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ORIGINAL PAPER

Cost-Utility Analysis of the Housing and Health Intervention for Homeless and Unstably Housed Persons Living with HIV

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Abstract We present a cost-utility analysis based on data from the Housing and Health (H&H) Study of rental assistance for homeless and unstably housed persons living with HIV in Baltimore, Chicago and Los Angeles. As-treated analyses found favorable associations of housing with HIV viral load, emergency room use, and perceived stress (an outcome that can be quantitatively linked to quality of life). We combined these outcome data with information on intervention costs to estimate the cost-per-quality-adjusted-life-year (QALY) saved. We estimate that the cost-per-QALY-saved by the HIV-related housing services is $62,493. These services compare favorably (in terms of cost-effectiveness) to other well-accepted medical and public health services.

Disclaimer The findings and conclusions in this paper are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or the Department of Housing and Urban Development.

This study was conducted for the Housing and Health Study Team.

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Introduction

The roles that homelessness, instability of housing, and housing assistance interventions play in the HIV/AIDS arena have been the subject of a rapidly growing scientific literature (including an entire special issue of this journal) [1]. Further, the topic of HIV-related housing was given special attention by President Obama's administration when it hosted a December 2009 forum at the White House on this topic. The need for HIV-related housing is also noted in the recently released National HIV/AIDS Strategy (NHAS) and a specific metric on improving such housing is included in the NHAS [2]. A conference entirely devoted to housing and HIV is now a major annual event and is coordinated by the National AIDS Housing Coalition and a

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Access to adequate housing has been declared by the United Nations General Assembly to be a fundamental human right [3]. Therefore, many would argue that there should be no need to further justify the provision of housing services for homeless people and those who are at risk of becoming homeless (regardless of HIV status) as long as the need for these services exists. Given economic and political constraints, however, the reality is that maintaining and expanding housing services is often dependent upon evidence regarding the health-related and economic benefits that housing provides. Evidence has accumulated in recent years that homelessness is associated with increased risk for HIV infection and a wide range of other health problems [4, 5]. People who are homeless or unstably housed have HIV/AIDS rates that are three to nine times as high as those who are stably housed [6]. Homeless and unstably housed people living with HIV are at greater risk of transmitting HIV, have poorer access to health care and have poorer health outcomes compared to their stably housed peers [1, 3–6]. Homeless and unstably housed people living with HIV who are able to obtain stable housing report improved physical and mental health and in some cases reduced risk behavior [1, 3–6].

What has received relatively less attention in the housing and HIV literature are studies of the economics of HIV-related housing services. There are a number of "administrative records" studies in which the investigators examine service delivery records to estimate the public assistance costs for homeless persons now receiving housing assistance versus those who do not receive such services [7–9]. These administrative records studies typically find that housing services either totally or largely offset their costs by savings in other types of services that would have otherwise been required.

One of the two major randomized trials of housing assistance, the Chicago Housing for Health Partnership study, includes an HIV-specific sub-study but the main trial focused on health outcomes more broadly defined for homeless persons being discharged from the hospital and receiving supportive housing [10, 11]. The broad economic impact of this study was favorably reported in the Wall Street Journal and has recently been published in the scientific literature [12].

In this paper, we present a cost-utility analysis based on previously published cost and effectiveness data from the Housing and Health Study sponsored by CDC and HUD [4]. The effectiveness study examined the effects of supportive housing for homeless and unstably housed persons living with HIV in Baltimore, Chicago and Los Angeles. As-treated analyses found significant associations between being stably housed and undetectable HIV viral load, less use of emergency rooms as a source of medical care, and lower perceived stress (an outcome which can be quantitatively linked to quality of life). Here, we combined information on these three statistically significant favorable outcomes with information on the costs of service delivery to mathematically model estimates of the cost-per-quality-adjusted-life-year-saved (cost per QALY saved) by the intervention.

Methods and Parameter Values

Cost data were collected using a standard micro-costing technique as captured in an EXCEL spreadsheet completed by each of the three study sites; these methods are standard and are reported in detail elsewhere [13]. The effects of supportive housing services delivered in the H&H analysis were obtained from the previously reported trial outcomes [4]. As-treated data were used rather than the data from the primary intent-to-treat analyses because 51% of persons in the comparison group were stably housed at the 18-month follow-up assessment [4]. This affected the interpretability of the intent-to-treat analyses as well as the statistical power to detect meaningful differences between persons who accessed stable housing through the H&H intervention arm and those who did not. The as-treated analysis compared those who spent at least one night homeless during the past six months to those who did not.

Standard methods of cost-utility analysis were employed as recommended by the U.S. Panel on Cost-effectiveness in Health and Medicine and adapted for use in HIV-related studies [14]. All costs are expressed here in 2005 dollars. All downstream costs or benefits were discounted into net present value at 3%. Analyses were performed in Microsoft Excel for Office 2007.

The main formula for this analysis is,

$$R = [C - E - (A \times T)] / [Q_{pss} + (A \times Q_{ta})],$$

where the parameters are defined as follows: R is the cost-per-QALY saved by the Housing and Health intervention. C is the average cost per client per year to receive the Housing and Health services, and E is the average medical cost savings per client accrued because of lowered emergency department use. A is the number of HIV transmissions averted to HIV seronegative partners of HIV seropositive clients in this study. T is the net present value of downstream medical care costs saved when an HIV infection is averted. Q_{pss} is the average number of QALYs saved for each client living with HIV in this study due to improvements in perceived stress. Q_{ta} is the net present value of the downstream QALYs saved each time an HIV transmission is averted from one of the HIV seropositive clients in the study to an HIV seronegative partner.

The parameter A is estimated by taking the product of three parameters: (a) the difference between those who

received housing and those who did not in terms of possibility of transmission to a seronegative partner (where we assume for simplicity that in order to transmit HIV there needed to be some risk behavior and some detectability of viral load); (b) the average number of sexual behavior partners per year for Housing and Health study clients; and (c) the literature-based average probability of HIV transmission per partnership (estimated separately for men and women, and adjusted by the gender mix of the Housing and Health Study).

The main cost-utility analysis formula and these parameter values are sufficient to conduct the base case analysis. However, we also conducted sensitivity analyses to explore the impact of uncertainty in key parameter values on the cost-utility ratio. While there is no single, universally accepted cutoff value for determining if a cost-utility ratio indicates a cost-effective intervention or not, there is increasing attention being paid to $100,000 per QALY saved as one reasonable convention for determining cost-effectiveness (up from the $50,000 often used in years past) [15, 16]. CDC has recently noted that the literature also contains assertions that a reasonable cut off value to determine cost-effectiveness might be as high as $143,000 to $388,000 (in 2010 dollars) [17, 18]; hence, our use of a $100,000 cut off value is potentially conservative. We sought to determine how low the parameters A and Q would have to go (individually) before this possible line of demarcation is crossed; this type of sensitivity analysis is called a threshold analysis and was executed using the Goal Seek function in Microsoft Excel.

Results

Taking the average per-client cost across Baltimore, Chicago and Los Angeles (from our previously published analysis), we estimate C at $12,288. E is estimated at $97. This is derived by taking the average cost of an emergency department visit, $492, and multiplying by 0.197; the difference in emergency department usage between housed clients and clients without housing was 19.7 %. The percentage of housed clients who used an emergency room one or more times in the prior six months was 28.9 %; for clients without housing this was 48.6 % (for a difference of 19.7 %). While this emergency room differential reflects only a six month period not one year, we conservatively used this differential as being reflective of the entire year. T is estimated at $315,904 (net present value) based on a previously published study of medical care costs for HIV and converted to 2005 dollars using the medical care component of the consumer price index [19].

The parameter A was estimated at 0.01567 transmissions averted, and the calculations that results in this estimate are as follows. The percentage of all Housing and Health Study participants who engaged in any risk behavior was 13.3 %; the percentage of housed clients with detectable viral load was 61.4 %, and the percentage of clients not housed with detectable viral load 79.1 %. (The only study of which we are aware that showed an effect of housing on viral load was an examination of the experiences of just 26 clients [20].) Therefore, we estimate that the proportion of housed clients who might potentially transmit was 8.18 % (0.1332×0.614) and the proportion of clients not housed who might potentially transmit was 10.54 % (0.1332×0.791); subtracting these two percentages gives a difference of 2.36 %. The average number of sex partners for Housing and Health Study participants was 3.813 per client; however, this number is for all partners (some of whom might have been already living with HIV) and over a 90 day recall period (we used this 90-day recall, 3.813 partners statistic to conservatively represent the entire year). Taking literature-based estimates for HIV transmission per partnership for men and women [21], and adjusting for the gender make-up of the Housing and Health Study participants, yields an estimate of 17.42 % per partnership. Taking these estimates all together yields a resultant estimate for A of 0.01567 HIV transmissions averted per client in the Housing and Health Study. This value would appear to be conservative in that no downstream secondary infections averted are claimed in this analysis.

The Housing and Health Study found a 3 % difference in perceived stress for housed versus not housed clients. The literature contains a study that examined the quantitative relationship between a perceived stress scale and quality of life score (in particular, quality of life equals 1.08 times perceived stress according to that study) [22]. Both the Housing and Health Study and the Weaver et al. study employed a Perceived Stress Scale (PSS) based on the work of Cohen et al. [23, 24]. The Housing and Health Study used the ten item version of the PSS (PSS10), and the Weaver study used the fourteen item version (PSS14). The PSS10, as well as a shorter four item version (PSS4), are derived from the original PSS14 [24]. Factor analytic research has shown the PSS14 and PSS10 to be very highly related to each other [24]. Therefore, we use the translation of a PSS score into a quality of life score here following the Weaver et al. approach. This means that a typical Housing and Health study client experiencing a 3 % difference in perceived stress would have a 3.24 % (3 % times 1.08) difference in quality of life over a one year intervention. Therefore, we estimate that for the average Housing and Health Study client, 0.0324 QALYs were gained due to improvements in perceived stress and thereby quality of life.

The literature contains previous estimates of Q_{ta}. However, since these estimates were published, the literature on

the impact of HIV treatment has grown substantially, and therefore we provide an updated estimate of Q_{ta} here. Considering the average age for HIV infection in the U.S. is 35, prior articles have estimated life expectancy with HIV to be roughly 28 years after infection, and we assume life expectancy without HIV infection post-35 years of age to be 37 years [25]. We assume that without HIV infection, quality of life is not a perfect 1.0 (on a scale of 0 to 1.0) but is rather approximately 0.94 based on earlier surveys of the general population [26]. Following the work of Sanders, we assume that after HIV infection quality of life drops 0.1 for 1 year (during acute infection), 0.05 for three years during a relatively asymptomatic phase, 0.11 for 22 years during a mildly symptomatic phase, and 0.21 for two years near end of life [27]. Taken all together, this means that averting an HIV transmission saves 9 years of life, 11.55 undiscounted QALYs, and 5.33 QALYs discounted at 3 %. (CDC has recently estimated Q_{ta} to be 6.433 based on somewhat older quality of life weights [28]; therefore, our estimate of Q_{ta} is potentially conservative relative to the CDC estimate of 6.433.)

Using the parameter values and the main cost-utility ratio formula described above, we estimate that the cost-per-QALY-saved by the provision of housing services in the Housing and Health Study is $62,493.

The threshold analysis for the parameter A indicated that even if A sank as low as 0.01054, the cost-utility ratio would be $100,000 or less. The value of 0.01054 is to be compared to the base case estimate of parameter A of 0.01567; in other words, even if the base case estimate overestimates A by 32.7 %, the result would still indicate cost-effectiveness. This is also true if the value for Q_{ta} decreased to as low as 2.56.

Discussion

The base case result of $62,493 per QALY saved is below an increasingly accepted standard for determining cost-effectiveness of interventions (and only slightly above a previously accepted standard). But since there is not one and one only cutoff possible, it is perhaps even more instructive to compare this result to the cost-per-QALY-saved by a number of specific medical and public health interventions. A sampling of these interventions and the cost-per-QALY-saved is displayed in Table 1. It can be seen that HIV-related housing compares favorably in economic terms with services such as screening mammography, kidney dialysis, and even the effects of early HIV treatment on the health of people living with HIV. The threshold analyses presented here also give evidence of the robustness of the base case findings to uncertainty in some key parameters.

Table 1 Cost-utility ratios for selected public health interventions

Intervention	Approximate cost per QALY saved
Kidney dialysis	$52,000 to $129,200 (2000 dollars) [29]
HIV screening every 5 years	$42,200 (2001 dollars) [30]
Mammography, 50–69 years old	$57,500 (2001 dollars) [30]
Type 2 diabetes screening >25 years old	$63,000 (2001 dollars) [30]
PrEP	$298,000 (2006 dollars) [31]
Early vs deferred HAART	$15,159 to $36,301 (2005 dollars) [32]
Deferred vs no HAART	$46,423 (2005 dollars) [32]

The National HIV/AIDS Strategy released in July 2010 highlighted the importance of HIV-related housing services as a key part of a comprehensive HIV service delivery package. The results reported here would suggest that such housing services are not only important for improving the health and quality of life of persons living with HIV, but also are a sound economic investment.

Certainly this analysis is subject to some important limitations. First, since the H&H Study did not measure HIV transmission directly (and it is hard to know how this could ever directly be achieved), it was necessary to estimate HIV infections averted. Still, our estimates were based on the epidemiologic literature and were conservative in our choice of parameter values. Second, we used results from the as-treated analysis, rather than the intent-to-treat analysis, so we cannot definitively establish a causal relationship between housing status and our outcomes of interest. Third, our estimate of Q_{ta} is based on a rapidly growing and emerging literature on the effects of HIV treatments on survival and quality of life for persons living with HIV; certainly work on the "true" underlying value of this parameter will and must unfold in the years ahead. However, our approach to estimating this parameter was also conservative. Fourth, we made some simplifying assumptions such as omitting estimation of all secondary transmissions from currently HIV seronegative partners. These simplifying assumptions were all conservative and tended to bias against the Housing and Health intervention with one possible exception and that is the assumption that persons with no detectable viral load would transmit to HIV seronegative partners. Clearly, it is theoretically possible for transmissions to occur even with undetectable viral load, but it would appear that the percentage of such occurrences would be low. Because the effect of this assumptions "acts" through parameter A, the threshold analysis for A provides some reassurance that even if there is a small chance of transmission at undetectable viral load, the base case result is likely sufficiently robust to accommodate such a small change.

It cannot be assumed that the study participants are representative of all homeless or unstably housed PLWHA in the United States. In fact, recruitment through HIV service organizations resulted in a sample that was initially better connected to medical and social services than would have been the case had the sample been assembled using other selection criteria recruitment methods (e.g., street-based recruiting methods). For example, at baseline interview, over 90 % of the sample had seen an HIV primary medical care provider and was receiving case-management services. As other research has shown, engagement in medical care and supportive services is associated with reductions in HIV risk behaviors. Thus the prevention 'return on investment' of addressing housing needs among homeless persons less integrated into the HIV care system may be greater.

Though not the main point of the analysis presented here, our work provides some interesting insights as to the HIV transmission rate for persons provided housing compared to persons who are not. The best current published estimate of the HIV transmission rate (incidence divided by prevalence times 100) for persons aware that they are living with HIV is 2.7 (i.e., 2.7 HIV transmissions per 100 people aware that they are living with HIV per year) [33]. Here the calculations for parameter A can be interpreted as estimating the transmission rate for persons aware that they are living with HIV and receiving housing to be 5.4, and persons aware that they are living with HIV but experiencing homelessness to be 7.0. While these are clearly estimates with some uncertainty, they do provide another way of quantifying the relatively high rates of HIV transmission among persons who are now or have recently experienced instability of housing. Although the Housing and Health Study did not find that stable housing led to a significant decrease in unprotected sex with serostatus discordant partners, the sexual behavior of people living with HIV who experience homelessness or housing instability puts them at greater risk of HIV transmission.

Based on the analysis above, it appears that the HIV-related housing services meet generally accepted standards for determining cost-effectiveness of medical and public health services. This is true even in conservative analyses, and threshold analyses indicate that the results are reasonably robust to uncertainty in the two parameters most difficult to estimate.

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