Deploying Usability Research Within Low-to-Middle-Income Countries

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SUMMARY

This paper explores the human factors (HF) and usability research conducted during the early-stage development of a novel respiratory device designed to prevent the spread of respiratory viruses in a pandemic scenario. It highlights the application of methods within the disciplines of human factors, user-centred design (UCD) and ethnography in low-and middle-income countries (LMIC) to ensure the device design meets the diverse needs of a global population. The paper highlights the importance of an inclusive, adaptable approach to design and iterative testing to ensure effectiveness and accessibility across varied environments.

KEYWORDS

Human factors, user-centred design, ethnography, low-and-middle-income countries, global health, nasal respiratory device, COVID-19, inclusive design.

Introduction

In recent decades, the world has witnessed the emergence of several viral pandemics with devastating consequences on public health, economies, and societies, ranging from Human Immunodeficiency Virus (HIV) in 1981, to the H1N1 Influenza A Virus in 2009, the Ebola virus outbreak in 2013, and the most recent Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in 2019 (WHO, 2022).

Whilst the characteristics of future viral infections cannot be known with certainty, the extensive investigations into the COVID-19 impacts provide a wealth of data with which we can seek to better prepare humanity for further pandemics. A snapshot of COVID-19 vaccination coverage revealed significant health inequalities between low and high-income countries (E. Mathiew et al.). Equitable global access to healthcare technologies is essential in controlling future pandemics.

The present usability work defined key requirements of a device suitable for the inhaled delivery of antiviral or prophylactic drugs to fight future pandemics.

A crucial differentiator in the development of such a device is the targeting of users in developing countries as well as developed, where limited financial resources and cultural differences make a high ease of use paramount.

Methodology

Human factors (HF) is the discipline that focuses on understanding the capabilities and limitations of human abilities and the application to such knowledge to the design of human-machine systems (Lewis, 2010). Within medical device design, HF involves a comprehensive understanding of the intended users, the use environment and the device user interface in the context of use, with the purpose of optimising the user interface to minimise use problems while ensuring a safe and effective use (FDA, 2016).

This is particularly complex when designing for a global population, which requires a broad perspective as the vast diversity in user characteristics and contexts of use must be considered to design a device suitable to use across the world. This wider scope requires the application of a novel approach, one that enables the application of methods to both capture real-world use behaviours and assess the usability of the designed solutions, enabling the rapid integration of knowledge into cyclical design iterations. To do this, we adopted a hybrid approach incorporating (1) user-centred design (UCD) and ethnography to capture real-life interactions with (2) HF methods to evaluate the user interactions with the device design. By leveraging the unique advantages of each field, integrating two approaches resulted in a robust methodology tailored to the design brief.

At Crux, our unique integration of design, engineering, and human factors expertise enables us to implement innovative approaches effectively, all within a single organization. Our multidisciplinary nature enables us to rapidly iterate and integrate user feedback to refine and optimise device designs. This flexibility allows us to tailor our approach to meet the specific project needs.

A summary of the methods deployed within this project are described below:

User-centred design (UCD). An iterative design process that prioritises the user needs, preferences, and limitations of end users throughout the design and development process to create highly usable and accessible products tailored to the end users' requirements (Interaction Design Foundation, 2016). UCD methods were deployed to understand global user needs, inform rapid iterative design cycles and guide the development or early-stage concepts through four phases: research, requirements, design and evaluation.

Ethnography. This qualitative research method was used to observe the behaviours and social dynamics of users in their natural environment (Lewis, 2010), exploring the influence of culture and social context on the adoption of a future respiratory device.

Human Factors. HF activities complemented the UCD broader approach, focusing on the study and evaluation of participant's interactions with the device's user interface, identifying potential use errors and informing the design optimisation. At this early stage, HF-specific activities conducted included a Task Analysis and the deployment of usability methods during user studies.

Throughout the four phases of the UCD approach, various activities were implemented, with user feedback continuously incorporated to inform design decisions and guide refinements across each of the following phases:

- *Research.* Primary and secondary research was conducted to investigate the key requirements of a device suitable for global use. Alongside usability work, investigations were deployed in the fields of life science (investigating the respiratory tract patterns), device design (investigating the effect of design choices in usability) and technology (uncovering development trends and novel technologies), (Quigg et al., 2022).
- *Requirements.* The research informed several technical, design and usability requirements intended to define the device operation as well as the user interactions with the device.
- *Design.* Usability and technical requirements informed the design of five early-stage device concepts. These were planned to be polarising to determine the suitability of different design features during the evaluation phase.
- *Evaluation.* Semi-functional prototypes were assessed by potential patients and healthcare professionals in real-use environments. Although label design was not in the scope of this phase of work, quick-reference guides (QRG) were provided to guide first-time use. Participants simulated use of the devices and provided subjective feedback and preference between the concepts and individual features.

As part of the research and evaluation phases, two user studies were conducted in Colombia (HFS001) and India (HFS002), nations chosen for their diverse healthcare systems, infrastructure, residential conditions, and cultural and geographical landscapes, each within a single nation. The sessions aimed to understand the use environment, current healthcare practices, user needs and insights surrounding the recent response to the COVID-19 pandemic, and the suitability of polarising prototype designs to support correct use in such environments.

The studies took the form of 60-minute, one-to-one semi-structured interviews, conducted in a variety of urban and rural locations within the participants' communities, including community centres and local healthcare facilities. Additional to these sessions, the study team conducted ethnographic observations to capture the real-use environments where the future respiratory device may be used. These included homes and workplaces.

Figure 1: User studies conducted in the rural areas of La Guajira, Colombia

The study recruited speakers of several languages, such as English, Spanish, Wayuunnaiki, Hindi and Bengali. Sessions were held in English or Spanish. If the participant was not able to communicate in either of these languages, an interpreter supported the translation of the interviews in real-time, facilitating communication between the moderator and participants. To ensure consistency, the Study Guide was available in English, Spanish, Hindi and Bengali and provided to the interpreter when needed. As the Study Guide was not available in Wayuunnaiki, the sessions were conducted in Spanish with the assistance of an interpreter.

A total of 34 interviews with urban and rural participants were conducted across the two studies, 18 in Colombia (13 potential end users, and 5 healthcare professionals) and 16 in India (8 potential end users, 6 healthcare professionals and 2 health facility administrators).

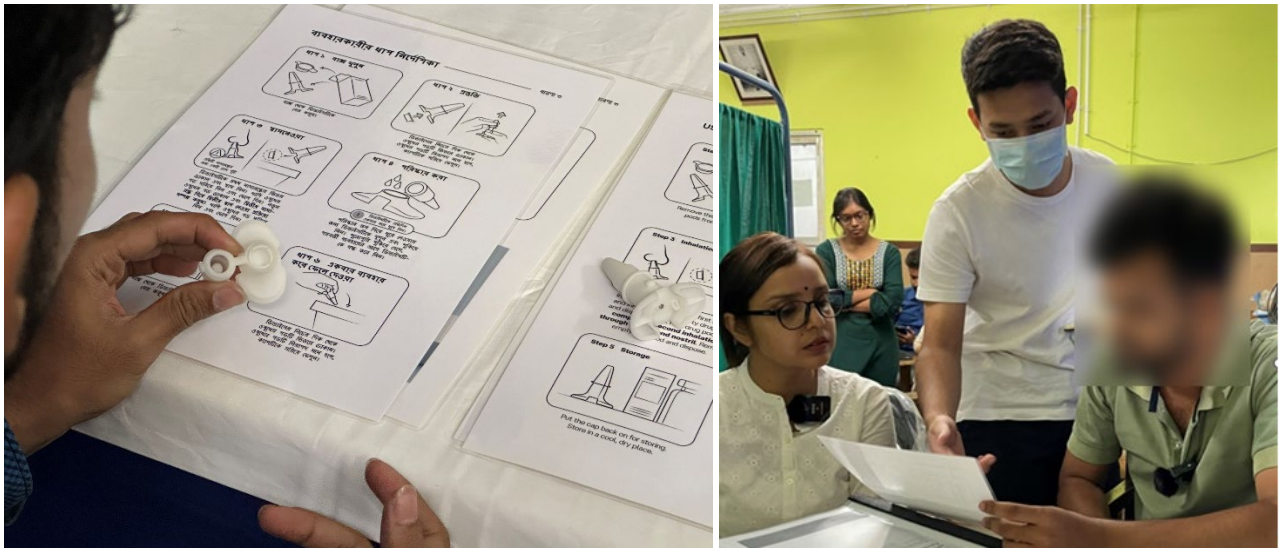

Figure 2: The study materials for HFS002 were translated in multiple languages

Main results

The first study in Colombia identified key challenges faced by both rural and urban users in accessing healthcare technologies and services. These key areas of opportunity informed the development of five polarising respiratory device prototypes, which were then assessed by users in the second usability study in India. The results from these studies were key in identifying factors that may promote correct device use in LMIC environments.

Environment: Facilities and storage

Interviews conducted in Colombia and India highlighted how families struggle to meet their basic needs, with limited access to clean water, refrigeration, and sanitation infrastructure, posing a significant barrier to proper device use. This includes in maintaining a controlled temperature, sanitising reusable devices between uses and disposing of them appropriately.

Furthermore, observation of the rural homes of the Indigenous Wayuu community (La Guajira, Colombia), constructed from basic materials like adobe and wood, evidenced the limited protection they offer from harsh environmental conditions. This underscores the need for devices that can withstand such climates, even when stored indoors.

Figure 3: Community kitchen within the Wayuu community, where a future device may be sanitised or stored

Cultural Acceptance: Engagement and suitability

The research evidenced how cultural and community dynamics could pose challenges to the adoption of a novel respiratory device. For example, the matriarchal culture of the Wayuu, with its strong adherence to customs and language, presents an additional barrier to embracing new health technologies, as the community tends to prioritise traditional medicine over Western treatments.

Furthermore, the study uncovered how negative perceptions surrounding the COVID-19 pandemic resulted in stigmatisation within communities. In Colombia, this was evidenced by the stigma faced by healthcare professionals during the vaccination campaigns. Whilst in India, these negative perceptions were evidenced by sick individuals who were rejected by their neighbours and often asked to leave their homes due to fear of disease transmission.

This underscores the importance of designing with thorough understanding of cultural behaviours, prioritising the design of an intuitive, easy-to-use device that minimises the need for assistance from healthcare professionals, and equally important, incorporates community-led strategies to address the community concerns and foster adoption.

Correct Use: Reduced instructional burden

During the prototype assessment in India, intuitive use emerged as a key factor contributing to correct device use. The findings revealed that single-use devices were perceived as more intuitive, as they required fewer steps for operation. Moreover, visual and/or auditory feedback was identified as a key design element, effectively communicating the device's status (e.g., ready to use or end of dose) and guiding users toward correct use.

Across all participants, challenges with reading and comprehending instructions were noted, stressing the importance of intuitive design to reduce cognitive load. Prototypes that featured a familiar form factor were perceived as easier to use, potentially minimising the need for instructions and assistance. This highlights the value of designing devices that align with user expectations and promote seamless, independent use.

Convenience of use: Driving user preference

The research uncovered that convenience was a key factor influencing device preference and adoption. The Wayuu community, for example, often travel long distances to access healthcare services, such as collecting prescriptions or attending appointments. In India, muslin-weaving workers provided invaluable insight into the work practices, highlighting how their busy routines – characterised by long commutes and limited storage space both on-the-go and at the workplace – made out-of-home use not suitable for their routines and needs during the day. These insights underscore the importance of designing a device that is compact and ease to store, enhancing convenience during transport and aligning better with user's routines.

Conclusion

The rise in pandemic events, such as COVID-19, underscores the importance of pandemic preparedness and the need for design solutions that help prevent the spread of diseases, ensuring that the global population is better equipped to handle future health crises.

This project has shown the importance of the application of novel approaches to capture real-world use behaviours, understand the influence of socio-cultural and environmental aspects on future

device use, assess the usability of designed solutions and facilitate the rapid integration of insights into iterative design cycles.

At Crux, we combined methods from user-centred design, human factors and ethnography, creating a powerful approach that not only captured user interactions with the device user interface but also considered the broader context, including the healthcare system and the communities. The findings of this investigation evidenced that these considerations are fundamental for the successful design and adoption of a device intended for global use, particularly in LMIC, where key barriers to adopting respiratory treatments, such as cultural behaviours, a lack of trust in Western medicine, environmental challenges, and insufficient access to meet basic needs were revealed.

Furthermore, the evaluation of prototypes identified crucial design features that promote correct use in LMIC environments, including intuitive use, fewer steps for operation, designs that align with familiar products and increased convenience.

These insights stress the need for inclusive and adaptable design solutions that consider the cultural, environmental and socio-economic factors, while also addressing the needs of a global population.

Limitations and applicability

Although primary research was limited to two countries, in-field observations were consistent with the results of the broader secondary research, which covered a wider geographical area. Despite the two countries being geographically and culturally distinct, common socio-cultural behaviours, beliefs and challenges related to accessing healthcare and basic services were evident across both contexts. This suggests that the findings of this research may have applicability beyond the specific locations where the studies were conducted, and the design improvements derived from this work could have a far-reaching impact, benefiting a broader population in LMIC.

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References

World Health Organization. (2022). WHO Coronavirus (COVID-19) Dashboard | WHO Coronavirus (COVID-19) Dashboard With Vaccination Data. Available at: https://covid19.who.int/ (Accessed: 7 Sep. 2022).

Mathieu, E., et al. (2021). A global database of COVID-19 vaccinations. Nature Human Behaviour, 5(7), 947–953. https://doi.org/10.1038/s41562-021-01122-8.

Lewis, J. R. (2010). Human Factors Engineering. CRC Press eBooks, pp. 383–394. https://doi.org/10.1081/e-ese-120044161.

U.S. Food and Drug Administration (FDA). (2016). Applying Human Factors and Usability Engineering to Medical Devices. Available at: https://www.fda.gov/media/80481/download.

Interaction Design Foundation. (2016). What is User-Centered Design? The Interaction Design Foundation. Available at: https://www.interaction-design.org/literature/topics/user-centered-design.

Kirmayer, L. J. (2025). Ethnographic research in psychology: A cultural–ecosocial view. Qualitative Psychology, 12(1), 110–122. https://doi.org/10.1037/qup0000328.

Quigg, T., Harley, P., Pisa, A., Sefton-Collings, R., Fosker, N., Prescot, A., Hoare, J., Wade, B., and Muminov, R. (2022). Pandemic Preparedness, Exploring the needs of a respiratory device for the rapid global treatment of future viral infections. Crux Product Design.