Diabetes and Hypertension Prevalence in Homeless Adults in the United States: A Systematic Review and Meta-Analysis

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We estimated hypertension and diabetes prevalence among US homeless adults compared with the general population, and investigated prevalence trends. We systematically searched 5 databases for published studies (1980–2014) that included hypertension or diabetes prevalence for US homeless adults, pooled disease prevalence, and explored heterogeneity sources. We used the National Health Interview Survey for comparison.

We included data from 97 366 homeless adults. The pooled prevalence of self-reported hypertension was 27.0% (95% confidence interval = 23.8%, 29.9%; n = 43 studies) and of diabetes was 8.0% (95% confidence interval = 6.8%, 9.2%; n = 39 studies). We found no difference in hypertension or diabetes prevalence between the homeless and general population.

Additional health care and housing resources are needed to meet the significant, growing burden of chronic disease in the homeless population. (*Am J Public Health.* 2015;105: e46–e60. doi:10.2105/AJPH.2014.302330)

IN 2012, THE ESTIMATED US homeless population was a little more than 630 000 individuals at any single point in time.[1] There are 2.5 to 3.5 million people, or 0.9% to 1.2% of the US population, homeless over the course of a year.[2] Lifetime prevalence of homelessness has been estimated to be even higher, at 7.4%.[3] These estimates share a definition of homelessness known as "literal homelessness," referring to individuals with no stable residence living either in a temporary shelter or unsheltered location not meant for habitation (e.g., the street, a subway station, or a parked car). Another definition of homelessness, used by the US Department of Education, for example, would include those who are "doubled-up," or staying in temporary arrangements with friends or family.[4]

Homeless individuals have significant health needs in several domains, including chronic diseases, communicable diseases, mental health, and substance abuse.[5] In addition, other common reasons for seeking health care include environmental insults such as injuries, insect bites, and complications from heat and cold exposure. All contribute to significant premature mortality in this population,[6–10] with an average estimated life expectancy of 42 to 52 years for chronically homeless individuals.[11] Factors contributing to the health problems of homeless people include extreme poverty, inadequate access to health care, nonadherence to therapy, and the adverse health effects of homelessness itself.[12,13] Those who are homeless identify lack of health insurance and financial resources as key barriers to accessing health care.[13] Homeless individuals may be exposed to harsh outdoor environments or crowding in temporary shelters. They may even lack access to clean water and basic hygiene supplies. For these reasons, a cycle is created in which poor health is a risk factor for homelessness and homelessness increases health needs.[5]

There is growing consensus that the adult homeless population in the United States is aging.[14–16] This trend, which applies primarily to single homeless adults rather than families, is hypothesized to result from multiple economic and social challenges facing the cohort born in the late 1950s to early 1960s, including the economic recession of the 1980s and the crack cocaine epidemic.[15]

Although the mean age of the homeless population is increasing, the adult homeless population is still overall younger than the US population.[17] The much lower proportion of adults aged older than 62 years in the homeless population reflects the premature mortality of this group. Age is a well-known risk factor for many chronic diseases, including hypertension and diabetes. The homeless have been shown to have rates of chronic disease in middle age that are comparable to those of older adults.[18] Thus, the effects of an aging trend among the homeless on chronic disease rates may be magnified.

Reported rates of diabetes and hypertension in the homeless population range from 2% to 18% for diabetes and 18% to 41% for hypertension.[19–23] Reasons for this variation include different disease measurement approaches (e.g., self-report vs physiological methods), study setting, sampling, and when the study was conducted. Among the homeless population, cardiovascular disease has been identified as the second leading cause of death, after injuries or overdoses.[6]

In the general US population, both hypertension and diabetes are common chronic diseases. The incidence and prevalence of hypertension are increasing in the United States; the number of adults with hypertension more than doubled between 1995 and 2005.[24] Hypertension occurs in 29% to 31% of US adults and is the most common reason for prescription medication.[25] Hypertension is more common in African Americans than in Whites and in men than in women.[26] Treating hypertension reduces the risk of developing heart failure, myocardial infarction, and stroke.[27] In 2010, the estimated prevalence of diagnosed diabetes for US adults was 8.2% and has been sharply increasing since the mid-1990s.[28] Diabetes is also more common in racial minorities.[29] It is the seventh leading

TABLE 1—Sample Medline Search Strategy Using Controlled Vocabulary

Homeless	[Homeless persons OR homeless.mp OR street people.mp OR homeless*.mp] AND
Diabetes	[Diabetes mellitus OR diabetes mellitus.mp OR
Hypertension	Hypertension OR hypertension.mp OR high blood pressure.mp OR
Chronic disease	Chronic disease OR chronic disease.mp OR
Health status	Health status OR health status.mp]

cause of death and a major contributor to cardiovascular disease, the leading cause of US deaths.[29]

In the homeless population, African American race is overrepresented by about 200%.[30] Rates of heavy alcohol use, which contributes to the development of hypertension, are also high in the homeless population.[31] In addition, diets provided by food pantries and meal programs are often high in sodium,[32] which may contribute to or exacerbate hypertension. Furthermore, a paradoxical association has been made between food insecurity and obesity, another risk factor for both diseases.[33] In a national sample of chronically homeless adults, 57% were overweight or obese.[34] Finally, it has been hypothesized that the chronic stress of homelessness could contribute to the development of hypertension, though this has not been explicitly studied.

Homeless adults are known to be high utilizers of the health care system.[35] They are up to 5 times more likely to be admitted to the hospital than the general population[36] and often obtain care in the emergency department because of poor access to primary care services.[37] A subpopulation of the homeless are "superutilizers" with extreme levels of health care use.[38] These utilization patterns are associated with high health care costs[39] and suggest that the current safety net is inadequate to support the health care needs of the homeless population. Identification of key trends in chronic disease rates among the homeless population will help public health organizations plan for allocation of appropriate resources to meet the growing health needs of this population.

In light of the variations in previously published rates of diabetes and hypertension in the homeless population and indications of an aging trend in the homeless population over time, the primary aim of this study was to determine the prevalence of hypertension and diabetes in homeless adults in the United States between 1980 and 2014. Secondary aims were (1) to compare the prevalence of each disease to the background prevalence in the United States, (2) to investigate trends in the prevalence of each disease over time between 1980 and 2014, and (3) to explain the variation in estimates of disease prevalence among the various studies.

METHODS

This study adhered to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations for reporting on systematic reviews.[40]

Search Strategy

We conducted a systematic search of published articles with Medline, PsychINFO, Cumulative Index to Nursing and Allied Health Literature, Cochrane, and Science Citation Index. Search terms varied slightly on the basis of controlled vocabulary for all databases except Science Citation Index (which lacks a controlled vocabulary). We chose the search terms following a review of Medical Subject Heading terms used in a variety of articles known to meet inclusion criteria. As a representative example, the Medline search strategy is shown in Table 1. (A complete list of search strategies for all databases is provided in Table A, available as a supplement to the online version of this article at http://www.ajph.org.)

TABLE 2—Adapted Quality Assessment Tool for Systematic Review of Hypertension and Diabetes Prevalence in Homeless Adults in the United States, 1980–2014

Questions	Loney[41]—Prevalence of Dementia[a]	Adaptation—Prevalence of Hypertension and Diabetes in Homeless Adults[b]
Are the study methods valid?	Are the study design and sampling method appropriate for the research question?	Is a probability sample taken or the whole population surveyed?
	Is the sampling frame appropriate?	Is the sampling frame (list or method for study recruitment) appropriate?
	Is the sample size adequate?	Is the sample size adequate?
	Are objective, suitable, and standard criteria used for the measurement of the health outcome?	Are objective, suitable, standard methods used for the measurement of the health outcome?
	Is the health outcome measured in an unbiased fashion?	Is the health outcome measured with the same method for all participants?
	Is the response rate adequate? Are the refusers described?	Is the response rate adequate? Are those who refused or were not included described?
What is the interpretation of the results?	Are the estimates of prevalence or incidence given with confidence intervals and in detail by subgroup, if appropriate?	Are adequate statistical methods presented in the manuscript? Are the estimates of prevalence given in detail by subgroups?
What is the applicability of the results?	Are the study participants and the setting described in detail and similar to those of interest to you?	Are the study participants and the setting described in detail? Do the participants seem to represent the overall population of homeless adults?

[a]0 or 1 point each; total score 0–8.
[b]0 or 1 point each; total score 0–9.

We limited the search to studies published after January 1, 1980, and to the English language because the review only includes studies conducted in the United States. The final search date was April 24, 2014. We did not include unpublished data in the analysis because of difficulty assessing the study design and quality of these studies and problems with a lack of a systematic method of rigorously searching for such sources. However, we evaluated published theses for eligibility. We also searched the reference lists of the studies that met eligibility criteria, as well as those of review articles about chronic disease, hypertension, diabetes, or cardiovascular disease in the homeless population.

Eligibility Criteria and Review Process

We established criteria for eligibility before beginning review of search results. Inclusion criteria were publication in the English language on or after January 1, 1980, and studies conducted in the United States that presented prevalence data on diabetes and hypertension among homeless adults. Studies that we excluded were those that were unpublished; did not contain primary data; were not in English or were conducted outside the United States; were published before January 1, 1980; were not conducted in homeless adults; included children aged younger than 18 years; did not contain hypertension or diabetes prevalence data; or presented duplicate data of other included studies. (See Supplement B, available as a supplement to the online version of this article at http://www.ajph.org, for a full description of eligibility criteria.)

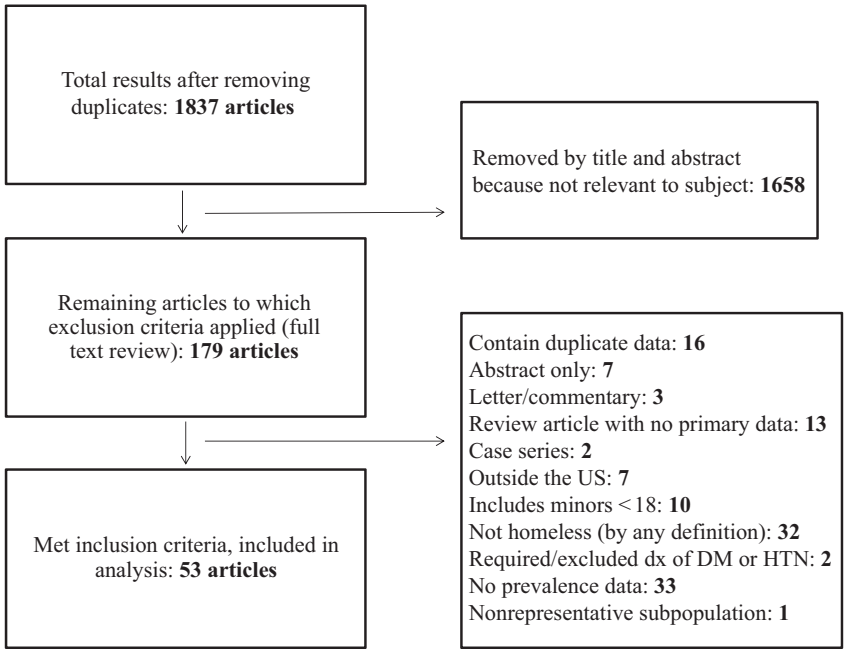
We removed exact duplicates automatically; we removed near duplicates after manual review. The primary reviewer (R. S. B.) then performed a preliminary review by title and abstract to remove articles that were clearly not relevant to the study question or did not meet eligibility criteria. Two reviewers (R. S. B. and E. J. P.) independently reviewed the remaining articles in full text, and they each noted whether the article should be included or excluded, and if so, the reason for exclusion. If an article had multiple reasons for exclusion, they chose the primary reason for exclusion in the order in which they were listed on the eligibility form (Supplement B, available as a supplement to the online version of this article at http://www.ajph.org). They discussed all articles until they reached consensus about study eligibility; a third reviewer resolved remaining discrepancies (L. N. M.).

Data Collection and Quality Assessment

The principal investigator created a preliminary data abstraction form based upon data elements of interest and piloted with included studies. Three independent reviewers (R. S. B., L. N. M., and J. L. J.) performed data abstraction. For each article, a primary reviewer first abstracted all available data elements. A secondary reviewer then confirmed all data. Discrepancies were discussed and consensus achieved.

The goal of quality assessment was to determine the quality of the disease prevalence estimate provided by each study. Thus, the quality scores are an assessment of the study's quality in estimating disease prevalence and not in achieving the individual aims of each study.

Two independent investigators (R. S. B. and J. S. J.) conducted quality ratings by using an adaptation of the disease prevalence quality tool created by Loney et al.[41] This tool, originally developed to assist in evaluating studies of the prevalence of dementia, has subsequently been adapted to evaluate the quality of prevalence estimates of other conditions.[42] We assessed 3 overall factors contributing to quality of prevalence estimate: validity of the study methods, accurate interpretation of the results, and applicability of the results. As listed in Table 2, we modified the tool by separating the interpretation of results by use of appropriate statistical methods and analysis by subgroups (item 7 of the original tool) into 2 items. This separation gave us 9 total items and produced a score of 0 to 9. (For more information about application of this quality assessment tool, see Supplement C, available as a supplement to the online version of this article at http://www.ajph.org).



Note. DM = diabetes mellitus; dx = diagnosis; HTN = hypertension.

FIGURE 1—Systematic review search results and reasons for exclusions: diabetes and hypertension prevalence in homeless adults in the United States, 1980–2014.

TABLE 3—Summary Characteristics of Included Studies on Diabetes and Hypertension Prevalence in Homeless Adults in the United States, 1980–2014

Study Characteristic (No. of Studies Reporting)	No. of Studies (%)
Study design (n = 53)	
Observational	53 (100)
Prospective	41 (77.4)
Retrospective	12 (22.6)
Sample selection (n = 53)	
Census	17 (32.1)
Probability	13 (24.5)
Convenience	16 (30.2)
Not specified	7 (13.2)
Sample size (n = 53)	
< 200	31 (58.5)
200–399	9 (17.0)
400–599	4 (7.6)
600–799	1 (1.9)
800–999	2 (3.8)
1000–1999	1 (1.9)
2000–2999	2 (3.8)
3000–3999	1 (1.9)
≥ 4000	2 (3.8)
Sample recruitment locations[a] (n = 44)	
Emergency shelter	22
Medical clinic	18
Meal program	11
Street or homeless enclaves	11
Homeless service agencies	8
Day shelter	6
Transitional housing	4
Mental health facility	2
Substance abuse program	2
Single room occupancy	2
Mobile outreach	2
Hospital	2
Flophouses or slum apartments	1
Year of study (n = 55[b]; average used if spans multiple yrs)	
1980–1989	13 (23.6)
1990–1999	13 (23.6)
2000–2010	24 (43.6)
≥ 2011	5 (9.1)
US region (n = 53)	
Northeast	19 (35.9)
Midwest	9 (17.0)
South	9 (17.0)
West	10 (18.9)
National or multiple regions	6 (11.3)
Population (n = 53)	
Urban only	48 (90.6)
Rural only	1 (1.9)
Both	3 (5.7)
Unclear	1 (1.9)
Special target subpopulation[a] (n = 53)	
Women	5 (9.4)
Older adults	7 (13.2)
Veterans	9 (17.0)
Chronically homeless	2 (3.8)

[a]May be more than 1 per study.
[b]Used Hahn[14] × 3, once for each chronological wave of data presented.

We calculated interrater reliability between reviewers by using the Spearman rank correlation coefficient, defining high correlation as a coefficient greater than 0.75.[43]

Comparison With the General Population

We made all comparisons by using data from the National Health Interview Survey (NHIS), a national probability survey containing self-reported chronic disease information. It has been conducted in the United States annually between 1980 and 2013 (data currently available through 2012). We chose a nationally representative sample of self-reported disease data rather than a sample containing physiological measurements because few studies using physiological measurements from the homeless sample were available to use for comparison.

Annual prevalence rates of diabetes from NHIS were available in published summary.[44] For hypertension, we manually extracted annual self-reported disease prevalence from the NHIS Web-tool Integrated Health Interview Series[45] by using the NHIS variable "hypertenev," which asked respondents "Have you ever been told that you have hypertension?"

Analysis

Study description and synthesis of results. We used descriptive statistics to summarize the number and percentage of studies with various characteristics, including types of study design, sample selection, sample recruitment locations, year of data collection, and study region. We also described sample characteristics, including definition of homelessness used, prevalence of chronic homelessness, sample age, race, gender, employment status, veteran status, and insurance status.

We calculated prevalence estimates for hypertension and diabetes by using a random effects model with study-level prevalence estimates, and we used the Wilson method to calculate 95% confidence intervals for those estimates.[46] We used the same methods to calculate prevalence estimates for mental health diagnoses, substance use disorders, and other medical conditions.

Risk of bias. We appraised study quality with the adapted standardized tool. We averaged scores from both reviewers to yield an overall quality rating for each study. We determined a cut-off point for a binary division between lower- and higher-quality scores by visual analysis of score

TABLE 4—Sample and Study Characteristics of Included Studies on Diabetes and Hypertension Prevalence in Homeless Adults in the United States, 1980–2014

Study and Year	Location	Special Population	Sampling Method	HTN or DM Prevalence	Diagnostic Method	Mean Age, Years	No. of Participants
Ballard 2009[61]	Greensboro, NC	Women	Convenience, shelter	Both	Self-report	42	111 DM; 116 HTN
van den Berk-Clark and McGuire 2013[76]	Los Angeles, CA	Older adults, veterans	Transitional shelter	Both	Self-report	74	59
Bharel et al. 2013[38]	Boston, MA	Medicaid-insured	Clinic	Both	Provider diagnosis (*ICD-9*)	45.5	6494
Bowdler 1989[51]	Richmond, VA	NA	Convenience, medical clinic	HTN	Chart review	28.7	90
Brickner et al. 1992[64]	New York, NY	NA	Unspecified sampling method, medical clinic	HTN	Measured BP > 140/90 mm Hg		5436
Brown et al. 2012[72]	Boston, MA	Older adults	Probability, shelter, and day shelter	Both	Self-report	56	247
Burt 1999[79]	Multiple—national	NA	Probability, every type of homeless assistance agency	Both	Self-report		2938
Child et al. 1998[80]	Boston, MA	NA	Census, medical clinic	HTN	Measured BP ≥ 140/90 mm Hg or antihypertensive medicines		252
Cohen et al. 1988[73]	New York, NY	Older adult men	Unspecified sampling method, street, flophouses, slum apartments	Both	Self-report	62	281
Craft-Rosenberg et al. 2000[77]	Iowa, city unspecified	Women-only rural	Census, shelter	Both	Self-report	35.5	31
Cronley 2013[81]	Fort Worth, TX	NA	Shelter, homeless service agencies	DM	Self-report	48.7	97
Dellon 1995[52]	Providence, RI	NA	Convenience, homeless service agency	Both	Self-report	38	102
Drake 1992[32]	Kansas City, MO	Women	Convenience, shelter	Both	Self-report	24.2	96
Ferenchick 1992[65]	Lansing, MI	NA	Census, medical clinic	Both	Chart review	34.3	181
Folsom et al. 2002[53]	San Diego, CA	Mental illness	Census, medical clinic	Both	Chart review	51.4	94
Gallagher et al. 1997[69]	Los Angeles, CA	NA	Probability, shelters, meal programs, street	HTN	Unspecified physical examination	38.1	363
Garibaldi et al. 2005[82]	Philadelphia and Pittsburgh, PA	NA	Probability, street, meal programs, shelter, SRO, transitional housing	HTN	Self-report		531
Gelberg et al. 1990[66]	Los Angeles, CA	NA	Census, medical clinic	Both	HTN: self-report or BP ≥ 140/90 mm Hg; DM: self-report	33.3	207 self-report; 186 measured

Continued

TABLE 4—*Continued*

Gelberg et al. 1990[18]	Los Angeles, CA	NA	Probability, street, shelter, meal program, service agencies	Both	HTN: self-report or BP ≥ 160/90 mm Hg; DM: self-report	34	529 self-report; 505 measured
Gibson et al. 2008[83]	Bedford, MA, and Dallas, TX	Veterans	Convenience, VA homeless programs	Both	Self-report	46	112
Glied et al. 1996[70]	New York, NY	NA	Probability, shelter	DM	Self-report	35.5	2335
Goldstein et al. 2010[84]	Multiple—Mid-Atlantic region	NA	Census, homeless veteran service providers, general homeless services	HTN	Self-report		3595
Hahn et al. 2006[14]	San Francisco, CA	NA	Probability, homeless service providers, SROs, shelters, meal programs	Both	Self-report	42.1	1716
Han et al. 2003[85]	Multiple—East Coast region	NA	Probability, meal programs	Both	Self-report	41.1	941
Kim et al. 2008[67]	Philadelphia, PA	Men	Unspecified sampling method, shelter	Both	DM: self-report or random glucose ≥ 200; HTN: self-report, medicines, or BP ≥ 140/90 mm Hg	42.4	226 DM; 168 HTN[a]
Kramer and Barker 1996[74]	Los Angeles, CA	Older adult Native Americans	Convenience, shelters, flop houses, street	Both	Self-report	53	53
Larson 2002[86]	Nashville, TN	NA	Convenience, day shelter	Both	Self-report	37.4	145
Lebrun-Harris et al. 2013[87]	Multiple—national	NA	Probability, medical clinic	Both	Self-report		618
Lee et al. 2007[54]	Honolulu, HI	Micronesian	Census, medical clinic	Both	Self-report		47
Levitt et al. 2009[21]	New York, NY	Chronically unsheltered	Census, street	Both	Self-report	46.2	1093
Linton and Shafer 2014[88]	Phoenix, AZ	Unsheltered, chronically homeless	Street	DM	Self-report	47	260
Luder et al. 1990[68]	New York, NY	NA	Convenience, day shelter, transitional housing, medical clinic	Both	Self-report	52.5	55 DM; 96 HTN
Macnee et al. 1996[23]	Johnson City, TN	NA	Convenience, medical clinic	Both	Self-report and "screen" not further specified		58 DM; 131 HTN
Mason et al. 1992[62]	Utah, city unspecified	Men	Census, shelter	Both	Self-report	41	100
Muirhead et al. 2011[89]	Chattanooga, TN	NA	Convenience, meal program	Both	Self-report	43.2	95
Notaro 2013[55]	Urbana-Champaign, IL	NA	Census, medical clinic	DM	Chart review, specified provider diagnosis		122
O'Toole et al. 1999[90]	Multiple—Pennsylvania	NA	Convenience, street, shelter	HTN	Self-report		194
O'Toole et al. 2010[91]	Providence, RI	Veterans	Census, medical clinic	Both	Chart review, specified provider diagnosis	51.8	177
O'Toole et al. 2013[92]	Providence, RI	Veterans	Medical clinic	Both	Provider diagnosis (*ICD-9*)	51.2	127
Ritchey et al. 1991[63]	Birmingham, AL	NA	Probability, shelters, meal programs, street	HTN	Self-report	33.4	100

Continued

TABLE 4—*Continued*

Ropers and Boyer 1987[56]	Los Angeles, CA	NA	Probability, shelters, meal programs, street	Both	Self-report	37.45	269
Rowland 1995[93]	Buffalo, NY	NA	Probability, shelter, meal program, inpatient psych, inpatient rehab, street	Both	Self-report	31.5	413
Savage et al. 2006[57]	Cincinnati, OH	NA	Census, medical clinic	Both	Self-report	43	110
Schaffer et al. 2000[94]	St Paul, MN	NA	Convenience, shelter, day shelter	HTN	Self-report	37	101
Schanzer et al. 2007[71]	New York, NY	Newly homeless	Unspecified sampling method, shelter	Both	Self-report	36.9	351
Tsai et al. 2013[95]	Multiple—national	NA	Unspecified sampling method	Both	Self-report	45.5	725
Tsai et al. 2013[96]	National	Veterans	Medical clinic, emergency room	DM	Provider diagnosis (*ICD-9*)	51.8	64 091
Vijayaraghavan et al. 2012[78]	New York, NY	Women	Probability, shelter	Both	Self-report	37.9	329
Viron et al. 2014[97]	Boston, MA	Mental illness	Transitional shelter	Both	Chart review, any source	43.4	60
Washington 2005[75]	Detroit, MI	Women, older adults, African Americans	Convenience, shelter, warming center, clinic, hospital, mental health clinic, meal program	Both	Self-report	52.6	100
Weinstein et al. 2013[58]	Philadelphia, PA	Mental illness, Chronically homeless	Census, multiservice housing first program	Both	Self-report, chart review, best available	49.7	123
Wiersma et al. 2010[59]	Atlanta, GA	NA	Convenience, shelter	DM	Self-report	46	78
Wojtusik and White 1998[60]	San Francisco, CA	NA	Convenience, mobile outreach van	Both	Self-report	41	128

Notes. BP = blood pressure; DM = diabetes mellitus; HTN = hypertension; *ICD-9* = *International Classification of Diseases, Ninth Revision*; NA = not applicable; SRO = single-room occupancy; VA = Veterans Affairs.
[a]n = 226 for reported DM and 168 for reported HTN, but n = 286 for measured DM and 287 for measured HTN.

distribution. On the basis of this distribution, we established a cut-off to define lower-quality studies as those with an average score less than or equal to 4, and higher-quality defined as an average score greater than 4. We examined this binary score as a potential source of heterogeneity between studies. Furthermore, we performed component analysis of the 9 individual items included, to identify which, if any, items were of primary importance to study quality.

Additional analyses. We assessed the presence of heterogeneity visually by using Galbraith plots,[47] and I^2.[48] We interpreted degree of heterogeneity as low, moderate, and high corresponding to I^2 values of 25%, 50%, and 75%, respectively.[49] We explored heterogeneity in our data by using meta-regression. Potential variables that could contribute to heterogeneity included year of publication; mean study age; gender; race; prevalence of substance abuse, smoking, and chronic homelessness; study design; and method of sample selection. We evaluated trends in the mean sample age by study year by using a nonparametric test for trend across ordered groups, developed by Cuzick,[50] which is an extension of the Wilcoxon rank-sum test and incorporates a correction for ties. In addition, we compared the pooled prevalence of hypertension and diabetes in the homeless population with the estimated prevalence in the general US population from NHIS by adding the NHIS prevalence rates, by year, with standard errors to the meta-analysis data set.

We used random effects meta-regression to compare the prevalence rates between the homeless and general population, with and without adjustment for study year. In brief, meta-regression pools

TABLE 5—Demographic Characteristics of Included Study Participants in Meta-analysis of Diabetes and Hypertension Prevalence in Homeless Adults in the United States, 1980–2014

Sample Characteristic (No. of Studies Reporting)	Number (%) or Mean % ±SD
% of sample male[a] (n = 53)	
0%–19.9%	5 (9.4)
20%–39.9%	1 (1.9)
40%–59.9%	6 (11.3)
60%–79.9%	22 (41.5)
80%–100%	19 (35.9)
Age, y[b] (n = 45)	43.3 ±9.0
Age, y[c] (n = 39)	41.1 ±6.7
Homeless category (n = 53)	
Literally homeless[d]	22 (41.5)
Other	31 (58.5)
Chronically homeless[a] (n = 14)	0.44 ±0.26
Race/ethnicity[a,e]	
White (n = 44)	0.40 ±0.23
African American (n = 39)	0.47 ±0.24
Other (n = 36)	0.20 ±0.22
Employed (n = 21)	0.20 ±0.14
Veterans (n = 18)	0.49 ±0.34
Have health insurance (n = 26)	0.58 ±0.28

[a]Used Hahn[14] × 3, once for each chronologic wave of data presented.
[b]Includes studies targeting older adults.
[c]Excludes studies targeting older adults.
[d]Individuals with no stable residence living either in a temporary shelter or unsheltered location not meant for habitation (e.g., the street, a subway station, or a parked car).
[e]Does not sum to 100% because all studies did not include data for each race.

data by using a least-squares approach with analytic weighting of study by ζ, a measure of between-study heterogeneity. We compared the rates of change in prevalence of both diseases over time observed in the homeless and general population data sets by testing for the significance of the interaction between the groups (homeless vs general population) and study year. We used an alpha of .05 throughout. We performed all analyses with Stata version 13.1 (StataCorp LP, College Station, TX).

RESULTS

We identified a total of 1837 unduplicated articles with our search strategy. Of these, we eliminated 1658 by title and abstract. We examined the remaining 179 articles in full text, yielding 53 articles for inclusion. Reasons for exclusion are detailed in the PRISMA flowchart (Figure 1).

Description of Studies Included

The 53 included studies had considerable heterogeneity in their individual study aims. Many described the health status of a local homeless population,[14,21,51–60] whereas others examined health behaviors or health risks.[61–63] Although the search strategy targeted studies that included the prevalence of hypertension or diabetes, some studies had broad health foci, and others focused on specific conditions.[64–67] Two studies examined the nutritional status of the diets of homeless individuals.[32,68] Other studies explored health care access or utilization among the homeless.[34,53,69–71] There were 2 subpopulations targeted by multiple studies: older homeless individuals[53,72–76] and women.[32,61,75,77,78]

All included studies shared an observational study design. The majority of included studies were prospective cross-sectional samples, whereas 23% of studies were retrospective medical chart reviews. Sample selection was by probability or census in more than 50% of studies. The majority of studies had fewer than 200 participants; 76% of studies included fewer than 400 participants. However, 6 studies had more than 1000 participants and 3 had more than 3000. A total of 97 366 homeless adult participants were sampled across all the included studies. The sampling frame overall focused on temporary housing shelters and medical clinics serving the homeless, with fewer than 25% of studies including unsheltered homeless. Studies were concentrated on the East Coast, but sampled all regions of the United States; 6 studies were regional or national. The included studies focused on urban regions, with only a single study targeting the rural homeless.[77] (See Tables 3 and 4 for detailed study characteristics.)

Participant Characteristics

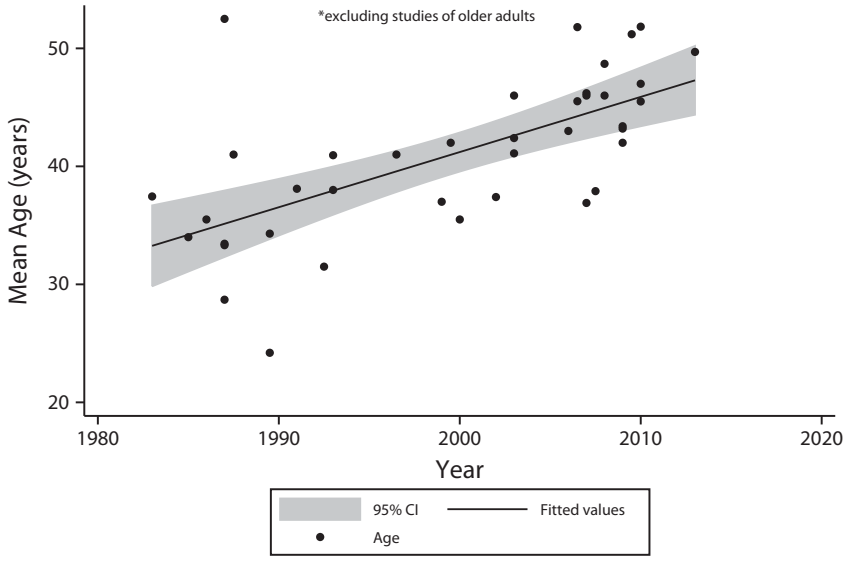
Participant characteristics are detailed in Table 5. The average age was 43.3 years (SD = 9.0), and 69% of the sample was male. However, 6 studies were predominantly female. Forty percent of study participants were White, and 47% were African American. Forty-two percent could be classified as literally homeless. Twenty percent of all study participants were employed, and 58% had health insurance. Forty-nine percent of homeless in the included studies were veterans.

When we plotted the mean ages of the samples over time, after we excluded studies targeting older adults (Figure 2), we observed a statistically significant aging trend ($P < .001$). Sample mean ages increased from the mid-30s in the 1980s to the mid-40s by 2013.

Disease Prevalence Findings

The pooled prevalence of self-reported diabetes, based on 39 studies, was 8.0% (95% confidence interval [CI] = 6.8%, 9.2%; Q = 245.93; $I^2 = 84.5\%$). Seven studies assessed diabetes prevalence with physiological measurement, combined for a prevalence of 12.4% (95% CI = 8.9, 15.9%; Q = 180.97; $I^2 = 96.7\%$). The pooled prevalence of self-reported hypertension, based on 43 included studies, was 27.0% (95% CI = 23.8%, 30.2%; Q = 869.35; $I^2 = 95.2\%$). Nine studies that measured blood pressure had a pooled hypertension prevalence of 25.7% (95% CI = 19.5%, 31.9%; Q = 374.16; $I^2 = 97.9\%$).

We made a comparison between measured and reported disease prevalence for studies that included both. There were 4 studies that included both self-reported hypertension and blood pressure measurements for a combined sample size of 990 participants. There was no significant difference in hypertension prevalence between the self-reported diagnoses and diagnoses determined by blood pressure measurement ($P = .51$). Only 2 studies included both self-reported diabetes and glucose measurements for



Note. CI = confidence interval. Studies of older adults were excluded. For trend, $P < .001$.

FIGURE 2—Trends in homeless adult mean sample age for included studies: United States, 1980–2014.

a combined sample of 284 participants; again, we found no significant difference in diabetes prevalence between self-reported diagnosis and glucose measurement ($P = .97$).

Rates of other chronic diseases are also reported in Table 6. Rates of chronic respiratory disease were high, and nearly three quarters of the homeless smoked. Rates of mental health diagnoses and drug and alcohol abuse were also high. Studies were too variable in their individual definitions of overall mental illness or substance abuse to present prevalence that was not diagnosis-specific.

TABLE 6—Behavioral Health and Medical Disease Prevalence in Homeless Adults in the United States, 1980–2014

Diagnosis[a]	Prevalence, % (95% CI)	I^2, %	Q (*df*)
Hypertension	27.0 (23.8, 30.2)	95.2	869.35 (42)
Diabetes	8.0 (6.8, 9.2)	84.5	245.93 (38)
Asthma	14.6 (12.6, 16.6)	80.5	112.70 (22)
COPD	11.0 (6.5, 15.5)	99.3	2452.57 (18)
Cirrhosis	4.4 (2.3, 6.6)	97.9	188.83 (4)
Cancer	4.1 (2.7, 5.6)	96.1	407.56 (16)
CVA	4.3 (2.8, 5.9)	92.8	179.83 (13)
Chronic renal disease	4.9 (3.9, 5.8)	56.0	15.92 (7)
Dental disease	41.7 (24.0, 59.3)	99.5	2648.66 (12)
Hepatitis	13.6 (8.3, 19.0)	96.6	353.96 (12)
HIV	4.6 (3.5, 5.8)	95.3	360.41 (17)
Hyperlipidemia	26.2 (17.6, 34.8)	90.6	64.16 (6)
Depression	40.6 (33.6, 47.5)	99.3	2579.47 (19)
Anxiety	31.8 (24.4, 39.2)	99.0	815.31 (8)
PTSD	16.7 (7.7, 25.7)	99.7	2019.12 (7)
Bipolar disorder	17.9 (11.1, 24.8)	99.0	776.69 (8)
Schizophrenia	18.2 (14.4, 22.1)	98.1	527.04 (10)
Substance abuse			
Alcohol abuse	34.9 (29.2, 40.6)	99.1	2859.60 (25)
Drug abuse	33.1 (25.7, 40.5)	99.4	3024.27 (18)
Tobacco use or smoking	70.8 (62.3, 79.3)	96.5	395.84 (14)

Notes. CI = confidence interval; COPD = chronic obstructive pulmonary disease; CVA = cerebrovascular accident (stroke); *df* = degrees of freedom; PTSD = posttraumatic stress disorder.
[a]All diagnoses by self-report.

Risk of Bias

There was high interrater reliability for bias assessment (Spearman's $\rho = 0.83$). The distribution of averaged quality scores between the raters is shown in Figure 3 and reflects a wide range of study quality. Study quality was significantly associated with lower diabetes prevalence ($P = .03$) but not with hypertension prevalence ($P = .24$).

When we evaluated quality by using each individual quality measure (component analysis), use of appropriate sampling frame and applicability to the general homeless population was associated with lower diabetes prevalence ($P = .03$ and .01, respectively) and use of a probability sampling method was associated with lower hypertension prevalence ($P = .02$). See Table 7 for the full component analysis.

Heterogeneity Analyses

We observed a high degree of heterogeneity in the pooled prevalence rates of diabetes and hypertension. The impacts of study-level characteristics are shown in Table 8. We found mean sample age and year of study to be significantly associated with increasing prevalence of both diabetes and hypertension, and together to account for 18.5% of the variation in diabetes prevalence and 47% of the variation in hypertension prevalence. In addition, having health insurance was associated with increased prevalence of diabetes ($P < .001$); however,

insurance status was not significantly associated with hypertension prevalence ($P=.12$).

We did not find prevalence of alcohol abuse ($P=.47$ and $P=.65$ for diabetes and hypertension, respectively) and tobacco use ($P=.63$ and $P=.58$, respectively) to be significantly associated with change in prevalence of either disease, nor were gender ($P=.51$ and $P=.51$, respectively) or African American race ($P=.53$ and $P=.92$, respectively). Proportion of the sample with depression was significantly associated with increased prevalence of diabetes ($P=.02$) but not significantly associated with hypertension prevalence ($P=.42$). There was a marginally significant association between anxiety and increased prevalence of hypertension ($P=.05$), but it was not associated with diabetes prevalence ($P=.42$). Bipolar disorder ($P=.84$ and $P=.91$ for diabetes and hypertension, respectively) and schizophrenia rates ($P=.97$ and $P=.87$, respectively) did not significantly change the prevalence of either disease.

Comparison With the General Population

The pooled prevalence of hypertension in the general population from 1982 to 2011 was 25.0% (95% CI = 24.0%, 26.1%; $Q=1.6\times10^7$; $df=22$; $I^2=100\%$), compared with the homeless sample, which had a prevalence of 27.0% (95% CI = 23.8%, 30.2%; Q = 869.35; $df=42$; $I^2=95.2\%$). There was no significant difference between the hypertension prevalence in the homeless sample and the general population, with or without adjustment for study year ($P=.48$ and $P=.45$, respectively).

The pooled prevalence of diabetes in the general population from 1980 to 2011 was 5.2% (95% CI = 4.6%, 5.9%; Q = 85.19; $df=22$; $I^2=63.6\%$), compared with the homeless sample, which had a prevalence of 8.0% (95% CI = 6.8%, 9.2%; Q = 245.93; $df=38$; $I^2=84.5\%$). We found a significantly higher prevalence of diabetes in the homeless sample than the general population in unadjusted analysis (coefficient = 0.026; 95% CI = 0.008, 0.044; $P=.006$). However, after we adjusted for study year, this difference was no longer significant ($P=.80$).

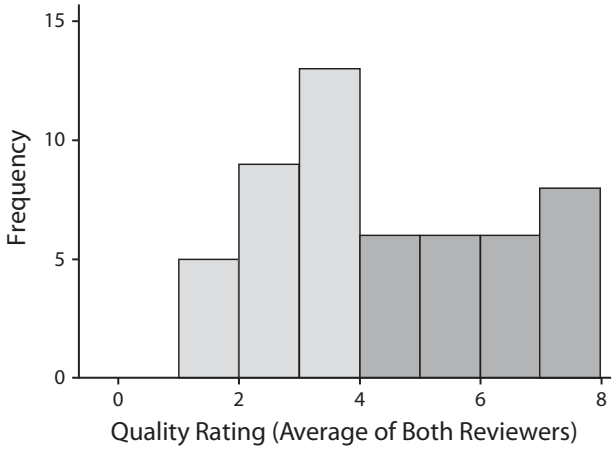
Trends in Disease Prevalence Over Time

The prevalence of hypertension was found to be increasing over time, by study year, in both the homeless data set and in the general population ($P<.001$ for both groups). Likewise, the prevalence of diabetes was also found to be increasing over time ($P=.02$, homeless sample, and $P<.001$, general population).

The estimate provided by meta-regression is an absolute increase in diabetes prevalence of about 0.2% per year and in hypertension of 0.4% per year. However, the rates of increase in disease prevalence between the homeless and general population were not statistically different in either the diabetes or hypertension prevalence analyses ($P=.06$ and $P=.34$, respectively; Figures 4 and 5).

DISCUSSION

Among homeless American adults, approximately 27% have hypertension and 8% have diabetes mellitus. Our sample included an overrepresentation of men and African Americans, mirroring the general homeless population in the United States.[30] There is evidence that the prevalence of both diseases is increasing as this population ages. Given the observed trends of increasing prevalence of both hypertension and diabetes in the homeless and general populations over the past 30 years, a simple comparison between prevalence in both groups could



Note. We included 53 studies in the analysis.

FIGURE 3—Distribution of quality ratings of included studies using modified Loney tool.[41]

TABLE 7—Quality Assessment Component Effects on Prevalence of Diabetes and Hypertension in Homeless Adults in the United States, 1980–2014

Reported Prevalence, Item Score (1 vs 0)	Coefficient (SE)	*P*
Diabetes		
Probability sample	-0.038 (0.019)	.054
Sampling frame	-0.042 (0.019)	.033*
Sample size	-0.034 (0.023)	.152
Diagnostic methods	0.023 (0.041)	.573
Consistent methods	-0.019 (0.045)	.679
Response rate	-0.003 (0.029)	.908
Statistical methods	-0.048 (0.028)	.096
Subgroups	-0.020 (0.023)	.407
Applicability	-0.053 (0.020)	.011*
Hypertension		
Probability sample	-0.116 (0.046)	.015*
Sampling frame	-0.055 (0.049)	.273
Sample size	-0.040 (0.066)	.545
Diagnostic methods	0.049 (0.099)	.619
Consistent methods	0.150 (0.081)	.072
Response rate	-0.100 (0.061)	.106
Statistical methods	0.029 (0.065)	.658
Subgroups	-0.016 (0.055)	.770
Applicability	-0.097 (0.051)	.062

*$P < .05$.

TABLE 8—Meta-regression of Variables Contributing to Heterogeneity in Hypertension and Diabetes Prevalence in Homeless Adults in the United States, 1980–2014

Variable	Diabetes (Reported)		Hypertension (Reported)	
	Coefficient (SE)	*P*	Coefficient (SE)	*P*
Retrospective versus prospective	0.046 (0.035)	.193	-0.059 (0.061)	.34
Region (Ref: East Coast)				
Midwest	0.002 (0.040)	.958	-0.063 (0.069)	.372
South	0.012 (0.031)	.694	0.016 (0.077)	.835
West Coast	-0.014 (0.026)	.592	-0.004 (0.063)	.955
National	0.007 (0.040)	.84	-0.004 (0.080)	.957
Sample selection method (Ref: census)				
Convenience	0.010 (0.028)	.732	0.044 (0.062)	.48
Probability	-0.027 (0.026)	.321	0.010 (0.061)	.877
Unspecified	-0.010 (0.034)	.748	0.084 (0.081)	.307
Age, mean of sample	0.005 (0.001)	<.001	0.011 (0.002)	<.001
Year of publication[a]	0.002 (0.000)	<.001	0.004 (0.001)	.016
Year of publication, adjusted for age	0.001 (0.001)	.382	0.002 (0.002)	.511
Male, % of sample	-0.024 (0.036)	.507	0.055 (0.083)	.511
Race/ethnicity, % of sample				
African American	-0.035 (0.055)	.533	0.012 (0.126)	.924
White	-0.079 (0.056)	.171	-0.099 (0.120)	.419
Other	0.154 (0.061)	.018	0.037 (0.133)	.782
With health insurance, % of sample	0.125 (0.029)	<.001	0.244 (0.149)	.12
Chronically homeless, % of sample	0.076 (0.035)	.068	0.172 (0.182)	.365
Prevalence of depression	0.215 (0.079)	.018	0.195 (0.234)	.422
Prevalence of alcohol abuse	-0.112 (0.152)	.471	0.099 (0.211)	.645
Prevalence of drug abuse	-0.116 (0.070)	.119	0.032 (0.202)	.877
Prevalence of tobacco use	0.097 (0.198)	.633	0.147 (0.255)	.576

[a]Excluding studies of only older adults.

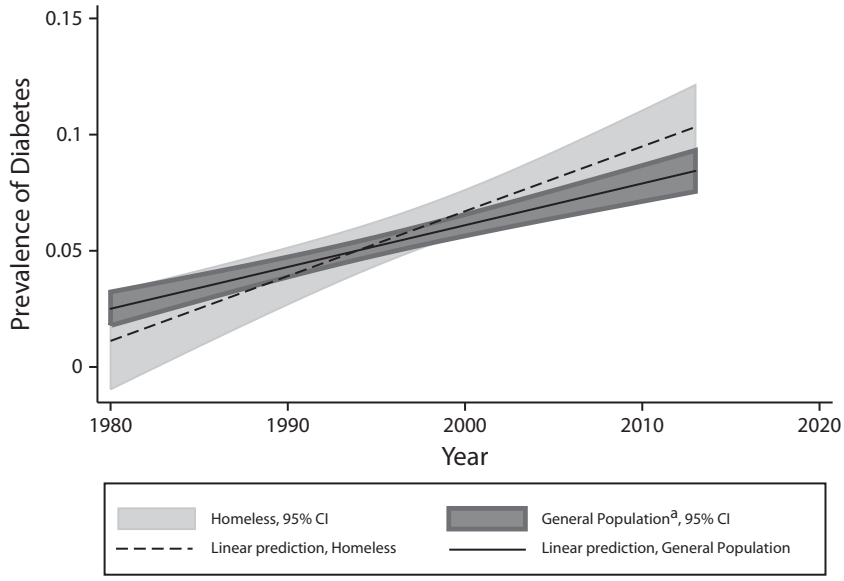
not be made without considering the change over time. Our data suggest a widening gap in the rate of increase of diabetes and hypertension between the homeless and general population. This is an expected consequence of the aging of the homeless population relative to the general US population.

We did not find a significant difference in the overall pooled prevalence of diabetes or hypertension between the homeless and general population, nor a statistically significant difference in the change in prevalence over time between the 2 groups. There is inadequate data in this study to evaluate whether there are differences in prevalence at the present time. The power of meta-regression to compare these 2 groups is limited, however, given the heterogeneity of the prevalence estimates in the homeless population. The question of comparing disease prevalence rates between the homeless and general populations would be an important area for further investigation by direct comparison.

We did not find a significant difference in hypertension or diabetes prevalence between estimates from patient self-report and estimates derived from measurement of blood pressure or blood sugar. This finding could have important implications for future research of these diseases in the homeless by decreasing the complexity and expense incurred by taking physiological measurements. However, the limited available data would suggest caution in accepting this finding.

There were few studies that screened for diabetes or hypertension by using physiological measurement, presented data from treating physician diagnosis, or confirmed previous diagnosis with a rigorous methodology. A single random glucose measurement, the method used in the available screening studies, is considered an acceptable method of diabetes screening only if accompanied by classic symptoms of hyperglycemia.[96] Because of its low sensitivity of 39% to 55%,[98] it is the least preferred method of screening when compared with fasting glucose, oral glucose tolerance testing, or hemoglobin A1C. The studies that used physiological measurement to estimate hypertension prevalence also had limitations that made them less likely to detect a higher prevalence than estimates based on self-report. Those with normal blood pressure measurements who were taking antihypertensive medications were not counted as having hypertension in all of the studies, and 1 study only reported blood pressure measurements with a threshold above 160/90 mm Hg.[18] None of the studies measured blood pressure on separate occasions, as recommended in establishing the diagnosis.

In the general population, approximately one third of patients with diabetes and one fifth of people with hypertension are unaware of their diagnosis.[29,99] With the numerous challenges faced by the homeless in receiving medical care, it is likely that unawareness may be even higher in this population. This is supported by this study's finding that those with health insurance, who have less financial barrier to accessing health care, are more likely to self-report a diagnosis of diabetes than those without health insurance. Thus, the reported prevalence of both diseases presented in this analysis is likely to underreport the actual disease prevalence. Determination of the rate of underdiagnosis of these conditions in the homeless population would be a subject for further research. The recent introduction of random A1C for diabetes screening,



Note. CI = confidence interval.
[a]Data are from the National Health Interview Survey.[44]

FIGURE 4—Prevalence of self-reported diabetes in homeless and nonhomeless adults in the United States: 1980–2014.

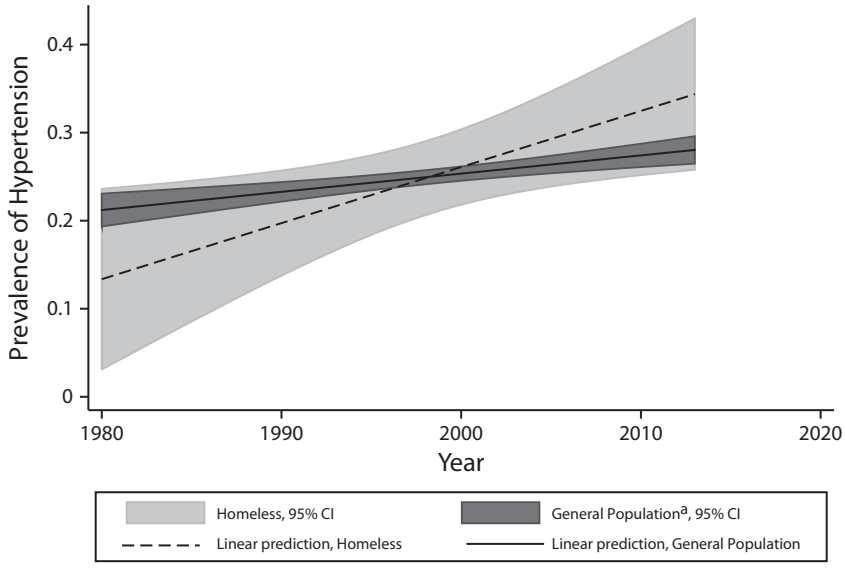
without requirement of fasting or glucose tolerance testing, helps to simplify diabetes screening in future research in the homeless.

This study adds to the growing body of evidence of the aging of the homeless population. Despite the limitations of using mean sample age as the observation level, we observed a clear trend over the past 30 years. Over this period, homeless adults, as a group, appear to be aging at the rate of almost 6 months per year, similar to the estimates provided by other studies.[14,100] One significant advantage of the estimate provided by this project compared with others that have described the aging trend is the systematic review yielded a broad data sample, including different regions of the country, a variety of settings, and multiple homeless subpopulations.

Furthermore, this study begins to explore the impact of the aging trend on the prevalence of chronic diseases. As expected, hypertension and diabetes prevalence have increased over the past 3 decades. Over the next decade, as the homeless population continues to age, this may translate into dramatic increases in cardiovascular disease and diabetic complications. This growing disease burden will have a critical impact not only on affected homeless individuals, but also on safety net primary care providers, hospitals, homeless service programs including medical respite care, Medicaid agencies, and others.

Although not explored in this study, there is likely an increase in rates of other chronic diseases. The relatively high rates of chronic respiratory diseases are similar to rates in other literature,[101] and are likely associated with the well-known high rates of smoking among homeless adults.[6] The sample participants also had high rates of mental health and substance use diagnoses. Taken together, these findings are consistent with previous research identifying causes of (or determinants of) premature mortality of the homeless population.

This systematic review demonstrates a broad literature base investigating chronic diseases experienced by homeless adults,



Note. CI = confidence interval.
Source. Data are from the National Health Interview Survey.

FIGURE 5—Prevalence of self-reported hypertension in homeless and nonhomeless adults in the United States: 1980–2014.

TABLE 9—Age Distribution of Participants From Included Studies Compared With General Population Sheltered Adults: United States, 1980-2014

Age, Years	Meta-analysis Sample,[a] %	2012 Sheltered Homeless Population (Adults Only),[16] %
18–30	4.4	30.4
31–50	73.3	45.3
51–61	17.8	20.2
≥62	4.4	4.1

[a]Percentages listed are of sample mean ages.

including some large and methodologically rigorous studies. The included studies targeted a wide variety of homeless subpopulations, including young women raising children, single men, the chronically homeless, older homeless adults, clinic patients, unsheltered homeless, and several racial or ethnic subgroups. The overall sample has excellent applicability to the general homeless population.

Limitations

Participants in the meta-analysis sample may be somewhat older than the general homeless population, as captured in the 2012 Annual Homeless Assessment Report (Table 9). This difference lies in the relative proportions of adults aged 30 years and younger versus those aged between 31 and 50 years in the meta-analysis sample. As such, it is not affected by the inclusion of 5 studies targeting older adults. The proportion of the homeless population aged 51 years and older in the meta-analysis sample is actually slightly lower than in the general population.

It is possible that the 16 clinic-based studies included skewed the sample toward middle-aged adults, who are more likely to have medical conditions that cause them to seek care. This may result in higher pooled prevalence rates of diabetes and hypertension than in the true homeless population. Of note, the true age distribution of the meta-analysis sample is only estimated by the distribution of sample mean age given in Table 9.

The quality of the pooled estimate is constrained by the quality of the studies included in the analysis. Likewise, certain variables that would have been useful for heterogeneity analysis, such as rates of obesity, were unavailable. The relatively higher number of young adults relative to middle-aged adults and higher prevalence of chronic homelessness should be considered before one generalizes these results to the entire homeless adult population; furthermore, because of the heterogeneity of the homeless population, generalizability to all subgroups is difficult. The majority of available studies used self-reported data. Finally, all included studies used a cross-sectional design; causality between homelessness and having a diagnosis of hypertension or diabetes cannot be inferred.

Important findings of this study, namely that hypertension and diabetes rates in the aging homeless population are increasing, are particularly salient in light of recent changes in our health care system. Through the Affordable Care Act and Medicaid expansion in 28 states, including Washington, DC, homeless individuals are experiencing increased access to health insurance. A recent study comparing health service utilization in chronically homeless persons with and without health insurance[100] has demonstrated increased use of outpatient medical services and preventive care among homeless individuals with insurance. Furthermore, a significant randomized controlled study assessing the impact of receiving Medicaid on the uninsured found that newly obtaining Medicaid is associated with receiving a new diagnosis of diabetes.[102] Major efforts will be needed to encourage newly eligible homeless adults to enroll in Medicaid, to increase availability of primary care providers for this population, to encourage clinicians to screen for these and other conditions in newly insured homeless, and to continue efforts to address the many other nonfinancial barriers to ongoing chronic disease management for the homeless.

Conclusions

In this systematic review and meta-analysis of the prevalence of hypertension and diabetes in homeless adults, we found that both conditions have had increasing prevalence over the past 30 years. These differences are, to a large extent, attributable to the aging of the homeless population. This study builds upon the existing literature regarding this aging trend by drawing from a broad sample and directly linking aging trends to chronic disease rates. With heterogeneity analyses, we identified several other factors that contribute to variations in estimated diabetes prevalence, including insurance status and depression.

Although the homeless population today has significant unmet health needs, which contribute to devastatingly premature morbidity and mortality, this study suggests that over the next 2 decades there will be an increasing burden of cardiovascular disease in this population. Increased access to Medicaid will help reduce financial barriers to care, but the many remaining barriers will need attention. Preventive measures such as improving nutritional content in meal programs, increasing the availability of treatment of alcohol abuse, and encouraging physical activity may help decrease the incidence of new hypertension and diabetes. Efforts are urgently needed to increase access to care for the homeless individuals who already have diabetes or hypertension, and to prevent future disease. ■

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Contributors

R. S. Bernstein originated and designed the study, led data collection, performed data analyses, and led the writing. L. N. Meurer supervised the study, contributed to study design, assisted in data collection, and assisted with writing and revising. E. J. Plumb assisted with data collection and revised the article. J. L. Jackson supervised the study, contributed to study design, assisted in data collection, supervised and assisted in analysis, and assisted in writing and revising.

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Note. The article's contents are solely the responsibility of the authors and do not necessarily represent the official views of the National Institutes of Health.

Human Participant Protection

This study, which used only published group-level data, did not constitute human participants research and did not undergo review by an institutional review board.

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