Diabetes care and its predictors among persons experiencing homelessness compared with domiciled adults with diabetes in New York City; An observational study

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Summary

Background There is a dearth of data regarding diabetes control among patients experiencing homelessness

Methods We retrospectively collected type 2 diabetes-related measurements, sociodemographic, and clinical indicators from medical records of all incoming adults with diabetes (n = 418; homeless: 356 and domiciled: 58) seen in shelter-clinics in New York City in 2019. The outcomes were the rates of inadequately managed diabetes and associated factors.

Findings Bivariate analysis showed that patients experiencing homelessness (63% Black; 32% Hispanic) 134/304 (43·9%) were more likely than domiciled patients 13/57 (22·8%) to have inadequately managed diabetes (OR 2·67, CI 1·38−5·16, p = 0·003). The average HbA1c among homeless (8·4%, SD± 2·6) was higher than that of domiciled persons (7·3%, SD± 1·8, p = 0·002). In logistic regression, domiciled status (OR 0· 42, CI 0·21 − 0·84, p = 0·013), older age (OR 0·97, CI 0·95 − 0·99, p = 0·004), and non-Hispanic/Latino ethnicity were associated with well-managed diabetes. Among persons experiencing homelessness, non-Hispanic/Latino (OR 0·61, CI 0·37−0·99, p = 0·047) and older age (0·96, CI 0·94−0·99, p = 0·003) were associated with well-managed diabetes. In linear regression, mental illness (-0·11, p = 0·048) and older age (-0·15, p = 0·010) were associated with lower HbA1c, suggesting better support in respective shelters. There was no statistically significant association between inadequately managed diabetes with several traditional risk factors including substance or alcohol use disorder, health insurance, or other chronic diseases.

Interpretation Interventions at shelters or shelter-clinics should target subgroups in addition to addressing traditional risk factors to improve diabetes control. mHealth strategies could be considered to improve engagement, care delivery, and medication taking. Ultimately, homelessness itself needs to be addressed.

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Keywords: Diabetes mellitus; Primary care; Quality care; Homeless; Health disparities

Introduction

Worldwide, over 100 million people, including millions of Americans, experience homelessness each year.[1−3] The population of adult persons experiencing homelessness is aging, and the risk for chronic diseases among this population is rising.[4] Persons experiencing homelessness are at the same risk for developing diabetes mellitus (DM) compared to the general population.[5−9] Diabetes management in persons experiencing

Abbreviations: HbA1c, hemoglobin A1c; DM, diabetes mellitus; BMI, body mass index; LDL, low density lipoprotein; GFR, glomerular filtration rate; CKD, chronic kidney disease; CAD, coronary artery disease; BP, blood pressure; HTN, hypertension; PCP, primary care physician

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Research in context

Evidence before this study

Homelessness is a widespread social problem and patients experiencing homelessness are subject to multi-level barriers that affect healthcare. Limited studies suggest that patients experiencing homelessness are at equal or higher risk of developing diabetes mellitus as compared to the general population and are at higher risk for diabetes-related complications. There is still a dearth of data to characterize diabetes management in patients experiencing homelessness, and diabetes control strategies have not been studied in this marginalized population.

Added value of this study

To our knowledge, this is one of few studies to characterize diabetes and predictors of inadequately managed diabetes in a population of patients experiencing homelessness compared with domiciled patients. Our results show that patients experiencing homelessness are at much higher risk for inadequately managed diabetes than underserved domiciled patients. Although there were several traditional risk factors associated with inadequately managed diabetes in bivariate analysis, most did not retain significance in multivariable analysis. Based on our findings, housing status, ethnicity, and age were independent risk factors for diabetes management. Patients with mental health had better managed diabetes which we hypothesized was possibly due to mental health medication adherence services in the shelters. Homelessness itself likely masks the impact of other traditional risk factors for inadequately managed diabetes.

Implications of all the available evidence

Diabetic patients who experience homelessness are at higher risk for inadequately managed diabetes than domiciled patients. Adapted strategies, such as health facility- and shelter-level interventions or mHealth solutions, could be of significant benefit to support these patients in the management of diabetes. Nevertheless, addressing homelessness itself as an important social factor should not be overlooked in the care of chronic diseases among patients experiencing homelessness.

homelessness has not been well-studied.[10,11] Persons experiencing homelessness with diabetes have a higher rate of emergency room visits and hospital admissions for diabetes complications than domiciled adults.[12] Persons experiencing homelessness experience mental illness or substance misuse, encounter discrimination and stigma within the healthcare system, and face barriers to accessing primary care and achieving therapeutic lifestyle changes.[13–15]

Generic diabetes management strategies have been evaluated and established in the general population, but they have not yet been assessed or adapted among patients experiencing homelessness. Limited qualitative studies have demonstrated barriers to optimal diabetes management among persons experiencing homelessness, including prioritizing diabetic care, diabetes-related expenses, limited access to healthy food, and inadequate health resources.[16] Additional barriers such as competing demands, substance abuse, and stress could complicate diabetes management in this population.[17] There is a paucity of data regarding the rates and predictors of inadequate diabetes management among people experiencing homelessness. This study aims to assess diabetes control and rates and predictors of diabetes that is not well-managed among patients experiencing homelessness compared with those of domiciled patients who receive medical care at New York City's shelter-clinics. The results will guide interventions aimed at improving diabetes management among this vulnerable population.

Methods

Population studied

The Community Medicine Program of New York University School of Medicine supports multiple clinics throughout New York City including shelter-based clinics which provide medical services to the population who experience homelessness. Clinics operate on weekdays and provide a wide range of primary care services including general medicine, psychosocial and substance abuse services, onsite laboratories and a wide range of health promotion activities. Services are offered free of charge to persons who experience homelessness and medications are available free of charge through the state-run public insurance, Medicaid. Providers include internists, family physicians, nurse practitioners, social workers and mental health providers such as psychiatrists and psychologists. A few clinics also have medical students and resident physicians. The clinics use electronic medical records that are shared across all community medicine clinics. Community medicine clinics offer medical services to around 7000–8000 patient-visits per year. Shelter-clinics are also open and available to non-homeless individuals who are often from low-income surrounding communities. We retrospectively reviewed the medical records of all incoming, unique patients to the shelter clinics with the diagnosis of diabetes to determine and compare the rates of inadequately managed type 2 diabetes between persons experiencing homelessness and domiciled patients with diabetes who sought care at the shelter clinics. We evaluated sociodemographic factors and clinical indicators to identify those associated with inadequately managed diabetes.

Patients on average have 3–4 visits per year. However, this may differ widely for the homeless persons

who may use the clinic services from somewhere between a month to 12 months depending on their living arrangement. We accessed electronic medical records to identify all incoming patients with a diagnosis of type 2 diabetes who were seen for an appointment between January 2019 and December 2019 in the shelter-clinics. Inclusion criteria included patients with diabetes age 21 and above who received care at Community Medicine's shelter-clinics during 2019. We extracted the most recent hemoglobin A1c (HbA1c) and blood glucose levels in 2019. As a standard clinical practice, the most recent values are used to adjust the clinical management for a patient with diabetes. HbA1c was considered inadequately managed when 8% or greater. While stringent glycemic control (HbA1c <7%) is recommended for non-pregnant adults, less stringent A1c goals (HbA1c <8%) may be appropriate for patients with risk of hypoglycemia, older patients with diabetes, extensive co-morbidity, longstanding DM or in people who may have more difficulty in diabetes management.[18] We also collected sociodemographic information and clinical indicators recorded during 2019, including age, race, gender, health insurance status, housing status, duration of homelessness, most recent body mass index (BMI), glomerular filtration rate (GFR), lipid levels, and blood pressure readings. We also recorded active chronic diseases including hypertension, chronic kidney disease, coronary artery disease, hyperlipidemia, tobacco use, alcohol and other substance use disorders, and mental illnesses including mood disorders, anxiety disorders, and psychosis.

Homelessness is not a well-defined term. Housing status was ascertained through a combination of factors including determination by the Department of Homeless Services, social security information, and medical record review as self-reported status. Duration of homelessness was recorded if indicated in the medical records. Blood pressure was evaluated based on the Eighth Joint National Committee Guidelines for the Management of Hypertension in Adults. A data extraction checklist/tool was created in Excel. One trained research team member reviewed all medical records and extracted data. The same researcher double-checked the data for accuracy one more time. A random sample of medical records was double-checked for data accuracy by a second researcher. The research team discussed and reviewed the definitions for indicators/co-variates and potentials for measurement errors. They devised appropriate processes to decrease measurement errors because the data was from medical records and collected and documented by multiple providers. This helped to improve consistency in definition and measurements to the extent that was possible. In cases that one indicator/covariate was documented inconsistently throughout the medical records, the most recent documentation and/or the most commonly used form of documentation was used and recorded. These processes were consistently applied to any specific indicator/covariate obtained from all medical records. (For example, if during three visits in 2019 a person indicated different number of cigarettes a day or different number of episodes of homelessness etc.). The shelter clinics are primarily based in the shelters but also accessible to non-sheltered individuals who are from low-income surrounding communities or individuals who are no longer homeless but continue to see their established providers. Therefore, while an overwhelming number of patients seen in these clinics are the ones who are currently homeless, there are other non-homeless patients seen in the clinics.

Study outcomes and statistical analyses

The primary outcome was the rate of inadequately managed diabetes in persons experiencing homelessness and domiciled patients. Diabetes management was evaluated by HbA1c level (both measured as a dichotomous variable with threshold of HbA1c <8% as well as a continuous measure). We collected sociodemographic factors and clinical indicators associated with inadequately managed diabetes in persons experiencing homelessness and domiciled populations. The HbA1c level was measured as a percentage using either lab-analyzed blood samples or point-of-care testing. Continuous variables were duration of homelessness (years), age (years), BMI (kg/m^2), blood glucose (mg/dL), total cholesterol (mg/dL), low-density lipoprotein (mg/dL), systolic and diastolic BP (mmHg), glomerular filtration rate (mL/minute), number of chronic diseases and mental illnesses, and number of daily cigarettes. All other independent variables were categorical.

We calculated and reported the numbers and proportions of primary outcomes and associated factors. Descriptive statistics, univariate and bivariate analysis using χ^2, student *t*-test as well as logistic regression with adjusted odd ratios with 95% Confidence Interval (CI) were performed as indicated. Statistical significance was determined by the two-sided χ^2 or *t*-test. In logistic regression, potential confounders with a statistical significance of less than 0.1 in bivariate analysis or important clinical relevance were included in the model through a step-wise approach. We looked at the correlation of predictors with HbA1c level and their association with adequately versus inadequately managed diabetes in study participants. There are established processes in the clinics to include and document most clinical and sociodemographic data from different entry points consistent with the requirements at the City, State, and Federal government. Therefore, missing data for an overwhelming number of indicators was not a significant issue and we did not use any statistical data analysis to account for the potential impact of missing data. SPSS Version 25·0 was used for data analysis. We used STROBE guideline to report this observational study. This study was

retrospective and a secondary analysis of data from medical records of patients with diabetes seen in the community medicine clinics. There was no subject contact, and no informed consent was obtained for the purpose of this secondary data analysis. As part of the usual care in the clinics, all patients provided informed consent to care and for their de-identified data to be used for the purpose of research and evaluation. The Institutional Review Board of New York University School of Medicine approved this study (Protocol #: i19–01887).

Role of the funding source. There are no founding sources to declare.

Results

In this retrospective secondary analysis study, the total population studied was 418 patients, including 356 (85%) patients experiencing homelessness, 58 (14%) domiciled patients, and 4 (1%) patients of unknown housing status. All eligible subjects were included in the study and their data was analyzed. Due to logistical factors, not all sociodemographic and clinical indicators were available for all patients.

Comparison of findings between two groups, patients experiencing homelessness versus non-homeless

Tables 1–3 present findings and analysis of data among the overall homeless and non-homeless subgroups. Among the total population, the average age of participants was 50·4 years (standard deviation (SD)±10·2). Patients experiencing homelessness were more likely to be younger (average age 54·7 years, SD±9·6) than domiciled patients (average age 61·0 years, SD±11·7 years; $p < 0·001$). Most patients were male (319/416, 76·3%). Patients experiencing homelessness were more likely to be male (283/354, 79·9%,) than domiciled patients (33/58, 56·9%, 95% confidence interval (CI) 1·69–3·50; $p < 0·001$). Among the subgroup of patients experiencing homelessness, race and ethnicity data were as follows and compared with the rates among New York City's general population based on the United States Census Bureau 2019 estimates: African American (64·7% vs. 24·3%), Hispanic (31·9% vs. 29·1%), white (23·6% vs. 42·7%), and other (11·6%, vs. 18·3%). Patients experiencing homelessness were significantly more likely to be Black (200/309, 64·7%) than domiciled patients (21/52, 40·4%; $p = 0·005$). Among the total population, 8·7% were uninsured, with patients experiencing homelessness (35/352, 9·9%) significantly more likely to be without health insurance than domiciled patients (1/58, 1·7%; $p = 0·05$).

Patients experiencing homelessness were more likely to have inadequately managed diabetes (defined as A1c ≥ 8%) compared to domiciled patients (134/305, 43·9% vs. 13/57, 22·8%; OR 2·67, SD±1·38–5·16; $p = 0·003$). The mean HbA1c among patients experiencing homelessness was 8·4% (SD±2·60) compared to 7·3% (SD±1·80) among domiciled patients ($p < 0·001$). Among patients experiencing homelessness, 32·9% had a HbA1c of 9·0% or higher, compared to 10·5% of domiciled patients ($p = 0·003$). Patients experiencing homelessness had higher average random glucose levels than domiciled patients (198, SD±107 vs. 159, SD±89; $p = 0·01$). Patients experiencing homelessness were significantly more likely to have inadequately managed hypertension (defined as systolic blood pressure (SBP) ≥ 140 or diastolic blood pressure (DBP) ≥ 90) than domiciled patients (104/332, 31·3% vs. 8/57, 14·0%; OR 2·79, CI 1·28–6·11; $p = 0·008$). Patients experiencing homelessness compared with domiciled patients were less likely to have hyperlipidemia (177/355, 49·9% vs. 40/58, 69·0%; $p = 0·007$), though were more likely to have a most recent low-density lipoprotein (LDL) value over 100 (82/221, 37·1% vs. 8/47, 17·0%; $p = 0·008$). Patients experiencing homelessness were more likely to have active substance abuse compared to domiciled patients (81/350, 23·1%, vs. 4/56, 7·1%; OR 3·91; 95% CI 1·37–11·15; $p = 0·006$), and were more likely to smoke cigarettes compared to domiciled patients (191/349, 54·7%, vs. 19/56, 33·9%; OR 2·35, 95% CI 1·30–4·23; $p = 0·004$). Additional sociodemographic characteristics are and clinical indicators are included in Table 1.

Among the overall population, factors associated with inadequate diabetes management were shown in persons experiencing homelessness (OR 2·67, 95% CI 1·38–5·16, $p = 0·003$), Hispanic/Latino ethnicity (OR 1·57, 95% CI 1·01–2·45; $p = 0·05$), lack of primary care provider (112/215, 52·1%, vs. 99/147, 67·3%; $p = 0·001$), and higher total cholesterol (179 ± 45 vs. 162±39; $p = 0·001$).

In bivariate analysis with diabetes management measured with HbA1c as a continuous variable, older age (correlation coefficient -0·19; $p < 0·001$) was correlated with lower HbA1c. Ethnicity was not significantly associated with higher HbA1c, though the mean HbA1c was higher among Hispanic/Latino patients (8·5 ± 2·7 vs 8·1 ± 2·4; $p = 0·09$). Patients with mental illnesses had a lower average HbA1c compared to those without mental illness (8·0%, SD 2·40, vs. 8·5%, SD 2·59; $p = 0·03$). Additional bivariate analysis is included in Table 2.

In logistic regression of the total patient population when housing status, age, ethnicity, provider status, insurance status, history of hypertension, diastolic blood pressure, total cholesterol, history of mental illness, cigarette smoking, alcohol use disorder, chronic kidney disease, CAD, and sex were in the model, domiciled status (OR 0·42, 95% CI 0·21–0·84; $p = 0·01$), older age (OR 0·97, 95% CI 0·95–0·99; $p = 0·004$), and non-Hispanic/Latino ethnicity (OR 0·63, 95% CI 0·40–0·99; $p = 0·05$) were associated with adequately managed diabetes. In linear regression with HbA1c as a continuous

	Total (*N* = 418)	Experiencing Homelessness (*N* = 356)	Domiciled (*N* = 58)	*p*-value
Age, mean (SD)	54·9 (10·2)	54·7 (9·6)	61·0 (12)	<0·001
Sex, No· (%)	416/418 (99·5)	354/356 (99·4)	58/58 (100)	
Male	319/416 (76·3)	283/354 (79·9)	33/58 (57)	<0·001
Female	97/416 (23·2)	71/354 (20·1)	25/58 (43)	
Race No. (%)	365/418 (86·4)	309/356 (86·8)	52/58 (90)	
Black	223/365 (61·1)	200/309 (64·7)	21/58 (40)	0·005
White	100/365 (27·4)	73/309 (23·6)	25/58 (48)	
Asian	8/365 (2·2)	6/309 (1·9)	2/58 (4)	
Other	26/365 (7·1)	23/309 (7·4)	3/58 (6)	
>1 race	8/365 (2·2)	7/309 (2·3)	1/58 (2)	
Ethnicity, No. (%)	416/418 (98·6)	354/356 (99·4)	58/58 (100)	
Hispanic/Latino	136/416 (33·0)	113/356 (31·9)	23/58 (40)	0·25
Non-Hispanic/Latino	279/416 (67·0)	241/356 (68·1)	35/58 (60)	
Language, No. (%)	418/418 (100)	356/356 (100)	58/58 (100)	
English	376/418 (90·0)	318/356 (89·3)	54/58 (93)	0·63
Spanish	40/418 (9·6)	36/356 (10·1)	4/58 (7)	
Other	2/418 (0·5)	2/356 (0·6)	0/58 (0)	
Provider, No. (%)	418/418 (100)	356/356 (100)	58/58 (100)	
No primary care physician	258/418 (61·7)	251/356 (70·5)	5/58 (9)	<0·001
Shelter primary care physician	109/418 (26·1)	60/356 (16·9)	48/58 (83)	
Community primary care physician	51/418 (12·2)	45/356 (12·6)	5/58 (9)	
Insurance status, No. (%)	414/418 (99·0)	352/356 (98·9)	58/58 (100)	
Uninsured	36/414 (8·7)	35/352 (9·9)	1/58 (2)	0·05
Insured	378/414 (91·2)	317/352 (90·0)	57/58 (98)	
Medicaid/Medicare	369/414 (89·0)	311/352 (88·4)	54/58 (93)	0·13
Other insurance	9/414 (2·2)	6/352 (1·7)	3/58 (5)	
Inadequately managed DM, No. (%)	147/362 (40·7)	134/305 (43·9)	13/57 (23)	0·003
A1c level, No. (%)	362/418 (86·7)	305/356 (85·4)	57/58 (98)	
< 8	215/362 (59·6)	171/305 (56·3)	44/57 (77)	0·003
8·0 — 8·9	41/362 (11·1)	34/305 (10·9)	7/57 (12)	
≥ 9·0	106/362 (29·4)	100/305 (32·9)	6/57 (11)	
A1c, mean (SD)		8·4 (2·6)	7·3 (2)	<0·001
Glucose, mean (SD)		197·5 (107·0)	159·4 (89)	0·01
Obesity, No. (%)	176/413 (42·7)	154/356 (43·6)	21/57 (37)	0·34
Body mass index, mean (SD)	30·4 (7·5)	30·4 (7·7)	29·9 (6)	0·63
Hypertension, No. (%)	284/414 (68·4)	237/356 (66·6)	46/58 (79)	0·05
Uncontrolled hypertension (≥140/90), No. (%)	112/389 (28·8)	104/332 (31·3)	8/57 (14)	0·008
Systolic blood pressure, mean (SD)	130 (19·5)	130·2 (20·0)	127·0 (15)	0·25
Diastolic blood pressure, mean (SD)	79 (10·3)	79·2 (10·4)	75·9 (9)	0·02
Coronary artery disease, No. (%)	39/414 (9·4)	33/356 (9·3)	5/58 (9)	0·86
Chronic kidney disease, No. (%)	38/414 (9·2)	32/356 (9·0)	6/58 (10)	0·75
Glomerular filtration rate < 60, No. (%)	45/302 (14·9)	32/248 (12·9)	13/54 (24)	0·04
Glomerular filtration rate, mean (SD)		87·71 (29·75)	75·40 (23)	0·005
Hyperlipidemia, No. (%)	217/413 (52·5)	177/355 (49·9)	40/58 (69)	0·007
Low-density lipoprotein > 100, No· (%)	90/268 (33·6)	82/221 (37·1)	8/47 (17)	0·008
Total cholesterol, mean (SD)		171·81 (44·41)	152·84 (36)	0·005
Mental illness, No. (%)	206/409 (50·4)	179/352 (50·9)	27/57 (47)	0·63
Number mental illnesses, mean (SD)	0·6 (0·8)	0·65 (0·76)	0·61 (0·7)	0·73
Number chronic diseases, mean (SD)	3 (1·2)	2·96 (1·23)	3·26 (1)	0·08
Substance use disorder, No. (%)	85/406 (20·9)	81/350 (23·1)	4/56 (7)	0·006

Table 1 *(Continued)*

	Total (*N* = 418)	Experiencing Homelessness (*N* = 356)	Domiciled (*N* = 58)	*p*-value
Alcohol use disorder, No. (%)	32/405 (7·9)	32/348 (9·2)	0/57 (0)	0·02
Cigarette Smoking, No.(%)	211/405 (52·0)	191/349 (54·7)	19/56 (34)	0·004
Cigarettes per day, mean (SD)	5 (7)	5·0 (6·8)	3·7 (7)	0·19
Packyears, mean (SD)	8·2 (12·2)	8·36 (11·6)	6·21 (14)	0·31

***Table 1*: Demographics and baseline characteristics of patients experiencing homelessness and domiciled patients, New York City shelter-clinics, 2019.**
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variable, older age (standardized coefficient -0·19; $p < 0·001$) and mental illness (standardized coefficient -0·13; $p = 0·02$) were associated with lower HbA1c with an adjusted R-squared of 0·04.

Findings from patientsexperiencing homelessness

Tables 4 and 5 present analyses of data among the subgroup that experience homelessness. In bivariate analysis, factors associated with inadequately managed diabetes among patients experiencing homelessness are as follows. The average age of patients experiencing homelessness with inadequately managed diabetes was younger compared to that of patients with adequately managed diabetes (52·9 years, SD 9·1 vs. 56·4 years, SD 9·9; $p = 0·002$). Patients experiencing homelessness with inadequately managed diabetes (defined as HbA1c ≥ 8) were more likely to be of Hispanic/Latino ethnicity than patients experiencing homelessness with adequately managed diabetes (51/133, 38·3% vs. 46/169, 27·2%; OR 1·66, 95% CI 1·02–2·71; $p = 0·04$). Patients experiencing homelessness with inadequately managed diabetes were more likely to have higher total cholesterol than patients experiencing homelessness with adequately managed diabetes (180·3, SD 45·5 vs. 166·5, SD 40·5; $p = 0·01$). Patients experiencing homelessness with inadequately managed diabetes were less likely to have hypertension than those with adequately managed diabetes (83/133, 62·4% vs. 125/171, 73·1%, OR 0·57, 95% CI 0·36–0·95; $p = 0·03$); however, they were not different in hypertension management considering the most recent blood pressure readings with SBP ≥140 or DBP ≥ 90 (OR 1·28, 95% CI 0·74–2·26; $p = 0·40$).

In bivariate analysis with diabetes management with HbA1c as a continuous variable, older age was associated with lower HbA1c, with a correlation coefficient of -0·11 ($p = 0·02$). Increased total cholesterol was correlated with higher HbA1c, with a correlation coefficient of 0·21 ($p = 0·001$). However, Hispanic/Latino compared with non-Hispanic/Latino ethnicity lost its significance with HbA1c as a continuous variable (8·9 ± 2·8 vs. 8·3 ± 2·6; $p = 0·06$). Patients with mental illness had lower average HbA1c compared with those without mental illness (8·15%, SD 2·48 vs. 8·74%, SD 2·66; $p = 0·05$). Notably, traditional risk factors such as insurance status and several other clinical indicators were not significantly associated with inadequately managed diabetes or HbA1c as a continuous variable. Additional bivariate analysis is included in Table 4.

In logistic regression when housing status, age, ethnicity, provider status, insurance status, history of hypertension, diastolic blood pressure, total cholesterol, history of mental illness, cigarette smoking, alcohol use disorder, chronic kidney disease, CAD, and sex were in the model, non-Hispanic/Latino ethnicity (OR 0·61, 95% CI 0·37–0·99; $p = 0·05$) and older age (0·96, 95% CI 0·94–0·99; $p = 0·003$) maintained significant association with adequately managed diabetes mellitus. In linear regression, mental illness (standardized coefficient -0·11; $p = 0·05$) and older age (standardized coefficient -0·15; $p = 0·01$) were associated with lower HbA1c with adjusted R-squared of 0·049. Hispanic/Latino ethnicity lost its significance with higher HbA1c (standardized coefficient 0·10; $p = 0·07$). Multivariable regression analysis data is included in Table 5.

Discussion

Previous studies have documented equal or higher prevalence of diabetes among subgroups of persons experiencing homelessness (i.e., veterans) compared with that of the general population.[5–9] In our study, the rate of inadequately managed diabetes (HbA1c ≥8) among patients experiencing homelessness (43·9%) is nearly twice the rate among domiciled patients (22·8%) who are already from low socio-economic communities. Moreover, the very high rate of HbA1c level above 9% among patients experiencing homelessness (32%) is alarming. Few other studies have documented relatively high rates of inadequately managed diabetes among patients experiencing homelessness, including 32% (HbA1c > 8%) and 50% (A1c> 7·3%) compared with 20% among domiciled persons with diabetes, which were significant across ethnicity and race.[10–11] Considering the higher prevalence of other important risk factors for cardiovascular events such as inadequately managed hypertension, hyperlipidemia, and cigarette smoking among patients experiencing homelessness shown in our study and other literature, effective treatment and better diabetes management among patients experiencing homelessness gains even more importance.[19–20]

	N (%)	Adequately managed DM (*N* = 215)	Inadequately managed DM (*N* = 147)	OR	95% CI	*p*-value
Persons with homelessness, No. (%)	304/361 (84·2)	170/214 (79·4)	134/147 (91·2)	2·67	1·38–5·16	0·003
Age, mean (SD)	362 (100)	57·6 (10·5)	53·5 (9·4)			<0·001
Sex, No· (%)	360/362 (99·4)	215/215 (100)	145/147 (99·3)			
Male	279/360 (77·5)	161/215 (74·9)	118/145 (81·4)	1·47	0·87–2·46	0·15
Female	81/360 (22·5)	54/215 (25·1)	27/145 (18·6)			
Race, No· (%)	318/362 (87·8)	194/215 (90·2)	124/146 (84·9)			
Black	190/318 (59·7)	116/194 (59·8)	74/124 (59·7)			0·28
White	90/318 (28·3)	53/194 (27·3)	37/124 (29·8)			
Asian	8/318 (2·5)	7/194 (3·6)	1/142 (0·8)			
Other	33/318 (10·4)	12/194 (6·2)	11/142 (8·9)			
>1 race	7/318 (2·2)	6/194 (3·1)	1/124 (0·8)			
Ethnicity, No· (%)	360/362 (99·4)	214/215 (99·5)	146/147 (99·3)			
Hispanic/Latino	119/360 (33·1)	62/214 (29·0)	57/146 (39·0)	1·57	1·01–2·45	0·05
Non-Hispanic/Latino	241/360 (66·9)	152/214 (71·0)	89/146 (61·0)			
Language, No· (%)	362/362 (100)	215/215 (100)	147/147 (100)			
English	323/362 (89·7)	192/215 (89·3)	131/147 (89·1)			0·48
Spanish	37/362 (10·3)	21/215 (9·8)	16/147 (10·9)			
Other	2/362 (0·6)	2/215 (0·9)	0/147 (0·0)			
Provider, No· (%)	362/362 (100)	215/215 (100)	147/147 (100)			
No primary care physician	211/362 (58·3)	112/215 (52·1)	99/147 (67·3)			0·001
Shelter primary care physician	106/362 (29·3)	79/215 (36·7)	27/147 (18·4)			
Community primary care physician	45/362 (12·4)	24/215 (11·2)	21/147 (14·3)			
Insurance Status, No· (%)	356/362 (98·3)	211/215 (98·1)	145/147 (98·6)			
Insured	327/356 (91·9)	197/211 (93·4)	130/145 (89·7)	0·62	0·29–1·32	0·21
Uninsured	29/356 (8·1)	14/211 (6·6)	15/145 (10·3)			
Obesity, No· (%)	161/359 (44·8)	100/213 (46·9)	61/146 (41·8)	0·81	0·53–1·24	0·33
Body mass index, mean (SD)	358 (98·9)	31·01 (7·96)	30·11 (6·89)			0·27
Hypertension, No· (%)	254/362 (70·2)	159/215 (74·0)	95/147 (64·6)	0·64	0·41–1·01	0·06
Uncontrolled hypertension (≥140/90), No· (%)	88/252 (34·9)	52/159 (32·7)	36/93 (38·7)	1·30	0·76–2·21	0·34
Systolic blood pressure, mean (SD)	360 (99·4)	130·6 (18·3)	129·6 (20·6)			0·96
Diastolic blood pressure, mean (SD)	360 (99·4)	78·0 (9·4)	79·8 (10·9)			0·09
Coronary artery disease, No· (%)	34/359 (9·5)	17/212 (8·0)	17/147 (11·6)	1·51	0·74–3·06	0·25
Chronic kidney disease, No· (%)	33/362 (9·1)	23/215 (10·7)	10/147 (6·8)	0·61	0·28–1·33	0·21
Glomerular filtration rate< 60, No· (%)	43/293 (14·7)	30/180 (16·7)	13/113 (11·5)	0·65	0·32–1·31	0·22
Glomerular filtration rate, mean (SD)	292 (80·7)	85·3 (29·1)	87·5 (28·9)			0·53
Hyperlipidemia, No· (%)	196/361 (54·3)	120/215 (55·8)	76/146 (52·1)	0·86	0·56–1·31	0·48
Low-density lipoprotein > 100, No· (%)	89/267 (33·3)	51/166 (30·7)	38/101 (37·6)	1·36	0·81–2·29	0·25
Low-density lipoprotein, mean (SD)	273 (75·4)	87·7 (34·2)	92·6 (36·0)			0·26
Total cholesterol, mean (SD)	289 (79·8)	162·2 (39·7)	179·2 (45·3)			0·001
Mental illness, No· (%)	149/357 (41·7)	113/211 (53·6)	66/146 (45·2)	0·72	0·47–1·09	0·12
Number mental illnesses, mean (SD)	340 (93·9)	0·7 (0·86)	0·6 (0·7)			0·23
Number chronic diseases, mean (SD)	358 (98·9)	3·1 (1·2)	2·9 (1·3)			0·41
Substance use disorder, No· (%)	72/355 (20·3)	41/210 (19·5)	31/145 (21·4)	1·12	0·66–1·89	0·67
Alcohol use disorder, No· (%)	21/353 (5·9)	10/208 (4·8)	11/145 (7·6)	1·65	0·68–3·98	0·27
Cigarette smoking, No· (%)	184/354 (52·0)	102/210 (48·6)	82/144 (56·9)	1·4	0·91–2·15	0·12
Cigarettes per day, mean (SD)	330 (91·2)	4·5 (6·7)	5·2 (7·0)			0·36
Packyears, mean (SD)	228 (63·0)	7·3 (11·4)	9·5 (13·7)			0·19

***Table 2*: Bivariate analysis of adequately versus inadequately managed diabetes mellitus (HbA1c ≥ 8) among persons experiencing homelessness and domiciled patients, New York City shelter- clinics, 2019.**
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Substance and alcohol use disorder have been discussed as potential factors in inadequate diabetes management[17]; however, we did not document this in our total study population or subgroup of persons experiencing homelessness. Obesity was not independently associated with inadequately managed diabetes

	Odds ratio/ standardized coefficient*	95% CI	*p*-value
Housing status (housed)	0·42	0·21 – 0·84	0·01
Ethnicity (non-Hispanic/Latino)	0·63	0·40 – 0·99	0·05
Age (older)	0·97	0·95 – 0·99	0·004

***Table 3*: Multivariable logistic regression analysis of independent variables and inadequately managed DM (HbA1c ≥ 8) among persons experiencing homelessness and domiciled patients, New York City shelter-clinics, 2019.**

* Please see limitations regarding the interpretation of results of logistics regression.

among the total population or the subgroup of persons experiencing homelessness likely because of a high level of obesity in our study population. A significant number of our study population also had hypertension, which is consistent with our previous study of uncontrolled hypertension among patients experiencing homelessness.[21] There was no statistically significant association between mental illness and inadequately managed diabetes. On the contrary, within population of persons experiencing homelessness, those with mental illness had lower HbA1c levels independent of other risk factors, which we hypothesize was possibly due to increased support and supervision surrounding medication taking and engagement within the shelter system for patients with mental illness. This would suggest that developing medication taking strategies for persons experiencing homelessness with diabetes at the shelter level could improve diabetes management. The impact of lack of housing itself as an important social factor likely masks the association of many traditional risk factors with diabetes care as it more strongly affects access to care, medication taking and engagement, and healthcare support. We did not directly collect data on adherence, but we hypothesize that less adherence to medications or diet due to limited access to healthy food choices or exercise opportunities during homelessness could contribute to inadequate diabetes management.[16–17]

Among the overall study population as well as the subgroup patients experiencing homelessness, younger age was associated with higher HbA1c, which is different from the expected relationship between age and A1c level.[22] We hypothesize that older patients experiencing homelessness have had more time to develop potential coping strategies to manage some of the social barriers to diabetes management. Additionally, Hispanic/Latino ethnicity was associated with inadequate diabetes management, which we hypothesize is due to language barriers and sociocultural issues that are not adequately addressed.[23]

Using shelters, where many patients experiencing homelessness reside,[3] as the place of health interventions as well as other social supports could help address the multilevel barriers to diabetes management, such as poor diet, access to medications and cost of diabetic care, inadequate healthcare resources and competing interests.[16,24] The stigma surrounding homelessness, provider prejudice, and the focus of the health system primarily on the provision of acute care for patients experiencing homelessness, could impact interactions and communication with providers and therefore diabetes management.[25,26] In addition, the mobility of this population lacking consistent housing could impact preventive care, adherence, and health education opportunities. These barriers could potentially be addressed using mHealth strategies to better manage diabetes through reminders and targeted health education and should be evaluated in patients experiencing homeless.[27–29] Additional shelter-level interventions such as peer-led diabetic education programs have shown to improve patients' knowledge scores of signs, symptoms, and complications of diabetes and its medications.[30] A systematic review of evidence to improve management of non-communicable disease among patients experiencing homelessness has shown that educational case-management interventions will improve knowledge and medication taking but fail to improve biomarkers.[31] Studies have suggested using a framework that emphasizes adaptability, self-organization, and empowerment with engagement and involvement of patients and medical and social service providers could address barriers in care.[17]

There is increasing evidence on the effectiveness of social policies to prevent homelessness or provide temporary housing, and a secure and safe place of living likely impacts access to healthcare.[32–33] Supportive housing has been shown to decrease incidence of diabetes among the persons who were previously homeless and improve diabetes management.[34] With a renewed emphasis on understanding the impact of social factors on health disparities and access to healthcare, there should be a collective commitment on devising and evaluating strategies to address them in and outside the healthcare settings especially among the very marginalized population who experience homelessness.

There are limitations to our study. Medical record review by its nature poses limitations to objective assessments of important factors that may have not been documented in medical records, such as duration and severity of mental illness, substance or alcohol use disorder, other chronic diseases, or current length of homelessness. However, our shelter-clinics use a consistent process to measure all indicators with established quality assurance services. We expected that several clinically plausible variables have statistically

	N (%)	Adequately managed DM (*N* = 171)	Inadequately managed DM (*N* = 133)	OR	95% CI	*p*-value
Age, mean (SD)	304 (100)	56·4 (9·9)	52·9 (9·1)			0·002
Sex, No· (%)	302/304 (99·3)	170/171 (99·4)	132/133 (99·2)	1·66	0·90–3·04	
Male	246/302 (81·5)	133/170 (78·2)	113/132 (85·6)			0·10
Female	56/302 (18·5)	37/170 (21·8)	19/132 (14·4)			
Race, No· (%)	266/304 (87·5)	152/171 (88·9)	114/133 (85·7)			
Black	168/266 (63·2)	98/152 (64·5)	70/114 (61·4)			0·28
White	66/266 (24·8)	35/152 (23·0)	31/114 (27·2)			
Asian	6/266 (2·3)	5/152 (3·3)	1/114 (0·9)			
Other	20/266 (7·5)	9/152 (5·9)	11/114 (9·6)			
>1 race	6/266 (2·3)	5/152 (3·3)	1/114 (0·9)			
Ethnicity, No· (%)	302/304 (99·3)	169/171 (98·8)	133/133 (100)			
Hispanic/Latino	97/302 (32·1)	46/169 (27·2)	51/133 (38·3)	1·66	1·02–2·71	0·04
Non-Hispanic/Latino	205/302 (67·9)	123/169 (72·8)	82/133 (61·7)			
Language, No· (%)	304/304 (100)	171/171 (100)	133/133 (100)			
English	269/304 (88·5)	151/171 (88·3)	118/133 (88·7)			0·45
Spanish	33/304 (18·0)	18/171 (10·6)	15/133 (11·2)			
Other	2/304 (0·7)	2/171 (1·2)	0/133 (0·0)			
Provider, No· (%)	304/304 (100)	171/171 (100)	133/133 (100)			
No primary care physician	206/304 (67·7)	109/171 (64·1)	97/133 (72·9)			0·08
Shelter primary care physician	58/304 (19·1)	40/171 (23·5)	18/133 (13·5)			
Community primary care physician	40/304 (13·2)	22/171 (12·4)	18/133 (13·5)			
Insurance Status, No· (%)	299/304 (98·4)	167/171 (97·7)	132/133 (99·2)			
Insured	271/299 (90·6)	154/167 (92·2)	117/132 (88·6)	0·66	0·30–1 44	0·29
Uninsured	28/299 (10·4)	13/167 (7·8)	15/132 (11·4)			
Obesity, No· (%)	140/302 (46·4)	81,169 (47·9)	59/133 (44·4)	0·87	0·55–1·37	0·54
Body mass index, mean (SD)	301 (99·0)	31·2 (8·4)	30·3 (7·1)			0·29
Hypertension, No· (%)	208/304 (68·4)	125/171 (73·1)	83/133 (62·4)	0·59	0·36–0·95	0·03
Inadequately managed hypertension(≥140/90), No· (%)	81/304 (26·6)	46/171 (26·9)	35/133 (26·3)	1·28	0·74–2·26	0·40
Systolic blood pressure, mean (SD)	303 (99·7)	131·0 (18·8)	130·2 (21·0)			0·73
Diastolic blood pressure, mean (SD)	303 (99·7)	78·4 (9·5)	80·3 (10·9)			0·12
Coronary artery disease, No· (%)	28 (9·3)	13 (7·7)	15 (11·2)	1·50	0·69–3·28	0·30
Chronic kidney disease, No· (%)	28/302 (9·3)	19/170 (11·2)	9/132 (6·8)	0·58	0·22–1·32	0·19
Glomerular filtration rate <60, No· (%)	31/239 (13·0)	21/139 (15·1)	10/100 (10·0)	0·62	0·28–1·39	0·25
Glomerular filtration rate, mean (SD)	238 (78·2)	87·6 (30·1)	89·2 (29·6)			0·68
Hyperlipidemia, No· (%)	157/303 (51·8)	92/170 (54·1)	65/133 (48·9)	0·81	0·51–1·28	0·36
Low-density lipoprotein > 100, No· (%)	81/220 (36·8)	45/129 (34·9)	36/91 (39·6)	1·22	0·70–2·13	0·48
Low-density lipoprotein, mean (SD)	226 (74·3)	91·6 (34·2)	93·9 (35·1)			0·62
Total cholesterol, mean (SD)	240 (78·9)	166·5 (40·5)	180·3 (45·5)			0·01
Mental Illness, No· (%)	152/300 (50·7)	91/167 (54·5)	61/133 (45·9)	0·71	0·45–1·12	0·14
Number of chronic diseases, No· (%)	289 (95·1)	3·1 (1·2)	2·89 (1·3)			0·28
Substance use disorder, No· (%)	68/279 (24·4)	40/167 (24·0)	28/112 (25·0)	0·86	0·49–1·48	0·58
Alcohol use disorder, No· (%)	21/298 (7·0)	10/167 (6·0)	11/131 (8·4)	1·43	0·59–3·48	0·43
Cigarette smoking, No· (%)	164/298 (55·0)	91/167 (54·5)	73/131 (55·7)	1·05	0·66–1·67	0·83
Cigarettes per day, mean (SD)	278 (91·4)	4·9 (6·8)	5·01 (7·0)			0·91
Packyears, mean (SD)	190 (62·5)	7·47 (9·9)	9·30 (13·7)			0·29
Years of homelessness, mean (SD)	181 (59·5)	1·6 (3·7)	1·4 (2·4)			0·68

***Table 4*: Bivariate analysis of adequately versus inadequately managed diabetes mellitus (HbA1c ≥ 8) among patients experiencing homelessness, New York City shelter-clinics, 2019.**

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significant association with the outcomes of uncontrolled diabetes but they did not. Due to sample size and less adequate power, lack of precision in measuring some variables, and the distinction between mediating and confounding variables, we caution the interpretation of relationship between some covariates and the outcomes of uncontrolled diabetes in logistic regression analyses. Our sample size included all incoming

	Adj·Odds ratio/ Standardized Coefficient*	95% CI	*p*-value
Ethnicity (non-Hispanic/Latino)	0·61	0·37–0·99	0·05
Age (older)	0·96	0·94–0·99	0·003

***Table 5*: Multivariable logistic regression analysis of independent variables and inadequately managed DM (HbA1c ≥ 8) among patients experiencing homelessness, New York City shelter-clinics, 2019.**

* Please see limitations regarding the interpretation of results of logistics regression.

patients with the diagnosis of diabetes who were seen in the shelter clinics which include a small number of persons who were not homeless. It is possible that a small number of these patients were previously homeless as well. However, this helps us better evaluate the impact of homelessness itself as an important social factor on diabetes indicators. Due to established and consistent processes in the clinic to record clinically relevant data for management of chronic diseases, we did not encounter significant issues with relevant missing data. We did not have data on diabetes awareness or engagement and medication taking. A more comprehensive examination of the behavioral and psychosocial factors associated with inadequate diabetes control in future research with the addition of a qualitative component will provide better knowledge of the pathway to diabetes care among persons experiencing homelessness. Considering the limited data on the predictors of diabetes management in patients experiencing homelessness, we believe that our study makes an important contribution to the understanding of inadequately managed diabetes, related barriers, and risk factors among persons experiencing homelessness as compared to domiciled patients and provides direction for future research and recommendations.

Quality diabetes care for patients experiencing homelessness has been largely neglected by providers, researchers, and policy makers. Inadequately managed diabetes poses significant cardiovascular risks and mortality. Diabetes is less managed among patients experiencing homelessness, who often lack social support and resources to cope with its complications, compared with domiciled patients. Introducing interventions to target ethnic and age subgroups and evaluating potential mHealth strategies in places that patients experiencing homelessness reside or seek care should be considered. Further health services research will help generate valid and appropriate evidence on the characteristics of strategies to effectively address diabetes management among patients experiencing homelessness. Nonetheless, comprehensive approaches to address important social factors, provide targeted social services, and improve consistent access to healthcare must be considered in caring for patients experiencing homelessness. In the end, an approach to implement larger societal strategies to address homelessness should be advocated for and reinforced.

Contributors

RA made substantial contribution to this study, including conception and design, acquisition, analysis and interpretation of data, drafting and critical revision of the manuscript for important intellectual content, technical, and material support and supervision, and approval of final version of the manuscript.

EB made substantial contribution to this study, including acquisition, analysis and interpretation of data, drafting and critical revision of the manuscript for important intellectual content, and approval of final version of the manuscript.

RN made substantial contribution to this study, including interpretation of data, editing and drafting, and critical revision of the manuscript for important intellectual content, and approval of final version of the manuscript.

Data sharing statement

De-identified data could be available upon reasonable request and under following conditions: (a) clearly stated objectives and for scientific purposes only, (b) intention to submit for potential publication, (c) emailing the request to the corresponding author.

Declaration of interests

The authors declare that there are no conflicts of interest.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.eclinm.2022.101418.

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