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# Mobilizing Medicine:
# A Design Response to the Accessibility and Cost Issues in Healthcare

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# Mobilizing Medicine:
# A Design Response to the Accessibility and Cost Issues in Health Care

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# Abstract


## Mobilizing Medicine:
## A Design Response to the Accessibility and Cost Issues in Health Care

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Nationally, there is increasing concern over the accessibility, cost, and quality of the American health care system. While the quality of the care given is generally out of the control of designers, it has received increased attention in recent years, as is evidenced in the trends of healing gardens, private patient rooms, and improved social settings. As beneficial as these trends are to the patients they serve, they often have a negative effect on overall accessibility and cost of care due to the constant construction and renovations needed and their largely urban presence. While quality health care is very important and should not suffer as a result, how can designers address non-environmental sustainability issues of cost and access in the American healthcare system?

Due to the trend in increasing cases of chronic illness, as opposed to more pathogenic ailments of the past, the necessity for all healthcare settings to be highly controlled and sterile environments should be reevaluated. While less popular and not as fully developed as the typical facilities most Americans are familiar with, an increase in mobilized health care units could be a solution to the lack of economic and social access and sustainability in the current healthcare model while still providing safe, quality care. By examining current instances of mobile clinics, I will explore the design requirements necessary to make mobile clinics accessible and cost effective. In addition, I will look for facilitators and barriers to these systems, such as improvements in mobile communication technologies and lack of stakeholder support.

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# CHAPTER 1: INTRODUCTION

## 1.1. Current Trends: A Healthcare System Reaching Crisis

With media coverage increasing daily, we have seen an increased number of stories on the health crisis in the U.S. For decades, political battles over government involvement in health care have created a complex system of care with high costs, making medical access difficult for many Americans across the country. Access to health care is defined as "the ability to obtain needed, affordable, convenient, acceptable, and effective personal health services in a timely manner" and is affected by "poverty, long travel distances, rural topography, weather conditions, and limited availability of personal transportation."[1] Unfortunately, those most medically vulnerable are often the ones who experience the worst access to care. However, in the Obama administration, the Affordable Care Act (ACA) was introduced in hopes of increasing access to health care through changes to insurance programs and policies.

While the current and projected effects of the ACA have yet to be seen, it is certain that this complex problem will not be solved with insurance alone due to the increasing cost in health services in addition to the increase in medical procedures being offered.[2] The United States typically spends about 17% of its GDP on health care (about $8,086 per American), compared to the average 9% in European nations, made even more out of balance considering many European systems are government funded.[3] And while many healthcare industries, such as healthcare architecture, experienced recent

[1]Shi and Singh, Delivering Healthcare, 2012.
[2]Schroeder et al, Sustainable Healthcare, 2012.
[3]Schroeder et al, Sustainable Healthcare, 2012.

growth, this growth is not likely to last long due to the degrading health of the American population and the unsustainable system of care it is embedded in.

## 1.2. Problem: The Positives and Negatives of the Current System

To say medical care in the United States is a disaster is a bit unfair. Actually, much of the care delivered is of outstanding quality and draws many international users every year. The past century has yielded very advanced care due to medical research and technological development. Additionally, strict quality care measures executed in high quality environments has helped improve medical outcomes. As a result, Americans have seen a reduction in mortality and infection rates, a common marker of a nation's development and prosperity. Also, with the birth of the internet and easy access to its wealth of information, including online information on health care, patients today are more aware and informed than ever. [4]

On the other hand, there are many problems with the American system of care as well, because it has not kept up with the changing needs of people today. While there has been a decrease in mortality and infection, there has been an increase in morbidity and chronic disease, with 50% of Americans reporting at least one chronic illness and seven out of ten deaths being tied to chronic diseases or their complications.[5] And in many households, there is chronic illness and morbidity in addition to infectious disease. [6] The situation is so serious, the September 2011 UN General Assembly Summit focused on chronic illness, identifying tobacco use, physical inactivity, and poor diet as the major

[4]Brown and Dennis, Impacting Patient Outcome Through Design, 2006.
[5]Shi and Singh, Delivering Healthcare, 2012.
[6]Guenther and Vittori, Sustainable Healthcare Architecture, 2013.

risk factors. [7] While diet plays a large role in many chronic illnesses, many of the positive changes in our healthcare system are the cause of the increase in occurrence. For example, as medical knowledge improves and new procedures lead to improved outcomes and longer life expectancy, there are resulting increases in the pool of people who experience chronic illness due to the natural aging process paired with increased lifespans.[8]

Adding to increased lifespan, the baby boomer generation is retiring. By 2050, 80 million people, or one in five adults, will be over the age of 65.[9] Older adults typically experience higher health care needs, face fixed or degrading economic means due to retirement or inability to work, and feel less motivated to make changes. Current trends reveal that an estimated 75% of Americans passing in hospitals despite wishes to die at home.[10] This population also wishes to age in place rather than in the nursing homes, meaning modification to housing and home care may be needed.[11]

There is also a disproportionate amount of care takes place in urban cores. Rural areas average 59 primary care physicians per 100,000 people versus 94 in metropolitan areas, even though rural physicians are in high demand due to a higher population of older adults and vulnerable individuals.[12] Older adults in rural areas tend to have less education regarding wellness, may have fears about leaving their local community for care, and often have less local family support due to urban migration trends of young and middle aged adults, all of which create a burden for the local medical staff due to a

[7]Guenther and Vittori, Sustainable Healthcare Architecture, 2013.
[8]Shi and Singh, Delivering Healthcare, 2012.
[9]Kelly and Donham, Design for Life, 2011.
[10]Schroeder et al, Sustainable Healthcare, 2012.
[11]Kelly and Donham, Design for Life, 2011.
[12]Shi and Singh, Delivering Healthcare, 2012.

decreased patient support network that cares for them on a regular basis. [13] Despite these facts and the medical community's realization of them, a physician's freedom to practice where they want often results in a choice of urban practice and therefore inadequate distribution continues. [14]

The problem is exacerbated by the large population of medical professionals are a part of the baby boomer generation and almost a third plan to retire by 2020.[15] Stressful working conditions often make recruitment and retention difficult, making shortages in the future very likely.[16] Another reason to fear a shortage in the supply of medical professionals is the increased demands in primary care due to the ACA, and the inadequate supply of professionals could cause the preventive goals of the ACA to fail.[17] To combat this strain, efficiencies in care are being channeled through new techniques in care management that aim to reduce overlaps and duplications in care, unnecessary or inadequate treatments, and errors in order to increase efficiency, improve outcome, and reduce cost.[18] While waste is a necessary evil to health care providers, these inefficiencies wasted $700 billion that could have been used for those in need.[19]

## 1.3. Solution: Increasing Preventive Care

An overwhelming amount of evidence reveals that an increase in and improvement of primary care will mitigate many of the issues in the care system today.

[13]Alexy and Elnitsky, Rural Mobile, 1998; Ray, Interior Design for Rural Healthcare, 2009; Wiebe and Hubert, Community Mobile Treatment, 1996.
[14]Shi and Singh, Delivering Healthcare, 2012.
[15]Physcians Foundation, Survey, 2010.
[16]Brown and Dennis, Impacting Patient Outcome Through Design, 2006.
[17]Shi and Singh, Delivering Healthcare, 2012.
[18]Flower, Healthcare Beyond Reform, 2012.
[19]Grove, Healthcare Reform, 2011.

For example, decreased access to preventive care leads to more expensive and avoidable services, health outcomes (such as infant mortality and decreased life expectancy), and compounds income inequality. [2021] Experts believe that 75-85% of the population needs only primary care in a given year, but the current availability and utilization of these services do not reflect these needs.[22] In fact, a Deloitte customer satisfaction survey revealed that the younger the adult, the less likely they are to have a regular primary care physician despite reported perceptions of health being relatively similar across the population.[23] The problem is not simply an issue of motivation. Iin order to address the issue of underutilization, we need to reevaluate the way we deliver primary care.

According to the World Health Organization (WHO), the most progressive primary care systems are those that empower communities; are comprehensive to include promotional, preventive, curative, rehabilitative, and palliative services; demand accountable practice from concerned and knowledgeable practitioners; promotes teamwork and continuity in care; and ensures equality through outreach to vulnerable populations.[24] The healthcare system as it stands today cannot support such a system due to these complex issues previously discussed. However, it deserves serious attention if the United States desires to maintain a strong medical presence in the world.

The issues of cost and access will continue to put strain on the medical system as a whole, threatening system collapse.[25] Medical professionals need incentivizing to enter into primary care as it often yields a lower personal gain in terms of professional prestige

[20]Grove, Healthcare Reform, 2011.
[21]Shi and Singh, Delivering Healthcare, 2012.
[22]Shi and Singh, Delivering Healthcare, 2012.
[23]Ridgeway, Convenient Care Clinics, 2011.
[24]Kagioglou and Tzortzopoulos, Built Environment Infrastructure, 2010.
[25]Shi and Singh, Delivering Healthcare, 2012.

and economic return, in comparison to more specialized, complex care.[26] Responses to this issue have come from multiple industries and organizations. *So how can designers address the non-environmental sustainability issues of cost and access in the American healthcare system?*

## 1.4. Introduction to the Design Problem

These issues are difficult to address by designers who have no obvious influence on these factors, outside of adding to the problem of cost through expensive buildings. In order to develop a system the WHO recommends, experts believe responses need to be personal, voluntary, incentivized, and targeted to specific populations (especially those considered vulnerable, such as the poor and elderly).[27] The value of designers contributing to health care environments is proven through success in many past interventions, so it is entirely possible that designers could find a response for health trends today.[28] For example, traditional care involves a patient travelling to their provider and then returning to the environment that their health issues developed in. Recognizing this, designers could begin advocating for an increase in distributed care. Distributed care, or health and medical interventions that take place outside of traditional care settings, could be an answer to the issues of cost and access by bringing care to the patient.[29] The home healthcare industry is already facing increased demands due to the aging population and employers are including medical services on-site.[30]

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[26]Moore et al, Contraception and Clean Needles, 2012.
[27]Flower, Healthcare Beyond Reform, 2012; Devlin and Arneill, Environment and Patient Outcomes, 2003.
[28]Kagioglou and Tzortzopoulos, Built Environment Infrastructure, 2010.
[29]Kelly and Donham, Design for Life, 2011.
[30]Flower, Healthcare Beyond Reform, 2012.

This approach to care also matches cultural trends of increased mobile technology. Mobile health technologies, also known as mHealth, are making distributed care systems increasingly obtainable.[31] If we mobilize medical clinics in the same way we've mobilized medical technology, is it possible that the same benefits will be shared? *If designers advocate an increase in distributed healthcare for primary care in the current system of care by improving mobile clinic systems, health care costs will be reduced and there will be increased access to health care in rural settings*. While mobile clinics are not the total solution, it is one way in which designers can aid in finding the optimal solution.

In order to investigate the plausibility of mobile clinics, the current use of mobile clinics will be reviewed alongside their supporting systems. In addition, the principles of healthcare architecture and design will be discussed to aid in developing an optimal design guideline and prototype for future clinics and for designers to utilize to further reduce costs in the planning stage.

[31]Schroeder et al, Sustainable Healthcare, 2012.

# CHAPTER 2: PREVIOUS RESEARCH

## 2.1. Alternative Care Environments

### 2.1.1. WHAT IS DISTRIBUTED CARE?

> "Developments in facilities technology is making it increasingly safe and acceptable for diagnostic tests and acute clinical treatments to be delivered in settings beyond large hospitals--even in mobile and modular facilities. The digitalization of both pathology and imaging mean that patients need not travel to hospitals for the majority of their diagnostics tests. The tests can be administered locally and results can be read and interpreted anywhere."[32]

Due to evolving care models, the time spent in hospitals has decreased significantly. However, that does not mean that the period of care has been shortened. Instead, most care models are increasing the use of outpatient and home administered self-care, even in cases where the patient's daily quality of life or abilities have been drastically impaired or reduced. In many cases, family and friends are able to step in and aid their loved ones, but others have no choice but to rely on personal nurses who make visits to their home. However, with aging baby boomers beginning to place large demands on the healthcare system as a whole, the current mode of care may not work going into the future. Patients will need something more available, accessible, and cost effective.[33] Many healthcare networks are responding to this increase in outpatient services by increasing their ambulatory services in efforts to keep patients in their system and to continue generating revenue after the initial hospital stay.[34] This geographic expansion of healthcare services is referred to as "distributed care," a mode of health care taking place outside of the typical hospital and primary clinic services.

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[32]Barlow et al, Care Closer to Home, 2010.

[33]Kelly and Donham, Design for Life, 2011.

[34]Shi and Singh, Delivering Healthcare, 2012.

Several modes of distributed care exist, however their popularity and availability in comparison to traditional places of care are still low. Examples of distributed care include but are not limited to the following: telehealth, outreach workers in a fixed facility, towed trailer clinics (mobile clinics), convenient care clinics, and home-based care.[35] The common perception is that hospital and clinic based care is superior to other health interventions and tools, such as community-based care. The truth is that no investigation has been done to compare effectiveness. At this point, there is no evidence that care taking place in a certain type of facility has greater or lesser risk of hospitalization in the future.[36]

There are many reasons to increase distributed care, but there are also many options suited to different needs. For example, small community clinics work very well in urban environments where cost access is low and geographic access is high, but home-based care might be the only option for someone with low geographic access and low ability to maintain activities of daily living. Online doctor services show potential in all instances of care needs, offering care packages or membership fees (often at low cost), but these services may not be appropriate for older generations less comfortable with these technologies.[37] In-house worksite programs, where health professionals travel to worksites with promotional or mandatory health screening and care, have proven successful in reducing overall care costs. In some cases, there is as much as 25% difference between participants and non-participants, and have resulted in reductions in blood pressure, stress, smoking, body weight, and substance abuse.[38] However, such programs require not only a job, but a workplace that includes such services. This leaves

[35]Muolavie et al, Things to Consider Before Buying, 1999; Shi and Singh, Delivering Healthcare, 2012.
[36]Guo et al, Mobile Crisis Services, 2001.
[37]Flower, Healthcare Beyond Reform, 2012.
[38]Aldana et al, Mobile Worksite Health Promotion, 1992.

the most accessible option being home-based care.

A large, but underutilized, component of distributed care is the home healthcare business, and hospitals are increasingly utilizing this mode of care to keep patients within their care system.[39] Home-based care gives the patient the ability to recover and continue life in the comfort of their home without sacrificing medical monitoring and assistance of their health care needs. It may be used to make sure patients are able to maintain a certain quality of life, to avoid the high cost of hospital stays during long-term illness, and for post-care treatment where a nurse or physician operates nomadically.[40] In some cases, home care is the only way to avoid institutionalization in hospitals and medical homes, and home health care aims to put patients in the least restrictive environment.[41]

While this nomadic care model offers medical professionals freedom from typical workplaces, it does require consideration on how to maintain communication with other medical staff and how to coordinate patient care needs and appointments independently. In 2007, the majority of home-based care was offered by private, for profit companies, and typically private services are more expensive than publicly offered care, making it less accessible to many individuals.[42] Medicaid federally mandates the availability of home healthcare for its recipients, but due to high costs it is restricted to the most critical cases.[43] For the most part, the underutilization of home-based care is due to the costs of personalized care, but an overall shortage in medical staff is also a factor. For these reasons, home healthcare is mostly offered to the elderly and people with disabilities who have low social support and inability to perform most activities of daily living.

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[39]Shi and Singh, Delivering Healthcare, 2012.
[40]Christensen et al, Geo-Health, 2007.
[41]Shi and Singh, Delivering Healthcare, 2012.
[42]Shi and Singh, Delivering Healthcare, 2012.
[43]Shi and Singh, Delivering Healthcare, 2012.

Historically, the health care field started with distributed services, with more than 70% of female nurses operating on a private, nomadic basis prior to World War I.[44] The Visiting Nurse Associations (VNAs) was once a prominent source of care, but now only account for about 6% of Medicare-certified agencies.[45] Going into the future, many healthcare experts predict that distributed care models will become the norm due to the increasingly mobile society and increased regular care needs. The convenience of community care clinics has already shown popularity, with consumers within a one mile radius increasing their utilization by 7.5%.[46] And between 2007 and 2009, the overall use of community care clinics alone increased from 1.48 million patient visits to 5.97 million.[47]

It is expected that the Affordable Care Act will have some effect on services offered and reimbursement strategies, but it is predicted that it will place greater emphasis on ambulatory and community-based services and will reward "procedure producing places," such as hospitals and specialty clinics, less.[48] Unfortunately, how to most effectively use distributed care at a reasonable cost within the deeply integrated healthcare system that exists today presents many challenges and prompts discussions of which options to most heavily pursue.

### 2.1.2. THE VALUE AND POTENTIAL OF MOBILE CLINICS

#### 2.1.2.1. What are mobile clinics?

The concept of mobilized care clinics is emerging as important inclusion to health

[44]Shi and Singh, Delivering Healthcare, 2012.
[45]Shi and Singh, Delivering Healthcare, 2012.
[46]Ridgeway, Convenient Care Clinics, 2011.
[47]Mehrotra and Lave, Retail, Clinics, 2012.
[48]Marberry, State of US Healthcare Building and Design Industry, 2009.

service packages, complementing most services and adjacent settings well.[49] Mobile clinics enable staff to work remotely, going to the patient without sacrificing the resources found in many care facilities. This mode of care allows diagnostic services to reach small communities that are traditionally underserved, offering rural patients the same conveniences as urban patients. The range of services that mobile clinics offer is increasing with advancements in technology: delivering acute, preventive, and chronic care; facilitating telehealth connections with specialists; offering screening and diagnostic services to control the spread of disease; offering support for maternity, elderly, disabled, and mental health patients; and providing immunization services.[50] In 2008, there were 21 mobile health care services available across the US, however, most of these services focused on urban, high risk populations. Additionally, most mobile clinics are run through university medical programs, utilizing practicing students for inexpensive care, but locally tied mobile services are limited in their geographic outreach.[51]

Although mobile clinics have been available for several decades, there has been little in terms of evaluating the effectiveness of these services. Instead, the available literature on mobile care clinics is limited to descriptions and short-term results of specific of programs.[52] Additionally, brief comparisons between various program results have shown to reduce hospital use, although the effectiveness in comparison to other modes of care have not been carefully examined.[53] Utilization surveys have revealed that medical professionals and patients who have used mobile clinic services often report high satisfaction and preference for the convenience and services that mobile clinics are able

[49]Liebman et al, Effectiveness of Mobile Medical, 2002.
[50]Guruge et al, Immigrant Worker Experience, 2010.
[51]McNeal, UMDNJ, 2008.
[52]Guo et al, Mobile Crisis Services, 2001.
[53]Guo et al, Mobile Crisis Services, 2001.

to offer. These qualitative studies reveal that people prefer the informal, familiar, and convenient environment and staff report better communication and relationships with their patients.[54] For example, a rehabilitation center in Ottawa, Canada surveyed their patients after using their mobile services, discovering that 97.2% preferred the convenience of care coming to them and 91.4% reported a willingness to attend future appointments.[55]

#### 2.1.2.2. The Benefits of Mobile Clinics

The benefits and successes of mobile clinics has been well documented via reports of individual programs. Mobile clinics are widely reported to remove traditional barriers to care, such as long waiting times, transportation challenges, cost, scheduling difficulties, and inconvenient hours.[56] Some individuals find these settings more comfortable and safe when compared to traditional medical examinations, such as with sex workers and immigrants who may have trust issues with state run facilities.[57] By enabling staff to work remotely and eliminating or reducing travel needs of patients, mobile clinics effectively reduce the collective costs and emissions resulting from automobile travel, estimated to be almost one million travel miles for some programs in a single year.[58] Mobile clinics offer the unique ability to not only quickly screen high-risk individuals, but to also serve as effective teaching and promotion tools.[59] When paired with educational programs, they can be learning tools for medical students who volunteer or gain credit hours working in them, providing them with hands on experience while

[54]Hill et al, Knowledgeable Neighbors, 2012.
[55]Wilson, Consumer Satisfaction, 1995.
[56]Moore et al, Contraception and Clean Needles, 2012.
[57]Moore et al, Contraception and Clean Needles, 2012; Edgerley et al, Early Access to Prenatal Care, 2006.
[58]Schroeder et al, Sustainable Healthcare, 2012.
[59]Liebman et al, Effectiveness of Mobile Medical, 2002.

simultaneously reducing health care costs associated with labor.[60] While proponents of mobile clinics admit that they can't satisfy all health needs, it is believed that these programs are instrumental in meeting the preventive health care needs for most populations, especially in poor communities.[61]

While initial costs for starting mobile clinic programs are high, they often result in long-term cost effectiveness.[62] The costs of mobile clinics, mainly offering services for free or at a low cost, are often covered by donation. However, some programs found that the funds recovered from decreased emergency room use fully covered costs.[63] Other programs successfully integrated mobile care clinics by pairing it with other programs.[64] In one case, a mobile clinic that screened and treated sexually transmitted diseases among sex workers was paired with an established needle exchange network (due to correlations between drug use and sexually transmitted diseases) and the reulting cost per client was about $85, which included labor and supply costs.[65]

The public health benefits of mobile clinics has been widely reported. Based on the convenience and often low cost of care offered through mobile clinics, people experience fewer barriers in accessing care as opposed to a traditional primary care clinic. With reduced barriers to care, we see an increase in service utilization, an increase in compliance with post-care instructions due to the education and awareness offered, and, as a grand result, overall improved health outcomes. Mobile clinics have proven very effective at screening for communicable diseases, cancers, and chronic illnesses.[66] They

[60]Alexy and Elnitsky, Rural Mobile, 1998.
[61]Liebman et al, Effectiveness of Mobile Medical, 2002.
[62]Muolavie et al, Things to Consider Before Buying, 1999.
[63]Guo et al, Mobile Crisis Services, 2001.
[64]Moore et al, Contraception and Clean Needles, 2012.
[65]Moore et al, Contraception and Clean Needles, 2012.
[66]Alexy and Elnitsky, Rural Mobile, 1998

also raises public health awareness, both among the community and amongst the operating medical staff.[67] In a program offering maternity care, women who used mobile clinics began care an average of three weeks earlier than women who used other community clinics, indicating that the outreach efforts encourage people to seek out health services.[68] The insight a medical professional gains through first-hand experience in their patients' homes and communities is invaluable, giving them better information about how to best treat their patients based on their surroundings.

#### 2.1.2.3. Barriers to Integration

Beyond gaining initial support, mobile clinics still face barriers to seamless integration. Recent developments in telehealth and mHealth technologies have eliminated many of the past barriers of delivering mobilized care, such as difficulties in connecting with other professionals (solved with the availability of wireless internet and phone) or providing the diagnostic capabilities of in-place facilities (such as portable screening equipment). Despite enthusiasm from patients utilizing these services, care providers have revealed limitations on the supply side, such as some remaining limitations in the physical set-up, confidentiality issues, concerns about follow-up compliance, and pressure to see a large amount of clients.[69] The constraint of dependable fuel sources in rural areas would require additional planning among care providers.[70] Some practitioners also express issues of social isolation in offering these services in lieu of forced interaction from institutionalization due to decreased interaction with colleagues and decreased interaction with longer term patients . Additionally, the

[67]Alexy and Elnitsky, Rural Mobile, 1998.
[68]Edgerley et al, Early Access to Prenatal Care, 2006.
[69]Guruge et al, Immigrant Worker Experience, 2010.
[70]Muolavie et al, Things to Consider Before Buying, 1999.

population of medical professionals willing to work remotely as opposed to having a private office spaces are in the minority, making recruitment and retention of professionals more difficult.[71]

## 2.2. Supportive Systems for Integration

While mobile clinics are meant to operate in a fairly independent, nomadic fashion, their ability to succeed is highly dependent on larger care networks and available technologies.

### 2.2.1. Supportive Healthcare Systems

The current trend in health care delivery is through connected networks of care providers, moving away from the current private practices and segregated specialists. Many hospitals attempt to accommodate all examination and diagnostic needs by providing all services in-house, meaning either within the facility itself or in the medical campus. Where in-house services are not possible, hospitals form networks with external care sources to keep patients within their system of care and therefore achieve better continuity in care. These external but networked sources of care then act as "feeders" back into the hospital.[72] Through partnership, merger, acquisition, and consolidations, these healthcare networks attempt to solve some of the current issues facing healthcare, such as increased care costs due to duplication of services.[73] It also attempts to move care closer to home by allowing patients to utilize local sources for follow-up care rather than having to return to the original specialist or hospital that provided care, which are

[71]Alexy and Elnitsky, Rural Mobile, 1998.
[72]Grove, Healthcare Reform, 2011.
[73]Kim, Texas A&M Dissertation, 2011.

often geographically distributed unequally.[74]

The reach and success of a healthcare network is dependent on the linkages between facilities (avoiding partnerships outside their current geographic reach), the technologies and competencies offered across the network, cooperation amongst medical professionals operating within the network, and the correct matching of services to the population of interest.[75] In order for a mobile care clinic to successfully reach its desired populations, it is critical for these programs to network with a larger care network. The system of medical, administrative, and other supportive staff is also critical to the operation of mobile care clinics. Careful coordination of care is essential to the continuity and comprehensiveness of care delivered, which has more recently created a new form of medical professional, the care coordinator, charged with following patients throughout their whole care process.[76]

In order to remain cost effective, most mobile care clinics rely on community health workers, nurse practitioners (NPs), or medical students to reduce labor costs. By allowing medical students to aid in and perform a majority of the care delivered in mobile health clinics, the clinic benefits from reduce labor costs as medical students often participate on a voluntary basis to obtain the necessary experience prior to graduating from their programs. While it might seem like the quality of care would be impacted by using the less experienced staff, proper supervision of this kind of service would result in better health outcomes due to the increase in available practitioners and the improved training of new professionals. The level of supervision needed can often be obtained through use of nurse practitioners (NPs) and physician's assistants (PAs), which are

[74]Kagioglou and Tzortzopoulos, Built Environment Infrastructure, 2010.
[75]Kim, Texas A&M Dissertation, 2011.
[76]Shi and Singh, Delivering Healthcare, 2012.

nurses with advanced training and can perform care at almost physician level, however, not all states allow this practice.[77] In many cases, states require higher certification levels or an established relationship with a licensed physician and may limit authority on diagnostic and prescriptive functions.[78]

Community health workers (CHWs) do not offer the same level medical care but have the advantage of being embedded in the local culture to improve outreach. CHWs offer a broader level of care beyond peer counseling and support by bridging the gap between the community and medical professionals while providing the same level of cultural competencies that peer services offer.[79] CHWs often have training on community relevant interventions, such as how to manage diabetes or administer vaccines, but do not have any formal medical training or certification.[80] As CHWs are often recruited within the community they are serving, they have begun to reduce disparities through the administration of culturally sensitive health education and care due to increased trust between the CHW and the patient. Culturally relevant care is critical in communities that may not trust outside sources for information and services due to financial, legal, language, or cultural barriers, such as immigrants fearing deportation.

### 2.2.2. SUPPORTIVE TECHNOLOGIES

#### 2.2.2.1. Types of Medical Technologies

Beyond traditional equipment found in medical facilities, new forms of technology based on wireless internet and phone technologies are finding overwhelming

[77]Ridgeway, Convenient Care Clinics, 2011.
[78]Ridgeway, Convenient Care Clinics, 2011.
[79]Viswanathan et al, Outcomes and Costs, 2010.
[80]Viswanathan et al, Outcomes and Costs, 2010.

and quick acceptance amongst patients and care staff. The major types of medical technologies are eHealth, mHealth, and telehealth.

eHealth: eHealth relates to all types of care delivered via the internet connections and programs. The delivery of care and access to information via the internet is expected to have the most significant impact and payoff benefit on patients in the long term for health care delivery.[81] The major applications of eHealth are data and information management systems through electronic medical records (EMR) maintained by care networks and insurance companies; communication and decision making professional networks; personal health monitoring through hospital and commercially generated websites; and knowledge sharing and information promotion.[82]

mHealth: The increase in web-based services, availability of internet access, and applications of GPS tracking have created new possibilities in portable and personal health technologies as never seen before.[83] Additionally, the increased use of personal mobile technologies has created an increased demand for these health technologies.[84] Often a part of eHealth services, mHealth is any portable and personal form of medical technology that is able to gather, store, process, or share health related information. These technologies make remote monitoring of patients possible and detects emergency situations sooner than traditional human monitoring, which the Brookings Institute estimates will save $197 billion worldwide in care costs and avoidance of decreasing health.[85] And an increasing number of users believe that mHealth technologies have the ability to significantly change the way they monitor their health, even going so far to

[81]Baker, Patient Centered Healthcare, 2001.
[82]Shi and Singh, Delivering Healthcare, 2012.
[83]Christensen et al, Geo-Health, 2007.
[84]Morgan and Agee, Mobile Healthcare, 2011..
[85]Morgan and Agee, Mobile Healthcare, 2011..

encourage positive health actions.[86]

Telehealth: Telehealth is any health service delivered by phone, but its popularity is decreasing due to the increasing popularity of eHealth and mHealth technologies. Examples include care compliance reminders, health information sharing and promotion, and facilitation of appointments by video conferencing, connecting patients with their physicians for appointments and staff with specialists. The most popular use of telehealth is for mental health and addiction support, providing immediate response from care providers in times of crisis and offering care in rural areas where such services are difficult to obtain. Telehealth has proven successful at reducing travel-related emissions, saving time for patients and staff, and improving access to care.[87]

#### 2.2.2.2. Functions, Quality Measures, and Potential

Medical technology development is a fast growing industry with applications at all levels of health care. Due to the advancements in other types of technologies, such as cellular networks, GPS capabilities, bluetooth functions, SMS (text) and GPRS (radio) messaging systems, movement tracking, touch screen capability, and integration of loadable applications, the current and potential uses of technology in health care are seemingly endless. The primary goals in using medical technologies is to improve communication, collaboration, and support amongst patients and medical staff; improve efficiency and accuracy in diagnosing; patient tracking; and reduce workload and effort required to perform these tasks. However, a strong knowledge of and comfort with technology is required for successful selection and integration of new types of technology.

The first function of medical technology is for diagnosis and treatment, aiding in

[86]Morgan and Agee, Mobile Healthcare, 2011..
[87]Schroeder et al, Sustainable Healthcare, 2012.

behavioral and emotional health support, overcoming addiction, production of radiology and digital imaging, bio-optical sensing, and decision support for patients and medical professionals. The second function is for health monitoring, such as assessing bodily systems performance, helping manage diet and exercise, tracking chronic illness complications, and following the spread of infection, illness, and immunization. The third function of medical technologies is education and awareness through improving data collection for research purposes, providing training resources for staff and patients, reminding patients about appointments and medications, and delivering important health related news and information. The fourth function is for administrative support, such as billing and insurance, care scheduling and coordination, and health record and inventory management. [88]

Medical technology can take the form of fixed and portable equipment, software programs, and network connections and are used by healthy individuals, the chronically or acutely ill, and health personnel to connect relevant information to the patient and their care provider and in some cases pass information to insurance companies and government agencies for analysis. The relationship between the user and the technology can take multiple forms, such as the following: active user and active system, where the user physically gathers and enters information and the system analyzes it; active user and passive system, where the user gathers data and the system simply stores it for later analysis by a professional; passive user and active system, where the system gathers information and analyzes data; and the passive user and passive system, where the system simply gathers data.[89]

The quality of medical technologies available greatly affect their acceptance as a

[88]Melgara et al, Nomadic Users, 2006; Morgan and Agee, Mobile Healthcare, 2011.
[89]Christensen et al, Geo-Health, 2007; Rodrigues et al, Adaptable Home Healthcare, 2011.

care aid and its proper use. Overall, usability is of highest concern, such as technical competency required for use, battery life, completeness of functions, and possibility for personalization. Considerations between fixed and portable features depend on the type, frequency, and location of use. Highest possible processing power enables multiple functions to occur simultaneously without affecting speed and satisfaction of use through the ability to handle and observe multiple data types and sources as well as analyze the data and provide feedback. The feasibility of using the technology depends on several factors, such as affordability, network availability, population applicability, privacy and access to information, and compatibility with other technologies.

The potential benefits of increased use of medical and mobile health technologies are great. They can improve the availability and quality of care in underserved areas, reduce stress on patients and staff while improving productivity and quality of life, and reduce the long-term cost of services.[90] The health monitoring capabilities have the potential to reduce the need for health service for personal health management and to improve relationships between patients and staff due to resulting feelings of security and satisfaction with care delivered.[91] However, many barriers to integration do exist and improper implementation often results in inability to ever successfully use the technology. A major barrier is a resistance to use, often expressed by older or less tech savvy users. This is sometimes the result of improper design, such as creating a too sophisticated and complicated system or creating a design that only appeals to certain groups.[92] Some barriers are more psychological, with patients reporting paranoia and depression regarding constant monitoring, feeling a loss of identity from the illness and

[90]Varshney, Wireless Health Monitoring, 2007.
[91]Sanders et al, Telehealth and Telecare, 2012.
[92]Baker, Patient Centered Healthcare, 2001.

guilt for making unhealthy decisions.[93] Medical staff report struggles in handling the changes in workloads, not knowing where to draw the barrier on patient interactions via phone and internet and putting pressures on them to reduce their time with patients to increase the amount of patients they see based on the improved efficiencies.[94] Other barriers include privacy, data integrity, content validity, and legal concerns.[95]

## 2.3. Healthcare Design

### 2.3.1. The History of Healthcare Design

In order to fully understand why we have the facilities we do and what we might need in the future, it is helpful to look back at why we made these design decisions throughout history to determine what is really still necessary or unnecessary. In the record of human history and advancement, spaces meant for human health are a relatively new concept, and like the field of medicine, have undergone many transformations over the past few centuries. The earliest examples of health care spaces go back to ancient Egyptian and Greek temples, where priests acted as physicians for both physical and spiritual needs.[96] With the rise of the Roman empire, human health and its importance to the collective gained notoriety with civic decree in 325 AD that cities have buildings dedicated solely to public health needs.[97]

With a rise in Christianity in Medieval times, we begin to see an evolution from spaces for health care and the spaces it takes place in.[98] Due to lack of knowledge on the

[93]Sanders et al, Telehealth and Telecare, 2012.
[94]Baker, Patient Centered Healthcare, 2001.
[95]Baker, Patient Centered Healthcare, 2001.
[96]Schroeder et al, Sustainable Healthcare, 2012.
[97]Schroeder et al, Sustainable Healthcare, 2012.
[98]Kim, Texas A&M Dissertation, 2011.

spread of diseases, these spaces (often called almshouses), served more than just the ill. In addition to hosting and caring for the sick, these facilities also acted as a home for orphans, the decrepit, and the mentally ill and offered shelter to the poor and travelers, all cared for by members of the local church.[99] Constructed in cruciform plan, a long hallway connected several open patient spaces to the center of the cross, with the main purpose of housing as many individuals as possible regardless of the individual's needs, meaning no separation between the ill and healthy.[100] Often located on the edges of towns, it is commonly thought that their placement was to isolate disease, although lack of medical knowledge and their late integration in town development denote that this is due to lack of space near civic centers.[101]

With the dawn of the Renaissance, exploration and knowledge of the human body flourished, however, human health relative to the local environment was not yet realized and therefore little change occurred in almshouses. While the cruciform plan developed into radial plans for surveillance benefit, the continued lack of understanding about the spread of disease meant no division between patrons based on health. Due to this, almshouses were often associated with death due to their high mortality rates.[102] For example, the Hotel Dieu in Paris (where we begin to see the word hospital gain popularity, stemming from hospitality) was known to house multiple patients in a single bed, with understandably negative outcomes.[103] In their time, almshouses were recognized more as a place to die than a place to get well.

It wasn't until Florence Nightingale's revolutionary observations on human health

[99]Cook, Design Quality Manual, 2008.
[100]Cook, Design Quality Manual, 2008.
[101]Cook, Design Quality Manual, 2008.
[102]Cook, Design Quality Manual, 2008.
[103]Cook, Design Quality Manual, 2008.

and the environment that health care spaces began to change form and focus. Led by Victorian theory that 'miasma,' or bad air, causes the spread of disease, Nightingale reasoned that subdividing spaces based on use and increasing ventilation would improve patient outcomes.[104] This produced the pavilion plan hospital, a collection of window-ventilated buildings connected by courtyard. This design was intended to increase airflow within and between the buildings, segregate patients by type into wards (still large, multiple patient rooms) to increase medical staff efficiency, and reduce the spread of disease.[105] While the new hospital plan had some success in reducing the spread of the disease, they were expensive to construct and mortality rates still remained high.[106] By the 20th century, the pavilion plan had already become obsolete due to developments in mechanical ventilation and air conditioning.[107]

Public health study and policy began to gain importance beginning in the 20th century. Mass advertising on personal hygiene and sanitation greatly improved both human health and living conditions and eventually made its way into health care spaces through means of physician hygiene and sanitation of spaces and equipment. The effects on mortality rates were outstanding. In addition, the medical profession began to legitimize itself, requiring education to practice medicine and giving diagnostic and treatment power to doctors. Up to this point, anyone could call themselves a doctor, such as barbers who also acted as local surgeons (the classic red and white striped barber pole is actually symbolic of blood and bandages). With the educated doctor replacing the religious official as medical personnel, the connection between physical and spiritual

[104]Kim, Texas A&M Dissertation, 2011.
[105]Kim, Texas A&M Dissertation, 2011.
[106]Kim, Texas A&M Dissertation, 2011.
[107]Cook, Design Quality Manual, 2008.

health also saw a divide, bringing a curative focus in healthcare.[108]

With a legitimization of the healthcare professional in the early 20th century, we also see a legitimization of healthcare spaces, what some refer to as the Hill-Burton era in healthcare design. Doctors began making fewer house calls in favor of performing their care in more controlled spaces, necessitating mass construction of mental health facilities, hospitals, and local practices. These new facilities gained legitimacy due to inventions and discoveries such as indoor environmental control systems, elevators, germ theory, antiseptic methodology, expanded use of anesthesia, and radiology.[109] With further specialization of medical professionals and spaces amidst large movements in medical knowledge, the equaled development in medical technologies became invaluable and diagnostic and curative machines became a commonplace element of all health spaces. As a result of all these trends, the Hill-Burton approach to medical space design took authority. Often symmetrically designed into "H", "U", and "E" block footprints, these facilities (some still in use today) were often bleak and harsh in terms of aesthetics and felt "unfeeling, uncaring, and impersonal," which is only recently being recognized as a point of stress in the health care environment.[110]

As a result of new understanding of the psychological effects of health care environments and its corresponding effects on overall health, the Hill-Burton hospitals are the target of new criticism and are now being replaced and redesigned at a rapid rate. Influenced by residential, hospitality, and shopping mall design, newer facilities aim to create a healing atmosphere by creating a home-like environment that caters to all of the patients needs (under one roof, if possible).[111] This translates into multiple building

[108]Guenther and Vittori, Sustainable Healthcare Architecture, 2013.
[109]Kim, Texas A&M Dissertation, 2011.
[110]Kim, Texas A&M Dissertation, 2011.
[111]Devlin and Arneill, Environment and Patient Outcomes, 2003.

forms and types, ranging from designs on pastoral campuses to dense, urban high-rise facilities. Depending upon the design, its location, and its intended uses, health care facilities house more than just patient and surgery rooms and now include spaces such as surgical amphitheaters, and outpatient departments.[112] But with rapid evolution in medical science and technology alongside changes in political involvement and population health, health care spaces are likely to undergo physical and functional changes as well.

The roles of interior designers in health care are likely to undergo major changes as well. While a slowdown occurred in healthcare construction during the recent recession, the future challenge of adapting to the new healthcare reform creates a very uncertain future.[113] The large driver of the healthcare design market is in replacing the outdated Hill-Burton era hospitals, replacing their cold environments with a more caring, family- and patient-centered approach to care.[114] Increasing evidence of the effects of the surrounding environment on human health will help legitimize the role of the healthcare interior designer. For example, studies have shown that when an individual feels as little as two forms of discomfort, their performance is affected, revealing that proper design could help to mitigate some of these discomforts.[115] Along with the standard duties of space planning and material selection, with much more aesthetically pleasing options than in the past, current and future healthcare designers are expected to balance the needs of patients, staff, visitors, and the local community while increasing profitability and

[112]Kim, Texas A&M Dissertation, 2011.
[113]Marberry, State of US Healthcare Building and Design Industry, 2009.
[114]Guenther and Vittori, Sustainable Healthcare Architecture, 2013.
[115]Manchanda and Steemers, Environmental Control, 2012.

promoting healing.[116] While this is no easy challenge, increases in design research and sustainable practices are making these goals far more accessible.

### 2.3.2. RECENT TRENDS IN HEALTHCARE DESIGN

In the sea of free information and lifestyle improving technologies, patients' demands and needs have changed greatly from that of past generations. Beyond the traditional requirements of positive health outcome, affordability, and caring medical professionals, today's patients demand high quality spaces and personalized care that matches hospitality standards. They also require access and control of personal health information and decisions, an uncomplicated care systems, and mobilization where possible. Simultaneously, the American health care system is in a state of turmoil. Besides industry stressors such as uncontrolled care costs, rapid changes in medical knowledge and supporting technologies, and political and public turmoil amidst policy changes in healthcare and insurance, many paradigmatic changes are occurring in health care and its support facilities will need to reflect them.

Rosalyn Cama, author of Evidence Based Healthcare Design (2009), identifies these as shifts between a focus on sickness and overall health, event-based care and continuous care, standardization and customization, obscurity and transparency, and individual effort and increased collaboration. Responses to these changes in health care and population demands have come from many industries, but the major systematic changes are driven by patient-centered care, sustainable practices, and research based design.

#### 2.3.2.1. Patient-Centered Care and Healing Design

The biggest movement in health care delivery is referred to as patient-centered care.

[116]Kim, Texas A&M Dissertation, 2011.

Much like its title would reveal, patient-centered care puts focus on the patient, but it does so in a way that shifts focus from the specific ailment to the patient's whole well-being. Patient-centered care requires consideration of a patient's attitudes and beliefs, personal preferences, and immediate and long term needs. Combined with coordinated and integrated care efforts, a patient-centered approach continues outside of the care setting by preparing patients for a smooth transition back into everyday life after their illness. [117]

In addition to the physical ailment, consideration of family, social, and emotional needs and patients are given more health care information and education to become a decision maker in the course of there care.[118] While the lack of research yields little evidence in support of this focus in care, it has gained popularity amongst patients, medical professionals, and shareholders.[119] Several organizations have helped shape the guidelines for the patient-centered approach, such as the popular Planetree model that also aims to incorporate alternative and complementary medicines (such as acupuncture, hypnotherapy, and nutritional planning).[120]

Patient-centered care also requires a more healing, holistic environment. As Roger Ulrich notes, the two major sources of stress for patients are those related directly to their illness (such as reduced capabilities, fear about outcomes, and perception of pain) and those related to the physical and social environment, so in order to reduce patient stress and improve healing, both sources must be addressed in the care process.[121] Traditionally, hospitals and health care spaces were designed around Western medicine

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[117]Devlin and Arneill, Environment and Patient Outcomes, 2003.
[118]Devlin and Arneill, Environment and Patient Outcomes, 2003.
[119]Devlin and Arneill, Environment and Patient Outcomes, 2003.
[120]Stichler, Patient Centered, 2011; planetree.org 2014.
[121]Ulrich, Effects of Interior Design on Wellness, 1992.

practices, and as a result the mental, social, and spiritual aspects of health and design were excluded.[122] In the future, designers may need to familiarize themselves with alternative forms of care in order to understand their spatial needs and relationships with different types of patients.

#### 2.3.2.2. Sustainable Practice and Design

It is becoming more widely accepted that the built environment has a large role in the overall impact humans have on the natural, physical environment.[123] Improved understandings of the intricate and complex relationships between human, environmental, and economic realms have resulted in an expansion of the demands put on designers in addressing sustainability issues at a variety of scales from an individual piece of furniture to the cultural needs of a community. Interventions can also be physical, such as selecting a flooring finish made of renewable materials like bamboo, or systematic, such as locating a new facility in a place that encourages public or human powered transportation. Sustainability can also be addressed in many unrelated ways, such as water consumption or durability of materials.

Environmental design has come a long way from its initial focus on saving energy. More recent initiatives include achieving zero emissions and carbon neutrality in addition to steep energy use reductions.[124] However, these efforts are not spread equally across trades, as is evidenced in the decreasing $CO_2$ emission levels from the industrial, extraction, and manufacturing industries since the 1960s alongside an increase in emissions in the transportation and building industries over the same time span.[125] The

[122]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.
[123]Guenther and Vittori, Sustainable Healthcare Architecture, 2013.
[124]Guenther and Vittori, Sustainable Healthcare Architecture, 2013.
[125]Guenther and Vittori, Sustainable Healthcare Architecture, 2013.

sustainability issues plaguing the architectural and design fields have been exposed through increased discussion and literature, such as through the works of Michael McDonough and his "cradle-to-cradle" concept of "waste equals food." Innovations in building materials and systems hit the market so fast that no single technology, process, or design has proven to be the best answer to any design problem. A variety of organizations and initiatives have developed their own guidelines for sustainable design, with the most popular being Leadership in Energy and Environmental Design (LEED) through the US Green Building Council (USGBC).

While policy regarding sustainable design is still relatively nonexistent, education by design professionals on the benefits of sustainable design can help to transform the industry as a whole. For example, in convincing a financial stakeholder of the benefits of choosing more sustainable building methods, the financial benefits could be discussed. In general, sustainably approached designs often have a higher initial cost over non-sustainable approaches (approximately 2% more or $3-5 per square foot more), but the lifetime costs and efficiency savings make up for the increased initial investment (over a 20 year span, the per foot savings could be as high as $5.80 in energy costs and $8.50 per square foot in operating costs).[126] However, these initially higher costs are expected to go down as the novelty of sustainable design wears off and builders and designers improve their execution.

#### 2.3.2.3. Research Based Design

There are more than 600 studies that link patient health to environmental and architectural quality.[127] Inadequate and poor design has real health implications, such as increased anxiety, delirium, elevated blood pressure, and increased pain perception and

[126]Frumkin and Coussens, Green Healthcare Institutions, 2007.

[127]Brown and Dennis, Impacting Patient Outcome Through Design, 2006..

intake of pain medication.[128] These are often cited and linked to the stress induced from the environment, such as stresses from way finding, unpleasant noise, invasions of privacy, reduced feelings of security, color and lighting, ambience and texture, and accessibility.[129] While past research yielded more experiential, subjective evidence, an increase in objective evidence is entering the body of study (such as patient diagnostic levels in response to designed stimuli). As a result, the healthcare design professional is increasingly important in all phases of the design process in order to maintain a physically, emotionally, and socially supportive environment.

Research design is a relatively new idea among scholars, however, observations about the effects of design have occurred over many centuries (see section 2.3.1). For example, observations on the importance of private rooms, hand washing sinks, decentralized workstations, and inclusion of family space have proven their importance without rigorous and directed study.[130] The main focuses in research based design today are on patient and staff safety, way finding, room functionality, daylight and artificial light, and view.[131] More advanced studies study looks into concepts such as biophilia (the bond and similarities of humans and other living systems), environmental toxicity and air quality, environmental stress reduction, and emerging patient safety requirements. Discovered design implications are large and small, such as the importance of a patients access to natural views or patients feeling they have better access to information (such as health records or education materials) when they are seated rather than laying down.[132]

Regardless of reaching affect on health and overall design outcome, this

[128]Ulrich, Effects of Interior Design on Wellness, 1992.
[129]Frasca-Beaulieu, Ambulatory Care Facilities, 1999.
[130]Atkinson, Hohenstein, McCullough; Evidence Based Strategies, 2011.
[131]Marberry, State of US Healthcare Building and Design Industry, 2009.
[132]RDC, Health Design, 2009

intensified study of the human relation to its environment will yield importance beyond its intended focus. Research design also has possible economic benefit. In a 2011 report developed by the Fable Hospital on their new construction project, it was estimated that a $350 million project would cost approximately $29 million more to improve the design based researched suggestions, but these same improvements would save the hospital about $10 million a year.[133] Increased use of Post Occupancy Evaluations as a mode for research-based design will help to reveal more benefits such as these in the future.

### 2.3.3. EMERGING GUIDELINES FOR HEALTH CARE SPACES

The interior design community has taken a special interest in health care spaces within the past few decades. Derived from academic, consumer, and post-occupancy evaluation research, guidelines for healthy and enriching spaces are constantly evolving to meet the increasingly complex needs of the American healthcare consumer. Along with changes to medical practice and process, integration of anthroposophic medicine (commonly known as alternative medicine) and debates on salutogenic care (a focus on whole body well-being, as opposed to previous focus on disease and specialization) are continually shaping and changing design strategies.[134] Cama notes that the health care space requires convenience and accessibility, focus on well-being, encouragement of positive social interaction (especially between patient, family, and staff), safety and confidentiality, and connection with its surroundings (both between rooms and the surrounding environment).

In order to meet these standards, some design goals to consider are efficiency, supporting medical processes, incorporation of new technology, flexible environments, the psychological and health needs of patrons, market viability, and ability to connect

[133]Sadler, Fable Hospital, 2011.
[134]Dilani, Pscyhosocially Sensitve Design, 2008.

with other healthcare networks.[135] Beyond considerations of unique room and medical functions; circulation of visitors, staff, and patients; demanding storage requirements; and the obvious attention to aesthetics, the following characteristics of health care spaces are regarded as essential considerations to improve design performance and user well-being.

#### 2.3.3.1. View and Light: Increasing Natural Access

Extensive research exists regarding the positive effects of patient rooms with desirable views and the therapeutic effects of nature. Most of this research uses market research on patient, family, and staff satisfaction with the medical services they received and the facility it took place in, but original research focused on patient states and outcomes. For example, in 1992 Roger Ulrich successfully linked blood pressure reduction and muscle relaxation in patients with access to views of nature, citing noticeable effects in as little as five minutes.[136] Additional observed effects have included shorter postoperative hospital stays, decreased use of numbing and pain medication, and higher staff satisfaction.[137]

Ulrich attributes this to "positive distraction," citing that similar effects can be found with exposure to laughter, smiling faces, music and companion animals. However, popular integration of this strategy in building design results in increased focus on exterior views from rooms, space planning to improve patient access to windows, and, most popular, the inclusion of healing gardens.[138] While patient access to these healing gardens is still a challenge (largely due to unique medical needs or lack of encouragement from staff), major improvements have already been made in most newer and renovated

[135]Kim, Texas A&M Dissertation, 2011.
[136]Devlin and Arneill, Environment and Patient Outcomes, 2003.
[137]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.
[138]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.

facilities to at least improve visible access for most inhabitants.

The majority of daylight and interior lighting research lies in study of commercial buildings, focusing on the daytime, full-time employee. While this information is very valuable to the design of the health care space, the unique needs of patrons using these spaces and their 24/7 operability demand special consideration. For example, mass research on the benefits of increasing day lighting in interior spaces to improve worker productivity and mood may be translated to a need to regulate natural circadian rhythms in patients confined to beds for long period of times. Improved task lighting, meant to mitigate eye strain, can prevent inaccurate diagnostic readings. The intensity and color of light has been increasingly used for psychological and social effect, such as lowering light levels in counseling settings, shown to improve patient-physician communication through the creation of a pleasant, safe, comfortable, and relaxing setting.[139] Being able to control and eliminate all light in a given space is equally important as well. Patients with views of both outside and nursing areas need the ability to block incoming light from adjacent spaces while patient samples and tests may require darkness or specialized bulbs in order to maintain quality.

In preventive care spaces, lighting requirements are often not as critical as hospital environments, however they still should maintain special consideration over residential and commercial uses. In non-acute settings, patient outcome is not as dependent on improved view and lighting, but it might determine patient comfort and security. The ability to go between consultation and counseling to patient examination might require task lighting in addition to dimmable ambient lighting. As preventive care often takes place in smaller, single story facilities, the incorporation of skylights to

[139]Miwa and Hanyu, Effects of Interior Design on Communication, 2006.

increase daylight and decrease lighting loads is far simpler than in more complex, multi-story hospitals. However, view becomes a challenge as windows introduce privacy concerns. In response, curtains may be used for complete privacy, but semi-transparent window treatments, such as allowing view out but not in (an example being observation glass) or sandblasting to distort view quality, help to manage privacy issues while still incorporating daylight and possibly view.

#### 2.3.3.2. Noise Pollution: Masking and Elimination

As medical spaces often include extremely private, restful spaces located along busy, public hallways and staff areas, the ability to control noise is not as simple as zoning spaces based on noise levels and travel. With noise listed as one of the largest stressors in hospitals, it becomes not only a challenge but also a major concern.[140] Noise in medical spaces can come from a variety of sources, but the majority can be attributed to medical equipment and conversation. It has been linked to negative health outcomes such as increased perception of pain and increased medication use, sleep deprivation, and patient confusion or disorientation.[141] Staff report that it degrades interpersonal relationships, impedes cognitive work, and quickens fatigue.[142]

As noise elimination is impossible due to the necessity of medical equipment and social interaction, the answer becomes masking and insulating against offending sounds. For example, the incorporation of white or pleasing background noise can mask low level, continuous noise. Using music as background noise also has the added benefit of providing distraction and has been shown to reduce anxiety, stress, the perception of pain,

[140]Brown and Dennis, Impacting Patient Outcome Through Design, 2006.
[141]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.
[142]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.

nausea, and improve overall mood.[143] In cases where noise levels need to be reduced or near eliminated, increased insulation is required. For example, patient confidentiality is dependent on the elimination of the noise transfer between patient rooms. Common design practice is to cluster systems such as plumbing and ventilation pipes to reduce cost, which in past hospital design often meant that mirrored rooms were used to allow these systems to run up one wall with access to two rooms. However, same-handed rooms reduce noise transmission that often occurs along the bedside wall and may reduce errors from staff switching between left-handed and right-handed layouts, but no hard evidence has proven this to be the most economic response.

In preventive care, the concern for confidentiality is more critical than comfort levels when regarding noise travel, but as with light and view, maintaining comfort in all health care spaces is critical to patient compliance and continuation of services. Noise transfer between quiet patient rooms and louder corridors and nursing stations is often not as high of a concern due to lower traffic, but noise transfer between patient rooms needs to be prevented for patient confidentiality. Music can be easily and economically incorporated to mask noise exterior to the patient area and provide ambiance, but ability to control levels in individual spaces should be considered as opposed to single access control.

#### 2.3.3.3. Privacy and Control

When one's sense of control over their body is diminished, having a sense of control on one's surroundings can increases the perception of comfort, security and ability to heal while providing a feeling of home when being home is not possible.[144] Recent trends in care processes are responding to this need by including patients in

[143]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.
[144]Ulrich, Effects of Interior Design on Wellness, 1992.

making decisions about the course of their care and allowing them access to their medical records, such as displaying information on whiteboards or keeping patient records in the patient's room rather than at nursing stations.[145]

Common design responses include the ability to personalize a space (for example, with family pictures), such as the use of private, single occupancy rooms that have the ability to adjust room temperature, lighting, beds, and music. Private rooms mitigate obvious privacy and noise concerns, but they also result in improved communication between patient and staff, reduced medical errors and infection rates, and easier integration of family into the care process through increased space given to individual patients.[146] However, completely denying visual access between corridors and patient rooms makes monitoring patients more difficult and may cause unnecessary interruptions.[147]

Staff privacy also needs to be considered, such as a need for staff only break areas and safe, convenient storage of personal property, and the ability to personalize a workstation provides a sense of control. While a patient's sense of control is still important, preventive care spaces demand more control on the staff side rather than the patient side due to their short duration of use. Allowing medical staff to personalize patient examination spaces may allow them to work more efficiently and effectively with their patients by allowing them to adjust the space to each patient's immediate needs, such as creating a more intimate feeling for discussion and counseling and then easily transitioning into diagnostic space by increasing light levels.

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[145]Christensen et al, Geo-Health, 2007.

[146]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.

[147]Aliber, First 15 Feet, 2009.

#### 2.3.3.4. Social Support and Facilitation

While privacy is very important, complete isolation is not the goal. In fact, extensive research has linked high levels of reported social support to improved outlook and mood which in turn can reduce healing times and improve overall patient outcome. Social support can come from family, facility and medical staff, and public interaction space, although the latter is rarely used in hospital settings. Family involvement in patient care leads to improved outcomes as family members will continue to care for the patient after discharge. Because of this, ensuring that each patient has adequate space for the family is an important consideration.[148] In the past, spaces were poorly designed for larger social groups leaving public waiting areas as the only option for often personal and private interactions among emotional and stressed family members.[149] In preventive care spaces, including spaces for long-term family use is not necessary, but considering how to incorporate family support in the smaller spaces is still very important (such as a space for children to busy themselves or a seat near the examination space for a trusted family member to be involved in the care).

Nurse culture and work conditions often result in stressed staff which creates negative environments for social interaction between staff members and their patients. Promoting communication by including convenient and semi-private spaces for quick conversation can help to ease this issue. Increased use of electronic communications (such as email and text) and social networks aid in bettering communication amongst staff. In addition, the ability of staff to quickly connect with other physicians for specialized knowledge or patient information improves patient care processes and diagnoses. While all health care spaces demand this social facilitation, preventive care

[148]Atkinson, Hohenstein, McCullough; Evidence Based Strategies, 2011.
[149]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.

often demands more communication with sources outside the current facilities whereas hospitals have increased communication intra-facility.

#### 2.3.3.5. Safety and Sanitation

The physical well-being of all users is a high consideration in all designed spaces, but the unique requirements of health care spaces also results in special design requirements. Decreased mobility and weakened immune systems mean a higher risk for future medical problems, such as falls and infections, requiring accessibility to go beyond ADA requirement and sanitation at higher levels than in any other type of space. Newer trends in obesity mean a change in space requirements and the size of furniture and medical equipment.[150] Simultaneously, a review of locations and designs for hand washing stations, such as locating them near entrances to patient rooms and near their examination space, have shown increases in hand washing compliance and decreases in infection.[151] Almost a century of sanitation awareness means high use of non-porous materials designed to prevent bacteria growth and transfer, creating resulting materials marketed solely for health care spaces.

William McDonough has argued for improved indoor air quality for several decades, citing negative health consequences such as headaches, asthma, and depression in relation to the off gassing of interior materials and poor indoor circulation.[152] Pleasing aromas have positive effects on patients, such as slowing respiration, and unpleasant aromas have negative effects, such as increasing perceived pain levels due to increased discomfort.[153] Airborne bacteria and viruses can cluster in a small area, which means an

[150]Horwitz-Bennett, Health Guidelines, 2010.
[151]Atkinson, Hohenstein, McCullough; Evidence Based Strategies, 2011.
[152]McDonough and Braungart, Cradle to Cradle, 2010.
[153]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.

increased load on ventilation and filtration systems. While preventive care spaces don't share the extreme accessibility and sanitation needs of hospitals, it is still of high concern. Unless the specific function of the space necessitates or allows for reduced sanitation and accessibility requirements (such as therapeutic spaces and counseling spaces), all spaces that may include medical processes should hold the same sanitation and accessibility standards of high acuity settings to ensure safety.

#### 2.3.3.6. Adaptability and Modularity

The almost constant construction and improvement of health care spaces can mean frequent disruption to services and unpredictable lifetime building costs. The ability of a health care space to adapt to multiple uses or quickly be improved means decreased time spent on improvements and less interruption to patients and staff. Experiments in universal and acuity adaptable patient spaces have already shown cost savings and operational efficiencies by reducing the number and types of spaces needed. Universal and acuity adaptable rooms adapt to the changing needs a patient without transferring rooms. Transferring rooms is a common practice in many health care facilities, but this has been shown to add to stress with 50% expressing complaint or exhibiting a changed physical or mental state.[154]

With the increased use and variety of medical technologies paired with their rapid evolution and development requires designers to plan for easy updates of equipment. easy integration This can be accomplished through careful electrical and internet planning, creative storage solutions, and quick setup for use. Adaptable diagnostic headboards that have plug and play operability as well as conceal and reveal storage are one of the ways that designers approach this challenge.[155] The trend in building care networks as opposed

[154]Brown and Dennis, Impacting Patient Outcome Through Design, 2006.
[155]Brown and Dennis, Impacting Patient Outcome Through Design, 2006.

to individual practice necessitates preparation for future service integration and changes as well as planning for future additions.[156]

In addition to adaptability requirements, design modularity is showing increasing promise in health care spaces. Modular units constructed off site in controlled conditions mean high quality production, decreased construction time on site, cost savings, and reduced delays and interruptions to building services in health care spaces where continual improvement occurs.[157] As materials, fixtures, and equipment all have different life spans, designing a space to be easily taken apart reduces effort required to replace failing parts of an interior, such as quickly replacing a nursing station with a degrading counter and then repairing the counter in the controlled facility off-site. [158] While modular and prefabricated construction do not often come with initial cost savings, situations where a building shell could remain unchanged for several decades while the interiors are changing every few years on rotation, such as in health care spaces, cost savings are often experienced over the life-time costs of the building and through operational costs.[159]

#### 2.3.3.7. Staff Satisfaction and Workflow

"The statement that the guards do more time than the inmates regarding prisons applies to health care settings, as well."[160] Among the 600 studies linking health care spaces to patient outcomes are an equally significant body of research that shows the physical environment has an impact on the stress and fatigue levels of staff members.

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[156]Kagioglou and Tzortzopoulos, Built Environment Infrastructure, 2010.
[157]Horwitz-Bennett, Health Guidelines, 2010.
[158]Kagioglou and Tzortzopoulos, Built Environment Infrastructure, 2010; Guenther and Vittori, Sustainable Healthcare Architecture, 2013; Ray, Interior Design for Rural Healthcare, 2009.
[159]Horwitz-Bennett, Health Guidelines, 2010.
[160]Devlin and Arneill, Environment and Patient Outcomes, 2003.

While stress and fatigue may have an effect on patient healing, it has a far more dangerous effect when experienced by staff as it can affect their performance levels, increasing errors and harming patient outcome.[161] Additionally, 78% of nursing directors report that the design of their facilities has an impact on recruiting nurses which can harm distribution and continuity of care due to shortages.[162] And due to the high needs of their patients, health care facility staff are occasionally compromised in the design of the facility itself.

A recently popular response to reducing the stress and fatigue of staff is accomplished through intense study of the workflow and processes of staff members in order to uncover the most efficient and safe layout of spaces and fixtures. For example, the 2010 Health Guidelines incorporated a new requirement called the Patient Handling and Movement Assessment in the preliminary design phase.[163] Studied through a variety of methods, such as surveys and logs from staff or video monitoring, designers can begin to gain a deeper understanding how medical staff move through and interact with their environment, revealing that much of a nurse's time is spent walking throughout their facility to gather supplies and relay information rather than being able to spend more time with patients. As a result, building elements that were often focused in one area, such as having one large pharmaceutical storage location, are being divided into smaller elements and distributed throughout the facility to increase efficiency. While preventive care facilities are typically smaller than hospitals, the efficiency of staff processes still has the benefit of increasing the number of patients seen without affecting staff work flows and quality time with patients.

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[161]Frumkin and Coussens, Green Healthcare Institutions, 2007.
[162]Kagioglou and Tzortzopoulos, Built Environment Infrastructure, 2010.
[163]Horwitz-Bennett, Health Guidelines, 2010.

### 2.3.3.8. Aesthetics and Artwork

While aesthetics are more often subjective than objective, there is increasing evidence that certain types of aesthetics may be more conducive to healing than others. For example, the increasing popularity of birthing centers is representative of the increased demand for more homelike care settings as opposed to the traditional Hill-Burton era, hyper-sanitary appeal of more traditional hospital settings.[164] However, the physical manifestation of "home" varies across cultures, regions, and even families, which denotes that designing a home-like environment is more complicated than it initially appears and requires review from project to project. For instance, an increasing amount of rural care facilities desire to use as much local material and labor as possible, which can aid in maintaining a local aesthetic. While color can be subjective, Faber Birren's work on color in health care settings revealed that green is an effective color for eye relief after looking at blood or internal organs for extended periods of time. Additionally, the employment of warm and cool colors can create a psychological response to room comfort, with test participants feeling cooler in rooms with cool greens, blues, and purples as opposed to the warm reds, oranges, and yellows, even though actual room conditions were otherwise the same.

A more recent increasing field of study surrounds the types of artwork used in patient and waiting areas and their possible psychological effects. In Ulrich's earlier works, he revealed that images depicting serene, open nature or people with positive emotion were the safest forms of art for all facilities. Going deeper, studies have revealed that patients who view natural scenes (both real and pictorial) had less anxiety and need for pain medication and that over stimulating images had negative impacts on

[164]Huelat, Art and Science, 2008.

anxiety and pain perception.[165] However, even in designs since his revolutionary work, abstract art is commonly used in patient and visitor spaces. While this may seem harmless, if you consider the power simple ink blot tests have on the cognition and emotions of mental health patients, it becomes much more apparent. It is now increasingly accepted that artwork used in health care spaces are beneficial when they ambiguously depict natural scenes, leisure, or happy relationships and people. In opposition, artwork deemed possibly harmful may depict provocative, abstract, busy, and repetitive forms and scenes with negativity (such as an ocean storm or anger) or that create artificial eye contact.[166]

[165]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.
[166]Schweitzer, Gilpin, and Frampton, Healing Spaces, 2004.

# CHAPTER 3: METHODS

## 3.1. Research Design: Case Study

While the occurrence of mobile health clinics is low in comparison to other health care environments, the ones in existence are often very well documented due to their joint cooperation with scholarly programs. Due to this, it is possible to examine these programs in case study format in order to draw conclusions necessary to define both the client and the design requirements. The case study format is an important research method in studying design and architectural theory despite its criticism of generalization based on few samples.[167] As I am not attempting to determine cause and instead looking to explore and prescribe possible solutions to generalized problems through architectural means, the case study format is an appropriate mode. Additionally, my research attempts to guide designers through the process of making design decisions for mobile clinics based on specific client needs, so the process of analyzing case studies will act as an example of identifying criteria necessary to the design process.

A shortcoming of the literature describing the mobile clinics in regards to design research is the often brief and absent descriptions of the vehicle used in relation to descriptions of the programs and their outcomes. Based on this, thorough analysis of the designs is not possible without intensified research of individual programs. However, the detailed descriptions of program characteristics and operations act as client profiles in determining the needs of mobile clinics. These descriptions offer unique insight into the differences in health care facility use between mobile clinics and more traditional health care environments. By identifying specialized needs of mobile clinics in comparison to

[167]Groat and Wang, Architectural Research Methods, 2002.

the currently recognized and accepted needs of other health care environments, a more detailed design process and set of criteria can be determined.

## 3.2. Ontology and Epistemology

The most complicated part of studying the issues related to health care is that every living human is a stakeholder. Since there are so many actors involved in the healthcare industry, too many to examine within one study, examining a range of actors within mobile care should reveal the a priori knowledge necessary to draw conclusion. Through this examination of current mobile health systems, I will determine the advantages and disadvantages of integrating distributed health into the current healthcare system as well as their ability to increase accessibility and decrease costs. In addition, I will look for barriers and facilitators to these systems, such as mobile health monitoring technology, mobile medical units, and communication issues within the medical community.

My epistemological assumption is that validity of results can be attained by looking at a wide range of sources, using not only multiple cases and sources but also through experiential observable (such as patient satisfaction surveys) and quantifiable results (such as program costs). In order to gain the support of decision makers within health care, such as hospital CEOs, it is necessary to show evidence that such systems are possible and beneficial before beginning serious designer considerations. In order to gauge the consequences of adding mobile and home care to the American system, I took a naturalistic approach by examining a couple of small case studies of current mobile clinic systems. Through review of their operations, I attempted to gather both quantitative (i.e. statistics, economic review, health outcomes) and qualitative (i.e.

experiences from staff, patients, and community members) data to support my findings by this inductive approach. After triangulating data from several cases, I compared and contrasted each mobile care system to determine trends.

## 3.3. Case Studies

### 3.3.1. THE MARYLAND WELLMOBILE

The Maryland Wellmobile, also called the Governor's Wellmobile, is a full service mobile clinic program run by the University of Maryland's School of nursing, focusing mainly on family and child care.[168] Developed in 1994 as a public-private enterprise, the program was developed as a way to meet the growing health needs of the community and to provide education and practice to medical students. The program's primary goal is to improve the health status of the families in underserved communities and to help patients find an appropriate primary care physician, although, it offers a full range of services to meet the immediate needs of the community.[169] It's aim is to fill the gaps in the current primary care system by focusing on those who lacked access to regular care, connecting acute cases with immediate care and channeling insured individuals to more permanent means of care (Fiscal Year 2013 Annual Report). The second goal of the program is to provide clinical practice to advanced students who require a certain set of experiences and procedures in order to become a legal practitioner (Fiscal Year 2013 Annual Report).

The program is operated by nurse managers, nurse practitioners and community health faculty and supported by advanced nursing students. Undergraduate students are

[168]Swartz, Wellmobile, 2009.
[169]Heller and Goldwater, Governor's Wellmobile, 2013.

involved in public health operations in the program (such as promotion and community outreach).[170] Operations also require regular maintenance work and a properly licensed driver. Traveling on a regular schedule with established routes, the Wellmobiles move throughout communities in Maryland, often setting up at community centers, schools, senior centers, and other strategic locations.[171] Offering both appointment and walk-in flexibility, the program aims to connect patients with in-place physicians. However, due to difficulties in receiving other forms of community care, many participants rely heavily on the program as a their regular source of care (Fiscal Year 2013 Annual Report).

Depending on appropriated funds for the fiscal year, operations cost the state of Maryland anywhere between $250,000 and $570,000, costing $563,053 in 2013 (Fiscal Year 2013 Annual Report). While the program has a limited budget, it has been able to expand its geographic outreach by partnering with local agencies and health institutions.[172] Program faculty have worked throughout the years to obtain grants to keep up with demand.[173] The market value of the professional care received averages about $192 per patient, however, pairing professionals with students and community health workers has reduced costs to about $152 per patient.

Initially working with one clinic, it has now expanded to four units operating in nine counties, four days a week (Fiscal Year 2013 Annual Report). The Wellmobile clinic vehicles range in size from 33-37 feet, fully equipped to operate as a primary and preventive care clinic. On the interior, the clinics are much like a small version of their more permanent counterparts, containing a waiting/intake area, two exam rooms, a

[170]Heller and Goldwater, Governor's Wellmobile, 2013.
[171]Heller and Goldwater, Governor's Wellmobile, 2013.
[172]Heller and Goldwater, Governor's Wellmobile, 2013.
[173]Heller and Goldwater, Governor's Wellmobile, 2013.

laboratory, and small office (Fiscal Year 2013 Annual Report).[174] Costing about $200,000, the clinic units were purchased directly from the manufacturer and modified to meet the needs of the clinic and to adhere to the same standards seen in other clinics. [175] A major drawback to the mobile clinic is its non-ADA compliant access, requiring patients to climb a short set of stairs to enter the Wellmobile.

Despite financial and geographic expansion, the program has not yet been able to meet the care needs of the community (Fiscal Year 2013 Annual Report). However, it has proven to be successful on many different levels. In 2013, on a total budget of $563,053 (with private and public funds), the Wellmobile program was able to provide 1,641 nurse practitioner, 129 nurse care manager, 1,169 social worker, and 754 outreach worker visits as well as helping with 745 medical assistance applications and referring 325 patients to specialized services (Fiscal Year 2013 Annual Report). Year after year, the program has also been able to cut down on the number of total emergency room visits. In 2008, 80% of responding participants indicated they would have used emergency services if the mobile clinic had not been available, which was estimated to save $2.7 million in emergency room bills that year. More recently, the 2013 Financial Report estimated an avoidance of $453,654, but did not estimate the additional tests and procedures that are often incurred in emergency rooms. So despite continued need, demand, and shortages experienced in the program, the Wellmobile clinics have had very clear and measurable positive results.

### 3.3.2. THE RUTGERS NURSING SCHOOL PROJECT

Originally directed by the University of Medicine and Dentistry of New Jersey (UMDNJ, now a part of Rutgers University), the Rutgers Nursing School Project aims to

[174]Heller and Goldwater, Governor's Wellmobile, 2013; Eason, Wellmobile Serves, 2009.
[175]Heller and Goldwater, Governor's Wellmobile, 2013.

address the needs of underserved urban communities through promotion of general wellness provided in mobile clinics. The goals of the program are as follows: provide patients and their families with health promotion, disease management, and treatment assistance to reach optimum wellness; provide counseling and guidance on community based resources; involve patients in the decision making of their care needs and processes; provide culturally and linguistically sensitive health education; and provide research-based, nationally standardized care.

Gloria McNeal, a major player in the initial development of the project at UMDNJ, believed that due to the unique capabilities of academic health centers, university and medical school programs will become major providers of community based care due to their decreased focus on profit (as many programs are meant to educate through practice and research) and will be able to address accessibility problems that private and commercial medical outlets cannot.[176] She assessed that the major barriers to care in underserved communities was not simply financial and included insufficient numbers of doctors serving poor patients, inconvenient clinic locations and lack of transportation, language and cultural barriers, and negatives attitudes towards established care methods. Therefore secondary objectives of the program were established: to increase the number of referrals and attendance, increase participant satisfaction, increase community involvement in healthcare and processes, and decrease mortality and morbidity rates.

Site visit locations are determined by local community-based health organizations. Coordinators use door-to-door outreach to publicize the weekly schedule, normally five to six days a week. Patients are registered on-site, screened for

[176]McNeal, UMDNJ, 2008.

reimbursement eligibility by a third party, treated by an advanced practice nurse (APN), and connected with a primary care provider for long term care, all at no out-of-pocket cost to the patient.[177] Overall, the Rutgers mobile clinics see anywhere from five to twenty-two patients a day, making about 4,000 visits a year.[178] Staffed by APNs and nursing faculty, the program is further supported by community leaders, medical directors, drivers, pediatricians, and social workers in addition to the school's advanced students. While services vary between individual mobile clinics, the spectrum offered include:

> -immunizations, cancer screenings, body weight monitoring, electrocardiogram, vision and hearing testing, exercise and medication instruction, HIV/STD testing and counseling, community services referral, lead screenings, OB/GYN care and referral, cholesterol screening and nutrition assessment, comprehensive physical examination, vision and hearing tests, cancer testing, treatment of medical illness, substance abuse and mental health referral, dental assessment and referral, and social services

The program has been successful in obtaining financial support through various means, such as medical foundations; state, city, and federal grants; pharmaceutical companies, third-party payors, and charity resources. It is also heavily supported by its network referrals, which includes oncologists, cardiologists, otolaryngologists, dental ophthalmologists, psychological and mental health professionals, pediatricians, gerontologists, neurologists, urologists, endocrinologists, and OB/GYNs.

Jumpstarted by a $500,000 grant from the Webkinz Foundation, the Rutger's mobile clinic is a 40-foot, retrofitted, second-hand bus with space for two exam rooms travelling between 12 sites.[179] The program is heavily dependent on the availability of electronic medical record (EMR) systems, which not only improves accuracy and quality

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[177]McNeal, UMDNJ, 2008.

[178]McNeal, UMDNJ, 2008.

[179]Jackson, Mobile Health Unit, 2009; Forman, Youth of Newark, 2010.

of care but also facilitates communication with other medical professionals. Like the Maryland Wellmobile, the Rutgers project was successful in decongesting the emergency room.[180] In 2008, a total of 1,360 patient encounters were made with approximately one to three follow-ups per month, providing care for the following: 31.5% physical examination, 18% dental examination, 4.5% genitourinary conditions, 3.8% respiratory conditions, 11% infectious disease, 4.5% dermatological conditions, 3% psychiatric conditions, 2.5% musculoskeletal conditions, 0.5% neurological conditions, 4% tumor/palpable mass conditions, 3.5% positive pregnancy tests, 4.5% gastrointestinal issues, and 0.5% endocrine conditions.[181]

### 3.3.3. Conclusions on Case Study Findings

As previously discussed, the majority of the data and description on mobile clinics regards the services, clients, and outcomes. While in depth detail about the design of these clinics would be beneficial, the information revealed does create an adequate client profile for making a prototype design. Designs for any specific program would benefit from more thorough analysis of the community's health needs and geographic limitations. Mobile clinics and their staff need to possess sensitivity to the social and cultural climate of their communities and need to work closely with community members for continued use of the clinics and for establishing connections to other care networks for more specialized needs, however this could be said of any medical program.[182]

In reviewing these two cases prior and other case briefs during the review of the literature, clear trends emerge in both the operations and designs of mobile clinics. Programmatically, most mobile clinics are connected with an established medical

[180]Jackson, Mobile Health Unit, 2009.
[181]McNeal, UMDNJ, 2008.
[182]Wiebe and Hubert, Community Mobile Treatment, 1996.

education program or community program, such as in a case for STD testing that originally served solely as a safe needle exchange program.[183] A major benefit of teaming with a community health program is the fast generation of a client list due to referral. However, pairing with a medical school offers the benefit of reduced labor costs while exposing future medical professionals to the social realm of health care delivery, "to keep humanism in medicine."[184] While many of the programs do operate on a rotating schedule to expand their geographic outreach, the availability of these programs are still largely urban in their site choices when a majority of health services are already being offered in these areas. This is a major disadvantage to more rural communities where the need for mobilized services may be much greater.

The generalized medical needs of mobile clinics differ from traditional health clinics by a reduction of some diagnostic capabilities, such as radiography, however, many medical devices for primary care are available in portable versions for convenience in any setting. Despite a lack of detailed description of the design, a quick review of currently operating mobile clinics reveals two trends. First, the majority of clinic vehicles are somewhere between 30 and 40 feet, containing two exam rooms with space for staff and waiting patients. Second, most vehicles are not ADA accessible, requiring patients to climb a short set of stairs to enter the unit and following with narrow hall paths and inadequate space for wheelchair turn-around. This is a failure in mobile clinic design in the long run as mobile clinics would most benefit those who have trouble leaving their homes and communities in the first place. A critical factor in designing a prototype will therefore be accessibility in addition to the costs and social outreach that are already a large focus of mobile clinic programs.

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[183]Moore et al, Contraception and Clean Needles, 2012.

[184]Reynolds, Free Medical Clinics, 2009.

# CHAPTER 4: ANALYSIS

## 4.1. The Client: The System of Care

As with any design problem, a clear understanding of the client is critical for both the success of the design and in some cases the successful use of that type of design in general. As mobile clinics are not yet the norm, the following is a description of the client(s) being served and the benefits and barriers of such a system of care.

### 4.1.1. System Description

Mobile care clinic systems vary in purpose and goals, but in general, they aim to provide care within the community of their patients at a reduced cost or for free in hopes of removing typical access barriers, citing that this is better for all participants. The theory behind this goal is that by providing care in a more continuous, preventive manner that the community's health will benefit overall due to a reduction in seriously ill individuals from the improved care provided. It is also argued that if medical staff have a better understanding of their patients home surroundings that they will be better able to provide care.

#### 4.1.1.1. Clinic Operations

Depending on the exact population of use, the exact operative goals of clinics will vary. In general the medical focus should be on preventive care, such as vaccination, disease screening, and education; primary care, such as minor illness or injury, family planning, and yearly physicals; chronic illness management, such as counseling, diabetes management, and disability care; and special population services, such as acting as a dialysis or chemotherapy station for populations with high occurrences. These clinics are

not ideal for emergency or intensive care, however, their ability to quickly move into an area of crisis make them a viable resource for emergency care to assist those affected by the crisis. Unless medical technology changes, these units are not safe or supportive for long-term critical care or invasive medical use.

The goal of the mobile unit must be accessible for 100% of the population, both in terms of geographic accessibility and ADA accessibility. There are two scenarios for geographic outreach that determine the operation of mobile clinics. The first is by operating as a routine walk-in or appointment clinic, moving from community to community and setting up at convenient locations for patients to come to the clinic. The set-up locations would rotate on a regular schedule, creating health maintenance days in each location. For example, the clinic could set-up at a workplace or school, providing care to the individuals at that location. It could also set-up at a local mall, and residents in that surrounding community would be made aware, and eventually made accustom to, the regularly scheduled visits at that location. Both program designs would create a group awareness and encouragement of use due to the increased convenience. This could result in recovered productivity that people lose in the process of gaining medical care during regular business hours due to less time taken off.

The second geographic scenario would be travelling to patients' homes for those who have difficulties travelling or who require assistance maintaining home-based care. While this option is far less efficient than the first scenario, it is a needed resource for many with chronic and life-debilitating conditions. The expectation with home care is often that the individual in need of care will have a family member or friend available to help, but some find themselves alone, making taking care of themselves and getting to medical appointments a daunting task. Home nursing services do exist, but their extent of care is currently limited and expensive. By offering a moving care center for these

individuals, less time can be spent coordinating their care and instead be better spent on the other daily living needs.

#### 4.1.1.2. Clinic Staffing

As with clinic operations, the exact staffing will depend on individual clinic system needs. Most programs will need a coordinator, whether they be one of the medical staff or a separate position depends on individual programs. If special operator permits are required to handle larger clinics, such as those on buses, a driver will need be hired unless one of the medical staff becomes certified. However, travel between locations may be a prime time for medical staff to complete paperwork and communications. Regular vehicle maintenance may be required, which may prompt some organizations to hire an off-staff mechanic, however, most mobile clinics in existence rely on existing mechanics at ambulance facilities connected with their parent hospital.

The medical staff will vary by local ordinance and state laws regarding who is qualified to diagnose and prescribe. The optimal solution in terms of cost containment would have an Advanced Practice Nurse (APN) head medical operations with support of telemedicine and referral for required situations, however, some states would require a physician to deliver care. A second optimal staffing solution would be the use of practicing medical students instead of fully licensed nurses, monitoring their practices while helping them get hands on experience. The medical staff will also vary based on local community health needs. For example, some programs may require medical specialists or drug counselors whereas others may need pediatricians and OBGYNs.

#### 4.1.1.3. Clinic Network

The success of many currently operating mobile clinic programs is dependent on

its connection to a larger care network. Most commonly, they are paired with a medical school for their availability of researching medical physicians, who would benefit from in-community research and are already paid by the school, and student nurses, who require the hands on experience to become certified. Some pair with insurance companies for use at their insured group locations (such as a workplace), improving compliance with health screenings that the insurers may require. Others pair with charitable group, such as community clinics or needle exchange services. While not often seen today, the possibility of pairing with a private hospital or network is also viable.

These pairings with a larger care network have two benefits. The first is the provision of a storage and maintenance location, or home-base. These remove the need for a separately designed facility to house the mobile clinics when not in use or when in need of repair. The second is the provision of patients themselves. An independently operating mobile clinic may have trouble forming a client base, but referral from already trusted services would improve the success of their operations. Some regions with larger immigrant populations often find it difficult to gain the trust of their patients due to cultural and language barriers. These patients may trust a mobile clinic associated with a trusted community clinic that is catered to their unique needs. Additionally, incorporation into a larger network would improve continuity of care through the ability to refer patients to another provider for specialized needs, reducing procedure and diagnostic duplication.

### 4.1.2. Benefits and Barriers of Implementation

The benefits of mobile clinic systems span from the individual to the community level. At the patient level, mobile clinics have the obvious benefit of improved outreach,

but this benefit alone has residual benefits. These benefits are of course inflated to represent the possible extent of benefit, however, they are possible. Making health care more convenient and accessible may translate into high utilization and, therefore, better maintenance of health through education and regular screening, thus improving the quality of care given overall. This would reduce the use of emergency services and possibility prevent the development of chronic, but avoidable illness that currently plagues the United States. Most importantly, improved patient health evolves into improved quality of life and reduced medical costs.

At the community level, the improved health of community residents would arguably affect the productivity and health of the community at large due to healthier members. By reviewing and diagnosing a whole community over time, it becomes easier to identify, track, and treat health concerns that are affecting a large part of the community. It may also make it easier to identify the causes of these health concerns and thereby make it easier to eliminate them. This would improve the development and planning of health trends, hopefully enhancing the care in the process. Additionally, in the case of rural communities that do not have local medical services, there would be reduced patient travel time.

Finally, the staff of mobile units would have benefits unique to their in-office counterparts. By gaining first-hand experience of the living conditions and resources of their patients, staff may be better able to properly diagnose and effectively treat their patients due to increased understanding and awareness of the patients environmental circumstances. For medical professionals gathering data for their research, mobile clinics give the opportunity of studying health using a more controlled population based on geography. As previously mentioned, the use of student nurses improves their educational experience, better preparing them for the working world and, as some would

argue, humanizes medicine.[185] Finally, unless a medical professional is from a rural area or has special interest in rural areas, it is often hard to attract professionals to rural areas for permanent work due to the draws of urban and suburban living. Mobile clinics would make it possible for staff to work where needed while living where desired.[186]

Despite the many possible and hopeful benefits of mobile clinic systems, there remain barriers to implementation that threaten their ability to gain a foothold on the patient market. An obvious barrier is the challenge of discussing cost with relevant parties. Often there is reluctance to invest money in more care facilities when primary clinics are already in present, despite their low start-up and operational costs of mobile clinics. Some medical professionals may not wish to leave their coveted office setting, resulting in a lack of enthusiasm from the medical community. The complication of preparing for and understanding regional road regulations may result in costly mistakes, such as illegal road use in terms of load capacity or variances in road quality may cause unexpected delays or failures.[187]

The often unanticipated costs of mobile clinics run the risk of program closures due to difficulties in containing costs, such as overtime pay. The costs of transporting medical equipment and waste in addition to the cost of vehicle insurance, storage, and security are also hidden costs. Fluctuating fuel costs make accurate cost predictions difficult, although ideally the latest energy efficient vehicle would be used. Additionally, the receptivity and consistent usage of accessible care is not guaranteed, bringing to mind the phrase of "you can lead a horse to water, but you can't make it drink." Just because the service is there, doesn't mean it will be accepted, especially when concerns of

[185]Reynolds, Free Medical Clinics, 2009.
[186]Shi and Singh, Delivering Healthcare, 2012.
[187]Muolavie et al, Things to Consider Before Buying, 1999.

confidentiality and anonymity are present.[188]


Illustration 1: Exterior rendering of a 16' trailer clinic prototype.

## 4.2. The Design: Mobile Clinic Prototype

The following is a description of the design requirements for mobile clinics and suggestions of what can be included in mobile clinics. This is not the description of a specific mobile clinic design and consideration of individual program needs would need to be considered. The suggested drawings should not be used for final designs without adapting them to special needs and should be used more to understand the maximum capacity of space.

[188]Muolavie et al, Things to Consider Before Buying, 1999.

### 4.2.1. DESIGN GOALS OF MOBILE CLINICS

The goals of the final design should be consistent with the goals of the client but also be balanced with what is currently recognized as the architectural needs and standards of healthcare facilities. As the healthcare consumer is the ultimate client in this scenario (even though it is further broken down by an individual program when actually executing a design), this means the goals of mobile clinics are lowered costs and increased accessibility. In order to meet this goal, it may be necessary to consider reclaimed goods and materials when safe and appropriate, such as purchasing a used trailer instead of a custom design. Careful analysis of material and fixture durability, maintenance, and expected lifespan in comparison to initial cost of material and installation should be done to ensure that the minimum cost at construction can be achieved without sacrificing the overall use of the clinic. Planning for electrical use and not just minimum and maximum electrical use will help in analyzing levels of operating costs.

The additional client need of accessibility must also be of top importance when designing mobile clinics in both terms of geographic accessibility and physical accessibility. Most mobile clinics in operation require the ability to climb a short set of stairs in order to be seen, and this eliminates a large population of those best served by mobile clinics. In order to effectively serve the majority of the population, tough analysis of ADA accessibility in relation to small spaces is required. However, following ADA guidelines for space requirements may not be enough given the profile of the targeted population, such as creating a mobile clinic for the severely obese. While geographic accessibility is obviously addressed by making the clinic mobile, deep analysis of geographic accessibility may reveal that the clinic will need to travel on unfinished roads, make tight turns, or climb steep inclines, meaning a smaller vehicle with a stronger

engine may be required. Geographic isolation requires self-sustaining energy sources, such as solar, and fuel efficiency in order to operate with little or no interruption. Separation of vehicle and clinic may be optimal for more remote locations so that the clinic can treat one patient while the vehicle drives another to the hospital for more intense diagnostics.

However, the current healthcare architectural standards should also be demonstrated through supportive and adaptable designs for the rapidly evolving fields of medicine and technology. Analysis of how each space will be used is needed to determine specific requirements for each sub space within the mobile clinic, such as how a physician workstation could be optimally designed for efficient use in a small space. Both patients and staff should find the space pleasant and supportive to their needs to maximize use satisfaction levels and improve outcome. Research regarding the effects of aesthetics should be considered, even though most literature regarding healthcare architecture discuss hospital and long-term use design and are focused on healing while the patient is in the space. As the mobile clinic will serve patients for a short time, design costs put into "healing design" may not be as paramount as "supportive design" for the staff who need to work in the more compact spaces when considering indoor environmental quality.

Sustainable design should be inherent in both construction and use and, if possible, obvious to the end users to further encourage understanding and promotion of sustainable action. As healthcare changes so rapidly, the ability of the design to be quickly updated and adapted is highly important. Using modular and prefabricated design is more expensive initially, but it may reduce cost of lifetime repairs, improve clinic efficiency due to it's decreased time spent being updated and repaired (due to improved efficiency in replacement and repair of parts), and will help ensure quality

across mobile clinics. Designing a space for modular parts also means that medical technologies could be quickly updated without having to change other components of the design and may cause quicker acceptance and integration of new medical technologies and practices. Designing for electrical, material, water, and operational efficiency addresses both issues of cost and environmental degradation. Making statements about sustainability through architectural features, such as visible solar panels and energy monitors, also helps educate the general public about the benefits of sustainable architecture.

### 4.2.2. DESIGN GUIDELINES

While the shape of each program will truly determine the final form of any mobile clinic, the following are elements to be considered when designing mobile clinics, such as space requirements, material selections guidelines, and electrical planning. Visual representation of this analysis will also reveal possible maximum space plan and usage requirements for varying sizes of mobile clinics at the 16-foot, 31-foot, and 41-foot levels. For a more complete explanation of performance and design, see the referenced diagrams.

#### 4.2.2.1. Vehicle

Selecting the correct shell and engine component for the mobile clinic is critical to its end design and use as well as its overall performance. Proper selection may also depend on local driver, vehicle, and road laws. For example, a large commercial sized bus may require a special driver's license designation or vehicle permit. Some roads may not permit vehicles over a certain weight. Program directors should coordinate their planned outreach and driving routes prior to committing to a mobile clinic vehicle.

#### *4.2.2.1.1. Separate versus Integrated Engine*

The type of shell and engine combination needed will depend on two things: size needed, number of patients seen at one time, and expected driving conditions. The expected driving conditions - such as road surface (ex. paved, dirt, narrow, etc.), parking space available, and maneuvering needs (tight turns, weather, elevation changes, reverse, low clearance, etc.) - will determine whether it is legal, safe, efficient, or manageable to operate certain vehicle types and sizes on certain roads. For example, a small trailer pulled by a truck may fare better on rough back roads than a motor home. The desired size, based on number of patients to be seen at one time or diagnostic expectations, will also determine the type of vehicle. Most commercially available trailers average between 16 and 30 feet long and longer vehicles are available in bus and motor home form. Therefore, high diagnostic needs and a desire to see multiple patients at one time will require a large motor home or bus.

Additionally, the ability to separate the vehicle from the clinic means that it could serve multiple purposes by using the clinic to see patients at one location while transporting staff or patients in the vehicle to another location. This separation may make it easier to update and maintain the mobile clinics. For example, if the vehicle needed to be repaired, the clinic could still be used while the vehicle is being repaired as the vehicle could be more easily and quickly changed out. The vehicle could also easily and more cost effectively updated to the latest sustainable car technology while still possibly gaining a return on the previously used vehicle. Maintenance may be more easily obtained and performed on a smaller car or truck rather than on a large commercial sized vehicle based on space and expertise required.

#### *4.2.2.1.2. Sizing for Needs*

In addition to the desired separation or integration of the motor, the size of the

vehicle purchased will depend on three things: the expected diagnostic capabilities, how many patients will be seen at one time, and the population density of the mobile clinic's site, which all closely intertwine. How many patients can be seen at one time will depend on needed diagnostic equipment and lab space and remaining space for patient rooms. For example, urban locations that are closely located to hospitals with vast diagnostic capabilities and often have higher population density may benefit more from seeing multiple patients at one time and bringing more lab work back to the main station. In contrast, a rural location may benefit from one patient space and vast room for diagnostic equipment as it is more likely that the clinic would travel to fewer patients in one trip and the patients would benefit more from the diagnostic capabilities due to the low availability in their communities.

#### *4.2.2.1.3. New versus Used, Custom versus Retrofit*

The source of your vehicle will depend on available funds and specialty of need which will in turn determine whether or not the vehicle can be purchased used or if a custom vehicle is required. If funds are limited and the diagnostic requirements are low, it will be more likely that a used, retrofitted vehicle will be appropriate for the program. In comparison, if the program calls for large diagnostic equipment, a new custom fit vehicle may be needed. Custom designs are generally more expensive, however, they often result in better performing facilities with more possible end uses. Retrofitted designs can perform as well as their newer counterparts but may require more careful design in order to create an accessible and high performing unit.

#### *4.2.2.1.4. Energy Sources*

With current technology, the optimum energy source for mobile clinics is achieved through inclusion of solar panels in addition to standard electrical connection

already available in mobile clinics. In this scenario, the mobile unit has enough solar panels to collect the energy needed for the unit's daily needs, but if desired or needed, the standard hookup is available for connection at the location. Using a battery (locally or from the vehicle), generator, or other sources of energy that are available (such as hookup at the site), but are not as sustainable in terms of environmental impact and ability to work remotely for long periods of time. Additionally, solar panels continue to advance in technology and design while declining in cost, so it is likely to be a more popular and obviously beneficial integration in the future.

#### *4.2.2.1.5. Ramp Access*

Adherence to ADA standards is of highest importance to entry into the vehicle. In most cases, a ramp will be needed to make the units accessible. In order to make a more compact design (for use on smaller sites), it will be more efficient to design the ramp so that it runs parallel with the vehicle at a minimum of a 1:12 slope. It would be most feasible to design the ramp so that it folds up the side of the trailer, however a more complex design may make underbelly storage possible. Automatic assembly (such as motorized drop-down) is best, however some designs may make manual setup possible. Hydraulic or pneumatic lowering mechanisms used to lower the vehicle closer to the ground when parked at the site will reduce the length of ramp required, reducing bulk weight and size.

### 4.2.2.2. Space Planning

At a minimum, a mobile clinic needs an entry space, a bathroom, a medical professional workstation, a patient bed or chair, extra seating for family or caretakers, and storage. More spaces may be required based on program need, such as lab space, diagnostic equipment, and multiple patient rooms. While multiple patient rooms or

multiple large diagnostic pieces can be included, it is important to consider whether or not it is better to create a slightly more spacious interior or a maximized, but more crowded, interior. For example, if the mobile clinic is meant for mental health professionals, you could physically design a large bus with three or four patient rooms, however, having small, crowded rooms may have a negative effect on some patients. For a detailed requirement of what is required of mobile clinic rooms/spaces, see Tables 1 and 2.

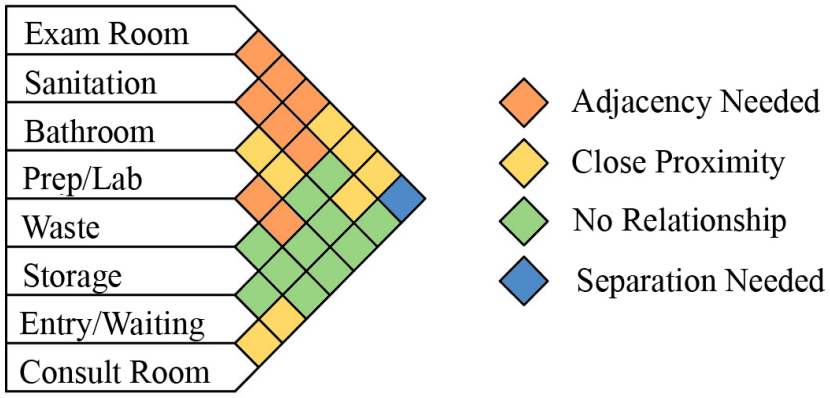


Illustration 2: Adjacency Matrix for mobile clinic spaces.

All mobile clinics should strictly follow ADA guidelines for access and use. All circulation routes should be wide enough for wheelchair use and, at a minimum, the visitor furniture and spaces should accommodate wheelchair use. See Table 1 for a more detailed analysis of ADA requirements that impact mobile clinics. Spaces designed for staff use should focus on user efficiency, such as considering workflow orders in lab spaces. The distance to hand washing areas is critical for many staff occupied areas. However, including multiple sinks is inefficient, so careful planning is required. Spaces designed for patients should consider visual and audio privacy between the interior and exterior and between patient spaces. See Illustration 1 for a spatial adjacency analysis.

| Feature | ADA Guidelines |
|---|---|
| Ramp | -36" high railing<br>-1:12 slope maximum<br>-30" maximum run<br>-Landing 42" (out from door) by 54" (edge to start of landing)<br>-Automatic open |
| Bathroom | -Side approach bathroom needs min of 60" approach space (wide from door to wall) and 56" deep from toilet to sink<br>-Sink has clearance beneath for wheelchair in bathroom (27" clearance, 34" tall max, 17" deep)<br>-33-36" rails in bathroom<br>-Bathroom rail extending 54" out<br>-Mirror at 40" high<br>-Toilet 18" from wall |
| Clearance | -32-36" passageway minimum<br>-48" clearance inside doorway<br>-4" maximum wall protrusion |
| Misc | -Braille plates<br>-Clear signage<br>-54" maximum reach for wheelchair<br>-Wheel chairs are 26" wide, and 42"+ deep<br>-30" clear wheelchair seating space |

Table 1: ADA Standards relevant to mobile clinic planning.

#### *4.2.2.2.1. Storage Needs*

Storage for multiple types of inventory and waste will be required for all mobile clinics. Program directors and designers should consult local authority and experts on best storage and transport practices of pharmaceuticals, blood, medical equipment and supplies, perishables, and water for medical use to determine the specific space requirements. A similar consultation and analysis should be performed for storage and transport of different forms of waste, such as waste, recycling, biological, hazardous, and needles. Such a careful analysis is required to adhere to strict medical guidelines and codes which are put in place to reduce the spread of disease. While it may be most efficient to group all storage together for both inventory and space maximization

purposes, it is likely that immediate access to at least some form of storage and waste storage will be required in multiple spaces.

#### *4.2.2.2.2. Doors, Windows, and Skylights*

All wall penetrations must consider privacy and space utilization. Whether or not operation is manual or automatic will depend on location (such as ADA requiring automatic entry doors) and access (such as skylights being out of reach for some users). Doors must follow ADA standards in width and function. Whether or not the door is a swing, folding, or pocket door will depend on use and space allowances. In most cases, a swinging door for the entry and pocket or folding doors between spaces will be optimal choices. Locks should be available on most doors, but access should be possible in some way from both sides (such as switch locking from the inside but providing key lock from the outside). The size and height should be maximized when possible where there is patient access. Noise transmission between spaces through the door should be especially considered when multiple patient rooms are designed into the space, possibly using acoustic materials like cork to absorb sound.

Skylights may be more feasible than eye level windows in many mobile clinics. Skylights are an important inclusion for day lighting (if designed for light reflectivity), ventilation (if operable), and privacy purposes. However, if possible, eye level windows provide an exterior view that many staff and patients will find pleasant. However, privacy and glare are of major concern in integration of windows. In order to be considered, multiple window treatments may be required on each window. For example, some windows may need to be slightly opaque for visual privacy with blackout window coverings to completely remove light in patient spaces. Other possible solutions include mirroring, tinting, and applied pattern graphics (seen on commercial buses), however

changes in view between interior and exterior changes from day to night and creates challenges for privacy at the street level. See Table 4 for more guidelines.

#### 4.2.2.3. Furniture and Fixtures

All pieces and parts within mobile clinic should be designed for transportation and easy deconstruction and reconstruction. If something is not attached to the shell, it should be designed for easy storage. Prefabricated, modular parts make repairs and replacements simple without causing significant disruption to clinic services and make updating the clinic over time easier.

##### *4.2.2.3.1. Seating, Surfaces, and Cabinetry*

Seating and surfaces should be designed with integrated storage or to be stowed away in order to maximize space, but should not sacrifice ADA accessibility in order to do so. Furniture should be built-in or connected to wall or floor surfaces in order to reduce stowing before travel, but function should not be lost as a result. For example, seating for staff using the lab may be more efficient if attached to the wall in some way, seating for extra visitors should readily stow away, and seating for staff in the exam space would be most functional if it were free moving (possibly with locking wheels). Cabinetry should be designed to open with minimal effort but without giving to movement of stowed materials during transport. In most cases, they should be lockable to further prevent spillage of contents and to prevent theft (such as on cupboards storing pharmaceuticals). The patient exam space will depend on exact need. Most spaces will require a patient bed, however some may simply require a patient recliner (for example, in dental clinics) or seating (for vaccinations or mental health). If the mobile clinic is meant mainly for diagnostic purposes, there may be limited seating for patients in interest of increasing space for equipment. See Table 4 for more information.

| Room | Seating/Surface | Contents | Storage |
|---|---|---|---|
| Entry/Waiting | -Drop down seating for patient/family<br>-Staff chair<br>-Staff workstation | -Weight/height<br>-Artwork<br>-Info pamphlets<br>-Activity<br>-Fire extinguisher<br>-Signage | -Coat |
| Consult | -Exam chair<br>-2 family chairs<br>-Staff chair<br>-Staff workstation | -Artwork<br>-Hand sanitizer<br>-Paper towl<br>-Gloves | -Desk storage<br>-Regular waste<br>-General |
| Bathroom | -ADA rail<br>-Small sink counter | -Handwashing<br>-Small mirror | -Regular waste |
| Exam | -Fold down seat<br>-Staff chair<br>-Staff workstation<br>-Exam bed | -Medical equip<br>-Artwork<br>-IV hook<br>-Gloves<br>-Paper towels | -Regular waste<br>-Needle waste<br>-General<br>-Desk<br>-Above desk |
| Prep/Lab | -Staff workstation (1-2)<br>-Staff chairs (1-2) | -Vision test<br>-Sanitation station | |
| Exterior | -Canopy | -Bright door<br>-Signage | -Ramp |

Table 2: Seating, work surface, content, and storage analysis of mobile clinic spaces.

#### *4.2.2.3.2. Lighting*

A variety of lighting levels and types should be available in mobile clinics, but designing for day lighting should be explored as a means to reduce electrical requirements. Most spaces should include ambient light set on dimmers with flexible task lighting that is built in but can be stretched and focused. Entry lighting and lighting along the ramp will be required for use in darker conditions. Signal lights above hand washing stations have proven effective at alerting users and encouraging compliance. In interest of energy, replacement, and lifetime cost effectiveness, LED lighting is suggested based on currently available technology. Controls for lighting should be available in all rooms/spaces and strategically placed at entries and workstations. See Table 3 for more guidelines.

| Room | Electrical Needs | Lighting |
|---|---|---|
| Entry/Waiting | -Min. 2 outlets<br>-Speakers<br>-Bodyweight Scale (ADA) | -Low treatment windows<br>-Ambient light<br>-Skylight |
| Consult | -TV monitor<br>-Laptop Computer<br>-Min. 4 outlets<br>-Speakers with volume | -High treatment windows<br>-Dimmable ambient<br>-Task lighting<br>-Skylight |
| Bathroom | -Hand dryer | -Ambient light |
| Exam | -High res./micro camera<br>-TV monitor<br>-Laptop computer<br>-Min. 8 outlets<br>-Speaker with volume<br>-Medical Equipment: sphygmometer, pulsometer, glucometer, defibrilator, oxygen, etc. | -High treatment windows<br>-Dimmable ambient<br>-Movable task lighting<br>-Skylight |
| Prep/Lab | -2 mini refrigerators(hazard & non)<br>-System/Environment monitors<br>-Min. 6 outlets<br>-Audio control and speakers<br>-Laptop computer | -Medium treatment window<br>-Ambient light<br>-Task lighting<br>-Skylight |
| Exterior | -Solar collectors<br>-Min. 2 outlets | -Entry light<br>-Ramp light |

Table 3: Electrical and lighting analysis of mobile clinic spaces.

#### *4.2.2.3.3. Health Care Supportive Technology*

Mobile clinics need to have, at a minimum, WiFi and GPS capabilities in order to most effectively operate. Having these will ensure that the staff will be able to sufficiently operate the clinic remotely by providing them with access to eHealth programs, sites, and information, critical to many health organizations today, and safely and efficiently routing them to and from sites, even detouring them through traffic. Having a radio antenna could be useful during dangerous weather conditions and traffic or could be connected to an overhead system for background noise throughout the day (also wired for MP3, CD, and internet audio output). While some mobile clinics would

need to have a computer, staff could also work from personal laptops and tablet devices which consume less energy. These devices linked with a high resolution TV screen could assist in communications with specialists and patients, be an educational element, or aid in diagnostic work.

Illustration 3: Interior rendering of a 16-foot trailer clinic.

Equipment required for medical purposes would vary based on the programs uses, however, it would be most efficient if mobile clinics were designed for fast and easy adaptation for other uses. Many diagnostic tools are available today in mobile form and battery operated, known as mHealth technology, such as pulsometer, sphygmometers (blood pressure readers), and defibrillators. However, some tools will need an outlet connection, such as a high resolution, microscopic camera or a mammography unit. Most

units would benefit from basic first aid equipment and basic diagnostic devices, such as thermometers and body weight scales. The patient exam area or bed should be carefully designed so that multiple forms of diagnostic equipments can be quickly and easily swapped out to transform the mobile clinic for other uses, although this goal should not overwhelm the main health operatives of the mobile clinic.

#### 4.2.2.4. Material Selection

All materials selected for mobile clinics must meet the same health care quality standards as selected for their hospital counterparts for safety. All materials need to be easily cleaned and sanitized with a variety of cleaning materials and must be able to withstand frequent and possibly harsh cleanings. It should also be commercial and health care grade quality for overall durability. Materials must be water resistant, anti-bacterial, hypoallergenic, and have low to no VOC off gassing. When and where possible, materials selected should be produced from renewable and recycled materials and should be easily reinstalled in the event of replacement. Material elements should be aesthetically pleasing together, although tones should range between light and medium to allow more light reflectance and make the clinic seem brighter. The main difference between mobile clinic and in-place clinic material selection is that materials should be analyzed for weight to reduce energy required for hauling.

While the availability and cost of specific brands and styles of materials quickly changes, there are certain types of materials that would be both safe and sustainable. For example, linoleum would be a proper choice of flooring. If this is paired with cork ceilings and doors, audio pollution can be controlled within the unit. Bamboo wood paired with aluminum hardware for doors and cabinetry are also sustainable and lightweight options. Any carpet included should be low pile and cleanable by light

sweeping for quick cleaning. The heaviest anticipated material to source with both low VOC and low weight requirements are countertops and work surfaces, but a resin based counter material may be best. Reflective materials like mirrors would help make the

| Feature | Qualities Needed |
|---|---|
| General | -Antibacterial<br>-Antiviral<br>-Hypoallergenic<br>-No VOC<br>-Easily maintained/cleaned<br>-Stain repellent<br>-Dark tone for visual acuity<br>-Non-busy pattern for visual acuity (solid recommended)<br>-Withstands frequent, intense cleaning<br>-Lightweight material if possible |
| Staff Desk/Counter | -Water proof<br>-Dark tone for visual acuity<br>-Non-busy pattern for visual acuity (solid recommended)<br>-Withstands frequent, intense cleaning<br>-Lightweight material if possible |
| Floor | -Water proof<br>-Easily dry/wet cleaned<br>-Medium tone to manage wear<br>-Semi-resilient for durability and improved sound quality |
| Walls | -Lighter colored to increase lightness of space<br>-Some reflective Quality |
| Guest Seating | -Soft surface<br>-Water repellent surface<br>-Fold down |
| Patient Bed/Chair | -Water proof<br>-Low to no pattern<br>-ADA accessible |
| Staff Seating | -Rolling and fixed<br>-Water repellent material |
| Windows | -Distorted or covered for privacy<br>-Translucent for light transfer |
| Window Treatment | -Varying translucency for need |
| Doors | -Folding or pocket where possible<br>-Entry should be swing |
| Harware | -Touch release<br>-Low profile, but clear to use |

Table 4: Material and fixture qualities required for mobile clinics.

interior feel more expansive and reflect any daylight that enters the space, reducing energy requirements.

#### 4.2.2.5. Monitoring and Maintaining

Regular maintenance and cleaning is critical to the safe operation of mobile clinics. All vehicle and trailer need to be regularly checked by a certified technician to prevent breakdowns while between sites. Wheels need to be frequently checked for pressure and drivers should be aware of where gas and emergency maintenance services are available at and between sites.[189] Parts should be efficiently replaced if faulty and designing for deconstruction and fast installation can make this possible. If possible, this maintenance will take place at the storage, repair, or hospital base, however, they may need to take place elsewhere when needed.

Close monitoring of vehicle systems and operations should be recorded to ensure utility and cost efficiency as well as safety.[190] If available, towing vehicles should have system monitoring software and clinic trailers should have environmental monitors for temperature, humidity, and carbon dioxide levels. Gas, water, and electricity use should be computer monitored and evaluated by operating staff to ensure operational and system efficiency. If necessary, some mobile clinics will require advanced weather monitoring technology based on local conditions or intentions of emergency deployments. It is suggested that all monitoring systems are linked together to make physical and cost analysis more efficient.

[189]Muolavie et al, Things to Consider Before Buying, 1999.
[190]Muolavie et al, Things to Consider Before Buying, 1999.

### 4.2.3. THE PROTOTYPES

The following illustrations is a spatial analysis of a 16-foot trailer clinic based on the Airstream Sport© (previously Bambi) interior standards. This prototype would be most suitable for rural cases or home visit scenarios. The small units can only accommodate one patient or diagnostic space, but this will vary based on program needs. Depending on the exact needs of the clinic, a bathroom may not be needed, however, including one for staff or emergency situation use should be strongly considered. The design is the most suitable design for more difficult routes and conditions, but dangerous routes should be avoided for staff safety.

In this example, a low-profile or stowable height and weight diagnostic station are placed at the entry. At the end of the patient bed, two stowable seats are included to accommodate additional guests. At the head of the patient bed, an adapatable diagnostic headboard is included. The physician's station is located between the patient bed and lab space for quick access to both. A large television is mounted in the corner for staff and patient visual access to accommodate video conferencing or to display health information or results. In addition to storage located throughout the lab station are two small, stacked refrigerators for cold storage.

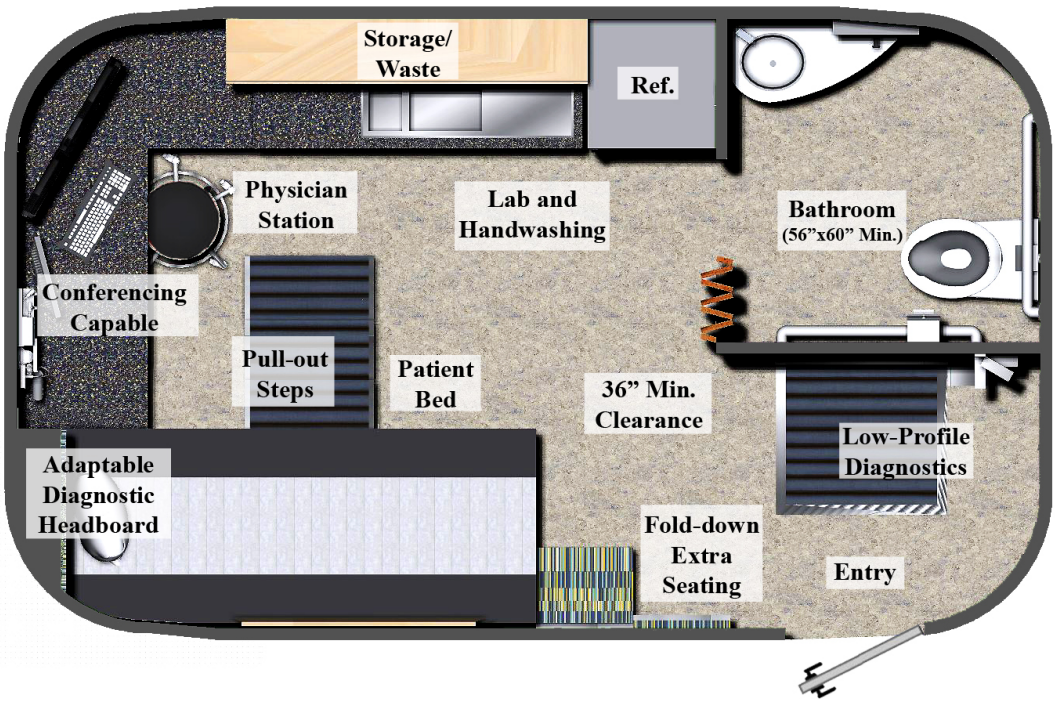


Illustration 4: Spatial Analysis of a 16-foot trailer clinic

Illustration 5: Section of 16-foot trailer mobile clinic.

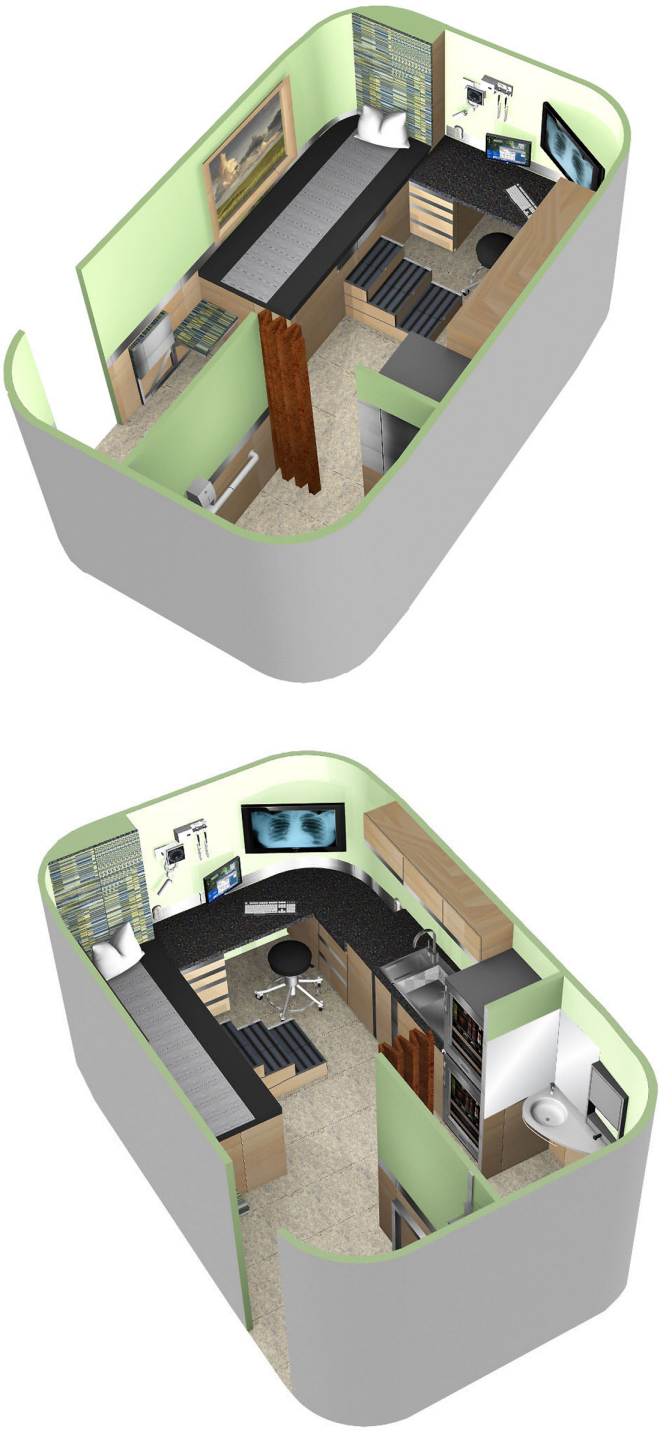

Illustration 6: Views: patient bed and physician workstation

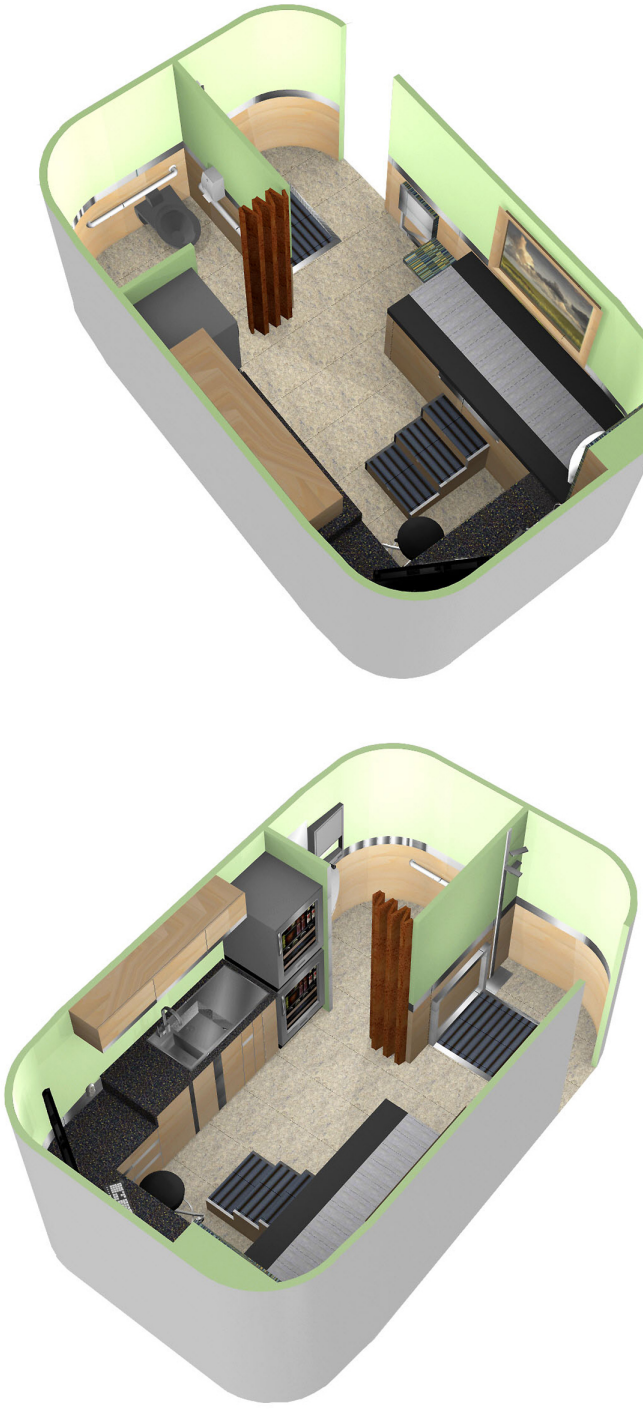

Illustration 7: Views: bathroom, lab, and entry spaces

Below is illustration is a spatial analysis of a 31-foot trailer clinic based on the Airstream Flying Cloud© interior dimensions. This design would be intended for suburban and urban communities, but could be used in rural areas when physically possible and accessible. In this design, there is space for a consult room and an exam room, however, many variations are possible, such as an exam room and diagnostic equipment space. Additionally, a lab or diagnostic space may not be needed for this type of clinic. For example, in delivery settings near the clinic's base location is, a lab may not be needed because they are so close to those resources already. It also would be more likely that, due to the denser population served in urban areas, it may be more practical to omit a lab in favor of more patient rooms instead.

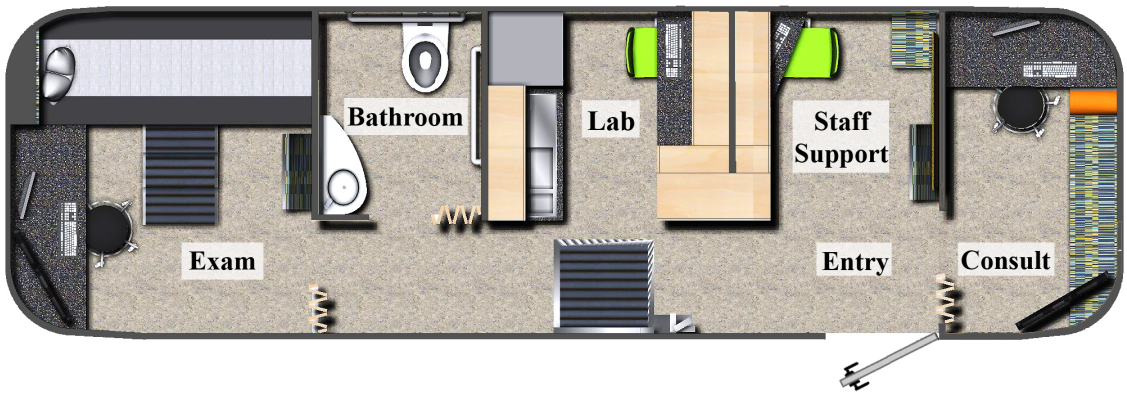


Illustration 8: Spatial analysis of a 31-foot trailer clinic

The final image is a spatial analysis of a 42-foot motor home clinic based on the Winnebago Tour© interior dimensions. This prototype would be mainly intended for suburban and urban uses with patients traveling to designated sites, but it may be practical for use in larger rural communities. However, it would not be suitable for difficult routes and conditions, which may make some communities inaccessible. In this

unit, some walls pop out when parked on site, so the ability for interior pieces to move together in some areas is critical. There is space for a maximum of three to four exam or consult spaces when diagnostic and lab spaces are included, however the latter may not be need for some mobile clinics.

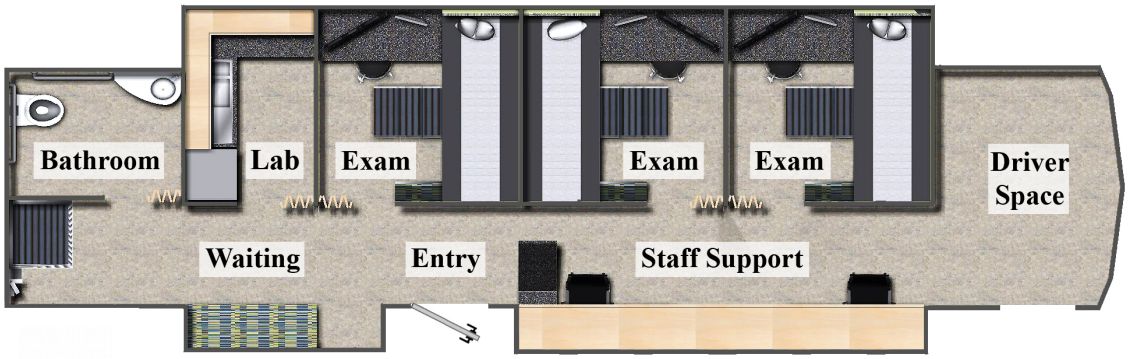


Illustration 9: Spatial analysis of a 42-foot motor home clinic

### 4.2.4. BENEFITS AND BARRIERS TO USE

The benefits of using mobile clinics in terms of outreach are documented in reports on individual programs. The goal of achieving meaningful outreach and even promoting return visits has proven successful in several populations, such as in immigrant populations or in urban, underprivileged neighborhoods. Clinic cost has much higher variability due to ranges in clinic needs, expectations, and site locations.[191] While mobile clinics can achieve very low costs through purchasing used vehicles and reducing material quality, they can also be very expensive when new, custom-fitted designs are constructed. It is already evident that mobile clinic are less expensive to construct than similar facilities with a foundation, however long term costs in comparison have not been

[191]Muolavie et al, Things to Consider Before Buying, 1999.

analyzed.

Due to more compact systems and equipment, mobile clinics are more energy efficient than their permanent counterparts. Due to their ability to change location based on solar and shading resources, they are great candidates for solar energy use and can move to more shaded locations on warmer days. They also achieve greater energy efficiency in terms of miles travelled. While a deeper analysis of road miles saved would need to be conducted at a programmatic level (which is not analyzed by any current program reports), efficiency would be achieved when medical staff travel to a rural site location to visit several patients throughout the day rather than the patients driving separately to the main hospital or medical facility where the services came from.

In Table 5, the electrical requirements of the three prototypes are analyzed. Based on this, an analysis of solar planning for a 16-foot trailer clinic is displayed in Table 6. These tables are only examples and should not be used for determining individual clinic needs and efficiency results may vary. Battery requirements should also be calculated with considerations for multi-day use. However, it should be noted that a backup generator should be included to prevent disruption to service and possibly affect the safety of the inhabitants.

However, there are still barriers to determining optimal design and use of mobile clinics that need to be addressed. The major barrier is limited size in comparison to expected use. If programs wish to have the ability to see several patients at one time, circulation becomes much tighter (although still adhering to ADA guidelines) and storage can be difficult to adequately spread throughout the unit. While this barrier was expected, circulation space between patient and staff areas was a major consumer of square footage, so maximizing patient space over creating slightly less cramped interiors could be a point of debate for some program directors. This space limitation will never

completely go away, but advances in building technology may make it less of a problem in the future.

| Item | Wattage | Hours Used | Single Quantity | Single W/Day | Double Quantity | Double W/Day | Triple Quantity | Triple W/Day |
|---|---|---|---|---|---|---|---|---|
| Outlets | 50 | 4 | 12 | 2400 | 20 | 4000 | 28 | 5600 |
| Stereo Receiver | 20 | 12 | 1 | 240 | 1 | 240 | 1 | 240 |
| Speakers | 5 | 12 | 2 | 120 | 4 | 240 | 5 | 300 |
| TV monitors | 40 | 6 | 1 | 240 | 2 | 480 | 3 | 720 |
| Computers | 85 | 12 | 2 | 2040 | 4 | 4080 | 5 | 5100 |
| Mini Frig (avg.) | 40 | 24 | 2 | 1920 | 2 | 1920 | 2 | 1920 |
| High Res/Microscope Camera | 20 | 1 | 1 | 20 | 1 | 20 | 1 | 20 |
| Oxygen Machine | 45 | 0.5 | 1 | 22.5 | 1 | 22.5 | 1 | 22.5 |
| HVAC | 100 | 12 | 1 | 1200 | 1 | 1200 | | 0 |
| **TOTAL** | | | | **8202.5** | | **12202.5** | | **13922.5** |

| Light | Wattage | Hours Used | Single Quantity | Single W/Day | Double Quantity | Double W/Day | Triple Quantity | Triple W/Day |
|---|---|---|---|---|---|---|---|---|
| Flexible Task | 7 | 8 | 3 | 21 | 6 | 336 | 8 | 448 |
| Dimmable Recessed | 10 | 12 | 4 | 40 | 9 | 1080 | 16 | 1920 |
| Track Lighting | 15 | 12 | 1 | 15 | 1 | 180 | 1 | 180 |
| Exterior Sconce | 15 | 4 | 1 | 15 | 1 | 60 | 1 | 60 |
| Signal Light | 1 | 12 | 1 | 1 | 2 | 24 | 1 | 12 |
| **Total** | | | | **92** | | **1680** | | **2620** |

| Single Total | 8294.5 | Double Total | 13882.5 | Triple Total | 16542.5 |
|---|---|---|---|---|---|

Table 5: Electrical load analysis.

ENERGY ALTERNATIVES

## PV System Calculator

### 1. Calculate AC Load

| AC Load | Watts x (Amps x Volts = Watts) | Hours Per Day | Days x Per = Week | Watt Hours |
|---|---|---|---|---|
| camper | 8300 | 1.0 | 6.0 | 49800 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |

AC Weekly Watt Hours: 49800
x
AC Inefficiency Factor = 1 + 25% (25% for mixed systems, 30% for AC only): 1.25
=
Total AC Weekly Load (Watt Hours): 62250

Peak Load (everything on): 8300 Watts

### 2. Calculate DC Load

| DC Load | Watts x (Amps x Volts = Watts) | Hours Per Day | Days x Per = Week | Watt Hours |
|---|---|---|---|---|
| Inverter standby | 5 | 14.0 | 1.0 | 70 |
| Inverter running | 20 | 10.0 | 1.0 | 200 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |

DC Weekly Watt Hours: 270
x
DC Inefficiency Factor = 1 + 20% (20% in most circumstances): 1.20
=
Total DC Weekly Load (Watt Hours): 324

+
Total AC Weekly Load (From Section 1): 62250
=
Total Weekly Load (Watt Hours): 62574

-
Backup Contribution Percentage (From Generator or Alternate Source): 0%
=
Adjusted Weekly Load (Watt Hours): 62574

### 3. Calculate Battery Size

Total Weekly Load (From Section 2): 62574
÷
Days of Use per Week: 6
÷
Battery Voltage: 24
=
Total Daily Amp Hours: 435
x
Days of autonomy (Usually 3.5 Days): 3.0
=
Normal storage capacity in Amp Hours: 1304
÷
Maximum Drawdown (Typically 50%): 50%
=
Required Battery Capacity in Amp Hours: 2607
÷
Derating Factor for Cold Weather: 100%
=
**Total Required Battery Capacity (Ah): 2607**
÷
Single Battery Capacity in Amp Hours: 330
=
Number of Batteries in Parallel: 8

Battery Voltage (From Above): 6
÷
Rated Battery Voltage: 6
=
Number of Batteries in Series: 4
x
Number of Batteriess in Parallel: 8
=
**Total Number of Batteries: 32**

### 4. Calculate PV Array Size

Adjusted Weekly Load (From Section 2): 62574
÷ 7 =
Daily PV Energy Budget (Watt Hours): 8939
÷
Battery Voltage (From Section 3): 24
=
Average Daily Amp Hours: 372
÷
Bright Sunshine Hours (From Table): 5
=
Array Current in Amps: 7.9
÷
Module Current in Amps: 7.9
=
Number of Modules in Parallel: 1
Solar Module Wattage: 175

Battery Voltage (From Section 3): 24
÷
Solar Module Voltage: 29
=
Number of Modules in Series: 4
x
Number of Modules in Parallel: 2
=
**Total Number of PV Modules With MPPT controller: 8 / 11**


www.energyalternatives.ca

Table 6: Solar Panel Calculator for 16-foot trailer with 5 hours of sun a day.

# CHAPTER 5: SIGNIFICANCE

## 5.1. Where can health care occur?

The exploration into increasing mobile clinics introduces a broader question: what kind of space does health care really need to take place in? Obviously the health care environments of the past cannot be repeated, but is a continuation of the current delivery spaces the answer instead? Medical facilities have been adapted to meet modern medicine and technology, but we are failing to meet modern public health need as designers. Was doing away with home doctors for minor illness really what human health needed?

Increasing the availability and popularity of mobile clinics could have much wider implications on the healthcare system as a whole. While I doubt it would replace any mode of care currently used, it does have the likelihood of increasing the demand and instances of home delivered care. As a result, residential design may change to include retrofitting for health care delivery and to create a new understanding of the functions of the home. In the future, where a doctor comes to the patient rather than the reverse, we might see the introduction of the health room in the American home. It might also decrease the demands on hospitals, reserving those facilities for emergency use or more intense diagnostics or care.

A more immediate possible outcome of increasing mobilized care across the U.S., as has been seen with current examples, is a decrease in the inappropriate use of emergency room care. As this is the standard mode of care for those who have no access to health care otherwise, increasing the availability of alternative services will divert a significant portion of emergency room requests to more appropriate methods, either

through receiving care through alternatives such as community clinics or by avoiding the need for it through more regular care. Also, if there is less inappropriate use of this expensive mode of care, there should also be a decrease in care costs for everyone and those funds can be used on more serious and dire cases.

By challenging the current system of care, designers can begin to look for answers to deeper concerns within the American healthcare system and the population it serves. Regardless of the outcome, I hope that my investigation will stimulate conversation regarding the forms of health care settings to uncover what is truly necessary of certain types of care rather than *all* types of care. While many designers are not afraid to think outside the box when it comes to forms of human spaces, health care has far less flexibility due to its specific needs and vulnerable users. However, I believe that by examining already successful models of health care different from our own, we can find solutions to problems that history has already solved.

In addition, I hope my research stimulates further conversation into what designers can do to help the healthcare industry control cost and access without hurting the quality of care and the business behind healthcare. Designers often think they have no control over the social, economic, and political issues in their designs, but when all participants in the health care industry work together on these issues, the increased perspective makes it more likely that an optimal solution will actually be found. While the discovery process could be long and complicated, I believe it's necessary for the sustainable future of healthcare and, more importantly, the society it serves.

## 5.2. Why do designers need to be involved?

If designers wish to have a part in the future of healthcare, they need to keep themselves relevant to it. The healthcare architecture and interiors industry is growing with the boom in construction, but if the current model is unsustainable, then so is the increase in construction. Healthcare designers are currently serving a volatile client and should be prepared to rapidly adjust along with the market. While many designers enthusiastically practice sustainable design, striving for high LEED ratings and setting the ingenuity bar higher and higher, they may be wrapping unsustainable practices in sustainable packaging. Shareholders focus on economic challenges of healthcare and medical professional focus on biophysical challenges of healthcare. They may not carry the interest, study, and practice of the geophysical and architectural challenges of healthcare. Therefore, designers need to redirect their focuses to fully encompass the challenges a health care facility will face in relation to its surrounding and connecting parts.

## 5.3. How could this benefit the University of Texas?

As the University of Texas excitedly anticipates its new medical school program, I invite the new dean of the Dell Medical School to consider the adoption of a mobile clinic program for the benefit of the students, staff, and local community. While it will obviously benefit the community and possible other magnet locations in terms of free or low cost services, it has benefits to the school and program as well. The ease of including epidemiological studies for faculty and higher level students has extreme advantages for both the school's progress and medical advancement. Students will benefit from hands on experience by volunteering or gaining course credits for their work on mobile clinics. Finally, it would generate positive publicity for the new program as

well as the university at large.

## 5.4. Generating Debate

Finally and most important, it is of increasing importance that the greater public begin discussing and debating healthcare challenges. Everyone is a client of healthcare, or at least a possible client. Everyone has a stake in the ability of the healthcare system to efficiently and effectively deliver care. Everyone should hope that health care can go beyond sustaining life to enriching it. Everyone needs to be talking about it. The more people are talking about it and the more diverse the participants, then the more solutions that will come to the surface. While this may complicate the process, it is more likely to reveal the optimal solution. It's more than the economic consequences that we need to be worried about. The health and livelihood of Americans depend on solutions.

# CHAPTER 6: CONCLUSION

## 6.1. Summary of Contributions

There are no simple answers to America's health care problems. The problems and solutions discussed in this paper attack only some of the issues facing Americans today and will not solve the problem in its entirety. In fact, no single action can be a solution. There are many people working on finding answers before this reaches crisis level, but answers may come from unlikely places and it will take cooperation and effort to find them. Every profession will be affected by the unsustainabilities of healthcare system if the population is too sick and poor to be producing and consuming. So therefore, designers should join other fields in presenting responses based on their expertise. Designers frequently focus on the environmental sustainability of their clients, but how can they address the non-environmental sustainability issues of cost and access in the American healthcare system?

The suggestion from the medical community is to increase regular, preventive measures to avoid larger health issues with higher costs and consequences, but the current issues of cost and accessibility prevent this effort from taking hold. With an aging population and increases in chronic illness paired with an inefficient and unequally distributed system of care, we can only expect this solution of increased preventive measures to be harder to implement. Government regulation has begun to make movements towards this concept of prevention, however, the cultural and political climate may make changes in this realm less effective than hoped. Therefore, to support the effort designers could advocate for increases in mobilized health care units to remove traditional barriers to care.

Mobile clinics are not a new concept, they are just not a widely used. In an investigation of their operations, it was evident that mobile clinics have many advantages over traditional care facilities, but they are largely from charitable or educational sources and therefore not regular forms of care. Even though the client in this case is technically the entire American population based on the problems addressed, no effective design solution will come from trying to address everyone at one time. Therefore a profile of common mobile clinic operations and operators was compiled based on general survey and closer case study analysis in order to explore prototypes for mobilized care. A large body of research is forming that supports scientific practice in designing and constructing safe and healing health based architecture, however the focus lies in hospital care and very little emphasis is given to preventive and non-emergency care spaces. While the two types of care are related and require similar qualities in their environment, it is deduced that most preventive clinics will not need the same healing elements due to shorter patient use and instead staff gain higher consideration due to their increased time spent in the facilities.

Based on review of current mobile clinics and the needs of health care spaces, three mobile clinic prototypes emerge, but operate solely as example of what can be done with different mobile spaces. Individual programs should only use these as a guide and should consider their own individual needs, hiring a designer for consultation if needed. A small, 16-foot unit can hold one patient space or a few smaller diagnostic machines and would be more suitable to rural locations where less patients would need to be seen at one time and the need for diagnostic services is greater due to low local availability. A medium, 31-foot unit can hold up to two patient spaces, one patient space and some diagnostic machines, or can operate as a mobile diagnostic clinic and would be suitable for suburban and urban uses but could also be used in accessible rural towns. The largest

41-foot unit can hold up to three patient spaces or any combination of diagnostic capability and would be best suited for suburban and urban use.

Sizing is only a small part of planning and designing a mobile clinic program. While it may be desirable to see a maximum number of patients at the same time, a more cramped interior may yield lower satisfaction with the clinic and therefore reduce its outreach impact, even though all prototypes meet ADA access standards. Using built-in elements that fold up or tuck away can help create more space without removing functionality. Whether or not a trailer and truck is purchased over a large commercial bus effects how many patients can possibly seen, but it also affects overall function due to differences in maneuvering ability. Designing for deconstruction will reduce time spent on repairing and updating the mobile clinic and therefore will increase productivity. The main issues that remain in the successful design of mobile clinics in the struggle to acquire maximum circulation and storage space with maximum patients seen simultaneously and to recreate the private atmosphere that traditional clinics offer.

## 6.2. Implications for Future Research

Future explorations of this topic could be aimed at designing for implementation of a mobile clinic programs through several different routes. The first is through implementation at the University of Texas at Austin in the new nursing program. While it would demand extra funding that is currently directed at replacing supporting facilities, investment in a similar program would provide training for students and give them market edge on obtaining jobs post graduation. It would also create a better relationship between the school and surrounding underserved populations. There are also many local charitable organizations that would likely be willing to contribute to such a program

based on current funding provided to in need hospital patients. The alternative routes for implementation are through other university or charitable programs, emergency relief efforts, partnership ventures with recreational vehicle manufacturers (possibly creating healthcare lines), or through government support (or policy change) for more widespread American implementation. Mobile clinics could also be a solution to the health care needs in foreign countries, so planning for international design, construction, and implementation could also be a future mode of exploration.

Possible future interpretations of the mobile clinic concept could evolve to include a greater variety of vehicle and location type, such as mobile care delivered in war zones or during water or air travel. Should public transportation expand rail use, mobile surgical and diagnostic cars could become a replacement for modern day hospitals. However, in order to further develop any mobile clinic, several modes of research and planning would need to occur. After the care program has been designed for community needs and sustainable use, a detailed cost and electrical analysis will need to be performed by the proper experts in order to ensure viability of such a program. Care staff and program directors will need to pair with designers to develop a representative branding scheme to establish both aesthetic and marketing plans. Designers should also review the intended users and the medical uses of the vehicles to determine the proper vehicle and interior needs.

## 6.3. Advocates and Opponents

While studying the current and future use of mobile clinics, it became very clear that there are few opponents to the idea. Discourse with the general public has resulted in eager discussion of how to create a program and how it would benefit them personally. Medical professionals who recognize or have experienced the benefits of working with

patients in their local communities might argue that going to the problem will be more effective than waiting for the problems to come to them, especially considering the barriers in doing so. Developers of mHealth technologies would find mobile clinics lucrative to their own business, bringing them more development opportunities due to larger use and increased use capabilities (due to the ability of a vehicle to go and gather data) and possibly even seeing this as the logical next step in care. Producers of recreational vehicles would also find widespread implementation lucrative to their business (as mentioned, even possibly creating whole lines focused on health care). Senior care facilities would need to rely less on family members to bring their loved ones to get care and tests could be brought to them, and the same goes for the large amount of elderly aging in place in their rural communities. Think of the productivity gained from hours of work not lost to health care needs!

While support for the mobile clinic response to American health care problems has resulted in high levels of support and very few global criticisms, there are some expected critics that would slow or prevent successful integration of a mobile clinic program. For example, some car friendly communities and able-bodied people may prefer the comfort of in-place clinics and not see the full benefits of mobile clinics. For some medical professionals, to finally have a personal office is considered a job perk and they may not be willing to sacrifice this setting. Healthcare architects and designers may worry about lost income from the highly expensive hospital projects that are currently popular, however, it is hoped that it would instead encourage them to work ahead of the curve

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