mHealth for Child: A Collaboration of Human and Machine

mHealth & Child Health Record for psycho-physical well being

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ABSTRACT
In this paper we explore a mHealth approach where the relative strengths of both physical and digital artifacts are combined into an object aimed to record and convey child health records. We face the design challenges and opportunities associated with the combination of human-readable data and machine-readable data as two different levels of complexity of information.

Specifically, we are designing a solution that combines both a physical bracelet with a physical representation of an aesthetic symbol and digital medical data with vaccination information that is stored in a hidden NFC tag contained into the bracelet. Thus, the bracelet contains both human-readable data with the symbols designed, inspired by African tattoos and machine-readable data with the information contained in the NFC tag. While the users can directly read the primary information (administered vaccines) by simply interpreting the physical tattoo, doctors can interact with the digital data by employing NFC-enabled smartphones in order to obtain richer information such as vaccination dates.

CCS CONCEPTS
• H.5.m. Information interfaces and presentation (e.g. HCI): Miscellaneous. H.5.2 [User Interfaces]: Theory and methods, User-centered design, Graphical user interface.

KEYWORDS
Child Health Record, mHealth, Collaboration of Human and Machine, Vaccination, Human-readable data, Machine-readable data, NFC tags.

1 INTRODUCTION
The Global Observatory for eHealth (GOe) defines mHealth or mobile health as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices [12].

In this paper, we address the problem of child health management (particularly vaccination management) from a mHealth perspective. This problem poses important challenges. For instance, when the core user is a child who has unclear communicative expressions, the environment of the child has a dominant influence [4, 6]. We conducted literature reviews and stakeholder interviews on the topics of child health and vaccination status, as well as on African tattoos.

The concrete mHealth prototype we have designed is inspired by African body art. Bianchi’s studies on ancient Egypt document both the earliest known firm evidence for a tattoo in human history and its clear Black African (i.e. Nubian) roots. Extended forward in time through Coptic, Islamic, and modern forms, the Egyptian record of 4500 years of tattooing is presently the longest in human history [5]. Today, tattoos are everywhere. In 2015, nearly one in three Americans had at least one tattoo. The practice of marking our skin, however, goes back to ancient civilizations, when tattoos served as a symbol of status, coming of age, or life achievements [11].

2 RELATED WORK
Our earlier studies described a specific context that we have been working on [1, 2, 3, 4], followed by case studies conducted with child health records, along with the ethnography design method we applied [1, 8, 9]. Other authors have been inspired by skin tattoos as well. For instance, Elastic Electronic Skin [10] is a highly elastic and thin elastic skin display capable of exhibiting simple characters and even moving graphics with an array of 16 x 24 micro LEFs. Its purpose extends beyond skin deep novelty: the minimally invasive medical system was developed to keep doctors connected with their patients ill served by current smartphone and computer UI.
3 **CHALLENGES AND OPPORTUNITIES**

Recently, mHealth applications have started to address not only physical health, but also mental health. In this sense, an increasing number of health monitoring and recording apps include cognitive behavioral approaches and mindfulness [9].

New approaches are now necessary to avoid the stress and anxiety that dealing with health data can induce to the users. This paper aims to address some of the challenges and opportunities associated with the combination of human-readable data and machine-readable data as a collaboration of human and machine. These challenges include user research, design, and evaluation challenges for child health record.

### 3.1 User Research Challenges

How can we better understand parents, healthcare and surveyors' motivations and needs for child health record via mHealth in order to develop a more useful application? What are appropriate methodologies to understand their needs for child health?

We employed qualitative research methods in order to explore the stakeholders’ necessities, motivations and interests. Particularly, we conducted both semi-structured interviews and predefined questionnaires intended to better understand their thoughts and feelings.

These two pictures (Figure 1) show examples of parents who have a tattoo to remember their kids in our interview. Carlton's tattoo (left) is a reminder of his infant son. A Mum's symbol (right) is also a reminder of the birth of her son but encodes multiple pieces of relevant data in the tattoo that contains the date and time, the location, and her son's weight and height at birth [1].

![Figure 1. A user-centred research in-depth interviews with parents who have tattoos as a memento for their child.](image)

At this stage, we openly ask parents about the possibility to tattoo their kids with symbols representing health related information with vaccination information. How do the parents feel about that strong proposal?

There is a difference between having a tattoo as a parent referring to their child and tattooing the baby after it is born. Parents said they see the value of the design proposal, but they argued that it is too early for a baby to be tattooed. However, they said they would love to have a bracelet as a child health record book. They even said they would consider having a tattoo if that’s related to their baby’s information. We also interviewed 60 participants who have a tattoo on their skin (figure 2).

![Figure 2. The primary motivation: an engagement (left), aesthetic beauty (middle), a memento (right).](image)

We were able to categorise the motivation of the tattoos based on our user study into the following main categories: Symbolic (meaningful personal values of religious belief), nominal (own useful values of affiliation), aesthetic (beauty), artistic (character, power), memento (remember/ memorise) and affective (significant person or passion) tattoos.

### 3.2 Design Challenges

What does the design space for mobile health applications look like, combining practical self-management and support for mental well-being? Can an Aesthetic, Expressive, and Functional Tattoo support for parents or child's mental well-being? What are the specific design trade-offs to be made? [9]. We decided to design our mHealth device as a wearable clothing accessory that does not resemble a mHealth device (figure 3).

![Figure 3. Design concept: The mobile app is automatically triggered whenever an NFC bracelet is nearby (left). The App visualizes the information pertinent to the corresponding vaccine (right) [1].](image)

We think that the user’s stress and anxiety that wearing medical data could induce in the user can be avoided if the user is not aware that she is wearing technology nor data. Moreover, by designing the device as a apparently a usual physical clothing accessory, we eliminate the design trade-offs normally made when designing medical devices.

### 3.3 Evaluation Challenges

How can we evaluate these effects of mental support? [9]. Our paper prototypes were used to communicate ideas between designer, developer, our target users (parents, healthcare) and other stakeholders (surveyor) in the early stages of the user-centred design process (figure 4).
Since this a qualitative study, we annotated everything the users said to get valuable information from their verbal expression (apart from the questionnaire). We also observed the parents and caregiver’s interaction with the paper prototype before our final interfaces are designed.

We have also presented the system to the targeted users who have a tattoo and a child. From a western parent perspective, combining tattoo culture and babies would be, in principle, an odd thing to do. In the user study, we explained that there is evidence in Africa's history of tattooing children as a healing ritual. Some parents said that the combination is excellent and that they wanted to use it.

4 Prototype

The prototype consists of two aspect: human-readable data and machine-readable data as two different levels of complexity of information. Specifically, vaccination data is encoded in a visual manner (resembling a tattoo). We combine this artistic image with an NFC tag in a bracelet, making up system readable by humans and machines.

4.1 Human-readable data

We applied a modern version of ethnography methods to child health record design in Africa [7]. Ethnography can be useful in helping designers find the communication strategy or insight required for a plan, method, or composition that allows for the most effective and natural communication under any given circumstances [6, 7, 8].

We created a graphic medium of the tattoo design inspired by African culture for the prototype (figure 5). Evidence of painful tattooing on the bodies of pregnant women and a little child shows a firm belief that such tattoos will chase away evil spirits and provide protection. It means that those symbols had been a medium for the mental support meaning that the child was being well.

Artistic transformations of the human body [5] can be appropriate methodologies to understand parents needs for their child's health and mental support as the tattoos have traditionally shown aesthetic, expressive and functional aspects. The examples shown in (figure 5) represent aesthetic tattoos, expressive tattoos, and functional tattoos that have vaccination data encoded in variations of the base tattoo design. The evolution from top to bottom shows how the tattoo increases its size and complexity as additional vaccinations are administered.

4.2 Machine-readable data

Our digital prototype consists of two elements: Bracelets containing NFC tags, and NFC enabled Android smartphones in order to manage the vaccine information contained within the bracelet (figure 6).

The NFC bracelets are intended to be worn by the children, while the doctors will use the smartphones to read and update the vaccine information contained within the NFC bracelets. The prototyped App allows managing information such as the vaccinations dates, the next vaccine, etc [1].

Our designed prototype aims to reduce the stress and anxiety that wearing medical data could induce. The user is not aware that she is wearing technology nor data. She wears a bracelet with a physical representation of an aesthetic symbol. The bracelet also includes a hidden NFC tag inside. NFC tags are passive data stores that can be read and written by an NFC device.

They are small electrical circuits that work through the inductance of a nearby device. That is, they do not even contain batteries.
They only work when the doctor approaches an NFC enabled smartphone. Thus, the user does not see nor feel the technology/data she is wearing in her daily life. We think that this kind of hidden technology embedded in wearable clothing accessories can be useful to encode/store other types of medical data apart from vaccination information.

5 DISCUSSION

The aim of the work presented here is to explain the development and validation of the Children Health Record, which can be used as part of a human-centered design approach to involve the child in the design of mHealth. There are several limitations to the study presented in this paper. First of all, the studies were performed in Portugal, with people who stay or visit Portugal. Although some of them are from Senegal, South Africa and Kenya, there may be cultural differences in how people imagine mHealth for Child, so it is possible that our findings are not representative for Africa local people. However, the drawings on which the tattoo elements of the child health record were based came from African rural area.

We also found that European parents were interested in this type of the mHealth: child health record, and wanted to use it. Because European parents also had problems that they could not remember where did they put their child health records and when the child needs to get the next vaccine. We plan to explore mHealth with other technology solutions to integrate into tattoo form as a child health record.

6 CONCLUSION

We have explored a mHealth approach that combines both physical and digital artifacts into an object aimed to record and convey child health records. We have described a concrete solution that combines both a physical bracelet with a physical representation of an aesthetic symbol and digital medical data that is stored in a hidden NFC tag contained into the bracelet. Thus, the bracelet contains both human-readable data (the symbols designed, inspired by African body art) and machine-readable data (the information contained in the NFC tag).

While the users can directly read the primary information (administered vaccines) by simply interpreting the physical tattoo, doctors can interact with the digital data by employing NFC-enabled smartphones in order to obtain richer information such as vaccination dates.

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