
Research and Applications

Applying a socioecological framework to chronic disease management: implications for social informatics interventions in safety-net healthcare settings

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ABSTRACT

Objective: Vulnerable populations face numerous barriers in managing chronic disease(s). As healthcare systems work toward integrating social risk factors into electronic health records and healthcare delivery, we need better understanding of the interrelated nature of social needs within patients' everyday lives to inform effective informatics interventions to advance health equity.

Materials and Methods: We conducted in-depth interviews, participant-led neighborhood tours, and clinic visit observations involving 10 patients with diabetes in underserved San Francisco neighborhoods and 10 community leaders serving those neighborhoods. We coded health barriers and facilitators using a socioecological framework. We also linked these qualitative data with early persona development, focusing on patients' experiences in these communities and within the healthcare system, as a starting place for our future informatics design.

Results: We identified social risk and protective factors across almost every socioecological domain and level—from physical disability to household context to neighborhood environment. We then detailed the complex interplay across domains and levels within two critical aspects of patients' lives: housing and food. Finally, from these data we generated 3 personas that capture the intersectional nature of these determinants.

Conclusion: Drawing from different disciplines, our study provides a socioecological approach to understanding health promotion for patients with chronic disease in a safety-net healthcare system, using multiple methodologies. Future digital health research should center the lived experiences of marginalized patients to effectively design and implement informatics solutions for this audience.

Key words: chronic disease management, diabetes, social informatics, safety-net patients, socioecological model, qualitative methods, persona methodology, user-centered design, vulnerable populations, social determinants of health, health promotion, electronic health records

LAY SUMMARY

Marginalized patients face many types of barriers to managing their health, and we need digital health solutions that center their lived experiences. Our study completed interviews, neighborhood tours, and clinic visit observations in San Francisco to understand important influences on health and wellness for patients who have been historically and presently marginalized within society (for example, those from racial/ethnic minority groups or facing poverty). We uncovered multiple examples of how structural problems, such as housing, influence or interact with individual health behaviors in everyday life, such as medication taking. We also aggregated findings across individuals and data sources to generate more holistic personas representing these multi-level influences on health. Moving forward, we provide examples of how digital health designers and researchers might use a broader and intersectional understanding of health when developing products or programs.

BACKGROUND AND SIGNIFICANCE

Chronic conditions such as diabetes are a leading cause of disease morbidity and mortality in the United States and disproportionately affect vulnerable populations including individuals from racial/ethnic minority backgrounds and those facing poverty.^{1,2} Substantial epidemiological literature has established that differences in chronic disease incidence and control result from multiple contributors, including individual, behavioral, social, and community factors as well as broader societal factors such as structural racism and economic inequality.^{3–5} Social determinants of health (SDoH)—defined as the circumstances in which people are born, live, work, and age—are recognized as having a powerful role in shaping disease risk and outcomes and contribute more to population health than healthcare services.^{3,6} There is robust evidence in the public health literature from the past 3 decades on the ways in which SDoH such as housing, food access, and social support affect the chronic disease management of racial minorities living in low-resource environments.^{7–11} In addition, social science and public health researchers have drawn attention to the synergistic interaction between multiple influential factors across socioecological domains, particularly co-occurring structural conditions (e.g. poverty, neighborhood violence), that contribute to increased risk (and clustering) of multiple diseases within vulnerable populations.^{12–14}

Digital health tools and platforms are evolving across multiple levels to address SDoH.¹⁵ For example, research has been conducted to understand barriers and facilitators in underserved communities associated with access to health-enhancing resources such as healthy foods and transportation technologies in order to build sociotechnical interventions (i.e. online grocery delivery services) that meets residents' needs.^{16,17} Furthermore, within healthcare, many national health and medical organizations recommend the capture and use of SDoH information in clinical settings to improve patient care and advance population health goals. For example, there are national guidelines for healthcare systems to leverage their electronic health records for SDoH screening and referrals (e.g. income, employment, housing, food availability/access) during routine clinical visits.^{18,19}

As the digital health field increases capture and use of SDoH data, we need a more purposeful and rigorous approach to understanding the multiple social needs and lived experiences of underserved populations.^{20–22} Given that social risk (and protective) factors often exist in combination rather than isolation, key questions remain on how various SDoH *interact* to influence outcomes such as diabetes and other chronic disease self-management and how technologies can incorporate intersectional perspectives of SDoH.^{20,21} These insights will be critical in all phases of digital health research, from discovery to design and implementation.^{16,17,23} Combining methods across phases (such as socioecologi-

cal qualitative inquiry and user-centered design approaches like persona development) can effectively bring patients' multi-factorial needs, contexts, and values to the forefront of digital health research and implementation.^{24,25}

In this paper, we draw insights from across disciplines to: (1) develop a socioecological, intersectional perspective of the SDoH of chronic disease management among diverse patients in safety-net healthcare settings, using diabetes as an exemplar, and (2) based on this empirical understanding, create personas of safety-net patients that may be used to inform the design and deployment of digital health intervention strategies for improving their care.

OBJECTIVE

The aim of our paper is to explore the multifaceted social risk and protective factors shaping the experiences of diverse safety-net patients with chronic conditions (using diabetes as an exemplar) living in socioeconomically deprived neighborhood contexts. Using varied qualitative approaches to inquiry, we seek to better understand how SDoH synergistically operate in the everyday lives of patients in order to inform the design of digital tools and information systems that are both robust and responsive to vulnerable individuals managing their diabetes and/or other chronic conditions alongside their broader health and wellness. We then apply user-centered design methodology to the qualitative data to develop empirically-derived personas, or archetypes of safety-net patients with diabetes, which can be used in future informatics work to tailor health informatics interventions to address patients' multi-faceted social needs.

METHODS

This study was part of the first phase of a National Library of Medicine-funded R01 entitled Mapping to Amplify the Vitality of Engaged Neighborhoods (MAVEN), which has been described previously.²⁶ The goal of this qualitative work was to inform the future creation of a mobile application to support community members and leaders in underserved neighborhoods to access relevant neighborhood health resources.

Study design

Qualitative research was conducted in this study in 3 ways: (1) interviews, (2) neighborhood tours, and (3) clinic visit observations. We conducted semi-structured interviews with patients in the San Francisco Health Network (SFHN, the public healthcare delivery system in San Francisco) and with community leaders working at local non-profits and community-based organizations (CBOs). This format

allowed for flexible conversations and in-depth explorations of facilitators and barriers to chronic disease management for individuals and broadly related to their environment(s). Patients were asked open-ended questions about their experiences living with chronic disease(s) including how they take care of their health, barriers/challenges in prioritizing their health, how chronic illness impacts their ability to manage their health, and where they find health information. Patients were also asked to describe places and resources in their neighborhood that do and do not contribute to health, where they spend time with family and friends, and whether they feel a sense of community. Community leaders were asked to describe their professional background and role, experience in their local community and neighborhood, relationships with clients, perspective on what health means to them and to their clients, and barriers and facilitators to their clients' health.

Next, we used neighborhood tours to better understand the neighborhood environment and how it relates to chronic disease management and health more broadly. Patients and community leaders each led the research team through their neighborhood to visit places relevant to their health management and daily living (where patients lived and/or most strongly identified; where community leaders' organizations were located, sometimes overlapping with where they lived) describing their usual activities, regularly frequented places, and people they interact with.

Finally, we conducted in-person clinic visit observations with 4 of the 10 patients and their primary care providers. Observations allowed an independent view of interactions described by participants and were useful to uncover insights about roles, processes, and patterns between providers and patients. Study staff interviewed patients after each clinic visit observation about their perceptions of the visit, their relationships with their healthcare providers, and what information about their neighborhood they felt would be useful for their healthcare providers to know.

Data collection and procedures

We purposively selected patients with prediabetes or diabetes ($n=10$) who owned a smartphone, and community leaders ($n=10$) from San Francisco (SF) neighborhoods, focusing on 5 SF neighborhoods (as defined by the San Francisco Planning Department)²⁷ with high diabetes prevalence (Mission, Bayview/Hunters Point, Excelsior/Visitacion Valley, Tenderloin, Western Addition).²⁸ We identified patients empaneled within the public healthcare delivery system in SF (SFHN) via primary care provider review of patient panels followed by phone screening by study staff, as well as purposive snowball sampling from patients suggesting additional SFHN patients in their community. While we sampled patients with diabetes, all patients managed multiple chronic conditions, allowing us to focus on chronic disease more broadly within this study. Community leaders from community-based health and social service organizations in the above neighborhoods were recruited using snowball sampling, beginning with a citywide coalition of CBOs focused on chronic disease prevention. Interviews with all participants were conducted in 2019 in patients' homes, at community organization sites, at health clinics, or over the phone.

Each interview lasted approximately 90–120 min, each neighborhood tour approximately 30–120 min, and each clinic visit approximately 30–60 min, all conducted in English. Interviews, neighborhood tours, and clinic visits were audio-recorded. Experienced research staff collected data under the guidance of the senior author (CRL) and first author (KHN), both researchers with experi-

ence in qualitative data collection. All patients completed a survey including demographic information, self-reported health, chronic conditions, physical activity, diet, and internet/technology access and use. We obtained informed consent from all participants. The University of California, San Francisco Institutional Review Board approved the study (study #18-25696).

Qualitative data analysis

Relevant characteristics from patient surveys were summarized. Transcripts of interviews, neighborhood tours, and clinic visit observations were read multiple times and independently coded by at least 2 study staff using Atlas.ti 8 software. We used the National Institute on Minority Health and Health Disparities (NIMHD) research framework¹⁵ as a theoretical lens during analysis (and not a priori for study design or data collection) to assess the complex and wide array of determinants that influence and contribute to chronic disease-related disparities among vulnerable populations. It is a conceptual framework that organizes health determinants relevant to health disparities by: (1) levels of analysis (individual, interpersonal, community, and societal) and (2) domains of influence (biological, behavioral, physical and built environment, sociocultural environment, and healthcare system).

For the analysis, transcripts of interviews, neighborhood tours, and clinic visit observations were read multiple times and independently coded by KHN and AGC using Atlas.ti 8. Authors KHN and AGC met several times to discuss and reconcile codes. Through inductive thematic analysis, we finalized a codebook informed by the NIMHD framework but iteratively adapted as ideas emerged.²⁹ We summarized overall findings mapped to the socioecological framework first, and then returned to the content areas with the largest number of codes (housing and food) to extract deeper examples of the intersectional SDoH domains emerging during the analysis.

Authors KHN, AGC, and JDF then developed initial code-level summaries that represented key concepts conveyed in the data. Authors KHN, AGC, JDF, and CRL met to review and refine these key concepts mapped to the NIMHD framework, contrasting and comparing cases as well as addressing discrepancies, before KHN and AGC systematically applied the framework to all codes to identify excerpts that reflected each of the 20 cells in the matrix. We collapsed the biological and behavioral domains in this study because of the lack of sufficient biological examples brought up by patients or community members in the qualitative data. Finally, KHN, AGC, JDF, and CRL also held frequent meetings to examine the intersectionality within the thematic data across levels and domains of the NIMHD framework, which led to broader contextual understanding of determinants of chronic disease management for patients facing structural, interpersonal, and individual barriers to health.³⁰ To ensure rigor, the research team implemented a variety of strategies such as debriefing (i.e. team meetings after qualitative encounters), data triangulation (i.e. capture of data from interviews, clinic visits, and neighborhood visits), and reflection (i.e. field notes and ongoing team meetings to promote insights) to promote trustworthiness, credibility, transferability, dependability, and confirmability.^{31,32}

Persona development

In the final stage of the analysis, we employed a persona methodology using our analyzed data, also mapped to the NIMHD framework.³³ Personas, a well-known technique used in the human-computer interaction field,^{33,34} are primarily used to inform the development of technologies for target users to ensure that the final

design resonates with the end users' needs and preferences throughout the building and ultimate implementation of a digital solution.²⁴ To employ this method, we iteratively compared and contrasted all 10 patient narrative summaries across NIMHD framework levels and domains to characterize the ways in which SDoH played out similarly or uniquely in patients' everyday lives. Our analysis and interpretation resulted in the development of 3 composite personas that captured the lived experiences of the safety-net patients in managing their diabetes/chronic conditions and overall health. To promote realism, each persona is ascribed a credible name and photo, and a narrative reflecting significant experiences and contexts with associated illustrative quotes from the data.³⁵

The use of the well-established SDoH framework from NIMHD allowed us to systematically bring in socioecological concepts into the persona methodology—not as universal characterization of patients, but as a tool to make the intersectional nature of SDoH more concrete for designers, clinical leaders, and researchers envisioning digital health solutions to better meet patients' complex medical and social needs.

RESULTS

Characteristics of the respondents

Table 1 shows participants' demographic characteristics. Patients had prediabetes or diabetes, were majority Black ($n = 6$), two-thirds female, average age of 62, had at least high school education, most earned less than \$20 000 annually, and had at least one other chronic condition. Community leaders' organizations included the public library, patient advisory councils, health and wellness organizations serving Black and other marginalized communities, non-profit cooking school, social services center, multi-ethnic family resource center, and Latinx cultural organization. Based on patients' demographic survey responses, nearly two-thirds of patients had Internet service available at home. Sixty percent used the Internet several times a day, with only 20% reporting not using the Internet. Although our inclusion criteria required smartphone ownership, only 40% of our patients felt very familiar with using a mobile phone, and half reported receiving help to set up their phone.

Summary of SDoH and chronic disease self-management within the NIMHD framework

Table 2 summarizes the major risk and protective factors for chronic disease management for our sample, mapped to the NIMHD framework. At least one example within each of the 20 cells is provided; however, these are not intended to constitute a comprehensive listing. In [Supplementary Appendix S1](#), we provide a more complete list of related examples and salient patient and community leader quotes from the study data to further illustrate each level of influence and domain intersection in depth.

At the individual level, patients had multifaceted medical, psychological, and social needs that affected their ability to manage their chronic disease, including physical disability, comorbidity, psychosocial factors, cultural and language barriers, history of substance abuse, and health and digital literacy. Coping and resilience factors were identified as sources of strength for patients.

At the interpersonal level, many patients lacked supportive social/family relationships for coping with their illness in everyday life. Family-related stress was cited by multiple patients as directly impeding their chronic disease self-care. Additionally, some patients had caretaking responsibilities that contributed to their stress level,

as well as difficult living arrangements that played an important role in their self-management behavior (e.g. inadequate kitchens). Patient-provider trust and communication were critical to diet and medication management.

At the community-level, the built/physical and social conditions of neighborhoods and residential environments affected patients' health and disease self-management behaviors. Disparities in the availability of health-related resources including supermarkets, affordable housing, public spaces, health services, and transportation posed significant challenges to engaging in health-promoting behaviors. Neighborhood factors such as exposure to substance abuse and violence as well as homelessness were identified as barriers to physical and mental health whereas social cohesion was a source of support.

At the societal level, participants (particularly community leaders) identified numerous structural factors that shape neighborhoods, ultimately impacting patients' ability to obtain the resources they need to maintain their health. These included laws and policies pertaining to housing and transportation as well as racism and economic inequality as underlying causes of structural barriers.

Exploring interactions in relationships between chronic disease self-management and both housing and food access

To illustrate the interaction of SDoH factors across domains and levels, we explored how 2 critical challenges most commonly identified by participants—housing and food—intersect with chronic disease self-management among study patients.

Housing

Individual Level. Housing was the most salient social determinant of health identified by all patients, community leaders, and providers. Every patient had previously experienced or was experiencing housing-related challenges, including housing insecurity and homelessness. Most struggled with paying rent on their limited income. Two patients reported spending the majority of their income on rent, leaving little money left for food and health resources.

Interpersonal Level. Physical/built aspects of the home environment also had significant impacts on patients' self-management. Some patients' shelters did not have adequate kitchens, posing challenges to planning and preparing nutritious meals. *"I have one patient who... doesn't have a stove, he only has a small fridge and a microwave. He was asking 'What can I eat? What are healthy options that I have?'... If patients could get like a stovetop or a microwave or a mini fridge, like those resources would be so useful,"* explained one community leader. Other characteristics of the built environment identified as barriers to patients' health included crowded conditions and substandard housing with mold and mildew.

Social and interpersonal aspects of housing contexts also presented barriers to chronic disease management. Most patients lived alone, making self-care more difficult if elderly or disabled. A community leader noted, *"A lot of our elder population... don't necessarily have someone to remind them that their pill or their appointment is due."* Among patients living in single room occupancy hotels (SROs), aspects of the sociocultural environment were identified as barriers to health. For example, a patient with a substance abuse problem told her primary care physician that fellow residents' drug use were impediments to her quitting. Another patient living in an SRO had his glucometer stolen from his room. Finally, a few patients identified positive

Table 1. Patient and community leader participant characteristics

Patients (N = 10)					
Race/ethnicity	Gender	Age group	Education	Income	Neighborhood
Black/African American	Female	60–69	High school	N/A	Bayview-Hunters Point
White	Female	60–69	College graduate	Less than \$20 000	Tenderloin
Black/African American	Male	60–69	Some college	N/A	Bayview-Hunters Point
Black/African American	Female	70–79	Graduate degree	Less than \$20 000	Western Addition
Asian or Pacific Islander	Female	60–69	College graduate	\$20 000–40 000	Tenderloin
Hispanic/Latinx	Female	40–49	Graduate degree	Less than \$20 000	Tenderloin
Black/African American	Female	50–59	Some college	Less than \$20 000	Bayview-Hunters Point
Black/African American	Male	50–59	Some college	Less than \$20 000	Tenderloin
American Indian/Native American	Male	60–69	College graduate	\$20 000–40 000	Excelsior
Black/African American; Multi-Ethnic	Female	60–69	Some college	Less than \$20 000	Bayview-Hunters Point
Community leaders (N = 10)					
Role	Organization description				Neighborhood
Librarians (2)	Public library with a robust health program/collection				Tenderloin
Patient Advocate	Coordination department for patient advisory councils at public health clinics				Tenderloin
Staff Leader	Health and wellness organization serving primarily Black communities				Bayview-Hunters Point
Staff Leader	Nonprofit cooking school serving low-income communities				Mission
Senior Services Staff (3)	Social services agency serving low-income seniors and minorities				Mission
Staff Leader	Social services agency serving low-income multi-ethnic families with young children				Excelsior/Visitation Valley
Former Staff Leader	Latinx cultural organization				Mission
Neighborhoods (N = 5)					
Neighborhood	Neighborhood characteristics ^a				
Bayview-Hunters Point	Significant Black and Asian communities, advanced gentrification, greatest SES needs				
Excelsior/Visitation Valley	Significant racial minority communities, advanced gentrification, greatest SES needs				
Mission	Significant Latinx communities, advanced gentrification				
Tenderloin	Significant racial minority communities, advanced gentrification, greatest SES needs				
Western Addition	Significant Black community; advanced gentrification, greatest SES needs				

^aInformation about neighborhood characteristics derived from reports by SF Department of Public Health and UCSF Center for Community Engagement.^{36,37}

aspects of the SRO such as free food access (coffee and pastry) and a sense of community. *“The people in the building—there’s a select handful that are sparkling and alive.”*

Community Level. At the community level, community leaders noted that securing housing is often the top priority for their clients, yet community leaders were unable to assist them due to the lack of affordable housing available. A community leader stated *“It’s hard when [clients are] looking for help, they’re waiting for months. They come with problems and we can’t do anything about it, just advise them.”* The high cost of housing in the city means that without more affordable housing assistance, residents were forced to live in substandard or unhealthy conditions, or even driven into homelessness—directly leading them back to individual-level barriers to managing their conditions.

Societal Level. Moreover, community leaders highlighted the underlying structural forces that shape inequitable access to housing for certain populations. Sociohistorical processes such as gentrification and redlining impacted an individual’s ability to live in certain

neighborhoods, often displacing many residents to under-resourced, less desirable ones. A community leader recounted, *“In [a] 15-year period, the Mission lost 10,000 individuals who were displaced. . . 8,000-10,000 were Latinos. . . It felt like communities are under attack, and it was losing something.”*

Food

Individual Level. These same types of interconnected patterns also persisted for food access. For example, several patients reported that after paying rent, they had little money left for health-related food expenses, which posed barriers to self-management. Those with disabilities experienced higher levels of poverty and unemployment, reducing financial resources for food. Some patients preferred eating healthfully but reported the high cost of food as a barrier. A community leader said stress, lack of time, and the convenience of prepared or fast foods were barriers to clients eating healthfully.

Community Level. Patients also lived in neighborhoods with few affordable, healthy sources of food. *“If you aren’t able to travel far*

Table 2. NIMHD framework adapted to reflect lived experiences of patients with chronic disease in an urban safety-net setting

Domains of influence	Levels of influence			
	Individual	Interpersonal	Community	Societal
Biological-behavioral	Disability/physical limitations Health and self-management behaviors (e.g. diet, exercise) Competing needs in everyday life Health Beliefs (i.e. locus of control) Psychosocial factors (e.g. drug use) Co-morbidity management <i>Positive coping strategies (e.g. spirituality, resilience)</i>	Caregiving responsibilities Stressful family relationships Unsafe/unhealthy household functioning (e.g. drug use in building) <i>Peer support (e.g. walking group)</i>	Persistent problem of homelessness Community violence Neighborhood substance use	Inequitable and poor infrastructure leading to pathogen and toxin exposure Toxic waste in Black neighborhoods <i>Local policies that support health</i>
Physical/built environment	Marginally housed/homelessness Unhealthy indoor housing conditions (e.g. mold/mildew)	Crowded household (e.g. lack of privacy)	High density of alcohol stores Availability/affordable food stores Lack of affordable exercise options Few public places for social interaction Few green spaces <i>Neighborhood churches Community-based organizations</i>	Transportation inequity Sociohistorical processes that affect housing (e.g. redlining, gentrification) Unfair criminal justice system
Sociocultural environment	Vulnerable sociodemographic background (e.g. low-income, immigrant) Language barriers History of trauma and violence	Limited social network (e.g. living alone, social isolation) Interpersonal discrimination Death/loss of loved ones <i>Supportive environments (e.g. senior buddy program)</i>	Distrust of police Weakened social ties <i>Community identity/sense of community Community organizing/advocacy</i>	Societal structural discrimination (e.g. structural oppression) Inter-generational poverty
Health care system	Poor/limited insurance coverage Navigation barriers (e.g. difficulty refilling medication) Limited health and digital literacy	<i>Patient-provider relationship Shared decision-making (e.g. patient activation, prioritizes social needs, team-based approach)</i>	Lack of cultural/linguistic services Safety-net services robust but still under-funded (e.g. EHR/informatics limitations) <i>Social service integration</i>	Healthcare policies <i>Some health systems prioritizing addressing patients' social needs</i>

Note: Plain text signifies risk factors, italicized text signifies protective factors.

when living in a food desert/swamp, you have no choice but to rely on expensive, unhealthy, corner store options," said a community leader. On a neighborhood tour, one patient took research staff to 3 different grocery stores to highlight the poor quality of produce and exorbitant pricing.

Community food assistance programs including food pantries, a produce voucher program, free food delivery services (e.g. Meals on Wheels), and cooking classes were identified by patients and community leaders as resources for patients with diabetes. A community leader said that even if they were able to connect clients to food pantries and soup kitchens, some would be unable to benefit because of their limited mobility or lack of a kitchen to prepare meals. Some patients felt they were able to get enough food with social service assistance, and others felt that the amount of assistance was inadequate.

Societal Level. Additionally, participants discussed racism experienced by people of color as exerting deleterious effects on food access or dietary patterns. For example, patients and community leaders explained that Black residents were deterred from entering certain neighborhoods or places (i.e. restaurants, grocery stores) because they felt unwelcomed or were perceived as a threat, thus limiting their ability to access health-promoting resources and services.

Personas of safety-net patients living with diabetes

These qualitative data demonstrated the complexities through which biological, psychological, social, community, and structural factors come together to shape the health of vulnerable patients with chronic diseases and their ability to manage their health. To make these lived experiences more concrete, we then developed personas

(see Figure 1) from patient narratives that illustrate the intersectionality and interplay of these factors, using direct quotes from participants. These personas demonstrate how different determinants intersect to impact health and an individual's ability to manage chronic conditions.

In future informatics work, these personas could be utilized to inform the design of digital solutions to improve health outcomes, such as: (1) referrals to/from healthcare and social service settings, (2) support for health behaviors individually and as a part of social gatherings, and/or (3) using data to better deliver place-based interventions to ameliorate structural disinvestment. For example, our findings suggest that for some patients, the levels closest to the individual and the interactions and relationships of their immediate surroundings exert the strongest influences. Other patients are most affected by factors beyond these, including societal forces which exert influences on their community contexts (e.g. transportation, food access). Knowledge of the links between the levels and domains can be leveraged to develop interventions with appropriate combinations of target(s) of change (e.g. health behavior, access to resources) and level(s) of influence (e.g. community or individual) to produce desired outcomes.

DISCUSSION

Our study applied a multi-dimensional lens of SDoH that examined multiple levels of influence on chronic disease outcomes, from individual/behavioral to structural domains.³⁸ These findings show that determinants of chronic disease management are intersecting and have synergistic influence on the health and wellness of marginalized patients. Incorporating a socioecological framework, such as the healthcare disparities framework from NIHMD, can produce extremely rich insights about SDoH, as well as point us in new directions for future digital health design and implementation.

This study synthesizes theories, methods, and insights across different disciplines, specifically public health, behavioral medicine, health informatics, and human-computer interaction. These results build upon these different streams of work for the informatics field by directly linking our in-depth qualitative findings of SDoH to personas and future digital design. Previous literature³⁹⁻⁴¹ has also provided real-world evidence about chronic disparities mapped to the NIMHD framework⁴² or other socioecological frameworks, which are consistent with our findings in this study.²² Our study reflects the interdisciplinary approach advocated by researchers and practitioners in guiding development and evaluation of health informatics interventions^{24,35} as well as applies an equity lens in health informatics with an explicit aim of ameliorating health disparities.^{24,35} In future research, these methods⁴³ can be incorporated to help designers, clinicians and healthcare leaders, and other stakeholders to be explicit about how proposed interventions or digital solutions are matched to the interconnected, real-life experiences of patients.

Moving forward, we also see concrete design opportunities (outside of our research study) for digital health interventions across all of the socioecological levels uncovered in this work. For example, patients who prefer/need to address an individual-level behavior or situation often currently use apps or platforms that focus on lifestyle changes. Digital tools at this level can better personalize content based on patients' lived experiences and/or goals, such as holistic action planning to focus on behaviors that are most important to patients (e.g. making improvements with mental health and stress before moving onto exercise).⁴⁴ Similarly, at the interpersonal level, digital tools that can facilitate peer coaching and/or matching on

broader lived experiences might be particularly beneficial.⁴⁵ Finally, patients who prefer/need to address a structural challenge that hinder healthcare tasks in their lives might benefit from digital tools that more seamlessly integrate social and medical needs screening and referral—in direct collaboration with social service agencies and community based organizations that have deep expertise in these domains.⁴⁶⁻⁴⁸

We have several limitations in this study. Despite the depth of the data collected, we focused on a smaller sample of vulnerable patients from one safety-net system and within specific neighborhoods of one city. We likely have overrepresentation from specific racial/ethnic groups given the social stratification in neighborhoods. Furthermore, 7 of 10 patients were English-speaking older adults in their 60s who received care for their chronic conditions at SFHN; thus, limiting generalizability. Despite their benefits, persona methodologies also have shortcomings, including risk of perpetuating existing stereotypes.⁴⁹⁻⁵² While we did not involve community members in shaping the personas in this study, we are moving forward with direct end-user involvement in our future technology build within the broader MAVEN study.⁵³⁻⁵⁵ Finally, we are unable to ascertain causal or life course relationships between determinants, even though previous frameworks have theorized that structural determinants such as racism are the root cause of diabetes (as well as other chronic illnesses) and has a cascading impact on diabetes outcomes.⁵⁶⁻⁵⁸

CONCLUSION

In summary, chronic disease disparities are a systemic public health problem, reflecting interacting individual, social, and community factors that cluster together and are driven by economic, political, and social forces.¹⁴ The digital health and informatics landscape is poised to combine multiple methodological approaches to address SDoH in meaningful ways to prevent and mitigate health and healthcare disparities within our field.

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AUTHOR CONTRIBUTIONS

KHN and CRL guided study design, data acquisition, data analysis, and manuscript draft and development. AGC, JDF, CRL, and KHN collected study data. WB and MP guided study design and edited and approved the manuscript. AGC and JDF supported data analysis and edited and approved the manuscript. All authors have fulfilled the criteria for authorship established by the International Committee of Medical Journal Editors and approved submission of the manuscript.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *JAMIA Open* online.

Safety-Net Patient Personas



Rhonda, 58

HEALTH SUMMARY

Activated and motivated to improve her health and requires coordinated care for multiple chronic comorbidities

BACKGROUND

- Native and Black mixed-race female with college degree who has lived in Excelsior for a long time.
- Diagnosed with diabetes 5 years ago. Also, has asthma and chronic kidney disease.

SOCIAL DETERMINANTS OF HEALTH

- Highly motivated to manage her diabetes. Took group diabetes education through the wellness center at the hospital. Very active at the hospital as a voluntary patient advocate and advisor to help other patients navigate the healthcare system.
- Hospitalized for pneumonia last year and almost died. Believes her hospitalization resulted from exposure to chemicals/toxins in her home. Her near-death experience led her to prioritize her health.

"When that chaplain came in, I lost it. I thought [he] was Jesus. The whole room kind of just lit up. It was like instant motivation."

- Credits her healthcare team with connecting her to a psychologist and a social worker who helped her get prescription glasses and dental services. The psychologist also helps her with depression, to help her "keep going" and focus on her other conditions.
- Comfortable with using technology to manage her health, including communicating with her provider through the online patient portal.
- Today, she tries to continue her walks around the neighborhood and eat healthier, frequenting her favorite local shops often.
- Feels a strong sense of community. However, she feels that her neighborhood is changing and becoming less racially and culturally diverse.

"This is a beautiful, beautiful city. It's a tragedy because they're losing so much of the culture and the ethnicity which made the city unique compared to anywhere in the world. It's the people."



Alicia, 67

HEALTH SUMMARY

Connected with multiple social and community resources, yet facing mobility barriers to access all available services

BACKGROUND

- Latinx female with a graduate degree who lives alone in the Mission neighborhood.
- Has pre-diabetes and previously had a stroke.
- Has limited mobility and uses a wheelchair.

SOCIAL DETERMINANTS OF HEALTH

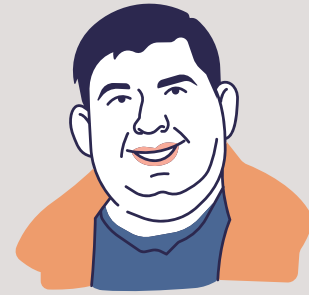
- Her biggest challenge is transportation because she dislikes having to wait for 45 minutes to get paratransit.
- Believes a higher power has more control over her health than her own self-management behaviors.

"From a spiritual standpoint, if I were to truly manage my diabetes, it would be a lot of work. I believe God is going to take care of me."

- Believes that she would more likely die from other causes because of old age, so diabetes does not worry her.
- Family is a big source of stress for her, leading her to cut family members out of her life.

"I had to just give a lot of people up that was no good for me. I have to leave a lot of people alone. Do what you want. I'm going to do me."

- Has a free "Obama phone", but uses it mostly for phone calls and texts as she isn't confident in downloading and using apps.
- Has lived in her neighborhood for many years and thinks there are good and bad parts of the neighborhood. Points to some activities such as drug selling that occur in the neighborhood and avoids unsafe places.
- Most of her social activities in the neighborhood center around different local churches and community organizations.
- Involved with helping the local Latinx community through her church.



Richard, 62

HEALTH SUMMARY

Connected to healthcare yet facing structural barriers such as housing access

BACKGROUND

- White male with high school education, lived in an SRO in the Tenderloin for 2.5 years.
- Has diabetes and high blood pressure.
- Unemployed; 1/2 disability benefits go to shelter.

SOCIAL DETERMINANTS OF HEALTH

- Improved diabetes control since connected to a primary care provider 4 years ago, but still has complications (i.e. foot ulcers and dizziness).
- Reported to primary care provider that glucometer stolen from his room thus unable to check his glucose levels.
- Eats pastries daily provided for free by the SRO.
- Has a cocaine addiction and feels unable to stop as other SRO residents come to his room to use with him. He reports depression and anxiety and stays in his room most of the day.

"Living in this one room drives me crazy, but it's better than not having a place and you have to start somewhere."

- Has a flip phone, but goes through long periods of not having a phone because he loses track of it or it gets stolen.
- A public health nurse comes to his residential building to help manage his medications. His primary care doctor coordinates with the public health nurse when there is a change in his blood pressure medication, and the nurse coordinates with the local pharmacy to send it to his residence.
- Much of his social interaction is with social services and outreach workers focused on homeless populations (i.e. Meals on Wheels).
- Recognizes that the Tenderloin has a lot of social problems such as homelessness and wishes that there was more awareness about the community's problems and ways to help them.

"[I'm] getting tired... seeing too much going [on] in the neighborhood."

Figure 1. Social determinants of health personas of safety-net patients.

CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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