The Mobile App to Assist with Tattoo-encoded Baby Immunization Records in Africa

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Abstract: This paper describes the design and implementation of a mobile application that assists with the interpretation and generation of tattoos which encode immunization records. That explains the application of ethnography design, in a broad way, to solve the issues of the vaccination system for children in Africa. We have derived the "tattoo of Africa" concept from a design that reflects African cultural backgrounds and has linked it with the health service design process. Tattoos, which have been common in Africa for thousands of years, have been redefined as a new ritual for child health records. Our design is applied to two different artefacts: a baby guide-book and a baby bracelet. We also describe our first prototype of the baby bracelet and its related App. The bracelet, which contains an NFC tag with information about the baby's vaccinations, can be read from or written to any NFC-enabled Android smartphone via the visual interface of the related App.

1. Introduction

Ethnographers and anthropologists have been involved in design, innovation and product development for more than 30 years, adopting and developing various roles and interdisciplinary approaches [12]. Some have worked from more traditional ethnographic positions, using fieldwork and ethnographic descriptions to render real-life settings and practices for design [1, 4]. The concept of ethnography and ethnographers has been widely applied in all areas from HCI (Human-Computer Interaction) to branding, computer-user collaboration, product development, tangible computing and advertising [6, 7]. In the 1950s, Dreyfuss mentioned a research method [2] that could seek a consensus among users in "Designing for People"; this observation [2] is considered to be the first case of combining ethnography with the design process [9]. Lucy Suchman's research at the Xerox Palo Alto Research Center (PARC) in the 1980s was the first known case of using ethnography for industrial design. In addition, in the mid-1990s, the "Dublin group" applied "video ethnography" by using videos for user observation [10].

Recently, as the scope and domain of design has expanded beyond previous boundaries, the definition of ethnography has also seen an expansion into a concept that surpasses its traditional academic sense. From the modern perspective, any type of

research that includes cultural factors is recognized as ethnographic research [11]. Ethnography strengthens design by exposing the user's surrounding environment and drawing out the understanding of cultural implications and primary users [9]. It can be effectively used particularly when it is analyzed in a broad sense related to overall strategy rather than direct feedback [2, 10].

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].

In this sense, we introduced some communication design recommendations [9] that fuel both the design and the prototype that are described in the present paper. We applied a modern version of ethnography methods to child health record design in Africa. We identified the health and vaccination status of African children as well as any relevant issues that have been considered social problems in media and literature, and defined the cultural meaning and target audience required to address these problems [9]. The present paper continues that work.

In the next sections we describe our designs and the first prototype. First, we describe the design of a dynamic symbol, inspired by both African tattoos and Adinkra symbols. Then, we detail the design of two artefacts that share the design: a baby guidebook and a baby bracelet [9]. Finally, we describe the first prototype of the bracelet and its accompanying App.

2. ETHNOGRAPHY DESIGN INTO AFRICAN TATTOO

We found that ethnography methods are useful for visual communication as an exploratory tool. Tattoos have existed for thousands of years in Africa; a tattoo discovered on a frozen hunter's body in 1991 is estimated to be the oldest evidence of tattoos in the world. The frozen hunter, who was found carrying a palstave, had 58 tattoos on his body and was estimated to have died in 3300 B.C [10].

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Evidence of painful tattooing was also found on the bodies of pregnant women and little children, which is said to have originated from a strong belief that such tattoos will chase away evil spirits and provide protection.

West African symbols known as Adinkra connote various meanings. They represent concepts or aphorisms and are extensively used in fabrics, pottery, logos and advertising. These symbols have a decorative function but also represent objects that encapsulate evocative messages that convey traditional wisdom and aspects of life or the environment. Therefore, within the context of African culture, we identified tattoos as a design element on skin user interface that is associated with improvement and empowerment.

The concept of the tattoo can be used as a unique identifier that is intimately connected to the child. It can also be a simple but powerful educational tool for families to learn more about health interventions. It will be a source of critical information for health workers about the child's health and vaccination status, and what the child needs at each point of contact with the health system. It can also be a source of critical information for the household surveyor, which many countries and policymakers rely on to validate coverage levels obtained from administrative data systems [9].

3. Symbol Design for Tattoo

We came up with an idea of an umbilical cord that connects a baby in the womb to its mother. It runs from an opening a baby's stomach to the placenta in the womb. The umbilical cord carries oxygen and nutrients from the placenta into the baby's bloodstream. It is essential to keep the umbilical stump area clean and dry, to prevent infection.

This element for a symbol design derives its archetypes from both African tattoos and Adinkra symbols. In placental mammals, the umbilical cord (also called the navel string [15] birth cord or funiculus umbilicalis) is a conduit between the developing embryo or fetus and placenta. During prenatal development, the umbilical cord is physiologically and genetically part of the fetus and, in humans, normally contains two arteries (the umbilical arteries) and one vein (the umbilical vein), buried within Wharton's jelly [13]. We have created a graphic symbol design of an umbilical cord to represent the birth of a child [9, 10]. The symbol design composes umbilical cord and sprout as a symbol of infant (Figure 1).

bud, leaf, petal

umbilical cord

Fig. 1 Umbilical cord and leaf [9, 10]

Our sprout pattern design that is linked with each additional vaccination also represents a tree of life that grows with the baby's growth (Figure 2). Every time the baby is vaccinated, new elements are added to their tree of life. Thus, this tree of life visually indicates the vaccines that have been administered to the child since birth [9].

15-18 months MR MR2

9-12 months MR MR1

14week Penta Penta3 PCV PCV3 OPV OPV4 RV RV3

10week Penta Penta2 PCV PCV2 OPV OPV3 RV RV2

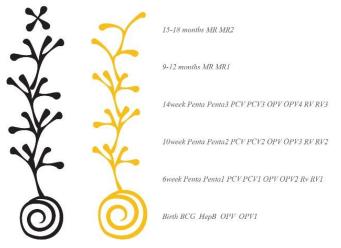*6week Penta Penta1 PCV PCV1 OPV OPV2 Rv RV1*

Birth BCG HepB OPV OPV1

Fig. 2 Growing Tree of Life as a symbol of living [9, 10]

The tattoo composition consists of one umbilical cord and 5 leaf elements. The umbilical cord symbol is tattooed on the baby's skin after being given the vaccinations: BCG, HepB, OPV OPV1. After this, each additional leaf symbol indicates vaccinations at 6 weeks, 10 weeks, 14 weeks, 9-12 months, and 15-18 months. (Figure 3).

15-18 months: MR MR2

9-12 months: MR MR1

14 week: Penta Penta3 PCV PCV3 OPV OPV4 RV RV3

10 week: Penta Penta2 PCV PCV2 OPV OPV3 RV RV2

6 week: Penta Penta1 PCV PCV1 OPV OPV2 Rv RV1

Birth: BCG HepB OPV OPV1

Fig. 3 The meaning of each element for tattoo composition

Composition is about arranging the elements of the tattoo in a pleasing and easy to read manner. When done correctly it guides the view towards the indication of the next vaccination date, and results in an overall more aesthetically pleasing tattoo. Families can also personalize their own tattoos by adjusting the composition of the leaf elements in various ways. (Figure 4).

Fig. 4 Variations with Tattoo elements

4. Baby Guide Book

Parents of every child are given a paper-based personal child health record. This health record contains general information about the child's health, growth and development.

We have created a visualization design for vaccine information that details which vaccines a child should receive from birth, in the appropriate order [9]. The basic vaccinations for children from birth to 18 months [10] are shown in (Figure 5). This diagram as a time reminder for child vaccination can be used GUI for screen devices such as PC, and mobile. It can operate as an interactive GUI on screen devices.

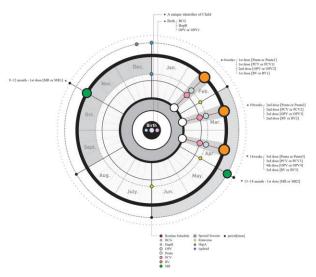**Designing for the Vaccine Schedule**

Time Reminder for Vaccination

Fig. 5 Design for the vaccine schedule and recommended routine immunizations for children [9, 10]

Our baby guidebook design contains a typographic design on the cover that displays the immunization information as the primary communication (Figure 6). The Baby guidebook is designed such that the details can be recorded in the pages of the book [9] (Figure 7). That design can also be applied to a web-based digital type of book [10].

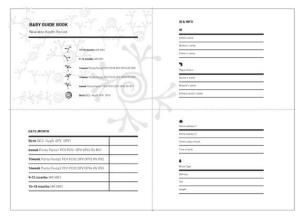Fig. 6 Front and back cover for Baby guidebook

Fig. 7 Contents components inside the baby guidebook

We have designed a baby guidebook as an analogue form. The guidebook is formed from a single sheet of paper that is yellow on one side and white on the reverse. The sheet is folded twice to create a total of 8 pages, including front and back cover pages (Figure 6).

On the front cover page, there is an area for parents or health workers to easily mark with a pen, to record vaccination status (Figure 8). It can also indicate clearly the date parents should bring their child to a Health Center (or a children's hospital) for their next immunization.

The contents component page is a normal form of guidebook (Figure 7). The typography used on the cover page has been designed to make the written vaccine information legible, readable, and appealing. This consists of selecting which typefaces, point sizes, line lengths, line spacing and letter spacing, and adjusting the space between pairs of letters.
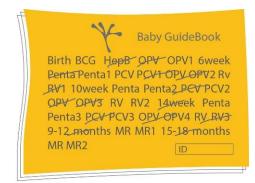

Fig. 8 Method of use Baby Guidebook with typography

5. Bracelet design

We have designed a bracelet that includes both physical and digital elements. On the one hand, the bracelet is physically "tattooed", that is, the growing tree of life is physically painted on the bracelet itself. Thus, it can be read and understood without any technology. Once our design becomes popular, both families and doctors will easily interpret the symbol and will know the vaccination status of every child (the vaccines administered to him) just by looking at the bracelet.

On the other hand, the bracelet contains an NFC tag. The NFC tag stores more complete information about the child's vaccination status (including dates). The information can be read and updated by using NFC enabled devices (Figure 9, 10).
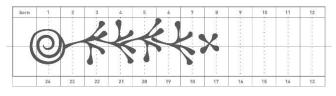

Fig. 9 Tattoo reading by electronic scanner

Fig. 10 A Child Health Record through Bracelet [9, 10]

6. Prototype

We have designed and developed a prototype we describe in this section. The prototype comprises both NFC tags that are placed within bracelets, and NFC-enabled Android smartphones. The NFC bracelets are 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.

NFC tags are passive data stores that can be read and written to by an NFC device. They are small electrical circuits that work through the inductance of a nearby device. Thus, when a phone is near an NFC tag, the electromagnetic field from the phone provides the power to fire up the NFC tag. NFC tags are cheap. For instance, waterproof NFC bracelets can be found in Alibaba for US $0.18. Moreover, since NFC tags are unpowered circuits, they do not require batteries. Thus, there is no cost associated with the maintenance of the tag.

Many current Android smartphone models include an NFC reader/writer. Thus, these phones can be used to read/write information from/to the NFC tags included in the child's bracelet. We propose to minimize the cost of our solution by reusing smartphones we already have. We argue that when we buy new phones, we can donate our old ones to be used by doctors in Africa. Since the current phone replacement rate is very high, there are (and there will be) many "old" devices to be reused.

To prototype our solution, we have designed a custom bracelet with a 1KB NFC tag inside (there are several types of NFC tag with different memory capacities, typically between 96 bytes and 8Kb). For rapid prototyping, we have used EVA foam for the bracelet (we will use silicone for the final prototype). Regarding the smartphone, we used a Google Nexus 5 to test all the prototype features while we developed the App. After the prototype was built, we tested it on a variety of other NFC enabled smartphones. The App has been designed in order to simplify the interaction of doctors and families with the information stored on the NFC bracelet (a formatted text string containing vaccine identifiers and the dates when the vaccinations were made). There are actually two versions of the App: one for doctors and another one for families. Both versions are very similar, though the version for families lacks the ability to update information.

Note that there are more than 2000 languages spoken in Africa [5] (more than 3000 according to some authors [3]). Moreover, many African countries have a very low literacy rate. Thus, we employ interaction through a visual interface where possible, using the tattoo design as a catalyzer for both the interaction and visualization of information. Where text is necessary, we employed English in the prototype, since English is the most widely spoken language in Africa [14]. More languages will be added in future versions in order to maximize legibility. When a smartphone (with the prototype App installed) is located very near the prototype NFC bracelet, the App is automatically launched and its main screen appears (Figure 11). It shows the whole symbol (tattoo) design. The parts of the tattoo corresponding to vaccines already administered appear clearly in a dark colour, while the other parts (corresponding to vaccines still not administered)

appear in a light colour.

Fig. 11 The App is launched when the smartphone is nearby the bracelet

By using the App addressed to families (in cases where the parents have a smartphone), the users can visually query the information. As shown in Figure 12, and 13, by touching any leaf of the tattoo symbol, the App shows the information corresponding to the related vaccine (the vaccine name, whether it has been administered or not, and the date it was administered or the date it is supposed to be administered). The App also warns the users when a vaccination date approaches.

Fig. 12 Visually querying the vaccination record

Fig. 13 Bracelet and mobile App with tattoo composition

The App addressed to health workers includes the features of the

parents App, but it also allows the users to update information regarding vaccinations (particularly, the dates the vaccines have been administered and the date of the next vaccination).

7. Conclusion

Where as previous studies placed emphasis on research methods-Ethnography design and information design with tattoos for immunization records. This research describes a mobile app to assist with tattoo-encoded baby immunization records. Our paper emphasizes the design and implementation of a mobile application that assists with the interpretation and generation of tattoos that encode immunization records.

The ethnography method in this research was significant in that it aimed to find a design solution within regional culture in Africa. Tattoos, the design element (which have survived throughout Africa's long cultural tradition), are reborn as a symbol of children's lives being saved [10]. Our design has been applied to two different artefacts: a baby guidebook and a bracelet for parents or baby. The bracelet (that aims to overcome the issues discovered through the ethnographic study) has been successfully prototyped along with the accompanying App. With follow-up research, we plan (in collaboration with NGOs) to conduct user research and experiments based on local children, parents and health workers. Further, we propose a method of additionally storing the same information that is present in the tattoo in a machine-readable digital form, such as an NFC tag. Before that, we honestly hope this work will benefit from the interaction with HCI community.

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