The Emerging Crisis of Aged Homelessness: Could Proposed Housing Solutions Be Funded from Avoidance of Excess Hospital and Nursing Home Costs?

BOSTON TECHNICAL REPORT

Thomas Byrne, Ph.D.; Daniel P. Miller, Ph.D.; Jae Quinn, MSW
Boston University

January 2019

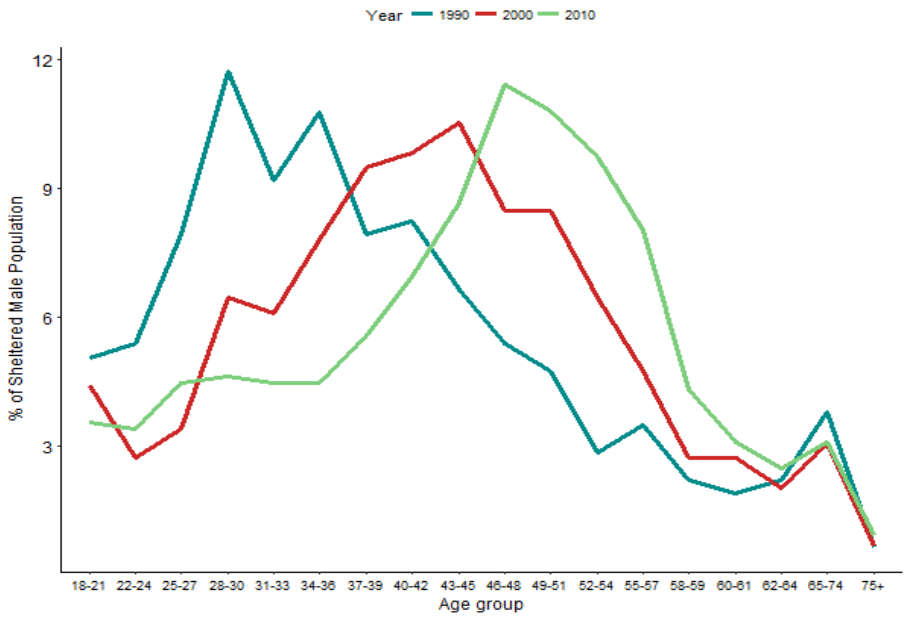
1. INTRODUCTION

This report is intended to accompany a report entitled *The Emerging Crisis of Aged Homelessness: Could Proposed Housing Solutions Be Funded from Avoidance of Excess Hospital and Nursing Home Costs?*, which reports on findings from a multi-site study involving the analysis of data from Boston, Los Angeles and New York City. That report is motivated by recent evidence documenting a cohort effect in the single adult homeless population, wherein persons born between 1955 and 1964 have faced a disproportionate risk of homelessness over the past two decades.[1] This cohort effect has driven substantial recent increases in the size of the older adult homeless population.[2] Persons in this cohort are now between the ages of 49 and 60, and an estimated 43**%** of the single adult homeless population in Massachusetts is currently age 49 or older, compared to only 22% in 1990 (see Figure 1). The existence of this cohort effect means that there is likely to be substantial growth over the next decade in the number of older adults experiencing homelessness both locally in Massachusetts and nationwide.

The aim of this technical report is to provide additional details about the data, methodology and results for the Boston-specific information summarized in the larger multi-site report. In this report, we first describe the data sources used in the Boston analysis and then report how these data were used to address the following aims, which broadly parallel those of the larger report:

1) To forecast the expected future trajectory in the size and age composition of the older homeless adult population
2) To model the expected health care and emergency shelter costs associated with growth in the size of the older homeless adult population;
3) To model the potential health care and emergency shelter cost offsets associated with policy interventions that would target a range of expanded housing options to this population.

Figure 1- Age Distribution of Sheltered Male Homeless Population in Massachusetts



Source: U.S. Census Bureau 1990, 2000, 2010 Decennial Census Special Tabulation

2. DATA

This study relies primarily on administrative data from two sources: Homelessness Management Information Systems (HMIS) data from the City of Boston and claims data provided by MassHealth, the Massachusetts Medicaid program. HMIS data are client-level data that allow for the tracking of utilization of the single adult emergency shelter system in the City of Boston by individuals over time. From these HMIS data, we identified a cohort of 4,804 individuals who spent at least one night in emergency shelter at some point between 2009 and 2015 and who were age 55 and older the time of their shelter stay. Only individuals with valid Social Security numbers were included in this cohort as this information was needed to link HMIS records with MassHealth claims data.

Table 1- Summary of Study Sample and Data Sources

Description	N (% of sample)	Data source used
Emergency shelter users age 55 and above (2009-2015)	4,804 (100%)	HMIS records
Emergency shelter users age 55 and above (2009-2015) with matching MassHealth record	4,333 (90.2%)	HMIS records & MassHealth claims
Emergency shelter users age 55 and above (2009-2015) with matching MassHealth record and at least one claim between 2009-2015	4,000 (83.3%)	HMIS records & MassHealth claims

The HMIS records for those in the study cohort were provided to MassHealth, which used deterministic matching based on Social Security number to link HMIS data with MassHealth claims data. A total of 4,333 (90.2%) of individuals in the study sample had a matching MassHealth record, and 4,000 (83.3%) had at least one claim during the period from January 1, 2009 to December 31, 2015. MassHealth provided all fee-for-service and managed care encounter claims data for this time period for all 4,000 of these individuals, who comprised the main analytic sample for this study. Table 2 presents a summary of the characteristics of these 4,000 individuals.

Table 2- Sample Characteristics

	N(%)
N	4,000 (100%)
Sex	
Female	930 (23.2%)
Male	3,052 (76.3%)
Other	18 (0.4%)
Age[1] (mean)	58.6
Age group	
47-50	194 (4.8%)
51-55	1,105 (27.6%)
56-60	1,530 (38.2%)
61-65	705 (17.6%)
66-70	268 (6.7%)
71-75	126 (3.1%)

76-80	56 (1.4%)
81+	16 (0.4%)
Ethnicity	
Hispanic / Latino	540 (13.5%)
Non-Hispanic / Non-Latino	3,362 (84.0%)
Unknown/Missing	98 (2.4%)
Race	
White	1,984 (49.6%)
Black	1,597 (39.9%)
Other/Missing	419 (10.5%)
Veteran status	
No	2,861 (71.5%)
Yes	549 (13.7%)
Unknown/Missing	590 (14.8%)
Number of nights in shelter[2] (mean)	218.5
Number of nights in shelter[2] (median)	67.0
Number of shelter episodes[2] (mean)	2.8
Number of shelter episodes[2] (median)	2.0

Note: All demographic characteristics are based on information in HMIS records
1- Age calculated as age on January 1, 2009;
2-Calculated over period from 2009-2015

The fee-for-service and managed care encounter claims data provided by MassHealth included information on the dates of service, claim type, provider code and total amount paid for all claims. The resulting linked dataset provides information about the history of shelter and health care services utilization among members of the study cohort. We constructed a measure of total health care costs over the observation period for all members of the study cohort based on the amount paid reported in the claims data. We converted all costs to 2015 dollars using the U.S. Bureau of Economic Analysis Personal Consumption Expenditures index.[3] In addition to creating a total health care cost measure, we used claim type and provider type codes available in the MassHealth claims to stratify health care costs into the following categories: 1)Inpatient behavioral health; 2) Inpatient medical; 3) Outpatient behavioral health; 4) Outpatient medical; 5) Nursing facilities; 6) Long-term services and supports (LTSS) other than nursing facilities; 7) Pharmacy; 8) Other.

2.1 Data Limitations

There are two key limitations to our data that bear mentioning. First, homelessness is a difficult phenomenon to accurately measure. The HMIS data we used in the present study provided information about individuals' utilization of emergency shelter, and they have been widely used in prior research. However, a key limitation of HMIS data is that they do not capture unsheltered homelessness (e.g. individuals sleeping on the street, public places, or places not meant for human habitation), and therefore cannot fully measure individuals' homeless experiences. We thus may fail to fully capture the unsheltered population in our analysis and population/cost projections.

Second, our analysis of health care utilization is limited only to those claims that were paid for directly by MassHealth or by a MassHealth managed care organization. We were not able to capture health care utilization and costs that may have been reimbursed by other payers. Given that the focus of this analysis is on older adults, the key missing payer is Medicare, and the inability to capture services reimbursed by Medicare represents an important limitation of this study. However, some members of the study cohort are also likely to have been covered by private insurance and/or accessed care through the Veterans Health Administration. Thus, our estimates are perhaps best interrupted as representing a lower bound estimate of the overall health care costs incurred by members of the study cohort.

3. FORECASTING THE EXPECTED FUTURE TRAJECTORY IN THE SIZE AND AGE COMPOSITION OF THE OLDER HOMELESS ADULT POPULATION

To forecast expected changes in size of older homeless adult population in Boston, we used the complete HMIS data from the period 2009-2016 to examine changes in the size and age composition of the sheltered population in Boston during this time period. We then used this information to forecast the likely growth in the number of shelter using homeless adults aged 55 and above between 2017 and 2030 using a demographic modelling approach known as the cohort-component approach.[4] Conceptually, the cohort-component approaches involves first using aggregate age stratified data on emergency shelter utilization to examine annual stocks (i.e. those currently or formerly experiencing homelessness) and flows (i.e. those changing status by entering, exiting or re-entering homelessness) to understand changes in the size and age composition of the sheltered population over a study period. In the current context, we used 2009 as our base year to develop initial age-specific estimates of our "stock" of shelter users and then calculated the stock in subsequent years (i.e. 2010-2016) by accounting for the following "flows" into and out of shelter:

1. Continued homeless = Homeless in Year X and Year X-1
2. Newly Homeless = Homeless in Year X, never homeless between Year 1 and Year X-1
3. Reentered homelessness = Homeless in Year X, not homeless in Year X-1, homeless between Year 1 and Year X-2
4. Exited Homelessness = Not homeless in Year X, Homeless in Year X-1

This step provided us with estimates of the age-specific growth rates in the sheltered population from 2009-2016. The next step of the analysis entailed developing a set of forecasts that extended observed trends from 2009-2016 in order to project future shelter population changes from 2017 to 2030. To do so, we developed a model in which we accounted for age effects (i.e. the tendency for shelter use to follow a specific age pattern across the life course, with in this case, persons typically rapidly exiting homelessness in their early 60s) and cohort effects (i.e. the fact that certain birth cohorts have higher rates of homelessness). We use data from 2009 to 2016 to develop smoothed estimates of these age and cohort effects. Because data for this entire time period did not appear to be complete for some of the shelters in the city, we relied on data from one of the largest shelters in the city to estimate these age and cohort effects. This approach assumes that the age and cohort effects in the shelter we used are the same as those observed in other shelters in the city, which we feel is a highly plausible assumption.

We then forecast age-specific estimates of the number of persons using shelter from 2017-2030 by starting with the actual observed number of persons using shelter in 2016 and applying our age and cohort effect estimates to increment the population forecasts for each year from 2017 to 2030. Since, as noted above, our forecast model was developed based on data from a single shelter, we extrapolated both the actual observed number of persons using shelter in 2016 and the forecasts from our single shelter to the entire shelter system in Boston. To do so, we applied an extrapolation factor to our 2016 observed and 2017-2030 forecasted counts. This extrapolation factor was created first by obtaining estimates of the total number of individuals using emergency shelter in Boston each year from 2010 to 2016 from publicly available local Annual Homeless Assessment Reports. Next, we calculated the proportion of these totals accounted for in each of these years by the shelter used in our models. The inverse of this proportion then served as the extrapolation factor we used to adjust our forecasts upward to represent the entire shelter system in Boston. This resulted in population-level projections of the size and age composition of the sheltered homeless population in Boston from 2017-2030. These projections were conducted in 2017. As such, data from 2017 and 2018 were not available to validate our projections against actual observed shelter utilization during these time years; however, such an analysis remains a possibility in the future.

Figures 2 and 3 show the results of the population projections. Overall, these results illustrate substantial projected growth in the number of older adults who will use shelter at some point over the course of a year. Figure 2 shows the dramatic expected aggregate growth in the homeless population aged 60+ throughout the period, with the most substantial growth concentrated at older ages. Indeed, the number of shelter users aged 70 and above in Boston is projected to increase by roughly 320% between 2016 and 2030 (from about 200 to about 850), and the number of persons aged 65-69 who use shelter at some point during the course of a year expected to increase by about 170% (from 300 to about 800) over that same time period.

Figure 3 shows the projected size of the 55+ and 65+ sheltered older homeless adult populations in Boston for the years 2009 to 2030. The data from 2017 forward reflect the continuation of existing trends. The overall number of individuals aged 55 and above using shelter in Boston is projected to increase by 45% from 2017 to 2029 (from 2,345 to 3,395). However, the figure also shows a gradual slowing and levelling out in the growth of the number of shelter users aged 55 and above as the largest age cohort of homeless adults passes fully through the age distribution. Indeed, though difficult to observe in the Figure, the number shelter users aged 55 and above in Boston is projected to decrease in 2029. On the other hand, the number of individuals aged 65 and above using shelter in Boston is expected to grow by about 230% (from about 500 to about 1660) between 2017 and 2030 at a steady rate, with this growth still continuing in 2030 at roughly the same rate.

Figure 2-Change in Sheltered Single Adult Homeless Population in Boston age 50+, Smoothed Historical and Forecast

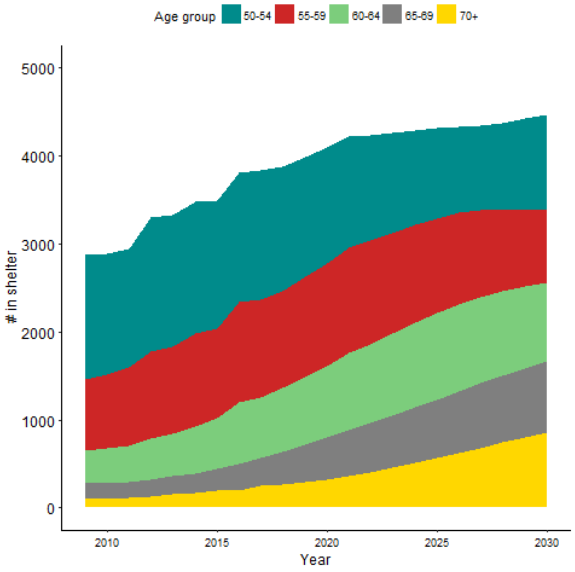
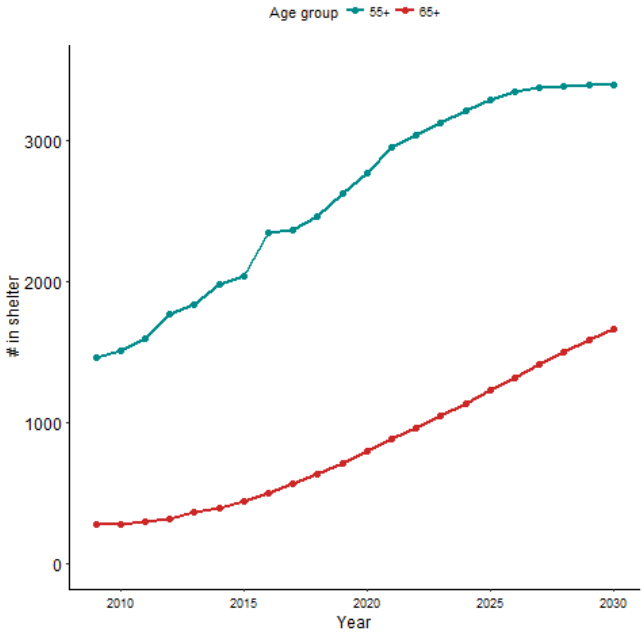


Figure 3—Projected Trends in Sheltered Population Aged 55+ and 65+ in Boston, 2009-2030



4. MODELING THE EXPECTED HEALTH CARE AND EMERGENCY SHELTER COSTS ASSOCIATED WITH GROWTH IN THE SIZE OF THE OLDER HOMELESS ADULT POPULATION

We modeled the expected growth in health care and shelter costs among older homeless adults by applying age-specific annual per person health care and shelter costs to our population projection estimates. Specifically, we used the following formula to develop these estimates:

$$Total\ Cost_{itk} = Pop_{it} * AvgCost_{k}$$

Where $Total\ Cost_{itk}$ is equal to the total cost for all individuals in age group *i*, in year *t*, for service cost type (e.g. inpatient medical, outpatient behavioral health, emergency shelter) *k*; Pop_{it} is equal to the forecasted total size of the shelter using population in age group *i* in year *t;* and $AvgCost_k$ is the average annual per person cost for service cost *k*.

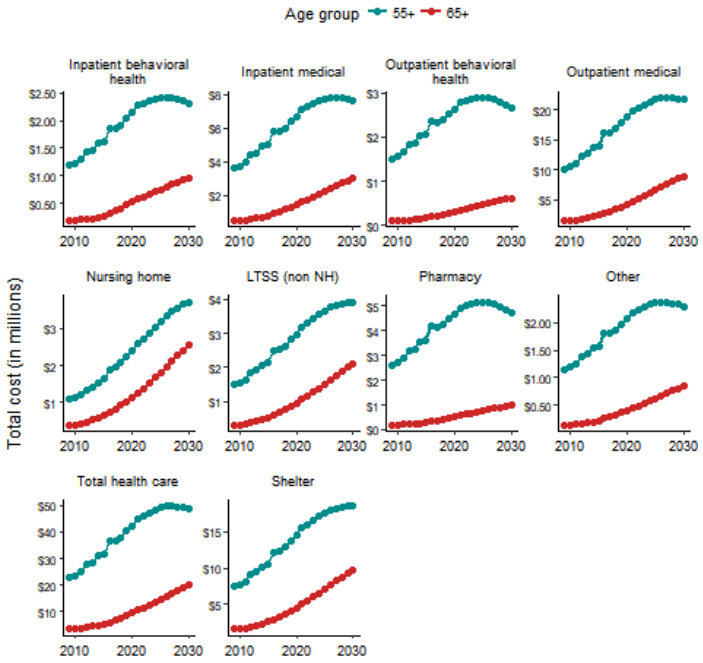
We used our linked administrative dataset to derive estimates of the *AvgCost* parameter. Specifically, we used MassHealth claims data to estimate average annual per person health care costs among members of our study cohort in years during which they spent at least one night in emergency shelter. We calculated these average costs separately for persons in each of the following age brackets: 55 to 59, 60 to 64, 65 to 69 and 70 plus. We likewise calculated the average number of nights in shelter for persons in each of these age groups, and multiplied this figure by an estimated nightly shelter cost. Table 3 presents the resulting age-group specific annual per person health care and emergency shelter cost estimates.

Table 3--Age Group Specific Annual Per Person Health Care and Emergency Shelter Cost Estimates

	Age Group			
	55-59	60-64	65-69	70+
Cost type				
Inpatient behavioral health	$934	$648	$984	$190
Inpatient medical	$2,543	$2,799	$1,926	$1,694
LTSS (non-NH)	$932	$1,155	$919	$1,603
Nursing home	$467	$896	$983	$2,045
Other	$849	$841	$512	$501
Outpatient behavioral health	$1,193	$1,162	$439	$313
Outpatient medical	$7,137	$7,628	$5,134	$5,555
Pharmacy	$1,892	$2,403	$876	$326
Total health care	$15,948	$17,533	$11,773	$12,228
Shelter days (mean)	87 @ $58/day	82 @ $58/day	94 @ $58/day	108 @$58/day

Figure 4 summarizes the projected total health care and shelter costs among older shelter users in Boston between 2016 and 2030. The figure shows that in 2016, users of emergency shelter in Boston who were age 55 or older were estimated to have incurred a total of $36.5 million in health care costs and $12.1 million in emergency shelter costs. These figures are projected to increase to $49.2 million and $17.6 million, respectively, or a combined total of about $66.8 million in 2025. By 2030, as the total number of shelter users in this age bracket begins to decline and gets older, total health care costs for this age group ($48.9 million) will also begin to decline. However, shelter costs will increase slightly to $18.5 million, due to the relatively longer shelter stays experienced by persons aged 65 and above, who will constitute a relatively greater share of all shelter users age 55 and above in 2030. In addition, the figure illustrates that cost trends are projected to differ by type of cost. Of particular note, while inpatient medical, outpatient behavioral health, outpatient medical, pharmacy and other types of costs among persons aged 55+ will rise before peaking in the mid-2020s and starting to decline, nursing home and other LTSS costs for shelter users age 55+ continue to increase over this time period, driven by higher average costs among relatively older shelter users.

Figure 4—Projected Trends in Health Care and Shelter Costs Among Sheltered Population Aged 55+ and 65+ in Boston, 2009-2030



Note: Y-axes on figures differ to illustrate trends.

5. MODELING THE POTENTIAL HEALTH CARE AND EMERGENCY SHELTER COST OFFSETS ASSOCIATED WITH POLICY INTERVENTIONS THAT WOULD TARGET A RANGE OF EXPANDED HOUSING OPTIONS TO THIS POPULATION.

Analysis to model potential cost offsets proceeded in three phases. First, we applied a statistical technique known as cluster analysis to the linked HMIS and MassHealth claims data to identify several distinct sub-groups of older homeless adults based on the complexity of their health conditions and their pattern of emergency shelter utilization. In the second phase, we matched each of the identified cluster groups with a specific housing intervention best calibrated to their level of housing and health care need, based on conceptual fit and input from a panel of experts. In the third and final phase, we attempted to estimate the likely impact on the projected future health care and emergency shelter costs of providing these housing interventions at scale to all older homeless adults in Boston.

5.1 Identifying distinct sub-groups of older homeless adults

We applied a statistical technique known as cluster analysis to the linked HMIS and MassHealth claims data to identify several distinct sub-groups of older homeless adults based on the complexity of their health conditions and their pattern of emergency shelter utilization. We did this in recognition of the fact that older adults experiencing homelessness are a heterogeneous population with respect to their housing, health care, social and other needs,[5,6] and thus are likely to require different housing interventions in order to obtain housing stability and promote health.

Specifically, we first identified all 1,904 members of our study cohort who spent at least one night in shelter over the period from 2010-2012. We focused on 2010-2012 in identifying these clusters so that, as detailed below, they could be validated using independent data from a period that was not used in generating the clusters themselves. We used diagnosis codes available in the MassHealth claims data for the period from 2010-2012 to assign all individuals in this group with a medical comorbidity score using the algorithm developed by Gagne and colleagues.[7] In addition to this comorbidity score, we also calculated the number of emergency shelter episodes and days in emergency shelter for the period from 2010-2012 for all 1,904 members of the study cohort used in the cluster analysis. The medical comorbidity score, number of emergency shelter episodes, and shelter days then served as the basis for conducting *k*-means cluster analysis to identify distinct sub-groups based on health conditions and shelter use. We tested 3, 4, 5 and 6 cluster solutions and found the 5-cluster solution to be the best from a conceptual point of view.

After identifying the preferred cluster solution, we then sought to validate them by conducting post-hoc comparisons of the average annual health care costs among members in each cluster over the period from 2010-2012 as well as the proportion in each group that experienced a nursing home stay during this time period. As these variables were measured during the same time period as those used in constructing the clusters and thus might be confounded with cluster membership, we also validated these clusters by conducting comparisons of the number of shelter days/episodes, total annual health care costs, and proportion of cluster members with a nursing home stay using data from the period from 2013-2015. In other words, we sought to address whether patterns of shelter use and health care costs observed during 2010-2012 for members of this group were predictive of their future shelter and health care costs as a way of confirming that our cluster groupings were actually capturing individuals with different housing and health care needs. For all cluster solutions we tested, the number of shelter days/episodes, health care costs and nursing home use measures for the period from 2010-2012 for each cluster were highly similar to their corresponding values for 2013-2015, suggesting a high degree of validity to the cluster solution obtained from the 2010-2012 data. Table 4 summarizes the results of the cluster analysis and post-hoc comparisons.

Table 4-Results of *k*-means cluster analysis

Cluster	N	% of cohort	Clustering variables			Validation Variables	
			Comorbidity score (mean)	Days in shelter (mean)	Shelter episodes (mean)	Annual health care costs (mean)	Nursing home stay (%)
1	968	51	0.3	60.2	1.5	$6,998	2.4
2	374	20	2.5	52.8	1.6	$23,813	18.2
3	293	15	0.9	150.2	5.3	$12,367	8.9
4	185	10	0.5	665.0	1.3	$8,590	5.9
5	84	4	6.2	85.3	2.2	$47,426	36.9

5.2 Matching sub-groups of older homeless adults to housing interventions

No single housing solution is likely to be suitable for all older adults experiencing homelessness. The cluster groups described above provide some indication of the relative housing and health care needs of this population, and after identifying these groups, we devised a population-level intervention approach

that would address these needs. Specifically, we propose implementing a "progressive engagement" approach that would offer increasingly intensive housing and support interventions based on health care and housing needs. It is important to note that this progressive engagement model is hypothetical; the model we describe does not reflect the current strategy employed by the Coordinated Entry system in the City of Boston These housing interventions and their estimated costs are summarized in Table 5, and described briefly below.

- **Group 1:** Due to their low medical complexity, low cost and limited shelter use, this group would receive a range of lighter-touch interventions. Prior research shows that homelessness is temporary for most single adults, and a non-trivial proportion are able to "self-resolve" their homelessness (i.e. exit shelter without any formal housing intervention). Based on this, we conservatively estimate that 1/3 of Group 1 will self-resolve with receipt of only limited housing advice or service referrals and the remaining 2/3 of Group 1 receiving the following:
    - Rapid rehousing, for those needing relocation grants and time-limited rental assistance (22%). We assume that the average cost per person of providing rapid re-housing to persons in this tier will be $3,872, which is the average cost per household served by the Department of Veterans Affairs' Supportive Services for Veteran Families (SSVF) program.[8]
    - A shallow-rental subsidy, assumed to equal about half the value of a full housing subsidy akin to a Section 8 Housing Choice Voucher (22%). We estimate that the annual cost of the shallow subsidy will be $5,963. This is based on the following assumptions. We assume that a shallow subsidy will be equal to half the full value of a subsidy needed to afford an efficiency/studio (0 bedroom) unit, for which the 2018 HUD Fair Market Rent in Boston was $1,253. We assume that tenants will pay 30% of their income for rent. Using the maximum SSI benefit in MA ($864) as a proxy for income, we assume tenants will contribute $259.20 towards rent, meaning that a full subsidy would be equal to $993.8 per month ($1253 - $259.20) or $11,926 per year. Thus a shallow subsidy is equal to $5,963 ($993.8 X 6).
    - A full rental subsidy, like those available through HUD's Housing Choice Voucher program, in addition to light case management (22%). We estimate that the annual cost of a voucher-level subsidy will be $11,926. This is based on same set of assumptions used to estimate the value of a shallow subsidy.
- **Group 2:** Based on their relatively more complex medical needs and higher costs, we assume that persons in Group 2 would require an intervention known as permanent supportive housing (PSH)—which is includes both a deep, permanent housing subsidy akin to a Section 8 Housing Choice Voucher and ongoing supportive services. We estimate the average annual PSH cost to be $15,707, of which $11,926 is for the full rental subsidy (as described above) and $3,781—the observed annual cost of services used by participants in a prior study examining Massachusetts' Community Support Program for People Experiencing Chronic Homelessness,[9]—is for services.[i]
- **Group 3:** Given their moderate medical complexity and episodic shelter use, a shallow-rental subsidy with light case management, like those provided through Critical Time Intervention, for

[i] Based on the per diem cost of providing services through the Community Support Program for People Experiencing Chronic Homelessness, the actual annual cost of providing such supportive services through the program is roughly $6,300. In this analysis, we use $3,781 because, in a prior analysis this is the actual average amount of services used on an annual basis by study participants, likely due in part to program turnover.

those moving in with a partner, friend or family member and who need minimal financial and social service support. We estimate the average annual cost of this intervention to be $7,463--$5,963 for the shallow subsidy (as described above) and $1,500 for services. We assume $1,500 for services because we anticipate that provision of such services will be time-limited and last for approximately three to nine months, depending on the client. Our estimate $1,500 is a rough estimate of what we expect to be the average cost of providing these time-limited services.

- **Group 4:** Based on their more intensive use of emergency shelter that would likely mean people in this group meet the official federal criteria for chronic homelessness, we assume that persons in this group will require also require PSH, at an estimated annual cost of $15,707
- **Group 5:** Based on their very intensive medical complexity, we assume that persons in this group will require PSH, with more intensive supportive services. We thus assume that the average annual cost of this intervention to be $19,488--$11,926 for the full rental subsidy and $7,526 for services (double the service cost for the traditional PSH model described above).

Table 5 –Summary of Distinct Sub-Groups among Older Homeless Adults in Boston

Group	% of cohort	Intervention	Cost
1	51	1. Self-resolve with housing advice/service referrals only (33%) 2. Rapid re-housing (22%) 3. Shallow rental subsidy (22%) 4. Full rental subsidy (22%)	1. $0 2. $3,872 3. $5,963 4. $11,926
2	20	Permanent Supportive Housing	$15,707
3	15	Shallow subsidy + light case management	$7,463
4	10	Permanent Supportive Housing	$15,707
5	4	Permanent supportive housing with more intensive services	$19,488

5.3 Estimating the likely impact on the projected future health care and emergency shelter costs of providing these housing interventions at scale to all older homeless adults in Boston

We attempted to estimate the likely impact on projected future health care and emergency shelter costs of providing the housing interventions described above at scale to all older homeless adults in Boston. To do this, we sought to mirror the conceptual approach of a meta-analysis, which is a statistical procedure for combining data from multiple studies that have examined the impact of the same intervention to arrive at an overall estimate of the effect of that intervention. In the present context, we aggregated information from 15 previously published studies that have examined the impact of permanent supportive housing interventions for persons experiencing homelessness on health care and emergency shelter utilization and costs. These 15 studies varied in terms of their methodological rigor, the locations in which they were conducted, the populations and specific interventions that they considered and the type of health care costs that they considered. For example, some studies focused specifically on individuals experiencing homelessness who have a serious mental

illness, whereas others focused on homeless individuals with serious alcohol disorders and yet others included persons with homeless individuals with complex medical problems. Likewise, the design of these studies varied, from the "gold standard" of an experimental study with randomly assigned treatment and control groups to less rigorous pre/post analysis with no comparison group. The variation in the design, populations, locations and costs considered contributed to variation in the results of these studies with respect to whether and by how much they found housing interventions were able to reduce health care costs for participants. To account for this variation, we used information from these 15 studies to develop three different scenarios representing a range of potential reductions to health care and shelter costs that might be expected, as described in more detail below.

We sought to extract information from each of these 15 studies about the percent change in health care and shelter utilization and costs associated with permanent supportive housing. In some cases, this information was reported directly in the studies themselves. In other cases, we calculated these changes based on information reported in the study. We extracted this information separately for each category (e.g. mental health, substance abuse) and/or type (e.g. inpatient, outpatient, emergency department) of cost reported in the study, and only included service categories/types for which we could calculate (or derive an approximate estimate of) change in cost or service use based on information reported in the study. Where possible, we extracted information about percent change based on units of service utilization (e.g. number inpatient hospitalization days, number outpatient visits), rather than cost, so as to account for potential variation in health care costs across regions/countries and time. Finally, we assigned each study with a weight based on its methodological rigor. Studies using an experimental design were assigned a 3; those involving a quasi-experimental design with a comparison group were assigned a 2; and those involving a quasi-experimental design with a single group pre/post comparison were assigned a 1. These weights were subsequently used in developing pooled estimates of the relationship between housing placement and health care costs under the different scenarios. Table A1 summarizes the 15 studies that were used in developing our cost reduction scenarios.

After extracting the information described above from each of the 15 studies, we then combined information from across all studies to develop pooled estimates of potential cost reductions associated with housing placement for two different scenarios, which are described below:

- **Scenario 1 (More conservative):** Scenario 1 is considered more conservative in terms of its estimates of health care cost reductions. It was constructed by calculating a weighted average of the percentage change in health care utilization/costs associated with housing placement observed in all prior studies that we considered, including those that did not identify a statistically significant change and those that identified statistically significant increases in utilization/costs. In calculating this average, studies that did not identify a significant change were assigned a "0" and a studies were weighted based on their methodological rigor score.

- **Scenario 2 (Less conservative):** Scenario 2 is considered less conservative in terms of its estimates of health care cost reductions. It was constructed by calculating a weighted average of the percentage change in health care utilization/costs associated with housing placement that were observed in all studies that identified a significant reduction in health care costs. In

other words, this Scenario represents cost reductions that might be expected should the implementation of the housing interventions described above have an effect more in line with what studies identifying relatively larger impacts have found. Once again, in calculating this average, studies were weighted such that studies with stronger methodological rigor had larger weight.

- **Scenario 3 (CSPECH scenario):** Scenario 3 is based on a recent study that examined the impact of the CSPECH program in Massachusetts on health care costs. The analysis uses the percentage change in health care costs that were observed in the difference-in-difference analysis conducted as part of that study. An advantage of this scenario is that it used identical cost categories as the present study, making it easier to directly translate study findings into potential future cost reductions

As prior studies have consistently identified a large effect of housing interventions for persons experiencing homelessness on emergency shelter utilization and costs, we assumed that reductions in emergency shelter costs would be consistent across all three cost reduction scenarios. To derive the estimated reduction in shelter costs, we calculated the pooled average across all studies that reported information on shelter costs. Table 6 summarizes the proportionate offsets by service type and scenario.

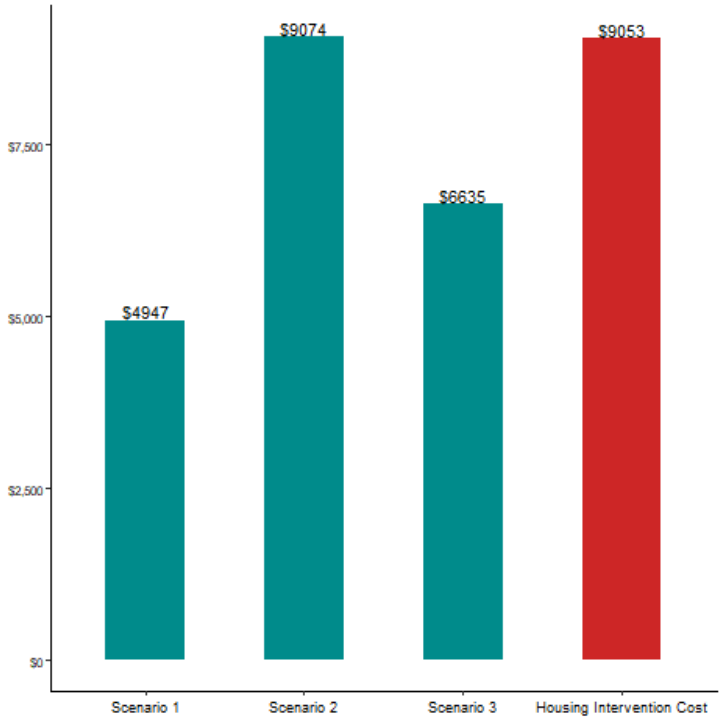
Table 6- Summary of Health Care and Shelter Cost Reduction Scenarios

Cost Category	Scenario 1 (more conservative)	Scenario 2 (less conservative)	Scenario 3 (recent MA study)
Inpatient medical	-18%	-33%	-22%
Inpatient behavioral health	-35%	-56%	-56%
Outpatient medical	-6%	-45%	-19%
Outpatient behavioral health	+48%	-29%	-29%
Nursing home	-42%	-90%	-42%
LTSS (non-NH)	+9%	0%	0%
Pharmacy	0%	0%	0%
Other	0%	0%	0%
Shelter	-71%	-71%	-71%

Figure 5 summarizes the results of the cost reduction scenarios. The figure averages the combined per person housing and shelter cost offsets averaged across all years from 2018 to 2030 under each of the three cost reduction scenarios. In other words, the cost offset estimates show what the average annual per person cost reduction would be in any given year between 2018 and 2030 were the progressive engagement approach for providing housing interventions to different sub-groups of older homeless adults that we described in Section 5.2 to be implemented. Likewise, the estimated annual housing intervention cost of $9,053 shown in the figure represents the annual cost of implementing this progressive engagement approach averaged across all years from 2018 to 2030. Put differently, the $9,053 is essentially a weighted average of the housing intervention costs for each of the five cluster groups shown in Table 5 across all years from 2018 to 2030, with the relative size of each of the cluster groups serving as the weight.

Comparing the estimated cost offsets under each scenario with the average cost of housing interventions provides an estimate of the net cost of implementing the housing intervention approach described in Section 5.2 at-scale for older homeless. As the figure shows, under the Scenario 1—the more conservative scenario—the result is a very modest cost savings of about $20 per person per year. Under Scenario 2—the more conservative scenario—the net cost of the housing intervention is about $4,100 per person. In other words, the expected per person shelter and health care cost offset of $4,947 under this scenario are enough to offset about 55% of the housing intervention cost. Under Scenario 3, the net cost of the housing intervention is about $2,418. Put differently, the estimated shelter and health care cost offset of $6,635 under this scenario is enough to offset 73% of the housing intervention cost. It is important to note again, that these cost offset estimates do not include Medicare spending. As such, they should be interpreted as representing lower bound estimates of actual health care cost offsets. Likewise, the corresponding net cost estimates represent lower bound estimates of the net costs of providing the housing interventions described above at-scale.

Figure 5—Cost Offset and Housing Intervention Costs, Average Per Person Per Year 2018-2030



REFERENCES

1. Culhane DP, Metraux S, Byrne T, Stino M, Bainbridge J. The Age Structure of Contemporary Homelessness: Evidence and Implications For Public Policy. *Anal Soc Issues Public Policy*. 2013;13(1):228-244. doi:10.1111/asap.12004.

2. U.S. Department of Housing and Urban Development. *The 2015 Annual Homeless Assesment Report to Congress: Part 2-Estimates of Homelessness in the U.S.* Washington, D.C.; 2016.

3. U.S. Department of Commerce Bureau of Economic Analysis. Consumer Spending. http://www.bea.gov/national/consumer_spending.htm. Published 2016. Accessed June 29, 2016.

4. Preston SH, Heuveline P, Guillot M. *Demography : Measuring and Modeling Population Processes*. Malden, MA: Blackwell Publishers; 2000.

5. Brown RT, Goodman L, Guzman D, et al. Pathways to Homelessness among Older Homeless Adults: Results from the HOPE HOME Study. Bayer A, ed. *PLoS One*. 2016;11(5):e0155065. doi:10.1371/journal.pone.0155065.

6. Brown RT, Hemati K, Riley ED, et al. Geriatric Conditions in a Population-Based Sample of Older Homeless Adults. *Gerontologist*. 2017;57(4):757-766. doi:10.1093/geront/gnw011.

7. Gagne JJ, Glynn RJ, Avorn J, Levin R, Schneeweiss S. A combined comorbidity score predicted mortality in elderly patients better than existing scores. *J Clin Epidemiol*. 2011;64(7):749-759. doi:10.1016/J.JCLINEPI.2010.10.004.

8. U.S. Department of Veterans Affairs. *Supportive Services for Veteran Families (SSVF): FY 2016 Annual Report*.; 2017.

9. Byrne T, Smart G. *Estimating Cost Reductions Associated with the Community Support Program for People Experiencing Chronic Homelessness*. Boston, MA; 2017.

REFERENCES FOR STUDIES USED IN DEVELOPING COST REDUCTION SCENARIOS

1. Aubry T, Goering P, Veldhuizen S, et al. A Multiple-City RCT of Housing First With Assertive Community Treatment for Homeless Canadians With Serious Mental Illness. Psychiatr Serv. 2016;67(3):275-281. doi:10.1176/appi.ps.201400587.

2. Basu A, Kee R, Buchanan D, Sadowski LS. Comparative cost analysis of housing and case management program for chronically ill homeless adults compared to usual care. Health Serv Res. 2012;47(1 Pt 2):523-543. doi:10.1111/j.1475-6773.2011.01350.x.

3. Rosenheck R, Kasprow W, Frisman L, et al. Cost-effectiveness of Supported Housing for Homeless Persons With Mental Illness. Arch Gen Psychiatry. 2003;60(9):940. doi:10.1001/archpsyc.60.9.940.

4. Stergiopoulos V, Hwang SW, Gozdzik A, et al. Effect of scattered-site housing using rent supplements and intensive case management on housing stability among homeless adults with mental illness: a randomized trial. JAMA. 2015;313(9):905-915. doi:10.1001/jama.2015.1163.

5. Byrne T, Smart G. Estimating Cost Reductions Associated with the Community Support Program for People Experiencing Chronic Homelessness. Boston, MA; 2017.

6. Culhane DP, Metraux S, Hadley T. Public Service Reductions Associated with Placement of Homeless Persons with Severe Mental Illness in Supportive Housing. Hous Policy Debate. 2002;13(1):107-163.

7. Gilmer T, Manning W, Ettner S. A Cost Analysis of San Diego County's REACH Program for Homeless Persons. Psychiatr Serv. 2009.

8. Larimer ME, Malone DK, Garner MD, et al. Health care and public service use and costs before and after provision of housing for chronically homeless persons with severe alcohol problems. JAMA. 2009;301(13):1349-1357. doi:10.1001/jama.2009.414.

9. Martinez TE, Burt MR. Impact of permanent supportive housing on the use of acute care health services by homeless adults. Psychiatr Serv. 2006;57(7):992-999. doi:10.1176/appi.ps.57.7.992.

10. Seligson A, Levanon S, Lim T, et al. New York/New York III Supportive Housing Evaluation: Interm Utilization and Cost Analysis. New York; 2013.

11. Srebnik D, Connor T, Sylla L. A pilot study of the impact of housing first-supported housing for intensive users of medical hospitalization and sobering services. Am J Public Health. 2013;103(2):316-321. doi:10.2105/AJPH.2012.300867.

12. Hunter SB, Harvey M, Briscombe B, Cefalu M. Evaluation of Housing for Health Permanent Supportive Housing Program. Santa Monica, CA; 2017.

13. Mares AS, Rosenheck RA. Twelve-Month Client Outcomes and Service Use in a Multisite Project for Chronically Homelessness Adults.

14. Thomas LM, Shears JK, Pate MC, Priester MA. Moore Place Permanent Supportive Housing Evaluation Study Final Report. Charlotte, NC

15. Wright BJ, Vartanian KB, Li H-F, Royal N, Matson JK. Formerly Homeless People Had Lower Overall Health Care Expenditures After Moving Into Supportive Housing. Health Aff. 2016;35(1):20-27. doi:10.1377/hlthaff.2015.0393.

APPENDIX

Table A1—Summary of Studies Used in Developing Cost Reduction Scenarios

INPATIENT SERVICE USE								
Study	**Population**	**Design**	**Weight**	**Substance use**	**Mental health/ Psychiatric**	**Physical / Medical**	**Behavioral health**	**Total**
Aubry et al. (2015)[1]	Homeless individuals with mental illness and high needs	Experimental	3		-	-		
Basu et al. (2012)	Homeless individuals with chronic medical conditions	Experimental	3	-68%				-23%
Rosenheck et al. (2003)[a]	Homeless Veterans with mental illness	Experimental	3		NS	NS		NS
Stergiopoulous et al. (2015)[1]	Homeless individuals with mental illness and moderate needs	Experimental	3					NS
Byrne et al. (2017)[a,2]	Chronically homeless individuals	Quasi-experimental (w/comparison group)	2			-22%	-56%	
Culhane et al. (2002)	Homeless individuals with severe mental illness	Quasi-experimental (w/comparison group)	2		-49.2%			-24%[5]
Gilmer et al. (2009)[a,2]	Homeless individuals with serious mental illness	Quasi-experimental (w/comparison group)	2					-46%[6]
Larimer et al. (2009)[a,3]	Chronically homeless individuals with serious alcohol disorders	Quasi-experimental (w/comparison group)	2	~-90%				
Martinez & Burt (2006)	Homeless individuals with two of following: serious mental illness, substance abuse disorder or HIV/AIDS	Quasi-experimental (w/comparison group)	2		NS	NS		-44%
Seligson et al. (2013)	Various populations	Quasi-experimental (w/comparison group)	2		-94%			
Srebnik et al. (2013)	Chronically homeless adults with medical illness and high prior acute service use	Quasi-experimental (w/comparison group)	2	-86%				NS
Byrne et al. (2017)[a,4]	Chronically homeless individuals	Quasi-experimental (pre/post no comparison group)	1			-12%	-13%	
Hunter et al. (2017)	Homeless individuals with complex medical and behavioral health issues	Quasi-experimental (pre/post no comparison group)	1	NS	NS	-61%		
Mares & Rosenheck (2009)	Chronically homeless individuals	Quasi-experimental (pre/post no comparison group)	1					-53%

Thomas et al. (2015)	Chronically homeless adults with behavioral or health issues	Quasi-experimental (pre/post no comparison group)	1						-62%	
Wright et al. (2016)[a]	Homeless individuals with complex medical and mental health issues	Quasi-experimental (pre/post no comparison group)	1			NS		-84%		
OUTPATIENT SERVICE USE										
Study	**Population**	**Design**	**Weight**	**Substance use**	**Mental health/ Psychiatric**	**Physical/ Medical**	**Behavioral health**	**Primary Care**	**Other**	**Total**
Aubry et al. (2015)[1]	Homeless individuals with mental illness and high needs	Experimental	3	+155%	+59%					+76%
Basu et al. (2012)	Homeless individuals with chronic medical conditions	Experimental	3		+32%	NS				
Rosenheck et al. (2003)[a]	Homeless Veterans with mental illness	Experimental	3							+
Stergiopoulous et al. (2015)[1]	Homeless individuals with mental illness and moderate needs	Experimental	3			-19%	-29%			
Byrne et al. (2017)[a,2]	Chronically homeless individuals	Quasi-experimental (w/comparison group)	2							+76%
Culhane et al. (2002)	Homeless individuals with severe mental illness	Quasi-experimental (w/comparison group)	2							+14%
Gilmer et al. (2009)[a,2]	Homeless individuals with serious mental illness	Quasi-experimental (w/comparison group)	2							
Larimer et al. (2009)[a,3]	Chronically homeless individuals with serious alcohol disorders	Quasi-experimental (w/comparison group)	2							
Martinez & Burt (2006)	Homeless individuals with two of following: serious mental illness, substance abuse disorder or HIV/AIDS	Quasi-experimental (w/comparison group)	2							
Seligson et al. (2013)	Various populations	Quasi-experimental (w/comparison group)	2							
Srebnik et al. (2013)	Chronically homeless adults with medical illness and high prior acute service use	Quasi-experimental (w/comparison group)	2			-36%	-7%			
Byrne et al. (2017)[a,4]	Chronically homeless individuals	Quasi-experimental (pre/post no comparison group)	1	NS	-44%	47%				
Hunter et al. (2017)	Homeless individuals with complex medical and behavioral health issues	Quasi-experimental (pre/post no comparison group)	1							-34%
Mares & Rosenheck (2009)	Chronically homeless individuals	Quasi-experimental (pre/post no comparison group)	1							+53%
Thomas et al. (2015)	Chronically homeless adults with behavioral or health issues	Quasi-experimental (pre/post no comparison group)	1				NS	NS	-42% (Outpat.	

									speciality care)/ -53% (outpat. labs & radiolog)	
Wright et al. (2016)[a]	Homeless individuals with complex medical and mental health issues	Quasi-experimental (pre/post no comparison group)	1	+155%	+59%					+76%
OTHER SERVICES										
Study	**Population**	**Design**	**Weight**	**Emergency Dept.**	**Pharmacy**	**Nursing home**	**LTSS**	**Other**	**Emergency Shelter**	
Aubry et al. (2015)[1]	Homeless individuals with mental illness and high needs	Experimental	3						-	
Basu et al. (2012)	Homeless individuals with chronic medical conditions	Experimental	3	-33%		-42%[7]			NS	
Rosenheck et al. (2003)[a]	Homeless Veterans with mental illness	Experimental	3						-50%	
Stergiopoulous et al. (2015)[1]	Homeless individuals with mental illness and moderate needs	Experimental	3	NS						
Byrne et al. (2017)[a,2]	Chronically homeless individuals	Quasi-experimental (w/comparison group)	2		NS		NS	NS		
Culhane et al. (2002)	Homeless individuals with severe mental illness	Quasi-experimental (w/comparison group)	2						-61%	
Gilmer et al. (2009)[a,2]	Homeless individuals with serious mental illness	Quasi-experimental (w/comparison group)	2	-46%[6]						
Larimer et al. (2009)[a,3]	Chronically homeless individuals with serious alcohol disorders	Quasi-experimental (w/comparison group)	2						~-90%	
Martinez & Burt (2006)	Homeless individuals with two of following: serious mental illness, substance abuse disorder or HIV/AIDS	Quasi-experimental (w/comparison group)	2	-56%						
Seligson et al. (2013)	Various populations	Quasi-experimental (w/comparison group)	2						-97%	
Srebnik et al. (2013)	Chronically homeless adults with medical illness and high prior acute service use	Quasi-experimental (w/comparison group)	2	-53%						
Byrne et al. (2017)[a,4]	Chronically homeless individuals	Quasi-experimental (pre/post no comparison group)	1		NS		+9%	NS		
Hunter et al. (2017)	Homeless individuals with complex medical and behavioral health issues	Quasi-experimental (pre/post no comparison group)	1	-80%					-59%	
Mares & Rosenheck (2009)	Chronically homeless individuals	Quasi-experimental (pre/post no comparison group)	1							

Thomas et al. (2015)	Chronically homeless adults with behavioral or health issues	Quasi-experimental (pre/post no comparison group)	1	-81%					
Wright et al. (2016)[a]	Homeless individuals with complex medical and mental health issues	Quasi-experimental (pre/post no comparison group)	1	-40%	NS			-61%	

Notes: NS = not statistically significant;

-/+ = study reported significant decrease/increase, but it was not possible to calculate exact magnitude of decrease/increase from available data;

a-Percent reduction based on reported change in costs, not units of service use;

1-Based on cross-site results from At-Home/Chez Soi study;

2-Based on difference-in-difference analysis reported in study. For difference in difference analysi,s percent change in costs calculated by comparing observed cost in "post" period for intervention group with assumed counterfactual post period cost (i.e. observed post period cost + observed pre/post cost difference for comparison group);

3-Cost reduction estimates are approximate and based on rate ratios displayed in Figure 2 in study, as exact reductions were not reported.

4-Based on fixed effects models using log-transformed cost as dependent variable (reported in study Appendix)

5-Based on Medicaid inpatient days

6-Study groups together inpatient and emergency department costs; same estimate is used for both categories

7-Statistically significant at p <.01 level