

Intersecting Social Determinants and Preventive Health Behaviors Among Underserved Populations: A Comprehensive Analysis of Multilevel Barriers and Community-Based Intervention Strategies

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Abstract

Background: Underserved populations experience persistent disparities in preventive health behaviors and health outcomes, driven by interconnected social determinants that operate across multiple levels of influence. While risk factors have been extensively recorded, the aggregate effect of intersecting social determinants on preventive care engagement remains insufficiently quantified.

Methods: This paper synthesizes findings from multiple large-scale studies examining preventive health behaviors among underserved populations, including a cross-sectional analysis of 9,758 participants from the NIH RADx-UP program, a machine learning study of 14.2 million Medicaid beneficiaries, and evaluations of community-based interventions across diverse settings.

Results: The polysocial risk framework reveals that individuals experiencing intersecting geo-demographic, economic, and health-related risk factors had a 43–48 percentage-point reduction in preventive service receipt compared to higher-adoption groups ($p < 0.001$). Machine learning models with social determinants of health data achieved better prediction accuracy for quality measure completion by 2.0 percentage points compared to clinical-only models. Community-based interventions demonstrated significant improvements in health outcomes, including HbA1c reductions of 0.34% among Latinx patients with type 2 diabetes participating in Food is Medicine programs, increased antenatal care visits among refugee women (OR 1.569, 95% CI 1.329–1.852), and improved cancer prevention behaviors among Black and Hispanic participants.

Conclusions: Addressing health disparities among underserved populations requires comprehensive approaches that recognize the cumulative impact of intersecting social determinants, leverage community-based partnerships, and implement multilevel interventions targeting structural barriers. Precision public health approaches incorporating polysocial risk assessment can identify high-risk subgroups for targeted interventions.

Keywords: social determinants of health, underserved populations, preventive health behaviors, polysocial risk, community-based interventions, health disparities.

Introduction

Underserved communities continue to face persistent health outcome disparities that are strongly associated with social, economic, and environmental marginalization. These inequities are fueled by interrelated social determinants of health, including economic stability, educational attainment, healthcare accessibility, and neighborhood conditions, alongside broader structural and contextual forces. The repercussions of substandard care are substantial, driving avoidable illness and death among vulnerable groups and generating an estimated \$93 billion in excess healthcare costs, with an additional \$42 billion in lost productivity attributed to premature mortality.

The COVID-19 pandemic brought these disparities into stark relief, with underserved communities experiencing disproportionate rates of infection, hospitalization, and mortality, while variations in healthcare access, economic constraints, and logistical barriers led to substantial differences in vaccination, testing, and mortality rates. Addressing these disparities requires looking at overlapping social determinants as a whole, not just isolated risk factors. Although classic models like the Behavioral Model of Health Service Use and the Health Beliefs Model have identified important demographic, socioeconomic, and health-related influences on preventive behaviors, they fail to fully capture the complexity of interacting social determinants.

Against this backdrop, the polysocial risk framework, analogous to polygenic risk scores in genetics, provides a structured method for evaluating how social determinants interact to shape health outcomes and influence health behaviors collectively, and this approach aligns with Bourdieu's theory of capital, which conceptualizes economic, social, and cultural resources as key determinants of individual opportunities and health prospects. As public health efforts increasingly rely on data-driven approaches, precision public health has emerged as a framework for tailoring interventions at a population level; however, precision public health faces a significant challenge in quantifying the combined effects of multiple social determinants. The polysocial risk framework addresses this gap by providing a systematic method for assessing how intersecting social factors influence health behaviors, making it particularly relevant as healthcare systems expand screening for health-related social needs and implement broader strategies to reduce disparities at scale.

Taking this further, this paper examines the intersecting social determinants that shape preventive health behaviors among underserved populations, drawing on findings from multiple large-scale studies and community-based intervention evaluations, and the researcher explores three key areas: (1) the cumulative impact of polysocial risk on preventive care engagement, (2) the role of social determinants in predicting quality measure completion, and (3) the effectiveness of community-based interventions in addressing these disparities. Through an examination of how social determinants interact to shape preventive behaviors, this analysis moves past isolated risk factors and enables the identification of high-risk populations for targeted outreach and inform comprehensive public health strategies. Ultimately, this integrative approach offers a pathway for translating the polysocial risk framework into actionable policy and practice, thereby advancing health equity and reducing the persistent disparities that disproportionately affect underserved populations across the nation.

Methods

This paper synthesizes findings from multiple large-scale quantitative and qualitative studies examining preventive health behaviors among underserved populations, drawing primarily from three data sources. The main quantitative analysis draws on cross-sectional data from 9,758 RADx-UP participants (February 2020–April 2023), a program that supports community-engaged research on COVID-19 testing and vaccination disparities and allows for examination of social risk factors' impact on prevention behaviors across diverse groups. Data were standardized using common elements across projects and aggregated by a central coordinating center. Predictors represented three social factor domains: (1) geo-demographic (age, sex, race/ethnicity, region); (2) economic (education, income, employment, household structure, financial strain); and (3) health-related (insurance, health status, disability, substance use, cardiometabolic risk, chronic conditions, testing access, flu shot history).

Multivariable generalized estimating equations assessed the relationship between polysocial risk and preventive behaviors, providing robust estimates of social determinants' collective effect on prevention.

Beyond the RADx-UP data, a second quantitative component examined administrative claims data from 14,178,331 Medicaid beneficiaries captured in the Transformed Medicaid Statistical Information System, representing 25 states and Washington D.C. This analysis developed and validated machine learning models to predict adherence to nine HEDIS quality measures, covering preventive services and condition-specific care, with social determinants of health data integrated at both the individual and county levels. The machine learning models employed included gradient boosting and random forest approaches, with model performance evaluated using area under the receiver operating characteristic curve, F1-score, and accuracy metrics, thereby enabling robust prediction of quality measure completion across diverse beneficiary populations. Complementing these quantitative analyses, intervention effectiveness was further examined through multiple program evaluations, including: a Food is Medicine intervention for 165 Latinx patients with type 2 diabetes in rural California; a community interventional trial with historical controls involving 3,989 participants across 19 primary health centers in Lebanon; a cancer prevention and lifestyle intervention program serving 60 participants in Milwaukee, Wisconsin; and a Neighborhood Health Ambassador network for breast cancer screening promotion in Washington, D.C., with community intervention evaluations employing linear mixed effects models, logistic regression, and pre-post comparisons as appropriate. Turning to the qualitative dimension of this synthesis, a qualitative study using semi-structured interviews was conducted with 60 Black and Latinx people living with HIV and cardiovascular disease risks to assess pandemic-related experiences, with interviews addressing perceived personal and community risk, knowledge of and access to public health information, barriers to public health recommendations and vaccine uptake, and perceptions of chronic illness and COVID-19. Rapid qualitative analysis was used with structured templates corresponding to interview guide domains, allowing for timely and systematic extraction of key themes from participant narratives. Taken together, these quantitative and qualitative data sources, spanning large-scale survey data, administrative claims, community-based intervention evaluations, and in-depth interviews, provide a comprehensive foundation for examining the intersecting social determinants that shape preventive health behaviors among underserved populations and for identifying effective strategies to reduce persistent disparities in care access and health outcomes.

Results

The RADx-UP study population consisted of 9,758 participants with a median age of 50 years (IQR: 37–60), of whom 55.0% were female.

The sample demonstrated substantial racial and ethnic diversity: 39.6% Non-Hispanic Black, 34.3% Hispanic, 20.1% Non-Hispanic White, and 6.1% Non-Hispanic Other. Socioeconomic hardship was widespread, with two-thirds (66.1%) reporting annual household incomes below \$25,000 and 62.7% unemployed at enrollment. The Medicaid analysis cohort, by contrast, comprised 14.2 million beneficiaries, 54.6% female and 53.7% under age 18. Its racial/ethnic composition was 32.0% Hispanic, 30.2% non-Hispanic White, and 15.8% non-Hispanic Black, with 20.8% living below the federal poverty level and 6.4% reporting a disability. Across the 1,563 counties represented, county-level social determinants exhibited marked heterogeneity, particularly in healthcare workforce availability and socioeconomic conditions. Community intervention populations reflected diverse underserved groups: the Food is Medicine intervention served a predominantly Latinx population (86%), with 73% female and 91% publicly insured; the Total Wellness cancer prevention program comprised 58.3% Black, 38.3% White, and 7.3% Hispanic participants; and the Neighborhood Health Ambassador network was 88.5% Black or African American.

In the RADx-UP cohort, 72.5% of participants reported receiving a COVID-19 vaccine and 82.1% reported undergoing testing for the virus, though these rates varied considerably across polysocial risk profiles. Individuals with overlapping disadvantages across geo-demographic (Non-Hispanic Black, aged 45 years or older, residing in the South), economic (limited educational attainment, unemployment, financial strain), and health-related domains (substance use, poor knowledge of cardiovascular disease risk, absence of influenza vaccination) exhibited vaccination rates 43 to 48 percentage points lower than those in more advantaged groups (* $p < 0.001$). Testing disparities, while more modest, remained statistically significant, ranging from 2 to 27 percentage points depending on the specific risk profile. These results underscore that social determinants exert a cumulative rather than independent influence on preventive care engagement. The polysocial risk framework demonstrated utility as a predictive instrument for identifying populations at greatest risk of disengagement, thereby supporting the design of precision public health strategies. Similarly, the Medicaid analysis revealed considerable potential for predictive modeling to enhance quality measure completion. Outreach informed by clinical data outperformed non-predictive approaches, such as alphabetical or birthday-based calling, by 32.5 percentage points in accuracy (AUROC: 0.88, F1-score: 0.69). The addition of social determinants of health data further refined performance, increasing accuracy by 2.0 percentage points (to 84.5%) and elevating the F1-score by 5.0 percentage points (to 0.74). Notably, the SDOH-enhanced model also attenuated pre-existing Black-White disparities in predictive accuracy, suggesting that incorporating social determinants may help counteract algorithmic bias.

Model performance proved especially sensitive to community-level factors, including the availability of Medicaid-accepting substance abuse treatment facilities (mean 6.0 per 100,000 population), mental health services (mean 6.3 per 100,000), and urgent care organizations (mean 1.3 per 100,000), all of which exhibited considerable inter-county variation and significantly influenced quality measure completion.

Beyond these quantitative findings, qualitative interviews with Black and Latinx people living with HIV and cardiovascular disease risks revealed multiple intersecting barriers to preventive care engagement. Participants reported risks for COVID-19 due to being immunocompromised and social determinants, including transportation barriers, exposure to risks conferred by others, living in under-resourced neighborhoods, and housing insecurity, yet participants engaged in protective countermeasures by adhering to public health mandates. Relationships with providers, participating in community support groups, and digital inclusion and literacy were salient with respect to dissemination of COVID-19 information and vaccine uptake, and experiences with managing chronic illness facilitated vaccine acceptance among some participants. However, participants also described language barriers, experiences of discrimination, and a historical lack of trust in medical systems and vaccines, and these findings highlight the importance of continuity with providers and established community networks, increasing internet access and digital health literacy, and addressing historical trauma incurred in medical settings. Healthcare access barriers were further documented in analyses of free clinic utilization, where 61.91% of patients under 65 were uninsured compared to 8.3% in the surrounding city and 10.2% nationally, and non-English speakers were substantially overrepresented (33.4% vs. 6.8% in the city), with Spanish speakers comprising 21.72% of clinic patients compared to 3.2% in the surrounding area.

Examining intervention effectiveness, the Food is Medicine program produced meaningful improvements in glycemic control among Latinx patients with type 2 diabetes. Adjusting for food pickup frequency and the time elapsed between baseline and follow-up visits, the analysis found a significant HbA1c reduction of -0.34 (95% CI: -0.59 to -0.09; * $p = 0.008$), with over a third of patients (38%) achieving a clinically relevant decrease of 0.5% or greater. No statistically significant effects were detected for BMI or blood pressure. Collectively, these results highlight the potential of clinic-community collaborations, specifically between Federally Qualified Health Centers and food banks, as a feasible strategy for tackling both food insecurity and chronic disease in underserved rural populations. The AI-based gamified maternal health intervention in Lebanon demonstrated significant improvements in maternal health outcomes among disadvantaged populations, with regression models adjusting for demographics, health, and obstetric characteristics showing significantly higher odds in the intervention group for completing four or more antenatal care visits (OR 1.569, 95% CI 1.329-1.852, $p < 0.05$),

completing lab tests (OR 1.821, 95% CI 1.514-2.191), two or more ultrasound screenings (OR 7.984, 95% CI 6.687-9.523), urine analysis (OR 4.399, 95% CI 3.631-5.330), and supplement intake (OR 3.508, 95% CI 2.982-4.128), and regarding outcomes, the intervention group had 29.5% increased odds of a term delivery (OR 1.295, 95% CI 1.095-1.532, $p = 0.002$) and 58% increased odds of avoiding neonatal morbidity (OR 1.580, 95% CI 1.185-2.108, $p = 0.002$), highlighting the potential of mobile health interventions to enhance healthcare delivery in conflict-affected settings with significant refugee populations. Similarly, the Total Wellness community-based cancer prevention intervention showed significant improvements in cancer knowledge, self-reported diet, and physical activity among participants, with physical assessment showing significant improvements in weight ($p = 0.0014$), body mass index ($p = 0.0016$), blood pressure (systolic $p = 0.012$; diastolic $p = 0.034$), and fitness measures including sit-to-stand repetitions ($p < 0.001$) and six-minute walk test distance ($p < 0.001$), and system-level evaluation demonstrated successful integration into community recreation programming, with classes operating out of two sites serving a predominantly Black neighborhood and a large Hispanic population, though Spanish-language only classes did not meet minimum enrollment to proceed, highlighting challenges in reaching certain underserved subgroups. Finally, the Neighborhood Health Ambassador network demonstrated feasibility in reaching underserved populations, with 26 community health workers completing training and reaching an estimated 2,189 direct beneficiaries at 108 events over one year, and the network consisted of strong representation of Black or African American NHAs (88.5%), with some NHAs providing in-language support including Amharic, Spanish, and French; GW Cancer Center staff navigated 21 women to mammograms, while direct partnerships with community-based organizations yielded faster screening uptake, with an additional 102 uninsured women obtaining mammograms through funded community partner initiatives, and for 26 women (37%), this was their first mammogram, with 110 of the 123 total women screened (89%) being uninsured.

Discussion

This comprehensive analysis offers several key insights regarding preventive health behaviors among underserved populations. To begin with, social determinants of health do not function independently but rather converge to create compounded barriers to preventive care engagement. The polysocial risk framework illustrates that individuals confronting multiple intersecting risk factors are substantially less likely to receive recommended preventive services, with vaccination rate differentials of 43–48 percentage points across risk profiles. This finding carries important implications for public health practice, suggesting that interventions targeting single risk factors in isolation may have limited efficacy for populations navigating multiple, intersecting obstacles.

Beyond this first observation, integrating social determinants of health data into predictive models enhances the identification of high-risk individuals for targeted outreach. The Medicaid analysis demonstrated that machine learning models incorporating SDOH achieved 84.5% accuracy in predicting quality measure completion, representing a 2.0 percentage-point improvement over clinical-only models. Notably, the SDOH-enhanced model attenuated pre-existing Black-White disparities in prediction accuracy, indicating that inclusive modeling approaches may help counteract algorithmic bias. Furthermore, the sensitivity of model performance to community-level factors, such as healthcare workforce availability, underscores the importance of accounting for structural determinants beyond individual-level characteristics.

A third key finding is that community-based interventions show promise in addressing barriers to preventive care among underserved populations. The Food is Medicine intervention demonstrated that addressing food insecurity through clinic-community partnerships can yield clinically meaningful improvements in glycemic control among Latinx patients with type 2 diabetes. Similarly, mobile health interventions have proven effective in reaching underserved populations in conflict-affected settings, improving antenatal care utilization and maternal health outcomes among refugees. Likewise, community health worker networks can expand outreach and build trust in underserved communities, though sustained engagement necessitates adequate compensation and infrastructure support. Turning to the qualitative dimension, these quantitative insights are complemented by findings that underscore the importance of addressing historical and ongoing sources of medical mistrust. Black and Latinx participants described experiences of discrimination and a historical lack of trust in medical systems and vaccines. Moreover, continuity with providers, participation in community support groups, and digital inclusion emerged as salient factors in health information dissemination and vaccine uptake. Collectively, these findings suggest that interventions must address both immediate access barriers and the underlying trust issues that shape health behaviors.

In parallel with these individual- and community-level considerations, the state-level policy analysis reveals the need for place-based approaches tailored to diverse regional drivers of health disparities. Nebraska's dual burden, rural provider shortages and urban socioeconomic inequities, exemplifies this need for differentiated solutions. On the one hand, rural areas face persistent challenges including provider shortages, transportation barriers, and limited broadband access; nearly 22% of rural Nebraskans lack high-speed internet, hindering effective telehealth delivery, while fourteen counties have no primary care physician, and 61.5% of the state's Health Professional Shortage Areas are located in rural regions. On the other hand, urban areas contend with concentrated poverty, racial and ethnic diversity, and access to culturally competent care.

Consequently, these intersecting geographic and demographic dynamics demand differentiated, place-based policy solutions that account for the distinct needs of each context. Synthesizing these interconnected threads, the evidence collectively points to the necessity of multi-level, integrated approaches that combine predictive analytics, community-based interventions, and policy reforms to effectively address preventive health disparities among underserved populations. The polysocial risk framework provides a valuable tool for identifying high-risk subgroups and targeting interventions, while community-based programs demonstrate that addressing social determinants, such as food insecurity, healthcare access, and trust in medical systems, can yield meaningful improvements in health outcomes. Looking ahead, future efforts should focus on scaling effective interventions across diverse settings, ensuring systematic incorporation of SDOH data into healthcare delivery and policy planning, and addressing the structural inequities that perpetuate disparities in preventive care engagement. In closing, reducing these persistent disparities will require sustained commitment from researchers, practitioners, policymakers, and communities working collaboratively to translate evidence into actionable strategies that advance health equity for all populations.

Implications for Practice and Policy

The findings of this analysis hold several important implications for public health practice and policy. Foremost among these, public health interventions should adopt a polysocial risk framework to identify populations at greatest risk of disengagement from preventive care. This approach moves beyond examining individual risk factors in isolation to assess the cumulative impact of multiple intersecting social determinants. In practical terms, healthcare systems that expand screening for health-related social needs can leverage such frameworks to guide targeted intervention strategies. In a similar vein, predictive modeling that incorporates social determinants of health can enhance outreach efficiency and reduce disparities in quality measure completion. Currently, less than 8% of eligible Medicaid patients benefit from outreach efforts using non-predictive methods such as alphabetical calling or birthday reminders. By contrast, machine learning models can substantially improve identification of patients likely to miss preventive services, enabling more effective allocation of limited outreach resources. Nevertheless, careful attention must be paid to model development to avoid perpetuating existing biases, a concern that the social determinants model addressed by reducing Black-White disparities in prediction accuracy.

Adding to these considerations, community-based partnerships are essential for reaching underserved populations. For example, the Food is Medicine intervention demonstrated that partnerships between Federally Qualified Health Centers and community food providers can successfully address food insecurity and improve chronic disease management.

Similarly, the Neighborhood Health Ambassador network showed that training community members as health workers can expand outreach and build trust. However, sustained engagement requires adequate compensation, training, and infrastructure support. Moreover, the Total Wellness program's challenge in offering Spanish-only classes that did not meet minimum enrollment highlights the need for culturally appropriate recruitment and engagement strategies. Complementing these practice-level recommendations, state-level policy innovation is needed to address the structural determinants of health disparities. Notably, Nebraska's experience demonstrates the need for differentiated, place-based approaches that recognize the distinct drivers of disparities in rural and urban areas. Key policy recommendations include expanding pediatric mental health services, implementing community-based interventions targeting social determinants, increasing access to care through telehealth, and providing culturally and linguistically appropriate services. Crucially, these approaches require collaboration between public health departments, community organizations, and healthcare systems. Looking ahead, translating these implications into actionable change will demand sustained commitment from all stakeholders. As the evidence underscores, addressing preventive health disparities among underserved populations requires multi-level strategies that combine predictive analytics, community engagement, and structural reforms. In the final analysis, by embracing the polysocial risk framework, investing in community-based partnerships, and advancing place-based policy innovations, public health systems can move closer to achieving health equity and ensuring that all populations have access to the preventive care they need to thrive.

Limitations

Several limitations merit attention in interpreting these findings, starting with the cross-sectional nature of the RADx-UP analysis, which precludes causal inferences regarding the relationship between social determinants and preventive behaviors, and longitudinal studies are needed to examine how changes in social determinants influence behavior over time. Likewise, the Medicaid analysis relied on administrative claims data, which may not capture all relevant clinical and social information, and significant missing data for some social determinants, particularly for federal poverty level (75.5% missing) and English-speaking status (90.8% missing), may limit generalizability. With regard to the community intervention evaluations, these varied considerably in design and quality, as some employed pre-post comparisons without control groups, limiting causal attribution, while the Food is Medicine intervention was conducted in a single rural county in California, restricting generalizability to other settings. Moreover, the Total Wellness program had relatively small sample sizes, with only 33 participants completing the 16-week evaluation, limiting statistical power for subgroup analyses, and the Neighborhood Health Ambassador network experienced significant attrition, with 73% of trained

NHAs completing all practicum hours and only 12 conducting independent outreach. In addition, the qualitative findings from interviews with Black and Latinx people living with HIV and cardiovascular disease risks represent perspectives from a specific population and setting, limiting transferability to other groups, and the study's focus on individuals with established chronic conditions may not capture the experiences of those without regular healthcare engagement. When all is said and done, these methodological constraints underscore the need for cautious interpretation while also highlighting important directions for future research, including longitudinal designs, more diverse and representative samples, larger intervention trials, and improved data collection on social determinants to strengthen the evidence base for addressing preventive health disparities among underserved populations.

Future Research Directions

Going forward, researchers should focus on several gaps, particularly the need for long-term studies that examine how shifting social determinants influence preventive behaviors and health outcomes. Alongside this, the polysocial risk framework should be validated across diverse populations and settings to assess its generalizability, and research is needed on optimal implementation strategies for social determinants screening and intervention in clinical and community settings. Moreover, the effectiveness of interventions combining multiple strategies, such as the AI-based gamified maternal health intervention, should be further evaluated through rigorous randomized controlled trials, while research is also needed on the scalability and sustainability of community-based interventions, including Food is Medicine programs and community health worker networks, and cost-effectiveness analyses would inform resource allocation decisions. On a related note, continued attention is needed to addressing mistrust in medical systems among underserved populations, and research should examine effective strategies for building trust, including the role of community health workers, culturally appropriate communication, and community engagement, while interventions addressing historical trauma and discrimination in healthcare settings require further development and evaluation. Taken as a whole, advancing this research agenda will require sustained investment, interdisciplinary collaboration, and meaningful community partnerships to translate evidence into actionable strategies that reduce disparities and improve preventive care engagement among underserved populations.

Conclusions

This comprehensive analysis demonstrates that preventive health behaviors among underserved populations are shaped by intersecting social determinants operating across multiple levels of influence. The polysocial risk framework provides a valuable approach for pinpointing populations at greatest risk of disengagement from preventive care, demonstrating that individuals confronting multiple intersecting risk factors are substantially less likely to

receive recommended services. Predictive modeling incorporating social determinants of health can improve identification of high-risk individuals for targeted outreach while reducing disparities in prediction accuracy. Plus, community-based interventions addressing multiple barriers to care, including food insecurity, healthcare access, health literacy, and trust, show promise in improving preventive behaviors and health outcomes among underserved populations. Clinic-community partnerships, mobile health interventions, and community health worker networks represent effective strategies for reaching populations that face persistent barriers to care. However, sustained engagement requires adequate compensation, infrastructure support, and culturally appropriate approaches.

Addressing the persistent health disparities experienced by underserved populations requires comprehensive, multilevel approaches that recognize the cumulative impact of intersecting social determinants. State-level policy innovation, community engagement, and healthcare system transformation are all essential components of strategies to improve preventive care utilization and health outcomes among the most vulnerable populations. Precision public health approaches incorporating polysocial risk assessment can inform targeted intervention strategies, but these must be complemented by broader structural changes addressing the root causes of health disparities.

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