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Reimagining Wearable-Based Digital Contact Tracing: Insights from Kenya and Côte d'Ivoire

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ABSTRACT

While digital contact tracing has been extensively studied in Western contexts, its relevance and application in Africa remain largely unexplored. This study focuses on Kenya and Côte d'Ivoire to uncover user perceptions and inform the design of culturally resonant contact tracing technologies. Utilizing a wearable proximity sensor as a technology probe, we conducted field studies with healthcare workers and community members in rural areas through interviews ($N = 19$) and participatory design workshops ($N = 72$). Our findings identify critical barriers to adoption, including low awareness, widespread misconceptions, and social stigma. The study emphasizes the need for culturally sensitive and discreet wearables and advocates for awareness campaigns over mandates to foster adoption. Our work addresses the unique needs of Kenyan and Ivorian populations, offering vital design recommendations and insights to guide designers and policymakers in enhancing digital contact tracing adoption across Africa.

CCS CONCEPTS

• **Human-centered computing → Field studies**; *Empirical studies in HCI*; **Empirical studies in ubiquitous and mobile computing**.

KEYWORDS

HCI4D, Africa, contact tracing, wearables, social acceptability

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1 INTRODUCTION

Contact tracing is the process of identifying individuals who may have been exposed to a person infected with a contagious disease so that appropriate measures for controlling the spread of the disease can be taken [34, 38]. As the COVID-19 pandemic ravaged the globe starting in late 2019, researchers and technologists rushed to research, develop, and deploy various technology-aided solutions, otherwise known as Digital Contact Tracing (DCT), to contain the spread of the virus. One of the earliest such solutions was the DP-3T system [132, 133], a decentralized proximity tracing system that uses ephemeral IDs to track the proximity of individuals while maintaining their privacy. Apple and Google soon followed

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suit, jointly developing exposure notification systems [82, 93] in their mobile operating systems.[1] These notification systems use Bluetooth technology to inform users of potential exposure anonymously. Thus, various mobile apps were developed [39], providing actionable risk assessments [143] and saving many lives during the pandemic [64, 115, 149].

A predecessor to DCT is Manual Contact Tracing (MCT) [14, 67, 79], a process where public health workers interview diagnosed individuals to collect details of those they have been in close contact with so that possible contagion chains can be identified. While DCT is way more effective than MCT [70]—if widely adopted [17]—most DCT solutions, particularly those in the form of mobile apps, require users to possess smartphones. This is a challenge for Low- and Middle-Income Countries (LMICs), where many people might not own smartphones [98]. Additionally, these DCT solutions were designed and evaluated in the West [64, 115, 132, 133, 149] without considering the unique socio-economic, cultural, and infrastructural contexts of LMICs. Thus, reliance on less efficient MCT techniques leaves most LMICs (which form the majority of the world population [92]) vulnerable to uncontrolled disease spread. Given the interconnectedness of the world and the rapid spread of diseases such as COVID-19 and Ebola, this not only affects local populations but also poses a threat to other regions that have otherwise contained the virus.

In this study, we seek to inform the future design of feasible DCT solutions suited to the unique needs and challenges of LMICs. Our work is further motivated by a recent stream of research [47, 78, 122, 123] showing that most existing Human-Computer Interaction (HCI) research and design is based on Western perspectives, now commonly referred to as WEIRD samples (i.e., based on the perspectives of users that are mostly Western, Educated, Industrialized, Rich, and Democratic). However, such designs often break down when shipped or used elsewhere [119, 138]. We aim to identify challenges and design culturally respectful and appropriate forms of DCT for LMICs, focusing on *Africa* and *wearable technologies*. This focus is driven by Africa's underdeveloped health systems [36], low smartphone penetration [98], and vulnerability to disease spread [127]. In particular, contagious diseases such as Tuberculosis, respiratory infections, and, during outbreaks, Ebola and Cholera remain significant health risks across Africa [127], taking thousands of lives each year [84, 91]. Furthermore, the high population growth rates in countries such as Kenya (1.98% [147]) and Côte d'Ivoire (2.47% [146]) increase the risk of disease spread. In this context, enabling DCT to help monitor and control multiple diseases would have significant and lasting relevance. To address these challenges, wearable technologies present a promising solution for effective DCT. Wearables offer advantages over smartphones that make them more feasible in Africa, such as being cheaper and more accurate than smartphones [28] and not requiring the population to pre-own a device. Such wearables have been proposed in Singapore, notably the Bluetooth-enabled TraceTogether token [25], to increase adoption among older adults. However, they have not yet been introduced in LMICs, particularly in Africa. In this study, we focus on Kenya in East Africa and Côte d'Ivoire in West Africa, aiming to answer the following two research questions (RQs):

RQ1. What are the possible incentives and challenges to the adoption of wearable-based DCT in Africa, particularly in Kenya and Côte d'Ivoire? What potential remedies could address these challenges?

RQ2. What are the expectations and preferences of African users regarding the design and functionality of wearable-based DCT?

To address our RQs, we developed an ultra-wideband proximity-sensing system called Wearable Proximity Platform (WPP) and utilized it as a technology probe [54]. We then conducted a field study [144] comprising semi-structured interviews ($N = 19$) followed by focus group discussions and participatory design workshops ($N = 72$) with participants recruited in Kenya and Côte d'Ivoire in both healthcare and rural settings. We used semi-structured interviews to get participants' in-depth perceptions and preferences for DCT, complemented by the participatory design workshops that are critical for designing technology that is appropriate and usable by the target users. Throughout the study, we directly worked with local communities to understand their needs and preferences for DCT.

Our study offers insights into the design and adoption of wearable-based DCT solutions across Kenya and Côte d'Ivoire. First, many participants preferred introducing wearable-based DCT gradually in normal situations (rather than during pandemics) to improve public understanding and acceptance. They also highlighted a lack of awareness and misconceptions as potential barriers to adoption. Second, participants identified cultural, social, and economic influences on adoption, particularly raising concerns about social stigma and emphasizing the need for culturally sensitive and discreet designs for DCT. In addition to these concerns, they also offered design recommendations, suggesting various ways to make wearables more discreet and thus more likely to be adopted. Third, there was a preference for portable, easy-to-wear DCT devices that do not interfere with daily chores and routines, provide notifications, and have long-lasting batteries to address electricity challenges that remain prevalent in rural areas. Finally, to boost adoption, participants pointed to the need for enhanced awareness and more education about DCT, highlighting the role of community health volunteers as crucial intermediaries in these efforts, with awareness campaigns being more likely to be effective than monetary incentives or government mandates. Our work makes the following contributions:

- First, our empirical study, to the best of our knowledge, is the first to shed light on the unique perspectives of Kenyan and Ivorian individuals in both rural and healthcare settings regarding DCT, addressing a critical gap by focusing on an otherwise underrepresented demographic.
- Second, we offer design implications and recommendations for future wearable-based DCT solutions grounded in participatory design and user feedback, which can significantly enhance DCT acceptance in Africa.
- Third, we provide valuable cultural insights and practical recommendations that can inform policymakers and technology developers aiming to improve DCT adoption in LMICs.
- Fourth, we share lessons learned from conducting fieldwork in African contexts, such as trust-building with local intermediaries

[1] See https://en.wikipedia.org/wiki/Exposure_Notification, last visited: Jan. 2025.

and ethical engagement with local communities. These insights provide practical guidance for future researchers who conduct studies in similar settings.

2 RELATED WORK

In this section, we first review studies that explore the factors influencing users' willingness to use DCT apps. Next, we summarize research involving understudied populations, particularly in LMICs and rural areas, and highlight the importance of understanding the DCT perspectives of African users.

2.1 Factors Influencing Adoption of DCT Apps

To be effective, DCT requires broad user *adoption* (i.e., at least 56% participation [17]). However, motivating individuals to adopt DCT apps remains a significant challenge [140]. A survey of Americans indicated that only 42% were willing to download and use DCT apps [153]. Prior research has extensively studied user perceptions and willingness to use DCT apps (see [4, 87, 103] for comprehensive literature surveys on the topic). For example, Altmann et al. [6] conducted a large-scale survey ($N = 5995$) across France, Germany, Italy, the UK, and the US, finding strong support for DCT apps but noting trust issues with governments. Utz et al. [134] found user acceptance highest in China and lowest in the US through a survey in Germany ($N = 1003$), the US ($N = 1003$), and China ($N = 1019$), with Chinese respondents preferring personalized data collection. Häring et al. [56] surveyed $N = 744$ German respondents on the Corona Warn App, noting high awareness but misconceptions about its functionality. Similarly, a UK qualitative study ($N = 27$) highlighted misconceptions that impact app use [142], which can, in turn, affect users' willingness to adopt these apps [125].

Overall, the willingness of users to engage with DCT apps is influenced by a complex interplay of factors. On the encouraging side, trust in app providers [63] and the perceived benefits of the app [1, 87, 124] play a key role. When users believe that the technology is effective in mitigating risks [87], aligns with societal benefits [124, 130], and is supported by a sense of collective responsibility [87], they are more likely to participate. The convenience [130] and usefulness [72, 100, 137, 141] of the app, combined with a positive attitude towards technology [59, 137], can further enhance willingness to use the app. Additionally, the presence of tangible or societal rewards [26], voluntariness in participation [1, 6], and the perception that the app is compatible with users' past user experience [100] contribute positively to adoption. Further, a higher level of education can influence willingness to use DCT apps [60].

On the other hand, several negative factors can deter the adoption of DCT apps. Doubts about the app's effectiveness [129], unmet information needs [87, 129], and technical concerns [129] can discourage participation. Moreover, the perception that the app is unnecessary [129] or a lack of trust in governments or service providers [6, 63, 72, 87, 102, 129, 137] can further erode users' willingness to engage. However, the most significant barrier to using DCT apps is privacy concerns, such as fears of data misuse and cybersecurity concerns, that have been identified in several studies across the US [6, 24, 33, 48, 58, 62, 69, 72, 77, 79, 100, 111, 125, 151], Canada [102], Australia [129], Fiji [124], Belgium [11, 141], Switzerland [40], France [6, 72], Germany [6, 52, 56, 69, 72, 130], the Netherlands [59, 60], Italy [6], the UK [6, 12, 142], Brazil [26], China [69], and Jordan [1]. To alleviate these concerns, researchers recommend transparency about data practices [125] and communicating app benefits [148]. In India, however, privacy concerns did not impact users' willingness [121]. This is echoed by a follow-up study on the Corona Warn app in Germany. Häring et al. [55] found that utility was a greater factor in adoption, with fewer participants citing privacy issues, contrasting with the authors' earlier findings [56].

At the same time, a majority of these studies have primarily focused on the adoption of *smartphone*-based DCT apps, leaving a gap in understanding how wearable-based DCT might be perceived and adopted. The only relevant evidence comes from Huang et al. [53], who, in a follow-up study ($N = 3240$), revealed the low adoption of TraceTogether in Singapore [25]. Additionally, Zakaria et al. [151] found that the mode of contact tracing (i.e., data collection modality) can significantly influence user willingness to participate, highlighting the importance of considering how wearable-based DCT might be perceived differently.

2.2 Studies with Populations from LMICs and Rural Areas

Our work—aligned with the HCI4D paradigm [31, 51, 136]—emphasizes local knowledge, practices, and values in technology development [3]. Technological solutions developed and evaluated in the West often fail in other regions and contexts because of unique local needs, challenges, and practices. For example, while smartphones are typically designed for individual use, cultural norms in South Asia often expect women to share their devices with other household members, causing unanticipated challenges with usability, security, and privacy [119]. In Kenya, financial adversity often supersedes security and privacy concerns for mobile loan app users [89]. Meanwhile, users of cybercafes face significant security and usability challenges with password creation and account management [138]. Similarly, South African Facebook users worry more about what their friends can see than data privacy [112], contrasting with findings in Western contexts. These examples highlight the need for HCI approaches tailored to the specific cultural and socio-economic contexts of LMICs. Consequently, researchers are exploring and designing technologies suited to the African and other underrepresented groups and contexts [107, 145].

In the context of DCT, a few studies have concentrated on at-risk populations. For instance, Alharbi et al. [5] found that older adults in Saudi Arabia struggled with DCT technologies, relying on others, potentially increasing the risk of contracting COVID-19. Similarly, Muzyamba et al. [90] discovered that Ugandan healthcare workers under enormous stress during the pandemic coped through strong communal links and networks. Several studies have investigated African individuals' perceptions of contact tracing [13, 21, 44, 57, 99]; however, these mainly were conducted before the COVID-19 era, focusing on *manual* contact tracing rather than digital. This limited focus highlights a gap in understanding how DCT might be perceived in these contexts. A prior work highlights that culture significantly influences perceptions of DCT among Chinese users [83]. Similarly, cultural factors have been shown to impact the design of DCT apps in India [101]. Therefore, developing culturally sensitive solutions for Africa necessitates a specific focus on African users to understand their perceptions and preferences.

3 METHODOLOGY

To explore users' perceptions, motivations, needs, and expectations toward contact tracing in Africa, we conducted a field study [144] comprising semi-structured interviews ($N = 19$) as well as focus group discussions and participatory design workshops ($N = 72$) in Kenya and Côte d'Ivoire. Interviews and focus group discussions allowed us to collect in-depth insights into users' perceptions and needs. The participatory design process [65, 66, 120], which integrates designers and target users in the design process, is crucial for ensuring that technology meets users' real-world needs. This is especially important in LMICs [46] and healthcare [30, 75] contexts, where user involvement is critical for adoption.

Our methodology included field trips [41] to engage directly with *healthcare workers in healthcare settings* (henceforth HCWs)[2] and *community members in rural areas* (i.e., henceforth Rural non-HCWs)[3] in Kenya and Côte d'Ivoire to understand their unique needs and challenges better. HCWs, being at the forefront of managing outbreaks, have unique expectations and requirements for wearable technologies that are critical to capture. Conversely, rural non-HCWs face distinct socio-technical challenges and have increased exposure risks due to limited access to healthcare services. The healthcare facilities we selected are in suburban or urban areas and serve the rural populations involved in our study, as these individuals often have to travel to these locations for medical care. Addressing the diverse needs of these two groups, which represent the extremes of the spectrum in terms of healthcare access and technology adoption, is vital for ensuring the acceptance and adoption of wearable-based DCT technologies.

Research materials, including the detailed protocol for selecting Kenya and Côte d'Ivoire, interview guide, participatory workshop procedure, codebook, and affinity diagram, were shared in compliance with the research transparency criteria outlined by Salehzadeh Niksirat et al. [117]. These supplementary materials are available in the OSF repository at https://doi.org/10.17605/osf.io/2htr3.

3.1 Research Sites

In selecting the countries for the study as well as a single point of contact (SPOC) for each country, we employed a rigorous multi-step approach (detailed in `Supplementary 1`), which led to the selection of Kenya and Côte d'Ivoire. Kenya and Côte d'Ivoire are lower-middle-income countries located in East and West Africa, respectively. Kenya has an estimated population of about 57 million [147], while Côte d'Ivoire's population is approximately 32 million [146]. Both countries are extremely diverse culturally [88, 135]; Kenya has over 40 different ethnic groups, while Côte d'Ivoire has more than 60 ethnic groups. Each of the countries has over 60 different languages spoken [88, 135], with English and Swahili being the official languages in Kenya, while French is the official language in Côte d'Ivoire. Approximately 31% of Kenya's population and 48% of Côte d'Ivoire's population live in urban areas [146, 147]. Both economies significantly rely on agriculture, with Nairobi being the capital of Kenya and Abidjan the capital of Côte d'Ivoire. As for SPOCs, for Kenya, we chose Center for Public Health and Development (CPHD)[4], and for Côte d'Ivoire, we selected Centre Suisse de Recherches Scientifiques (CSRS)[5]. We then established contact with both SPOCs and initiated discussions that enabled us to conduct the studies. We selected one healthcare facility and one rural village in each country (see Figure 1). Below, we describe each site.

- **Kitengela Hospital, Kitengela, Kenya:** This small suburban healthcare facility is located 33 km south of Nairobi. The facility was chosen for its accessibility. Two rooms were provided to conduct the study.
- **Olepolos Village, Isinya, Kenya:** This rural village, located 68 km south of Nairobi, was chosen for its distinct rural characteristics. The village faces challenges such as lack of proper roads, water scarcity, limited electricity, restricted healthcare access, and economic instability, which might present challenges for technology adoption. The local Methodist Church, led by a supportive pastor, served as the venue for our study.
- **CHU de Cocody, Abidjan, Côte d'Ivoire:** This major urban hospital is 6 km from Abidjan in Cocody. CHU de Cocody (or Centre Hospitalier Universitaire) was selected due to its scale and acute challenges, such as a shortage of functional ICU beds. The study was conducted in the hospital's conference room.
- **Petit Yapo Village, Prefecture of Agboville, Côte d'Ivoire:** Approximately 61 km north of Abidjan, this small village is characterized by its green, forest-covered surroundings and modest infrastructure. The village's basic amenities, such as limited cellular and internet coverage, present unique challenges for technology deployment. The village chief courteously allowed us to conduct interviews from his home.

3.2 Technology Probe: Wearable Proximity Platform (WPP)

We developed an ultra-wideband (UWB) proximity-sensing system, henceforth referred to as Wearable Proximity Platform (WPP), shown in Figure 2. Incorporating UWB radio technology, WPP offers precise measurements of relative distances between devices (accurate to about 10 cm), surpassing the accuracy [28, 76, 114, 150] of conventional Bluetooth used for smartphone-based DCT [81] and the TraceTogether token [25], as well as WiFi-based systems recently proposed for DCT [45, 131, 152]. This precision enables the detailed analysis of potential infection routes. The development of the onboard software, toolchain, and the post-processing software for WPP were informed by the experience of ISI Foundation on developing and deploying wearable proximity-sensing systems, building on the work of the SocioPatterns collaboration.[6] To enhance the WPP's functionality and reliability for data collection in real-world settings, we conducted a series of pre-deployment technical adjustments to optimize battery lifetime, distance estimation

[2]Participants categorized as 'HCW' include individuals working in healthcare settings regardless of their residential location (urban, suburban, or rural). Residential data was not collected for this group.
[3]Participants categorized as 'Rural non-HCW' refers to participants living in rural areas who are not employed in healthcare professions.

[4]See https://www.cphdev.org, last visited: Jan. 2025.
[5]See http://www.csrs.ch, last visited: Jan. 2025.
[6]See [23, 94, 104] and http://www.sociopatterns.org, last visited: Jan. 2025.

Figure 1: Overview of the four research sites involved in the study. Top Left: Kitengela Hospital in Kenya; Top Right: Olepolos Village in Kenya; Bottom Left: CHU de Cocody in Côte d'Ivoire; Bottom Right: Petit Yapo Village in Côte d'Ivoire.

accuracy, and on-board software stability. We also iterated on the software toolchain used by the field team to configure the sensors and to download data from them, with the goal of simplifying field deployment logistics.

In this work, we used WPP as a *technology probe* [54], aligning with the participatory design framework's emphasis on engaging users with technological artifacts to elicit design insights [7]. This allowed participants to share their perspectives and interactions with WPP, enabling us to introduce participants to the concept of DCT and observe their interactions with wearable technology. Technology probes, as defined by Hutchinson et al. [54], are exploratory tools designed to understand user needs and contexts and inspire future design ideas, rather than to undergo immediate refinement. Our study aligned with this traditional, established approach, focusing on initial data collection and contextual exploration.[7]

Our implementation did not include user input or device feedback *by design* for two primary reasons: first, WPP is not an actual DCT implementation, so there are no exposure notifications to report or receive. Second, we intend for future HCI design to be informed by our study.

[7]While some recent studies (e.g., [43]) have adopted hybrid approaches, incorporating iterative co-design with technology probes, our use of WPP retained the original exploratory purpose.

3.3 Ethics

Our study aligns with established ethical practices for HCI research [117]. This study was reviewed and approved by two institutional ethics review boards and two local ethics boards in Kenya and Côte d'Ivoire. Before the field studies, two co-authors traveled to Kenya and Côte d'Ivoire to engage in preliminary awareness meetings, understand the local context, and secure necessary permissions. Before conducting the main study, we provided participants with information sheets detailing the study. We also took time to provide more details about the study and address any questions from participants. All participants had to consent to the study before we started data collection. We did not collect any personally identifiable information from participants. We also obfuscated participants' faces and other identifiable information on all artifacts.

3.4 Recruitment and Demographics

SPOCs in each country facilitated recruitment via oral advertisements led by hospital managers and village chiefs. The main inclusion criterion for the healthcare setting was employment within that setting, whereas, for the rural setting, it was residency within the area. Table 1 summarizes the participants' demographics (complete demographics are detailed in Appendix A). We recruited $N = 19$ participants for the interviews and $N = 72$ participants for focus group discussion and participatory design workshops. In Kenya,

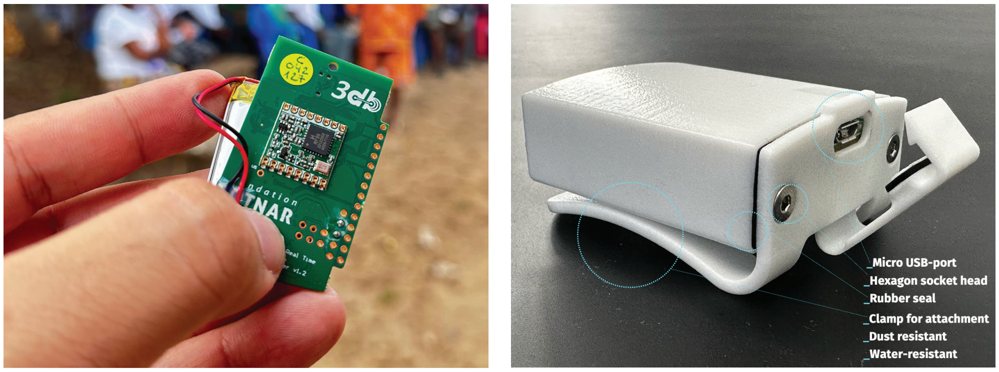

Figure 2: Wearable Proximity Platform (WPP). Left: The ultra-wideband WPP hardware is displayed. Right: A prototype 3D-printed enclosure is shown.

n = 36 participants participated in the focus group and participatory design workshop, with an even split between HCWs and rural non-HCWs. In Côte d'Ivoire, we had the same number of participants for the participatory design but with more participants from the rural setting (n = 20). Ivorian participants tended to be older, with 19 out of 36 falling within the 46–65 age range, whereas in Kenya, only 7 out of 36 were in this age group. For gender, and especially in Kenya, most participants were women (22 out of 36), compared to Côte d'Ivoire (19 out of 36). For interviews, we recruited N = 19 participants, with n = 10 from Kenya and n = 9 from Côte d'Ivoire. The participant sample for interviews was more balanced in terms of gender. Age and educational levels were consistent with participants in the participatory design workshops. Four participants from each country participated in both the interviews and the participatory design workshops.

Participants were compensated based on the activity: ≈ USD 20 for participatory design and ≈ USD 15 for interviews, paid in their local currencies. The compensation covered transportation and meal expenses, in addition to providing a token of appreciation for their participation. We settled on these amounts after consultations with the SPOCs.

3.5 Study Procedure

Figure 3a outlines the overall study procedure. The field study spanned two weeks from October to November 2023, with four co-authors traveling to Kenya during the first week and Côte d'Ivoire during the second. At each site, interviews were conducted first, followed by the participatory design workshops.[8]

3.5.1 Interview Procedure. We conducted semi-structured interviews [74] to explore various dimensions of user perception regarding contact-tracing technologies. Each session was facilitated by two researchers—one leading the interview and the other taking notes. The study languages in Kenya and Côte d'Ivoire were English and French respectively. For Côte d'Ivoire, since none of the interviewers speaks French, a translator provided by the SPOC was present to translate. Informed by our RQs, we designed the interviews around several blocks to comprehensively explore participants' perceptions and attitudes. These blocks guided the discussion on topics such as awareness and knowledge of contact tracing, scenarios where DCT might be beneficial, motivations to use DCT technologies, desired features, views on privacy and trust, and potential challenges. The interview guide is available in Supplementary 2.

In Côte d'Ivoire, the presence of a translator extended the duration of the interviews, averaging 71 minutes, while in Kenya, each interview took an average of 47 minutes. All interviews were audio-recorded with participants' permission.

3.5.2 Participatory Workshop Procedure. Our study design drew inspiration from previous participatory design research [27, 29, 42, 46, 85, 116]. The workshop was co-facilitated by three researchers (including one native French speaker) and one SPOC member. One researcher served as the primary facilitator, responsible for presenting the main instructions, while the other two assisted with conducting activities, managing discussions, taking notes, and recording the sessions. The SPOC member facilitated communication between the participants and researchers; this was crucial due to cultural differences between some researchers and participants. Translators provided by the SPOCs were also present to accommodate language preferences. In Kenya, the primary language of the study was English; however, translation was required for a few participants who preferred Swahili. In Côte d'Ivoire, the sessions were conducted in French, with a few participants preferring Abé. Figure 3b illustrates the workshop procedure. Between each session, we had short breaks. The whole session (in each setting) lasted approximately four hours. A detailed protocol is available in Supplementary 3.

Part I. Introduction (≈ 15-min): On arrival, participants consented to the study before completing a demographic questionnaire. Next, the primary facilitator explained DCT, including the potential benefits of wearable technology, and how WPP functions. To align expectations and ensure participants understood the value of their involvement, the facilitator also outlined the session's objectives.

[8]Concurrently, on the first day at each site, a team from our project conducted pilot studies to assess the reliability and feasibility of WPP. During these pilots, participants at each site were provided WPP devices from morning until evening. The data collected was later analyzed to evaluate the quality of WPP data capture in the field. These findings, along with the hardware and technical development of WPP, are planned to be presented in a separate publication focused on epidemiology.

Table 1: Summary of participant demographics. 🎤 represents interview participants. 👥💡 represents focus group and participatory design participants.

	Kenya				Côte d'Ivoire				Total	
	HCWs		Rural non-HCWs		HCWs		Rural non-HCWs			
	🎤	👥💡	🎤	👥💡	🎤	👥💡	🎤	👥💡	🎤	👥💡
Gender										
Woman	3 (15.8%)	12 (16.7%)	3 (15.8%)	10 (13.9%)	2 (10.5%)	8 (11.1%)	2 (10.5%)	11 (15.3%)	10 (52.6%)	41 (56.9%)
Man	2 (10.5%)	6 (8.3%)	2 (10.5%)	8 (11.1%)	3 (15.8%)	8 (11.1%)	2 (10.5%)	9 (12.5%)	9 (47.4%)	31 (43.1%)
Non-binary	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Undisclosed	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Age										
18-25	0 (0.0%)	2 (2.8%)	1 (5.3%)	3 (4.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (5.3%)	5 (6.9%)
26-35	0 (0.0%)	6 (8.3%)	3 (15.8%)	9 (12.5%)	1 (5.3%)	1 (1.4%)	0 (0.0%)	2 (2.8%)	4 (21.1%)	18 (25.0%)
36-45	3 (15.8%)	7 (9.7%)	1 (5.3%)	2 (2.8%)	2 (10.5%)	11 (15.3%)	1 (5.3%)	3 (4.2%)	7 (36.8%)	23 (31.9%)
46-55	2 (10.5%)	1 (1.4%)	0 (0.0%)	3 (4.2%)	2 (10.5%)	4 (5.6%)	0 (0.0%)	6 (8.3%)	4 (21.1%)	14 (19.4%)
56-65	0 (0.0%)	2 (2.8%)	0 (0.0%)	1 (1.4%)	0 (0.0%)	0 (0.0%)	3 (15.8%)	9 (12.5%)	3 (15.8%)	12 (16.7%)
Total	5 (26.3%)	18 (25.0%)	5 (26.3%)	18 (25.0%)	5 (26.3%)	16 (22.2%)	4 (21.1%)	20 (27.8%)	19 (100.0%)	72 (100.0%)

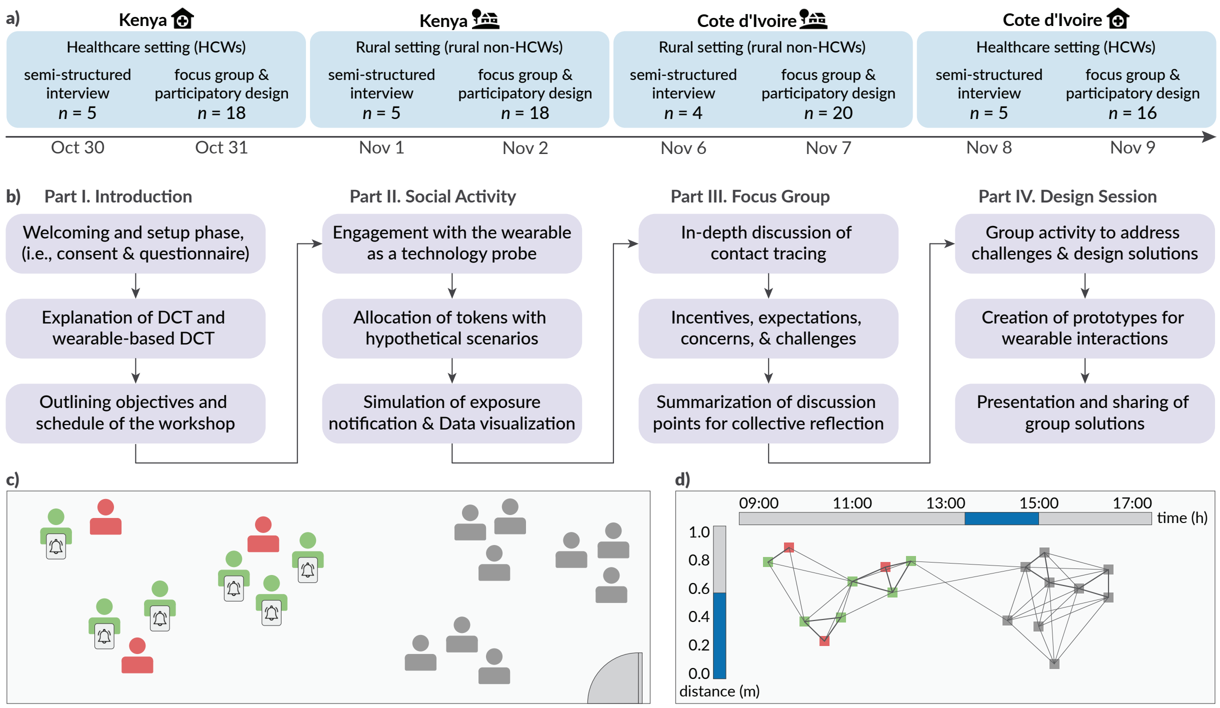

Figure 3: (a) Timeline of study procedure in Kenya and Côte d'Ivoire; (b) Schematic of the Participatory design workshop; (c) The seating arrangement of participants in the social activity. Physical tokens are given and colored to indicate *hypothetical* infection status: Red, hypothetically infectious; Green, contact potentially at risk; Grey, no contact, safe. Cards with a bell symbol represent the notification cards that participants with green tokens received; (d) A representation of the interactive demo illustrating WPP data. A User can adjust time and distance bars to visualize participants' proximity. The distance bar changes measurement sensitivity, accommodating different disease transmission parameters, while the time bar allows for flexible visualization periods. The colors were used solely within the interactive demo; the WPS itself does not utilize color indicators, as it functions purely as a proximity-sensing data collector.

Part II. Social Activity (≈ 45-min): For the social activity, we utilized WPP as a technology probe [54]. The social activity served as a contextualization process that (i) facilitated ideation in subsequent stages by helping participants understand the concept of contact tracing, (ii) enabled us to familiarize participants with wearable-based DCT, (iii) enabled us to observe their behavior with the wearables, and (iv) helped break the ice between participants and facilitators. We distributed WPP among the participants. Participants were then given tokens with different colors, each representing a *hypothetical* scenario—explained to the participants only at the end of the activity. For half of the participants sitting close to each other, grey tokens were given, while the other half received red or green tokens randomly (see Figure 3c). Participants were encouraged to engage naturally during the activity without focusing on WPP. The meaning of the token colors was revealed at the end of the activity: (i) Red: hypothetically infectious; (ii) Green: potentially at risk of infection due to close contact with red token holders; and (iii) Grey: safe with no close contact with red token holders. During this activity, we inquired about participants' awareness of contact tracing, particularly DCT. Next, we explained the meanings of the hypothetical scenarios associated with the tokens. We presented sample data visualizations (see Figure 3d) to demonstrate how WPP data could be represented and interpreted in real contact-tracing scenarios.[9] This demonstration aimed to illustrate potential insights that could be derived from such data. We also simulated exposure notifications where participants with green tokens received printed cards informing them that they were "hypothetically" exposed and might need to self-test and potentially isolate if they tested positive.

Part III. Focus Group (≈ 90-min): We facilitated a focus group discussion [71, 74] to gather insights and perspectives to inform the subsequent design phase (see Figure 4). In participatory design studies, focus groups are commonly used to lay the foundation for design activities and stimulate brainstorming [9, 116]. To facilitate meaningful discussions, we crafted thought-provoking questions in line with the interview questions. In particular, we probed about situations where participants would want to take part in contact tracing, incentives that would motivate them to take part, expectations for DCT, and any concerns and challenges that would inhibit the adoption of WPP. These discussions were audio-recorded. Additionally, one of the co-facilitators took notes, which were then affixed to a wall in the room. At the end of the session, the co-facilitator summarized the conversation, highlighting key points.

Part IV. Design Activity (≈ 90-min): To initiate the design session, we communicated two main objectives to the participants (i) to propose solutions and ideas addressing the challenges identified during the focus group, and (ii) to ideate on design, with particular emphasis on form and interaction. Participants were randomly divided into groups of three to five persons per group (see Figure 4). To achieve the first objective, each group selected one or two challenges among the identified challenges in the focus group discussions to address. They were given time to discuss and decide which challenges to focus on. Facilitators moved between groups, listening in and offering support as needed. For the solutions, participants were encouraged to think about and discuss potential ideas within their groups. Addressing the second objective involved contemplating the user interface of wearable-based DCT. Participants were asked to imagine a typical day wearing the WPP and to consider how they would prefer to interact with it. They were then instructed to create low-fidelity prototypes, including sketching or using materials to create physical prototypes. Participants were given resources such as paper, cardboard, colored pens, pencils, markers, Post-its, rope, scissors, and glue. Recognizing that participants were unfamiliar with sketching, the facilitator provided practical tips on rapid sketching [61]. Participants were reassured that messy designs and rough sketches were acceptable. Finally, one representative from each group presented their proposed solution.

3.6 Data Analysis

We collected various data types, including audio recordings from interviews and focus groups, written notes and transcripts from the design sessions, and drawings and physical prototypes crafted by participants.[10] All audio recordings were transcribed using Whisper, which was run locally on the researcher's computer to ensure data privacy. The first author manually reviewed and corrected the English transcripts. The French audio was also processed using Whisper and corrected by two SPOC members. For the interview and focus group data, the coding and theme development were conducted using reflexive thematic analysis [16, 18, 19], following an *inductive* approach. This involved multiple rounds of coding, reflection, and discussion among the first and second authors, allowing us to remain open to new insights and adapt our themes as we deepened our understanding of the data, ensuring that the themes were truly representative of participants' perspectives rather than simply reflecting the initial questions posed. Each coder independently coded the interviews before jointly discussing and resolving discrepancies. After coding the interviews, the same codebook was applied to the focus group data due to the similar focus of the two data collection methods. Themes were then developed by the first author and refined through discussions with the second author, iterating until consensus on the final themes was achieved. Since we reached a consensus, calculating intercoder reliability was deemed unnecessary [86]. Including a second coder, particularly African, enriched the analysis, providing nuanced insights rather than striving for unanimous agreement [20]. The details of the thematic map and the codebook are available in `Supplementary 4`. For the participatory design data, we employed affinity diagramming [80, 106]. The first author primarily analyzed data by labeling and categorizing it before iteratively grouping them. The second author then reviewed these categories. The details of the affinity diagram are available in `Supplementary 5`.

We present the findings together despite using different approaches to analyze interviews and focus groups (i.e., thematic analysis) and participatory design data (i.e., affinity diagramming). By integrating insights from all these data points, we provide a more nuanced and holistic picture of participants' perceptions, requirements, and suggestions. Additionally, while our initial analysis treated the dataset as a whole to identify shared themes and cross-country insights, we retrospectively revisited the data to explore potential country-specific differences.

Lastly, our positionality as researchers may have influenced our study design and the data interpretation. Therefore, we discuss our positionality in the next section.

3.7 Positionality Statement

Our multidisciplinary team comprises researchers from HCI, computer security, epidemiology, and wearable technology. The diversity of experiences in our team is a source of reflexivity, prompting us to continuously examine how our backgrounds influence our

[9]To this end, first, we used sample data from another study where we logged time-resolved proximity relations between participants with a temporal resolution of about 5 sec and a spatial resolution of about 10 cm. Second, we built an exploratory dashboard that displays the data and allows users to engage with the data.

[10]We deactivated the WPP during the participatory design session to not collect proximity data.

Figure 4: Participant engagement in various settings of the study. Left: A focus group discussion in a rural setting; Right: A design session in a healthcare setting.

research questions, design choices, and interactions with participants. The first and second authors were primarily involved in the study design, data collection, and analysis. The first author, originally from a non-African region with academic training in Japan and Switzerland, has limited first-hand knowledge of the African context. This perspective brought a fresh viewpoint and a rigorous scientific approach, balanced by the second author's deep regional expertise. The second author, natively from Africa, with academic training in the US, has conducted extensive research within African populations and brings a profound understanding of the local socio-cultural dynamics and public health challenges. The remainder of our team is from various parts of Europe, the US, and Africa. This diversity enriched our engagement with communities in Kenya and Côte d'Ivoire.

3.8 Limitations

Our study has several limitations that should be considered when interpreting the findings. First, this study was conducted in Kenya and Côte d'Ivoire, with a limited number of participants; thus, the findings cannot be generalized to other African countries. However, the goal of this study was not to generalize but to provide insights and implications specific to the contexts studied. Second, despite having a transparent recruitment strategy, field settings can introduce uncontrollable variables. Personal relationships among local people might influence the recruitment process and participant responses. For instance, we perceived potential biases in rural areas where local influential figures, like community leaders, might have affected how a few participants responded during interviews (e.g., being more positive about DCT). However, we believe this potential effect is negligible and does not impact the overall findings. Third, we used WPP as a technology probe in our focus groups and participatory design sessions. While this helped gather specific data on wearable-based DCT, it may have limited some participants' ability to think beyond WPP. Fourth, for interviews conducted in Côte d'Ivoire (i.e., with four participants), we acknowledge that the use of a French translator may have introduced biases. However, we mitigated this by preparing the translator beforehand, ensuring they were familiar with the interview guide and study objectives to facilitate accurate communication and translation.

4 FINDINGS

We identified four main themes revolving around participants' perceptions of DCT, factors influencing their adoption of DCT, their expectations for wearable-based DCT, and suggestions to improve the design and adoption of DCT.

Before presenting these themes, we first overview the participants' initial awareness and perceptions of contact tracing. Participants exhibited varying levels of familiarity with contact tracing, where HCWs (as expected) were generally more knowledgeable than rural non-HCWs. In terms of experience, rural non-HCWs had mostly never encountered contact tracing before, whereas HCWs had substantial experience with MCT but not DCT. After we explained what DCT is, most participants recognized its benefits as crucial for the greater good of society. Beyond contact tracing, most participants demonstrated a strong perceived necessity for technological innovation and an understanding of how technology can drive progress in health and development. This is important, as positive attitudes towards technology can enhance willingness to use DCT technologies [59, 137].

In presenting our results, we use the following symbols to indicate the source of data for each theme: 🎙 for results derived from interviews, 👥 for focus group discussions, and 💡 for participatory design sessions. We additionally provide the following symbols alongside the quotes for additional context: H for HCWs, R for rural non-HCWs, KE for Kenya, and CI for Côte d'Ivoire. For example, 👥 R-CI stands for a focus group response from a rural non-HCW in Côte d'Ivoire and 💡 H-KE stands for a participatory design insight shared by a HCW in Kenya.

4.1 Theme 1. Contexts and Potential Barriers to DCT Adoption

This theme explores the contexts in which DCT might be used and identifies key barriers to its adoption, including challenges related to awareness, misconceptions, beliefs, and privacy concerns.

Theme 1.1. Contexts and Scenarios for Using DCT [🎙 👥] Participants mentioned various contexts where they would feel comfortable or see a necessity for participating in DCT. The contexts varied from general settings to specific environments, reflecting the diverse situations in which DCT could be beneficial. Some participants expressed comfort in participating in DCT ***anywhere*** due to the severe disease threat. P4 (H-KE) stated that DCT *"should be used across the board. At work, at home, in public places, transport. So it should be used everywhere because everywhere we are interacting with people."* The necessity of DCT in ***public and crowded places*** was a recurring theme. Several participants mentioned that DCT was particularly important in areas with high human interaction, such as public transportation in African regions, where the risk of disease transmission is higher. P6 (R-KE) mentioned they are *"comfortable [participating in DCT] anywhere, but more preferably in more congested areas."* Other participants (R-KE) echoed this, adding that *"contact tracing should be used in places of gathering like schools, marketplaces, and churches."* There were mixed views on practicing DCT at ***home***. A few participants felt that DCT might not be meaningful in a home setting with no strangers, while others believed it was still important to monitor potential disease spread.

Timing was another crucial factor. Many participants were comfortable with DCT *during* epidemics or pandemics. Still, several suggested that introducing wearable-based DCT gradually in non-pandemic periods (i.e., *before* an outbreak) would help people better understand and accept the technology. For instance, a participant (H-CI) said that, *"these technologies are a little less known to the general public because we rarely see them. We see them often when there is an epidemic, so it should be regular. Everyone should have access to it, especially in prevention ... I think we should not see it once a year. It should be seen regularly."* However, another participant (H-CI) disagreed, stating that *"we should not use this technology continuously. There must be epidemics so that we feel the importance of this technology."* A few HCWs mentioned that the occurrence of another pandemic and its urgency and seriousness would motivate them to participate more actively in DCT efforts.

Theme 1.2. Awareness Challenges, Misconceptions, and Beliefs [ ] A potential barrier to DCT adoption was ***a lack of understanding and awareness*** about DCT. Even after explaining DCT, many participants (i.e., including both R and H) did not seem to fully grasp DCT and its functions. In rural areas, unfamiliarity with the term "contact tracing" and a lack of technical knowledge contributed to this barrier. Additionally, individuals with low literacy levels might overlook pandemic preparedness, making it challenging to introduce new technologies and educate them effectively. P7 (R-KE) stated that they were *"not aware of contact tracing. All I know is that I never come across that before."* P7 added, *"technology has a lot of things, and we don't understand many things."*

Misconceptions and misunderstandings about DCT can also pose significant barriers to its adoption. For instance, participants often confused contact tracing with social distancing and believed that isolation or quarantine would keep them safer than participating in contact tracing, despite evidence suggesting the importance of both strategies in controlling disease spread [49]. Many had incorrect mental models of DCT, thinking it could detect diseases directly. A participant (R-CI) thought that *"whenever [I] wore the device, it would just kind of automatically detect if [I] had any kind of diseases. [I] ... just want, even by wearing the device, to be cured directly."* Such expectations can make people neglect DCT when they are not fulfilled and may even put people in danger if they falsely believe the devices can cure them. We observed more misconceptions in Côte d'Ivoire than in Kenya. This may reflect differences in our samples' educational backgrounds, as our sample in Côte d'Ivoire included a higher proportion of participants with primary or no formal education compared to Kenya (see Appendix A). This finding highlights the need for targeted awareness efforts tailored to varying literacy levels. A prior work [60] has demonstrated the impact of education on willingness to use DCT apps. Future research could investigate how educational backgrounds influence perceptions of DCT, particularly in the context of LMICs with diverse literacy levels. Such false beliefs are not unique to Africa as they have also been observed among German users [56].

Beliefs, myths, and misinformation can also impact DCT adoption. Skepticism towards new technologies arose from misinformation, with some participants fearing side effects and risks associated with a wearable-based DCT. P5 (H-KE) mentioned how some HCWs were skeptical of participating in the pilot study, with some saying *"you never know this thing [WPP]. This can even be infectious. It can cause a certain disease, or these guys [researchers] may even control your life using this gadget."* P3 (H-KE) was worried that *"this [DCT] can have a risk to, you know, skin cancer or something. So if I got to wear that, definitely I won't be comfortable using it."* ***Religious and spiritual beliefs*** also influenced decisions, highlighting the need for culturally and religiously sensitive approaches. For example, previously, cultural beliefs prevented rural non-HCWs from utilizing a well-equipped hospital built on an old cemetery. Similarly, dismissing the severity of COVID-19 as witchcraft led to widespread illness and death. P5 (H-KE) said that *"during the Corona time, many people lost their lives because they did not believe that this disease exists. Some say, ah, no, this disease is just witchcraft."*

Theme 1.3. Privacy and Data Concerns [ ] Contrary to findings from the US and Europe (e.g., [6, 12, 125]), some participants ***did not have privacy concerns*** regarding DCT, often citing a lack of negative past experiences with data breaches or misuse. A similar phenomenon has been reported in India [121]. P6 (R-KE) stated that *"I'm okay. Yeah, sharing information in the healthcare system. I don't think there's a problem there. We are willing to share."* Despite the overall lack of concern, some participants emphasized that ***privacy and security are essential*** for health data and highlighted the importance of maintaining anonymity in health-related data. This was once again stressed by P6 (R-KE): *"in a hospital environment, you have to be very strict about confidentiality. When a patient is known to have a pathology, and we know that this pathology is a serious one, that it could have a negative impact on the family ... if you don't control the people to whom the data is given, it would be really complicated."* ***Concerns about data management*** were also prevalent. Participants raised issues related to data leakage and breaches. P8 (R-KE) mentioned that *"one of the negative implications is that any information that is currently in the digital thing [that] can be circulated to anyone else, especially through the Bluetooth thing."*

Some participants expressed distrust in the government's ability to manage data responsibly and were cautious of existing data management practices in the health sector. Lastly, Many participants also shared their ***reservations about the reliability of DCT*** and that they would be comfortable participating in DCT if the device was reliable. They expressed hesitations due to past experiences with unreliable phone data, data deletion, unauthorized access, and concerns about data loss if their device stopped working. P17 (H-CI) indicated that *"in the public health sector, data is not really secure … nothing would be backed up. All the data would be lost."* These findings may indicate that participants prioritize the reliability of the DCT device over privacy concerns.

Theme 1 Summary: Participants expressed a preference for introducing wearable-based DCT gradually during non-pandemic periods rather than only during pandemics to improve public understanding and acceptance of the technology. They also shared several potential barriers to the adoption of DCT, including misconceptions and myths about DCT, concerns related to DCT reliability, and management of their data.

4.2 Theme 2. Cultural, Social, and Economic Influences on DCT Adoption

This theme focuses on how socio-cultural norms and stigma, economic accessibility and technological familiarity, and trust in technology and institutions play crucial roles in shaping the acceptance and use of DCT solutions in Africa.

Theme 2.1. Socio-Cultural Norms and Stigma [] Participants emphasized the significant challenge of ***social stigma*** in the context of pandemic health measures. They noted that infectious diseases often lead to stigmatization, causing affected individuals to be ostracized by their communities. This issue is particularly severe in rural areas of Africa, where social stigma can even be fatal. The act of taking health precautions, such as wearing a mask, can itself result in social stigma, making it difficult for individuals to follow health guidelines due to community pressure. Several participants recounted personal experiences of social stigma during their one-day trial of wearing WPP.[8] For instance, a participant (R-KE) described going back to the village with the wearable *"blinking around my waist, and people thought I had a bomb because it's unique."*[11] Participants also stressed the challenges of mutual acceptance and their ability to explain what they are wearing and why. A participant (R-KE) mentioned that when having the wearable, *"I really tried hiding it because I did not want to be asked a lot of questions by my son. But still, he saw it and was like, Mom, what is that? Wait, let me see. And at times, you might want not to talk so much to people. Because I'm imagining if my son was asking, then other people would be asking me on the road."*

Given the pervasive challenge of social stigma, most participants expressed a need for ***culturally sensitive*** wearables to help mitigate this issue. They offered suggestions to enhance the cultural acceptance of wearable-based DCT. They recommended designing wearables to resemble familiar objects and incorporating cultural or religious symbols to make them more acceptable within their communities. Participatory design participants (R-H-CI-KE) illustrated the value of ***aligning wearable designs with local cultural expressions***, such as incorporating designs resembling Shanga, a traditional jewelry popular among the Maasai and Kenyans (see Figure 5A–B). By making wearables resemble culturally significant items like bracelets or necklaces, designers can foster a sense of pride and ownership, significantly enhancing social acceptance. Thus, researchers and technology designers should collaborate closely with local artists and designers to create devices that symbolize cultural identity and pride among the target users.

Additionally, most participants preferred ***discreet wearables*** that could be hidden when necessary, suggesting that the devices should be indistinguishable and seamlessly integrated into their daily attire to avoid unnecessary attention. A participant (R-CI) mentioned they preferred a device they could *"wear somewhere that's less visible to other people, somewhere hidden, maybe like a pocket."* Another participant (R-CI) agreed *"that the device needs to be more discreet, cause I don't want others to be able to see it."* In the participatory design sessions, many participants (R-H-CI-KE) designed wearables that resemble everyday accessories to ensure comfort and privacy. They suggested wristbands with small screens, necklaces with pendant sensors, or even devices mimicking flash drives as examples of discreet design (see Figure 5C–E). This diversity showed that they chose to incorporate wearables into their personal style to balance visibility and discretion according to their comfort levels.

While participants from both Kenya and Côte d'Ivoire highlighted the challenges of social stigma and the need for discreet designs, solutions leveraging cultural identity—such as referencing Shanga as an inspiration for design—came primarily from Kenyan participants. The absence of comparable cultural adaptations among Ivorian participants may reflect differences in cultural practices or perceptions of technology. For instance, participants in Côte d'Ivoire may perceive cultural artifacts as less naturally aligned with technology.

Lastly, a participant (H-KE) highlighted the social acceptability of existing health tools, such as those used for managing diabetes [85], as successful examples of integrating health technologies without social stigma. This suggests that the designers of wearable-based DCT could learn from socially accepted health tools to enhance adoption.

Theme 2.2. Economic Accessibility and Technological Familiarity [] Socio-economic factors, particularly accessibility, influenced participants' preferences for using DCT technologies. When asked about their preference between using wearables and smartphones for DCT, many stated that their choice depends on ***accessibility***. For example, a participant (R-CI) mentioned that *"a lot of people in the village don't know anything about technology. They don't have smartphones. That can be a problem."* They noted that the availability of these devices (i.e., wearables and smartphones) in their region would determine which one they would use. Some mentioned that wearables and smartphones could complement each other and be used together. P5 (H-KE) stated, *"two [wearables and smartphones] can work hand in hand … maybe those who do not have the smartphones, then they can have the sensor."*[12] Participants highlighted ***the lack of smartphone access***, especially

[11] The WPS device contains a small LED light on its circuit board that blinks to indicate the device is active and functioning. Although this LED is enclosed within the plastic 3D-printed case, its light remains faintly visible. This blinking light serves solely as an operational indicator and is unrelated to any other feature, such as infection detection.

[12] In Singapore, the TraceTogether Token [25] was used similarly for older adults who lacked smartphones during COVID-19.

Figure 5: This figure presents examples of participatory design outcomes showcasing various wearable-based DCT concepts.

in rural areas, as a significant barrier and considered wearables a more practical solution. Conversely, those who preferred using smartphones for DCT mainly cited ***familiarity***, as they already knew how to use their smartphones. Unlike rural areas, in urban areas (and mainly in Kenya), smartphone access was not a major issue, making smartphone-based DCT more feasible.[13]

[13]In Kenya, higher smartphone penetration and more advanced IT infrastructure likely contributed to participants' familiarity and access, particularly in urban areas.

Theme 2.3. Trust in Technology and Institutions Participants' perceptions of trust can significantly influence their willingness to adopt DCT technologies. Most participants indicated ***trust in entities handling DCT and health data***. In particular, several mentioned trusting the government to introduce and govern new technologies. P6 (R-KE) said that *"the government has the control and the capacity to control and mitigate all the data collected. Because the government is widespread, it's a big thing, it's stable, and accountability is there."* They also found organizations vetted or monitored by the government to be more trustworthy and saw NGOs and health organizations as trusted allies.

Context-dependent trust was a recurring theme, closely tied to how privacy is handled in different contexts, which aligns with Nissenbaum's concept of contextual integrity [95]. Most participants noted that trust in DCT depended on various factors, including the data source, storage, and usage. They felt more comfortable with DCT when implemented in healthcare centers (e.g., within a hospital) than in public spaces. Regarding the source, trust levels varied based on the entity handling the data, with skepticism towards foreign entities and concerns about the inclusion of third parties. P4 (H-KE) said that their trust in the *"mobile app and the sensor depends on who the owner of this app is. Or it all depends on the company who is installing the app for us. Also, the sensor. Where is this data going? How is it going to be used for our benefit? So all can be bad, all can be good."* Participants also indicated they would trust DCT more if the technology had proven useful.

We also noticed ***variability in the trust***, where a few participants preferred using smartphones for DCT, a few others found smartphones more vulnerable in terms of security, and several expressed a preference for wearables *specifically designed for DCT*, considering them more transparent, reliable, and trustworthy compared to *multifunctional* smartphones. The specific function of a device, such as a wearable designed solely for contact tracing, was perceived to offer greater control and accountability.

Broader trust issues and serious concerns impacting DCT adoption also emerged. Past incidents of corruption, tech scams, and misuse of technology contributed to a general distrust of tech-based health initiatives. In Kenya particularly, several participants mentioned previous incidents with an app called World Coin, with P6 (R-KE) mentioning that *"the other day, we heard about the World Coin. It was an app, and people were being … scammed."*

Theme 2 Summary: Participants highlighted social stigma and lack of access to technology, especially in rural areas, and discussed their influence on DCT adoption. Additionally, they shared ideas for designing culturally sensitive and discreet wearables, making them more likely to be adopted by users.

4.3 Theme 3. User-Centered Design Priorities for Wearable-based DCT

Participants had several expectations for wearable-based DCT devices, including interaction design and usability expectations. We discuss these below.

Theme 3.1. Interaction Design and Usability Regarding the ***form***, many participants preferred portable DCT devices, which are attachable to the body, small, lightweight, seamless, and easy to wear. To enhance social acceptability, they designed wearables (R-H-CI-KE) as accessories, such as watches, bracelets, necklaces, rings, belts, shirt pins, and even earbuds (see Figure 5F). Participants also stressed that wearable-based DCT devices should not interrupt daily chores or professional duties (e.g., by interfering with HCWs' professional attire) and should integrate smoothly into their daily lives. For instance, a participant (H-KE) said, *"as women, we run a lot of errands, and some of them include bending and standing up. So, like yesterday, I needed to wash dishes, but I was a bit afraid that it [WPP] could even fall inside water. So, as such, I would like something that is pinned, something that cannot, you know, drop when you're busy running your errands."* During the participatory design, participants suggested a preference for hands-free options like necklaces (R-CI).

Several participants expressed the need for ***interaction and control***. During the participatory design, they discussed the inclusion of simple controls, such as buttons for toggling the device on or off (R-H-CI-KE). Such a feature can empower users with greater control over their privacy and the device's operation. Participants also suggested designing an *optional to-use* companion app for users who can afford smartphones (H-KE).

Feedback was a critical feature. Participants expected the device to provide accessible and usable exposure notifications. About the ***feedback modality***, they suggested using lights, screens, audio, and (or) vibration to provide feedback on the device's status and proximity alerts (R-H-CI-KE). They also preferred receiving notifications via the wearable, the companion app, or SMS. Given the importance of discreet design (see Theme 2.1), several participants were concerned that exposure notifications could be creepy and traumatizing and preferred discreet, careful, and anxiety-free notifications. They also suggested that notification designs should be privacy-sensitive, specifying the danger but not the dangerous person. For example, they preferred vibration to minimize public awareness of an alert (H-KE).

About the ***feedback content***, participants mentioned that effective feedback mechanisms are essential for informing them about their proximity to potential health risks and enabling them to take measures (H-KE). Some participants emphasized the need for specific instructions rather than generic advice. However, others suggested that the former might cause fear and the latter would be better. Participants further mentioned that the system should enable feedback and impact measurement, informing users about the benefits of wearing the device and the status of disease spread in their region. Thus, the device should be responsive and provide necessary feedback to make users perceive its value.

Lastly, some participants (H-R-CI) suggested an innovative method for ***on-time notifications*** to encourage *proactive* social distancing measures rather than *reactive* ones. They prefer to be informed about contaminated areas (i.e., areas with higher report rates) to avoid them rather than receiving messages to quarantine themselves after exposure. This suggestion points toward a forward-thinking approach to DCT design. Future research needs to explore proactive health recommendations in the context of DCT.

However, when implementing such features, the designers and developers must carefully consider socio-technical aspects, such as social acceptance, ethics, and privacy.

Theme 3.2. Durable and Environment Adaptable Wearables [ ] Participants highlighted the necessity for wearables to ***stand against the harsh environmental conditions*** the community members usually face. They mentioned that they usually face heavy rain, intense sunlight, and the physical demands of daily chores and activities in rural areas. Therefore, they required devices to be waterproof, dustproof, and shockproof (R-CI-KE). Many also mentioned ***the lack of reliable electricity access*** in rural locations and highlighted the critical need to equip wearables with durable batteries and use solar power banks (R-CI-KE). Designers and developers should explore adaptable and innovative energy solutions for wearable-based DCT. This is supported by a previous study on solar charging practices in rural Africa [15], which emphasizes community-based solutions to overcome energy constraints. Additionally, participants highlighted significant challenges related to ***limited connectivity*** in rural locations. For example, P6 (R-KE) explained, *"I have a 4G network. Yes, but you see, in most places, it's not connected. So, that's the main problem."* Section 5.4 further discusses potential solutions for connectivity challenges.

Participants further emphasized the need for wearables to be ***easily maintainable and software upgradeable*** (H-KE). They suggested that local personnel should be able to perform maintenance. In the future, before deploying such devices on a large scale, authorities should plan to develop comprehensive training programs for local personnel to equip them with the necessary skills to maintain and repair wearables to encourage self-sufficiency and resilience within the community. Additionally, developers should equip the wearables with updatable software. Such flexibility can ensure that the devices can evolve and adapt to new health challenges, quickly adapting them to be usable for different infectious diseases. This is also in line with several participants' suggestions, who mentioned the device should trace multiple diseases *simultaneously* when there is more than one outbreak in the region.

Theme 3 Summary: Many participants preferred DCT devices that are portable, easy to wear and do not interfere with their daily routines. Participants also highlighted the need for these devices to be interactive and provide notifications. They also mentioned the need for DCT devices to be durable and have long-lasting batteries to overcome electricity challenges that remain prevalent in their local communities.

4.4 Theme 4. Policy-Level Strategies to Improve DCT Adoption

This theme highlights various high-level plans and actions to influence the adoption of DCT, including potential incentives and strategies to increase awareness.

Theme 4.1. Raising Awareness and Education [ ] To improve the adoption of DCT, participants overwhelmingly described the importance of ***awareness, sensitization, and education*** about contact tracing. Often, participants mentioned that people would be hesitant to participate in DCT if they had limited information about it. P5 (H-KE) stated that about *"contact tracing and disease management, what we lack with our people is health education. We really need to do a lot of health education and sensitization continuously for our people."* Similarly, another participant (H-CI) said, *"if there's a lack of information about the device's usefulness, if they don't know what it's for, if they're not sufficiently aware of it, they may have a setback."* Further, participants mentioned the need to educate people on how to properly use DCT. P3 (H-KE) mentioned that for *"the sensors, we need to also make people understand that it's important to have it on throughout. Yeah. If we don't explain this, I think most people will just put it down and, you know, can even leave it at home, thinking that you could still work and come back in the evening."* Participants also mentioned they would be comfortable using DCT once they have seen its benefits, have more knowledge about DCT, or do not encounter any negative effects after using DCT. P10 (R-KE) stated that they would *"be comfortable with it [DCT] because, for example, these ones that we had yesterday [WPP], they have caused no harm. So with me, I've gained trust that they are safe enough to be carried."* Participants discussed several strategies that can be used to increase awareness. For example, a participant (R-CI) said, *"I think that with all the means that are needed, through the media, body-to-body awareness, all of that can allow the population to participate."* P9 (R-KE) pointed to the need for the government to take a lead on this: *"the information, it's good to receive from the government, then you pass it to the community."* Some participants also mentioned how the younger generation plays an important role in helping older adults with technology and potentially DCT (i.e., similar to intergenerational practices studied in other contexts [118]). P13 (R-CI) said, *"even if I don't know what it is. I've got my son, who can read too, who can see things too. Maybe I'll give it to my son. Here's what they said on my mobile … You can look and tell me."*

Participants also discussed how ***government transparency*** can increase trust and engagement to improve adoption. P16 (H-CI) indicated that they are opposed to policy or solutions that trickle down from the top without any engagement of the community: *"We shouldn't be able to impose all our dictates on them … without taking into account what they consider as value … We also need to involve the people we're working with … to take into account their feelings and their perception of everything we do."* They also highlighted ***community engagement***, with many emphasizing the importance of community health workers and volunteers in health campaigns, including contact-tracing efforts. These individuals are seen as *crucial intermediaries* and *effective messengers* in educating the community and facilitating the adoption of health initiatives. Their *familiarity* with local regions and the *trust* they have built within their communities were highlighted as key factors. Participants noted that community members were more likely to trust and follow the guidance of these local health workers than directives from less familiar entities. P2 (H-KE) said that people would *"agree to someone who speaks their language. So when you go there, they see you, hey, you are one of them, and you wear like them."* Some participants also identified religious leaders as key figures in driving awareness campaigns and suggested outreach efforts (e.g., visiting churches, mosques, and schools) to ensure broad community reach.

Theme 4.2. Monetary Incentives and Affordability [] We asked participants if ***monetary incentives*** would encourage them to participate in DCT, with many responding affirmatively. A participant (R-CI) stated that *"the government giving money to everybody will be something that would encourage me to do it."* However, many participants mentioned that they were still willing to participate without money as they understood the benefits of DCT. P15 (H-CI) said, *"first and foremost, it's about striving for good health. So, if it [DCT] can help some people, that's good. It's not necessarily the financial aspect that's important. It's to reduce the risk of contamination."* P15 further added: *"If it's for the well-being of others, I can participate. Not necessarily for money."*

Beyond financial incentives, participants also highlighted the need for DCT to ***be affordable to the target users***. For example, a participant (H-KE) indicated that an obstacle to using DCT is that *"because it is a new thing, it will be expensive. Not all [healthcare] facilities will be able to acquire the device."* Thus, several participants suggested that DCT should be cheap or mentioned the need for government support to make DCT even more affordable (i.e., providing it for free or subsidized costs). A participant (H-CI) said, *"for the purchase of the device, I think that if we have to buy it, people should study the cost, so that according to the poverty line of the population, people can . . . Because in Africa, there are large families. The man and his wife live with their brothers and cousins, and twenty or fifteen of them are in a big house. So, if they can't pay for each one, there's no point in paying for two, and then the rest will stay. . . . if the state has sufficient means to offer it [for free], that would be best."* To make DCT affordable, some participants (H-CI-KE) mentioned that foreign financial aid could go a long way in supporting DCT initiatives. However, we note that foreign aid might not be sustainable [73] and instead advocate for the design of affordable DCT solutions that can quickly be leveraged in the case of an outbreak.

Lastly, participants (H-CI-KE) also suggested prioritizing ***equitable access for vulnerable populations***, indicating that African governments would need to develop *transparent* and *fair* criteria for distribution to ensure that support effectively reaches those with urgent needs.

Theme 4.3. Balancing Government Mandates and Educational Approaches [] When probed, many participants detailed how government mandates can be useful in encouraging them to adopt DCT. P4 (H-KE) said that government mandates would *"encourage because, you know, like even the era of COVID, it was the government who was giving directions about COVID . . . So if the government says that you have to have this to save your life, I think that one will encourage you to go because everyone wants to avoid disease."* However, participants also discussed how ***power imbalances*** would compel them to participate. P15 (H-CI) stated that *"we're going to do it because our employer decides . . . he's the one who employs us. He decides what we do."*

However, some participants expressed a preference for education and awareness about DCT and its benefits over mandates, with some participants expressing ***strong opposition to mandates***. For example, P5 (H-KE) described, *"some policies [in Kenya] are even passed without citizen participation, some policies are passed even by the national parliament, and they say any law passed by the national parliament supersedes all other laws, so then it means you have to participate whether you like it or not. So if it becomes a policy, then people have no option to participate, but I wish it could be done in a proper way, involving them, sensitizing them, making them participate in the process so that when it comes to the implementation part, it can be easier."* This was also echoed by P3 (H-KE) who argued that *"if it [DCT] is done under coercion, I don't think it's the right thing to do. Any change will always come with some resistance unless you first make people understand and let them participate voluntarily without really forcing it."* We agree that prioritizing user education and awareness about DCT rather than mandates is likely to have a better impact on DCT adoption.

Theme 4 Summary: To further boost the adoption of DCT in Kenya and Côte d'Ivoire, most participants pointed to the need for more awareness and education about the need and benefits of DCT. Local community health workers and volunteers were perceived as crucial intermediaries in contact-tracing efforts. While monetary incentives and government mandates can also encourage adoption, most participants felt that awareness and sensitization about DCT and its benefits would have more impact in encouraging its adoption.

5 DISCUSSION

Our study highlights the necessity of designing for Africa by considering the specific realities and contexts of the region rather than relying solely on knowledge from Western countries. Africa presents unique challenges and opportunities that differ significantly from Western contexts. Factors such as large family structures, cultural nuances, varying levels of technology access, and infrastructure limitations must be central to the design process. While most existing studies explore DCT perceptions *post-deployment*, our *proactive* approach involves qualitative and participatory methods to collect user insights about wearable-based DCT.

Although our findings were broadly consistent across Kenya and Côte d'Ivoire, we identified a few nuanced differences, such as the prevalence of misconceptions about DCT in Côte d'Ivoire and culturally specific design solutions like Shanga-inspired wearables in Kenya. These differences indicate the influence of local contexts and highlight the importance of tailoring DCT solutions to cultural and social nuances. Next, we discuss the key themes we observed, followed by lessons learned from our fieldwork and recommendations for future research.

5.1 Navigating Discreetness and Visibility: Culturally Sensitive Designs for Adoption

One central theme of our study is the socio-cultural stigma. Stigmatization in Africa has been identified in earlier studies related to MCT during the Ebola outbreak [44, 99]; however, it was tied to the fear of infection, not the use of technology. Our study highlighted the need for socially acceptable and discreet wearable designs. Indeed, social acceptability in HCI is a well-studied topic [68]. Design strategies such as subtlety (e.g., [108]), unobtrusiveness (e.g., [110]), avoiding negative attention (e.g., [97]), accessory-like shapes (e.g., [113]), and familiar styles (e.g., [96]) have been discussed by earlier studies—but not specifically for DCT. Such strategies should be explored further and implemented specifically for wearable-based DCT. Further, to ensure that the designs are socially acceptable not only to users but also to bystanders, future attempts should involve local artists, designers, and community members in the design process.

While designing discreet wearable-based DCT may initially seem like the ultimate solution to avoid social stigma, it is important to recognize that the effectiveness of DCT relies on widespread adoption [17]. Community-wide participation might require open encouragement and support from peers, potentially suggesting a need for more visible wearables (a.k.a "candid" forms [37]). However, this raises a critical question: *Should wearables be designed to be visible to encourage adoption, or should they be discreet to respect user preferences for discreetness and reduce stigma?* Participants suggested that culturally sensitive designs, such as wearables resembling traditional jewelry, offer a promising middle ground. Such designs maintain discretion while allowing the technology to be visible in a socially acceptable way. This suggests that discreetness might be an ongoing design strategy that can adapt and evolve to fit different cultural and social contexts.

5.2 Awareness and Leveraging Community Trust: Strategies for DCT Success

Our findings shed light on the crucial role of policy-level strategies in successfully deploying wearable-based DCT. One of the most recurring findings was the public's lack of awareness about DCT and its benefits. This poses a significant barrier to the adoption of DCT, as it can be exacerbated by existing misconceptions, misunderstandings, myths, and misinformation. Additionally, we found that religious and spiritual beliefs can influence technology adoption, further complicating efforts to implement DCT effectively. Participants emphasized the importance of raising awareness and educating the public. Education campaigns should convey the benefits of DCT and correct any misconceptions, with the involvement of trusted community figures, who people are more likely to trust. This approach is consistent with the principles of health promotion [8], which emphasize empowering communities through education and active participation, and aligns with research advocating for citizen science approaches to pandemic preparedness [128], where building trust through community involvement is critical.

Many participants preferred education over mandates or financial incentives, believing that an informed population would be more likely to adopt DCT voluntarily. This aligns with the concept of social acceptability [68], where acceptance of technology is enhanced by positive changes to the user's self-image and external image, facilitated through understanding and informed consent.

To implement these strategies effectively, comprehensive education campaigns leveraging trusted community figures are crucial. These campaigns should be tailored to address the specific misconceptions and beliefs prevalent in the community. Given the varying levels of smartphone accessibility in urban versus rural areas, a hybrid approach utilizing both smartphones and wearables seems advantageous for Africa. In urban areas, such as the hospital in Kenya, where smartphone accessibility is higher, smartphone apps can be utilized. However, in rural areas, where accessibility is limited, wearables should be provided. This hybrid approach ensures that both urban and rural populations are adequately covered. Lastly, such wearables should be funded by the government to ensure equitable access for low-income populations, similar to the equitable access initiatives for COVID-19 vaccines in LMICs [105]. However, implementing such systems, as seen in Singapore's deployment of TraceTogether, may also involve significant costs and logistical challenges that must be carefully considered [126].

5.3 Leveraging Low Privacy Concerns and Addressing Risks for DCT Adoption

Our study observed a notable difference in privacy concerns between previous findings from the WEIRD countries and our findings from Kenya and Côte d'Ivoire. In the West, privacy is a significant issue, even with secure and private DCT systems such as DP-3T [132, 133], where users still have concerns and misconceptions (e.g., [6, 62, 100, 125]). However, similar to India [121], our findings in Africa are different as many participants did not express privacy concerns. While the lack of privacy concerns per se is not inherently positive, it may facilitate the adoption of DCT technologies. Our participants were generally less concerned about privacy and more focused on other perceived risks, such as potential side effects of the technology. This difference in priorities means that privacy, a major barrier in the West, may not impede DCT adoption in African contexts. Instead, participants emphasized that raising awareness about the actual benefits and safety of DCT could address their concerns. Thus, targeted awareness campaigns should be tailored to enhance the public's mental models regarding the safety and efficacy of DCT. Focusing on educating the public about the safety and efficacy of these technologies and ensuring transparency in their implementation can enhance public trust and encourage broader adoption.

5.4 Enabling DCT Adoption in Rural Areas: Overcoming Connectivity Challenges

During the pilot study,[8] we used WPP entirely offline, manually extracting the data logged by the device. Nevertheless, participants raised concerns about technological accessibility, particularly the lack of reliable cellular connectivity in rural areas, identifying it as a potential hindrance to deploying DCT technologies. This reflects participants' forward-looking perspectives on barriers that may arise as the system scales beyond the prototype stage. However, participants did not propose solutions, likely due to their limited familiarity with technical infrastructure and potential alternatives.

Addressing the connectivity challenge is crucial to ensuring the feasibility of wearable-based DCT, particularly in rural African contexts. For small-scale DCT deployments (e.g., within a rural village or healthcare facility), it would be possible to resort to offline data collection, like in our study. The data could be stored locally on the wearable and periodically retrieved by a technician for analysis. An alternative would be to establish a local area network or leverage an existing one (e.g., in a hospital) by setting up a few interconnected access points that would cover the area of the intervention. For large-scale deployments (e.g., spanning several rural villages), a promising direction is leveraging low-power, long-range communication technologies, such as LoRa (Long Range) [10], which enables devices to transmit data over long distances (up to 16 kilometers in rural areas), connecting to decentralized gateways that forward data to a central server. Its successful applications in other rural IoT [22, 50] and health IoT systems [32, 109] make LoRa a particularly viable option for DCT in rural areas. Relying on network connections would also facilitate receiving infectious keys or alerts needed to locally generate exposure notifications in decentralized DCT systems, such as those using the DP-3T protocol [132, 133]. This would allow wearables to complete the DCT protocol without direct reliance on cellular networks.

5.5 Lessons Learned and Recommendations for Future Research

Conducting field research in African contexts provides valuable insights but also presents unique challenges that researchers should be prepared for. Here, we discuss some lessons we learned throughout this work.

5.5.1 Leveraging Local Intermediaries: Trust is pivotal in field research and participatory design. Local intermediaries, such as NGOs, can bridge the gap between non-native researchers and the community. In our field experience, local SPOC members' effective facilitation and crisis management were crucial in building trust and resolving challenges. Future researchers should prioritize establishing these relationships early. Finding the right local partners can be challenging. Researchers should systematically approach this by leveraging existing networks and reaching out to local organizations as we describe more in Supplementary 1.

5.5.2 Enhancing Consent Collection: Despite using standard consent forms and comprehensive information sheets, we found that participants often needed additional explanations to fully understand the study. Verbal consent and thorough verbal explanations should complement written consent to ensure comprehension [139]. This approach requires the research team to allocate more time for the consent collection process in their schedule.

5.5.3 Navigating Participant Recruitment: Field conditions can influence recruitment processes. Participant selection by local authorities might lead to a biased sample. Contrastingly, random selection can minimize such biases. Vigilance and flexibility in recruitment are thus key to obtaining a representative sample and mitigating power influences.

5.5.4 Overcoming Logistical Challenges: Finding suitable locations for interviews and group activities in rural areas may pose numerous challenges. In particular, noise and a lack of privacy can compromise data quality and ethics. Researchers should work with local contacts to secure appropriate spaces and be prepared to adapt to available infrastructure.

5.5.5 Avoiding Helicopter Research: Ethical engagement with local communities is critical in research. A participant noted that foreign researchers often collect technology they test, leaving no benefits to the community (H-KE). This sentiment resonates with the concept of "helicopter research," where researchers from high-income countries conduct studies in LMICs with minimal local involvement and little long-term benefit [35]. To mitigate this, we conducted follow-up in-person meetings, four months after our field data collection, where we shared the results and discussed future directions with the participants and community members. Moreover, our paper included local co-authors from Kenyan and Ivorian institutions, promoting meaningful collaboration and authorship inclusion [2]. We encourage other researchers to strive to provide tangible benefits and involve local stakeholders throughout the research process to foster trust and sustainable practices.

6 CONCLUSION

DCT has predominantly been designed, developed, and evaluated with WEIRD populations in mind, often overlooking the unique challenges and needs of other regions. This study addresses this gap by exploring the perceptions and requirements for DCT in Kenya and Côte d'Ivoire, with a particular focus on wearable technologies as a viable solution for Africa. Our findings highlight the critical importance of culturally sensitive designs, such as wearables resembling traditional jewelry, and emphasize the need to focus on reliability over privacy concerns, which are more prominent in Western contexts. These insights contribute to a more inclusive approach to digital health interventions, ensuring they are not only effective but also culturally and contextually appropriate. Our research was conducted with the broader goal of enhancing DCT technologies for *any* potential pandemics or infectious disease outbreaks, extending the lessons learned beyond the COVID-19 pandemic. The ongoing threat of emerging diseases, alongside the prevalence of regional epidemics in Africa (e.g., Ebola or Tuberculosis), emphasizes the need for adaptable DCT systems that can address both current and future public health challenges. As we look forward, further research should validate our recommendations in real-world settings and other LMIC regions, moving us closer to a future where DCT is a truly global solution that can adapt to diverse needs.

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A DETAILED DEMOGRAPHICS

Table 2: Demographics of interview participants

	Kenya				Côte d'Ivoire				Total	
	HCWs		Rural non-HCWs		HCWs		Rural non-HCWs			
	n	%	n	%	n	%	n	%	n	%
Gender										
Woman	3	15.8%	3	15.8%	2	10.5%	2	10.5%	10	52.6%
Man	2	10.5%	2	10.5%	3	15.8%	2	10.5%	9	47.4%
Non-binary / Prefer not to disclose	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Age										
18-25	0	0.0%	1	5.3%	0	0.0%	0	0.0%	1	5.3%
26-35	0	0.0%	3	15.8%	1	5.3%	0	0.0%	4	21.1%
36-45	3	15.8%	1	5.3%	2	10.5%	1	5.3%	7	36.8%
46-55	2	10.5%	0	0%	2	10.5%	0	0%	4	21.1%
56-65	0	0.0%	0	0.0%	0	0.0%	3	15.8%	3	15.8%
Employment										
Employed	5	26.3%	3	15.8%	5	26.3%	3	15.8%	16	84.2%
Homemaker	0	0.0%	1	5.3%	0	0.0%	0	0.0%	1	5.3%
Not Employed	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Student	0	0.0%	1	5.3%	0	0.0%	0	0.0%	1	5.3%
Retired	0	0.0%	0	0.0%	0	0.0%	1	5.3%	1	5.3%
Education										
No formal education (Not educated)	0	0.0%	0	0.0%	0	0.0%	2	10.5%	2	10.5%
Primary school (elementary school)	1	5.3%	0	0.0%	0	0.0%	1	5.3%	2	10.5%
Middle or High school (junior or senior high school)	1	5.3%	4	21.1%	1	5.3%	1	5.3%	7	36.8%
Trade/technical/vocational training	0	0.0%	1	5.3%	0	0.0%	0	0.0%	1	5.3%
Associate's degree (college graduate)	0	0.0%	0	0.0%	1	5.3%	0	0.0%	1	5.3%
Bachelor's degree (undergraduate)	3	15.8%	0	0.0%	1	5.3%	0	0.0%	4	21.1%
Master's degree (postgraduate)	0	0.0%	0	0.0%	2	10.5%	0	0.0%	2	10.5%
Doctorate/Ph.D. (postgraduate)	0	0.0%	0	0.0%	0	0.0%	0	0	0	0.0%
Prefer not to answer	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Total	5	26.3%	5	26.3%	5	26.3%	4	21.1%	19	100%

Table 3: Demographics of focus group and participatory design participants

	Kenya				Côte d'Ivoire				Total	
	HCWs		Rural non-HCWs		HCWs		Rural non-HCWs			
	n	%	n	%	n	%	n	%	n	%
Gender										
Woman	12	16.7%	10	13.9%	8	11.1%	11	15.3%	41	56.9%
Man	6	8.3%	8	11.1%	8	11.1%	9	12.5%	31	43.1%
Non-binary / Prefer not to disclose	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Age										
18-25	2	2.8%	3	4.2%	0	0.0%	0	0.0%	5	6.9%
26-35	6	8.3%	9	12.5%	1	1.4%	2	2.8%	18	25.0%
36-45	7	9.7%	2	2.8%	11	15.3%	3	4.2%	23	31.9%
46-55	1	1.4%	3	4.2%	4	5.6%	6	8.3%	14	19.4%
56-65	2	2.8%	1	1.4%	0	0.0%	9	12.5%	12	16.7%
Employment										
Employed	16	22.2%	7	9.7%	16	22.2%	11	15.3%	50	69.4 %
Homemaker	0	0.0%	7	9.7%	0	0.0%	7	9.7%	14	19.4%
Not Employed	0	0.0%	4	5.6%	0	0.0%	1	1.4%	5	6.9%
Student	2	2.8%	0	0.0%	0	0.0%	0	0.0%	2	2.8%
Retired	0	0.0%	0	0.0%	0	0.0%	1	1.4%	1	1.4%
Education										
No formal education (Not educated)	0	0.0%	2	2.8%	0	0.0%	3	4.2%	5	6.9%
Primary school (elementary school)	0	0.0%	3	4.2%	0	0.0%	8	11.1%	11	15.3%
Middle or High school (junior or senior high school)	1	1.4%	0	0.0%	5	6.9%	6	8.3%	12	16.7%
Trade/technical/vocational training	2	2.8%	1	1.4%	6	8.3%	1	1.4%	10	13.9%
Associate's degree (college graduate)	7	9.7%	5	6.9%	1	1.4%	1	1.4%	14	19.4%
Bachelor's degree (undergraduate)	7	9.7%	7	9.7%	2	2.8%	1	1.4%	17	23.6%
Master's degree (postgraduate)	0	0.0%	0	0.0%	2	2.8%	0	0.0%	2	2.8%
Doctorate/Ph.D. (postgraduate)	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Prefer not to answer	1	1.4%	0	0.0%	0	0.0%	0	0.0%	1	1.4%
Total	18	25%	18	25%	16	22.2%	20	27.8%	72	100%