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Current and Potential Uses of Green Roofs on Hospitals

by

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Current and Potential Uses of Green Roofs on Hospitals

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Abstract - Plants and planted landscapes have been recognized for their therapeutic benefits. Hospitals are increasingly adopting therapeutic landscapes like healing gardens, horticultural therapy gardens, and memory gardens. Despite this increase in the installation of healing landscapes at hospitals, the research on the therapeutic benefits of green roofs in hospital settings is limited. The primary objective of this project is to understand the current and potential uses of hospital green roofs and associated motivations for their installation. We have documented 105 hospitals nationwide which have green roofs. Of the 105 hospitals, 76 were general care. We found that 63 hospitals have accessible green roofs. Phone interviews were conducted with key stakeholders who played a major role in the planning and maintenance of these hospital green roofs. The questions focused on motives behind green roof installation, accessibility, and therapeutic benefits. A modified grounded theory approach was taken to analyze the qualitative portion of the surveys where both inductive coding and a priori codes were used. Themes emerging from the interviews suggest that stormwater management, energy savings, and therapeutic benefits were primary motivations for installation. The interviews also suggest that green roofs are actively being used by patients, staff, and visitors. Ongoing site use mapping and staff surveys will build on these interview findings. This information will be useful for determining how future green roofs can be designed for hospital settings to promote horticultural therapy.

Keywords – green roof, hospital, horticultural therapy, green spaces

INTRODUCTION

The American Public Health Association released a policy statement in 2013 urging health professionals to “increase the access to green spaces where people live, work, and play and to raise awareness about their value” (3). In this statement, they shared studies highlighting how access to nature has been related to higher levels of outdoor physical activity (5), restoration from stress (10), a greater sense of well-being (4), and greater social capital (1). The mission to provide people more access to nature can be seen in the healthcare industry as architects and healthcare professionals incorporate nature into the healthcare environment - from using biophilic design principles as seen

in the Swedish Ballard Behavioral Unit in Seattle, Washington to sustainable design at Legacy Emanuel Randall Children’s Hospital in Portland, Oregon. These sites are just two of many projects aimed at using the therapeutic values of contact with nature, whether that comes through visual or physical access. The American Horticultural Therapy Association (AHTA) is dedicated to researching and promoting the use of nature in healthcare settings through horticultural therapy practices which have been studied to positively impact patients, visitors, and hospital staff. These studies range from examples in which people find pictures of green space more calming compared to urban environments (25), to other investigations that documented reduced blood pressure in people who had walked through a park compared to a busy urban environment (7).

After Ulrich’s seminal study in 1984 showed the positive effects of viewing nature in hospital settings, the interest in the role of nature in healthcare settings has grown tremendously (26). Studies that followed suggest the following outcomes from human-nature interactions: reduction in stress (16, 27); increase in patient and visitor satisfaction (16, 30); and increase in hospital staff work satisfaction (20, 24). With these benefits, healthcare organizations can benefit economically as the cost of patient care reduces due to shorter hospital stays, personnel costs decrease as staff remain due to positive working environments, and revenue from patients increase through patient satisfaction and recommendations (9). As such, hospitals are increasingly adopting therapeutic landscapes such as healing gardens, horticultural therapy gardens, and memory gardens (18). Therapeutic landscapes are defined by AHTA as “[gardens] designed for use as a component of a treatment, rehabilitation, or vocational program” (2). One challenge that emerges with therapeutic landscapes is finding the space to place them on a hospital campus.

One solution is moving the therapeutic landscapes from the ground level to rooftops using green roofs. Green roofs are a type of green infrastructure that incorporate plant material on top of a substrate separated from a roof’s primary water-proofing membrane by protective felt and possibly by insulation (Figure 1). They are recognized for providing several ecosystem services including the improvement of stormwater management, reduction of urban heat island effect, and increasing habitat for wildlife (22). Green roofs have been used in a variety of building

types, from industrial settings to residential, commercial, and even school settings. With such a variety of building types that green roofs can be used on, they have great potential to provide ecosystem services. However, less is known about the ability of green roofs to provide benefits as a therapeutic landscape, specifically in the healthcare setting.

A small number of studies have examined how green roofs can impact well-being. Several have been conducted showing high preference for green roofs over bare concrete roofs by urbanites (12, 14, 29). One study examined how viewing a green roof can even provide restorative benefits on university students (13). Participants in this study who viewed the green roof had lower errors in a test than those who viewed a bare-concrete roof. This study argues that green roofs can be used in the cities to help provide restorative benefits to help boost networks of attention and ultimately improve wellbeing. Another study looked at how a green roof was being used for physical therapy (6). Through this study it was found that patients and therapists rated the green roof highly satisfactory because the green roof provided a creative approach to outdoor physical therapy. However, challenges that came up included poor maintenance of the green roof, lack of privacy on the green roof, and difficult accessibility for nurses.

The arguments against green roofs mainly revolve around high upfront costs for installation and funds for the long-term maintenance of the green roof. In addition, the lack of robust post occupancy evaluation studies of green roofs has made it difficult to show skeptics the impacts green roofs can have on hospital users. Despite the high upfront costs and long-term maintenance needed for green roofs, green roofs, in the long run, help with reducing building operation costs. The benefits green spaces offer to people also has an economic impact on hospital operations. Previous discussions between researchers and horticultural therapists revealed both advantages and challenges to the idea of utilizing green roofs as therapeutic landscapes. The main advantage is that green roofs can be designed to feature the benefits of therapeutic landscapes (physical

rehabilitation, sensory stimulation, and access to nature). They can provide easy access to both patients and staff who may not be able to make it to the ground floor due to medical restrictions or even a stressful work schedule. They also utilize a unique space on hospital campuses that would otherwise be unused. The main challenge then is the installation and maintenance needed to make sure these therapeutic landscapes benefit its users. Given the potential that green roofs can provide therapeutic benefits, our study asks, what are the current and potential uses of hospital greenroofs? In order to address this question, we assembled a list of hospitals in the United State that have greenroofs that we could find. We then conducted a series of phone interviews with key stakeholders at these locations who played a part in the design, planning, and/or maintenance of the green roof.

METHODS

This cross-sectional study used both qualitative and quantitative methods. Qualitative methods (phone interviews) were used to explore more closely the specific motivations and decision-making processes that went behind the installation of green roofs on participant's hospitals, as well as the current uses and challenges. Quantitative methods were used to evaluate the number of hospital green roofs by hospital type and accessibility. Using both methods has allowed us to examine our research topic on a national and case-by-case scale

Internet Search

An internet search was conducted to generate our own master list of hospitals in the United States that have green roofs. The primary goals of this internet search were to find out how many hospitals have green roofs and if they are accessible. The website, Greenroofs.com, was primarily used to generate this list of hospitals as it has its own database of green roof projects. Additional internet searches were conducted using the standard search engine, Google.



Figure 1: Photo of green roof at the Life Expression Wellness Center in Pennsylvania provided by study participant.

Keywords used while searching online included “green roofs,” “hospital,” and “healthcare.” Once projects were identified from these broad searches, additional projects were found by reviewing the websites of various architect firms, engineer companies, and green roof businesses. We also received practitioner input about additional roofs by attending local meetings of the Portland, Oregon Green Roof Information Thinktank (GRiT) and also at a poster presentation about this work at Cities Alive in Seattle 2017. From this master list, the green roofs were separated into several categories to highlight their accessibility, size, age, and the type of hospital on which they are located. These categories were made to help develop a better understanding about the extent to which green roofs are being considered at different types of hospitals in different locations. We were able to determine the accessibility and the type of hospitals the green roofs were installed on by reviewing multiple online sources which included individual hospital websites and the websites of contracted green roof installers, architects, and landscape architects.

Phone Interviews

Using the master list of hospitals, we reached out to fifty hospitals to see if they would participate in our study. We were able to conduct phone interviews with eleven hospitals. When contacting hospitals, we were focused on talking to key stakeholders who played a role in the planning, installation, or maintenance of these green roofs. A total of eighteen questions were asked throughout these interviews. Interviews lasted anywhere from 30 to 60 minutes depending on participants answers. The phone interview was designed to learn about the participant’s

position at the hospital, the characteristics of the green roof (number and age), accessibility of the green roofs, the process that was used when creating and discussing a green roof, the extent therapeutic benefits was discussed in the planning, motivation behind building a green roof, and current state of the green roof (Table 1). We were primarily interested in gathering data about the motivations behind the installation, the accessibility of the green roofs, and any discussions about the therapeutic benefits green roofs can have on users.

Phone interviews were recorded with participants consent and transcribed. To analyze these responses, we created a priori codes based on the literature, and also used a grounded theory approach to illuminate patterns and themes from the data. This modified approach allowed unique themes to emerge from the data. We used Dedoose, a cross-platform app for data management, excerpting, coding, and analysis. This application allowed us to evaluate inter-rater reliability and consistency in application of codes.

Research with Human Subjects

The IRB application for this research was accepted by the Portland State University Human Subjects Research Review Committee. Before interviews were conducted, the participants were given information about the project and the interview, and gave their consent to participate. Participation in the interviews was entirely voluntary and participants could decline to answer any question. All data has been treated confidentially to protect the privacy of participants.

Table 1: Study concepts and corresponding interview questions.

Study concept	Sample questions
We may be directed to different professionals at each location, depending on how roof management is assigned; these questions establish the role of the interviewee in the design process	Tell me about how you got involved with the green roof at [hospital name]. How long have you been involved with the green roof at [hospital name]?
Establishing design process and priorities as well as interviewee involvement/knowledge	Do you know when the green roof was installed? Was it within the last two years or closer to five years? Ten years? Can you tell me about the process that was used when creating and discussing building a green roof? [prompt: who was involved in that discussion?]
Explicitly addressing motivation for a therapy roof	Were therapeutic benefits considered when planning and designing the green roof? Why did the hospital put resources into a green roof? Is there staff access to the hospital's green roof? Patient access? Visitor access? General public access?
Comparing current conditions to design intent	In what ways, if any, has the green roof lived up to your original expectations? In what ways, if any, has the green roof lived up to the hospital's original expectations? In what ways, if any, has the green roof not lived up to the hospital's original expectations?

RESULTS

Internet Search

A total of 105 hospitals with green roofs were found in the United States. From this list, a map was generated to show the locations of these hospitals around the nation (Figure 2). This map provides a stronger understanding and appreciation for how disperse green roofs are on a national level. While 60 percent of the hospital green roofs we identified were determined to be accessible, 40 percent were not (Table 2). Green roofs were also found to be located in a wide range of hospital types with the majority being located on general hospitals (Table 2). Over half of these roofs were installed during the period from 2008-2013 (Table 3).

Interviews

The interviewees represented eleven different states distributed throughout the country. The types of participants included: groundskeepers, a building owner, a project manager, a vice president of campus planning and maintenance, a director of facility management, and a horticultural therapist. The range of experiences with their respective hospital green roofs split evenly between participants having more than 10 years of involvement and less than 10 years of involvement. The most involved participant worked on their hospital's green roof for 14 years while the least was only two years. Their involvement with the green roofs came throughout different phases from the beginning planning and design process to the post installation maintenance.

Motivation behind installation

The participants shared similar responses when addressing the motivations behind their hospitals installing green roofs. Nine participants said energy conservation and stormwater management were motivations for their green roof. One participant shared how their campus installed green roofs as a way to become LEED certified. Another shared how the design team looked at the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey to gauge patient satisfaction and design a space that would "transform the patient's experience with the new hospital." All interviewees expressed to some extent the benefits a green roof can have on human well-being. One participant stated that, "[the] intention of this particular garden was as a place for parents and patients to get out and just get some fresh air outside of the clinical space. It's a distraction from the clinical space."

Accessibility

We were interested in gaining better insight into the differences between accessible and inaccessible green roofs. Of the eleven participants, four indicated their rooftops were inaccessible, four were accessible, and three had both types. For green roofs that were inaccessible, participants highlighted how patients could still view something that was alive. One participant said that before the inaccessible green roof was installed, the view was "blinding white" from a



Figure 2: Map of hospitals with green roofs in the United States (n=105). (Map generated using EasyMapMaker.com)

Table 2: Number of green roofs according to hospital type and their accessibility.

Category	Frequency
Hospital Type	
General	76
Children's	12
Cancer	7
Active-Duty	3
Rehabilitation	3
Non-traditional	2
Veteran's	1
Women's Healthcare	1
Accessibility	
Accessible	63
Inaccessible	42

Table 3: Number of green roofs installed each year from 2000-2017.

Installation Year	Frequency
2000	1
2001	1
2003	2
2004	3
2005	3
2006	3
2007	5
2008	8
2009	14
2010	16
2011	11
2012	14
2013	12
2014	3
2015	3
2016	2
2017	4

stark white roof which could be viewed through tinted windows. After the installation of this green roof, the views were reported to be a lot more pleasant from hallways and patient rooms. This response was shared by other participants who had inaccessible green roofs.

Accessible green roofs were reported to be used both heavily and lightly. Some participants shared how infrequently the green roof was being used. Others shared how happy they were to see the green roofs being used by patients, staff, and visitors as a space to take a break, have lunch, socialize, play, and grieve. One participant said,

The garden was originally designed as a place for solace, respite - a quiet place to get outdoors. And it's been proven for the past several decades that being in a green, natural space is so soothing on the mind and actually lowers heart rates and blood pressures and so forth, and the garden just comes into play the same way. Whether it's a child, the patient, or a parent who has their child in the hospitals going through a lot of stress, you know, 'is this going to be okay? Is my child going to live or not?' So, getting outdoors in a natural setting just really calms the body and really gets your mind to meditate, to pray, and decompress, to kind of reassess your own mind and then go back into your problems - back into the hospital, the clinical space with the doctors, the nurses, and the patient's - you're kind of recharged.

Therapeutic benefits

When asked if therapeutic benefits were considered in the planning and designing of the green roofs, most participants said yes. All participants shared that their patients' well-being played a role in the design of their green roofs. Participants who had accessible green roofs highlighted how therapeutic benefits were part of the discussion when designing the green roof with the patient's experience in mind. Most participants shared how the green roofs were used as a place to be outdoors or as a way to bring the outdoors into the hospital. One participant shared how their green roof started as a place for solace and respite but over the years, occupational and physical therapy have been programmed onto their green roof,

I believe the whole idea was the healing garden - again a place for solace and respite... can [be] used as therapy as well. Now the garden was designed with rails, and areas patients could hang onto and do squats, and bending, and things like that. But it is a place where the physical therapists and the occupational therapists still take [patients] outside and it's even a goal. For example, [patients] could be working in their room doing PT and OT, and eventually working in the halls, trying to build up your endurance by walking down the halls.

Another participant shared how their landscape architect played a big role in helping to design a visually appealing



Figure 3: Inaccessible green roof at Sharp Memorial Hospital designed with musical notes to "Ode to Joy."

garden that also held features to help reduce noise pollution by nearly 20 decibels.

For the green roofs that were inaccessible, participants highlighted how the green roofs gave patients the opportunity to at least see nature versus a stark white roof. One participant shared how their inaccessible green roof actually has a planting scheme that shows musical notes to the song, "Ode to Joy", which is visible by three surrounding buildings (Figure 3). Despite having an inaccessible green roof, this participant shared how the design team at their hospital really wanted to help enhance the patient's experience at their hospital, and they saw a unique opportunity to design a visually appealing green roof.

Performance

We asked participants to share how the green roofs lived up to the expectations of the hospitals, and we received a range of responses. Some participants shared that there was little to no communication with the grounds keeping department when designing the hospital green roof. This led to maintenance issues the grounds keeping department faced which included weeding, irrigation, and intense microclimates. Another challenge was that because green

roofs are unique landscapes with specific weight loads and limited accessibility, everyday gardening tools can be difficult to use. Therefore, a lot of manual labor has to be conducted to maintain the green roof. This is problematic as we found that often times, the maintenance crew do not have the proper resources to keep up with the maintenance demands of green roofs due to labor and budget restrictions. Another response was that the green roofs were not used as often as they anticipated by patients. However, the green roofs were seen to still be used by staff during breaks and lunches.

DISCUSSION

Current Uses of Green Roofs

Generating the master list and map gave us an idea of the number of hospitals with green roofs and their location around the United States. We found that hospital greenroofs are increasingly common, and that these structures are distributed throughout the US. However, it is evident that there are not many green roofs in the mid states. We were able to determine that the majority of hospitals were general care. This is important to note as different types of hospitals provide different types of care to specific patient populations and therefore the healing spaces should be designed towards the anticipated patient groups. For example, a green roof designed for a general care hospital should be designed with different features than a children's hospital.

Through the interviews, we were able to gain insight of how individual green roofs are being used in the hospital environment and learn whether or not therapeutic benefits were considered in the design process. From the interviews, we have learned that the current uses of green roofs do involve therapeutic benefits, as interview participants noted the physical and visual access that patients, staff, and visitors have when using their green roof. We also learned that the motivations behind the green roof installations varied but all participants shared how human well-being played a role. This finding is exciting as it shows that even though stormwater management and energy efficiency played a role in the green roof installation, human well-being was still part of the conversation. One participant highlighted this importance saying,

The intention of the team here at the time was really to transform the healthcare experience. It wasn't going to be just construction of a new hospital. but it was also the experience that we were committed to delivering to the patients, as well as their loved ones.

Regarding accessibility, participants noted that even if their green roofs were not physically accessible, the visual access that patients and staff had still provided therapeutic benefits. The benefit of having a green roof is that it can be visually accessed by multiple floors and patient rooms. Participants highlighted several times how



Figure 4: Photos of an accessible green roof in the Olson Family Garden at St. Lous Children's Hospital.

seeing a green roof is more appealing than a white roof top with HVAC units. The current use of green roofs as a way to improve views for patients is notable. We know that views of nature have positive effects on patients (23, 26) and that direct connection can help improve human well-being (15, 16, 19). In the interviews, participants highlighted how views of nature had a positive impact at their hospital by bringing nature to patients and other occupants.

Through the interviews, we were also able to gain some insight about the design processes used which ties into the challenges that participants shared about their green roofs. The design process is the foundation of any healing landscape. It is imperative that different stakeholders be present so different user groups have spaces and features in the garden to use. Through the interviews, we learned that challenges arose when grounds keepers were not part of the design process creating maintenance challenges. One participant in our study said that because green roofs are unique landscapes, they require a different type of maintenance plan. Additional challenges that green roof healing gardens may pose is their design constraints on a rooftop. The literature has many studies and books about

design principles and approaches for ground level healing gardens (17, 18, 19), but the available literature regarding healing gardens on green roofs is limited. Considerations have to be made about roof weight load, irrigation lines, and other structural components necessary for a green roof. In addition, microclimates should be studied to incorporate in the design process. One study highlighted how shade structures should be well thought during the design process as direct sun may impact use of green roofs (28). The limitations mentioned can be a challenge, but a collaborative design approach between designers, engineers, therapists, hospital staff, and patients can lead to hospital healing gardens that fulfill the needs and requirements of different users.

Potential Uses of Green Roofs

Even though not all the roofs are accessible, the literature shows that inaccessible hospital green roofs provide benefits from visual access to nature. Sharp Memorial Hospital is an example of how an inaccessible green roof can go beyond the standard sedum inaccessible green roof (Figure 3). Typically, inaccessible green roofs are one dimensional with its planting scheme using sedums. Sedums are a type of plant that have become universal in the green roof industry. They are known for being resilient as they can survive harsh temperatures in only a few inches of substrate. Instead of using just sedums on their inaccessible green roof, Sharp Memorial designed a playful green roof depicting musical notes that are visible from three buildings. Their green roof was retrofitted on an old existing roof top. It is a prime example showing how even inaccessible green roofs can provide visually appealing access to nature by people inside the hospital environment. Future inaccessible green roofs should look to Sharp Memorial Hospital to see how their projects can be more than just a sedum green roof.

For the green roofs that are accessible, we learned that programming can develop when other departments are included. The Olson Garden (Figure 4) exemplifies the potential green roofs can have in hospitals. From the interview, we learned that the Olson Garden actively used a collaborative design process. This participant, shared that physical therapists and occupational therapists saw the green roof as another space to help patients. The result is a green roof that has many features to help enhance and optimize the therapeutic benefits of their green roof. In addition, the grounds keeping department was part of the design process resulting in a green roof that is easily accessible for maintenance. With different stakeholders involved from the design process up to the installation and maintenance of the green roof, the Olson Garden shows the potential that a collaboratively designed green roof can have to offer patients a unique space for therapeutic programming.

Another potential green roofs can have on a hospital campus is to bring healing gardens closer to patients who may have a harder time accessing ground level healing gardens. One participant shared how their third level green roof was more accessible to patients in higher levels

versus the ground floor. Hospital staff are other primary users of green roofs (30). One study found that staff would use outdoor green spaces more if it were closer to their work stations (21).

RECOMMENDATIONS

Based on our findings, we recommend that green roofs should be collaboratively designed between the landscape architect, therapists, clinical staff, and the groundskeepers. Having different key stakeholders present from the beginning of the design process can allow each stakeholder to have input on how the green roof is designed. This core team should discuss how the green roof will be used by patients, staff, and visitors. Once a design has gone through several iterations, patients and visitors should be able to share their own comments. With their input, the core design team and learn about how the intended user group feels about their design. Through this iterative and collaborative process, the final design plan can reflect the goals and desires of each stakeholder.

Other recommendations include having a horticultural therapist in the design process from the beginning. These specialists are trained to take an ordinary landscape and make it therapeutic. It is also necessary to have someone from the grounds keeping department. Through our interviews, it became apparent that maintenance was a big challenge. The result was some green roofs being very difficult to access and maintain by the groundskeepers. To ensure green roofs are being maintained appropriately, we suggest that hospitals focus their attention on building a maintenance plan as part of the design process to ensure the green roof can perform to its highest quality without overburdening maintenance staff..

Finally, more post occupancy studies must be conducted for us to learn from existing green roofs. These studies can range from surveys with staff and patients to behavior observations in order to learn how the green roof is actually being used by garden users. These types of studies can help inform how future green roofs can be designed to have features that provide garden users with the most therapeutic benefits.

LIMITATIONS & FUTURE RESEARCH

Because the internet search was the primary tool to find the hospitals with green roofs, it is safe to assume that there may be several hospitals who have not shared their green roof online. Therefore, the total number of hospitals with green roofs may be even greater than we found. Future research should look at including any recent or missed green roofs projects. Another limitation is the small pool of interview participants and the range of roles they played in the planning, designing, and maintenance of the green roofs.

It is interesting to note that there was no easily accessible list of hospitals with green roofs that researchers can find and use. This suggests that this is a fairly new research area in the healthcare and green roof industry. With limited research on this topic, it is imperative that future research be conducted to learn how green roofs can be used to further enhance the healing environment for patients, staff, and visitors. Future research should look at conducting more interviews to deepen our understanding of how green roofs are being used. During the interviews, we were not able to determine if therapeutic programming was being conducted on participant's green roofs. In the future, asking questions more focused on programming on the green roof can help provide a better understanding beyond just knowing whether or not a green roof exists.

It would also be useful to learn how the design teams of hospital green roofs view their projects compared to the clinical staff and patients. A future study could be conducted to send out surveys for clinical staff to learn their attitudes towards green roofs on hospitals as well as things they want improved.

CONCLUSION

As different types of green roofs are developed for similar purposes and uses, more research is needed to understand how people use these spaces in order to optimize design performance. This paper serves as a model for how teams of interdisciplinary researchers can collaborate to create spaces that provide both ecological and social benefit. We found that green roofs are currently being used in hospitals to: address stormwater management and energy conservation, create unique healing landscapes for users to engage with directly, and provide views of nature. Engaging with key stakeholders revealed that roof managers are generally happy with their hospital green roofs and have shared that the green roofs are being used by visitors, staff, and patients to access nature. At the same time, more work could be done to enhance programming and also to ease maintenance burdens. Creating our own database of hospitals with green roofs indicates that green roofs on hospitals are understudied and need to be evaluated by researchers to advance the current knowledge of hospital green roofs. Our study provides insight into how green roofs are currently being used and where they are located nationally. We aimed to document the current and potential uses green roofs can offer in the hospital environment. We found that a number were successful such as Sharp Memorial Hospital and the Olson Garden, but it is important to note that these projects are not without their own challenges like maintenance. Green roofs should still be considered valuable by the hospital industry because they present the unique opportunity to create a therapeutic landscape for staff, visitors, and patients.

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