



Characterizing the Technology Needs of Vulnerable Populations for Participation in Research and Design by Adopting Maslow's Hierarchy of Needs

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ABSTRACT

While various frameworks and heuristics exist within the HCI community to guide research and design for vulnerable populations, most are centered on the researcher's involvement. In this work, we developed a conceptual framework for supporting the participation of vulnerable populations in the research and design of technologies. Building upon Maslow's hierarchy of needs, we synthesized 84 research articles that focus on vulnerable populations and technology to develop our framework. This framework conceptualizes both the barriers, such as lack of technology access and digital literacy, and assets, like social relationships, that impact effective participation in research and design. Using our framework can guide researchers in identifying and fulfilling the technology-related needs of vulnerable populations, leading to more empowering research participation for these groups. The framework's guiding questions offer researchers the opportunity to reflect on their approach prior to and during their collaboration with vulnerable populations in technology research and design.

CCS CONCEPTS

• **Human-centered computing** → **HCI theory, concepts and models**; **Human computer interaction (HCI)**.

KEYWORDS

Vulnerable Populations, Research and Design, Conceptual Framework, Marginalized Communities, Motivation Theories, Systematic Review

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1 INTRODUCTION

Over the years, the SIGCHI community has contributed significantly to research and design approaches for working with vulnerable populations. Vulnerable populations refer to people who may have a low-socioeconomic status, identify as a racial and ethnic minority [166], or are susceptible to harm [141]. These populations can include but are not limited to, those who have experienced domestic abuse, those who live in poverty or in foster care, immigrants, refugees, economically and emotionally disabled, people with chronic illnesses, people who identify as LGBTQ+, youth, children, and older adults [108, 160]. In attempts to conduct responsible research while protecting the welfare of vulnerable populations, many researchers have developed frameworks and heuristics for engaging with these populations [3, 140, 177, 183]. For instance, Walker et al. [177] created heuristic guidelines for conducting research with vulnerable populations, encouraging researchers to ask key questions throughout the research process and even before a research project begins. In terms of design, Wong et al. [183] developed a framework to understand the unique health challenges of vulnerable populations when designing specialized health technologies. While these frameworks help orient the researchers' and designers' participation in engaging with vulnerable groups, the frameworks do not directly address the participation of the vulnerable individual. To the best of our knowledge, *no existing framework considers the needs and motivations of vulnerable populations when engaging them in research and design*. Therefore, our goal was to develop a conceptual framework that could serve as a lens for supporting the participation of vulnerable populations in technology research and design. Our work was guided by the following research question:

RQ1: How can the needs and motivations of vulnerable populations be conceptualized for technology research and design participation?

To answer this research question, it is important to build upon established theories of human motivation. We started by researching several well-known motivation theories used in the HCI literature. Theories explored included Maslow's theory of motivation [187], the theory of planned behavior (TPB) [41], and the self-determination theory (SDT) [85]. Based on this comparison, we decided to use Maslow's theory to build the conceptual framework for the following reasons; 1) The TPB and SDT emphasize behavioral change and behavior prediction, respectively. Considering that the goal of this research was not to change the behavior of vulnerable populations, but to orient researchers to their needs and motivations to participate in research and design, we argue that

behavioral change and behavioral prediction are not appropriate. Maslow's theory, on the other hand, focuses on behavior motivation. We believe this theory is suitable as it allows us to understand factors that could influence vulnerable populations' participation during technology research and design and how researchers can offer support. 2) Maslow's theory explains motivation through the satisfaction of needs. Following this theory allows us to investigate what needs exist for vulnerable populations in technology settings and how researchers may support their research and design participation by assisting in the fulfillment of these needs. 3) Like other motivation theories, Maslow's theory is robust in its coverage of human psychological and growth needs, critical factors when considering human behavior and motivation.

We scoped our research and conceptualized the technology needs for vulnerable populations' research and design participation using Maslow's theory of motivation [104]. Similar to Maslow's distinction between lower-order (deficiency) and higher-order (growth) needs, we characterized the technology needs as deficits-based and assets-based. Deficits-based technology needs are those that result from a deficit or shortcoming or a population's susceptibility to it. These needs, corresponding to the basic and safety levels of the hierarchy, include access to information and communication technologies, digital literacy skills, and the assurance of safety and privacy in technology-related environments. Assets-based technology needs, on the other hand, are derived from the assets or strengths that vulnerable populations possess, such as their social ties, their social identities, and the ability to lend their voice to research and design. These assets-based needs correspond to the relationships, self-esteem, and self-actualization levels of the hierarchy, respectively. The primary premise of our framework is that satisfying the various technology needs of vulnerable populations can motivate their engagement in technology research and design, making them feel more supported and empowered as a result.

To develop our framework, we conducted a systematic review of 84 research articles focusing on vulnerable groups and topics related to the different levels of Maslow's hierarchy (e.g., safety and self-esteem) in technology settings. We used a thematic analysis approach to analyze the research articles [23], which allowed us to identify several technology-related needs for vulnerable populations for each level of the framework. We discuss how theories, such as intersectionality [51] and design justice [36], can help researchers explore dimensions pertaining to vulnerable populations and satisfy these technology needs. Further, using the physiological concepts of empowerment provided by Schneider et al. [152], we describe how meeting the various technology needs in our framework could result in researchers empowering vulnerable populations through research and design engagements, and ultimately, supporting their participation. Our contributions include:

- A conceptual framework that guides researchers on how to support the participation of vulnerable populations in research and design.
- An understanding of how addressing technology needs can empower vulnerable populations through research and design participation.
- A set of questions for researchers to follow while engaging with vulnerable groups so as to empower them through technology research and design.

This paper is organized as follows. First, we provide related work on existing HCI research for vulnerable populations. We also present background on HCI research for engaging vulnerable populations in technology research and design and Maslow's theory of motivation. Second, we describe our method, including the process we followed for selecting papers and conducting thematic analysis. Third, we present our framework synthesis based on findings from our thematic analysis of relevant literature centered on vulnerable populations, technology-related settings, and topics related to the different levels of the Maslow's hierarchy. Finally, we present our discussion, limitations, and conclusions.

2 BACKGROUND AND RELATED WORK

In this section, we discuss related works on HCI research for vulnerable populations. We also discuss background work on methods used in engaging with vulnerable populations for research and design and Maslow's theory of motivation.

2.1 HCI Research for Vulnerable Populations

The SIGCHI community has made several efforts to research vulnerable populations and their use of technology. These studies have covered a range of topics, including health and wellness [149, 150], social support [4, 7, 25, 40, 44, 149], and safety [165, 170]. For example, Saksono et al. [150] designed a fitness application to support healthy attitudes among low-income households, and Brown and Grinter [25] developed a messaging app to help minimize vulnerabilities faced by refugees when they resettle in a new country. Similarly, Gomez et al. [60] designed a system to help Hispanic day laborers in low-income communities overcome emotional barriers to learning how to use computers. These studies demonstrate the value of technology in assisting vulnerable populations in maintaining their existing social support networks and facilitating emotional attachment. Focused on safety, the research by Thinyane et al. [170] examined the role of technology in mitigating the exploitation of vulnerable groups and developed an application to support the identification of victims of human trafficking. Safety and social support are well-studied topics in the HCI literature as they pertain to addressing the vulnerabilities and needs of marginalized populations. Our framework addresses these concepts to foster an understanding of the technology-related needs of vulnerable groups, with a focus on research and design contexts.

There is also a plethora of research on the technological challenges that vulnerable and marginalized populations encounter [25, 75] which are commonly attributed to dimensions such as social or cultural factors [70], digital inclusion [141], and digital inequity or digital divide [3]. For example, Harrington et al. [75] reveal how socio-cultural factors impact the conception of health technologies for older adults. Brown and Grinter [25] explain how cultural barriers, such as language limitations, prevent refugees from effectively utilizing technology. Newhart et al. [3] also highlight how systemic disparities in healthcare and education threaten digital equity for Latino populations in low-income neighborhoods.

To address these challenges, researchers have developed frameworks that guide the study of vulnerable populations and examine these dimensions. For instance, the framework by Newhart et al. [3] focuses on disparities within systems, resiliency, and familism in

the development of health technology for vulnerable groups. The framework by Perez et al. [141] explores the intersection of vulnerable populations and digital inclusion. Almohamed et al. [5] have also developed a framework that analyzes the specific challenges faced by refugees and asylum seekers, including cultural contexts, displacement-related struggles, and the impact of social capital on access to resources in host communities. Our framework similarly emphasizes the exploration of dimensions unique to vulnerable and marginalized populations, such as their social or cultural identities and the digital divide. However, our framework specifically centers on technology research and design with the goal of empowering and supporting the participation of these individuals. Furthermore, our framework incorporates established theories, such as social capital [66] and intersectionality [51], to address these various dimensions and provide guidance to researchers on how they can understand the technology needs of vulnerable and marginalized populations.

2.2 Engaging Vulnerable Populations for Research and Design within HCI

HCI researchers and designers employ various methods when working with vulnerable populations, with participatory research and design being among the most commonly used methods [15, 45, 48, 69, 143, 184]. Participatory design is based on the premise that individuals who will use an artifact should have the freedom to contribute to the design and function, giving them more control over the use and more room for action [48, 87, 174]. Participatory research, like participatory design, promotes deeper connections with marginalized or vulnerable groups and involves them as active stakeholders or research partners instead of just treating them as research subjects [48]. In their study with young forced migrants facing language barriers, Duarte et al. [48] utilized participatory methods and found that it facilitated communication and intercultural collaboration between the research team and participants. Similarly, Dillahunt et al. [45] used a participatory design approach in economically challenged areas to work with marginalized groups, leading to their understanding of the perceptions regarding the use of sharing-economy applications for employment and resource sharing. These studies demonstrate how participatory methods enable vulnerable groups to participate in the design of technology, regardless of their challenges, resulting in the development of tools that meet their community's needs [45, 184].

Participatory action research, like traditional participatory approaches, is another method commonly used in the literature [34, 42, 90]. This method provides valuable insights into the values, beliefs, and needs of marginalized communities [69] and emphasizes collective and community involvement in social action [48, 72]. As an example, Clarke et al. [34] used this approach to study the role of technology in supporting women survivors of domestic abuse and gained deeper insights into their values and contexts. Kotturi et al. [90] used the participatory action research method to work with local entrepreneurs in building a technical service application that benefits the community and promotes social change.

Participatory approaches can potentially empower vulnerable populations through research and design [48, 72]. Duarte et al. [48] found that using participatory design research empowered young

forced immigrants to make a difference in their everyday lives and improve the situation of others in similar situations. According to Wyche et al. [184], residents of rural communities who repaired mobile devices felt empowered to produce their own technology for their communities in the future through participatory design. The collective and community-based approach of participatory action research fosters a sense of autonomy and empowerment among participants [34, 90], as they are actively involved in identifying and addressing social issues that affect their lives. Our framework is inspired by the use of participatory approaches for conducting research and designing with marginalized and vulnerable communities and holds the potential to uplift these communities and empower them.

However, despite the advantages of participatory approaches, there are also drawbacks to consider, such as the significant burden placed on participants [47, 48, 79] and the potential disempowerment of some sensitive groups [96, 164]. To address these challenges, there have been calls for the community to carefully consider engagement methods that can empower vulnerable groups. Frameworks such as value-sensitive design [24, 57], design justice [36], and assets-based design [140, 183] have been used in the HCI literature to guide engagement with vulnerable populations. Value-sensitive design methodologies consider human values such as autonomy, privacy, accountability, and the right to own property. Assets-based approaches to research and design focus on the knowledge, strengths, and capabilities of individuals rather than their needs [183]. Design justice is a conceptual framework that recognizes the power of design to empower marginalized communities through collaborative and creative practices, emphasizing fair benefits for marginalized and vulnerable communities and justice in the design of technological systems [36]. These frameworks put the perspectives of various users and populations at the center of the design process, recognizing their underlying values and knowledge as important factors in informing technology design [74]. For example, Karusala et al. [88] used an assets-based framework to study how community health workers of diverse backgrounds and contracted status respond to the mandated use of digital payment methods and long payment delays.

Given our goal of supporting and empowering vulnerable populations in their engagement in technology research and design, our proposed framework builds on existing paradigms such as value-sensitive design, design justice, and assets-based design. We use these paradigms to guide discussions on how researchers can meet the technology needs of vulnerable and marginalized communities identified through our framework, with the ultimate goal of empowering these groups.

2.3 Maslow's Theory of Motivation

Abraham Maslow developed the hierarchy of needs model, the most well-known theory of motivation [104]. Maslow splits the category of human needs into lower-order (or deficiency) and higher-order (or growth) needs. He places physiological/basic (e.g., food, air), at the bottom of the deficiency needs, followed by safety and love/belonging/relationships. According to Maslow, deficiency needs arise due to deprivation. On the opposite spectrum, the growth needs include self-esteem and self-actualization and arise

due to an individual's motivation to grow and reach their full potential. As needs are met, new ones emerge to motivate behavior, until self-actualization is achieved. Maslow initially argued that higher-order needs must be addressed only after the lower-order needs have been met. He later stressed that these depend on context and that in some cases, higher-order needs may come before lower-order ones [176]. The Maslow theory of motivation has been applied in several domains, including education [116, 128] and business [101], and typically in the context of motivating performance. This theory has also been used within the HCI literature. For instance, Zhang et al. [187] used Maslow's theory to examine how technology may respond to the basic needs of older adults during times of crisis. Gou et al. [62] used this theory as a needs model to examine the personality traits of users from social media. The authors of [18] build upon Maslow's hierarchy of needs theory to examine the motivations of users who use peer-to-peer or sharing economy services.

Other theories of motivation commonly used in HCI include the self-determination theory (SDT) [146] and the theory of planned behavior (TPB) [82]. The TPB was created to predict behaviors over which people have only minimal voluntary control [158]. An example of its use is in the promotion of participation in physical activity [30]. Several studies in the persuasive system's domain inform their research and design using the TPB [8, 153, 169]. The Self-determination Theory introduces the concepts of intrinsic and extrinsic motivation to explain how individuals develop desired behaviors [146]. According to this theory, for a behavior to occur, three factors must be present at the same time: competence, autonomy, and relatedness. The SGT has commonly been applied in domains such as gaming [20, 171, 172], sports/health [31, 85, 93], and learning [17, 56]. The TPB and SDT are both used to understand behavior change and behavior prediction.

We used Maslow's theory of motivation to scope our framework for the following reasons; First, Maslow's theory emphasizes the satisfaction of needs that motivate humans and how these needs differ. Our work extends this concept to vulnerable populations and discusses technology needs that exist for vulnerable populations in research and design settings. Second, unlike the TPB and SDT which emphasize behavior change and behavior prediction, Maslow's theory is centered on behavior motivation. Our framework builds upon this theory of behavior motivation to conceptualize factors that can motivate participation during technology research and design. Third, like other theories of motivation, Maslow's theory is robust for covering both psychological and growth needs, which are essential for humans and motivation. Building on Maslow's theory, we categorize technology needs into deficits-based and assets-based, similar to deficiency and growth needs in the hierarchy. The deficits-based (lower-order) needs are those that arise due to lack and are based on the current limitations to which they are susceptible in the context of technology, such as their access to information and communication technologies and their online safety/privacy. Similarly, the assets-based (higher-order) needs are those that can be leveraged as strengths or assets (such as their social ties, social identities, and their voice) and which, when met, can help them attain the ultimate aim of self-actualization.

3 METHOD

To inform our conceptual framework, we consulted the literature to identify research articles focusing on vulnerable groups and topics related to the different levels of Maslow's hierarchy (e.g., safety and self-esteem) in technology settings. Our goal was to identify these papers and thematically analyze them to identify themes that align with the hierarchy levels.

3.1 Databases Searched

We identified relevant research articles across multiple disciplines (e.g., HCI, education, psychology, health, information technology) by searching both the Association for Computing Machinery (ACM) Digital Library and Web of Science databases. Journals retrieved include ACM Transactions on Computing Education (TOCE), Journal of Medical Internet Research (JMIR), International Journal of Technology Enhanced Learning (IJTEL), and Transactions on Computer-Human Interaction (TOCHI). Conferences include ACM Conference on Human Factors in Computing Systems (CHI), ACM Conference on Designing Interactive Systems (DIS), and ACM SIGACCESS Conference on Computers and Accessibility (ASSETS).

3.2 Search Process: Search Terms and Results

We searched the aforementioned databases using concepts from Maslow's hierarchy (e.g., safety and self-esteem) as key search terms. Because members of disadvantaged and underrepresented groups fall under our definition of vulnerable populations, it was important that we find relevant literature focusing on these groups. As a result, we included the keywords: "marginalized," "sensitive," "disadvantaged," or "underrepresented" in our search terms. For example, we conducted the following search for the safety concept of the hierarchy:

"technology" AND ("vulnerable populations" OR "sensitive populations" OR "disadvantaged populations" OR "underrepresented populations" OR "marginalized populations") AND "safety"

Following our initial search, we discovered several unique keywords associated with each concept within the initial articles. For example, the term "digital divide" was frequently associated with basic needs for technology participation, the terms "privacy and security" with safety needs, and the term "social identity" with self-esteem needs. As a result, we included these terms in our query to initiate the search. The modified search query we used for the safety needs concept of the hierarchy is shown below:

"technology" AND ("vulnerable populations" OR "sensitive populations" OR "disadvantaged populations" OR "underrepresented populations" OR "marginalized populations") AND ("safety" OR "privacy" OR "protection" OR "security" OR "safety needs")

Table 1 lists the keywords we used to search for articles corresponding to each concept in the hierarchy. We searched the entire article content in both databases (i.e., full text and metadata). Research articles retrieved were peer-reviewed, open access, written in the English language, and published within the last 10 years (1/01/2012–07/31/2022). There were 1,668 search results in total. It is worth noting that our search yielded a few articles that were not

Table 1: Search terms. We use these search keywords in combination with the terms [“(vulnerable populations” OR “sensitive populations” OR “disadvantaged populations” OR “underrepresented populations” OR “marginalized populations”) + “technology”] to search for articles corresponding to each level of the conceptual framework.

Motivation Concepts (or Needs)	Search Keywords
Basic	digital divide, basic needs
Safety	safety, protection, privacy, security, safety needs
Relationship (or Social)	social capital, social relationships, social support, social needs, relationship needs
Self-Esteem	self-esteem, social identity, esteem needs
Self-Actualization	self-actualize, self-fulfillment, self-actualization

published in English venues (or not written in English) and that was not open access ($N=4$), which we excluded from our search results. The following is a breakdown of the search results for each concept: Basic needs ($N=157$), Safety needs ($N=968$), Relationship needs ($N=325$), Self-Esteem needs ($N=205$), and Self-Actualization needs ($N=13$). It is important to note that we initially create separate corpora for each of the different motivation concepts. In this case, basic needs search results belong to one corpus, safety needs to another, and so on for the other concepts.

3.3 Selection Process: Inclusion and Exclusion

Before considering articles for screening, we removed duplicates, non-research articles (e.g., doctoral consortium, panel, keynote, conference proceedings, and symposium papers), non-peer-reviewed articles (e.g., workshops), and non-full text articles (e.g., conference abstracts and those with fewer than six pages, excluding references). This resulted in a total of 913 unique articles. Given that the goal of this work is to understand how vulnerable populations’ technology needs and motivations can be conceptualized, we included articles that met the following criteria:

- 1) The main focus of the paper is on vulnerable populations (**Note:** Articles with mentions of vulnerable populations but not as the primary user group being studied do not meet this criterion).
- 2) The research is centered on the context of technology use (**Note:** Articles that discuss their use of technology, a device, a system, or their participation in technology design meet this criterion. Articles that discuss a concept more generally (e.g., safety by social distancing during the pandemic) do not meet this criterion).
- 3) Contributions and implications of the research are focused on one of the five motivation concepts.

For articles corresponding to each concept, the first author examined the titles and abstracts of the top 50 articles (ranked by relevancy in the databases searched) using the above inclusion criteria. Articles that met the inclusion criteria were recorded and examined. We discovered that across all five corpora, relevant papers frequently referenced vulnerable populations (e.g., young children, older adults, people with disabilities, or low-resource job seekers) and the topic of focus (e.g., privacy, social support, or safety) in their titles, abstracts, and their author keyword tags. Therefore,

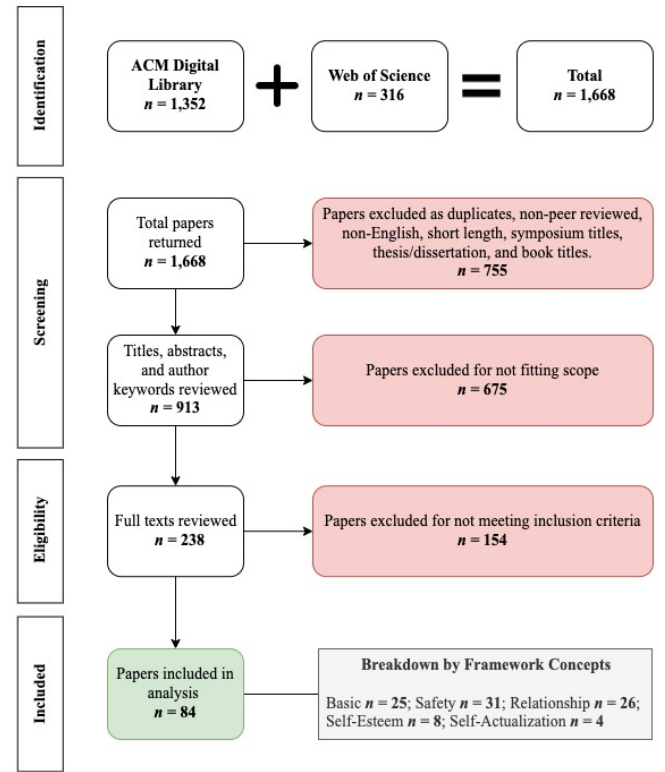


Figure 1: Search, screening, and selection process (flow diagram).

we scanned the remaining articles and excluded those that did not mention vulnerable populations and technology-related discussion in their titles, abstracts, or author keyword tags. This resulted in 238 unique articles that were within scope. After reading their full texts using our inclusion criteria, 84 unique articles remained for review: Basic needs ($N=25$), Safety needs ($N=31$), Relationship needs ($N=26$), Self-Esteem needs ($N=8$) and Self-Actualization needs ($N=4$). Figure 1 shows details on the screening and inclusion process. Table 2 presents a description of our final set of papers and includes the number of papers in each year and their publication venue.

Table 2: Publication year, counts, and venue of papers included in the analysis.

Year	n	Venues and References	
		Conferences	Journals
2012	0		
2013	1		Soc. Sci. Res. [118]
2014	2	CHI [39], DIS [103]	
2015	1	CHI [45]	
2016	4	CHI [9, 25]	CSCW [35], JAMIA [107]
2017	8	CHI [162], IDC [11], MobileHCI [50], NSPW [179]	CSCW [2, 83], IJTEL [188], JMU [117]
2018	11	AfriCHI [121], CHI [166, 181], IDC [148]	CSCW [81, 115, 151, 175], Edu+Training [123], ITD [124], TOCHI [48]
2019	10	CHI [84, 127, 131], MobileHCI [114], SMSociety [38]	CSCW [67, 88], IJTEL [189], JACR [156], TOCHI [4]
2020	10	CHI [80, 139, 187], IDC [157], IEEE [159], NordiCHI [102]	CSCW [65], IMWU [178], J. Inf. Commun. Ethics Soc. [95], MHealth [186]
2021	21	CHI [10, 54, 68, 94, 99, 110, 133, 161], Compass [168], FAccT [138], ICMI [135]	CSCW [13, 29, 129, 190], Mar. Policy [100], Mobile Media & Comm [59], SAGE [97], TOCE [154], TOCHI [111], TAC-CESS [16]
2022	16	ASSETS [77], CHI [19, 58, 120, 122, 132, 167, 182], DIS [137]	CSCW [6], Community Psychol. [76], Digital Health [33], GROUP [5], J. Fam. Violence [147], JMIR [185], IJTHI [145]

Table 3: Summary of themes developed from the data.

Motivation Concepts	n	Themes	Examples
Basic	25	Concerns about technology adoption	[19, 162]
		Psychological impacts of technology access	[95, 124]
		Psychological impacts of limited digital literacy	[154, 161]
Safety	31	Privacy concerns	[35, 190]
		Perceptions of online risks or harm	[167, 186]
		Safety perceptions of spaces or environments	[65, 147]
Relationship (or Social)	26	Composition of social relations	[99, 157]
		Roles of social relations in tech contexts	[59, 129]
		Impacts of access to social relations	[6, 148]
Self-Esteem	8	Triggers of low self-esteem in tech contexts	[58, 173]
Self-Actualization	4	Actions for self-actualizing	[103, 135]

3.4 Analysis

We used a thematic analysis approach to analyze our data [23]. The first author led the analysis. The entire research team met to confirm and discuss the themes. We started by reading a subset of the research articles ($\approx 10\%$) for each hierarchy concept and noting common findings in these papers in relation to our research questions. We focus on relevant sections such as the abstract, introduction, results, and discussion. We then created initial codes based

on these findings. We revisited previously read papers as well as the remaining unread papers in the corpus and applied the codes to them. We add new codes as they emerge in the articles. All codes were organized, reevaluated, and regrouped as needed, and then used to develop themes (see Table 3 for examples of themes that we developed from our analysis). Our analysis was iterative, as we continued to review our themes and data throughout the process to synthesize our findings.

3.4.1 Defining Empowerment. One important argument for our framework is that it can assist researchers in empowering vulnerable populations by meeting their technology needs during research participation. As a result, we tied each level of the framework to various forms of empowerment that may be achieved. Schneider et al. [152] developed a framework that characterizes empowerment in the HCI literature. The authors describe how psychological empowerment manifests itself in three ways: *knowing*, *feeling*, and *doing*. The acquisition of new skills is the result of empowerment through *knowing*. Taking action or exerting power is the result of empowerment through *doing*. Having a perception of control, competency, support, or confidence are some of the results of empowerment through *feeling*. We use these descriptions throughout the discussions in our framework to explain how by satisfying the different technology needs identified from our analysis, researchers may empower vulnerable populations through research and design participation.

4 FRAMEWORK SYNTHESIS

Researchers and designers must address the knowledge gaps and technology needs of vulnerable groups in order for those populations to effectively participate in technology research and design. We build on Maslow's hierarchy of needs to develop a framework based on a synthesis of the research papers identified in Section 3.3. As shown in Figure 2, the framework characterizes technology needs into two types: deficits-based and assets-based. The first two levels are based on deficits-based technology needs (corresponding to basic and safety needs), while the remaining three levels are based on assets-based technology needs (corresponding to relationships, self-esteem, and self-actualization needs). The tech-centric terms used to define each level of the framework were derived from our synthesis of the literature. The underlying basis of our framework is that ultimately, researchers can empower and motivate vulnerable populations to participate in technology research and design by fulfilling these technology needs.

In the rest of the section, we will further describe each level of the framework and provide insights into how researchers can empower vulnerable populations through their participation.

4.1 Basic Needs: Participating in a Technological Society

Our synthesis for the first level of the hierarchy was guided by the following question: *what are the basic needs for vulnerable populations to participate in a technological society?* Themes we observed from the literature include technology adoption concerns, psychological impacts of technology access, and psychological impacts of digital literacy or technology proficiency.

According to the literature, the basic necessities for integrating into a technology society include access to information and communication devices such as a phone, tablet, or computer, the Internet or a data plan, and the proficiency or literacy skills to use these technologies [19, 95, 140, 141, 154, 162, 188]. Several vulnerable (or marginalized) groups, however, are known to have more difficulty participating in a technological society than the general population, attributable to issues with technology access

[19, 33, 50, 59, 68, 124], technology proficiency, and digital literacy skills [19, 33, 107, 117, 118, 123, 162].

Technology Adoption Concerns & Psychological Implications. Research reveals that although several vulnerable groups, including older adults, have embraced technology over the years (e.g., mobile phones) [55, 100, 166, 185, 187], they frequently struggle to access essential technologies such as the Internet, data plans, or personal computers [28, 59, 63, 97, 107, 139]. Barriers to their access to technology are commonly due to socioeconomic limitations such as low income, limited education, or their geographic locations [29, 124]. For instance, Nemer et al. [124] found that some people in low-resource neighborhoods in Brazil were unable to properly utilize the Internet because they lacked the resources to buy smartphones, while for others it was because of the poor connectivity they received due to where they lived.

In today's society, using technology like computers, an Internet connection, smartphones, and a data plan is necessary for many tasks for vulnerable groups. For example, the Internet can provide foster youth with a wealth of information on topics of personal interest (e.g., medical health, employment, school work) [64]. Unfortunately, lacking basic technologies impose a number of limitations on vulnerable or marginalized populations. Vitak et al. [175], for example, discussed how people who lack Internet at home and rely on public computers to complete important tasks like job searching frequently get exposed to security and privacy risks, such as from leaving personal information and becoming vulnerable to theft. Vulnerable elders frequently require resources to assist them in using the digital monitoring systems that their doctors have advised, as well as Internet-based health education and advice [61]. Lack of ownership of relevant technologies frequently interferes with communication and information sharing between them and their care providers. Similarly, children from low-income households who do not have access to computers at home may be at a disadvantage compared to their peers who do have computers, such as for the completion of assignments and other school-related tasks [188]. This lack of access to computers can prevent these children from taking full advantage of educational opportunities.

Technology proficiency and digital literacy are yet other barriers that vulnerable and marginalized populations commonly face in integrating into a technological society [58, 107, 117, 118, 123, 125, 141, 145, 189]. Digital literacy refers to the variety of literacies involved with the use of digital technology, such as hardware or software [126]. For example, the ability to operate devices such as mobile phones or desktop computers [126], as well as having the knowledge to navigate, seek, and decode information through the Internet [145]. Difficulty with digital literacy often forces members of vulnerable or marginalized groups to rely on other people for help with their devices. For example, it is common for older adults to rely on family and peers to help them navigate their devices [127]. These difficulties could also interfere with important tasks in their daily lives. Ogbonnaya et al. [130] found that returning citizens often lacked digital literacy skills, which amplified the struggles they faced finding jobs using technology.

Unfortunately, struggles with digital literacy skills or technology proficiency may have psychological implications for vulnerable groups in technological contexts. According to the literature, relying on others may discourage them from using technology at all

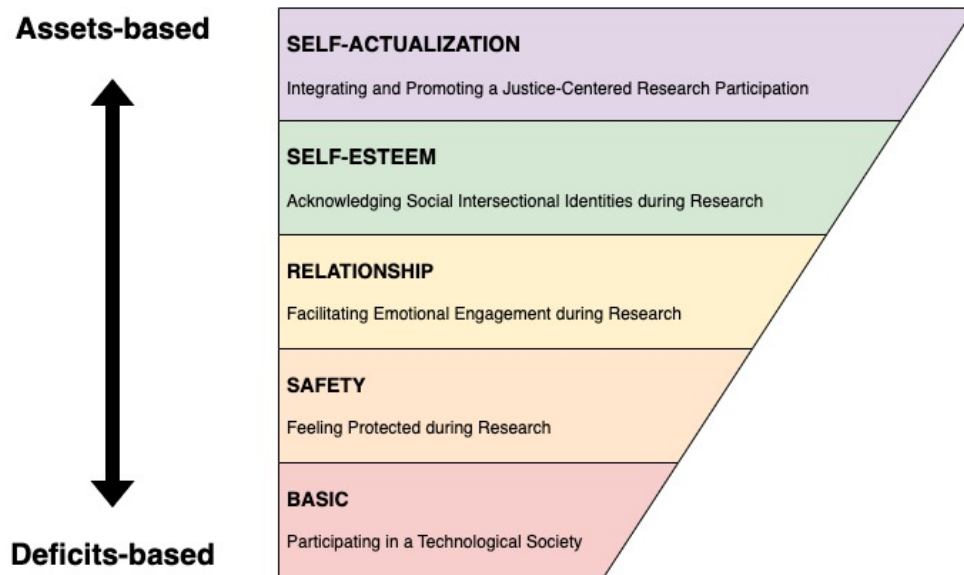


Figure 2: Framework for supporting vulnerable populations in their engagements in technology research and design. Technology needs are characterized as Deficits- and Assets-based.

for fear of ridicule [154, 168]. One example is the study by Seo et al. [154] who discovered that women who were formerly incarcerated and lacked digital literacy skills avoided using or owning technology out of fear of being consistently mocked by family or peers when they could not complete some simple tasks. Other detrimental impacts of a lack of digital literacy include a lack of confidence [168] and self-efficacy [154, 161, 168], which discourages vulnerable groups from using or owning technology [154, 161].

Technology access and digital literacy skills are both technological needs that must be addressed in order to motivate vulnerable populations' participation in technology research and design and to empower them. The literature shows that ownership and use of technology trigger a feeling of empowerment for vulnerable populations [95, 124]. Studies also reveal that having the necessary digital literacy skills increases one's sense of self-efficacy, confidence, and feeling of empowerment [123, 156].

Fulfilling Basic Needs. Researchers can motivate and empower vulnerable populations by providing access to the technology required for the technology research and design engagement design (e.g., a phone or tablet). Researchers must also make provisions to provide participants with the digital literacy skills required to use these devices. Doing so could be accomplished by organizing training workshops or programs to teach them relevant digital literacy skills [123, 131]. The benefits of such training would not only be related to the immediate use of technology, but it could also give them confidence during research and design engagements [51]. These access and digital literacy barriers can be analyzed by researchers using the digital divide lens [37, 97, 139]. Using this lens can help researchers understand their technology access issues, existing barriers, and how the research and design process can be better tailored to ensure that their basic technology needs are met.

Takeaway. *Vulnerable populations should be supported with the technical skills and equipment to participate in research.*

How Participants Achieve Empowerment. *Through Knowing (Acquiring Digital Literacy Skills) & Through Doing (Having Experience with Necessary Technology).*

4.2 Safety Needs: Feeling Protected during Research

The following question guided our synthesis for the second level of the hierarchy: *what safety needs might exist for vulnerable populations in technology contexts?* High-level themes we observed from our synthesis include: privacy concerns, perceptions of online risks or harm, and perceptions of safe spaces or environments.

By definition, vulnerable populations are already more susceptible to harm because of their identities [98, 105]. For example, vulnerable or marginalized persons who are racial or gender minorities could be targets of threats or physical attack [27]. Sexual abuse victims are also more likely to be attacked or stalked by their abuser [109]. Several safety concerns for vulnerable populations in technological contexts are also highlighted in the literature.

Privacy Concerns. Studies show that one of the critical safety needs for many vulnerable groups is privacy [10, 67, 77, 138, 151, 186]. For example, the authors of [186] explain how the global criminalization of sex work makes privacy equate to safety for female sex workers living with HIV. Invasion of privacy for these sensitive groups may result in stigma, harassment, problems with law enforcement, or even fatality. In general, privacy concerns are frequently tied to data collection and data sharing [2, 35, 65, 121, 122, 135, 154, 156, 186, 190], such as from the use of the Internet [65, 76, 154, 156, 186]. For example, Seo et al. [154] explains how women who were formerly incarcerated expressed concerns with

Internet-enabled devices as they feared that they were constantly surveilled by law enforcement. These privacy concerns are the reasons several vulnerable groups are discouraged from engaging with Internet-enabled technologies [154, 156].

Perceptions of Online Harm or Risks. Another safety concern that emerged from our synthesis is the perception of exposure to online risks or harm. Studies show that populations vulnerable due to their age, financial situation, immigration status, being part of a minority group, having a disability or cognitive challenge, or where they live are more susceptible to online risks than the general population [38, 81, 110, 167, 186, 189]. Older adults (typically those older than 60 years of age) face more online safety threats than younger adults, such as being targeted by online fraudsters [114]. Autistic children experience significantly more online safety risks and poorer well-being than non-autistic children [102]; as they are more likely to be sexually and financially exploited, bullied, and harassed, especially on social media [16, 91]. According to Badillo-Urquiola et al. [11], one in four teens is unintentionally exposed to sexually explicit materials online. Seo et al. [154] describes how women who were formerly incarcerated are often targets of Internet scams and fraud. Their susceptibility to online risks or harm is exacerbated by the fact that, while the Internet may expose them to these risks, several vulnerable groups are unaware of these risks or how to address them (e.g., older adults and children especially) [58, 179, 182].

Perceptions of Safe Spaces or Environments. Access to safe spaces or environments in digital contexts emerged as a third safety need for vulnerable groups. Sensitive populations, such as victims of abuse (e.g. domestic abuse), individuals with chronic health conditions (e.g., HIV), and minority groups, commonly have safety concerns stemming from sharing the same spaces with parties who may cause them harm or amplify their already existing vulnerabilities. For instance, the authors of [147] describe how women victims of domestic abuse are often at risk of safety due to sharing the same digital ‘spaces’ (or technologies) with their partners and where they can express themselves freely without being monitored. These women frequently go to great lengths to ensure that they can access environments that are free of scrutiny. Haimson et al. [65] discuss how people who identify as LGBTQ+ often seek safe spaces online, especially through social media sites, to connect with others and share their own experiences freely.

Fulfilling Safety Needs. Taken together, all of these safety concerns could also translate to the research settings. According to research, there may also be safety risks associated with vulnerable groups participating in research [152, 160, 177]. For instance, research with sensitive populations such as those with HIV and mental diseases might inadvertently put them at risk of facing stigma and discrimination if the methods for data collection and dissemination are violated [160]. Also, studies with undocumented immigrants focused on how they utilize technology to seek resources and help may unintentionally put them in danger [177].

When working with vulnerable populations, researchers must acknowledge that they face unique threats that are uncommon in the general population. To address their safety needs, it is important that researchers demonstrate and guarantee that they will not be exposed to harm or additional threats by participating in the research [13]. For instance, vulnerable individuals must understand that the tools being used during the research engagement (described

in Section 4.1) will protect their privacy and will not expose them to online harm. Researchers must also consider these safety needs when determining research and design methods. One factor to consider is ensuring that the vulnerable participants are comfortable with all parties present in the research. For example, Park et al. [137] ensured a safe and comfortable environment for their participants who were sexual assault survivors by having separate sessions with them and professionals who were also research stakeholders. This would also mean that if joint research sessions, such as a focus group, are deemed suitable and the participants include sensitive groups like domestic violence victims or individuals living with HIV, researchers must consider their context and prioritize their safety and privacy. Researchers should ensure that people who may make them feel uncomfortable, such as their partners, cannot observe or become aware of their participation. All of these factors for ensuring safety must be considered by researchers at every phase of the research engagements and the interactions with them. For example, Sabri et al. [147] discuss how victims of domestic abuse may be subject to more abuse if their partners found out they were involved in research or communicating with researchers.

Takeaway. *Vulnerable populations should be guaranteed no harm and made aware of protective measures for technology research and design engagements.*

How Participants Achieve Empowerment. *Through Knowing (Awareness of Safety Risks and How these are Mitigated) & Through Feeling (Perception of being Safe).*

4.3 Relationship Needs: Facilitating Emotional Engagement during Research

The following question guided our synthesis for the third level of the hierarchy: *what influence (or value) might social relations have on vulnerable populations in technology settings?* Three themes we observed from our synthesis are; the composition of social relations or networks, roles of social relations, and impacts of access to social relations.

The social capital theory is a useful framework for understanding the emotional and social relationships that people develop [66]. Social capital consists of two constructs—bonding and bridging capital [180]. **Bonding capital** is formed based on strong social ties, such as between family members and close friends [26]. Bonding networks are most likely to be sources of personal and comprehensive assistance and are frequently sustained over time [180]. Because persons who are connected in these networks are not just closely connected but also tend to be in similar conditions, bonding capital is regarded as “strong” [26, 180]. **Bridging capital**, on the other hand, refers to relationships that bring people together for shared interests without their being closely related or emotionally attached (e.g., between neighbors, colleagues, or organizations) [26, 113]. These types of relationships can be significant structures that facilitate diverse social interactions and new opportunities, as well as for sharing new ideas (e.g., job opportunities) [1, 53]. Unlike bonding networks, bridging capital is referred to as “weak” because it is formed by context-specific interactions such as through work, community-based groups, or leisure activities. For

the purpose of this work, social capital describes the value that vulnerable individuals' social relations provide in technology research and design contexts due to their network composition [83].

Composition of Social Relations. The literature reveals that the bonding social relations for vulnerable or marginalized groups in technological contexts are typically made up of immediate family members, such as parents, children, siblings, and relatives [4, 5, 39, 54, 59, 84, 115, 129, 157, 167, 178]. Examples of bridging social relations include their caregivers (e.g., for the elderly or children) [99], organizations in their local community [80, 83, 167, 181], their neighbors or local community members [25, 45, 83, 129, 132, 133], or friends from social networking sites (e.g., Facebook) [6, 45].

Roles & Impacts of Social Relations or Networks. Social ties or networks play various roles in technological contexts. Bonding ties are often the source of personal assistance for vulnerable groups when using technology. For example, older adults who struggle with technology proficiency often receive help from their children or other immediate family members [114, 155, 178], such as for navigating the Internet [129] and managing their privacy settings [178]. Bridging links may also be a source of comprehensive and emotional support. Care providers may be tasked with helping their wards (e.g., older adults or foster teens) in managing privacy and safety [11]. Ammari et al. [6] describe how women postpartum depression survivors use online digital spaces to connect with other women who have similar vulnerabilities and talk about subjects they might not feel comfortable discussing with family or close friends, receiving emotional support and feeling empowered as a result. These studies all demonstrate that vulnerable groups often have support networks available to them in technology settings. These support networks, whether bonding or bridging, can help a vulnerable person feel better emotionally, reduce technology risks, and minimize difficulties in technological settings.

Fulfilling Relationship (or Social) Needs. During research participation, vulnerable individuals may require access to their social ties for a variety of reasons, such as seeking support to handle challenges, offering emotional support, or when collaborating on design solutions. Studies have demonstrated that including close family ties can be empowering for vulnerable groups during research participation. This kind of collaboration is common when the participants are children, teenagers, older adults, or persons with disabilities [9, 13, 111, 148, 157]. For example, Sadka et al. [148] suggest that children may feel empowered during research collaborations if their parents are present to observe their behavior and mental states. Similarly, Sharma et al. [157] show that involving parents, caregivers, and others in the lives of children with special needs during research and design activities can make them feel more motivated and empowered. The study by McDonalds et al. [111] provides an example of a research collaboration involving bonding ties. In this case, the partners were older adult couples, with one having memory impairments, and they worked together to create a tool that would empower them to improve their security practices. Research collaborations involving bridging links are also common, especially in community-based research [132, 133]. For example, the study by O'Leary et al. [133] showed how focus groups conducted with racial minorities who belonged to the same church communities led to the identification of the community's

strengths and the collaborative design of a mobile health application to empower their community.

Researchers can fulfill the relationship needs of vulnerable populations by acknowledging their social ties as assets for technology research and design engagements. Researchers can provide access to social ties by allowing participants to bring a support person to research sessions and encouraging them to maintain contact with their social ties and to seek support as needed. By doing this, researchers are supporting their vulnerable participants with the help and resources that they need to effectively participate in research and design activities.

Researchers should keep in mind that these relationship needs may not be generalizable for all vulnerable groups and hence may not be a requirement for supporting vulnerable persons to participate in technology research. In other contexts, including a close family member in the research may potentially be more stressful emotionally than empowering [94]. In their study, Lee et al. [94] provided an illustration of how the presence of a participant's family (such as their parents), although necessary if they are a child, could be a source of distraction and pressure, particularly when they frequently comment on the child's design engagements. As another example, if research is being conducted with LGBTQ+ youth and intersectional identities are being explored, having family members present can be emotionally stressful or harmful if the youth has not yet come out to their family.

Takeaway. *The social ties of vulnerable populations should be considered assets during technological research and design engagements.*

How Participants Achieve Empowerment. *Through Feeling (Perception of Emotional Support or Sense of Community).*

4.4 Self-Esteem Needs: Acknowledging Social Intersectional Identities during Research

The following question guided our synthesis for the fourth level of the hierarchy: *how might self-esteem impact how vulnerable populations perceive themselves in technology settings?* The articles synthesized resulted in an overarching theme for this concept: triggers of lower self-esteem when using technology.

Self-esteem represents an individual's perception and assessment of his or her own personal value, self-worth, or accomplishment [21]. High self-esteem is often associated with autonomy, familiarity, confidence, and satisfaction [9, 92, 116, 134]. Self-esteem, therefore, reflects how much a person believes they are capable, meaningful, valuable, and successful; often in relation to personal beliefs about their skills, competencies, social interactions, and future outcomes [119]. Social factors such as race, age, class, and educational level among others, are known to impact people's self-esteem [119, 136]. Vulnerable individuals who are marginalized across multiple social identity dimensions, such as race, gender, class, ethnicity, socioeconomic status, cultural background, and sexuality [70, 71], may face technological challenges that can impact their self-esteem [58, 77, 173].

Lower Self-Esteem Triggers. Some vulnerable groups frequently struggle with technology mastery and competence [4, 78, 131], with several of these challenges associated with their social identities

[161]. For example, refugees and asylum seekers who do not speak English as a first language face challenges using popular social technologies to communicate with close friends and family [4], often forcing them to regularly rely on their hosts for translation. Job seekers in low-income communities are unable to use technology effectively for job search because popular employment sites (e.g., Indeed) rarely, if ever, have jobs for unskilled workers on their platforms [43]. Unfortunately, these technological difficulties, are one of the key factors contributing to lower self-esteem in technological contexts [173]. The authors of [173] worked with participants from a low-income community in India who were blind, to understand the struggles they faced finding content online. Their study revealed that participants had lower self-esteem due to difficulties understanding English and accents in screen reader software available on the devices they used.

Fulfilling Self-Esteem Needs. When conducting technology research and design with vulnerable populations, it is important for researchers to be aware of their intersectional identities [51]. This means recognizing and acknowledging the ways in which their social identities intersect and potentially impact their technology research and design activities. For example, a person who is marginalized across ability, race, and class, may feel that their experiences and perspectives are not valued or considered in technology research and design processes. This could lead to feelings of exclusion and low self-esteem, as they may feel that their unique experiences are not being considered. If, on the other hand, this individual is able to participate in technology research and design processes that are inclusive and supportive of their social identities, they may have higher self-esteem as a result of feeling included and valued.

Researchers can use the lens of intersectionality [144] to better understand and analyze the different social intersecting identities of their vulnerable research participants. To make the engagements more empowering, researchers should focus on the positive aspects of their social and cultural identities, or their assets [73]. For example, ethnicity can be a rich and diverse source of knowledge, experiences, and views that can enhance and guide the research. Researchers can provide opportunities for people who are marginalized because of their ethnicity, to share their unique views and experiences, which can help inform technology research and design activities. Also, language can be a source of pride and empowerment for vulnerable research participants because it plays a significant role in defining one's cultural identity. The ability to communicate in multiple languages is a valuable skill that can help people feel more confident and competent in a variety of ways. Acknowledging and affirming the value of their language as a cultural identity, can build their self-esteem and make them feel proud of who they are and where they come from. By acknowledging the participants' social and cultural identities (e.g., ethnicity and language), researchers can help to foster a sense of inclusion and competence among them. Another consideration for researchers when working with vulnerable populations is to avoid causing additional harm, whether by perpetuating stereotypes, interacting biasedly, or responding to problems that their vulnerable participants encounter superficially, based on their social identities [142]. For example, because of the complexity of social identities, certain indicators or triggers (such as remarks, actions, or behaviors) may have a negative impact on

vulnerable participants' self-esteem during research and design engagements [86, 154].

Takeaway. *The social identities of vulnerable populations should be acknowledged as assets for technology research and design.*

How Participants Achieve Empowerment. *Through Feeling (Perception of Competence).*

4.5 Self-Actualization Needs: Integrating and Promoting a Justice-Centered Research Participation

The following question guided our synthesis for the fifth level of the hierarchy: *how might vulnerable populations reach self-actualization in technology settings?* The overarching theme from our synthesis was: actions for self-actualizing.

More generally, self-actualization is the realization of a person's potential, self-fulfillment, the pursuit of personal growth, and the attainment of peak experiences [112]. In the context of technology, there is no single definition or approach to achieving self-actualization. For example, Bart et al. [89] explain how, in the case of recommendation systems, individuals may achieve self-actualization by being provided the opportunity to develop, explore, or understand their own unique interests and preferences. Several studies in the HCI literature show that encouraging self-reflection, sharing knowledge or experiences, and contributing to society are avenues for individuals to self-actualize or feel fulfilled [14, 22, 46, 106]. In light of these definitions, one thing is clear: self-actualization can result from empowering one to do something (e.g., speaking out, engaging in an activity, or making better decisions).

Actions for Self-Actualization. Only a few studies have defined self-actualization in the context of vulnerable populations and technology use. These studies commonly attribute the realization of self-actualization to autonomy and contribution to social actions [103, 120, 135]. Oviatt [135] explains that self-actualization (or personal autonomy) can occur in a socially supportive context that allows collaborative participation in social change to achieve community goals. Similarly, Marshall et al. [103] suggest that self-actualization is linked to actions that align with a person's values and goals. Given these findings, it is important that vulnerable populations be empowered to play an active role in shaping designs that reflect their values and goals, and that ultimately benefit their communities. This can lead to the self-actualization of these populations.

Fulfilling Self-Actualization Needs. The use of participatory methods in technology research and design offers opportunities for self-actualization among vulnerable populations. These methods involve directly engaging marginalized and vulnerable communities as active stakeholders in the research process and in the creation of technology that is tailored to them and their community's needs [72]. Not only does this address the issue of underrepresentation for these groups in technology research and design [71, 72], but it also empowers individuals by giving them a sense of agency and control over their lives [72]. Additionally, participating in technology research and design can lead to the acquisition of new skills and knowledge [48, 184], promoting personal and professional growth.

While participatory methods in technology research and design are well-intentioned, they do not provide a default path to empowerment or self-actualization for marginalized groups. The methods used to engage with marginalized groups can actually disempower them. For instance, a study by Spiel et al. [164] discovered that failing to take into account the specific needs of sensitive groups like those with ADHD in research and design efforts can lead to feelings of disempowerment. Moreover, it is common for researchers to engage individuals of vulnerable groups solely for the purpose of gathering data, with little to no follow-up or true relationship-building [36, 49], which can contribute to a sense of exploitation and further disempowerment [52]. To orient the research toward being more empowering for vulnerable groups, researchers should incorporate justice-centered approaches in their methods. These methodologies take into account the effects of the design on users and populations, as well as who owns or benefits from the design outcomes, the equitable distribution of the benefits and burdens of the design, and values that ought to be embodied in the design objects [36]. Employing justice-centered approaches allows researchers to both prioritize the unique perspectives of vulnerable groups and to ensure equitable benefit-sharing. This not only helps these populations understand the value of their contributions but also highlights the impact of their voices on research outcomes and design processes. As a result, they can be encouraged to play more active roles in the research and design of technologies, thereby supporting their self-actualization.

Another potential drawback of participatory approaches is that while they can empower participants to have more agency in the design process, there may be a disconnect between their values and the research agenda. To address this issue, researchers should consider incorporating value-sensitive design (VSD) [57] into their methods. VSD allows researchers to understand and align their research with the values and goals of vulnerable and marginalized groups, ultimately creating research that truly empowers and benefits these communities. Adopting VSD can ensure that research is conducted in a way that respects and supports the values and goals of the communities being studied, thereby fulfilling the self-actualization needs of the participants.

Takeaway. *Vulnerable populations should be given opportunities to contribute their voices to technology interventions that reflect their values and goals, and equitable practices for distributing research benefits should be put in place.*

How Participants Achieve Empowerment. *Through Doing or Taking Action (Contributing to Impactful Research) & Through Feeling (Perception of Autonomy and Being Valued) & Through Knowing (Awareness of the Outcome or Impacts of their Research Contributions).*

5 DISCUSSION

It is a common (and understudied) problem that people who are vulnerable or marginalized may have current needs that prevent them from effectively participating in technology research and design efforts. For example, Erete et al. [51] discuss how “in populations low socio-technical backgrounds, members may have limited knowledge of or exposure to technology and consequently may lack the skills or

confidence to participate in technology design.” Two things can be inferred in light of this issue: (i) Before engaging with vulnerable or marginalized populations for technology research and design, there is generally no common understanding of their existing technological needs and how these impact their participation. (ii) There is also no common understanding of the various ways in which they could be supported in the research and design process, and how participation could make them feel more empowered. The conceptual framework has been developed by adopting Maslow’s theory of needs hierarchy and synthesizing work in the literature to characterize the different technology needs of vulnerable populations. Our framework also highlights the various ways in which vulnerable groups can be empowered through engagement in technology design and research.

5.1 Theoretical Implications

In this research, we adopt Maslow’s theory of motivation [104] to develop our conceptual framework. According to Maslow’s theory, human motivation needs are divided into two categories: deficiency-based needs and growth needs. The former is focused on what people lack, while the latter is based on the urge to grow. Similar to this, we categorize the technological needs of vulnerable groups into deficit- and assets-based requirements, with the former arising from what they lack and the latter from assets they currently have (their strengths). Deficits-based needs correspond to their basic and safety needs. From the literature, we identified basic needs including access to technology and digital literacy skills. Safety needs included privacy, protection from online risks or harm, and access to safe spaces or environments. Assets-based needs corresponded to relationship, esteem, and self-actualization needs. These assets included their social ties, social identities, and voice. Similar to Maslow, we argue that deficits-based needs should be fulfilled before the assets-based needs, as the desire for competence, autonomy, and personal growth will only arise after people have their most fundamental needs met. A vulnerable individual may not realize that they have the ability to contribute to impactful technology research and design for themselves (or their communities) until they are empowered with the necessary skills to use technology and have become aware of the numerous possibilities that technology presents. However, we do not argue for a sequential approach to meeting these technological needs. For example, it is possible that both basic and safety needs are addressed in tandem. As reported in the literature, safety skills education is now integrated into several digital literacy training workshops [123]. We invite researchers to consider how to optimally address the various needs that we have characterized in our framework.

Our framework’s emphasis on the different ways that marginalized and vulnerable groups can be empowered by participating in design and research is another theoretical significance. The psychological impact of meeting each technology need, which we gathered from the synthesis, is congruent with different psychological components of empowerment [152]. First, fulfilling vulnerable populations’ basic need for research participation means empowering them through *doing* and *knowing*, since they will have the opportunity to interact with technology before the research begins

Table 4: Summary of the empowerment characterizations for the different levels of the conceptual framework. Psychological empowerment forms are adopted from the research by Schneider et al. [152].

Motivation Concepts	Descriptions of Needs	Suggested Interventions	Empowerment Forms and Descriptions
Basic	Access to ICT	Provide participants with the necessary technology (for example, smartphones or devices).	<i>Knowing</i> : Acquiring Digital Literacy Skills
	Digital Literacy Skills	Teach participants relevant digital literacy skills.	<i>Doing</i> : Having Experience with Technology
			<i>Feeling</i> : Perception of Self-Efficacy
Safety	Protection from Online Risks or Harm	Demonstrate and guarantee no exposure to harm.	<i>Knowing</i> : Awareness of Safety Risks
	Privacy	Provide transparency into and flexibility of the methods, settings, and spaces for the research.	<i>Knowing</i> : Awareness of Risk Mitigation Approach
	Access to Safe Spaces		<i>Feeling</i> : Perception of being Safe
Relationship (or Social)	Leveraging Social Connections	Include social ties during research, if necessary.	<i>Feeling</i> : Perception of Emotional Support
			<i>Feeling</i> : Sense of Community
Self-Esteem	Transcending Barriers of Social Intersectional Identities	Acknowledge social intersectional identities during research.	<i>Feeling</i> : Perception of Competence
Self-Actualization	Lending One's Voice in Research and Design	Leverage justice-centered design approaches.	<i>Knowing</i> : Awareness of Research Outcome/Impact
		Explore and acknowledge interpersonal values and goals.	<i>Doing</i> : Contributing to Impactful Research
			<i>Feeling</i> : Perception of Autonomy
			<i>Feeling</i> : Perception of being Valued

and will be learning the technical skills necessary to effectively participate in technology research and design. Second, by meeting their safety needs, researchers are empowering vulnerable populations through their *knowing* (or awareness) of safety risks and how these will be mitigated and the *feeling* of safety. By meeting relationship needs through research, vulnerable populations will be empowered by having a *feeling* of emotional support and having a sense of community. Fulfilling self-esteem needs would mean that vulnerable populations are empowered through *feeling* competent and confident in their skills and abilities, as their social identities will be acknowledged as assets during the research. Lastly, by meeting self-actualization needs, vulnerable populations will be empowered through *doing* or engaging in impactful work, the *feeling* of autonomy and being valued, and *knowing* about the outcomes or impacts of their research contributions. We show a summary of these characterizations in Table 4. To the best of our understanding, there are no existing works that have characterized both technology needs for vulnerable populations in technology settings and the forms of empowerment that may be achieved. Our findings call for the need for researchers and designers to carefully consider how their collaborations with vulnerable research participants could be better oriented to support and empower them.

5.2 Putting the Framework into Practice

Researchers can use the framework during both the research planning phase and while conducting their research. When working with a vulnerable group of participants, researchers should consider asking questions related to each level of our framework, as listed below. While not exhaustive, we believe this is a starting point for planning research with vulnerable populations and for considering ways to support them. The research team developed these questions based on insights gained from our synthesis (Section 4) and those inspired by our literature review, including the heuristics by Walker et al. [177] and the perspective by Erete et al. [51] on designing for marginalized communities.

Basic Needs. We developed these questions to respond to the issue of lack of technology access and digital literacy skills among marginalized communities [59, 139, 141, 189], which can affect their ability to effectively participate in research and design [51].

- Have they [research participants] used (or been exposed to) technology before?
- Do they currently have access to technology? Mobile devices? The Internet?

- What level of familiarity do they have with technology?
- What digital literacy skills do they have (or currently lack)?
- What barriers do they face when accessing technology or digital content?

Safety Needs. *We developed these questions based on the identified safety risks and potential harm that marginalized communities may face in technology research and design settings [147, 177, 186]. These questions encourage researchers to think about how they can make sure marginalized communities feel safe and protected during the research process.*

- Have they fully understood the risks of participating in the research?
- Are they comfortable with the research methods, settings, and ‘spaces’ or environments in which the research is conducted?

Relationship (or Social) Needs. *We created these questions to address the potential importance of incorporating emotional support, observation, or design collaborations with social ties in technology research and design as identified in the literature [111, 133, 148, 157]. These questions also encourage researchers to assess the community’s receptiveness to including these ties in the research process.*

- Could emotional support or observation or design collaborations with social ties be valuable for the research?
- Do they need or feel comfortable including social ties in the research?

Self-Esteem Needs. *In light of potential challenges that may arise in technology settings due to one’s social and cultural identities [4, 173], we developed these questions as a means of encouraging researchers to critically examine their approach towards working with vulnerable groups of participants and to ensure their social intersectional identities are acknowledged throughout the entire research and design process.*

- What social and cultural identities do they have?
- What needs, challenges, and strengths might exist in light of these social and cultural identities?

Self-Actualization Needs. *These questions address the potential for disempowerment and lack of mutual benefit in research collaborations with marginalized communities [36, 49, 164] by encouraging researchers to consider the alignment of their research with community values and goals, fostering mutual benefit, and supporting self-actualization.*

- What are their long-term values and goals?
- How could we [the researchers] create a learning and growth opportunity for them?
- What would a meaningful and long-term impact of this research look like for them?
- What is the most accessible method to present the research findings to them to facilitate learning and self-fulfillment?

5.3 Limitations of the Framework and Future Work

Vulnerability occurs in all shapes and sizes, causing people to experience it in various ways. Everyone, including people who have disabilities, people marginalized across racial, gender, or social status, immigrants who have been displaced from their home countries, and indigenous people, all of whom are vulnerable in different ways, has their own unique needs, values, experiences, and practices. As a result, we recognize that the characterization of technology needs described in this work for engaging vulnerable populations may not be universal to all vulnerable or marginalized groups. For instance, one vulnerable or marginalized group’s needs for *safety* may be completely unique from those of another group in the same situation. This is because the concept of safety depends on the context and can take on a variety of meanings to different individuals (e.g., foster teenagers vs. teenagers, in general, [11, 12]). We acknowledge that understanding these unique technology needs is important for our future work even though they may not be fully covered in this research.

We also recognize that it may not be appropriate to engage all vulnerable groups in technology research and design, and hence findings from our synthesis might not be applicable to all groups. For example, indigenous communities are frequently ingrained with their rituals and traditional practices [32] and there are potential repercussions associated with engaging with specific aspects of their culture and collecting data from them. Researchers working with indigenous people must take special considerations into the methods for engaging them in the first place or even when technology research is necessary, given how the knowledge for these communities is deeply ingrained in their culture [163]. Because our framework covers the needs and motivations of vulnerable and marginalized groups, a need to not harm these communities’ rituals and traditions should be considered.

Additionally, while we characterize various technology needs to support research and design engagements, we recognize that these needs may not be exhaustive for empowering and supporting them. We invite researchers to expand on our work by investigating whether there are technology needs that go beyond the concepts in Maslow’s hierarchy to expand upon our framework.

Finally, we plan to expand our work by investigating the collaborations of HCI researchers with various vulnerable groups to ascertain how they addressed the needs based on our framework and whether satisfying these needs impacted the outcomes of these collaborations.

6 CONCLUSION

Empowering vulnerable or marginalized populations through research is a topic that has been well-studied in the HCI community. Various frameworks and heuristics have been created to guide research and design for vulnerable populations. However, they typically center on the researcher’s engagement while ignoring needs that can motivate vulnerable populations to participate in research and design. The conceptual framework presented in this paper can be used to support and empower vulnerable populations through their participation in research and design. To develop our framework, we synthesized the research literature using Maslow’s

framework concepts as a guide (e.g., safety, self-esteem, and self-actualization). We have shown that these concepts can help researchers in identifying technology needs that if not addressed, may hinder vulnerable populations from effectively participating in research. We discuss how researchers might meet these technology needs using several HCI theories, including intersectionality. Understanding and addressing technology needs for research participation can not only ensure that vulnerable populations are supported and empowered through research, but also result in more effective research and design engagements.

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