Abstract

**Background:** The Scanning Ears for Child Health (SEARCH) system is a biometric patient identification tool which uses a pattern recognition algorithm to translate an image of the ear into a unique identifier. If integrated into an electronic medical records (EMR) system, it would provide a patient identification solution that replaces unreliable paper, under-five card (UFC), or number-based identifiers. This study aims to understand the relative advantage of the biometric system, the sociocultural and pragmatic compatibility, and the extent of UFC deterioration over time.

**Methods:** Interviews on impressions of the novel biometric patient identification tool were conducted in urban and rural settings in Zambia. Focus group discussions included 59 participants and key informant interviews included 5 healthcare workers and 2 government officials. Transcripts were coded into thematic categories for analysis. We sought to understand 1) the perceived relative advantage of a biometric system over the traditional UFCs among Zambian mothers, 2) the perceived sociocultural compatibility of a biometric system in the healthcare setting, and 3) pragmatic compatibility of the proposed system.

**Results:** We found that the current UFC system presents issues for continuity of care and quality of data management, therefore posing disadvantages relative to the proposed system. Sociocultural and pragmatic barriers to acceptance included the existing fear of Satanism and electrical power issues throughout Zambia. Mothers and healthcare workers expressed that adoption of the biometric system could be successful given efforts to sensitize the community.

**Conclusions:** Switching to an EMR backed by biometric identification
would fill a critical gap in Zambian healthcare information systems and has numerous perceived advantages in both urban and rural settings. We determine that strategies for implementation should be localized, context informed, and conducted by trusted community members with knowledge of best approaches to diffusing information and a deep understanding of the novel biometric system.

**Keywords**
global health, patient identification, relative advantage, sociocultural barriers, compatibility, electronic medical records, data management
Introduction
Throughout Zambia, health record management systems remain largely paper-based, with pediatric care relying on the use of an under-five card (UFC) system. This is a decentralized system that relies on the caregiver to maintain a physical card containing the child’s most important healthcare information. Notable challenges with the UFC system include frequently misplaced or damaged cards leading to lost data, significant burdens imposed on caregivers to retain the record, data quality concerns, and unavailability of data for programmatic planning. Shifting to an electronic medical record (EMR) system would centralize data curation at clinics. However, any centralized system still needs to be accompanied by reliable patient identification in order to be effective.

The recent introduction of EMRs in Zambia has not been without its own set of challenges. Over the past several years, PATH, in collaboration with the Zambian Ministry of Health (MoH) and the Bill and Melinda Gates Foundation, has implemented the Zambian Electronic Immunization Registry (ZEIR) platform in roughly 300 clinics throughout the Southern Province. Issues with data availability and data quality persist in this centralized system, many of which root back to the continued reliance on UFCs to identify children. In the event an UFC is forgotten, misplaced, or damaged, there remains no reliable patient identification method to link a patient to their medical record. As a result, fragmented and missing data negatively impact quality of care and health information management despite use of a centralized EMR.

Given the difficulties of developing a robust identification system based on ID cards or other external identifiers, there is considerable interest in establishing a biometric tool for linking patients to their records. Through a partnership between the University of Zambia and Boston University, Project SEARCH (Scanning Ears for Child Health) has focused on this persisting challenge and has optimized an ear biometric system for reliable patient identification. The current SEARCH system is a mobile application that uses a pattern recognition algorithm, Scale Invariant Feature Transformation (SIFT), to translate an image of the ear into a unique identifier. The SEARCH system also makes use of a hardware component, termed ‘the Donut’, a 3-D printed plastic cylinder that interfaces between the phone camera and the patient’s ear, to standardize distance, lighting, and angle during image capture. The SEARCH system correctly identified 100% of individuals across three distinct cohorts of increasing complexity. The SEARCH system, if integrated into an EMR system like ZEIR, would provide a patient identification solution that replaces notoriously unreliable paper or number-based identifiers.

As part of Project SEARCH’s larger efforts, we conducted a series of investigations to understand 1) the perceived relative advantage of the SEARCH system over the traditional UFCs among Zambian mothers, 2) the perceived sociocultural compatibility of a biometric system in the healthcare setting, 3) pragmatic compatibility of the SEARCH system, and 4) physical deterioration of the UFC over time.

Methods
To better understand how the SEARCH system would be perceived if implemented, we conducted a series of focus group discussions (FGDs) and key informant interviews (KIIs) with mothers and health officials in rural and urban settings of Zambia in February 2020. Ethical approval for the study was granted through University of Zambia Biomedical Research Ethics Committee (Ref No. 224–2019). Our research is grounded in the first two of five factors presented by Roger’s Theory of Innovation: 1) relative advantage, how much better the innovation is compared to the product it replaces, and 2) compatibility, how the innovation is consistent with the values, experiences, and needs of the target population.

Sampling
Participants for this study were recruited from three health facilities across urban (Lusaka Province) and rural settings (Southern Province). Focus group participants were recruited using a set list of inclusion criteria, where participants 1) were mothers younger than 45 years of age, 2) had one or more children, and 3) had experience using the UFC. These criteria were used to capture perspectives from mothers who were currently using or had recent experience using the UFC system. In-depth interviews were conducted with nurses in charge and clinicians at each of the three health facilities, and with the District Health Director or Information Officers at the district level. In Lusaka Province, focus groups were facilitated at Chawama First Level Hospital, and participants were recruited from an ongoing longitudinal study tracking infant ear growth. They were approached during one of their clinic visits, had the study described to them, and underwent a consent discussion. Participant requirements were narrow enough to address bias and broad enough to account for diversity in opinions; all mothers were familiar with the SEARCH system and had been introduced to the biometric tool prior to recruitment. In the Southern Province, focus group discussions were facilitated at the Naluja Rural Health Centre, and participants were recruited from the waiting room where mothers were attending the clinic for antenatal visits. We conducted FGDs with 59 mothers across the three health facilities. Participants were recruited until budgetary and timing constraints didn’t allow for further interview recruitment. Each participant was compensated with 50 Kwacha.

Key informant interviews were conducted in both urban and rural settings. Recruitment targeted clinic staff, including clinicians and head nurses, working at the clinics where the FGDs were conducted, in addition to the Information Officer and District Health Officer from the Kalomo District (Southern Province). Potential clinic staff participants, whom the recruiter and facilitator had a working relationship with, had the purpose of the study described to them and underwent a consent discussion. Each participant was compensated with 50 Kwacha.

Enrollment and data collection
Participants received information on the study in their preferred language (Nyanja, Bemba, or Tonga). After confirming
that they understood the study, they gave written informed consent to participate and have audio recorded. Interviews lasted between 45 and 60 minutes. Shorthand field notes were taken during and after the interviews; they were later filled out and completed.

The number of mothers in each FGD ranged between 5 and 7, a standard and manageable focus group size, with one facilitator (A.H. or E.M.) guiding the discussion. Facilitators were affiliated with Right to Care Zambia and the University of Zambia and work as a data quality officer and researcher respectively; both are males with master’s in Public Health and trained through Collaborative Institutional Training Initiative (CITI) in good clinical practice, Health Insurance Portability and Accountability Act (HIPAA) research data security, National Institute of Dramatic Art (NIDA) good clinical practice, pharmaceutical and health product management, social epidemiology, implementation, and monitoring and evaluation. Relationships between the researchers and participants were established during the organization of FGDs and the SEARCH project. The FGD guide included a set of preliminary questions to gather information about participants, including their age, number of children, marital status, and familiarity with biometrics. The SEARCH system was then demonstrated in real-time to all participants, followed by a discussion centered around a series of questions about the UFC system, and finally a set of questions relating to how a biometric system for identification coupled with a digitized registry would be received from a personal and community perspective.

Similarly, the key informant interview guide included a first set of questions aimed at gathering information about the interviewee, including job position, length of time working at current post, and previous experience using biometrics. The SEARCH system was demonstrated, followed by a set of questions centered around the current UFC system, and finally a set of questions about how a biometric system might be perceived from the perspective of a provider. All participant materials including information sheets and interview topic guides can be found as extended data.

Qualitative analysis
Figure 1 explains our process for data analysis. All recordings from FGDs and KIs were translated from local languages into English and transcribed into Word documents. Four reviewers (P.L., M.K., J.S.S., L.E.) used NVivo 12 software (QSR International) to conduct an iterative qualitative analysis of these transcripts. This process involved a first read-through of all transcripts, establishing a codebook to define emerging themes as codes and sub-codes, a first round of review, an iteration of the codebook, and a final round of review. Coding techniques and disagreements were resolved through virtual collaboration and in-depth discussions about the data.

Coded data was exported into Excel 15.37, and categorized into three main codes of relative advantage, sociocultural compatibility, and pragmatic compatibility. Within relative advantage, codes were categorized as either relating to the existing UFC system or the proposed biometric system, and further identified as being either positive or negative. Sub-codes for relative advantage included data management, data quality, patient experience, cost, efficiency, availability of records, and privacy. Within sociocultural compatibility, partner acceptance, religion (including fear of Satanism, which is a common concern in Zambia), and fear or political distrust were identified as sub-codes. Within pragmatic compatibility, technological challenges, sustainability, and community uptake were identified as sub-codes.

Perspectives from mothers, healthcare workers, and government officers, are presented below. We defined relative advantage as the gap between negative comments made about the current UFC system and positive comments made about the proposed biometric system, and we defined compatibility as the sum of sociocultural barriers to adoption of the proposed system and pragmatic challenges to implementation.

---

**Figure 1.** Data collection and analysis process map.
Quantitative analysis of UFC condition
Data from a separate longitudinal study, where Zambian mothers came for their child’s periodic immunization visits, captured the degradation of the under five card over time (unpublished data). In this study, each mother was given a brand new UFC at their first visit, and the UFC’s physical condition was empirically measured at each visit for a period of 6 months. The data collector recorded characteristics relating to the condition of the UFC. Based on how many characteristics were selected, the card was categorized into one of the following: like new (like new selected), minor damage (1 characteristic), moderate damage (2 characteristics), or extreme damage (3 or more characteristics). Characteristics included cracked, crinkled, stained, faded, ripped or torn, water damaged, folded corners, and ink bleeding. We calculated the proportion of cards falling into each category, grouped by visit during the data collection of the longitudinal study (unpublished data).

Results
Participant characteristics
In total, ten focus groups were conducted, seven at the Chawama Clinic in Lusaka Province (urban), and three at the Naluja Rural Health Clinic in Southern Province (rural). All participants were from the local community, received care at the clinics where the focus groups were conducted, and had experience with the UFC paper-based system. A majority of participants were married (70%), and had 2–3 children (43%). In total, 36% of participants had heard of or used a biometric tool at the clinics where the focus groups were conducted, and had experience with the UFC paper-based system. A majority of participants were married (70%), and had 2–3 children (43%). In total, 36% of participants had heard of or used a biometric

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td>15 (25)</td>
</tr>
<tr>
<td>Urban</td>
<td>44 (75)</td>
</tr>
<tr>
<td>Age*</td>
<td></td>
</tr>
<tr>
<td>17–20</td>
<td>4 (7)</td>
</tr>
<tr>
<td>21–30</td>
<td>31 (52)</td>
</tr>
<tr>
<td>31–40</td>
<td>14 (24)</td>
</tr>
<tr>
<td>40+</td>
<td>3 (5)</td>
</tr>
<tr>
<td>*age was not disclosed by remaining 12%</td>
<td></td>
</tr>
<tr>
<td>Marital status*</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>41 (70)</td>
</tr>
<tr>
<td>No</td>
<td>9 (15)</td>
</tr>
<tr>
<td>*marital status was not disclosed by remaining 15%</td>
<td></td>
</tr>
<tr>
<td>Number of children</td>
<td></td>
</tr>
<tr>
<td>1 child</td>
<td>8 (14)</td>
</tr>
<tr>
<td>2–3 children</td>
<td>29 (49)</td>
</tr>
<tr>
<td>4–5 children</td>
<td>17 (29)</td>
</tr>
<tr>
<td>5+ children</td>
<td>5 (8)</td>
</tr>
</tbody>
</table>

Table 1. Focus group participant characteristics.

Key informant interviews were conducted with healthcare workers and government officials. In Lusaka Province, interviews were conducted with the nurse in charge at Chawama Clinic and the nurse in charge and clinic officer at Railways Clinic. In Southern Province, interviews were conducted with a clinic officer and the nurse in charge at Naluja Rural Health Clinic, the Kalomo district health officer, and the Kalomo information officer (Table 2).

Relative advantage
Across 17 transcripts total, including focus groups and key informant interviews, we categorized comments made about the current system and the newly proposed biometric system as either positive or negative. A total of 489 negative and 26 positive comments were made about the UFC system, while 49 negative and 399 positive comments were made about the proposed biometric system. We further categorized all positive and negative comments into 7 themes. Themes identified and coded for were data management, data quality, patient experience, cost, efficiency, availability of health data, and privacy (Figure 2). We discuss these below.

Data management. Participants emphasized that the UFC is easily damaged or forgotten, often rendering patient health data hard to use, inaccessible, and when lost, irretrievable. While most respondents had no experience using a centralized biometric system, they noted that if patient records were reliably maintained centrally, they could be accessed easily. Data management concerns made up 40% of all negative comments made about the current UFC system (195 comments). In contrast, 43.9% of all positive comments related to the proposed biometric system were categorized as relating to the opportunity for improved data management (175 comments).

Data quality. Participants expressed similar grievances about data quality when the UFC is absent. It was noted that in the case of a missing UFC, it is often up to the caregiver to recall what vaccinations and healthcare the child has received, often rendering patient data incomplete and inaccurate. Data quality concerns accounted for 16.6% of all negative comments made about the UFC system (81 comments).

In contrast, participants noted that it would be difficult to lose or damage a biometric, and that if a centralized biometric system were used for record keeping this would result in more accurate patient data. Healthcare workers noted that given accurate patient data, the quality of the delivery of care would improve. While the majority of comments regarding the proposed system were positive (56 comments, 14% of all positive comments), a few raised concerns about the reliability of accurate identification using the proposed system given ear growth and how that could negatively affect data quality (6 negative comments).

Patient experience. Focus group participants expressed feeling shamed and made to feel foolish by clinic staff when their card was lost or forgotten, often getting scolded by the
Table 2. Key informant interview participant characteristics.

<table>
<thead>
<tr>
<th>Urban – Lusaka Province</th>
<th>Position</th>
<th>Clinic</th>
<th>Time at post</th>
<th>Previous work</th>
<th>Previous experience with biometrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse in Charge (NIC)</td>
<td>Railways Clinic</td>
<td>2 years</td>
<td>University Teaching Hospital (UTH), in Chainda, Kalingalinga, &amp; Mutendele, Zambia</td>
<td>Used fingerprint identification</td>
<td></td>
</tr>
<tr>
<td>Nurse in Charge (NIC)</td>
<td>Chawama Clinic</td>
<td>3 years</td>
<td>Urban health center in Lewanika, Zambia; Matero Level 1 Hospital as NIC; Chaisa Clinic as NIC</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Clinic Officer</td>
<td>Railways Clinic</td>
<td>3 years</td>
<td>Matero Referral Clinic; Chaisa Clinic in Kalomo, Zambia</td>
<td>Used fingerprint identification method for ART, OPD services</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rural – Southern Province</th>
<th>Position</th>
<th>Clinic</th>
<th>Time at post</th>
<th>Previous work</th>
<th>Previous experience with biometrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinic Officer</td>
<td>Naluja Rural Health Clinic</td>
<td>7 months</td>
<td>Correctional facility; military hospital</td>
<td>Used fingerprint identification method on phone</td>
<td></td>
</tr>
<tr>
<td>District Health Officer (DHO)</td>
<td>NA</td>
<td>2 years</td>
<td>DHO in Pemba &amp; Gwembe, Zambia</td>
<td>Used fingerprint identification method to vote</td>
<td></td>
</tr>
<tr>
<td>Information Officer (IO)</td>
<td>NA</td>
<td>6 years</td>
<td>Teacher; National Fund Agency</td>
<td>Used fingerprint identification method for national registration process, facial recognition software for pediatric immunization program in the Southern Province</td>
<td></td>
</tr>
<tr>
<td>Nurse in Charge (NIC)</td>
<td>Naluja Rural Health Clinic</td>
<td>6 years</td>
<td>DHO at rural health center in Sijabulile, Zambia</td>
<td>Used fingerprint identification</td>
<td></td>
</tr>
</tbody>
</table>

clinic staff. Due to these negative experiences, participants shared that they have stayed home instead of visiting the clinic, compromising their child’s vaccination and growth schedule. Experience references made up 17% of all negative comments related to the UFC system (83 comments). An alternative perspective was also offered, where it was noted from a very few participants that they had not had difficulties retaining the UFC and therefore were satisfied with the current system (5 positive comments).

Cost. Participants noted a financial burden placed on the patient when a new card needs to be purchased. In some cases, this financial burden was a barrier to receiving care at the clinic (Figure 2). While mentioned in both rural and urban contexts, there was greater emphasis on financial burden in rural settings. Financial burden of the UFC system accounted for 11.7% (57 comments) of all negative comments made. In contrast, participants commented that the cost of the proposed biometric system, which would not rely on paper identifiers that could be lost or misplaced, would not be placed on the patients, a positive change. Cost made up 12.8% (51 comments) of all positive comments to the biometric system.

Efficiency. Both healthcare workers and mothers made note of longer clinic wait times when cards are misplaced or forgotten, since priority is given to those who have their child’s UFC. Healthcare workers expressed frustration and concerns around efficiency when the UFC is absent. Without a known medical history of the patient, care becomes inefficient given that the provider does not reliably know which vaccinations have already been received. Without the card, the child will often have to be weighed before treatment is given or medications prescribed, delaying care. Many noted that if a biometric system were effective, it would drastically improve coordination of care and would lead to shorter wait times. A cautionary comment was made that if the users of the system are not properly trained, this could lead to longer queues and a further delay in care until the adopters of the system become comfortable. Efficiency references account for 5.1% (25 comments) of all negative comments regarding the UFC system. In contrast, efficiency references made up 16.5% of all positive comments made about the proposed system.

Availability of records. Government clinic stock-outs of the UFC were cited by healthcare workers across both Lusaka and Southern Provinces. For the UFC system, availability references make up 3% of all negative comments (15 comments).

Privacy. Healthcare workers interviewed expressed positivity toward the opportunities for concealing, storing, and securing patient health information with the biometric system.
Figure 2. Relative advantage of a biometric system. (A) Proportional representation of relative advantage of biometric system as compared to under-five card (UFC) system. This figure visualizes relative advantage as the number of times negative comments were expressed about the current system compared alongside the number of times positive comments were expressed about the prospect of switching to a centralized, biometric-based system. Comments made about each system are represented by circles, where area is proportional to the number of comments made. Within the comments, sub-themes of data management, data quality, efficiency, cost, experience, and availability were established. The comments attributed to each of these sub-themes are represented as a total count, a percentage of the total, and a proportionally sized circle. (B) Transcript excerpts for relative advantage, grouped by thematic category. Columns indicate whether the quote is related to the current under-five card (UFC) system or the proposed biometric system. Quotes in red boxes were interpreted as negative and quotes in green boxes were interpreted as positive. The notation for where the quote is taken from is the following: type of interview (FGD- focus group discussion or KII - key informant interview), location (Lu – Lusaka or Ka – Kalomo), job title (HCW – healthcare worker, DHO – district health officer, IO – information officer, none – mother in a focus group).
There were a total of 3 comments made on this topic, and all relayed that a digitized patient record system maintained centrally would improve confidentiality and could ultimately build trust in the health system.

Compatibility

Across the FGDs and KIs, many comments were made about compatibility of the proposed biometric system. We defined general compatibility of the proposed system as the sum of sociocultural compatibility (partner acceptance, satanism, fear or political distrust) and pragmatic compatibility (technological concerns, community uptake).

Sociocultural compatibility. A total of 109 comments related to sociocultural compatibility of the proposed system were made (Figure 3). Themes identified were partner acceptance (41 comments), satanism and religion (26 comments), and fear or political distrust (21 comments).

Partner acceptance (41 comments)

Participants gave varied feedback relating to partner acceptance of the proposed biometric system. Out of 59 FGD participants, 13 mothers (22%) expressed concern over their partner not understanding or accepting the biometric technology. Reasons included their partner’s aversion to western world technologies, fears of satanism or other malicious intent, and an unwillingness to support change.

The majority of women, however, claimed that their partners would accept the biometric system if they were given adequate information. Participants who believed their partner would accept the proposed system also commented on how the biometric system would save them from asking their husbands for money for a new UFC, providing additional advantages.

Satanism and religion (26 comments)

Satanism and religious objection was identified as a potential barrier to adoption of the novel biometric system. There was a commonly mentioned belief that without proper community sensitization, the public would accuse proponents and developers of the biometric system as using it as a means to spread satanism.

For context, fears exist in Zambia surrounding the ‘mark of the beast 666’ described in the book of Revelations. People are wary of the spread of evil and are concerned over the intention of innovators or outsiders. About 85–90% of Zambians identify as Christian; this is largely a result of missionary efforts beginning in mid-end of the 19th century. Some missionary organizations supported liberation movements and offered Christian-based schooling. Therefore, Christianity has been a key stakeholder in political efforts, education systems, and social issues in the country; Zambia was declared a Christian nation in 1991 and it is embedded in the 1996 constitution.

Figure 3. Transcript excerpts related to sociocultural compatibility of the proposed biometric system. The notation for where the quote is taken from is the following: type of interview (FGD- focus group discussion or KII- key informant interview), location (Lu – Lusaka or Ka – Kalomo).
Fear or political distrust (21 comments)
Respondents expressed concerns about implementing a new technology during a time of widespread fear and violence in the country. At the time when interviews were conducted, there had been several instances of murder by way of gassing homes with insecticides; subsequent riots broke out over frustrations with the inaction on behalf of police and the government. Strangers entering the community to explain the biometric system would likely face adversity from the community. There were 21 comments made related to apprehension and distrust amongst community members. Respondents commented that fear and distrust could lead people to believe that the technology could destroy their children’s ears, that it could later be revealed that their children’s ears were being sold, and that they could be exposed to new diseases. Reasons for apprehension ranged from distrust in government to distrust in foreigners who developed the system.

Technological challenges (18 comments)
Interviews with healthcare workers and the information officer highlighted potential technological challenges of the proposed biometric system. Most notably, unreliable connectivity and electrical power.

For reliability purposes, health facilities are likely to resort to using the old system if they are unable to connect using the proposed system in real-time.

Similarly noted, poor electrical infrastructure in Zambia poses a significant burden in terms of maximizing successful implementation, especially in rural areas. The issue, however, is not limited to rural areas; urban areas also suffer consistent loss of electrical power. Because the biometric system would require a mobile device to be charged, unreliable access to electricity presents potential barriers to consistent use of the biometric identification tool.

In order for the biometric system to have value, it needs to work reliably and unhindered. Connectivity and electrical power limitations could pose significant barriers to effectiveness of the biometric system and consequently would adversely affect acceptance. To this end, the information officer in Kalomo noted that sustainability of the proposed biometric system is a cornerstone of successful implementation.

Pragmatic compatibility. A number of system-level implementation challenges of the proposed biometric system were identified through key informant interviews conducted with healthcare workers and government officers. These challenges were defined as pragmatic compatibility, and revealed themes of technological, provider uptake, and sustainability concerns (Figure 4).

Figure 4. Transcript excerpts of pragmatic barriers to biometric acceptance. The notation for where the quote is taken from is the following: type of interview (KII- key informant interview), location (Lu – Lusaka or Ka – Kalomo), job title (HCW – healthcare worker, IO – information officer).
Community uptake (132 comments)

Users understanding the technology was referenced as a potential challenge for implementation 132 times across all transcripts. Throughout the KIIs it was noted that if the system is complicated or if the community is not adequately informed about the system, acceptance and use on the part of patients and healthcare workers could be delayed. Many mentioned an initial rejection or apprehension of something new, however many also claimed that given time and understanding healthcare workers would be able to adapt.

UFC physical condition

Data from a longitudinal study, where Zambian mothers came for their child’s periodic immunization visits, captured the degradation of the under five card over time. A total of 133 mothers were enrolled at their child’s first vaccination visit (6 days). Of the 133 mothers enrolled at the 6 day visit, 109 mothers returned at 6 weeks, 107 mothers at 10 weeks, 113 mothers at 14 weeks, 111 mothers at 4 months, 55 mothers at 5 months and 79 mothers at 6 months. We experienced a loss to follow up in the first few visits, and data collection paused for about a month mid-way through data collection for the 5 month visit due to coronavirus disease 2019 (COVID-19).

Figure 5 shows that by the seventh visit, 6 months after initiation with 79 mothers returning, the condition of the card degraded significantly (32% showing extreme damage, 41% moderate damage, 23% minor damage, and 5% like new).

Discussion

In this qualitative analysis of health care providers, health care consumers, and government officials, there was wide agreement that the current paper-based, decentralized system for patient identification had significant problems. By contrast, a centralized EMR, facilitated through biometrics, offered significant advantages across a wide range of tasks, and was nearly universally preferred over the existing status quo. Sociocultural barriers to acceptance and pragmatic compatibility pose challenges to successful implementation and require serious consideration at all stages of rollout.

The disadvantages of the current under-five card (UFC) system present an opportunity for a digital health innovation. Respondents associated the UFC with a financial burden placed on the caregiver when the card is misplaced, lost or damaged. Contrasting the current system, respondents noted that the cost of a new centralized system would not be placed on patients, since their health data would be stored centrally in an EMR at the clinic level. Shifting cost burdens for record keeping off patients and onto health clinics effectively could reduce avoidable deaths by improving attendance to health clinics. Comments were also made related to high illiteracy rates and therefore it being easy for mothers to bring the wrong card (the UFC of one of their other children for example) to the clinic. Bringing the wrong card, or misplaced the card often results in mothers showing up to the clinic without the correct UFC. In these situations, patients are often

![Figure 5. Proportional representation of under-five card (UFC) condition grouped by visit. This shows empirical evidence of how the UFC condition changes in the first 6 months. The categories of damage are defined as follows: extreme, 3 or more characteristics checked off; moderate, 2 characteristics checked off; minor, one characteristic checked off; like new, ‘like new’ selected.](image-url)
scolded by clinic staff and consequent feelings of shame deter patients from seeking out health services in the future. Healthcare workers expressed the difficulty of assessing vaccinations and children’s needs given the unreliable way of preserving information. Healthcare workers and mothers mentioned the card being easily damaged. A sentiment reinforced by empirical evidence of the UFC degrading quickly (Figure 5). Respondents noted instances of mothers arriving at the clinic without the UFC —consequently losing information about which vaccines are left to administer. Mothers mentioned this added stress exacerbating existing financial and socio-cultural struggles. The relative disadvantages of the current system are numerous and addressing these requires the establishment of a new approach to patient identification in Zambia. Advantageous patient identification systems should be a priority given that medical recordkeeping is understood to be a cornerstone of improving quality of care, especially in resource-limited settings.6,9

Understanding the compatibility of a novel technology with the community in which it is implemented using a multi-method approach including consideration of cultural context, is crucial to the success of the tool.16 We found that approaches to implementation mentioned by participants differed across participant groups, and further analysis is necessary to compare technology preferences across populations and localities in Zambia. Furthermore, in-depth examination of implementation strategies given data from this study and future research would aid in structuring appropriate and effective efforts to educate the population about the biometric tool and diffuse barriers to adoption; successful diffusion of biometric innovations relies on reducing people’s concerns about biometric technology through education and awareness.11

The socio-cultural landscape and potential barriers to adoption are critical to consider in designing locally-informed, pragmatic implementation strategies. Reaching out to communities about this new biometric tool will be met with a lot of skepticism related to Satanism, use of the ear, intentions of foreigners, and acceptance on behalf of their family members. Patients and healthcare workers alike agreed that hesitancy for adopting the biometric system by the patients would be able to be eased with time through various community efforts. Community members understand the advantages of the new system when explained, but transcripts indicated that initial reactions may be negative or prompt many questions.

The aim and methodology of this research are rooted in cultural humility: an ongoing practice of self-reflection in order to best understand the complexity of value and culture, and to strive for continuous active engagement with communities and individuals with dynamic backgrounds.12 We acknowledge our limitations as researchers, but through our qualitative methodology with interviews conducted in the local languages and by respected members of the community, we attempted to center the experiences of the target communities in this research.

While individual in-depth interviews were conducted for health officers, mothers were interviewed via focus group discussions. Acknowledging the differences in these modalities is important, as peer influences and majority bias affected responses provided in the FGDs, whereas the individual nature of IDIs may limit the generalizability of these responses. Therefore, quantifying any of the FGD responses could yield results that would differ from results had the women been interviewed individually. However, both modalities also present strengths, where FGDs can elicit reactions and discussions that might naturally occur amongst community members, and IDIs do not suffer from the same biases as FGDs.

Additionally, the study sample size (n=59) was small, limiting generalizability on perceptions around adoption. That being said, we reached saturation within the data—as similar themes emerged early and consistently. There was a larger number of respondents from urban areas (n=44) than rural (n=15), particularly limiting the generalizability of our findings for rural Zambia. Additionally, the study team interpreted translated transcripts as interviews were conducted in participants’ native language. Therefore, some quotes from respondents could have lost their true meaning through translation and/or thoughts expressed did not have an accurate or culturally comprehensive translation to English.

Conclusion

Overall, a switch to an EMR backed by biometric identification would fill a critical gap in Zambian healthcare information systems. Implementation of the proposed system has numerous perceived advantages in both urban and rural settings in Zambia. As with the introduction of any new technology, there are important sociocultural barriers and pragmatic implementation challenges that should be considered during the rollout of this new technology. Implementation should be localized, context informed, and conducted by trusted community members with knowledge of best approaches to diffusing information to their community. Opportunities for further study include evaluation of this technology during implementation. Characteristics of relative advantage and compatibility laid out in this study can be used as indicators to guide monitoring and evaluation efforts in the future.

Consent

Informed consent was obtained by all participants prior to their focus group discussion or interview.

Data availability

Underlying data


This project contains the following underlying data:
- FDGTranscripts.pdf (Transcripts for FGDs 1–3 in Kalomo and FGDs 1–7 in Chawama)
- KeyInformantInterviewTranscripts.pdf
- UFC Condition.xlsx (Raw data gathered on the condition of Under-Five Cards over time)

Extended data

This project contains the following extended data:
- FGDInterviewGuide.pdf

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

References

Aman Kamboj
National Institute of Technology Jalandhar, Jalandhar, Punjab, India

In this work the authors have performed a case study to replace under five card based system with electronic medical records system using bio-metrics.

However these following concerns need to be taken care of before indexing:
1. The paper is submitted to the research article category. However, in this work no novel method has been proposed.
2. The paper does not have any statistical test to validate the system.
3. The paper lacks citation of the related work.
4. Moreover, the authors have suggested to propose an ear-based biometric system, but no further details for ear biometrics are provided.
5. Fig. 2 (B) needs to be improved for better quality.

Is the work clearly and accurately presented and does it cite the current literature? No

Is the study design appropriate and is the work technically sound? Partly

Are sufficient details of methods and analysis provided to allow replication by others? No

If applicable, is the statistical analysis and its interpretation appropriate? No
Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Computer vision, biometrics, deep learning

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.