

2018

# Effects of housing on homeless individuals' glycemic control

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BOSTON UNIVERSITY  
SCHOOL OF MEDICINE

Thesis

**EFFECTS OF HOUSING ON HOMELESS INDIVIDUALS) GLYCEMIC  
CONTROL**

by

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B.S., St. Johns University, 2010

Submitted in partial fulfillment of the  
requirements for the degree of  
Master of Science

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Thank you to my friends and family, I could not have done this without you.  
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**ABSTRACT**

Homelessness has long been a part of society and is defined by a lack of permanent residence. The approach to homelessness has varied with time and recently an effort has been made to eradicate it in the United States. Several studies have shown the deleterious effects of homelessness on an individual's health and the cost it brings to society. Others have demonstrated improvements in cost when these individuals are provided "low threshold housing." Low threshold housing is an approach which seeks to house individuals without many of the requirements previously in place, such as sobriety or employment. This is becoming more widely implemented.

The effect of low threshold housing on specific common health conditions remains to be seen. Diabetes is an extremely common health concern which affects both the housed and homeless equally, however, it is markedly more difficult to address while homeless. This study will seek to evaluate the effects of housing upon homeless individuals diabetic control.

A cohort of newly housed individuals with poorly controlled diabetes will be selected and their glycemic control documented for the year following housing. Glycemic control will be measured via an individual's Hemoglobin A1C at 3-month intervals. The values will be compared and evaluated for significant change. This information will

allow us to evaluate the effects of housing on this common medical condition and to make appropriate changes to policy going forward.

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**LIST OF ABBREVIATIONS**

- BU..... Boston University
- BGL.....Blood Glucose Level
- DM..... Diabetes Mellitus
- MHSA..... Massachusetts Housing and Shelter Alliance

## INTRODUCTION

### Background

Approaches to homelessness have varied from society to society as well as with time. In ancient Rome, homeless individuals sought wealthy sponsors.<sup>42</sup> After a large revolt in England in the 1300s, homeless individuals were at risk of being imprisoned.<sup>23</sup> Today, the best solution to homelessness is an issue of debate but providing housing is one accepted solution.<sup>11</sup>

In the United States under the Obama administration a large push was created in the direction of housing homeless individuals.<sup>39</sup> Due to the relative novelty of this approach many of its effects remain to be seen. Specifically, the effects of housing on health remain largely to be determined.<sup>37</sup>

Diabetes affects 8.3% of Americans and is similarly prevalent among the homeless population.<sup>25</sup> It is an expensive and complex medical condition, which requires diligent control of diet and administration of medications. It costs the US an estimated 245 billion dollars annually.<sup>9</sup> Adequate control leads to a healthier population and a reduction in these costs.<sup>9</sup>

As the number of homeless individuals in public housing increases, our lack of knowledge regarding its effects on health becomes more apparent. It seems prudent to begin to evaluate the effects housing policy has upon individuals and specifically, their health and well-being. Diabetes is a common medical problem in America and one which the state of homelessness renders difficult to control

## **Statement of the Problem**

It has been shown that homelessness leads to decreased food security, difficulty obtaining medications, and leaves one more susceptible to infection and hospitalization.<sup>1,15</sup> This collection of impediments causes diabetes to be particularly difficult to manage while homeless. The illness requires careful control of diet, diligent monitoring of blood glucose levels (BGL), and medication adjustment, as well as compliance. Further, having poorly controlled BGL leaves an individual at risk of several comorbidities and infections.<sup>16</sup>

As individuals are placed in housing their ability to properly manage their diabetes would be expected to improve. However, there is a paucity of evidence on the potential beneficial effects housing has upon the health of the newly housed. Further, if there is no improvement seen in their health, specifically in their glycemic control, it ought to augment our approach to caring for this at-risk population.

## **Hypothesis**

Providing housing to homeless diabetic individuals will lead to an improvement in glycemic control.

## **Objectives and specific aims**

The objective of this study is to demonstrate the health benefits of providing housing to the homeless. We will specifically try to demonstrate the benefits it has upon glycemic control. The method by which glycemic control is achieved will be recorded. We wish to examine the more general effect housing has upon diabetic control and also the manner in

which it was achieved by successful individuals. The specific aims of this study are as follows:

- Record individual's hemoglobin A1Cs (a test which tells you the average blood glucose level over the past 2-3 months)<sup>27</sup> upon receiving housing and at 3 month intervals, thereafter, for at least one year
- Demonstrate a significant reduction in A1C of 0.5% following housing
- Record the methods of diabetic control used

## REVIEW OF THE LITERATURE

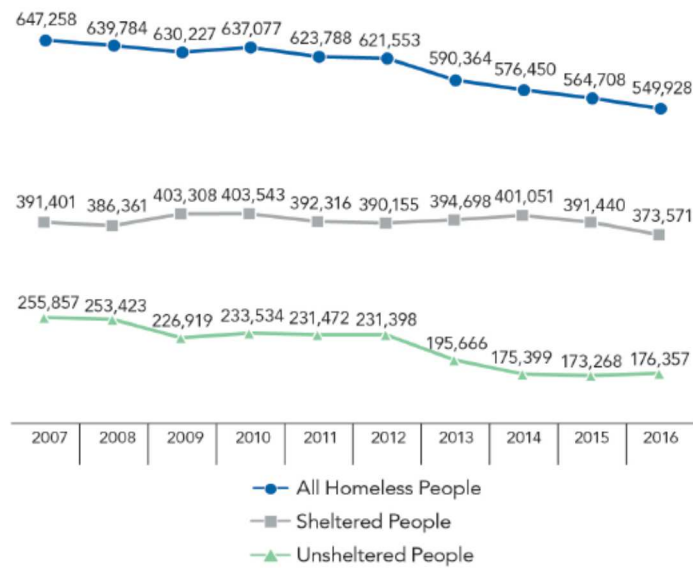
### Overview

On a single night in January of 2016, almost 550,000 people (0.16% of the population) in the United States were experiencing homelessness according to the Annual Homelessness Assessment Report. This number is large but has declined by 97,330 since 2007<sup>11</sup> due to a large initiative by the federal government to end homelessness all together. This came secondary to “*Opening Doors: Federal Strategic Plan to Prevent and End Homelessness*” developed by the Obama administration. President Obama stated that, “The previous administration began the work to end chronic homelessness. Now is the time to challenge our nation to aspire to end all homelessness across all populations-including families, youth, children, and veterans.”<sup>39</sup>

Opening Doors is a program, began in 2010, that provides housing to homeless individuals. It is a federal program but works with state and local agencies as well as the private sector. This program works by removing barriers that previously existed between local agencies and federal resources.<sup>39</sup> The program has resulted in a 33% decline in homelessness among veterans, 21% decline in chronic homelessness, and a 15% decline in families without homes.<sup>11,39</sup> This rate of decline in homelessness since this program began in 2010 is markedly greater than the 3 years prior to its implementation (Figure 1).

**Figure 1 Annual estimates of individuals who are homeless (adapted from the Annual Report on Homelessness, 2016).<sup>11</sup>**

## EXHIBIT 1.1: PIT Estimates of People Experiencing Homelessness By Sheltered Status, 2007–2016



This program seeks to change the way the United States approaches homelessness. It begins with the principle that providing a home to someone with minimal pre-requisite is pivotal in allowing them to achieve change within their life.<sup>39</sup> This change can manifest itself as a number of things but, principally, involves allowing these individuals the stability to pursue happiness and become contributing members of society again. Previous housing program policy had required several changes, such as sobriety or employment, before an individual was a candidate for housing.

The plan seeks to prevent the problem as well, increasing the availability of affordable housing to those who are at risk of homelessness due to financial hardship. Individuals or families are considered at risk if they make 30% or less of the area's



median income. For these people, housing is thought to be affordable if it is 30% or less of their income and is subsidized appropriately. Due to an increase in the number of units available between 2011 and 2013, the number available per 100 renters increased from 39 to 65.<sup>39</sup> This program, in cooperation with the efforts of many local organizations, has been effective in reducing homelessness and the taxing effect it has upon our society and healthcare system. However, much work remains to be done in proving the beneficial effect housing has upon the health of these individuals and one of the most difficult illnesses to control in this unstable environment is diabetes.

## Diabetes

### Epidemiology

Diabetes is generally characterized into two distinct subsets with two distinct etiologies, referred to as type 1 and type 2 diabetes. The different types of diabetes affect different populations. Type 1 diabetes is traditionally a disorder of childhood, however, up to 50% of cases are diagnosed after 20 years of age.<sup>25</sup> Peak ages of diagnosis are 11-13 years of age and 30-40 years.<sup>25</sup> Type 2 diabetes generally affects an older population and has the highest incidence at age 60, however, this disease can arise in the younger population as well, which is becoming increasingly more common.<sup>8</sup>

Diabetes affects 8.3% of the US population and 8.5% of the world population<sup>26,41</sup>. Additionally, its global prevalence is increasing, from 4.7% in 1980 to 8.5% in 2014<sup>41</sup>. The majority of these cases are type 2 diabetes which accounts for over 90% of cases in the US.<sup>25</sup>

Type 1 diabetes incidence has shown an association with latitude in China amongst 0-14 year olds.<sup>40</sup> Among German children aged 0-5, temporal, seasonal, and geographical variations in incidence have also been demonstrated.<sup>30,40</sup> In combination these studies suggest an environmental contribution but do not prove it. There is a strong genetic component of Type 1 diabetes, as well. Type 2 diabetes has several well characterized risk factors, such as increased weight, maternal family history, and ethnicity (Native American, African-American, Latino, Asian American, Pacific Islander).<sup>2</sup>

### Pathophysiology

Type 1 diabetes is due to a deficiency of insulin production. It is caused by autoimmune destruction of beta cells in the pancreas, which normally produce insulin. Insulin is a hormone, which allows one's body to utilize sugars in the blood stream.<sup>16</sup> This destruction tends to occur at a young age and leads to hyperglycemia (high blood sugar).<sup>16</sup> Hyperglycemic symptoms include polydipsia (increased thirst and consumption of water), polyuria (frequent urination), and polyphagia (increased hunger), lethargy, weight loss, and possibly stupor or syncope. This autoimmune destruction generally begins in youth and, as such, individuals present with symptoms at a young age leading to a younger diagnosis.

Type 2 diabetes is caused by a deficiency in both secretory function of the pancreas and a decreased response to the insulin that is released. This process generally begins later in life and is frequently associated with obesity.<sup>16</sup> There are other rare causes of diabetes, including Cystic Fibrosis Related Diabetes (CFRD), Cushing's Syndrome,

and iatrogenic diabetes.<sup>24,28,43</sup> The diagnosis of type 2 diabetes usually occurs from screening at-risk or symptomatic individuals. Symptoms of uncontrolled type 2 diabetes are similar to type 1.

### Complications

The symptoms and complications of the disease are best understood in conjunction with the pathophysiology of diabetes. Decreased insulin sensitivity results in persistent hyperglycemia. This causes end organ effects, particularly in the kidneys, eyes, nerves, and blood vessels.

In the United States, diabetes is the leading cause of end stage renal disease, adult onset blindness, and non-traumatic lower extremity amputation secondary to atherosclerosis, peripheral neuropathy, and peripheral vascular disease.<sup>16</sup> Patients may also develop severe periodontal disease with uncontrolled diabetes.<sup>2</sup> Symptoms early in the stage of these diseases include frequent urinary tract infection, changes in vision, decreased sensation, or fluctuations in mental status.<sup>16</sup>

### Treatment

Treatment of diabetes depends on the type of diabetes. Type 1 diabetes requires a multi-pronged approach. DM1 (Diabetes Mellitus 1) requires exogenous insulin in order to allow the body to absorb sugar from the bloodstream. The amount of insulin required depends upon the amount of glucose (a type of sugar) in the blood, which is determined by dietary intake and metabolic state.<sup>29</sup> In order to keep blood glucose levels (BGL) consistent, diabetics are encouraged to have a stable and consistent diet and to routinely check their BGL. Diabetics or their caretakers generally become capable of adjusting

their insulin dosage based upon BGL. The general goal for a diabetic is to keep their BGL between 90-130 mg/dl and their hemoglobin A1C below 7.5 %. Hemoglobin A1C is the percentage of a certain type of hemoglobin, which is glycosylated (has extra sugar attached to it). However, these goals must be maintained while consistently avoiding hypoglycemia, a dangerous complication of too much insulin. More recently small pumps have become available which sample the blood and provide insulin accordingly. <sup>2</sup>

Type 2 Diabetes requires a slightly different multi-pronged approach. It is managed with several different oral medications, lifestyle, diet modifications, and insulin, if necessary. Exercise is important in order to achieve an average Body Mass Index of 20 to 25 kg/m<sup>2</sup>, a desired outcome for diabetics. This helps reduce complications of diabetes and also aids in maintaining a more stable BGL. Wide fluctuations in activity or states of high stress (eg mental, physical, illness, etc) can increase glycemic demand, resulting in hypoglycemia, and so insulin must be adjusted during these periods.<sup>16,29</sup> Diet is pivotal in maintaining stable BGL and meeting glycemic goals. Diets should be low calorie, low fat, and high in complex carbohydrates.<sup>16,29,38</sup> However, even with these interventions, most individuals require medications as well. <sup>38</sup>

The oral medications fall within several categories. The first line therapy is biguanides (most commonly metformin), which work by decreasing hepatic gluconeogenesis and increasing insulin sensitivity. The mechanism by which it suppresses gluconeogenesis is poorly understood, however, it increases insulin sensitivity by enhancing the effect of glucose transporter proteins on the cell surface. <sup>29</sup> Once first line therapy fails, there are a number of secondary medications.

Sulfonylureas are a common second line medication. The mechanism of action of these is to increase insulin release from pancreatic beta cells; they depolarize beta cells, causing a cascade of events, which eventually leads to insulin release. Meglitinides are another class. These medications operate by a similar mechanism to sulfonylureas but generally do not achieve as significant an effect. Alpha glucosidase inhibitors work by decreasing intestinal breakdown of sugars, thereby decreasing absorption. Thiazolidinediones cause a decrease in the availability of fatty acids in the blood stream, thereby increasing utilization of sugars instead. GLP 1 agonists are “incretin mimetics,” which increase insulin secretion. SGLT 2 inhibitors decrease reabsorption of glucose in the kidney, facilitating excretion of glucose.<sup>29</sup> There are other less common medications as well.<sup>29</sup>

### **Existing research**

Several studies have been performed which show an improvement in health care utilization and cost when permanent housing is provided. In 2009 Sadowski et al offered 201 homeless individuals housing and a social worker and 204 individuals the usual level of care. They found that this reduced their hospital utilization by 29% (Figure 2).<sup>32</sup> This study did not assess the type of hospital utilization (for example whether an ER visit was to fill a prescription or due to a serious condition) and did not utilize records of other medical services, such as primary care visits.

**Figure 2 Hospitalizations in newly housed homeless individuals (adapted from the Opening Doors Amendment, 2015)**<sup>4,32</sup>

After 18 months of housing and case management services, a group of formerly chronically homeless persons in Chicago, Illinois experienced fewer:

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Hospitalizations:	▼ 29%
Days in hospital:	▼ 29%
Emergency room visits:	▼ 24%

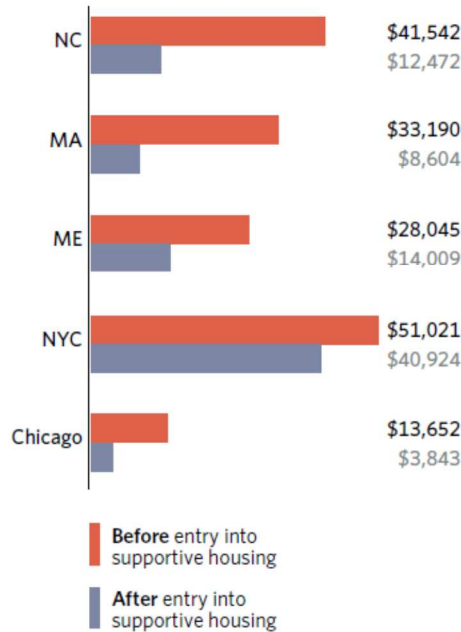
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*Sadowski, et al., 2009*

In 2012 Basu et al performed a cost analysis on a randomized control trial of 407 homeless individuals in Chicago who received public housing. They sought to demonstrate that housing was less expensive than the services utilized (nursing homes, shelters, substance abuse treatment centers, and case manager visits) by these individuals prior to receiving housing. They showed a non-significant decrease in major service utilization of \$9,803 ( $p = .23$ ).<sup>4</sup> Prior to housing average costs were \$13,652 per month and afterwards dropped to \$3,843 (Figure 3). These costs are compared to the findings of several other distinct studies, all of which show a decrease in cost but of varying degrees.

**Figure 3. Service utilization of homeless individuals before and after housing (adapted from the Opening Doors Amendment, 2015)<sup>4,32</sup>**

*Reductions in Utilization  
of Major Services  
Before and After Entry  
into Supportive Housing*



*MHSA et al., 2014*

A study conducted in Seattle placed 95 homeless participants with a history of alcohol abuse into a housing first program. The participants had average costs of \$4066/month due to service utilization (jail bookings, days incarcerated, shelter and hospital usage, Emergency Medical Service usage) in the year prior to intervention. Subsequently, their costs decreased to \$1492/month; with housing costs included total costs were \$2449/month. This equated to a statistically significant reduction in costs of 53% (95% CI, .25-.88) when compared with wait-listed participants.<sup>18</sup> The study was limited by its selection criteria since it included only homeless individuals with alcohol

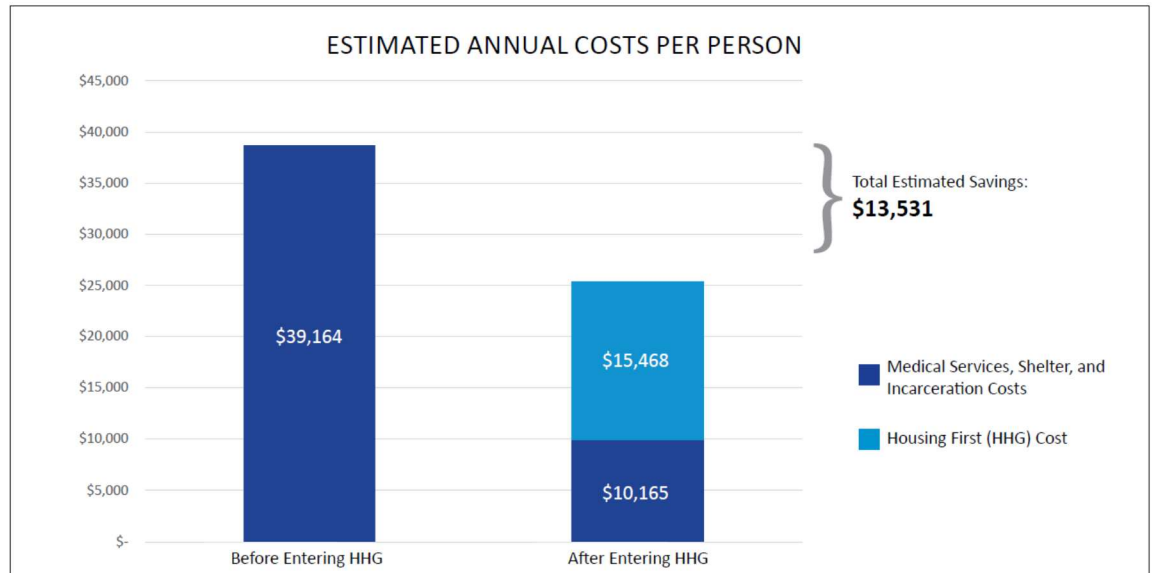
abuse problems. This could result in them having increased costs prior to housing as compared to the general homeless population.

Medicaid costs have also been shown to decrease with proper housing. 2827 NYC residents with Medicaid and significant psychiatric illness were placed in housing. The average annual Medicaid savings were shown to be \$9526 (95% CI = \$2,003 to \$19,038).<sup>20</sup> The amount saved was noted to increase if Medicaid expenditure was high prior to housing.<sup>20</sup>

The Massachusetts Housing and Shelter Alliance (MHSA) obtains data from individuals in Massachusetts who have been placed in permanent housing through the housing first initiative. This program serves chronically homeless individuals whom have been homeless for at least 1 year.<sup>21</sup> In 2017, they demonstrated a \$13,531 decrease in cost of individuals in the program (Figure 4), even after taking into account program costs. On a survey conducted, ninety seven percent of individuals stated a subjective improvement in well-being as well.

**Figure 4: Estimated costs of homeless individuals before and after housing (adapted from Massachusetts Home and Healthy for Good, 2017).<sup>21</sup>**





### Health risk among homeless individuals

Studies have also been done which show the deleterious effects of homelessness upon health and wellbeing. Data from a national survey of US adult state and federal inmates was assessed by Greenberg et al and found that prior homelessness was associated with incarceration. Nine percent of inmates reported an episode of homelessness in the year prior to arrest. This rate is 4-6 times greater than that of the general population when adjusted for age, race/ethnicity, and gender.<sup>10</sup> This study is limited by recall bias since the individuals self-reported homelessness. This could have resulted in them under reporting their homelessness, for example if they were embarrassed.

Food insecurity, which is associated with homelessness, is also a risk factor for many chronic illnesses.<sup>34</sup> A study by the journal of nutrition in 2009 using National

Health and Nutrition Examination Survey data showed that there was an association between food insecurity and hypertension (ARR 1.21; 95% CI: 1.04-1.41) and, when food insecurity included reduced quality or desirability of food, there was an association with diabetes (ARR 2.42; 95% CI: 1.44-4.08) as well. Food insecure individuals in this study also self-reported a higher incidence of hyperlipidemia compared to the general populace. This study was limited in that food insecurity was determined by household, so there may have been some misclassification of food secure or insecure individuals. This was a non-differential misclassification and so reported associations may underestimate the relationship between food insecurity and the health conditions studied.

In 2001 the Canadian Medical Association Journal (CMAJ) published a literature review which described the demographics of the homeless<sup>12</sup>, their associated medical problems and the health system response. Data from several shelters demonstrated that about 70% of the homeless population are single men.<sup>12</sup> Several of the following studies are from this literature review.

An article included in the review from Hwang SW utilized a cohort study to show that homeless men have increased mortality rate ratios when compared to men of similar age in the general population -- 3.7 (95% CI: 3.0-4.6) for men aged 25 to 44 years and 2.3 (95% CI: 1.8-3.0) for men aged 45 to 64 years.<sup>13</sup> This was a large study of 8933 participants and tracked them over more than 2 years. However, the study was not designed to provide any cause-specific mortality rates. Another included study from Roy et al demonstrated that for street youth the standardized mortality ratio is much higher

(11.67; 5% CI: 5.56–21.55) compared to the general youth population of Montreal.<sup>31</sup>

This was a small study with only ten participants, limiting its power.

A Finnish study demonstrated the increased mortality associated with homelessness as well. Over a 10-year period, 45% of homeless individuals died, whereas only 10.5% died in a control group. External causes (such as trauma) were responsible for 34% of the deaths. Medical causes showed a HR of 3.6 (95% CI 2.9 to 4.6)<sup>36</sup>, as compared to the normal population.

Salit et al collected 18,864 Hospital discharge records of homeless individuals in NY and showed that homeless use health care more frequently, often through the emergency department, and are admitted up to 5 times more frequently as compared to the general populace.<sup>33</sup> This article cited difficulties in discharge due to a court order in 1991, which required that all psychiatric patients be placed in supportive housing. This could have resulted in increasing apparent costs while waiting for these beds to become available. A study of 156 Homeless individuals in Toronto found that they fill prescriptions less frequently. Twelve percent of those surveyed at two Canadian shelters stated that they did not fill their prescriptions.<sup>15</sup> This compares to the national rate where 8.3% of Canadians over 55 don't fill prescriptions.<sup>35</sup>

Cathy Crowe and Kathy Hardill, two nurses from Toronto, interviewed 458 Homeless individuals in 1991 and 1992 and found that homeless individuals are afflicted by many common medical conditions at a greater rate than the general population; there was a 4 times greater prevalence of emphysema and chronic bronchitis. They found that epilepsy was 6 times more prevalent. They also noted that 40% of participants had been

assaulted in the past year.<sup>7</sup> Unfortunately, there were no p values or confidence intervals provided. This study utilized self-report rather than an objective measure such as health care records. This could have led to over reporting of illnesses that were not properly understood, for instance if syncope was thought to be a seizure.

Diabetic control is difficult among individuals with a stable environment but even more so amongst people who lack a regular nighttime shelter.<sup>14</sup> In 2001, a survey regarding the difficulty managing diabetes while homeless was conducted in Toronto. Individuals from 18 different shelters were surveyed. Participants were either approached randomly or identified by shelter staff and were then interviewed face to face, followed by A1C testing. The survey found that 44% of individuals tested had inadequate glycemic control according to A1C. Seventy two percent of individuals who participated cited difficulties in controlling their blood sugar due to their housing status, 64% stated lack of dietary choice and 18% reported difficulty regarding the scheduling and logistics of insulin dosing (Figure 5). This differs in comparison to the general population, where 56% report difficulty adhering.<sup>6</sup> Some limits of this study included selection bias; these individuals were all in shelters, with many of them having healthcare providers on staff which could have resulted in an underestimation of homeless individuals with difficulty managing diabetes. Also individuals with undiagnosed diabetes were not included, which could result in further underestimation of individuals with uncontrolled diabetes.<sup>14</sup>

**Figure 5 “Barriers to Appropriate Diabetes Management Among Homeless People in Toronto” (adapted from Barriers to Appropriate Diabetes Management Among Homeless people in Toronto, 2000)<sup>14</sup>**

**Table 3: Categories of difficulties with diabetes management described by study participants**

Category	Examples of difficulties	No. (and %) of subjects*
Diet	Inappropriate diet at shelters; inability to make dietary choices	32 (64)
Scheduling and logistics	Inability to obtain insulin and diabetic supplies when needed; inability to coordinate medications with meals	9 (18)
Stress	Belief that daily stresses of being homeless exacerbate diabetes	4 (8)
Insulin syringes and needles	Fear of theft of syringes and needles; shelter forbids possession of needles	3 (6)
Alcohol abuse	Failure to adhere to diabetic regimen when drinking	2 (4)
Competing priorities	More concerned about obtaining shelter than about caring for diabetes	2 (4)
Exercise	Difficulty exercising	2 (4)
Obtaining medications	Lack of prescription drug benefits	2 (4)
No difficulties reported	—	14 (28)

\*Sum of percentages is greater than 100 because each comment could be counted under more than one category.

Homelessness has a high association with morbidity and mortality and it also causes difficulty controlling chronic health conditions such as diabetes. One social worker from the state of Nevada Health and Human services stated there is not enough evidence demonstrating improvement of chronic medical conditions in homeless individuals who have been housed.<sup>5</sup> However, there has been evidence that improvements or renovations of housing results in the improvement of some medical conditions, such as asthma<sup>37</sup>. This improvement in asthma symptom was demonstrated in the Watcomb Housing Study in 2006, which compared a composite adult asthma symptom score before and after heating and ventilation improvements by the Mann–Whitney test ( $p=0.007$ ).<sup>3</sup>

Another study showed improvement in mental health as a result of housing. GJ Mchugo et al conducted a randomized control trial comparing Integrated Housing System

(IHS) (utilizing an integrated team of mental health workers and housing management) to Parallel Housing System (PHS) (distinct mental health workers and housing managers). The study recruited 121 individuals with severe mental health issues who were either homeless or at risk to become homeless. They compared several metrics, including the Colorado Symptom Index, a questionnaire used to evaluate mental health symptoms. Both PHS & HIS demonstrated a decrease in Colorado Symptom Index scores from the beginning of study to 18 months later -- 22.2 and 23.9 to 18.7 and 14.6 respectively.<sup>22</sup> There were no p values or confidence intervals provided and the method of intervention was not stated, which makes these results potentially less actionable. There is also some natural fluctuation in mental health symptom, which could cause an overestimation in symptom reduction if individuals are selected at the nadir of their symptoms.

Homelessness is a risk factor for some diseases and creates impediments to the proper management of others. It has been shown that housing reduces the cost of homelessness (through decreasing service utilization) and improves the mental health and happiness of individuals, as demonstrated by McHugo et al and the Massachusetts Home and Healthy for Good survey.<sup>21,22</sup> However, it remains to be proven whether housing will also improve the management of chronic disease. Diabetes does not affect the homeless population in any greater proportion than the regular population, however, the lack of a structured environment in homelessness makes management more difficult. Thus, study on the effect of public housing on glycemic control is prudent.

## **METHODS**

### **Study design**

This will be a longitudinal cohort study, which will utilize groups of homeless individuals waiting to undergo housing or who are recently housed. These individuals must also have either type one or two diabetes. Upon placement, hemoglobin A1C (the fraction of hemoglobin which is glycosylated) will be measured and then repeated every 3 months. The objective will be to evaluate if the change seen at 1 year is significantly different. An absolute change of 0.5% is clinically significant and so the study will be powered to detect this change.

### **Study population and sampling**

This will be a cohort study with individuals drawn from the greater Boston area utilizing homeless organizations, such as Boston Healthcare for the Homeless, New England Center for Homeless Veterans, Friends of Boston's Homeless, Massachusetts Housing and Shelter Alliance and other organizations who are willing to participate. Individuals must be homeless by the current definition (lacking a fixed regular and adequate nighttime residence) and scheduled to receive housing. Finally, individuals must have uncontrolled diabetes type one or two, defined by an A1C greater than 7%.<sup>2</sup> This will be determined by blood glucose testing upon entry into the study.

Using a paired T test, an absolute decrease in A1C of 0.5%, an alpha value of 0.05, beta value of 0.2, and a standard deviation of 1, the necessary sample size is at least 31 participants. Allowing for a dropout rate of 10%, this number will increase to 36.

Clinical significance of change in A1C is dependent upon A1C at start, however, a 0.5-1% decrease is generally significant in poorly controlled diabetes.<sup>19</sup> Thus, a change of at least 0.5% will be used in this study.

### **Intervention**

The individuals in this study will be provided housing through the standard avenues which are available to them. These include Friends of Boston's Homeless, Boston Healthcare for the Homeless, Boston Family shelter, Boston Housing Authority and others. Hemoglobin A1C will subsequently be recorded at 3-month intervals.

### **Study variables and measures**

The variable which this study will evaluate is the percent of glycosylated hemoglobin A1C of participants. A1C is a portion of hemoglobin separated on cation exchange chromatography. A1C is traditionally measured as the percent of this portion that is glycosylated.<sup>27</sup> The amount of glycosylated hemoglobin varies with the average blood sugar of an individual over a 3-month period. Red blood cells, which contain the hemoglobin being measured, generally have a life span of about 3 months so waiting this long allows for better evaluation of general BGL levels. This should coincide well with the standard of medical care, while blood sugar control is attempting to be achieved.<sup>17</sup>

The effect that a stable housing situation has upon one's ability to make doctor's appointments, obtain and take medications, and control diet are all independent factors and it is the collective effect which this study seeks to analyze. As such, this study will be



designed to simply evaluate the effect of housing upon glycemic control. However, as a secondary analysis the methods which individuals utilize to reach this goal will be recorded by way of survey.

### **Recruitment**

Participants will be recruited from local homeless shelters, as well as through participating organizations. Shelters will be visited in the evening after they open and the investigator will speak with staff and patrons in order to see who is diabetic and who is undergoing housing placement. If, during this period, potential participants become interested in housing, information can be provided to them but no direct effort at placement will be made by the investigator.

Contact will also be made with housing agencies in an effort to allow for smoother integration into the study. If it is reasonable, the study will collaborate with agencies to request consent of eligible individuals as they are housed. There will need to be a surplus of participants recruited due to some anticipated loss due to drop out.

### **Data collection**

A blood test will be performed at the participants home by the investigator who will visit the individual at home in order to obtain the sample with an A1C test kit (which is a smaller more portable way in which to obtain A1C values rather than utilizing a lab). This ensures objectivity. A release will be obtained first for this minor procedure. Methods of BGL maintenance since entry into the study will be obtained via survey upon obtaining A1C. This will include adherence to; diet, exercise plan, medication regimen,

and insulin regimen. This will be self-reported as adherence, non-adherence, or not applicable.

Diet will be defined as following the diet protocol given to them by their primary care provider 7 days a week. The exercise regimen will be defined by the patient's primary care provider and must also be followed seven days out of the week. Medication or insulin must be taken in its prescribed fashion 7 days out the week. Adherence is defined as meeting these criteria, non-adherence is defined as not meeting these criteria. Not applicable means there is no plan regarding this intervention in place from their primary care provider. The survey will cover the past three months or up until the time from the last survey that was taken.

This information will be recorded in a secure spreadsheet on Boston University servers. Private Health Information (PHI) will be stored separately. Method of glycemic control will be published but PHI would not be published.

### **Data analysis**

Individuals who do not complete the full year of housing will not be included in final results. Those who have values at the beginning and end, but not other values, will be included.

Initial values will be collected initially and then subsequently at three-month intervals. These values will be grouped according to time acquired and then a mean and standard deviation established.

The two data sets of chief interest will be the A1C upon entrance to the study and the one after one year. These two data sets will be compared using a paired T test and

evaluated for significance ( $\alpha = .05$ ). The percent of individuals with a change in A1C of 0.5%, will be presented, as well as the average change of A1C.

Methods of control will be documented via a table. The study will present the proportion of individuals that self-report adherence, non-adherence or not applicable to: diet regimen, exercise regimen, medication, and/or insulin regimen.

### **Timeline and resources**

In total, this study will take at least 32 months. One month will be required for IRB review. There will likely be a large lag time between the start of recruitment and completion thereof. This will result in participants being widely staggered between beginning and ending of the intervention. So long as 2-3 participants a month are obtained the minimum number of participants will be obtained by 18 months. One month will be required upon completion in order to analyze data.

The resources required for the study are minimal. The work will be done by a principal investigator finding participants and following up on results acquired by outside individuals and resources. If organizations providing housing are willing and able to aid in recruitment, the amount of effort required will be diminished. The principal investigator will require at least 1-2 days at the end of the month to obtain A1Cs from participants. This will require 36 at home A1C test kits, which will be utilized by the investigator to ensure objectivity. A secure computer will be required for data input and paper for consent forms.

### **Institutional Review Board**

This study will intend to submit an application to the Boston University Medical Campus Institutional Review Board (BUMC IRB). This will be a full board review application because it involves the collection of specimens from human subjects. The specimen will be a blood sample from which will be a derived a hemoglobin A1C value. These values will be compared following study protocol.

## **CONCLUSION**

### **Discussion**

The study may be limited by its geographic locale. Boston is a city which has several large healthcare institutions and, as such, may be different in its accessibility to healthcare as compared to some places. Also, there is currently public policy in Boston, which seeks to actively house its homeless population. These combined effects may result in individuals receiving more medical and social support than would be present in some areas. This could reduce its generalizability, as participants would fare better in Boston than other areas without the same volume of services.

A change in policy, which results in less housing of the homeless could affect the time required for this study or even its completion. There is always the possibility that no significant change will be found but even this is helpful in steering future policy towards providing more medical support. There may always be unforeseen complications as well.

This study is strong due to the direct comparison of objective values with little room for interpretation. Obtaining at home at home A1C values by the investigator will ensure values are objective and obtained regularly. It will also allow us to see the methods utilized for glycemic control. This cohort can also be utilized in the future.

### **Summary**

Homelessness has several deleterious effects on an individual's well-being. These individuals become ill more, spend an increased amount of time in the hospital, and have

a higher risk for mortality than the general populace. They also have a difficult time managing many chronic medical conditions, such as diabetes.

Diabetes is a prominent and difficult to control illness, which requires several interventions to properly manage. Being homeless results in increased difficulty managing the illness. It is a costly disease and adequate control has been shown to decrease these costs. <sup>9</sup>

Housing has been shown to result in less usage of major services and fewer days in the hospital leading to overall cost savings. The Obama administration sought to end homelessness in the United States, which has resulted in an increased number of individuals utilizing public housing.

Ensuring that housing is improving the health of these formerly homeless individuals will improve their well-being and prevent cost. Glycemic control is an important place to start because proper management of diabetes prevents many ailments in the future. Measuring the effect of this intervention on an individual's management of their diabetes is an important factor in steering our decision making as we move forward.

### **Clinical and/or public health significance**

This thesis has shown that homelessness is costly to our society and results in medical complications due to chronic disease for those who are homeless. Housing is a cost-effective approach to homelessness which is being used more frequently. Housing's effect on cost of chronic disease management has not been studied, specifically its effect upon diabetes. It has been demonstrated that diabetes is a costly, an estimated 245 billion

dollars in the US annually,<sup>9</sup> and debilitating disease which is difficult to control and that this difficulty is only compounded by being homeless. However, with proper control diabetes costs can be reduced.

This study will demonstrate whether housing improves glycemic control in homeless individuals with uncontrolled diabetes who have been housed. By ensuring these individuals have proper control of diabetes, we can reduce medical expenses, including the costly long-term complications of diabetes. These complications include retinopathy, kidney disease, and amputation. This will result in more available hospital beds, fewer emergency room visits, as well as increased health of these individuals. Healthier individuals will be better able to rejoin our workforce.

It is important to discern whether housing alone is effective in maintaining glycemic control so that we can alter our approach towards diabetic homeless individuals being housed if it is not. Discerning the effect of housing on glycemic control allows for cost effective approaches to diabetes care in the future. Also understanding the means utilized by the recently housed to achieve glycemic control informs us as to which approaches are likely to be utilized. Ensuring proper glycemic control in those homeless individuals who have been housed is important in increasing the cost effectiveness of public housing and the success of those housed.

## **LIST OF JOURNAL/RESOURCE ABBREVIATIONS**

AHAR	American Homelessness Assessment Report
NEJM	New England Journal of Medicine
BMJ	BMJ: British Medical Journal
WHO	World Health Organization



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## CURRICULUM VITAE

