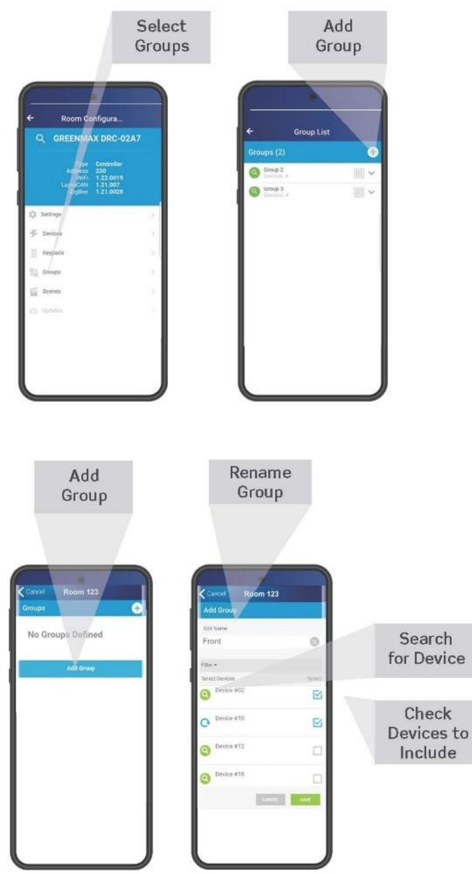

10

**Create Groups**

- Groups are the way the user interacts with the system and represent a group of lights controlled by the GreenMAX DRC Room Control System
- Common groups:
  - Front of room
  - Back of room
  - Side lights
  - Buffet lights
  - White board light
  - Entryway
  - Closet
  - Corridor
- Select "Groups" to create groups

**Group Programming**

- Select "Add Group" button
- Give the Group a name
- Use the Search buttons to determine which devices to include
- Check the boxes to include the devices within the Group
- Click "Save" when done
- Use the Search button to visually confirm the correct devices were added to the Group

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## Figure D87. Leviton Controls GreenMAX DRC App Cut Sheet 6

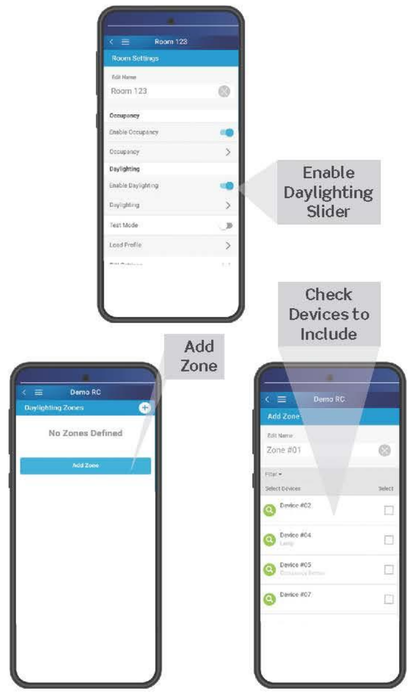
11

### Create Daylighting Zones

- Daylighting zones are groups of lights that work together in response to ambient light in a space to maintain a lighting level target
- Common daylighting zones:
  - Front of room
  - Back of room
  - Front of windows
  - Far from windows
- In Room Settings, press the "Enable Daylighting" slider to enable capabilities
- Return to the main menu and select "Daylighting Zones"

### Daylighting Zone Programming

- Select "Add Daylighting Zone" button
- Give the daylighting zone a unique name
- Use the search buttons to determine which devices to include
- Check the box(es) to include the device in the daylighting zone
- Click "Save" when done
- Use the search button to visually confirm the correct devices were added to the daylighting zone



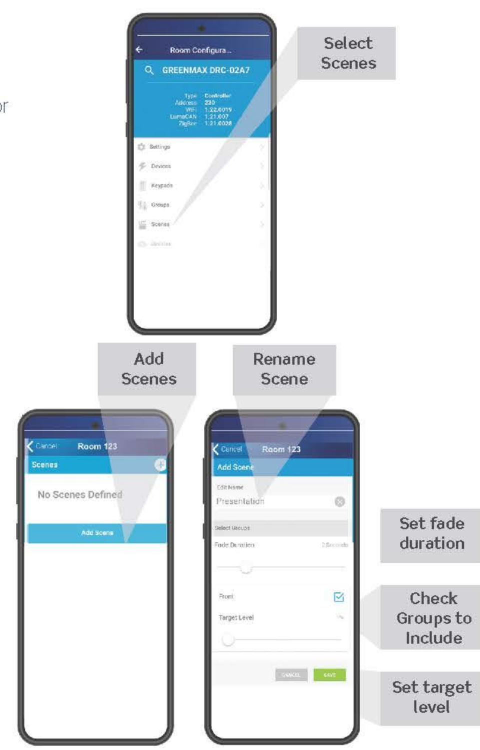

12

### Create Scenes

- A Scene is a collection of Groups with a fade time and predetermined level for assignment to a keypad button or recall from the control screen
- Common Scenes:
  - Presentation
  - Movie
  - Lunch
  - Meeting
  - Cleaning
  - Test-taking
- Select "Scenes" to create scenes

### Scene Programming

- Select "Add Scene"
- Give scene a meaningful name
- Select fade duration or fade time (2-5 seconds is common)
- Select which groups to include
- Set desired target levels for each group selected
- Click "Save" when done
- NOTE: Saves can fail if not all devices in all groups are contacted; try again fi it initially fails



## Figure D88. Leviton Controls GreenMAX DRC App Cut Sheet 7

13

### Program Keypad(s)

- Multiple Keypads may coexist
- First Keypad identified is “Master Room Controller”
- Other Keypads will be “Remotes and are added using the Devices screen
- Select “Keypads” and select the Keypad you want to configure

### Keypad Programming

- Select the gear icon on the Keypad button you wish to configure, then assign the action and any other necessary parameters:
  - ON/OFF—impacts entire room
  - Toggle Room—turns the room ON/OFF from the same button
  - Toggle Group—turns a group ON/OFF from the same button
  - Scene—executes a scene
  - Raise/Lower—multi-press raise/lower
- Click “Save” when done


14

### Configure Room Settings

- Room settings impact the entire room instead of a single device
- Select the “Room Settings” gear icon
- Occupancy Sensor Settings
  - Use the slider to enable/disable occupancy sensor capabilities
  - General > Sensitivity indicates how sensor responds Mode determines lighting behavior
  - Primary/Secondary Timeouts available
- Daylighting Settings
  - Use the slider to enable/disable daylight harvesting capabilities
  - Cap Target—lights always return to target
  - Override Allowed—user can set lights to any level until the override time elapses
  - Target Mode—auto or manual

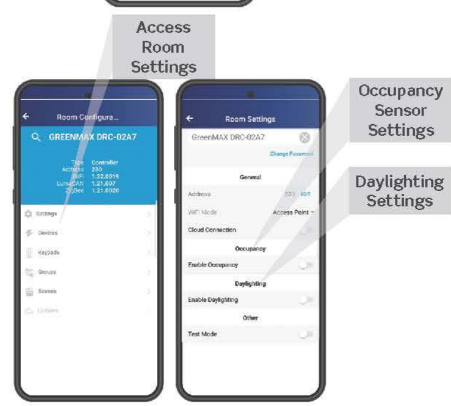


**Figure D89. Leviton Controls GreenMAX DRC App Cut Sheet 8**

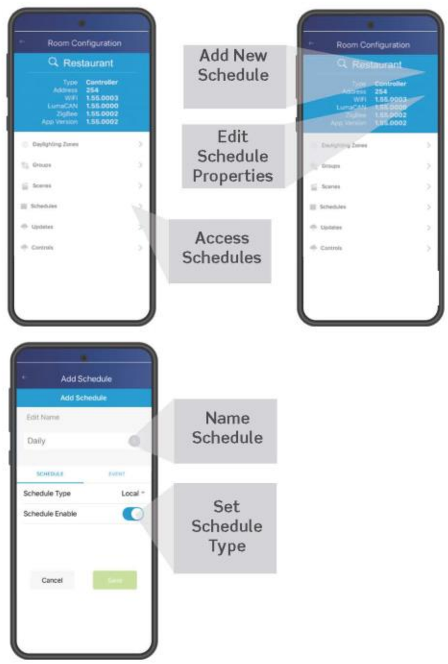
# Scheduling and Control

**All schedules are stored in the room controller**

- Ensure time is set from room settings screen before using the scheduler. See above.
- Each room controller can store up to (16) different schedules
- Each schedule can contain (32) events
- An event contains the time an event will occur, specifies how the lights will change, and determines any behavior changes for the room.

## 1 Access Schedules & Events

- From the room configuration screen, select "Schedules"
  - Click the **+** symbol to add and name new schedules
  - Click the settings icon to edit the schedule and edit events
  - Schedule names are determined for your specific needs and organizational requirements, typical Schedule Names
    - Daily Events – covering events that happen on a recurring schedule
    - Holidays – events that only occur on holiday Special – events that occur on specific dates (**i.e.** banquet room rentals, games, etc)
- Schedule Enable must be enabled for the schedule to run, the entire schedule and all of its events can be disabled by moving the slider to the disabled position
- Events are added on the Events tab, use the **+** symbol to edit an event or the settings icon to edit an existing events properties




## 2 Schedules and Events - Create, Name View

- Choose the event date/time
  - Fixed date—scheduling events on a specific date (**i.e.** outdoor lights turn red on Valentine's Day)
  - Date Range—events happening through an entire time period (**i.e.** during the summer or turning the lights on only during a time period in December)
  - Day of Week Range—events occurring only on set days between set months
  - Periodic—events that occur on a regular schedule - like the first Monday of every month
  - Periodic Range—events that occur on specific days and time (**i.e.** the first Monday between September and June)
  - Calendar—can be used for holidays (**i.e.** turn parking lots off on holidays)
- Event time type
  - Fixed Time (default)
  - Astronomical Time (**i.e.** 30 minutes after sunrise)

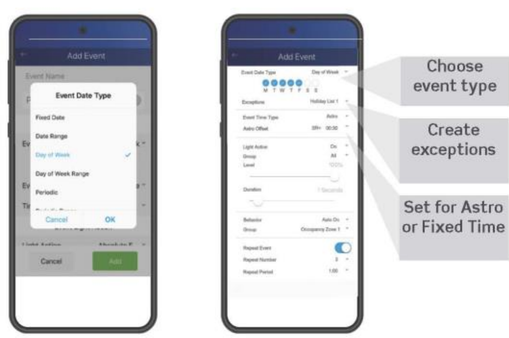
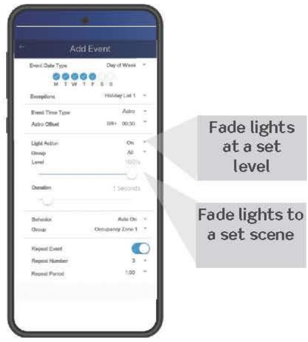


**Figure D90. Leviton Controls GreenMAX DRC App Cut Sheet 9**

### 3 Create Light Action*

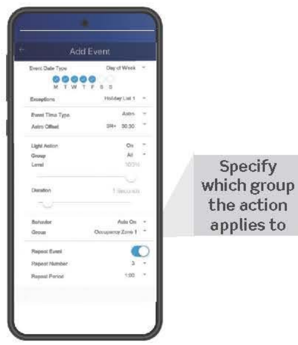
- Schedule when the light actions should occur
  - Disabled
  - Absolute fade
  - Scene fade




### 4 Set Event Behavior Action*

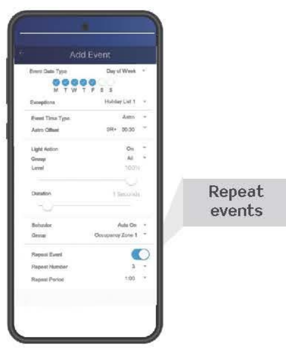
- How the room changes its operation
- Disabled
- Occupancy
  - Disabled
  - Manual ON
  - Auto ON
- Daylighting
  - Enable
  - Disable
- Keypad
  - Enable
  - Disable

*At least one action is required




### 5 Repeat

- Repeat can be used to re-trigger the event a specific number of times with a delay between triggers (**i.e.** sweeping the lights off every hour after closing)





**Leviton Manufacturing Co., Inc. Lighting & Controls**
20497 SW Teton Avenue, Tualatin, OR 97062 **tel** 800-736-6682 **tech line** (6:00AM-4:00PM PT Monday-Friday) 800-954-6004

**Leviton Manufacturing Co., Inc. Global Headquarters**
201 North Service Road, Melville, NY 11747-3138 **tel** 800-323-8920 **tech line** (8:30AM-7:00PM ET Monday-Friday) 800-824-3005


**Visit our website at: www.leviton.com/greenmaxdrc**




G-10365C/E21-aa
REV MAY 2021

**Figure D91. Intelligent Lighting Controls Cut Sheet 1**

| Catalog Number: | Date: | Project: |
|---|---|---|

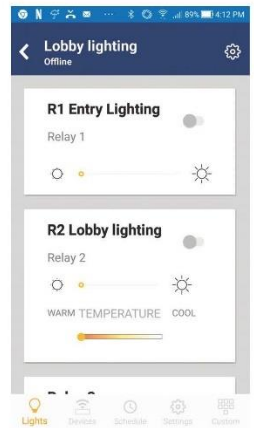
intelligent
lighting controls
A Cooper Lighting Solutions business

www.ilc-usa.com
952.829.1900

| LightLEEDer | ILC Pro |
|---|---|

## Overview

The ILC Pro App is an easy-to-use phone or tablet interface for programming and control of an EVO or LightLEEDer panel with a LightSync Bluetooth Interface or G3 Bluetooth switch. The ILC Pro App allows you to configure G3 switches, occupancy sensor inputs, photo sensors, and time schedules. The App can control relays on/off, adjust dimming levels with easy on-screen controls. The ILC Pro App is free and available on the iOS App Store or Google Play Store.


## Features

- **Made in the USA**
- **iOS or Android** compatible
- **Download** from App Store or Google Play Store
- **Direct control** of lighting from App
- **Programming** can be done on or offline
- **Connects** via Bluetooth
- **User or Admin** operation
- **Simplifies** panel configuration
- **Save/Open** a configuration file from phone memory
- **E-mail** configuration file directly from App
- **Easy set-up** for G3 switches, occupancy sensors and photo sensors
- **Scheduled** timer control
- **Password** for User and Admin protection

## Warranty

Five-year limited warranty

## Ordering

**ILC Pro App**

**ILC Pro**

Free Download:
iOS App Store
Google Play Store

ILC Pro Rev.B

# Figure D92. Intelligent Lighting Controls Cut Sheet 2

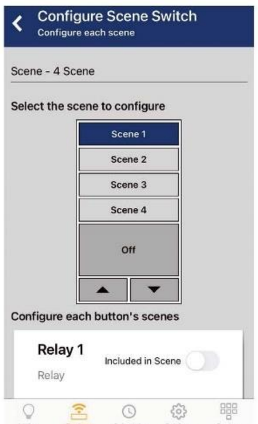
Catalog Number: | Date: | Project:

**intelligent** lighting controls
A Cooper Lighting Solutions business

www.ilc-usa.com
952.829.1900

LightLEEDer | **ILC Pro**

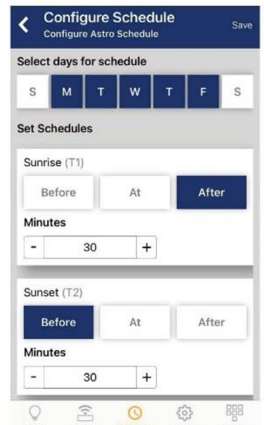
## Physical




**Configure G3 switch stations**
Supports all LightSync device types


**Configuring Occupancy Sensors**
Occupancy, vacancy, and combination occupancy dimmer levels and off settings


**Configuring Daylight Sensors**
Photo cell control for outdoor, indoor open loop and closed loop dimming




**Configuring Schedules**
For time of day, astronomical, and open/closer timers

## Specifications

- **System Settings:** Configure up to 20 relays and dimmer with user defined naming.
- **Dimmer output:** Configure control operation for intensity, color temperature or RGB color dimmers.
- **Switches:** Automatically finds connected LS devices and types, with easy to follow configuration.
- **Occupancy sensor:** Easy to follow occupancy, vacancy and occ/dim/off configurations.
- **Photocell:** Outdoor setting for On/Off and Indoor setting for open or closed loop daylight harvesting.
- **Clock Settings:** Link to device for time and location.
- **Schedule:** Set timer events for Time-of-day, open/close and astronomical time.
- **Open/Save:** Open or Save a configuration on device and send as an e-mail attachment.
- **Security:** Password protection for User and Admin level control
- **Free App Download:** from iOS App Store or Google Play Store

## Device requirements:

- **iOS 11 or greater**
- **Android 8 Oreo or greater**
- **Bluetooth communication**

ILC Pro Rev.B

A COOPER Lighting Solutions business

# APPENDIX E: THESIS DEFENSE PRESENTATION

The figures within this appendix include the visual presentation of the oral defense of this thesis. Refer to all figures as notated in the text. Additional figures from this presentation have been included as they may prove useful for future researchers.

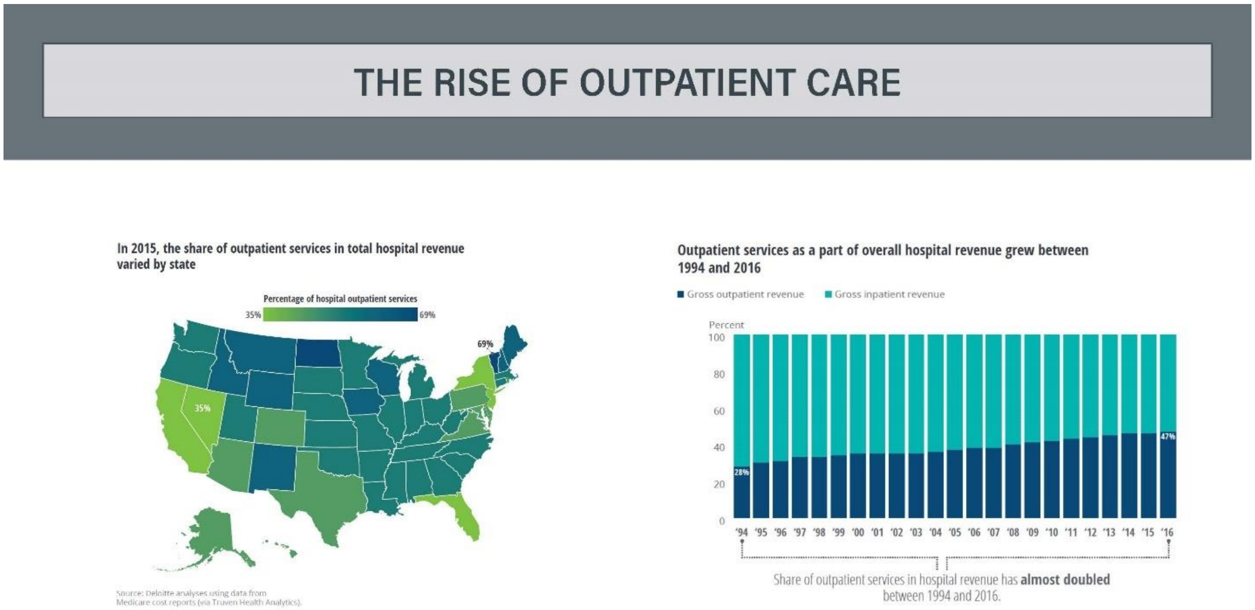
Reference to those additional figures are as follows: Figure E168 Thank You Page, Figure E169 References Slide – 1, Figure E170 References Slide – 2, Figure E171 Light Color Temperature Range, Figure E172 Existing Level 1 Pre-Operation Room – Extra Slide, Figure E173 Design Simulation Level 1 Pre-Operation Room – Extra Slide, Figure E174 Existing Level 1 Pre-Operation Unit – Extra Slide, Figure E175 Design Simulation Level 1 Pre-Operation Unit – Extra Slide, Figure E176 Design Simulation Level 1 Pre-Operation Unit – Extra Slide, and Figure E177 Existing Level 2 Post-Operation Unit – Extra Slide.

The provided information in this appendix has been covered previously in this thesis, however, this may be beneficial to further understand the processes and goals of this research investigation.

**Figure E93. Thesis Defense - Cover Page**

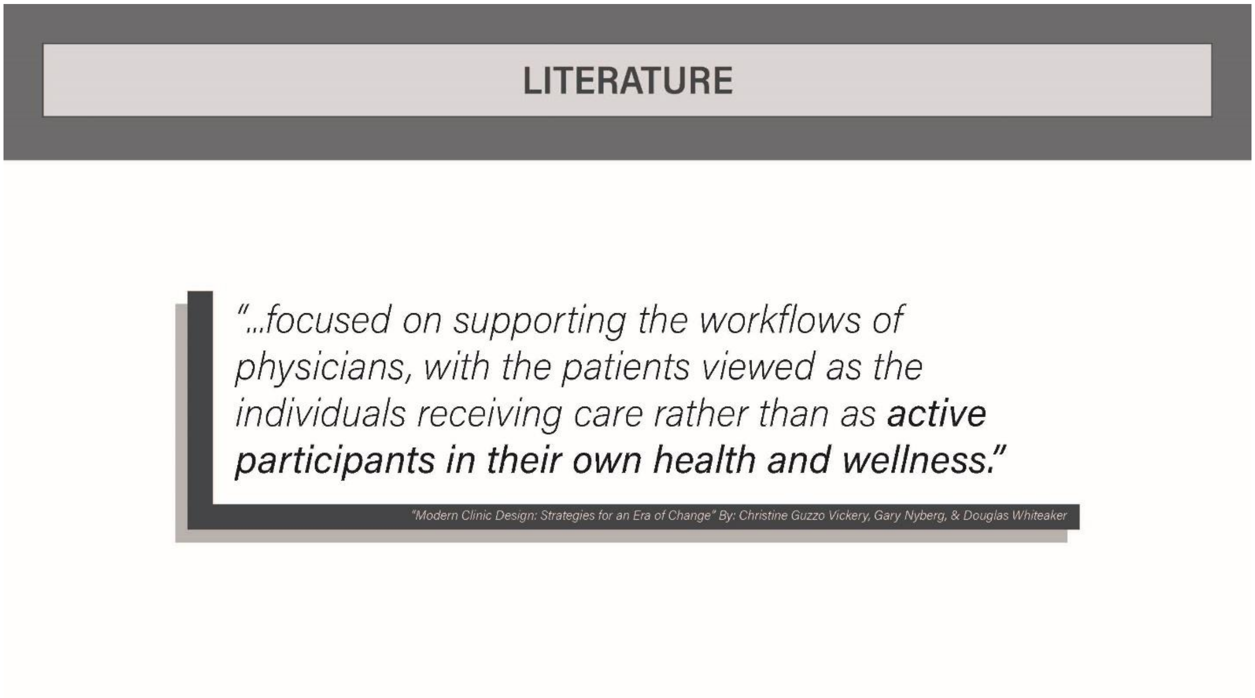

While this topic may not be of interest initially, the unfortunate truth is that everyone will at one time, or another receive some form of outpatient care. Whether that be outpatient surgery, childbirth, physical therapy, or a colonoscopy, all will enter and utilize some type of outpatient facility. See Figure E93 for visual representation.

**Figure E94. The Rise of Outpatient Care**



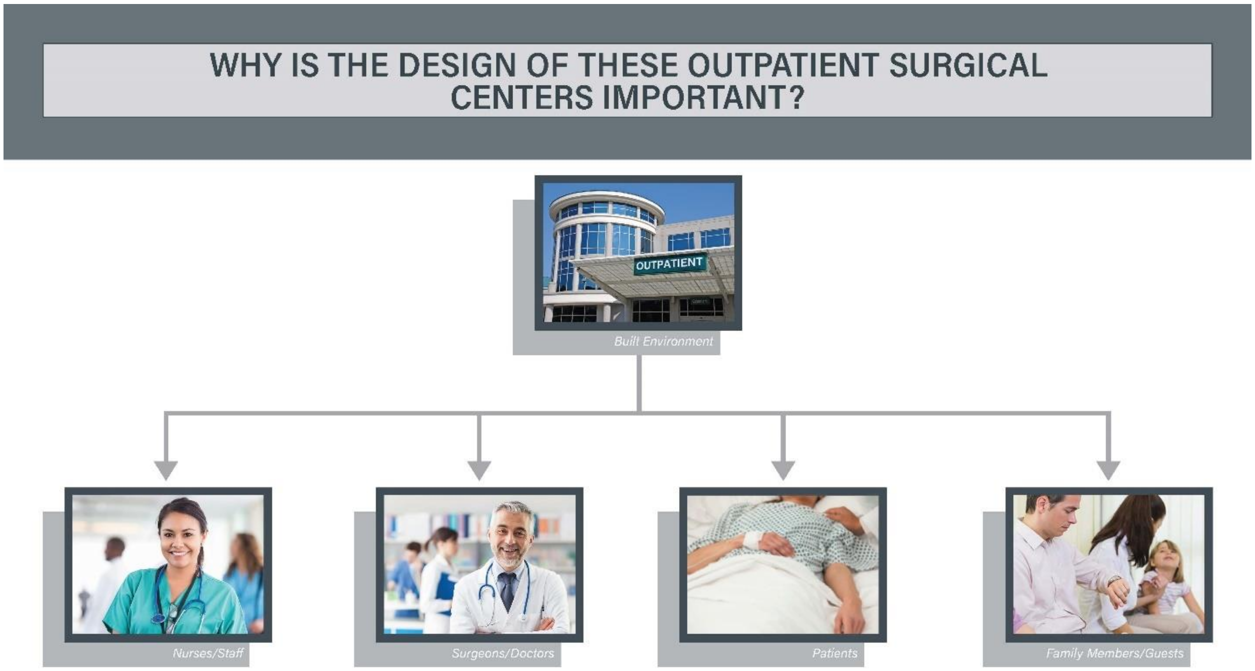

The use of outpatient services in the United States has risen significantly in the last decade. In fact, between 2005 and 2015 the use of inpatient services has declined 6.6 percent while the use of outpatient care has increased by 14 percent. Additionally, the hospital's outpatient revenue per visit has risen even faster. Between 2010 and 2015 the gross outpatient revenue grew 45 percent (*Growth in Outpatient Care*, 2018). See Figure E94 for visual representation.

**Figure E95. Literature**



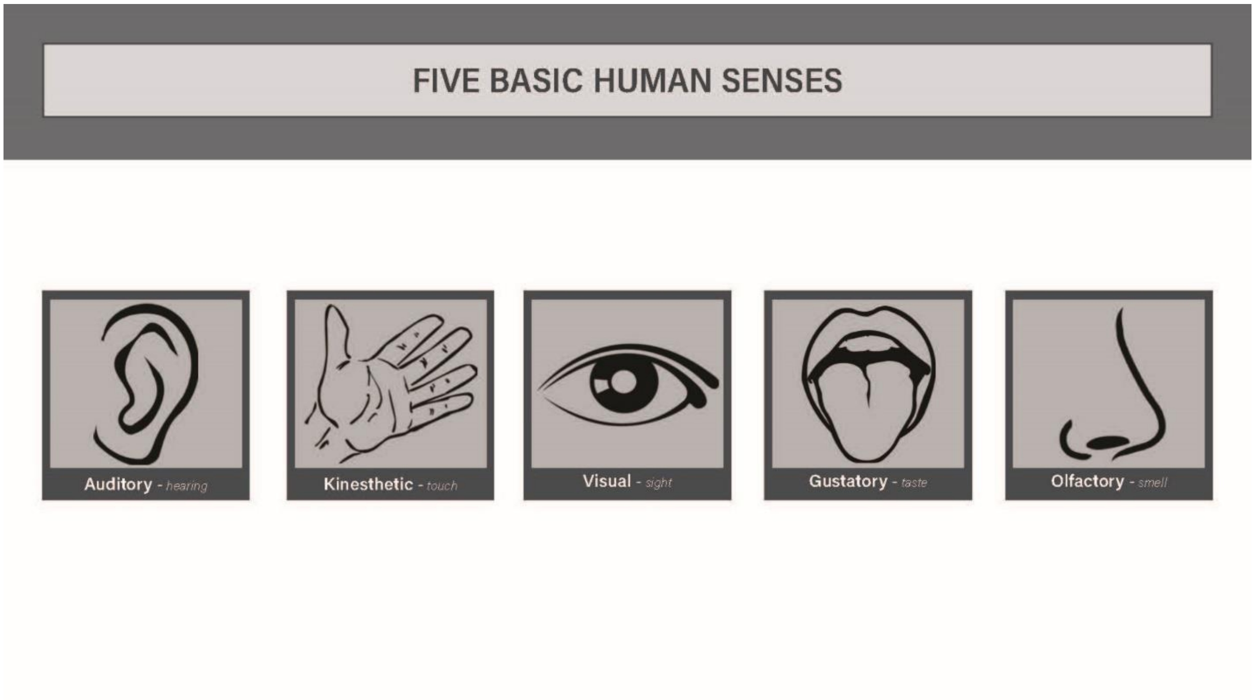

This is a quote from Modern Clinic Design which talks about how healthcare has been changing rapidly over the last couple of decades. In the past, the healthcare design was focused on the flow of physicians rather than that of patients. See Figure E95 for a visual representation of the quote referenced.

**Figure E96. Outpatient Built Environment Users**



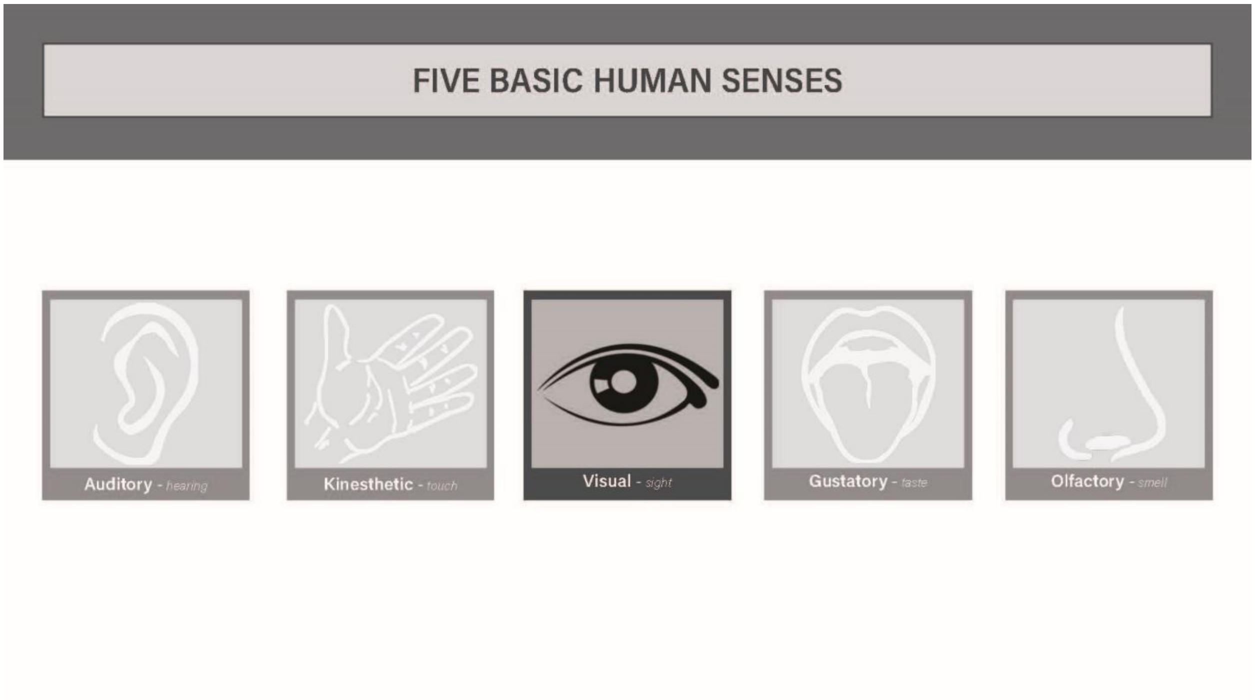

So why does this matter? Because of the rapid rise of outpatient care, the research of these facilities is lacking. These environments are all about convenience and unfortunately, have a "mill-like" feel to them. However, the design of these facilities does matter and does affect the users. Through this diagram, one can see the users that are affected by the built environment. However, for this research study, the focus will be on the patients. See Figure E96 for visual representation.

**Figure E97. Five Basic Human Senses**



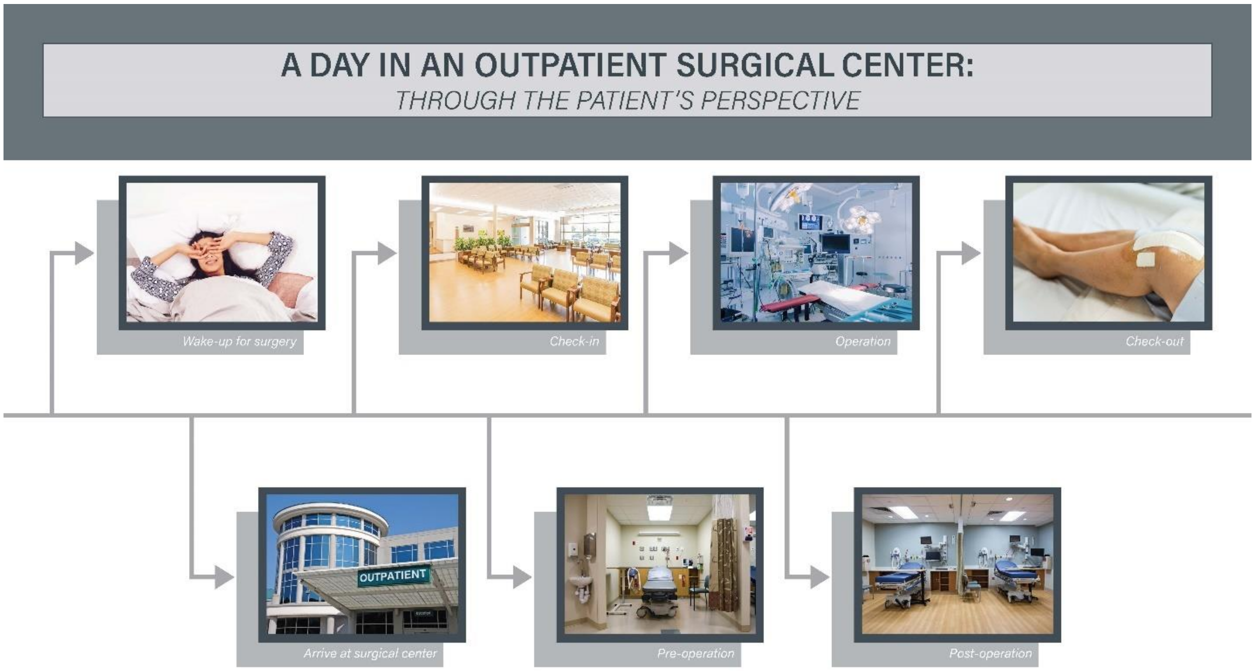

Let's look at the sensory parts. Humans experience every second of every day through the five basic human senses. With all these firing at a rapid pace, humans begin to experience the world around us. With these senses being experienced all at once, individuals tend to feel certain senses more intensely than others during specific experiences. See Figure E97 for visual representation.

**Figure E98. Five Basic Human Senses - Vision**



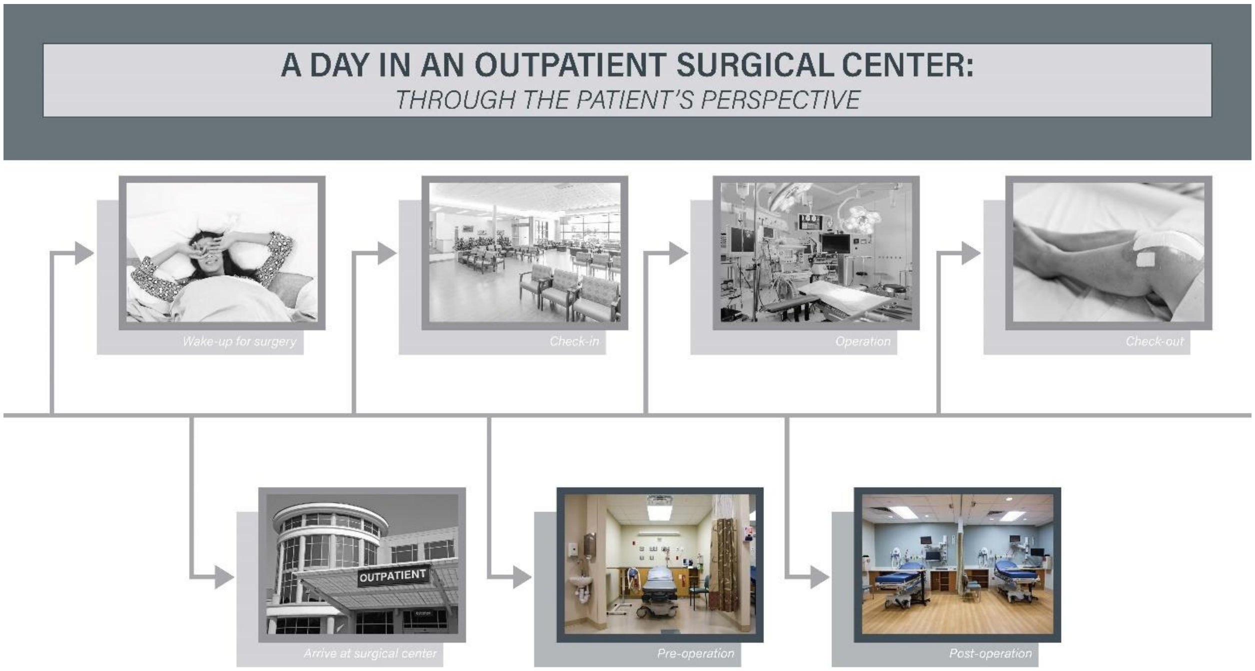

For this study, vision is the one sense that is focused on. Within outpatient surgical centers, vision is one sense people tend to feel and remember the most. Whether that be nurses and doctors running about, medical equipment, needs, or bright direct downlighting in their eyes. Vision allows individuals to take in the world around them. See Figure E98 for visual representation.

**Figure E99. A Day in an Outpatient Surgical Center: Patient's Perspective**



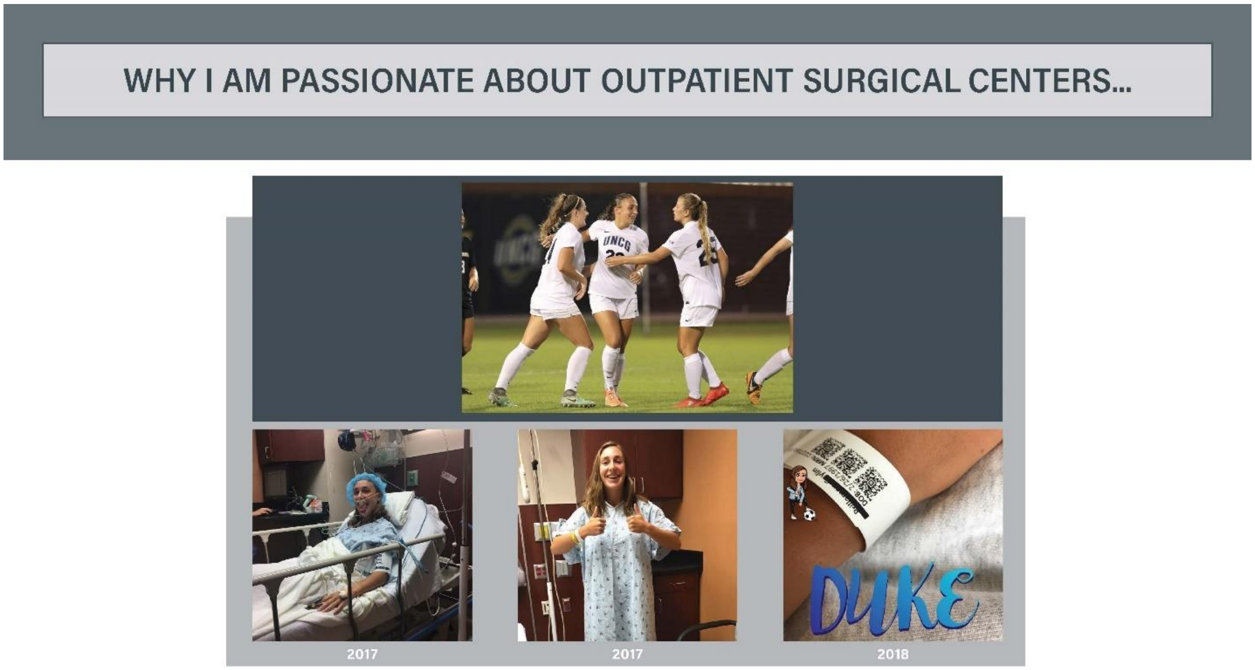

If one has not experienced surgery in an outpatient facility, it is important to understand the basic order of events for a patient in an outpatient facility. Please understand these are just the main events. This timeline does not go into depth on what is experienced in between and during these events. If the reader has experienced outpatient surgery, reflect on that experience. Be sure to focus on the five basic human senses and try to relive that experience. See Figure E99 for visual representation.

**Figure E100. A Day in an Outpatient Surgical Center: Patient Spaces**




As previously stated, the focus of this research is on the patients within outpatient facilities. Due to the nature of healthcare, the patients do not have much or any control over the physical environment and schedule. However, two areas can be considered the patient's space. These are the pre-operative and post-operative spaces. See Figure E100 for visual representation.

**Figure E101. Researcher Background**

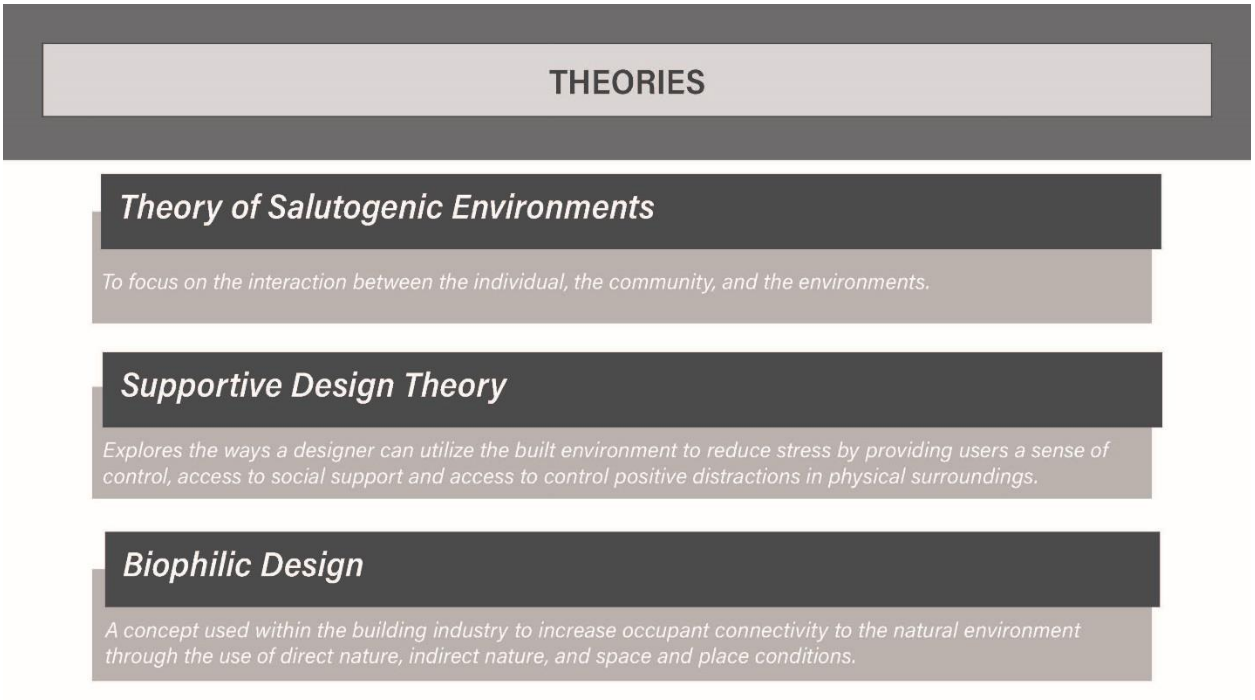



Throughout my undergraduate degree, I was a student-athlete and a member of the University of North Carolina at Greensboro women's soccer team. It was not until the beginning of my junior season that I first experienced outpatient surgery. I ended up having three different surgeries, in three different facilities, in under a year. When I think back to my own experience within those three facilities, I remember one thing more intensely than anything else, the bright direct downlighting in my eyes. I did have a unique experience not only from the patient's perspective but also as an interior architecture student taking a lighting class. These experiences coupled with my undergraduate studies sparked my interest in the effects of lighting in outpatient surgical centers for patients. See Figure E101 for imagery and dates.

**Figure E102. Research Question**

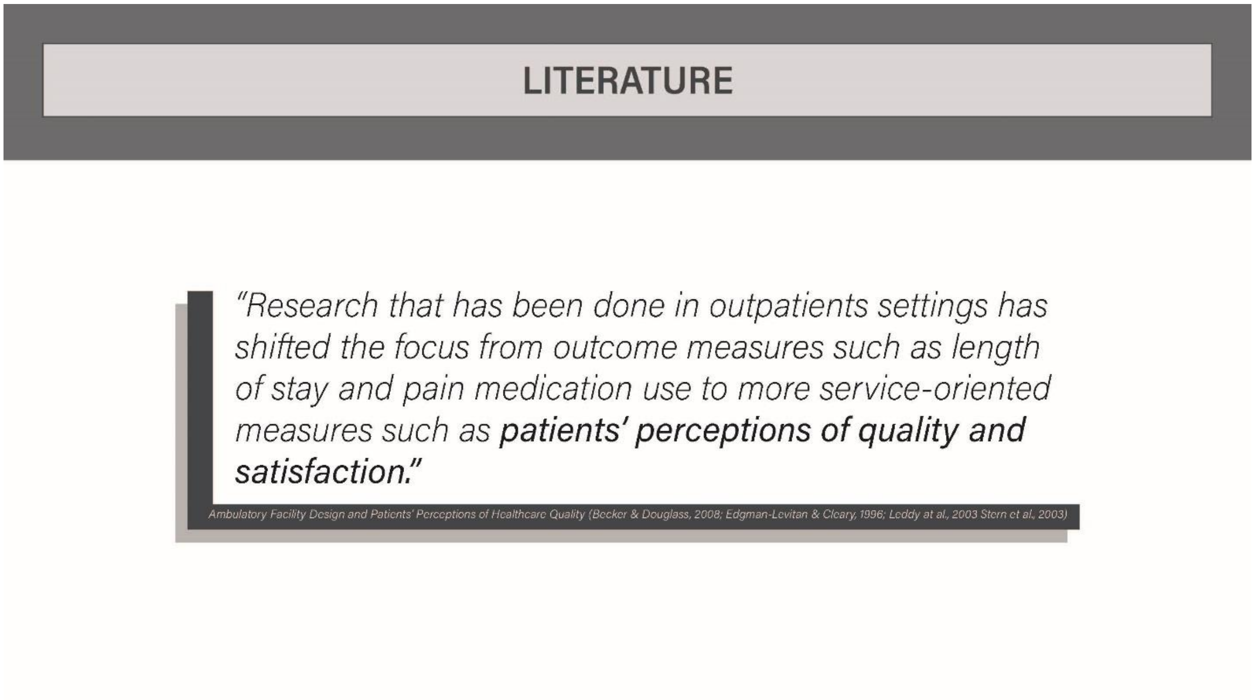

Now that there is a basic understanding of outpatient procedures and background information, this leads to the overall research questions. How can the pre and post-operating rooms be a more flexible environment that will not only empower patients but also enhance their experience through the controllability of lighting? See Figure E102 for a visual representation of the research question.

**Figure E103. Theories**




With the question in mind, here is a list of theories that are used to help ground the research. Environment Enrichment gives context to the research by saying that stimulating environments increases brain activity and lowers stress. Supportive Design Theory is an important one because it provides a sense of control in what can feel like an uncontrollable environment by providing positive distractions. Lastly, Biophilic Design is used because the healing powers of nature exist and are important within healthcare. While biophilia is not the main goal of this thesis, it will heavily impact the redesign of the pre and post-operative spaces. See Figure E103 for more information on the theories used.

**Figure E104. Literature**




This quote from ambulatory facility design and patients' perceptions of healthcare quality shows that research is beginning to shift when it comes to outpatient care. Furthermore, in this article, they explain that in other service-oriented fields such as banks, restaurants, and retail stores it has long been recognized that the physical environment can have an immediate effect on the attitudes and behaviors of consumers. So why would the same not be true within healthcare? See Figure E104 for a visual representation of the quote referenced.

**Figure E105. Research Goals and Purpose - 1**


**Figure E106. Research Goals and Purpose - 2**

**Figure E107. Research Goals and Purpose - 3**


**Figure E108. Research Goals and Purpose - 4**

**Figure E109. Research Goals and Purpose - 5**

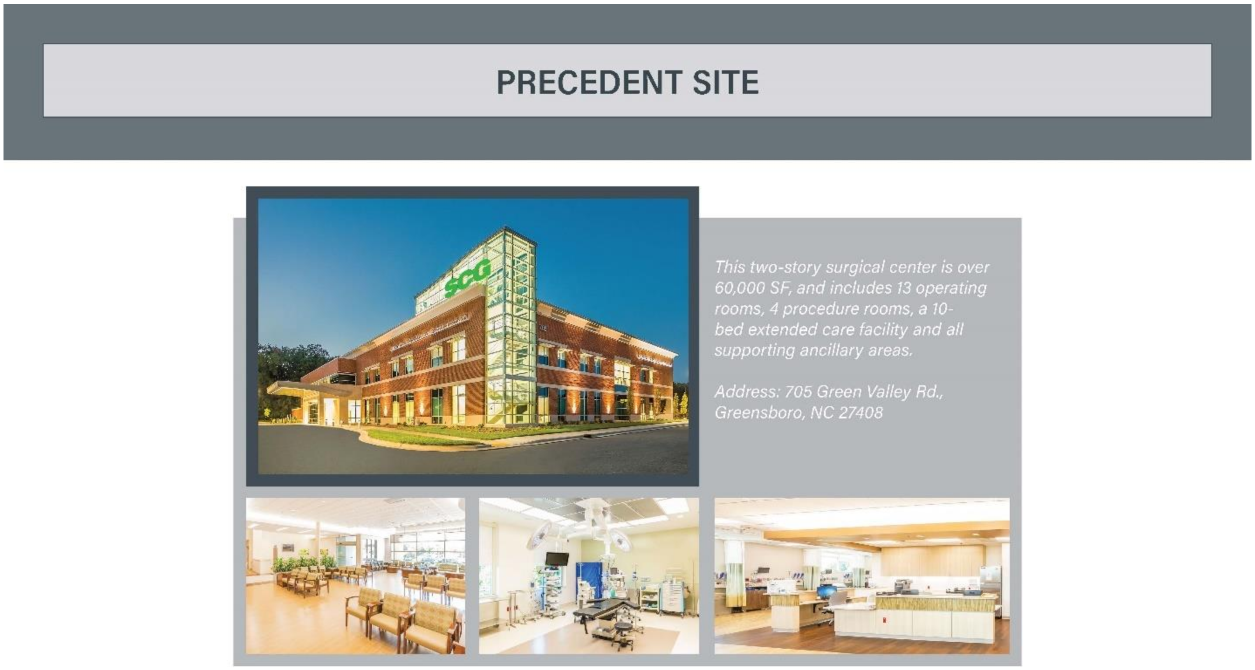

**Figure E110. Research Goals and Purpose - 6**

With the research question and theories in mind, let's walk through the research goals and purpose which will be visually represented in Figure E105, Figure E106, Figure E107, Figure E108, Figure E109, and Figure E110. First, to find an existing outpatient surgical center. Then by recreating the outpatient surgical center, the researcher can create design simulations and manipulate the added layers of light that will be proposed. Propose how the lighting layers will be controlled by the patients, explain any limitations that may have arisen throughout this research investigation, and offer directions for future researchers looking to build on the body of knowledge.

**Figure E111. Precedent Studies**

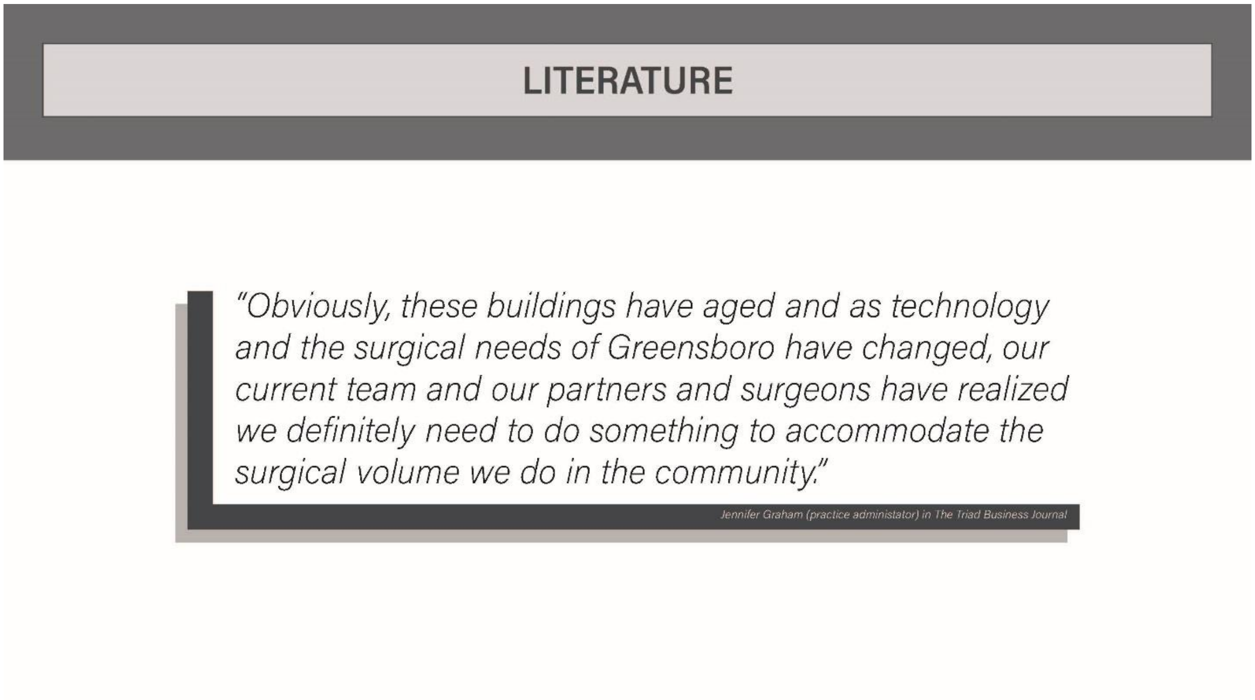

The researcher had three surgeries in three different outpatient facilities which are shown as precedent studies in Figure E111. When deciding on an existing space to use, the date on which they were built was extremely important. The goal was to use the most innovative or up-to-date space out of the three precedents.

**Figure E112. Precedent Site**



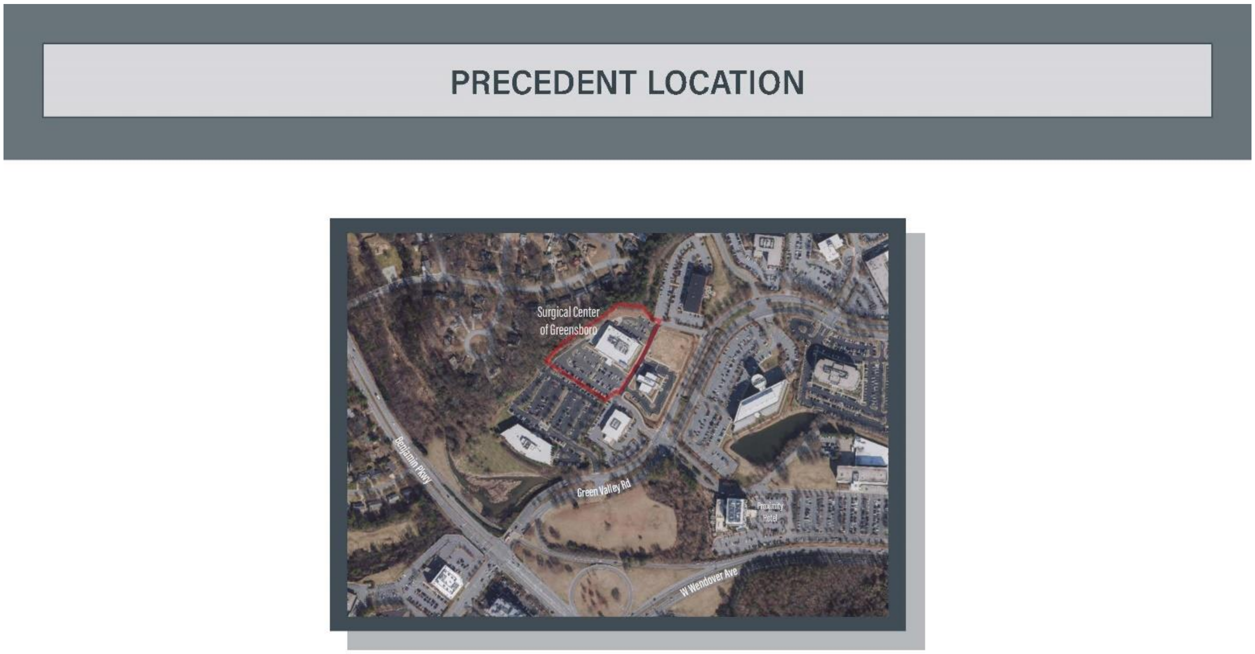

Because of that, the Surgical Center of Greensboro was chosen. This is a two-story 60,000 square-foot space that includes thirteen operating rooms, four procedure rooms, and a ten-bed extended care facility. The Surgical Center of Greensboro was designed by CJMW and built by Landmark Builders in the spring of 2017. Making this, the newest building out of the three precedent studies. See Figure E112 for more information.

**Figure E113. Literature**




This is a quote from Jennifer Graham, the practice administrator of the Surgical Center of Greensboro in an interview with The Triad Business Journal. They recognized that outpatient is on the rise and now that technology and surgical needs have shifted here in Greensboro, it is time for an updated facility to accommodate the surgical needs within the community. See Figure E113 for a visual representation of the quote referenced.

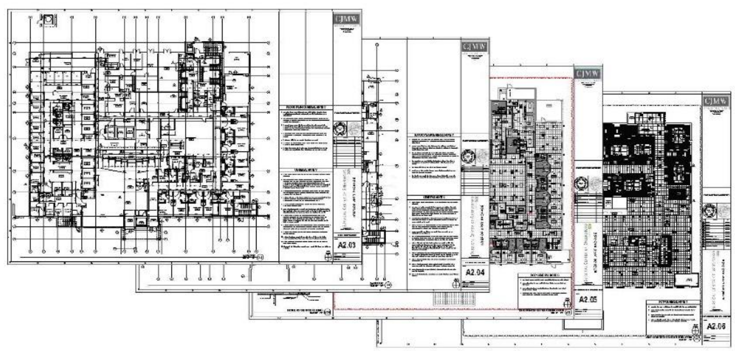
**Figure E114. Precedent Location**




This is a quick map to better understand where the Surgical Center of Greensboro is located. It is right off Green Valley Rd. and sits adjacent to the Proximity Hotel. Additionally, it is in close relation to the Friendly Shopping Center, which is not visible on this map but is located right over Benjamin Parkway. See Figure E114 for visual representation.

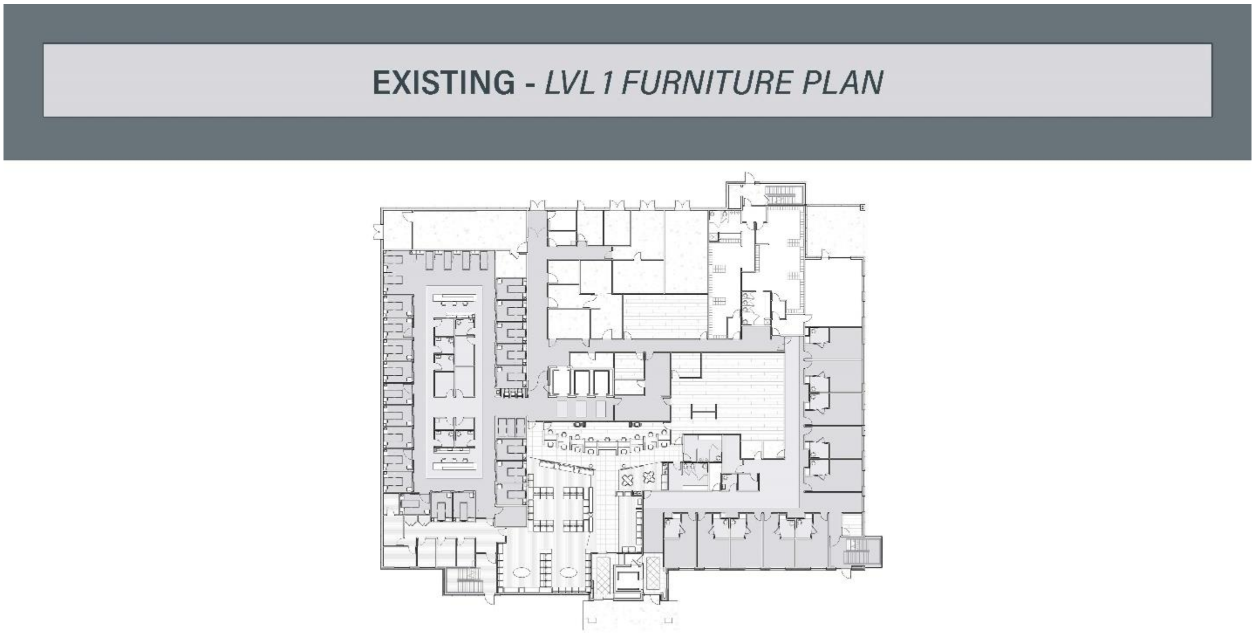
**Figure E115. Existing Construction Documents**

EXISTING CONSTRUCTION DOCUMENTS



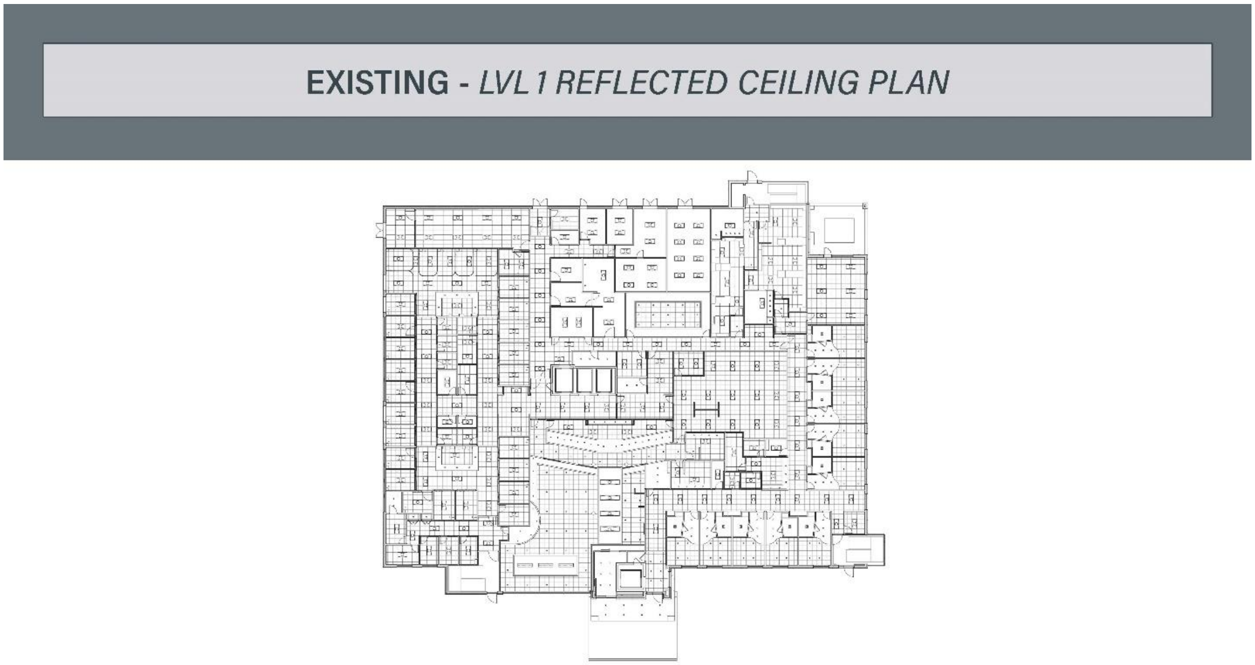

Interior plans and construction documents were obtained by Kim Givens at Landmark Builders in the summer of 2020. This was vital in accurately recreating the existing spaces and prepping for the additional layers of light and controllability options that are implemented in the design simulation. See Figure E115 for visual representation.

**Figure E116. Existing - Level 1 Furniture Plan**



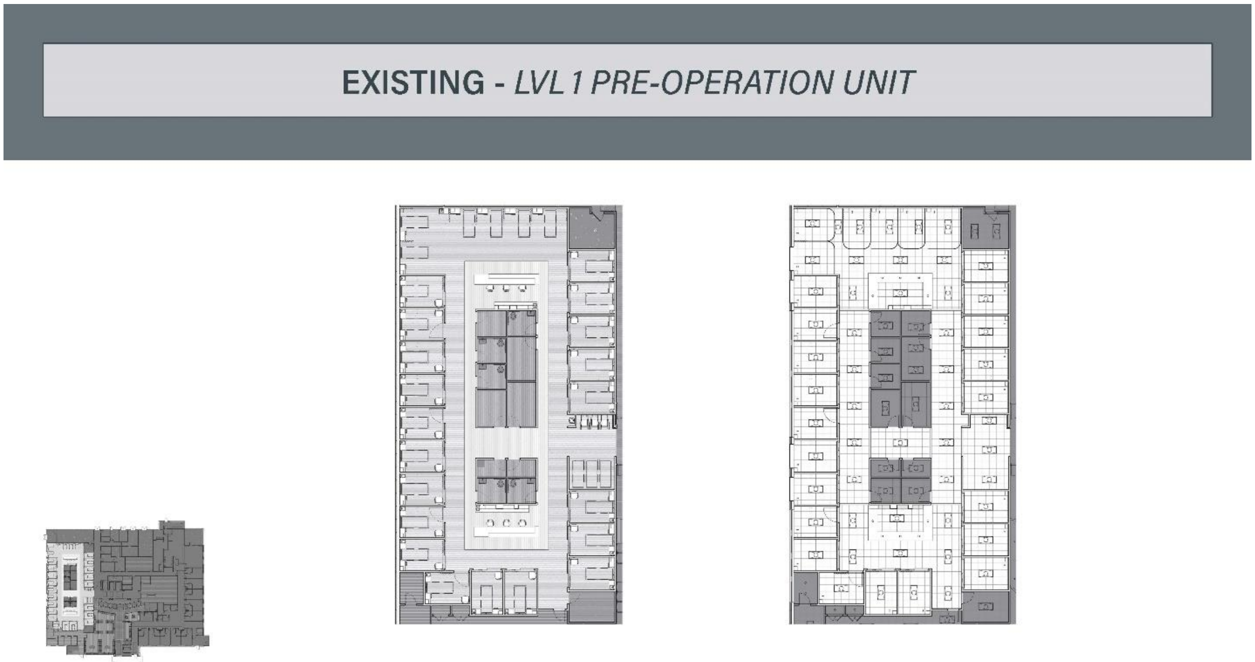

Here you see the existing Surgical Center of Greensboro's level one. This floor contains the entry, check-in, waiting room, and pre-operating unit, the ten-bed extended care facility, and back-of-house spaces. Just to note, there will be no changes to the existing floor plan. However, showing the entirety of level one for reference is beneficial to fully understand the space as seen here in Figure E116.

**Figure E117. Existing - Level 1 Reflected Ceiling Plan**



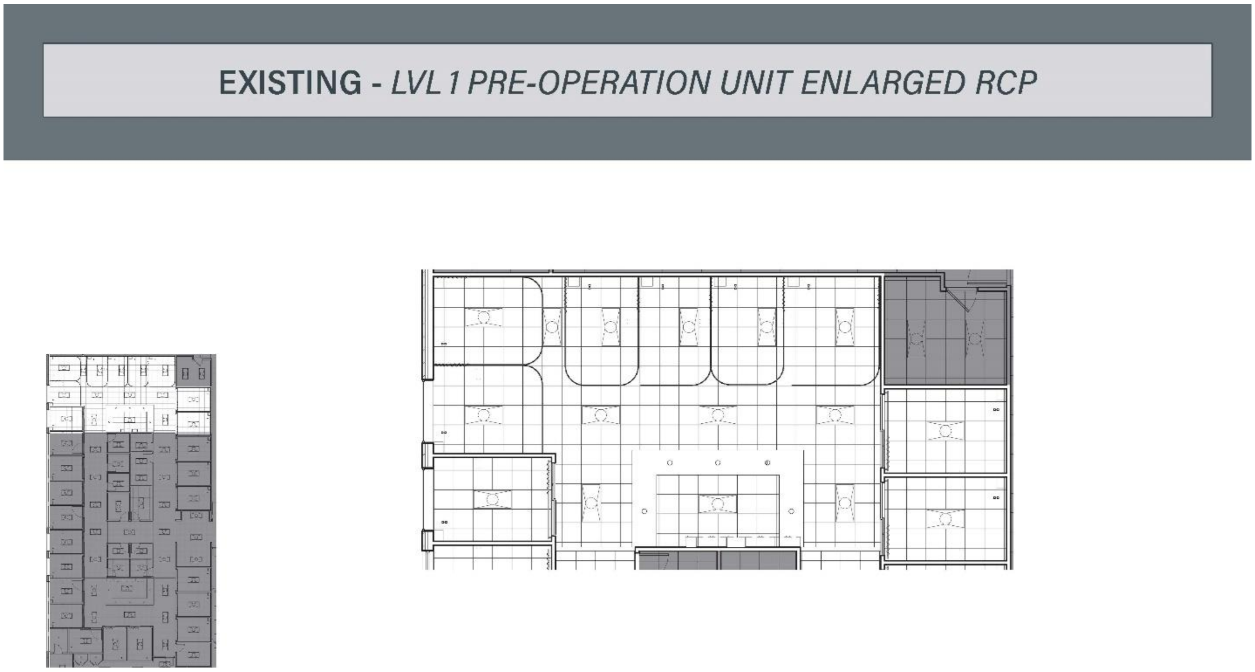

This is the existing level one reflected ceiling plan, as seen above in Figure E117. Due to the nature of this research, the focus will be predominantly on the reflected ceiling plan. There will be changes made to this plan, however, those will be pointed out later in the redesign portion of this presentation.

**Figure E118. Existing - Level 1 Pre-Operation Unit**



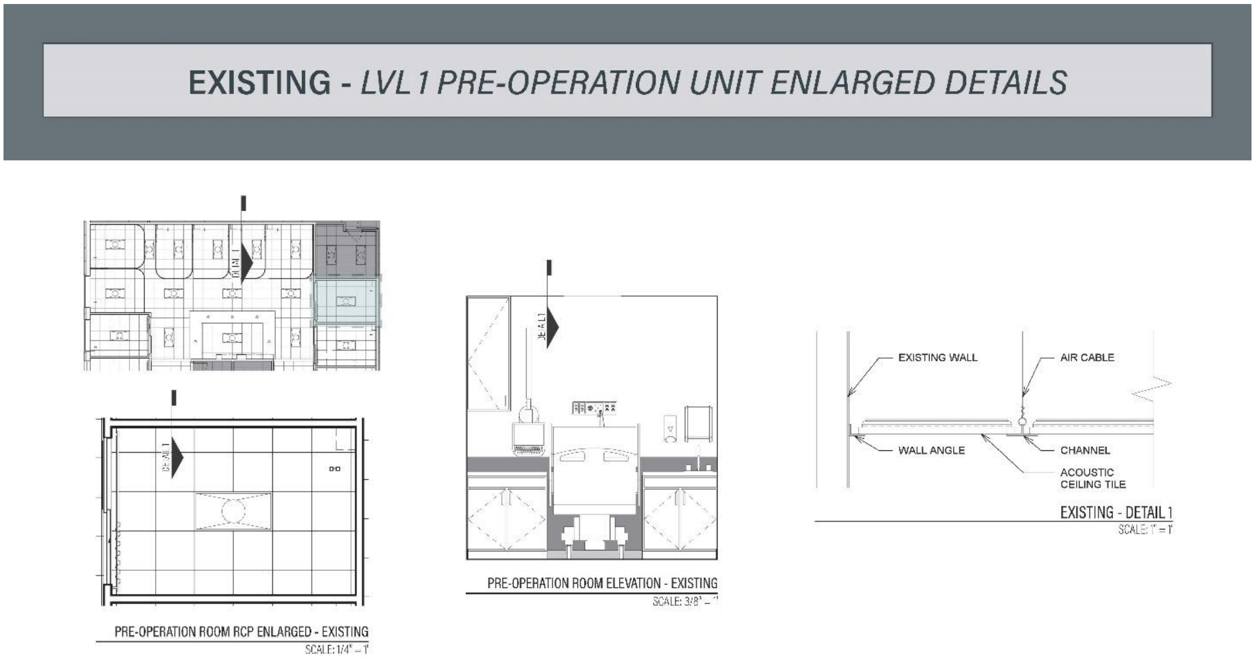

To reiterate, we will be focusing on the two areas that "belong" to the patient during their short visit. These are enlarged plans of the pre-operative unit on level one. Throughout the presentation, a key will be provided in the bottom left of the screen to assist in orientating oneself in the space. The dark grey region is used to show the areas that are not in scope. See Figure E118 for visual representation.

**Figure E119. Existing - Level 1 Pre-Operation Unit Enlarged Reflected Ceiling Plan**




Due to the previous plans being a smaller scale and hard to read, a further enlarged pre-operative unit's reflected ceiling plan is shown in Figure E119 Existing – Level 1 Pre-Operation Unit Enlarged Reflected Ceiling Plan. With this plan, one can see the existing ceiling and lighting conditions.

**Figure E120. Existing - Level 1 Pre-Operation Unit Enlarged Details**

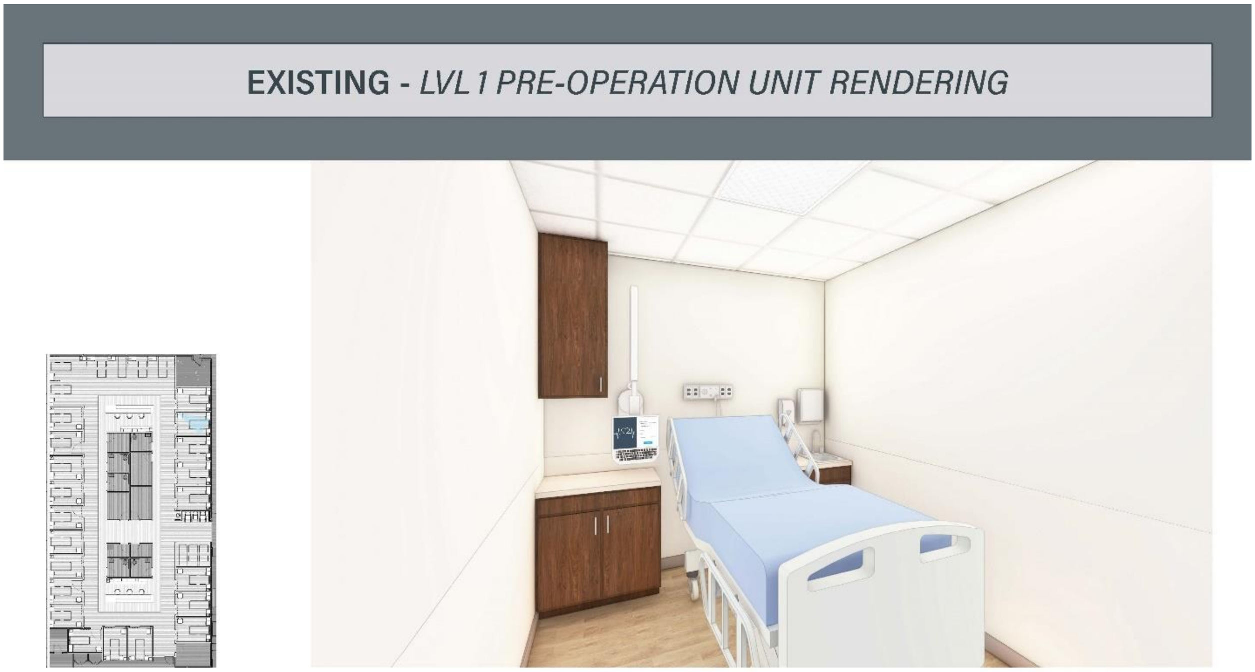



To better understand the conditions, an elevation and section detail of the existing ceiling has been provided and is visually represented in Figure E120 Existing – Level 1 Pre-Operation Unit Enlarged Details. The current ceiling is a 2x2 acoustic ceiling tile and grid with one light source. The light source is a 2x4 direct downlight. For some, these places will not help them understand the space. So, 3D renderings of the existing pre-operative unit have been provided. An additional note as one experiences the space three-dimensionally, all materials are existing to the space and were provided in the plans from Kim Givens at Landmark Builders.

**Figure E121. Existing - Level 1 Pre-Operation Unit Rendering - A**


To help orient yourself as we move through these renderings, please reference the key plan and utilize the small transparent viewport, to understand where the camera view is set up. See Figure E121 for visual representation.

**Figure E122. Existing - Level 1 Pre-Operation Unit Rendering - B**




Within this private pre-operation room please notice the existing 2x2 acoustic ceiling tile and grid with the singular 2x4 downlight. See Figure E122 and Figure E123 for visual representation.

**Figure E123. Existing - Level 1 Pre-Operation Unit Rendering - C**

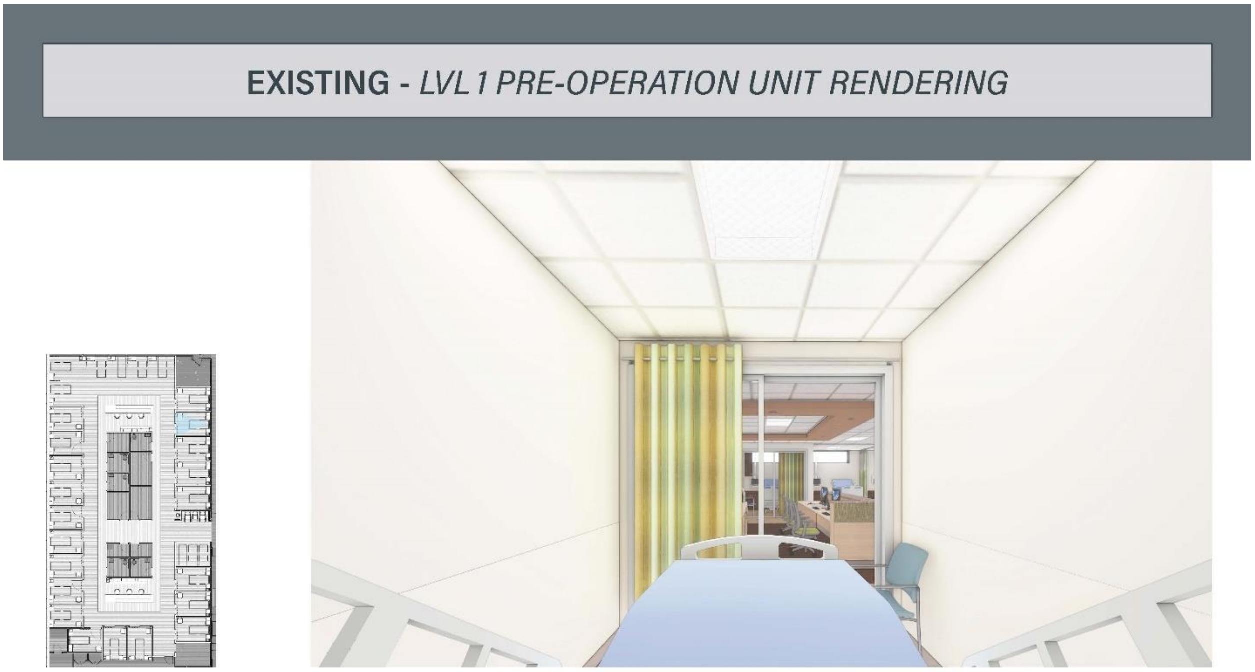
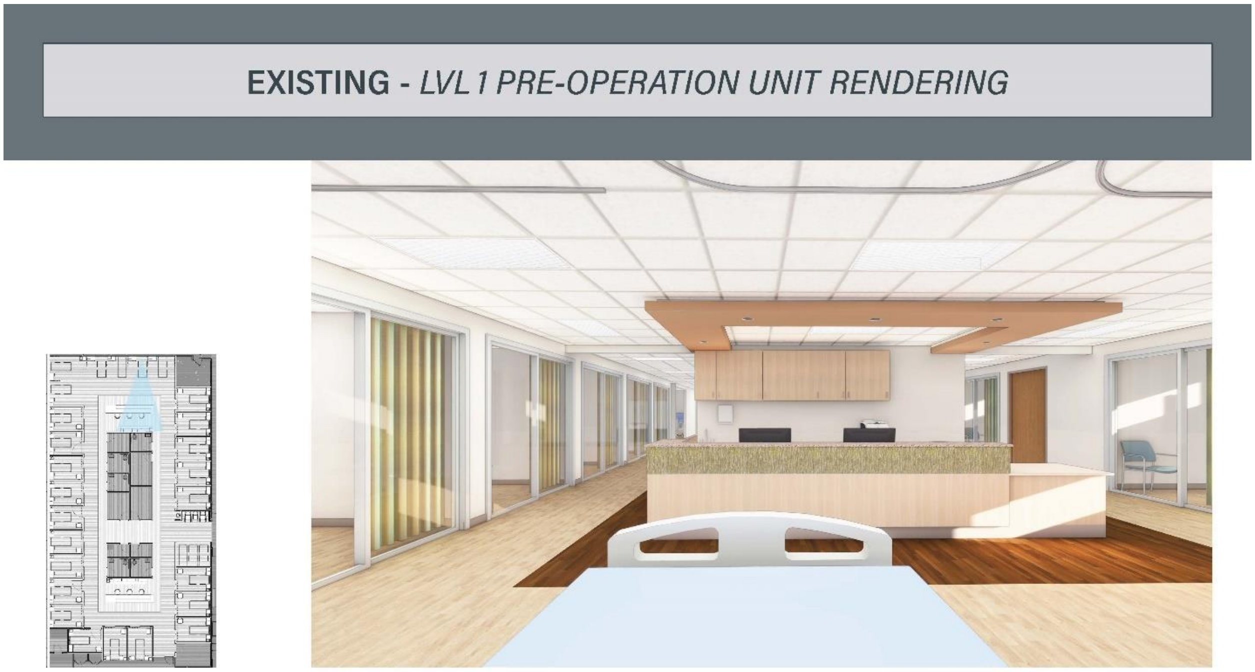


**Figure E124. Existing - Level 1 Pre-Operation Unit Rendering - D**

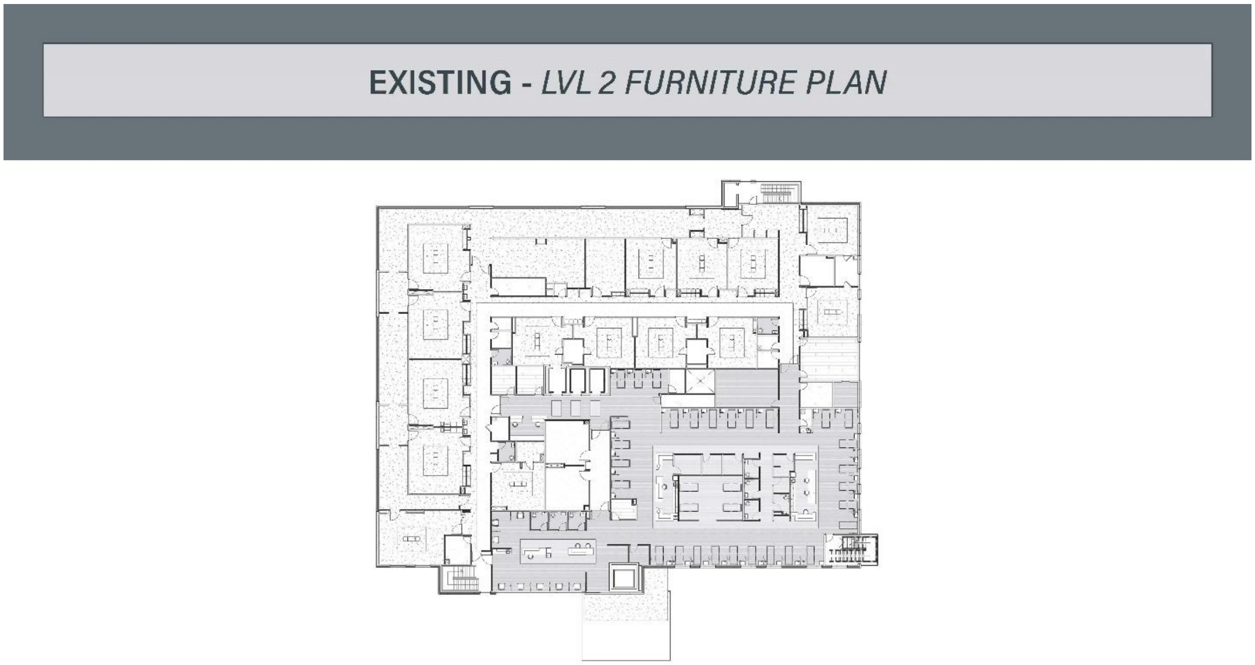

Again, please take note of the existing 2x2 acoustic ceiling tile and grid with the singular 2x4 downlight here in the open bay of the pre-operative unit. Shown here in Figure E124 and Figure E125.

**Figure E125. Existing - Level 1 Pre-Operation Unit Rendering - E**



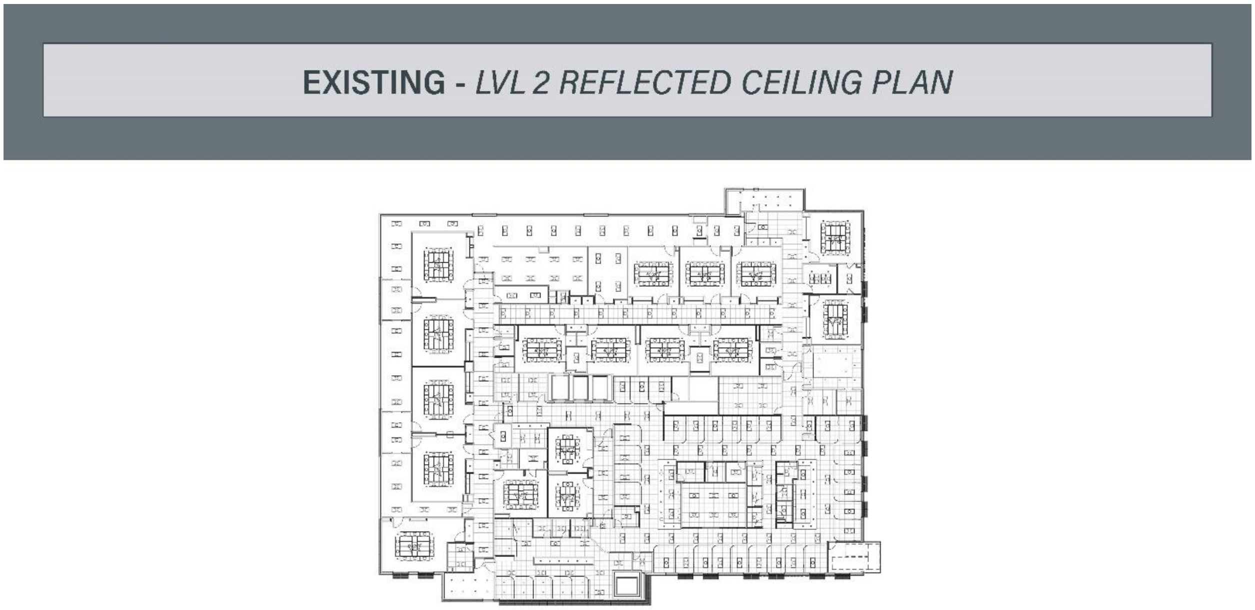

Within this rendering, there is access to daylighting in some areas of level one pre-operative unit as shown here in Figure E125.

**Figure E126. Existing - Level 2 Furniture Plan**



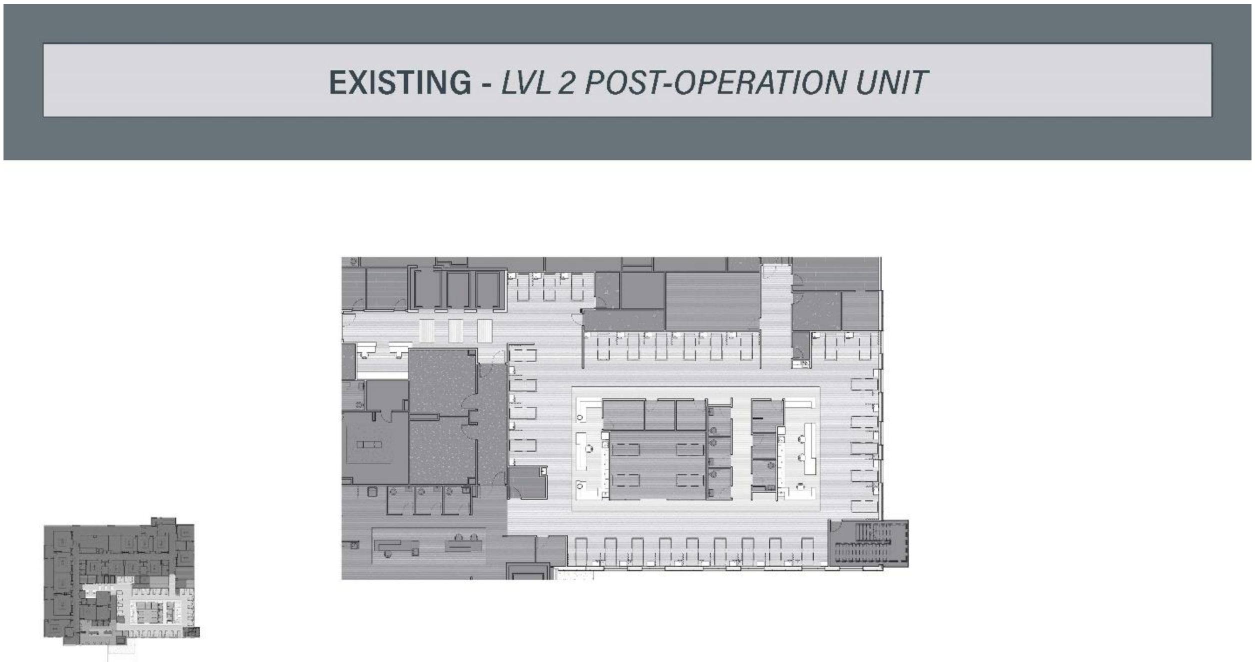

Moving upstairs to the existing level two. This floor includes 13 operating rooms, 4 procedure rooms, the post-operative unit, and back-of-house spaces. Similar to level one, there will be no changes to the existing level two floor plan. However, showing the entirety of level two for reference is beneficial to fully understand the space. See Figure E126 for visual representation.

**Figure E127. Existing - Level 2 Reflected Ceiling Plan**



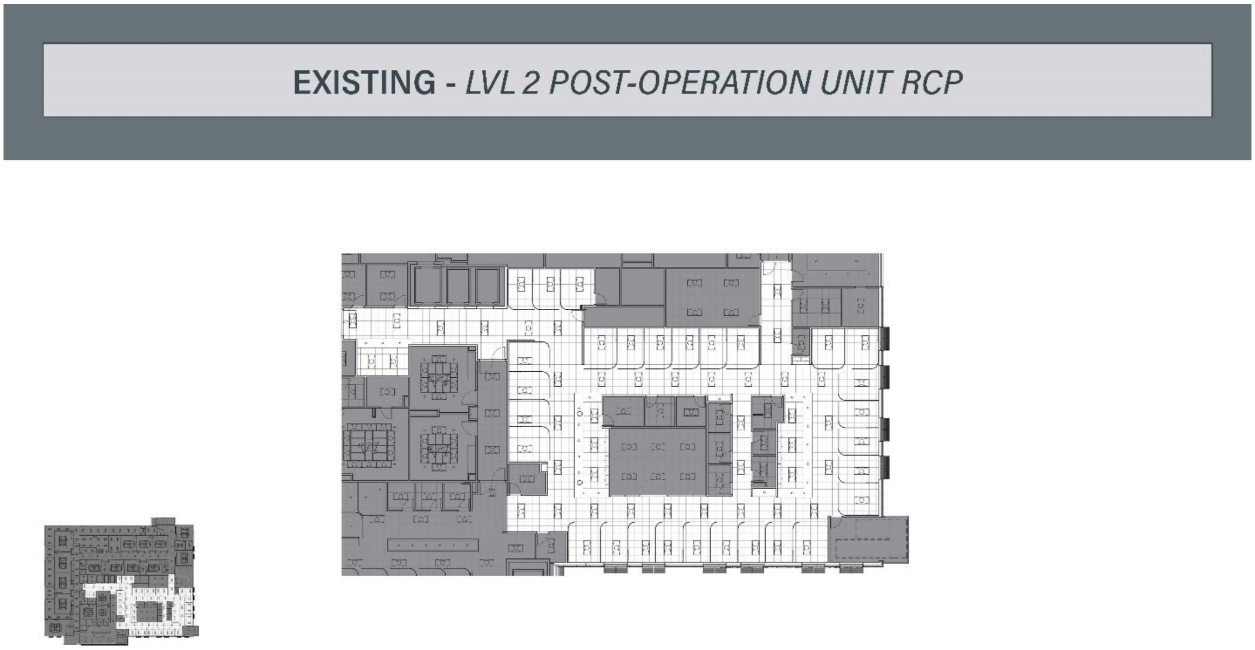

This is the existing level two reflected ceiling plan. Again, the focus will be on the reflected ceiling plans. There will be changes made to this plan which will be pointed out later in the presentation. See Figure E127 for visual representation.

**Figure E128. Existing - Level 2 Post-Operation Unit**



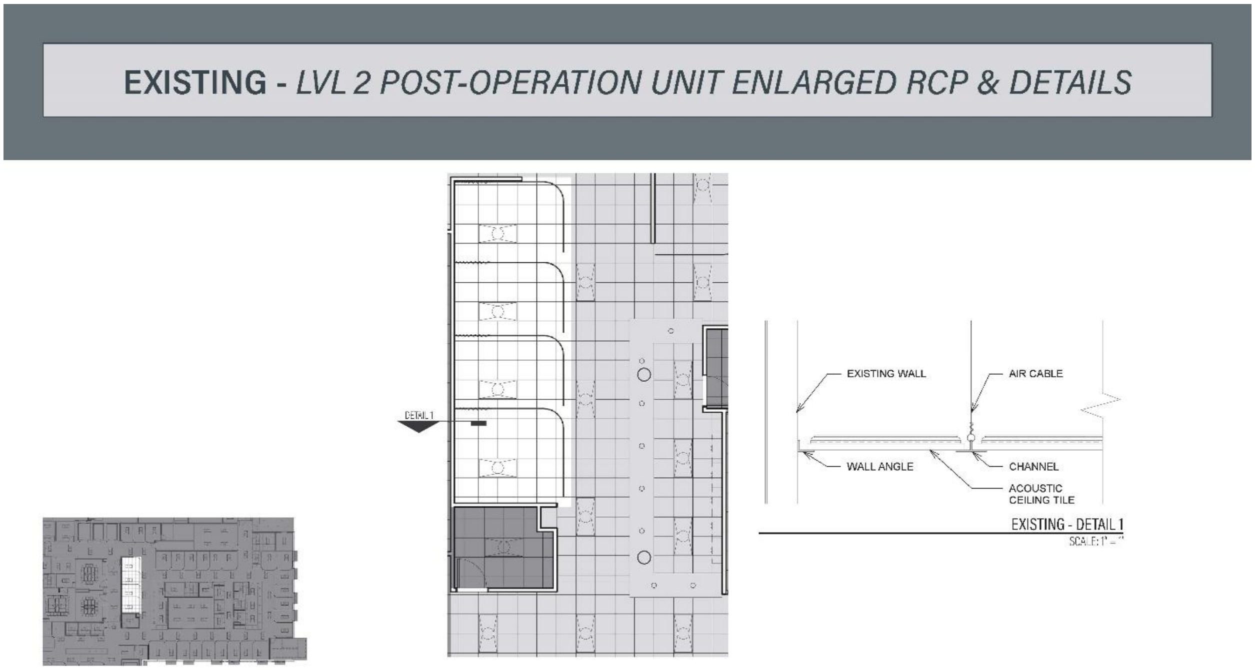

As we continue to focus on the two areas that "belong" to the patient, we are now seeing the enlarged post-operative unit on level two. See Figure E128 for visual representation.

**Figure E129. Existing - Level 2 Post-Operation Unit Reflected Ceiling Plan**




Here in Figure E129 Existing – Level 2 Post-Operation Unit Reflected Ceiling Plan is enlarged and shown.

**Figure E130. Existing - Level 2 Post-Operation Unit Enlarged RCP and Details**




Similar to the pre-operative unit, the current ceiling condition is a 2x2 acoustic ceiling tile and grid with one light source. This light source is a 2x4 direct downlight. However, unlike level one pre-operative space, the level two post-operative space is all open bay style. See Figure E130 Existing – Level 2 Post-Operation Unit Enlarged RCP and Details for more information.

**Figure E131. Existing - Level 2 Post-Operation Unit Rendering - A**


One thing to note on level two as we look at the space three-dimensionally is the amount of accessible daylighting. There are a few areas that do not have direct access to daylighting but may still receive more than that of level one pre-operative unit. See Figure E131, Figure E132, and Figure E133 for visual representation.

**Figure E132. Existing - Level 2 Post-Operation Unit Rendering - B**

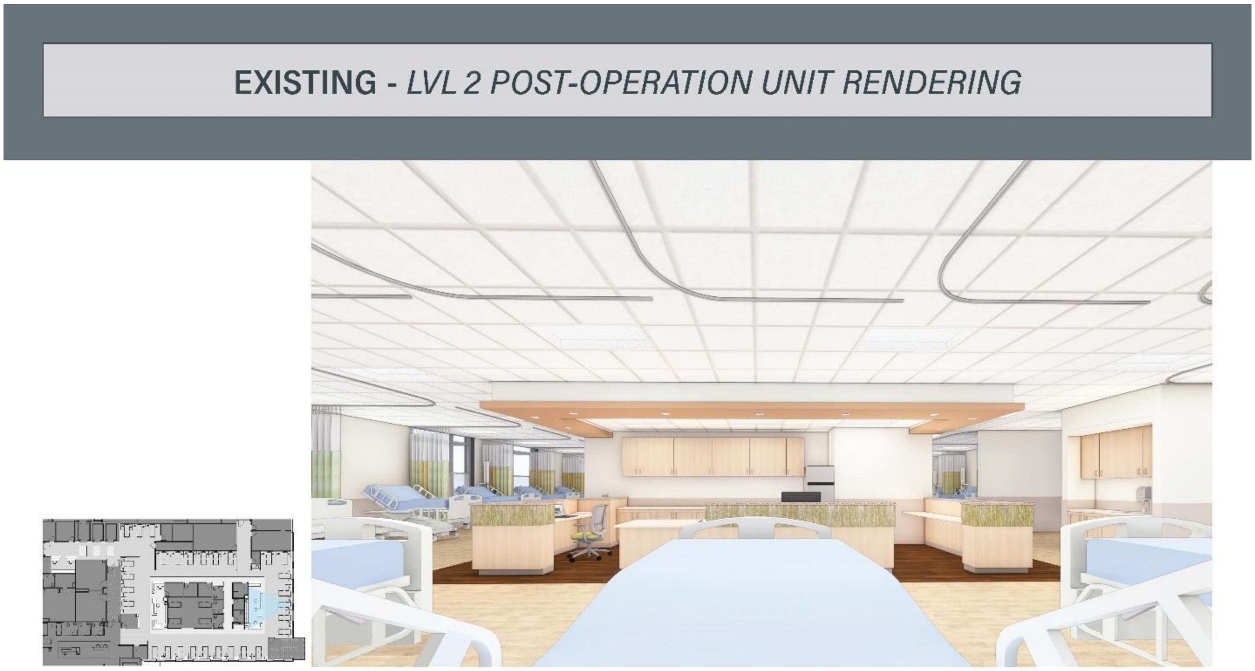
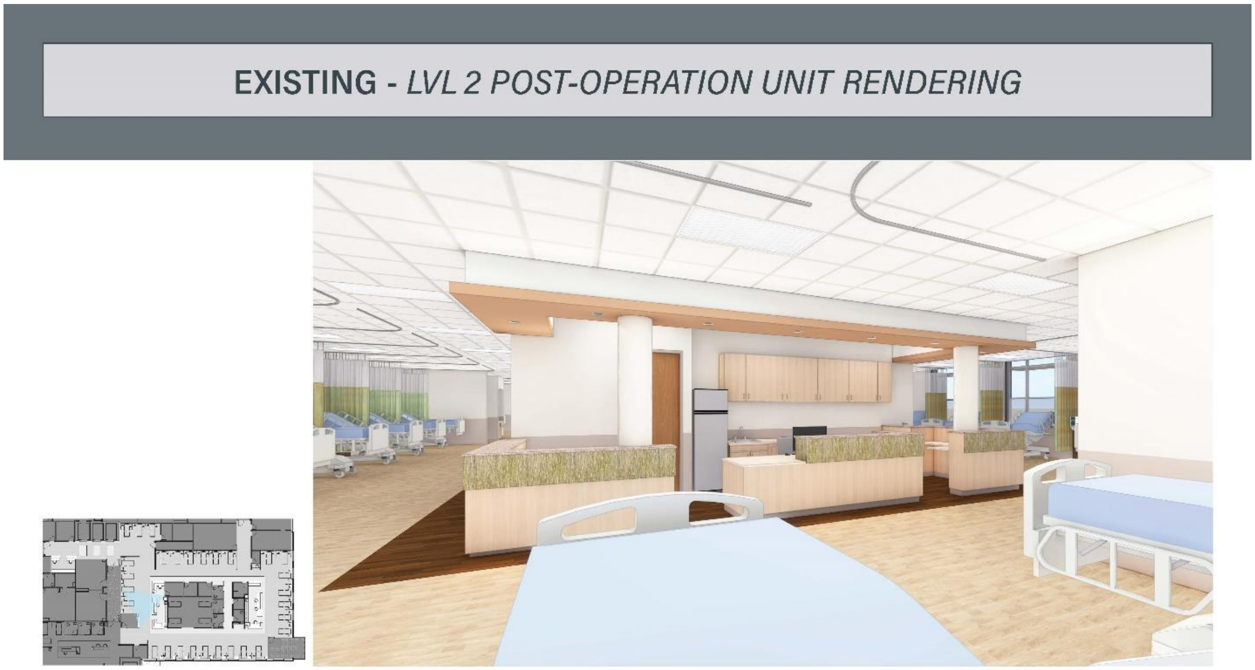



**Figure E133. Existing - Level 2 Post-Operation Unit Rendering - C**

**Figure E134. Existing - Level 2 Post-Operation Unit Rendering - D**

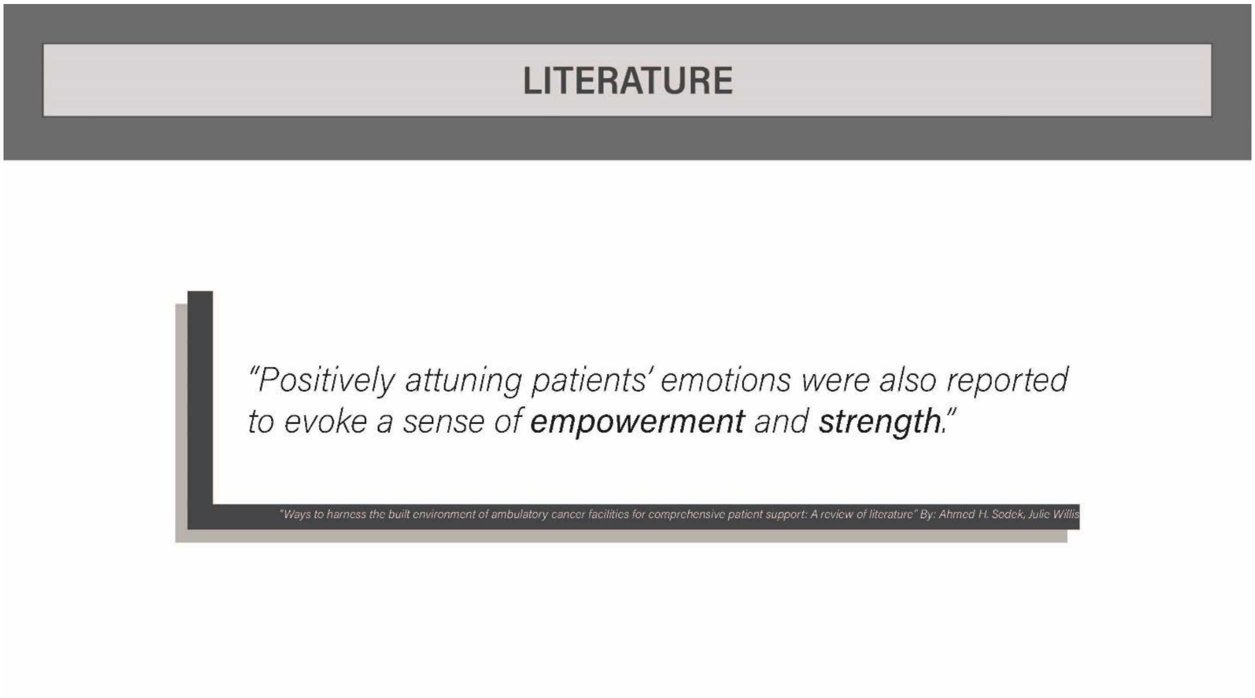



In Figure E134, there is indirect access to daylight in the distance to the right. However, the open bay to the left has less ideal conditions for accessible daylighting as it is further in the interior of the building and has its views blocked by ancillary spaces.

**Figure E135. Existing - Level 2 Post-Operation Unit Rendering - E**

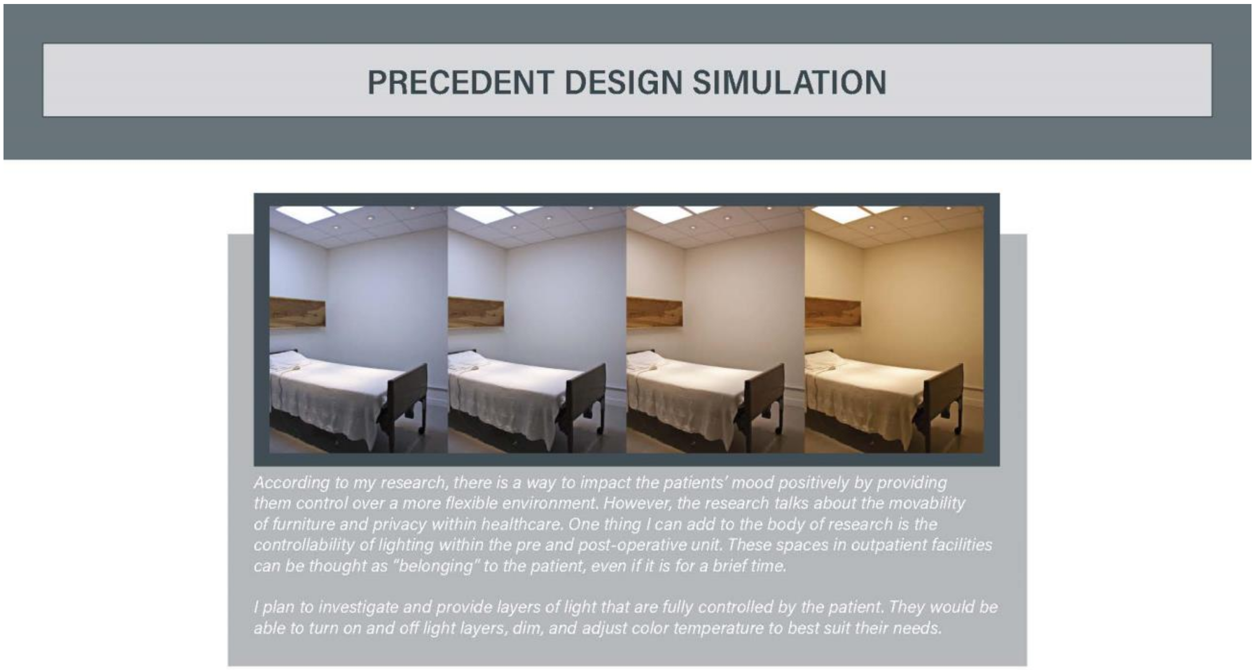

Figure E135 is used to represent another viewpoint within the post-operative unit.

**Figure E136. Literature**



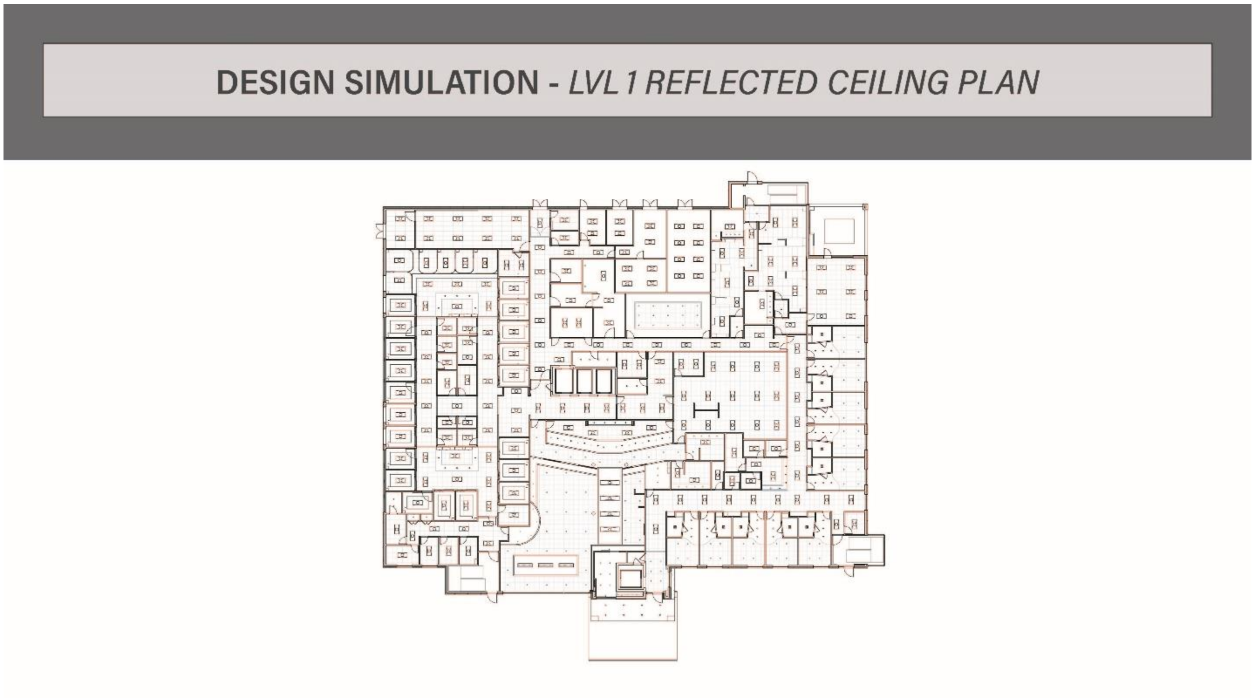

As the focus shifts to the redesign portion of this presentation, reflect on the bolded portions of the literature that have been covered thus far. First, "…active participants in their own health and wellness" (Guzzo Vickery et al., 2015).  Next, "…patients' perceptions of quality and satisfaction" (Becker et al., 2008). Lastly as shown here in Figure E136, "…positively attuning patients' emotions were also reported to evoke a sense of empowerment and strength" (Sadek & Willis, 2020).

**Figure E137. Precedent Design Simulation**



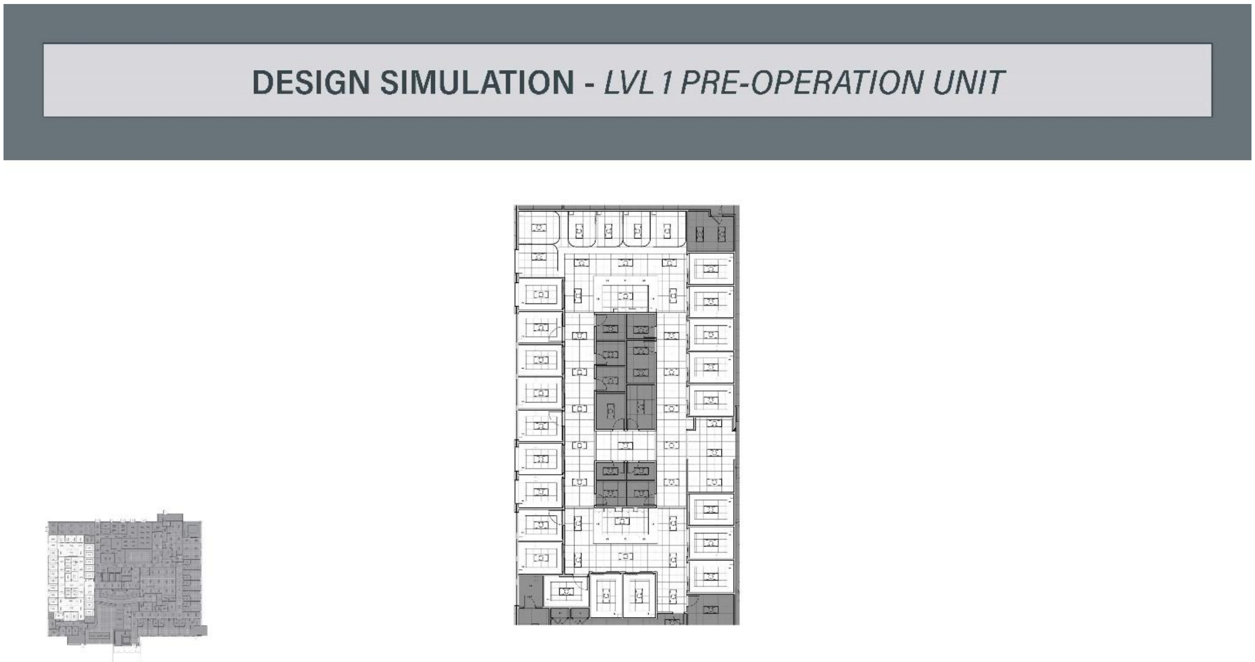

According to the research, there is a way to positively impact the patients' mood by providing control over a more flexible environment. Unfortunately, the research mostly talks about the moveability of furniture within healthcare, not the flexibility of lighting. Due to the nature of healthcare, the researcher was not able to control a physical environment to test the theory. Because of this, a design simulation was created based on the existing space that was just presented. The goal of this design simulation is to add to the body of knowledge by investigating the controllability of layers of lighting within the pre and post-operative units. See Figure E137 for more information.

**Figure E138. Design Simulation - Level 1 Reflected Ceiling Plan**



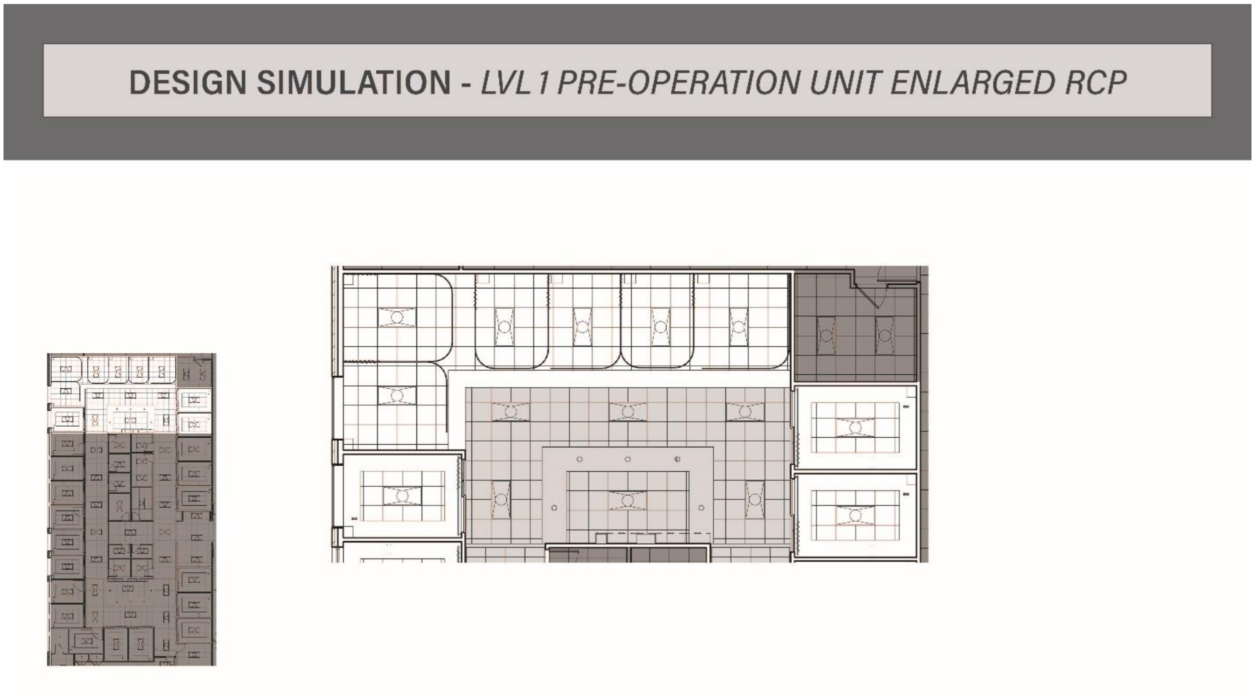

As the focus shifts towards the design simulation, it is important to mention that the floor plan has not been provided, as it will remain existing. Instead, the sole focus will be on the reflected ceiling plans. See Figure E138 for visual representation.

**Figure E139. Design Simulation - Level 1 Pre-Operation Unit**



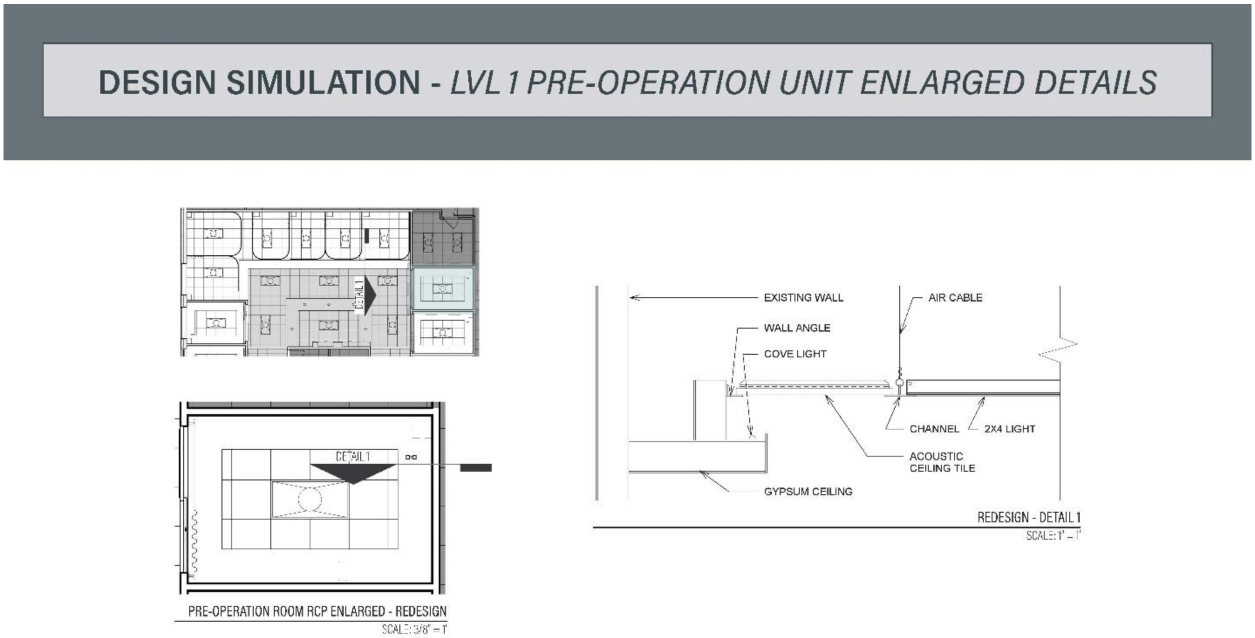

The design simulation will be presented in the same manner as the existing portion we just went through. Shown here is the level one pre-operative unit's reflected ceiling plan. Once again, a key plan is provided to help orient yourself within the space as seen in Figure E139.

**Figure E140. Design Simulation - Level 1 Pre-Operation Unit Enlarged RCP**



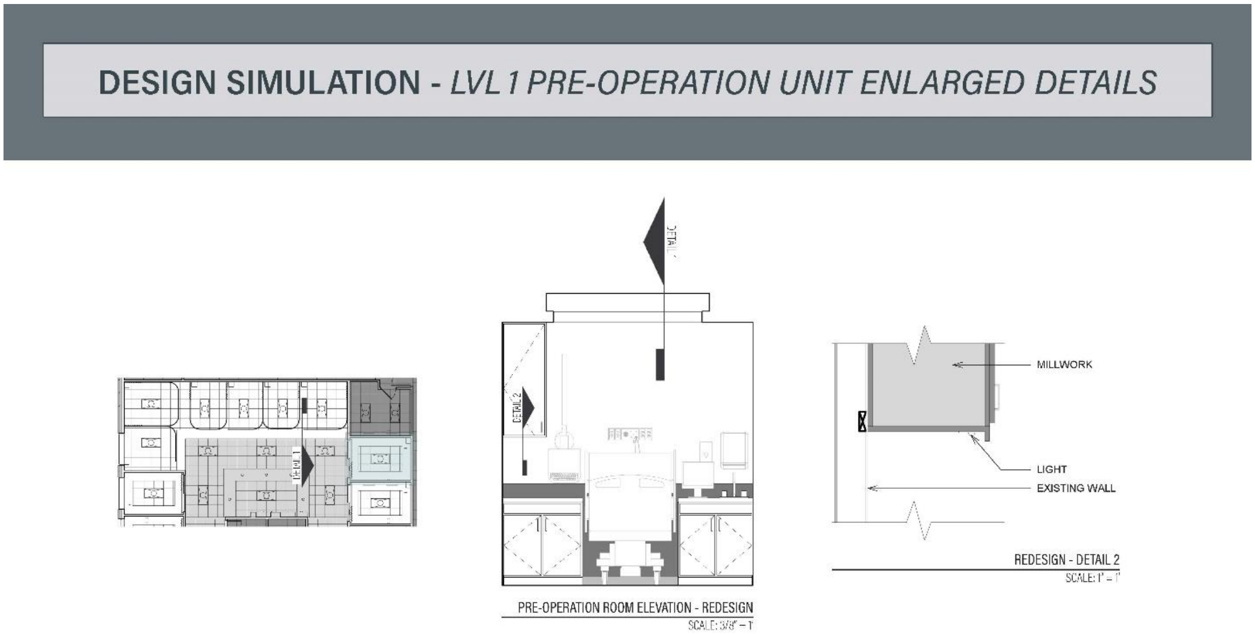

As we continue to enlarge the reflected ceiling plan the changes may begin to appear subtly. The ceiling conditions will still have both a 2x2 acoustic ceiling tile and grid with the 2x4 direct downlight. See Figure E140.

**Figure E141. Design Simulation - Level 1 Pre-Operation Unit Enlarged Details**




However, with the addition of a Gypsum Ceiling, a cove light was implemented in both the private room and the open bay of the pre-operating unit. This section detail of the cove light may make this clearer. This is illustrated in Figure E141.

**Figure E142. Design Simulation - Level 1 Pre-Operation Unit Enlarged Details**




In addition to the gypsum ceiling and cove light, an undercabinet light has also been introduced here in the pre-operative unit. If one is not comfortable reading section details and elevations, 3D renderings of the pre-operative unit are provided to better showcase the added layers of light in this design simulation. See Figure E142 for visual representation.

**Figure E143. Design Simulation - Level 1 Pre-Operation Unit Rendering - A**


At first glance, this rendering may appear familiar. That is because the materials have not been altered. Additionally, the camera angle for the renderings has remained the same. See Figure E143 for visual representation.

**Figure E144. Design Simulation - Level 1 Pre-Operation Unit Rendering - B**


With this view of the pre-operative room, one can see the gypsum ceiling that was added. At this time, the individual layers of light may not be easily recognized as all layers of light are turned on. The individual layers will become clear momentarily. Reference Figure E144 and Figure E145 for visual representation.

**Figure E145. Design Simulation - Level 1 Pre-Operation Unit Rendering - C**

**Figure E146. Design Simulation - Level 1 Pre-Operation Unit Rendering - D**


Here in the open bay of the pre-operative unit, the gypsum header that has been added to house the new cove light is noticeable. See Figure E146 for visual representation.

**Figure E147. Design Simulation - Level 1 Pre-Operation Unit Rendering - E**

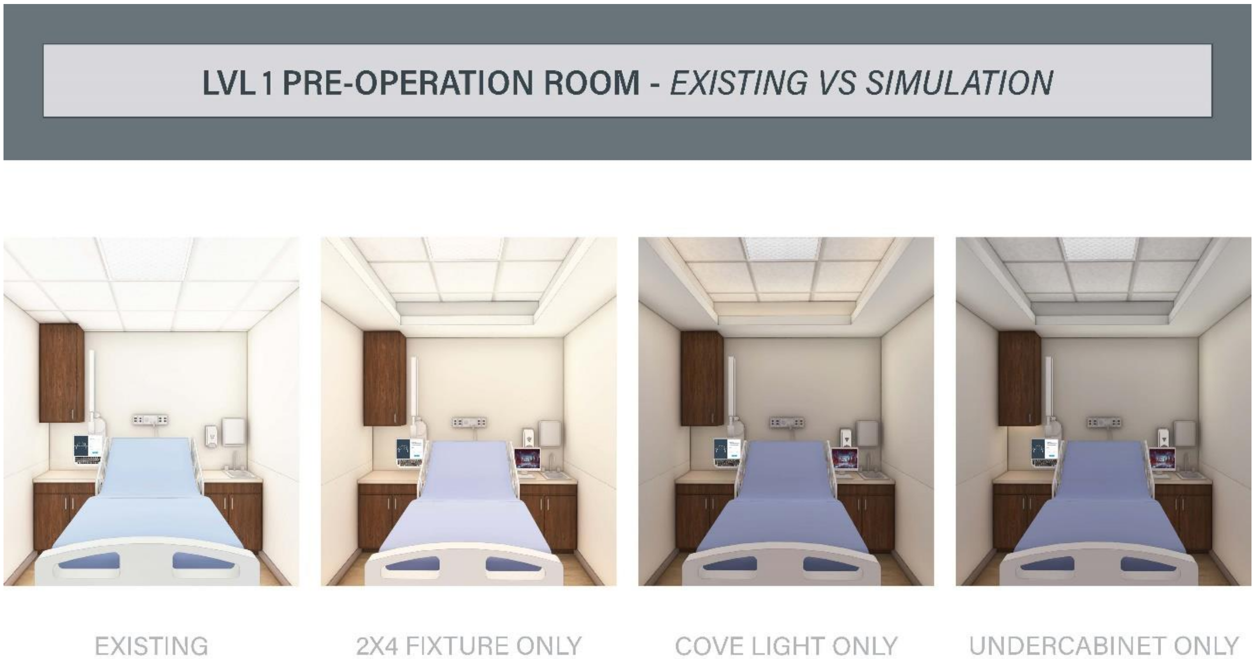

This is a different angle of the gypsum header that was added. Refer to Figure E147 for visual representation.

**Figure E148. Design Simulation - Level 1 Pre-Operation Room - Layers of Light**


Now that the overall changes have been shown, let's break down the layers of light implemented in the pre-operative unit. Refer to Figure E148 for visual representation.

The 2x4 direct downlight will remain. This light is essential for the nurses and physicians to provide quality care to the patient before surgery. The cove light added to the ceiling allows for the option of ambient lighting to be used and controlled by the patient. Lastly, the undercabinet lighting is seen more as a task light. Think of a task light as a desk or table lamp.

**Figure E149. Level 1 Pre-Operation Room - Existing vs. Simulation**

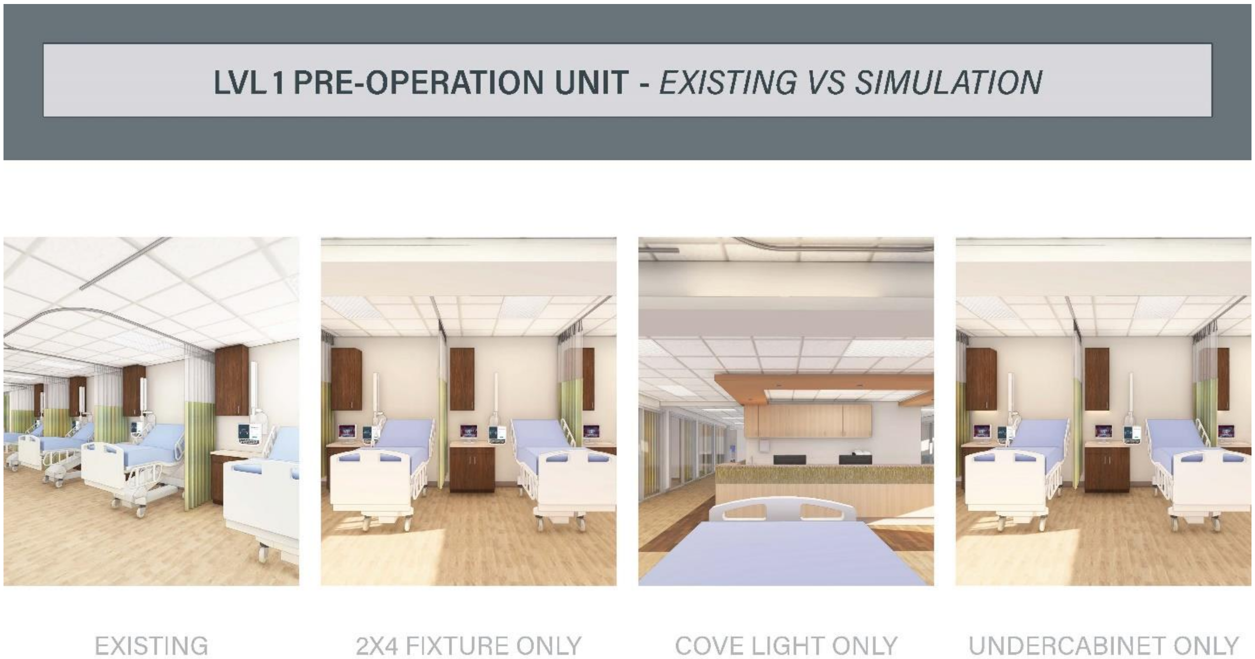



The hope in showing you the existing lighting condition, followed by the new layers of light here in Figure E149, is that although the changes are subtle, they are effective in providing a variety of controllable lighting options for the patient.

**Figure E150. Design Simulation - Level 1 Pre-Operation Unit - Layers of Light**

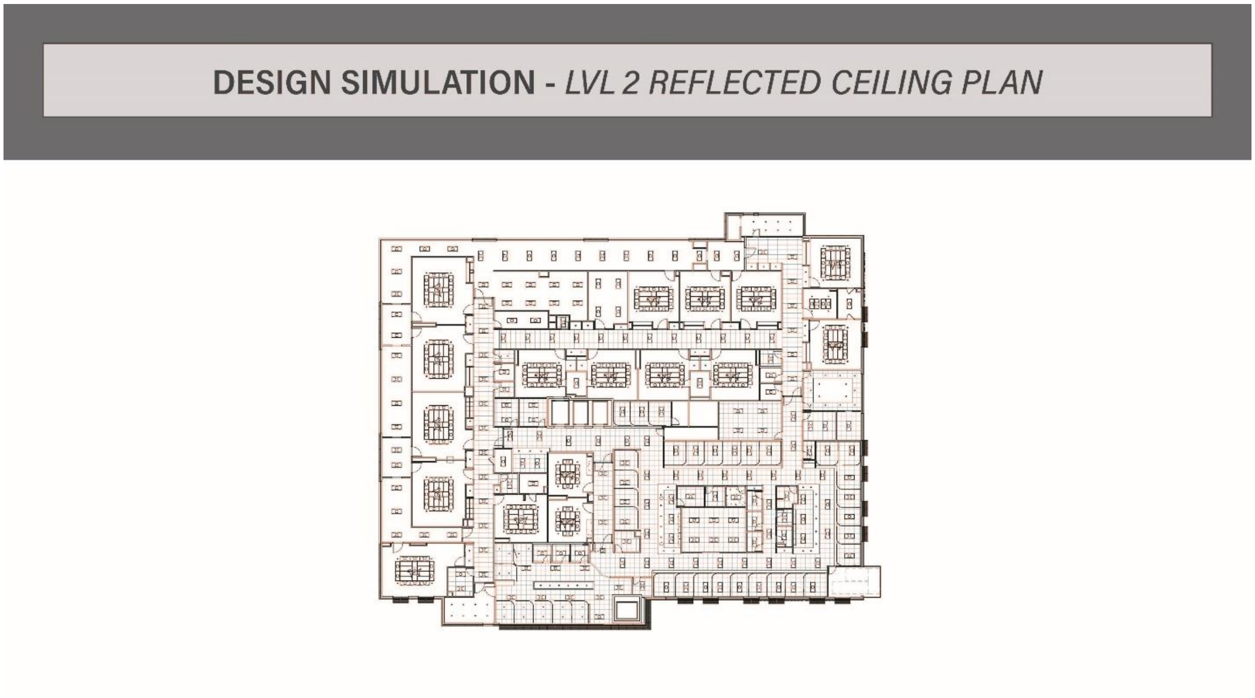

In the open bay of the pre-operating unit, one will see the same lighting layers as before. However, it is imperative to note that daylighting in this space plays a key role in how subtle the additional layers of light are in this area. Reference Figure E150. Daylighting can act as a fourth layer of light within the open bay area and private rooms that are equipped with windows.

**Figure E151. Level 1 Pre-Operation Unit - Existing vs. Simulation**



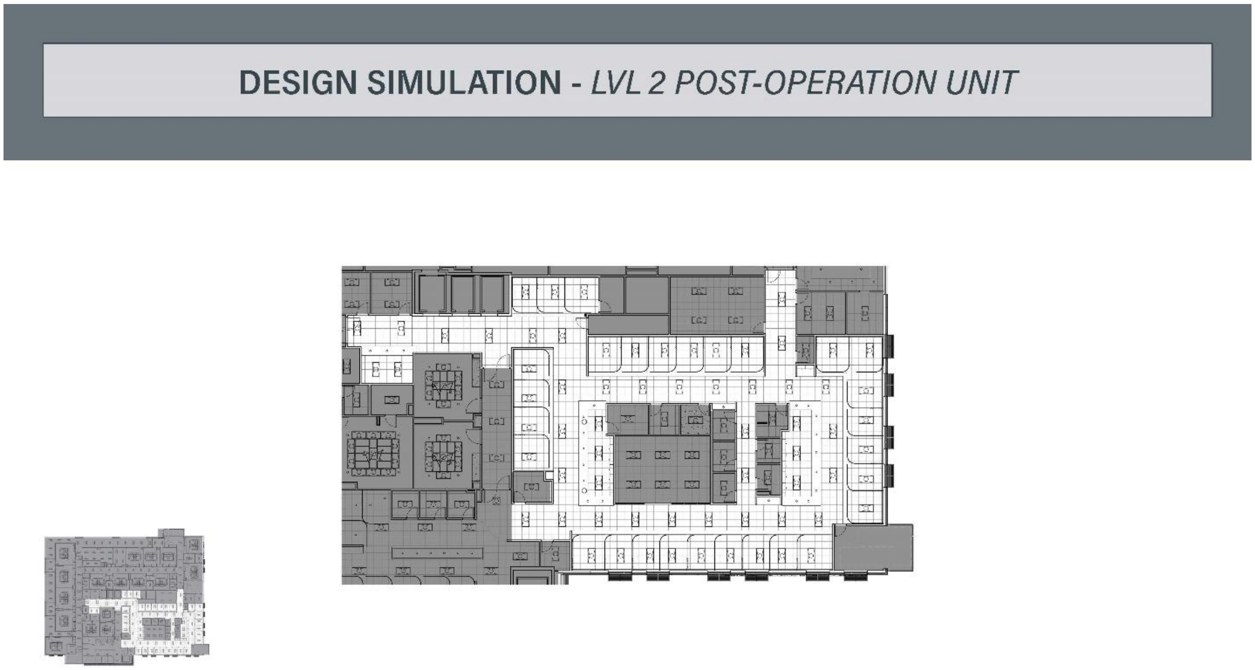

Again, by showing all four of these renderings together, one should be able to recognize the different layers of light. See Figure E151 for visual representation.

**Figure E152. Design Simulation - Level 2 Reflected Ceiling Plan**



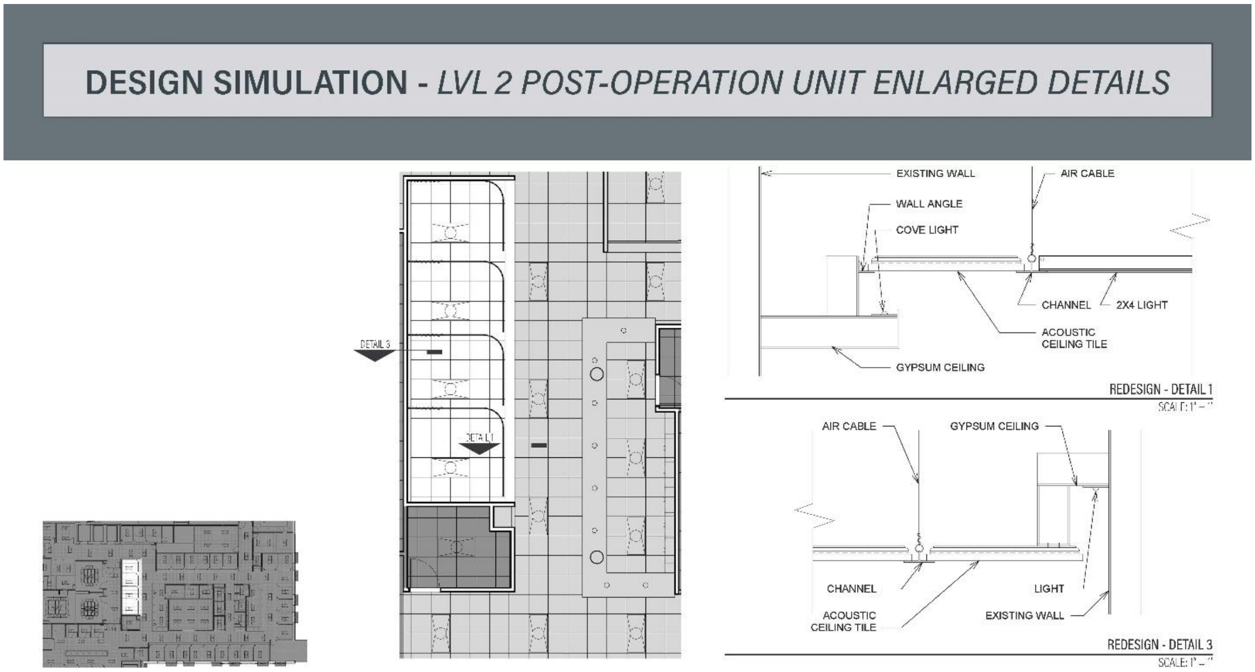

Let's move upstairs to level two. See Figure E152 for the entirety of the level two reflected ceiling plan. Again, the floor plan has not been provided, as seen previously, because it will remain existing.

**Figure E153. Design Simulation - Level 2 Post-Operation Unit**




Similar to the level one drawings previously shown, the redesign of the reflected ceiling plan in the post-operative unit will be broken down to best showcase the design changes. See Figure E153 for visual representation.

**Figure E154. Design Simulation - Level 2 Post-Operation Unit Enlarged Details**




There will still be the 2x2 acoustic ceiling tile and grid with the 2x4 direct downlight. But similar to level one, there is an addition of a gypsum ceiling and cove light. However, unlike level one, the level two post-operative unit does not have existing upper cabinets to add an undercabinet light. This posed a slight problem that forced some creativity. The additional layer of light here is a soffit light that will act as a wall washer behind the head of the bed. Reference Figure E154 for more information.

**Figure E155. Design Simulation - Level 2 Post-Operation Unit Rendering - A**


Just like level one, the materials and camera angle have not changed. Additionally, natural light continues to play a key role in the post-operative unit. See Figure E155 for visual representation.

**Figure E156. Design Simulation - Level 2 Post-Operation Unit Rendering - B**


Here one can see the gypsum header that will house the new cove light. As we move through these initial renderings, one may not be able to pick out the individual layers of light, as all layers are turned on and natural light is present. See Figure E156 for visual representation.

**Figure E157. Design Simulation - Level 2 Post-Operation Unit Rendering - C**


As we move towards the interior of the building, the presence of artificial lighting may become more apparent. See Figure E157 and Figure E158 for visual representation.

**Figure E158. Design Simulation - Level 2 Post-Operation Unit Rendering - D**

**Figure E159. Design Simulation - Level 2 Post-Operation Unit Rendering - E**


From this viewpoint in Figure E159, the gypsum header is visible in the foreground while the wall washing soffit is in the background. The individual light layers will soon become more apparent.

**Figure E160. Design Simulation - Level 2 Post-Operation Unit - Layers of Light**

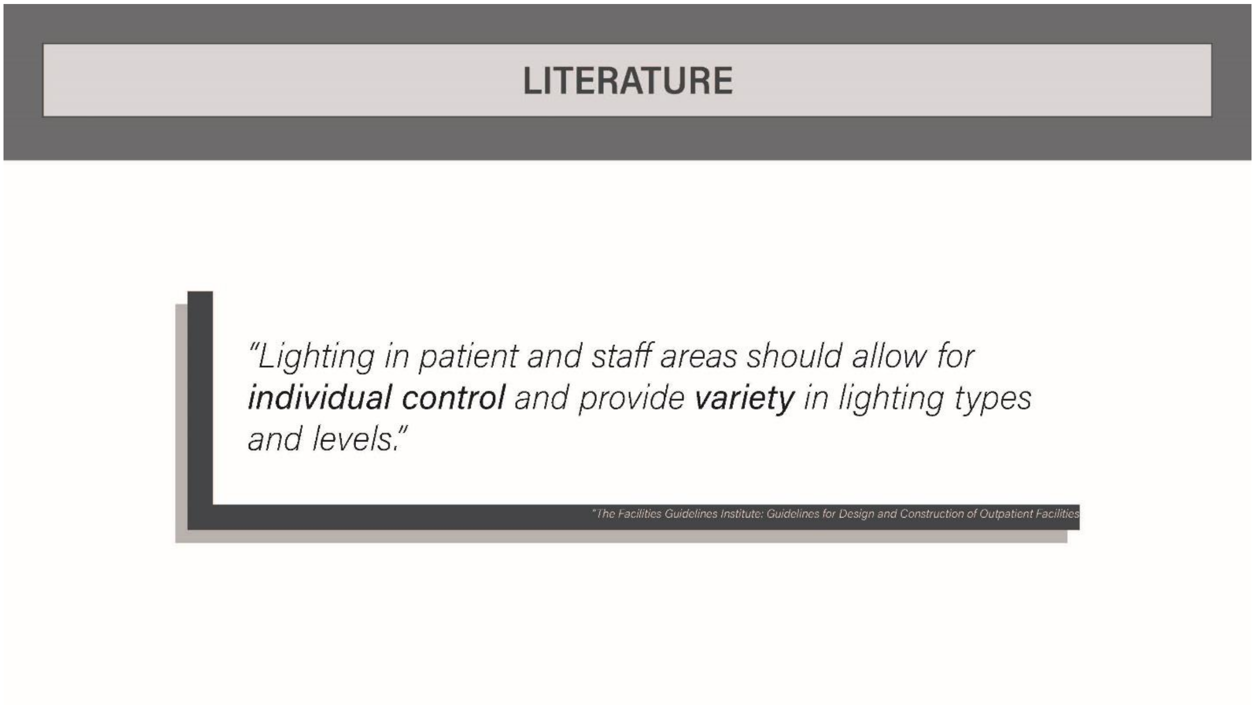

Now that the overall changes have been shown, let's break down the layers of light implemented in the post-operative unit. See Figure E160 for reference.

The 2x4 direct downlight will remain. This light is essential for the nurses and physicians to care for the patient post-surgery. The cove and soffit light allows for a soft glow of ambient lighting to appear in the ceiling and wall behind the patient. This allows patients to remove the necessary 2x4 downlight from their eyes, even if for a short time.

**Figure E161. Level 2 Post-Operation Unit - Existing vs. Simulation**

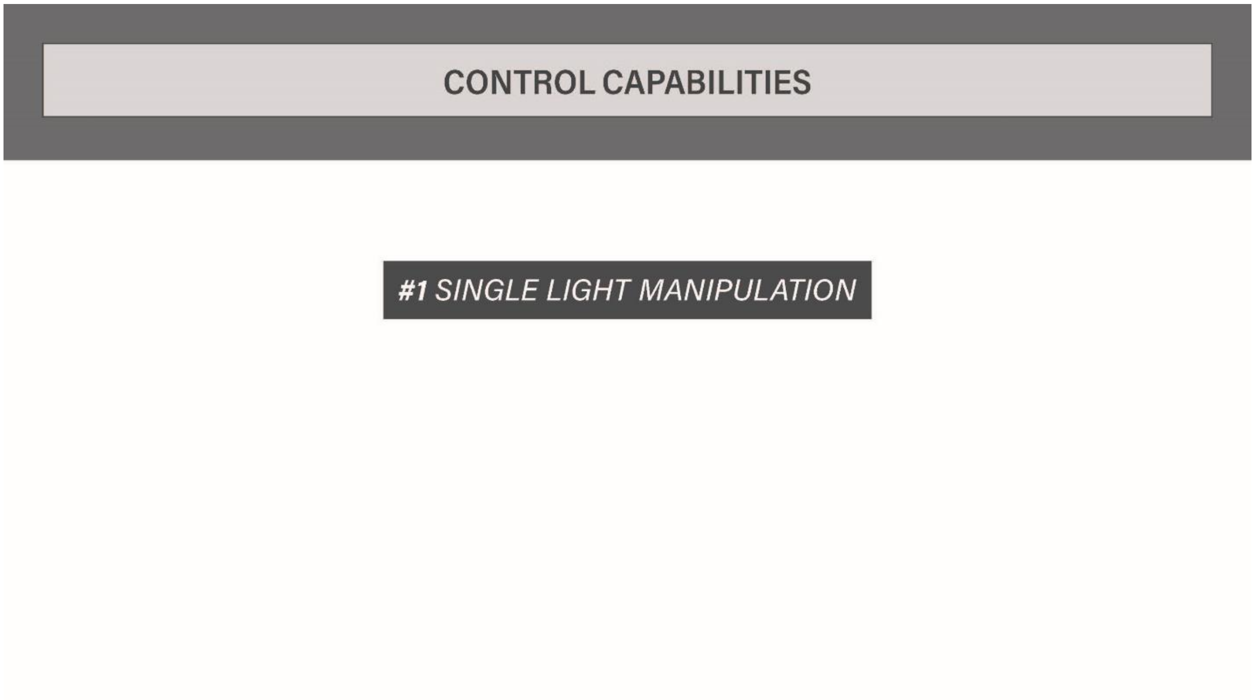

See Figure E161 for visual representation. By showing these four renderings together, the hope is the different layers of light are recognizable, even if they are subtle.

**Figure E162. Literature**




The controllability of these layers of light and giving that control over to the patients has been briefly mentioned. However, this quote from The Facilities Guidelines Institute calls out the exact goal of the design simulation. But what control would the patient have over the lighting in their space? And how would the patient operate the lighting? See Figure E162 for a visual representation of the quote referenced.

**Figure E163. Control Capabilities - 1**




Within the “patient’s space”, they would be able to manipulate a single light. Whether that be turning it on or off. The patient could adjust the color temperature. The Illumination Engineering Society or IES suggests that the color temperature ranges between 3,000-4,500 kelvin to ensure the color temperature is a neutral white to cool white. The patient would have control over the dimmability of the lighting. The range of illumination would range from 23-92 foot-candles which would allow patients to relax while physicians are still able to provide quality care. Lastly, when natural light is present, they would have the option of shade control. See Figure E163, Figure E164, Figure E165, and Figure E166 for visual representation. Still, how would the patients physically control the light within their spaces?

**Figure E164. Control Capabilities - 2**

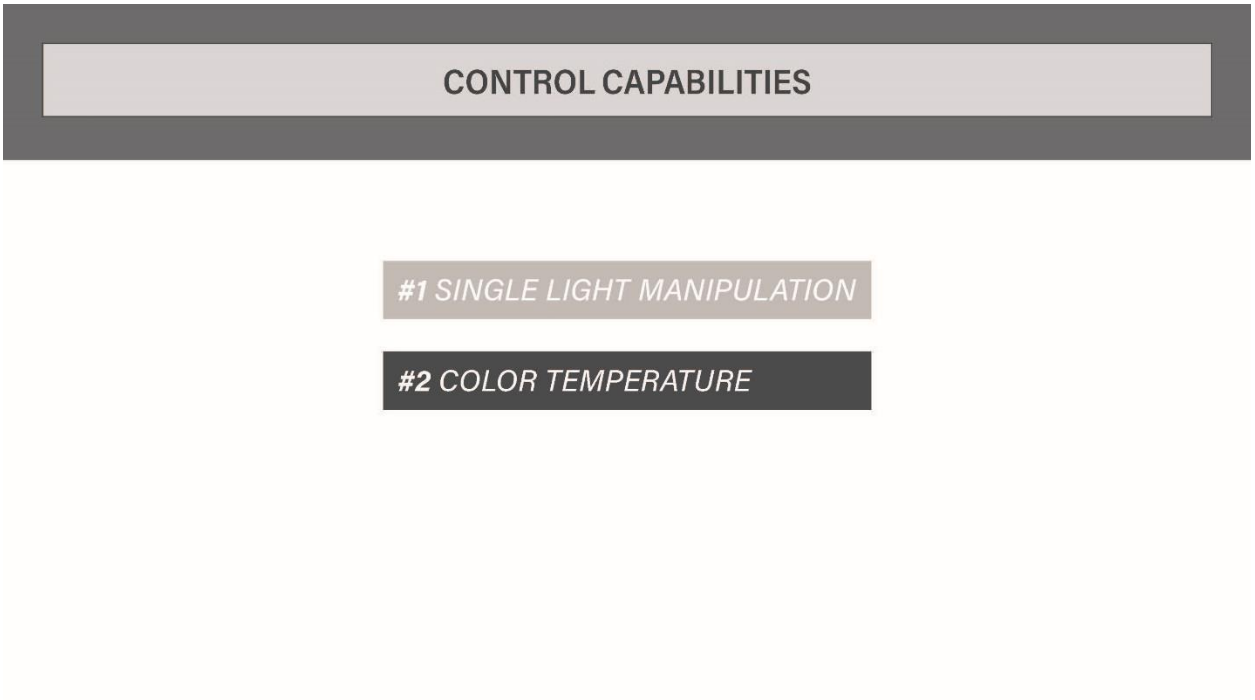



**Figure E165. Control Capabilities - 3**

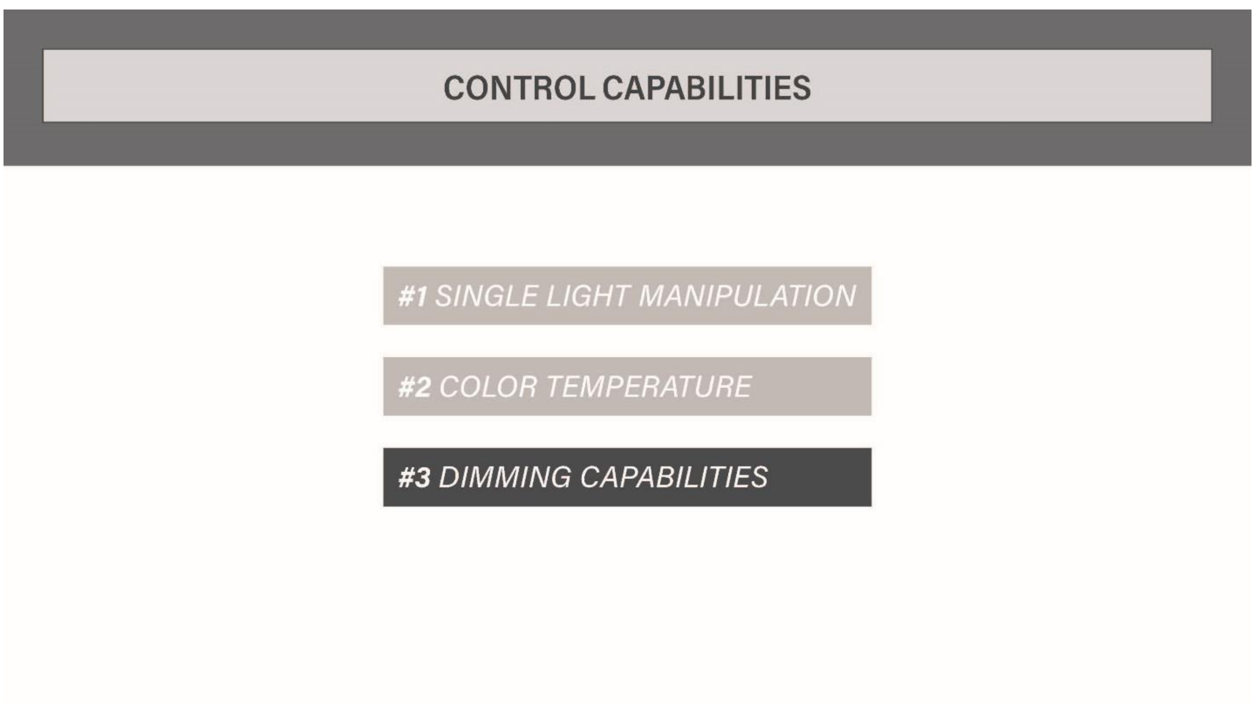


**Figure E166. Control Capabilities - 4**

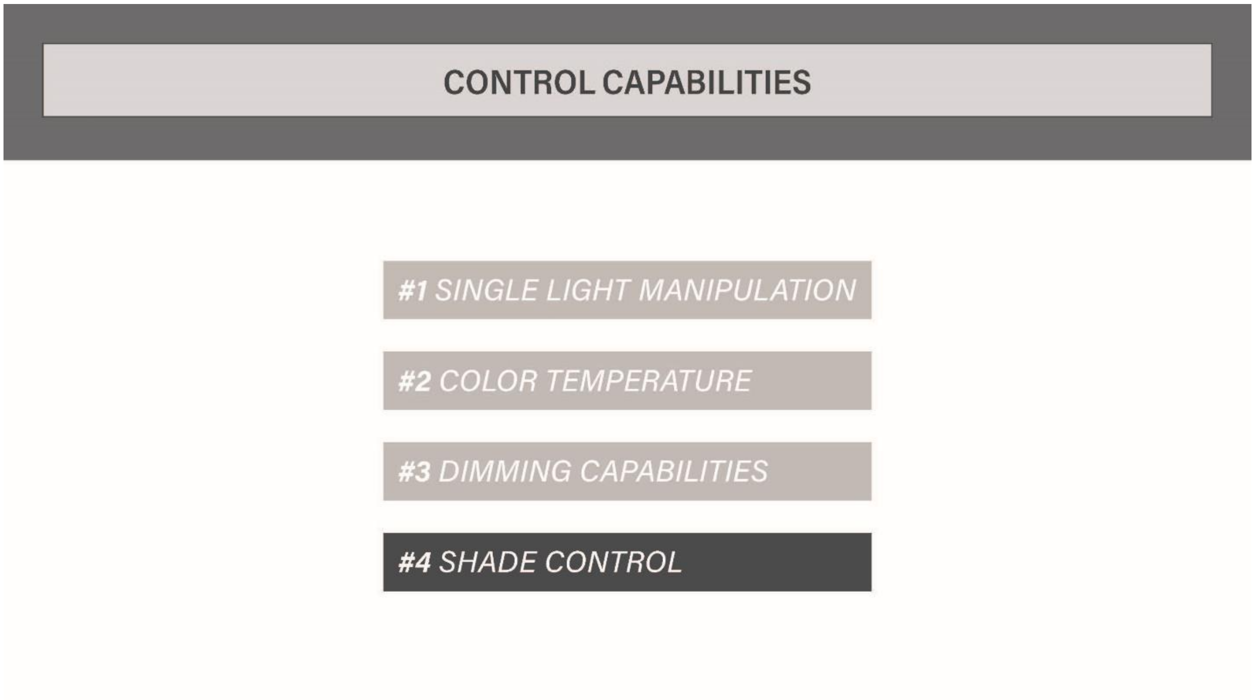
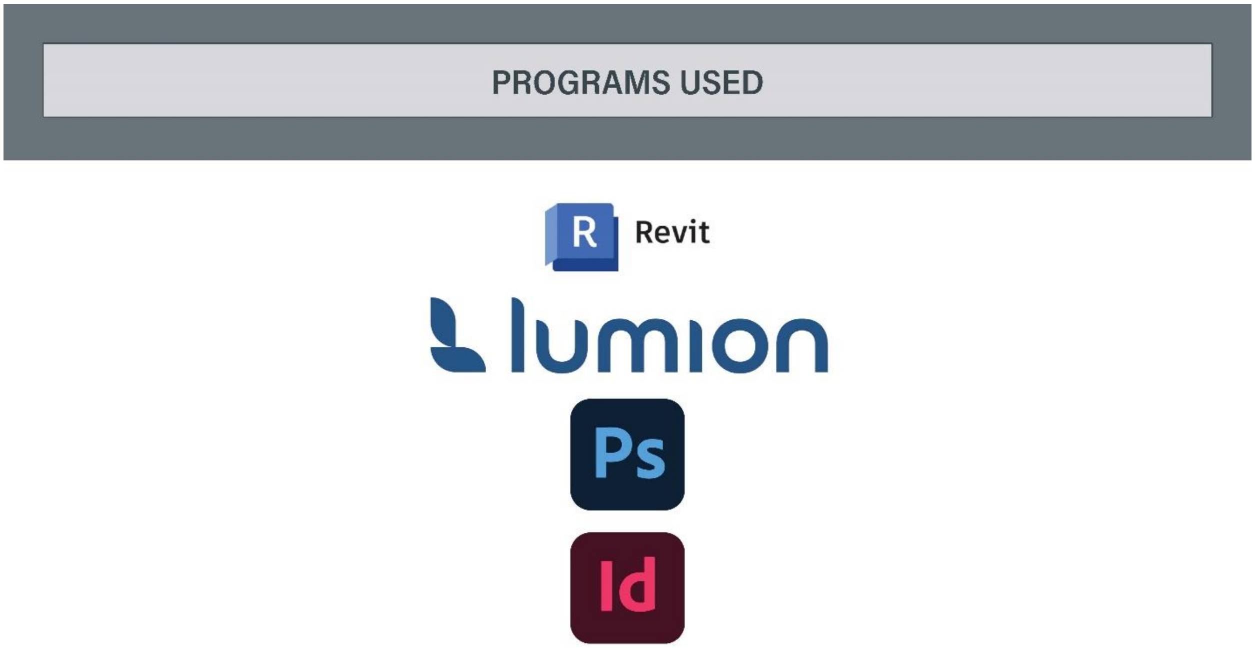


**Figure E167. Controls**


Johnson Controls is a company that offers services and technology to help make buildings smarter. They have a product called OpenBlue Patient Room Optimization. This allows for control of not only lighting but also temperature, shade controls, entertainment, and more. This is done with a downloadable app that allows the patients to control anything in their space from the safety of their bed, with a touch of a button. This is a great safety feature as patients are often a fall risk before and after surgery.

With this control, patients can turn off their lights, dim, and change the color temperature of their lighting. With that said, healthcare professionals should not worry that it would hinder their workflow. With a touch of a button, the facilities staff can reset the lighting levels to their needs. An additional feature of this product is its auto-reset. With occupancy sensors in each room, the lighting levels will automatically turn off and reset for the next patient to have full control over their space. Refer to Figure E167 for more information.

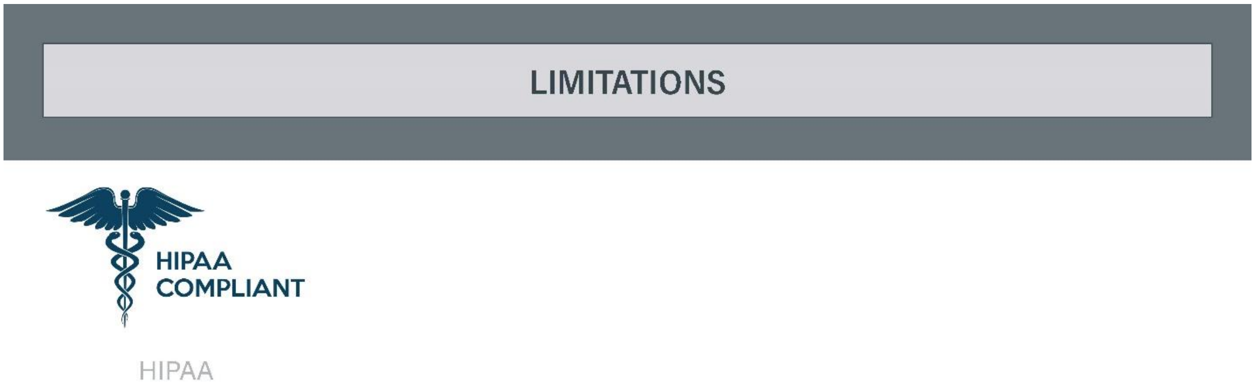
**Figure E168. Programs Used**




It is important to note the programs that were used, the limitations faced, and future research directions within outpatient surgical centers. Multiple computer programs and software were used for this design simulation, refer to Figure E168.

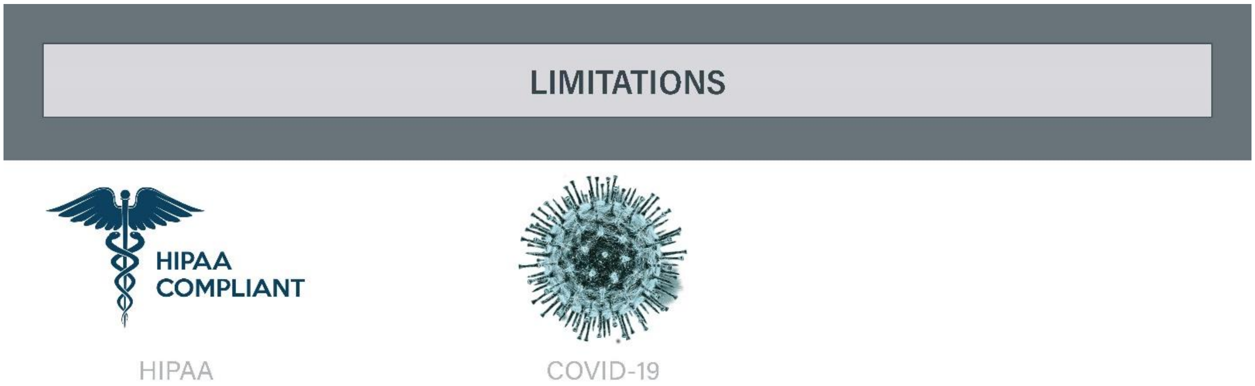
First, Autodesk Revit 2024 – Student Version was utilized to draw the existing building and the design simulation drawings. Once completed, the use of Lumion’s Student Version was vital in creating the renderings and manipulation of the layers of light. Adobe Photoshop 2023 was used to add control screens and make minor edits. Lastly, Adobe InDesign 2024 was used to create this visual presentation.

**Figure E169. Limitations - 1**



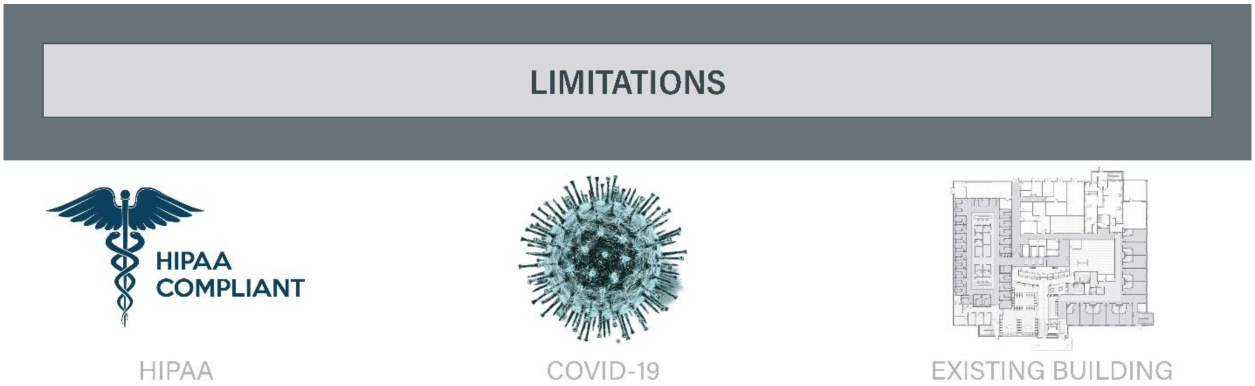

To begin with, the limitations of this research project are HIPAA Laws. These are of course very important and should be respected but did hinder the ability to navigate healthcare environments freely. See Figure E169 for visual representation.

**Figure E170. Limitations - 2**



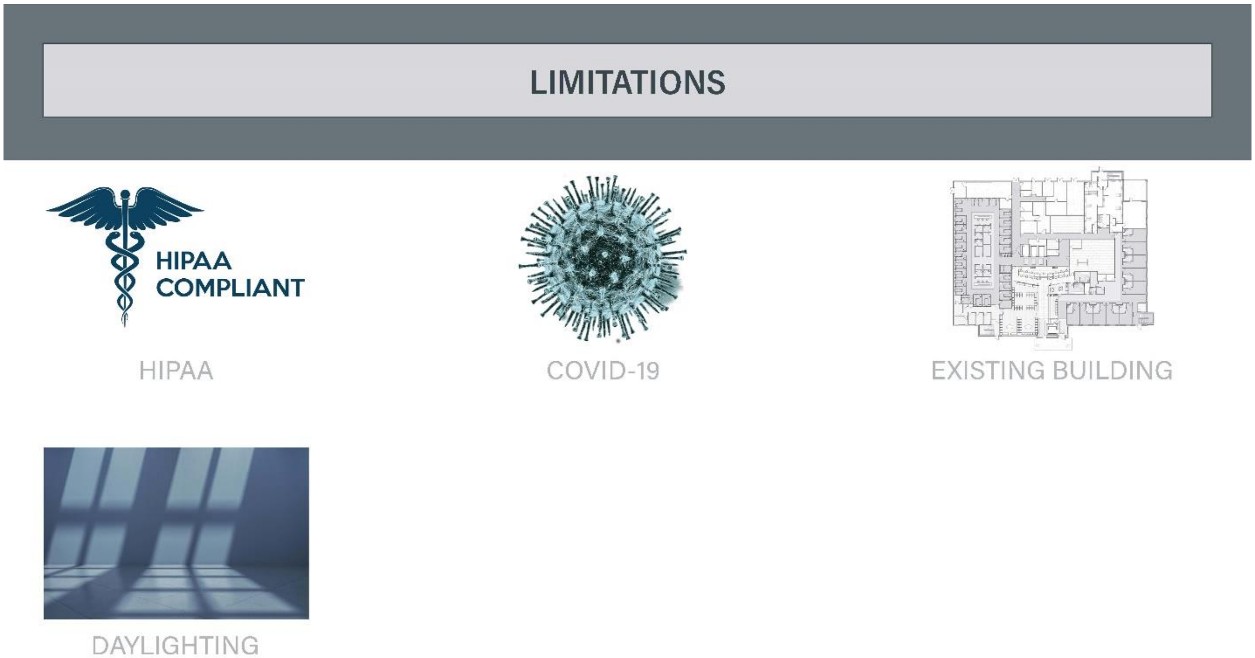

Next, the COVID-19 pandemic was the main limitation. As the world was shutting down, the researcher was trying to gain entry into healthcare environments. The pandemic prohibited the researcher from physically entering the Surgical Center of Greensboro to get accurate field measurements, and light-level readings, and interview patients or staff. COVID-19 forced the research to pivot from primary research methods to a project-based design simulation. See Figure E170 for visual representation.

**Figure E171. Limitations - 3**



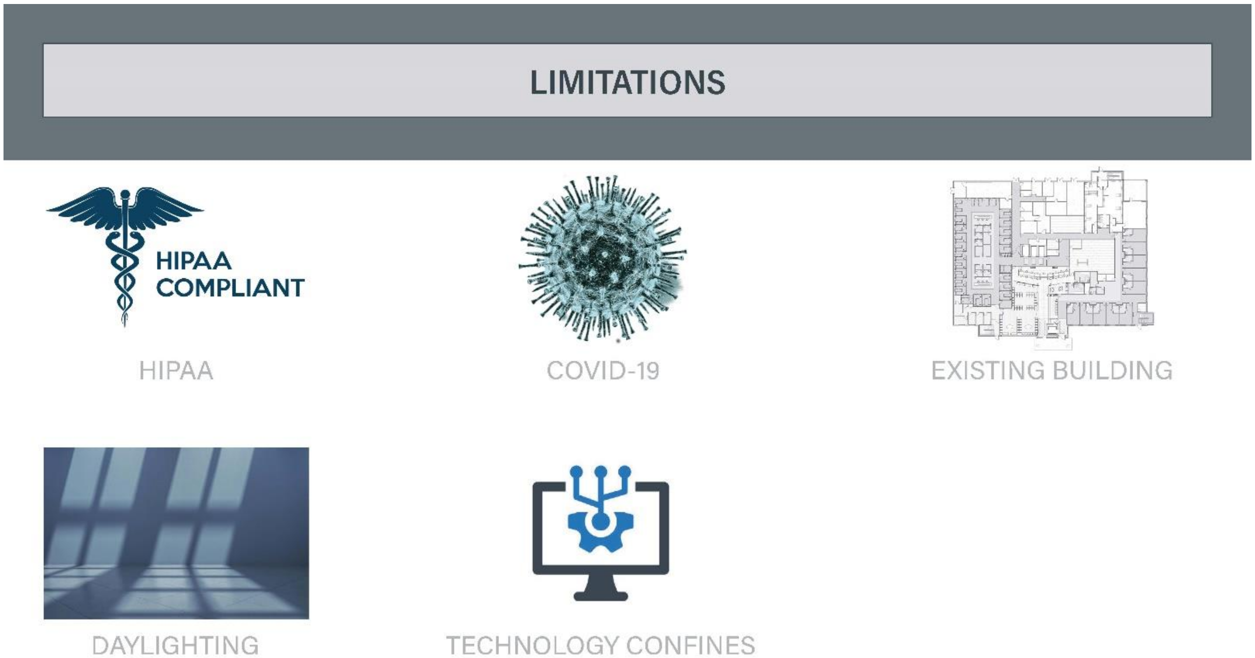

The confines of using an existing building as the floor plans, materials, and overall circulation of the space remained existing caused a third limitation. See Figure E171 for visual representation.

**Figure E172. Limitations - 4**



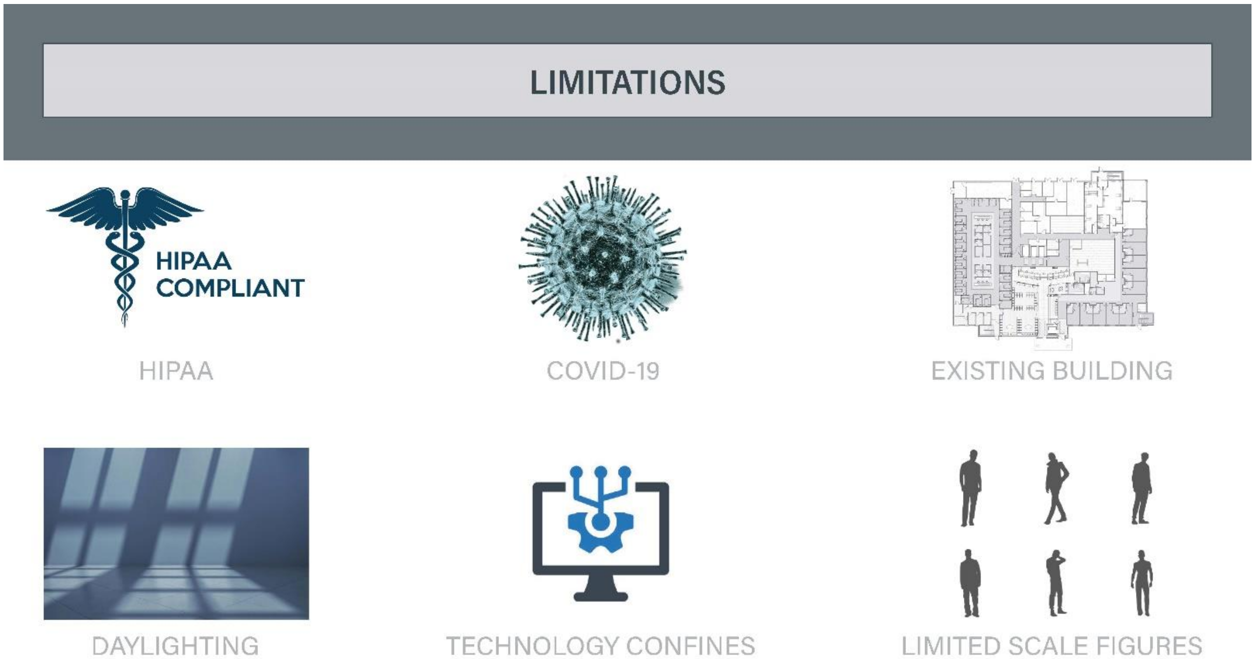

Additionally, daylighting was an issue. While the presence of daylighting is important, the minimal amount of daylight in the pre-operative unit was problematic while the abundance of daylighting in the post-operative unit created difficult design decisions. See Figure E172 for visual representation.

**Figure E173. Limitations - 5**




Even with the technological advancements of Autodesk Revit and Lumion rendering software, there were limitations within their capabilities. Revit alone allows you to label components as existing, demo, or new construction. The researcher utilized this tool until it was apparent that Lumion does not register the different phases. This caused the researcher to duplicate the existing Revit and existing Lumion to produce separate design simulation files. While this is an easy fix, it did take time and called for extra attention to detail. See Figure E173 for visual representation.

**Figure E174. Limitations - 6**



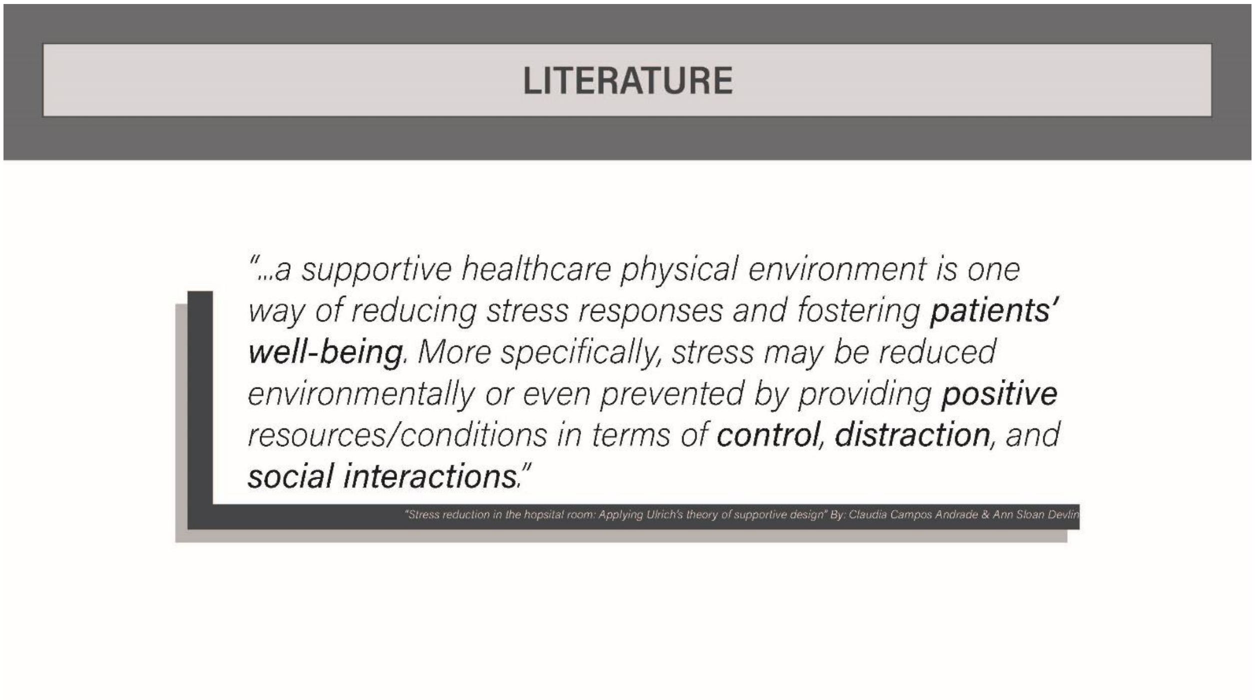

Lastly, within the 3D modeling and rendering software, there are limited healthcare-specific scale figures. Because of this, there are no scale figures present in the renderings. However, the intention and focus are on the patient experience. By adding scale figures, there is the risk of individuals not envisioning themselves within the space which could cause negative results. See Figure E174 for visual representation.

**Figure E175. Future Research**


There was mention at the beginning of this presentation that outpatient care is on the rise. According to the Centers for Medicare and Medicaid Services, the healthcare industry accounted for 19.7 percent of the United States Gross Domestic Product or GDP in 2020 and is projected to represent 30 percent of the GDP by the year 2030 (REIS, 2023).

Due to the limitations of this research investigation, there is room for others to expound upon the idea of controllability of lighting within outpatient surgical centers. This could be done in a variety of ways such as interviews, questionnaires, or further investigating possibilities to give control of the space to the patients outside of the idea of lighting. This research only focused on visual stimulation, which negates part of the population that is visually impaired. There is room for others to add to the body of knowledge and continue researching the design of outpatient surgical centers. See Figure E175 for visual representation.

**Figure E176. Literature**




The unfortunate reality is that everyone, at some time or another, will need medical care and the design of these spaces should be considered. By relinquishing some control over the built environment, patients can feel empowered to be active participants in their care. This decision has the potential to humanize the healthcare industry. Not by taking away from the healthcare professionals but rather adding to the overall health and wellness of patients who are receiving care. See Figure E176 for the closing quote.

**Figure E177. Thank You Page**

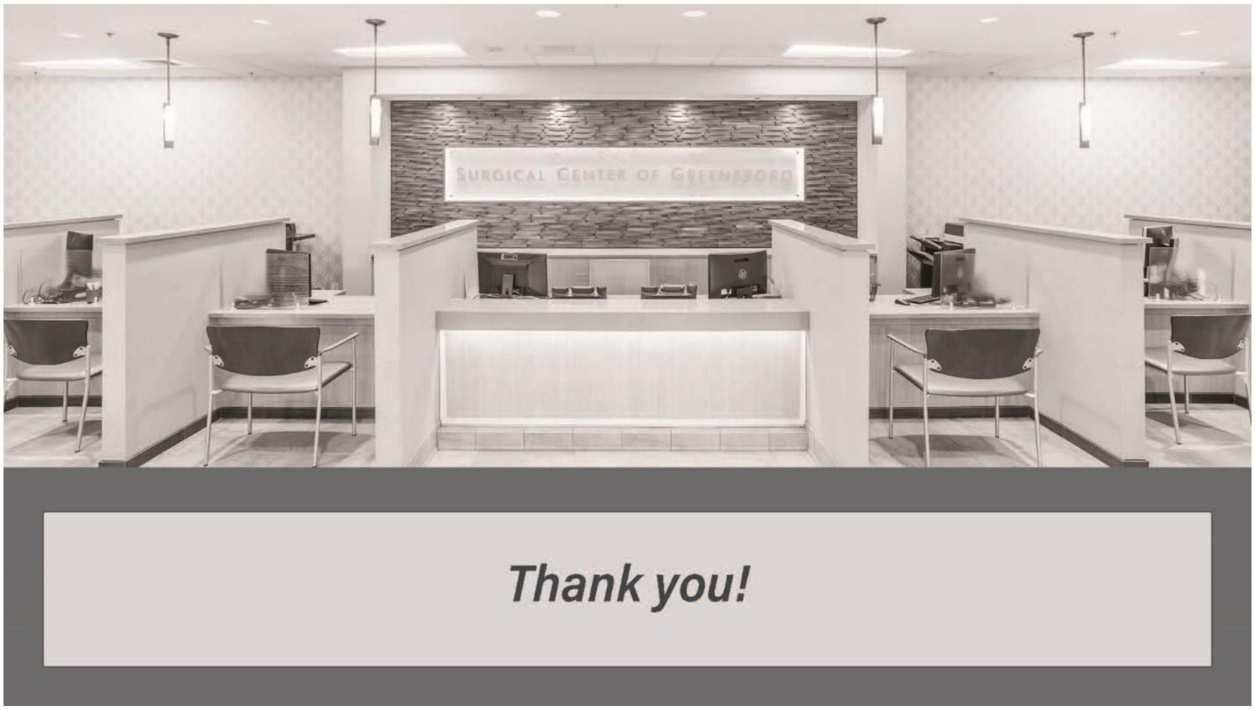



**Figure E178. References Slide - 1**

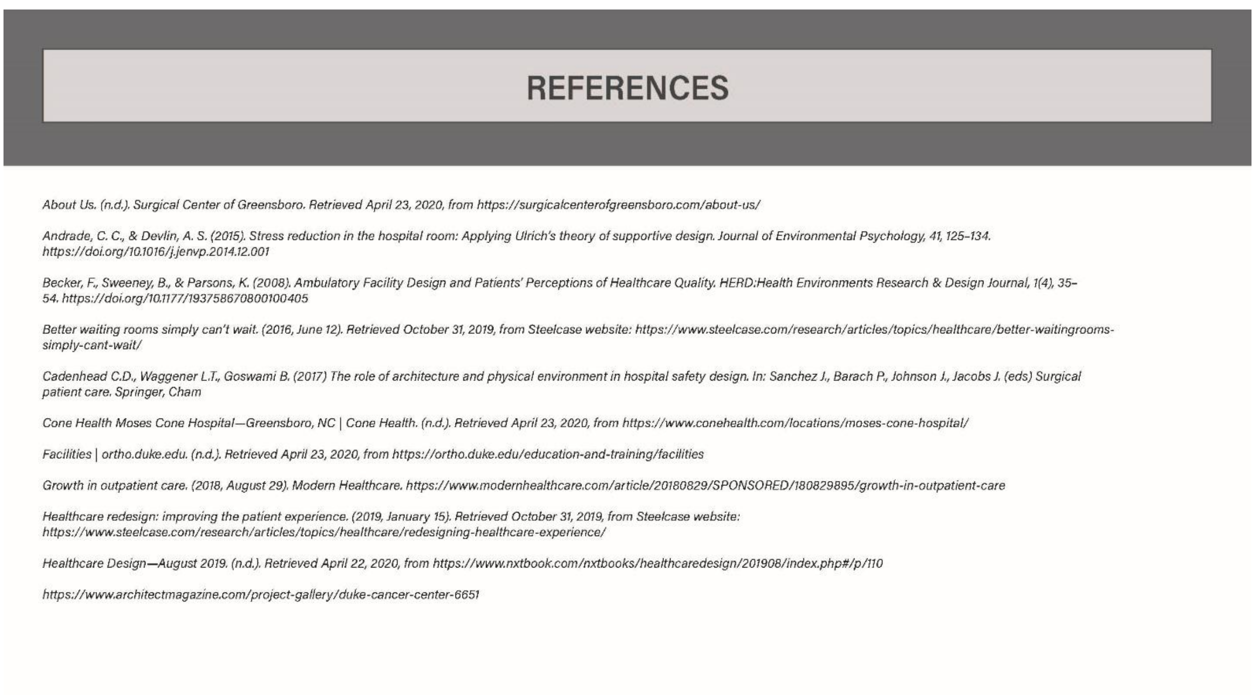


**Figure E179. References Slide - 2**

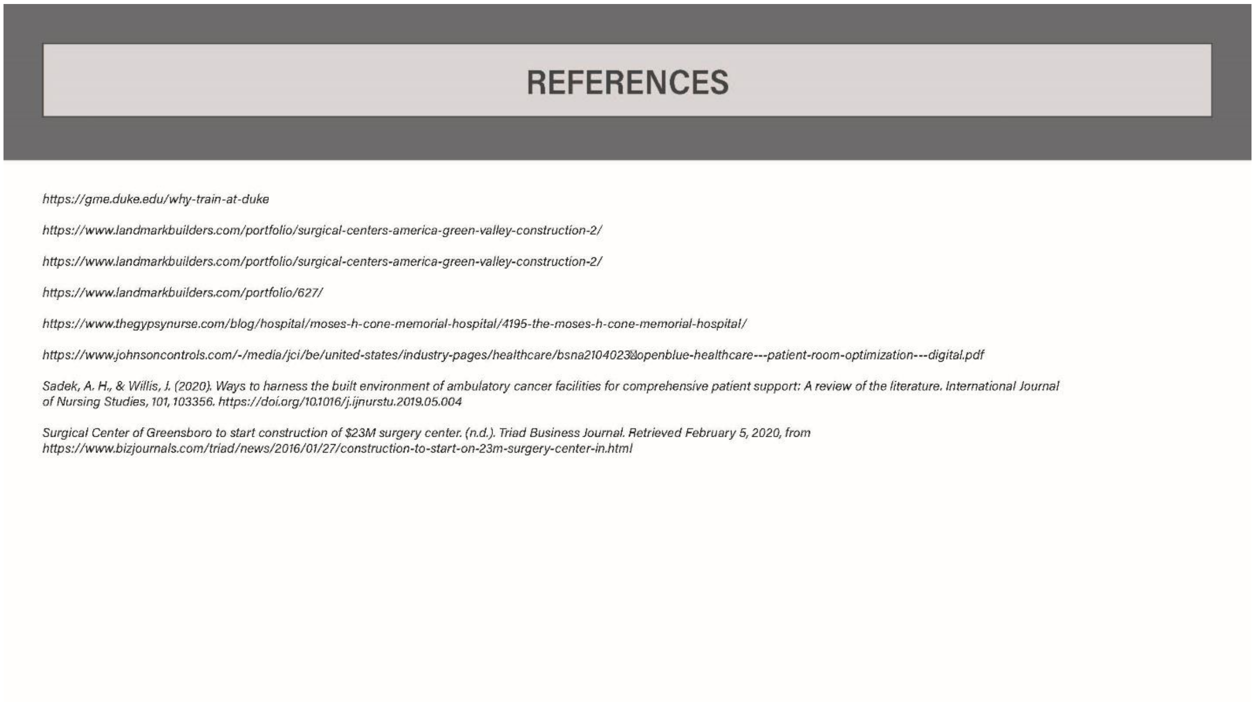



**Figure E180. Light Color Temperature Range**

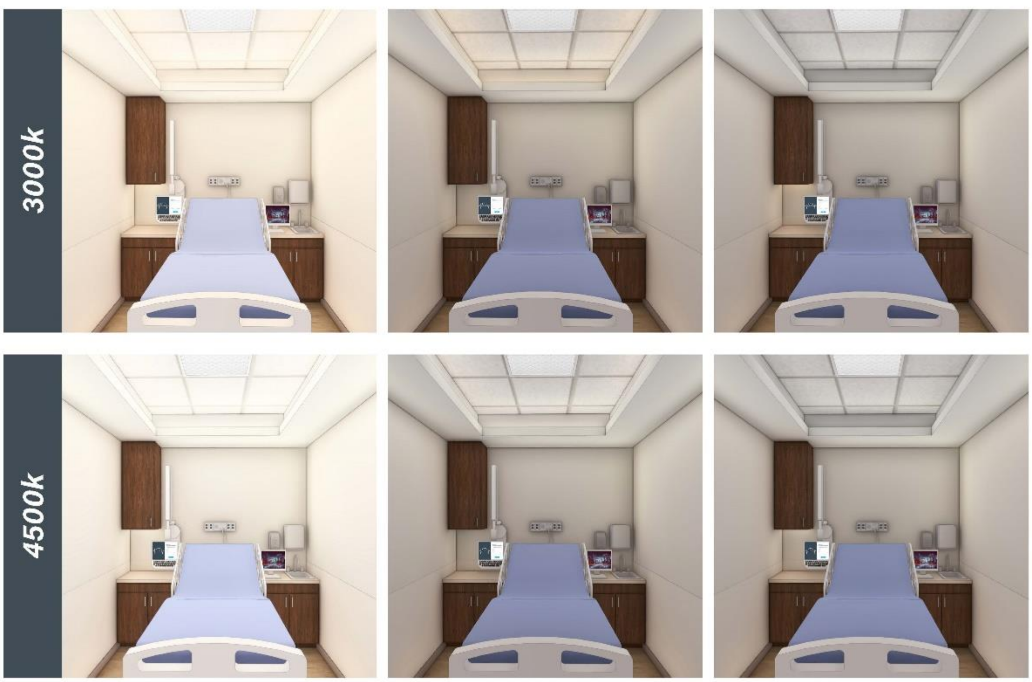


**Figure E181. Existing Level 1 Pre-Operation Room - Extra Slide**

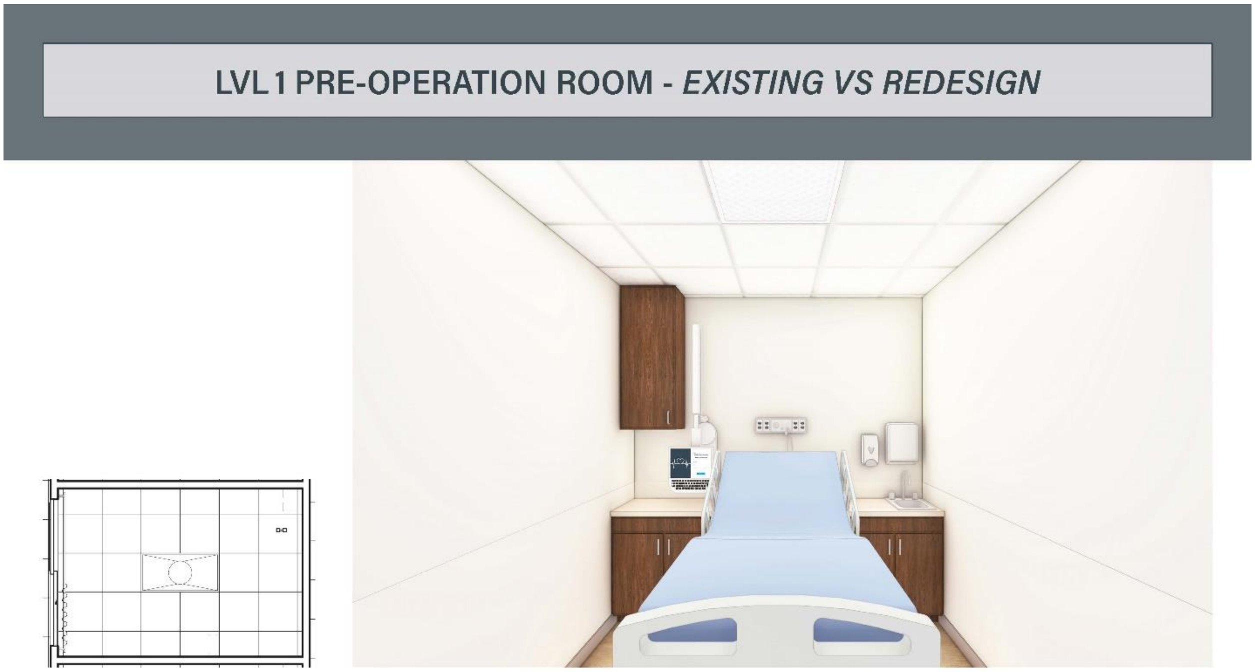



**Figure E182. Design Simulation Level 1 Pre-Operation Room – Extra Slide**

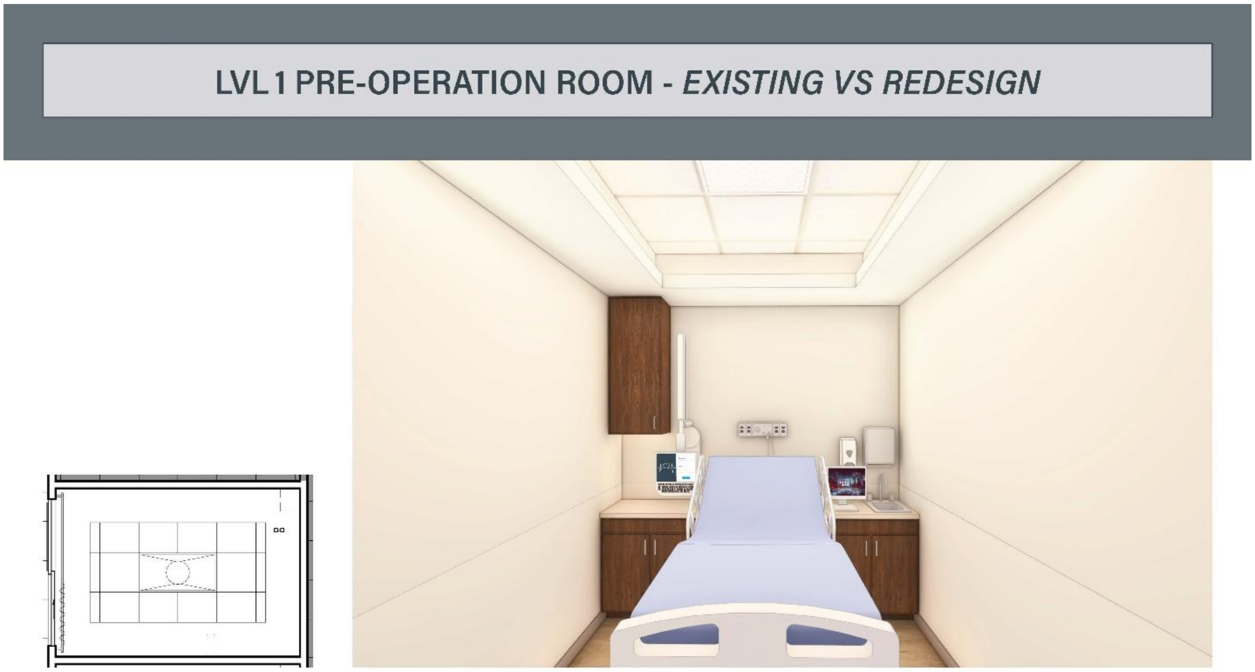


**Figure E183. Existing Level 1 Pre-Operation Unit – Extra Slide**

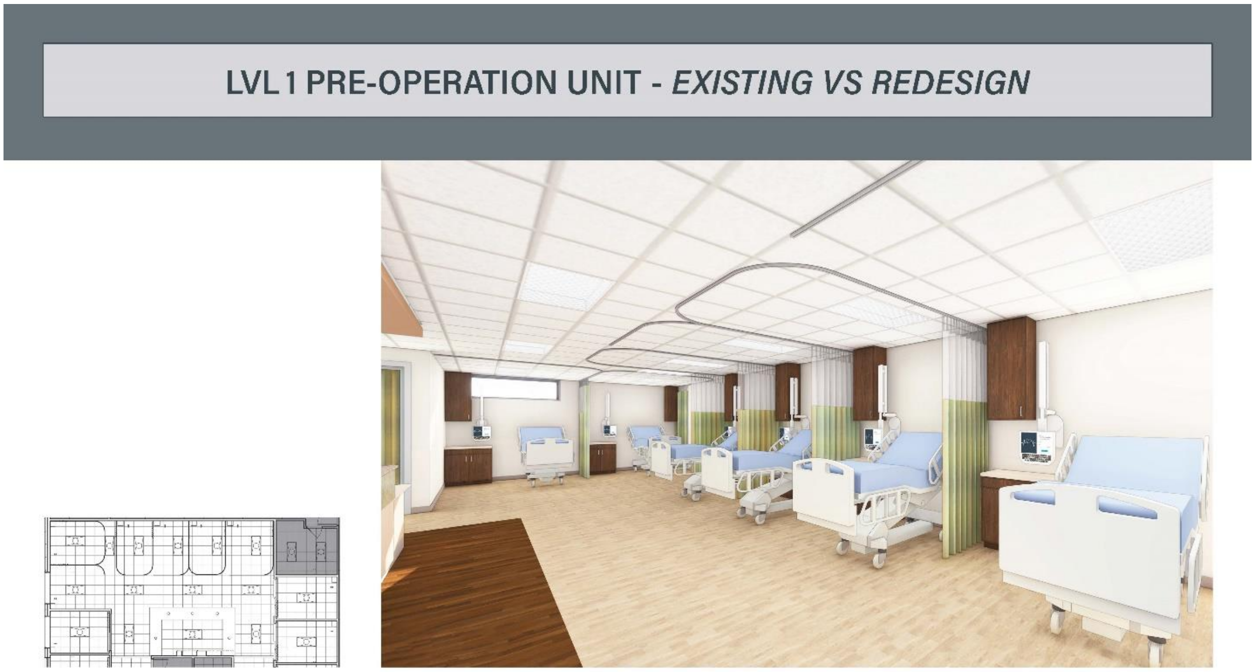



**Figure E184. Design Simulation Level 1 Pre-Operation Unit - Extra Slide**

**Figure E185. Design Simulation Level 1 Pre-Operation Unit - Extra Slide**


**Figure E186. Existing Level 2 Post-Operation Unit - Extra Slide**