ORIGINAL RESEARCH

Development of PRAPARE Social Determinants of Health Clusters and Correlation with Diabetes and Hypertension Outcomes

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Introduction: **PRAPARE is a leading social risk screening tool. No studies yet have simplified the 22 PRAPARE social determinants of health (SDoH) into clusters to analyze associations with chronic disease outcomes.**

Methods: **A federally qualified health center conducted cross-sectional PRAPARE screening on its general adult population. Exploratory and confirmatory factor analyses were used to identify SDoH clusters and construct cluster scores and SDoH total risk scores. Logistic regression assessed relationships between cluster scores and uncontrolled diabetes and/or hypertension.**

Results: **Of the 11,773 adults who answered the survey, 716 had diabetes only, 2,388 had hypertension only, 1,477 had both, and 7,192 had neither. We found 3 composite SDoH clusters (social background, social insecurities, insurance/employment) and 3 standalone clusters (housing status, social isolation, poverty). Among patients with diabetes, those at risk in social background, social insecurities, and insurance/employment were more likely to have uncontrolled diabetes. Among patients with hypertension, those at more risk in social insecurities were more likely to have uncontrolled hypertension.**

Conclusions: **We simplified the 22 PRAPARE SDoH into 3 composite clusters and 3 individual clusters and demonstrated the reliability and validity of PRAPARE. The 3 composite clusters were positively associated with uncontrolled diabetes and/or hypertension. (J Am Board Fam Med 2022;35:668–679.)**

Keywords: **Community Health Centers, Cross-Sectional Studies, Diabetes Mellitus, HbA1c, Hypertension, Logistic Models, Risk Factors, Social Determinants of Health, Vulnerable Populations**

Introduction

Much clinical research has focused on the ability of traditional medical care to improve clinical outcomes and how demographic and clinical factors—such as age, sex, and presence and severity of disease—can predict adverse outcomes. However, social determinants of health (SDoH) are major contributors to inequities in health outcomes.[1,2] The SDoH include social and economic factors, such as low income, unemployment, and lack of quality housing. While much research demonstrates the impact that individual SDoH factors have on health outcomes, little is known regarding how multiple SDOH factors affect outcomes.

In September 2013, a national patient SDoH risk assessment protocol, the Protocol for Responding to and Assessing Patient Assets, Risks, and Experiences (PRAPARE), was created, standardized, implemented, and promoted by the National Association of Community Health Centers,

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the Association of Asian Pacific Community Health Organizations (AAPCHO), the Oregon Primary Care Association, and the Institute for Alternative Futures.[3] PRAPARE contains 22 SDoH factors that align with national initiatives, including the standardized codification sets under International Statistical Classification of Diseases and Related Health Problems (ICD)-10[4] and Logical Observation Identifiers Names and Codes[5] as well as health centers' Uniform Data System (UDS).[6] PRAPARE is available for free in the most dominant electronic health record platforms and is translated into 26 languages.[7] It is the leading social risk screening tool used by Medicaid-managed care organizations[8,9] and most commonly used in federally qualified health centers (FQHCs) and other health systems.[6]

Patients with a great number of socioeconomic disadvantages are often served by FQHCs, rather than other health providers. They are disproportionately low income, racial/ethnic minority, limited English proficient, and uninsured or publicly insured compared with the population nationally.[10,11] The adverse effects of SDoH contribute to the higher prevalence of chronic conditions, such as diabetes and hypertension, in an FQHC population versus the general US population.[12,13]

Despite the widespread use of PRAPARE, evidence is limited regarding which SDoH measures matter most and which groupings of SDoH measures have the greatest impact on specific chronic disease outcomes. SDoH clusters could stratify patients into different risk groups, target interventions to particularly high-risk groups, and inform allocation of staff and other resources for goals such as reduction of costly emergency department utilization.[14–17] Our study uses the comprehensive SDoH assessment tool, PRAPARE, to identify clusters of 22 SDoH factors and discover associations between the clusters and health outcomes in an FQHC population that included patients with diabetes and hypertension.

Methods

Development of PRAPARE

The PRAPARE measure was developed through a 3-stage process. In the first stage, literature, environmental scans, and interviews of tool developers were conducted, and initial items were generated by a group of experts.[18] In the second stage, a pilot study of the measure was performed for validity and reliability using nearly 3000 patients in FQHCs.[9,18] The PRAPARE measure was subsequently readjusted. This study is for the third stage of the development of PRAPARE, identifying social risk clusters and correlating those to clinical outcomes.

Study Setting

Siouxland Community Health Center (SCHC, Sioux City, Iowa) began implementing PRAPARE in 2015 as one of the pioneer FQHCs that collaborated in the early development of the tool.

PRAPARE Assessment Survey

SCHC routinely screens the general patient population annually for SDoH using PRAPARE. During screening, the nurse or medical assistant (MA) typically provides an article copy of the PRAPARE questions to the patient or may ask the patient each question. The nurse or MA will then review the responses; if SDoH barriers are identified, the nurse or MA arranges for resources for the patients with the assistance of other care team members. If a patient screens positive for homelessness, partner violence, neighborhood safety, food insecurity, or transportation issues, a behavioral health case manager is called in to provide immediate assistance. The workflow for the PRAPARE assessment at SCHC can be found in Online Appendix Figure 1.

Among the PRAPARE 22 SDoH (Online Appendix Table 1), we excluded migrant/farmworker status and the optional open-ended "other" category under the material security question, which had high rates of missing data (> 95%). There were very few migrant/farmworkers in the region that SCHC serves, which is why the response rate for this question was low. For the purpose of constructing subsequent factor scores, the PRAPARE variables were binary coded or ordinal coded depending on the type of response categories (listed in Online Appendix Table 2).

Study Population

This cross-sectional study included 11,773 adults, aged 18 to 75 years, who visited SCHC between January 1, 2016 to June 30, 2018 and responded to the PRAPARE survey. Patients with diabetes and/or hypertension were defined based on ICD-10 diabetes and/or hypertension diagnosis codes. The blood pressure and HbA1c data were based on the patients' most recent measures relative to their PRAPARE assessment dates. Among the 11,773 patients, 716 had diabetes only, 2,388 had

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hypertension only, 1,477 had both, and 7,192 had neither disease.

Statistical Analyses

Before any analysis, we standardized the variables to ensure all variables ranged from 0 to 1. That is, for those ordinal-coded variables, we converted them into [0, 1] by dividing each by the maximum of that variable. Descriptive statistics were used to summarize the frequencies and percentages for categorical variables and the means and SD for continuous variables. The pairwise tetrachoric/polychoric correlation coefficients of all SDoH risk factors were calculated as inputs for further reliability and factor analyses to avoid missing data issues.[19] We then calculated both Cronbach's α and the greatest lower bound[20,21] for the internal consistency reliability. We used an exploratory factor analysis with Varimax rotation to cluster the SDoH risk factors. The SDoH items with correlations ≤ 0.35 were omitted from the exploratory factor analysis[22–24] and considered as standalone clusters. For the items with correlations > 0.85, we averaged them as a composite item for the exploratory factor analysis.[25] The number of constructs was determined as the number of eigenvalues greater than 1. We used a confirmatory factor analysis to evaluate and verify the constructs found in the exploratory factor analysis. More specifically, we used root mean squared error of approximation, standardized root mean residual, and goodness of fit index as criteria for evaluation.[26]

Clusters and Cluster Scores

Following the factor analyses, we applied the approximate method, commonly referred to as "sum scores," for a simplification of both factor analysis and factor score estimation procedure.[27,28] More specifically, we compared a loading of a factor to an average loading of all of the constructs. For a loading that was more extreme than the average loading, its factor was considered "salient" and assigned a value of +1. Otherwise, its factor was assigned a value of zero. Those "salient" SDoH risk factors constructed a cluster, that is, a simplified factor analysis. Then we summed those salient factors in that cluster with equal weights. To amend for the missing data, we averaged those available factors first and then multiplied it by the total number of factors in that cluster.[29,30] Similarly, we calculated an SDoH total risk score by summing all clusters with equal weights.

Associations with Clinical Outcomes

For patients with diabetes and/or hypertension, we assessed the associations of the PRAPARE cluster scores or total risk score with clinical outcomes. We used linear regression models for continuous outcomes (HbA1c, systolic blood pressure [SBP], and diastolic blood pressure [DBP]) and logistic regression models for binary outcomes (diabetes control and hypertension control). Consistent to UDS for dichotomizing outcomes, uncontrolled diabetes was defined as HbA1c $\geq 9\%$ and uncontrolled hypertension was defined as SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg. We adjusted for age, gender, and body mass index (BMI). Other demographics such as race/ethnicity, language, and education were not adjusted for because they were part of the SDoH factors.

Missing Data Analysis

We conducted missing data analyses by checking for any missing data pattern, imputing data, and then repeating the same regression methods for association evaluation. We used the multiple imputation method, via the Markov chain Monte Carlo algorithm to impute the data. We included all covariates and outcomes for the multiple imputations and generated 20 imputed data sets. We did not use the imputed data for the factor analyses, because there were no missing data in pairwise correlation coefficients of all SDoH, which were used as the inputs of the factor analyses. In addition, the missing rate of all paired SDoH was less than 17% on average, indicating that the pairwise correlation coefficients were well estimated with the total sample size $> 10{,}000$. The results from the complete data set were the primary analysis, and the results based on the simulated data were a sensitivity analysis.

Results

Participants' Characteristics Including SDOH

Table 1 shows descriptive statistics on patient characteristics per group. Among the 4 disease-status groups, the diabetes-only group had the highest rate of patients of Latino or Hispanic ethnicity (43% vs others: 24% to 39%). This group also had the highest rates of the following SDoH, compared with each of the other 3 groups: limited English proficiency (39% vs 24% to 31%), education level lower than high school (72% vs 67%), and having

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Table 1. Patient Characteristics and Social Determinant of Health Risk Factors across Disease Status

	Both (n = 1477)		Diabetes Only (n = 716)		Hypertension Only (n = 2388)		Neither (n = 7192)	
	N	%	N	%	N	%	N	%
Gender**								
Female	762	52%	405	57%	1196	50%	4765	66%
Male	715	48%	311	43%	1192	50%	2426	34%
Age (mean and SD)**	56	10	48	12	53	11	38	13
Ethnicity**								
Hispanic/Latino	411	28%	304	42%	576	24%	2787	39%
Non-Hispanic/Latino	1055	72%	404	57%	1786	76%	4313	61%
Race**								
Non-White	392	26%	251	35%	643	27%	2575	36%
White	1083	73%	462	65%	1726	72%	4544	63%
Language**								
Limited English proficiency	409	28%	279	39%	565	24%	2247	31%
English proficient	1068	72%	437	61%	1823	76%	4945	69%
Education**								
Less than high school	605	42%	331	48%	868	37%	2632	37%
High school	385	27%	183	26%	730	31%	2187	31%
Above high school	453	31%	178	25%	726	30%	2202	31%
Housing stability								
Worried about losing housing	89	7%	<50	-	143	7%	400	7%
Not worried about losing housing	1194	93%	579	93%	1855	93%	5350	93%
Food needs**								
Yes need	173	13%	98	16%	241	12%	696	12%
No need	1138	87%	523	84%	1851	88%	5344	88%
Utilities needs								
Yes need	115	9%	66	11%	156	8%	515	9%
No need	1182	91%	540	89%	1914	92%	5443	91%
Childcare needs**								
Yes need	<50	-	<50	-	<50	-	218	4%
No need	1243	99%	569	97%	1973	98%	5605	96%
Clothing needs								
Yes need	87	7%	<50	-	160	8%	482	8%
No need	1204	93%	556	92%	1921	92%	5482	92%
Phone needs								
Yes need	97	8%	51	9%	153	7%	507	9%
No need	1190	92%	548	91%	1918	93%	5429	91%
Other needs								
Yes need	<50	-	<50	-	<50	-	<50	-
No need	1031	99%	467	99%	1611	99%	4341	99%
Transportation**								
Transportation needs (medical)	105	8%	<50	7%	131	5%	413	6%
Transportation needs (nonmedical)	97	7%	<50	7%	118	5%	372	6%
No transportation needs	1159	85%	556	86%	1932	89%	5682	88%
Health care								
Medicine or health care needs	196	17%	116	21%	327	17%	952	18%
No health care need	963	83%	447	79%	1544	83%	4344	82%
Stress*								
Very much	143	11%	59	9%	240	11%	840	12%

Continued

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Table 1. Continued

	Both (n = 1477)		Diabetes Only (n = 716)		Hypertension Only (n = 2388)		Neither (n = 7192)	
	N	%	N	%	N	%	N	%
Quite a bit	104	8%	62	9%	219	10%	537	8%
Somewhat	262	19%	116	17%	426	19%	1312	19%
A little bit	403	30%	196	29%	656	29%	1979	29%
Not at all	447	33%	234	35%	687	31%	2130	31%
Domestic violence								
Yes	<50	-	<50	-	73	3%	304	5%
Unsure	<50	-	<50	-	<50	-	<50	-
No	1343	96%	646	95%	2176	96%	6426	95%
Safety								
Felt unsafe	60	4%	<50	5%	106	5%	388	6%
Unsure	<50	-	<50	-	<50	-	106	2%
Felt safe	1327	94%	646	94%	2122	94%	6327	93%
Employment**								
Unemployed	808	55%	327	46%	1068	45%	2868	40%
Employed or not looking for employment	653	45%	377	54%	1292	55%	4230	60%
Insurance**								
Uninsured	1048	72%	480	69%	1571	67%	3697	53%
Insured	404	28%	219	31%	758	33%	3222	47%
Federal poverty level (FPL)**								
Income <100% FPL	945	67%	492	73%	1601	71%	5161	77%
Income between 100% and 200% FPL	360	25%	142	21%	498	22%	1141	17%
Income between 200% and 400% FPL	101	7%	<50	-	143	6%	322	5%
Income > 400% FPL	<50	-	<50	-	<50	-	<50	-
Social integration*								
See or talk to people < once per week	148	11%	59	9%	199	9%	679	10%
See or talk to people 1 to 2 times per week	222	16%	128	19%	384	17%	1197	18%
See or talk to people 3 to 5 times per week	296	22%	148	22%	434	20%	1487	22%
See or talk to people > 5 times per week	705	51%	328	50%	1203	54%	3326	50%
Housing status**								
Lack of housing	95	7%	64	9%	201	9%	894	13%
Have housing	1328	93%	631	91%	2087	91%	5949	87%

Groups with counts of less than 50 were masked for confidentiality reasons.
*P value < 0.05, where P value was for all four groups comparison. A small P value (<0.05) indicates at least two groups significantly different in one characteristics or SDoH.
**P value ≤ 0.01, where P value was for all four groups comparison. A small P value (<0.05) indicates at least two groups significantly different in one characteristics or SDoH.
Abbreviation: SD, standard deviation.

food insecurity (14% vs 10% to 12%). The both-disease group had the highest rate of transportation needs (14% vs 10% to 12%), unemployment (55% vs 40% to 46%), uninsured status (71% vs 51% to 67%), and social isolation (11% vs 9% to 10%). The neither-disease group consisted of the most female participants (66% vs 50% to 57%) and were the youngest (mean age: 38 years vs others: 48 to 56 years, younger than 25 years old: 16.5% vs 0.2% to 3.6%). The neither-disease group also had the most lack of housing (13% vs 7% to 9%) and the most having income <100% federal poverty level (FPL) (77% vs 67% to 73%). The 4 groups had no clear difference in the following 4 SDoH factors: housing insecurity, medicine/health care needs, domestic violence, and feeling unsafe.

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Internal Consistency Reliability

The Cronbach's α was 0.86, and the greatest lower bound was 0.935, indicating good to excellent internal consistency reliability for PRAPARE.

Factor Analyses

Of the 22 SDoH risk factors, we excluded 3 factors from exploratory factor analysis due to very lower prevalence (<4%): migrant status, childcare needs, and other material insecurity. We considered 3 factors as standalone clusters because their correlations with the others were low (≤ 0.35): FPL, social isolation, and housing status (Figure 1). We averaged 4 factors as a composite factor "material needs" because they had high correlations (> 0.85) with each other: needs in food, utilities, clothing, and phone. Eventually, 13 SDoH factors including 1 composite factor entered the exploratory factor analysis (Figure 1).

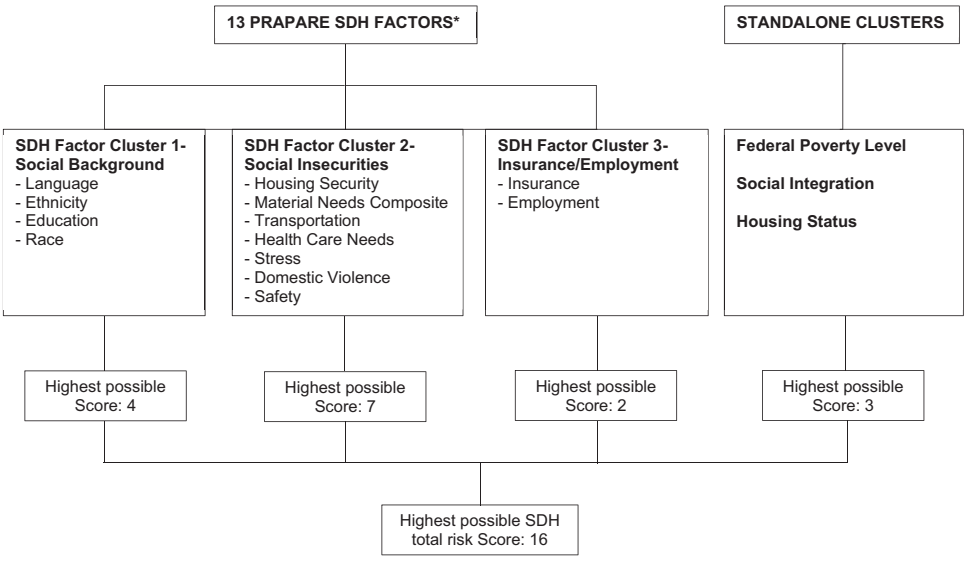
The exploratory factor analysis yielded 3 clusters with eigenvalues > 1, which accounted for 48.2% of the total variance. Its root mean squared error of approximation was 0.068, indicating that the exploratory factor analysis model fit is acceptable.[31] The original loadings of the 13 SDoH are in Online Appendix Table 3. The first cluster, "social background," consisted of 4 SDoH factors: language, ethnicity, education, and race. The second cluster, "social insecurities," consisted of 7 factors: housing security, material needs, transportation, health care, stress, domestic violence, and safety. The third cluster, "insurance/employment," consisted of 2 factors: insurance and employment. The confirmatory factor analysis confirmed the findings from the exploratory factor analysis using the following model fit criteria: root mean squared error of approximation: 0.093 (90% CI, 0.091, 0.096), standardized root mean residual: 0.074, and goodness of fit index: 0.923, all which were in an acceptable fit range.

We summarized all of these clusters per group in Table 2. The diabetes-only group had the highest social background risk score compared with each of the other 3 groups (0.45 vs 0.32–0.40). The both-disease group had the highest insurance/employment risk score (0.64 vs 0.47–0.58).

Associations between Clinical Outcomes and Cluster Scores

Table 3 shows the associations between outcomes and cluster scores by linear regression models. Among patients with diabetes, higher HbA1c was correlated with being younger (−0.024, $P < .001$), male (−0.166, $P = .047$), and socially isolated (−0.314, $P = .01$), and 3 SDoH clusters: higher risk in social background (0.114, $P = .001$), social insecurities (0.166, $P < .001$), and insurance/employment (0.124, $P = .02$). HbA1c was increased by 0.11% to 0.16%

Figure 1. Structure of PRAPARE SDH factors by factor analysis. Abbreviation: PRAPARE, Protocol for Responding to and Assessing Patient Assets, Risks, and Experiences.



* The material needs composite in the 2nd cluster -Social Insecurities combined and averaged five SDH factors: needs in food, utilities, childcare, clothing and phone, due to their naturally high correlation with pairwise polychoric correlation coefficients (≥0.87). The factor migrant status was not included in the factor analysis due to lack of migrants in the patient population.

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Table 2. Mean Scores Across the Three Clusters and the Three Standalone Domains

SDOH Clusters	Both (n = 1477)	Diabetes Only (n = 716)	Hypertension Only (n = 2388)	Neither (n = 7192)
Social background (ethnicity, race, language, and education)				
Mean cluster score* (SD)	0.34 (0.32)	0.45 (0.33)	0.32 (0.31)	0.40 (0.32)
Social insecurities (housing security, material needs, transportation, health care, stress, domestic violence, and safety)				
Mean cluster score (SD)	0.12 (0.15)	0.13 (0.15)	0.12 (0.15)	0.13 (0.16)
Insurance/employment (insurance and employment)				
Mean cluster score (SD)	0.64 (0.41)	0.58 (0.41)	0.56 (0.42)	0.47 (0.41)
Federal poverty level (FPL)				
Cluster score (SD)	0.86 (0.22)	0.89 (0.20)	0.87 (0.21)	0.90 (0.19)
Social integration				
Cluster score (SD)	0.29 (0.35)	0.29 (0.34)	0.27 (0.34)	0.29 (0.34)
Housing status				
Cluster score (SD)	0.07 (0.25)	0.09 (0.29)	0.09 (0.28)	0.13 (0.34)

*Cluster score is defined as the sum of the at-risk factors in that cluster.
Abbreviations: SDoH, social determinants of health; SD, standard deviation.

per composite cluster risk score increased by 1. Among those with hypertension, higher SBP and/or DBP was correlated with male gender ($P \leq .001$ for both SBP and DBP), higher BMI (both $P \leq .08$), higher risk in social background ($P = .02$ in SBP; not correlated with DBP), and higher risk in social insecurities (both $P < .001$). Those with higher risk in poor insurance/employment were associated with lower DBP ($P = .038$).

The results for the binary outcomes, uncontrolled diabetes and/or hypertension, by the logistic regression models (Table 4) were generally consistent with those of the continuous outcomes (Table 3). Uncontrolled diabetes was associated with higher risk in social background (adjusted odds ratio [OR] = 1.12, $P = .023$), social insecurities (OR = 1.18, $P = .004$), and insurance/employment (OR = 1.24, $P = .009$). Uncontrolled hypertension was associated with higher risk in social insecurities (OR = 1.16, $P = .001$). Among those who had diabetes and/or hypertension, the odds of uncontrolled disease were increased by 6% to 17% as the 3 risk scores increased by 1. There were 8% to 11% more odds of uncontrolled diabetes, uncontrolled hypertension, and uncontrolled diabetes or hypertension as the total risk scores increased by 1.

Missing Data Analysis

No missing data patterns were found, such as univariate, monotone, or file matching patterns.[32] The results using the imputed data were consistent with the results from the complete case analysis (Online Appendix Tables 4 and 5).

Discussion

Our exploratory factor analysis of patient-level data from 1 FQHC (total n > 10,000) identified 3 composite clusters among the 22 PRAPARE SDoH factors (social background, social insecurities, insurance/employment) and 3 standalone clusters (federal poverty level, social integration, housing status). The confirmatory factor analysis supported the validity of this structure. Cronbach's α and the greatest lower bound both showed the internal consistency reliability of the PRAPARE assessment tool. To our knowledge, our study is the first to simplify the 22 PRAPARE SDoH factors into clusters for further analysis.

The PRAPARE cluster scores were associated with diabetes and hypertension outcomes. The likelihood of uncontrolled disease was higher as the cluster scores (ie, social risks) increased, especially the "social insecurities" cluster, which included housing security, material needs, transportation, health care, stress, domestic violence, and safety. The total SDoH risk score was also associated with uncontrolled diabetes and hypertension. These findings highlight the importance of social risk screening for improving population health management and individual patient care. Our simplified SDoH clusters could also be used to inform risk adjustment for more appropriate payment for organizations serving higher-risk patient populations.[33,34]

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Table 3. Associations of Social Determinant of Health Risk Factors and Clusters with HbA1c and Blood Pressure Values by Linear Regression Models

Outcome	Factors/Clusters*	Coefficient	95% CI		*P* value†
Diabetes model (total n = 2193 and n = 1906 with complete data)					
HbA1c	Intercept	8.755	8.076	9.434	**<0.001**
	BMI	−0.007	−0.017	0.003	0.184
	Age	−0.024	−0.031	−0.017	**<0.001**
	Female (ref: male)	−0.166	−0.330	−0.002	**0.047**
	Social background score	0.114	0.049	0.178	**0.001**
	Social insecurities score	0.166	0.084	0.247	**<0.001**
	Insurance/employment score	0.124	0.019	0.229	**0.020**
	Federal poverty level score	−0.034	−0.416	0.349	0.864
	Social isolation score	−0.314	−0.553	−0.075	**0.010**
	Housing status score	−0.113	−0.425	0.199	0.479
Blood pressure model (total n = 3865 and n = 3338 with complete data)					
Systolic blood pressure	Intercept	118.445	113.955	122.935	**<0.001**
	BMI	0.175	0.112	0.237	**<0.001**
	Age	0.049	−0.002	0.099	0.058
	Female	−1.844	−2.899	−0.789	**0.001**
	Social background score	0.498	0.073	0.924	**0.022**
	Social insecurities score	1.026	0.486	1.567	**<0.001**
	Insurance/employment score	−0.138	−0.808	0.532	0.687
	Federal poverty level	−0.097	−2.565	2.371	0.939
	Social isolation	0.284	−1.277	1.846	0.721
	Housing status	0.001	−1.997	1.998	0.999
Diastolic blood pressure	Intercept	87.071	84.170	89.972	**<0.001**
	BMI	0.036	−0.004	0.077	0.080
	Age	−0.222	−0.254	−0.189	**<0.001**
	Female (ref: male)	−1.566	−2.247	−0.884	**<0.001**
	Social background score	−0.030	−0.305	0.245	0.832
	Social insecurities score	0.736	0.387	1.085	**<0.001**
	Insurance/employment score	−0.460	−0.893	−0.027	**0.038**
	Federal poverty level	0.023	−1.572	1.617	0.978
	Social isolation	−0.635	−1.644	0.374	0.217
	Housing status	−0.119	−1.409	1.172	0.857

*The actual effect of each composite cluster is the estimated coefficient multiplied with the actual number of positive SDoH factors in that composite cluster.
†The *P* values < 0.05 are bolded.
Abbreviations: SDoH, social determinants of health; BMI, body mass index; CI, confidence interval.

Our study builds on prior literature linking SDOH to adverse chronic disease outcomes. A study using the National Health and Nutrition Examination Survey found that race (black vs white) and insurance status (uninsured vs insured) were strongly associated with uncontrolled hypertension among US adults with hypertension.[35] A different study showed that for adults less than 75 years old, those with multiple SDoH risks were at more than a 2.5-fold greater risk for stroke than those with none.[36] Another study found that Mandarin speakers experienced a steeper increase in their HbA1c levels than English speakers.[37] Not only the type of SDoH risk factors but the number of total SDoH risks was also a factor in the overall patient health. The same stroke study showed that individuals younger than 75 years old who had 3 or more SDoH risks were at an approximately 50% greater risk for stroke compared with those with none, even after adjustment for confounding physiologic factors.[38] A study from a national sample of 17 FQHCs using PRAPARE data showed that the patient population with pre-existing diabetes and/or hypertension had an average of 10 SDoH risk

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Table 4. Associations of Social Determinant of Health Risk Factors and Clusters with Control of HbA1c and Blood Pressure by Logistic Regression Models

Outcome*	Factors/Clusters†	Odds Ratio	Lower	Upper	*P* value‡
Uncontrolled diabetes (total N = 2,193 and N = 1,906 with complete data)	Age	0.97	0.96	0.98	**<0.001**
	Gender	0.88	0.69	1.14	0.336
	BMI	0.99	0.97	1.00	0.141
	Social Background Score	1.12	1.02	1.23	**0.023**
	Social Insecurities Score	1.18	1.05	1.32	**0.004**
	Insurance/Employment Score	1.24	1.06	1.47	**0.009**
	Federal Poverty Level	0.69	0.39	1.23	0.204
	Housing Status	0.77	0.48	1.23	0.274
	Social Isolation	0.85	0.59	1.22	0.381
Uncontrolled hypertension (total N = 3,865 and N = 3,338 with complete data)	Age	1.00	0.99	1.01	0.425
	Gender	0.90	0.75	1.08	0.256
	BMI	1.00	0.99	1.01	0.788
	Social Background Score	1.00	0.93	1.08	0.984
	Social Insecurities Score	1.16	1.06	1.26	**0.001**
	Insurance/Employment Score	1.09	0.97	1.23	0.147
	Federal Poverty Level	1.31	0.83	2.06	0.244
	Housing Status	1.19	0.86	1.64	0.297
	Social Isolation	1.13	0.87	1.48	0.364
Uncontrolled combined diabetes/hypertension (total N = 4579 and N = 3,954 with complete data)	Age	0.99	0.99	1.00	0.050
	Gender	0.87	0.74	1.01	0.071
	BMI	1.01	1.00	1.01	0.223
	Social Background Score	1.06	1.00	1.13	**0.057**
	Social Insecurities Score	1.17	1.09	1.26	**<0.001**
	Insurance/Employment Score	1.17	1.06	1.29	**0.002**
	Federal Poverty Level	1.02	0.70	1.48	0.936
	Housing Status	1.04	0.79	1.38	0.773
	Social Isolation	1.072	0.854	1.346	0.549

*Uncontrolled diabetes was defined as HbA1c ≥ 9% and uncontrolled hypertension was defined as SBP ≥ 140 mm Hg and/or DBP ≥ 90 mm Hg.
†The actual effect of each composite cluster is the estimated natural log of odds ratio multiplied with the actual number of positive SDoH factors in that composite cluster.
‡The *P* values < 0.05 are bolded.
Abbreviations: BMI, body mass index; SDoH, social determinants of health.

factors, whereas the general patient population had an average of 5.7 risk factors.[39] Taken together, these studies demonstrate the importance of comprehensive SDoH tools and understanding multiple, simultaneous risks faced by patients to assist providers in supporting and addressing root causes of health.

Addressing these SDoH barriers and tracking their improvement should be an important component of care management. In a systematic review of interventions that address SDoH barriers, Taylor et al. found 32 (82%) studies reported positive effects on clinical outcomes (n = 20), health care costs (n = 5), or both (n = 7).[40] Of these 32 studies, 100% evaluated income-support programs, 88% care coordination and community-outreach interventions, 83% housing-support programs, and 64% nutritional-support programs.[40] Gottlieb et al. performed a systematic review of interventions that addressed patients' social and economic needs.[38] The 20 articles that studied health outcomes showed mixed although largely positive results. A 2020 American Diabetes Association systematic review catalogued promising SDoH interventions.[1] For example, in the Moving to Opportunity randomized controlled trial, the opportunity to move from a neighborhood with high poverty to one with low poverty was associated with a lower

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prevalence of HbA1c ≥ 6.5%.[41] A 2021 review of race, ethnicity, and hypertension emphasized the importance of addressing SDoH and summarized successful interventions including team-based care and community-based interventions and outreach.[42] Overall these initial studies support the importance of testing more interventions, models, and guidelines that address SDoH barriers with the aims of achieving better long-term outcomes at lower costs.

AAPCHO and partners have developed a national standardized data collection protocol for "enabling services"—supportive interventions including interpretation, financial counseling, case management, and transportation—that facilitate patient access to care.[43–45] They have created an integrated PRAPARE SDoH and enabling services/social interventions data collection protocol to enable clinics to collect these critical data with their social-service sector partners in our future work.

Limitations

Our study has some limitations. First, our study was conducted at one FQHC, and thus the findings may not be generalizable to other FQHCs or other health systems. The cluster structure might be different due to different loadings of SDoH factors if the national patient population is very different from this clinic's population. However, we used the approximate method, which is robust to the cluster structure.[27,28] In addition, we compared the poverty level of our study population with a summary of all 1375 FQHCs from the 2020 UDS data. As reported by the Health Resources & Services Administration, 68% of patients had income <100% FPL and 91% of patients had income <200% FPL.[46] Both poverty levels were similar to those in our study population: 74% and 94% had income <100% FPL and <200% FPL, respectively, in our study. Furthermore, we plan to validate the SDoH cluster structures with patient-level data from health centers in multiple states in future studies.

Second, the PRAPARE survey had missing data and less than 50% of patients answered all questions. However, for each question, the missing data rate was less than 10%, and between all paired items there was less than 17% missingness on average. Furthermore, to be able to calculate cluster scores for a patient, we used mean of available items to fill in missing items. Analyses of imputed data were consistent with analyses of the complete case. Third, some potential confounders such as medications, baseline chronic condition control, and time of disease diagnosis were not available, so they were not included in our regression models.

Fourth, the PRAPARE does not ask questions related to experiences of racism or trust in health care. The PRAPARE team is currently working with a national advisory committee to develop a revision to the tool that is considering these important factors. Lastly, our study excluded contextual data on enabling services or social interventions commonly provided by FQHCs to mitigate patient SDoH and thus may have underestimated the true volume of patient SDoH risk. For example, FQHCs that regularly provide transportation support to the clinic to address their patients' transportation needs may underestimate true transportation risk in the population.

Conclusion

Our study of 22 PRAPARE SDoH factors identified 3 composite clusters (social background, social insecurities, and insurance/employment) and 3 individual clusters (federal poverty level, social integration, and housing status) and demonstrated the reliability and validity of scoring tools. Future work should explore the use of the tools for improving population health outcomes.

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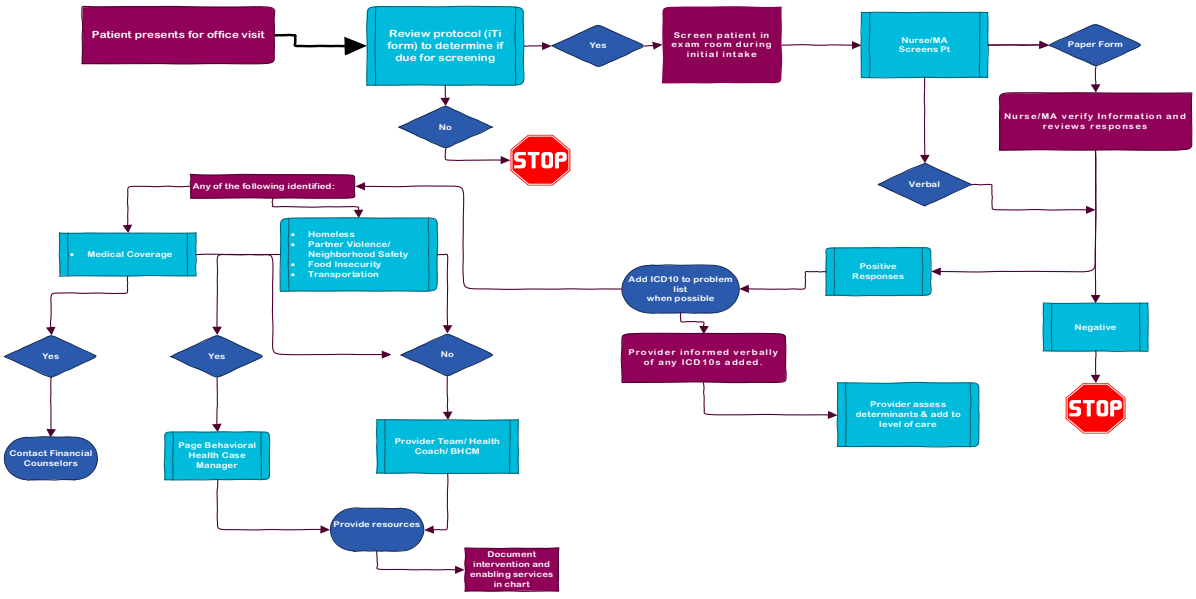
Appendix Figure 1. Workflow at Siouxland Community Health Center.



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Appendix Table 1. The PRAPARE questionnaire

Personal Characteristics

1. Are you Hispanic or Latino?

	Yes		No		I choose not to answer this question

2. Which race(s) are you? Check all that apply.

	Asian		Native Hawaiian
	Pacific Islander		Black/African American
	White		American Indian/Alaskan Native
	Other (please write):		
	I choose not to answer this question		

3. At any point in the past 2 years, has season or migrant farm work been your or your family's main source of income? (Excluded due to lack of data)

	Yes		No		I choose not to answer this question

4. Have you been discharged from the armed forces of the United States? (Excluded due to lack of data)

	Yes		No		I choose not to answer this question

5. What language are you most comfortable speaking?

	English
	Language other than English (please write)
	I choose not to answer this question

Family & Home

6. How many family members, including yourself, do you currently live with? _____

	I choose not to answer this question

7. What is your housing situation today?

	I have housing
	I do not have housing (staying with others, in a hotel, in a shelter, living outside on the street, on a beach, in a car, or in a park)
	I choose not to answer this question

8. Are you worried about losing your housing?

	Yes		No		I choose not to answer this question

9. What address do you live at? (N/A)
Street:_____
City, State, Zipcode: _____

Money & Resources

10. What is the highest level of school that you have finished?

	Less than high school degree		High school diploma or GED
	More than high school		I choose not to answer this question

11. What is your current work situation?

	Unemployed		Part-time or temporary work		Full-time work
	Otherwise unemployed but not seeking work (ex: student, retired, disabled, unpaid primary care giver) Please write:				
	I choose not to answer this question				

12. What is your main insurance?

	None/uninsured		Medicaid
	CHIP Medicaid		Medicare
	Other public insurance (not CHIP)		Other Public Insurance (CHIP)
	Private Insurance		

13. During the past year, what was the total combined income for you and the family members you live with? This information will help us determine if you are eligible for any benefits.

	I choose not to answer this question

14. In the past year, have you or any family members you live with been **unable** to get any of the following when it was **really needed**? Check all that apply.

Yes	No	Food	Yes	No	Clothing
Yes	No	Utilities	Yes	No	Child Care
Yes	No	Medicine or Any Health Care (Medical, Dental, Mental Health, Vision)			
Yes	No	Phone	Yes	No	Other (please write):
		I choose not to answer this question			

15. Has lack of transportation kept you from medical appointments, meetings, work, or from getting things needed for daily living? Check all that apply.

	Yes, it has kept me from medical appointments or from getting my medications
	Yes, it has kept me from non-medical meetings, appointments, work, or from getting things that I need
	No
	I choose not to answer this question

Social and Emotional Health

16. How often do you see or talk to people that that you care about and feel close to? (For example: talking to friends on the phone, visiting friends or family, going to church or club meetings)

	Less than once a week		1 or 2 times a week
	3 to 5 times a week		5 or more times a week
	I choose not to answer this question		

17. Stress is when someone feels tense, nervous, anxious, or can't sleep at night because their mind is troubled. How stressed are you?

	Not at all		A little bit
	Somewhat		Quite a bit
	Very much		I choose not to answer this question

Optional Additional Questions

18. In the past year, have you spent more than 2 nights in a row in a jail, prison, detention center, or juvenile correctional facility? (Excluded due to lack of data)

	Yes		No		I choose not to answer this question

19. Are you a refugee? (Excluded due to lack of data)

	Yes		No		I choose not to answer this question

20. Do you feel physically and emotionally safe where you currently live?

	Yes		No		Unsure
	I choose not to answer this question				

21. In the past year, have you been afraid of your partner or ex-partner?

	Yes		No		Unsure
	I have not had a partner in the past year				
	I choose not to answer this question				

Footnotes:

- The question 14 contains 7 SDOH factors.
- To obtain the poverty variable (see eTable 2), depending on number of family members (in Question 6), we categorized the annual total income (in Question 13) into the multiple levels.
- Therefore, there were a total of 22 SDOH factors after excluding those marked items.
- Its original form can be found via the link: https://www.nachc.org/research-and-data/prapare/prapare_one_pager_sept_2016-2/.

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Appendix Table 2. Description of the coded variables of the 22 PRAPARE SDOH

	Variable name	Type of variable	Values	Coded values (ranged 0-1)
1	Ethnicity	Binary	1=Hispanic, 0=non-Hispanic	1=Hispanic, 0=non-Hispanic
2	Race	Binary	1=Non-white, 0=white	1=Non-white, 0=white
3	Migrant	Binary	1=Yes, 0=No	1=Yes, 0=No
4	Limited English Proficiency	Binary	1=Yes, 0=No	1=Yes, 0=No
5	No housing	Binary	1=Yes, 0=No	1=Yes, 0=No
6	Worry housing	Binary	1=Yes, 0=No	1=Yes, 0=No
7	Education	Ordinal	2 = < HS, 1= HS, 0=>HS	1 = < HS, 0.5= HS, 0=>HS
8	No employment	Binary	1=Yes, 0=No	1=Yes, 0=No
9	No Insurance	Binary	1=Yes, 0=No	1=Yes, 0=No
10	Unable to get food	Binary	1=Yes, 0=No	1=Yes, 0=No
11	Unable to get utilities	Binary	1=Yes, 0=No	1=Yes, 0=No
12	Unable to get child care	Binary	1=Yes, 0=No	1=Yes, 0=No
13	Unable to get clothing	Binary	1=Yes, 0=No	1=Yes, 0=No
14	Unable to get phone	Binary	1=Yes, 0=No	1=Yes, 0=No
15	Unable to get others	Binary	1=Yes, 0=No	1=Yes, 0=No
16	Unable to get medicine health care	Binary	1=Yes, 0=No	1=Yes, 0=No
17	Lack of transportation	Ordinal	2 = need for medical, 1 = need for non-medical, 0 = no	1 = need for medical, 0.5 = need for non-medical, 0 = no
18	Social isolation	Ordinal	3 = talk < 1/week, 2 = 1-2 times/week, 1 = 3-5 times/week, 0 = > 5 times/week	1 = talk < 1/week, 0.67 = 1-2 times/week, 0.33 = 3-5 times/week, 0 = > 5 times/week
19	Stress	Ordinal	4= very much, 3= quite a bit, 2= or somewhat, 1=a little bit, 0=not at all	1= very much, 0.75= quite a bit, 0.5= or somewhat, 0.25=a little bit, 0=not at all
20	Unsafe	Ordinal	2 = yes, 1=unsure, 0 = no	1 = yes, 0.5=unsure, 0 = no
21	Domestic violence	Ordinal	2 = yes, 1=unsure, 0 = no	1 = yes, 0.5=unsure, 0 = no
22	Poverty	Ordinal	3 = ≤100% FPL, 2=≤200% FPL, 1=≤400%FPL, 0=>400%FPL	1 = ≤100% FPL, 0.67=≤200% FPL, 0.33=≤400%FPL, 0=>400%FPL

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Appendix Table 3. Loadings of the 13 coded variables of PRAPARE SDOH by the exploratory factor analysis with Varimax rotation

Rotated Factor Pattern						
	Factor1		Factor2		Factor3	
language2	98	*	-14		-12	
ethnicity2	80	*	-6		-10	
education2	70	*	-4		17	
race2	45	*	-4		-7	
worry_housing2	4		65	*	5	
food2	-7		64	*	16	
transportation2	-2		64	*	29	
HealthCare2	-4		57	*	9	
stress2	-35		52	*	1	
violence2	-10		48	*	3	
safety2	-3		44	*	3	
insurance2	-19		16		86	*
employment2	5		15		70	*
Printed values are multiplied by 100 and rounded to the nearest integer. Values greater than 0.399269 are flagged by an '*'.						

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Appendix Table 4: Associations of Social Determinant of Health Risk Factors and Clusters with HbA1c And Blood Pressure Values by Linear Regression Models, Using the Imputed Data

Outcome	Factors/clusters	Coefficient	95% CI		p-value*
Diabetes Model (total N=2,193)					
HbA1c	Intercept	9.139	8.497	9.781	0.000
	BMI	-0.010	-0.020	-0.001	**0.034**
	Age	-0.026	-0.033	-0.019	**0.000**
	Female (ref: Male)	-0.134	-0.287	0.020	0.088
	Social Background Score	0.085	0.024	0.146	**0.006**
	Social Insecurities Score	0.153	0.079	0.227	**0.000**
	Insurance/Employment Score	0.115	0.016	0.214	**0.023**
	Federal Poverty Level Score	-0.129	-0.490	0.232	0.484
	Social Isolation Score	-0.371	-0.603	-0.139	**0.002**
	Housing Status Score	-0.147	-0.444	0.150	0.331
Blood Pressure Model (total N= 3,865)					
Systolic Blood Pressure	Intercept	118.285	114.042	122.527	0.000
	BMI	0.177	0.118	0.236	**0.000**
	Age	0.045	-0.002	0.093	0.062
	Female	-1.818	-2.807	-0.830	**0.000**
	Social Background Score	0.564	0.168	0.960	**0.005**
	Social Insecurities Score	0.919	0.433	1.406	**0.000**
	Insurance/Employment Score	-0.048	-0.675	0.580	0.882
	Federal Poverty Level	-0.008	-2.346	2.329	0.994
	Social Isolation	0.224	-1.267	1.714	0.769
	Housing Status	1.713	-0.164	3.590	0.074
Diastolic Blood Pressure	Intercept	86.574	83.824	89.325	**0.000**
	BMI	0.044	0.006	0.082	**0.023**
	Age	-0.220	-0.251	-0.190	**0.000**
	Female (ref: Male)	-1.720	-2.360	-1.080	**0.000**
	Social Background Score	-0.067	-0.323	0.189	0.609
	Social Insecurities Score	0.559	0.243	0.875	**0.001**
	Insurance/Employment Score	-0.310	-0.717	0.096	0.135
	Federal Poverty Level	0.320	-1.205	1.845	0.681
	Social Isolation	-0.552	-1.524	0.419	0.265
	Housing Status	0.577	-0.637	1.791	0.352

Footnote: p-values <0.05 were bolded.

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Appendix Table 5: Associations of Social Determinant of Health Risk Factors and Clusters with Control of HbA1c And Blood Pressure By Logistic Regression Models, Using the Imputed Data

Outcome	Factors/clusters	Odds Ratio	95% Confidence Interval		P-value*
Uncontrolled Diabetes (total N= 2,193)	Federal Poverty Level	1.544	0.902	2.642	0.113
	Age	1.036	1.026	1.047	**0.000**
	BMI	1.016	1.002	1.031	**0.026**
	Social Background Score	0.925	0.845	1.012	0.091
	Social Insecurities Score	0.859	0.775	0.952	**0.004**
	Insurance/Employment Score	0.817	0.701	0.952	**0.009**
	Gender	1.078	0.856	1.358	0.525
	Housing Status	1.272	0.816	1.984	0.288
	Social Isolation	1.324	0.929	1.887	0.121
Uncontrolled Hypertension (total N=3,865)	Federal Poverty Level	0.710	0.463	1.089	0.116
	Age	1.006	0.998	1.014	0.164
	BMI	0.994	0.985	1.004	0.263
	Social Background Score	1.000	0.933	1.071	0.989
	Social Insecurities Score	0.876	0.811	0.946	**0.001**
	Insurance/Employment Score	0.900	0.806	1.005	0.062
	Gender	1.098	0.926	1.303	0.281
	Housing Status	0.701	0.526	0.935	**0.016**
	Social Isolation	0.873	0.679	1.122	0.288
Uncontrolled combined diabetes/hypertension (total N=4579)	Federal Poverty Level	0.944	0.665	1.340	0.747
	Age	1.011	1.004	1.017	**0.001**
	BMI	0.994	0.985	1.002	0.150
	Social Background Score	0.956	0.903	1.012	0.123
	Social Insecurities Score	0.867	0.812	0.926	**0.000**
	Insurance/Employment Score	0.853	0.777	0.936	**0.001**
	Gender	1.116	0.966	1.289	0.136
	Housing Status	0.842	0.655	1.082	0.179
	Social Isolation	0.962	0.775	1.195	0.729

Footnote: p-values <0.05 were bolded.

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