

# Design of a smart pacifier to detect dehydration in babies and shaping parents' behavior

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## ABSTRACT

This study proposes a smart pacifier to save a dehydrated baby's life. The pacifier estimates the hydration level of the baby and notifies the caregiver (e.g. parents) of the baby the baby's total body water (TBW) and guides appropriate action through the mobile app. We designed both the hardware and the software. The hardware consists of a sensor to measure the humidity from baby's lips and a pocket for oral rehydration solution (ORS) to get a baby's body rehydrated for the first aid. In addition, the system by collecting data from app allows a hospital to know infection area by checking a dashboard. In this paper, we propose the smart pacifier and the describe the mechanism.

## 1. INTRODUCTION

Every year, dehydration kills approximately 525,000 under-fives (World Health Organization, 2017). One of the main causes of dehydration is caused by *Rotavirus* gastroenteritis which induces vomiting, fever and diarrhoea. Approximately 40% of hospitalizations for diarrhoea among children aged under 5 years worldwide are due to *Rotavirus* infection (World Health Organization, 2008). The disease is ubiquitous, affecting nearly all children by the age of 5 years. Current methods to prevent *Rotavirus* infections are hygienic practices like hand washing or vaccination. However, hand washing is not a perfect solution due to the high contagiousness of the virus and the efficacy of the vaccine is about 70 percent in developing countries. Even in developed countries, *Rotavirus* infections are considered as a serious public health problem because most children get infected by the age of 5. Although hand washing and vaccination are currently considered the best solutions against the other viruses from a medical viewpoint, it is difficult to protect babies from *Rotavirus* for these reasons above. Therefore, it is important to deal with dehydration symptoms after onset. In this study, we consider the ways to prevent s from missing babies' dehydration symptoms, to guide them to take appropriate actions, and to encourage them to rehydrate the babies.

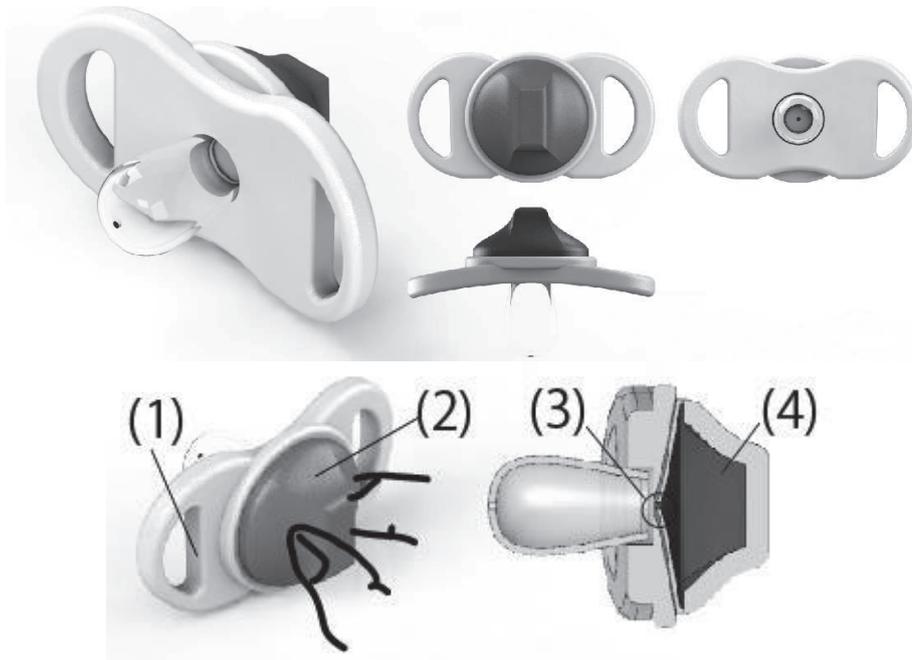
## 2. METHOD

In this study, we developed a pacifier to estimate TBW of a baby and recommend actions to the caregiver of the baby. Our design consist of a pacifier-type sensor that is linked to a smartphone application. As body dehydration symptoms, there are symptoms such as weight loss, lower limb body temperature, mucous membrane dryness, dry mouth, etc. (Masashi Kawano, Nobue Nakamura, 2010). Among them, we focused on dry mouth as a dehydration symptom. The pacifier sensor reads the humidity level of the baby's lips and sends it to the smartphone. When the humidity level is too low, the smartphone generates an alert for caregivers and displays a short questionnaire. The answers to the questionnaire and the humidity levels are used to recommend actions to caregiver, for example to provide water for the baby or take the baby to a doctor if the condition is serious.

Our product can also support doctors to identify epidemic outbreaks by analysing the disease data with the position information. We designed a dashboard so that they can prepare for a sudden increase of the patients in the outbreak in the regions.

### 2.1 Hardware Design

We used Arduino and a humidity sensor to develop the prototype. The 3D model of the pacifier was designed with the Autodesk Fusion 360. We designed the structure that extrudes air by pinching and pushes chemical into the baby's mouth. The pacifier's hardware prototype consists of the following four elements: a mouth shield (Figure 1 (1)), a finger grip (Figure 1 (2)), a check valve (Figure 1 (3)) and a pocket for ORS (Figure1 (4)).



*Figure 1: Pacifier's hardware design*

The mouth shield prevents a baby swallowing the pacifier and contacts with baby's skin softly. It is also a space to put fingers of caregivers. The finger grip is a knob for pushing out the ORS put in the pocket. It is designed to pinch effectively and efficiently. The check valve keeps the solution in the pocket and prevents reverse flow after extrusion. The pocket for ORS is a removable and disposable with a gradient to let out ORS easily.

The usage of the pacifier is simple. The simple design allows to use precisely even if the users (caregivers) are in panic at babies' vomiting or if the users don't have detailed medical knowledges. Figure 2 shows the usage procedure. The instruction message is written on the pacifier package as like "Vomit then put it". The user will open the package (Figure 2 (a)) and put the pacifier into the baby's mouth (Figure 2 (b)). The user just pinches the finger grip and can rehydrate the babies for a first aid (Figure 2 (c)). After that, user downloads the mobile application from the QR code printed on the package and connect it with the pacifier. After using the pacifier, user puts it into the package no to be infected (Figure 2 (d)).

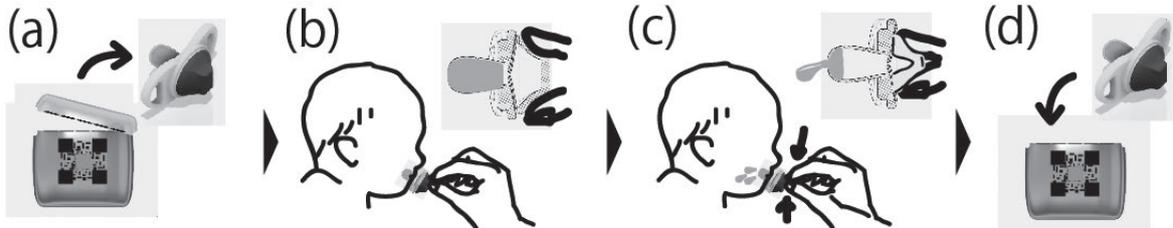


Figure 2: Pacifier's hardware usage diagram

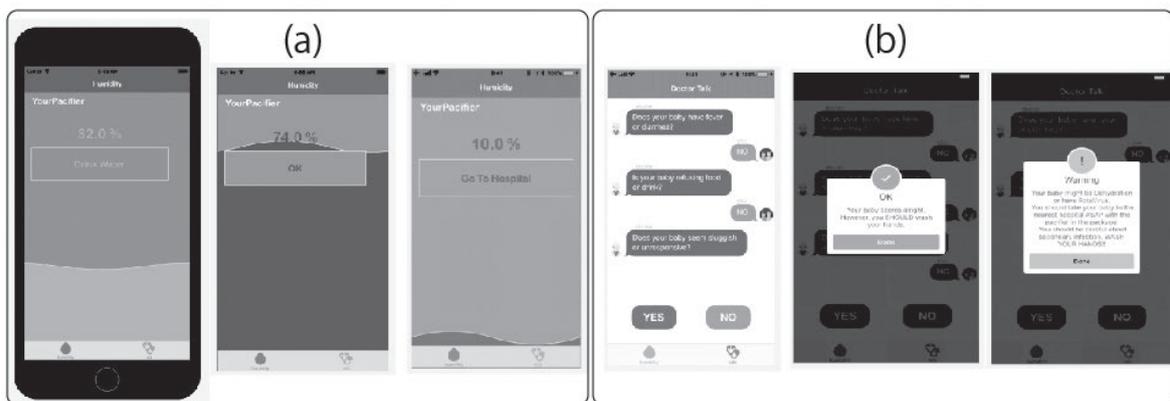


Figure 3: Application UI Design for User, (a) Sensor screen, (b) Questionnaire screen.

## 2.2 System & Application Design

We designed the mobile application for caregivers (Figure 3) and web application for the doctors (Figure 4). The application informs user the baby's TBW measured by the sensor (Figure 3 (a)). In case of dangerous dehydration symptoms, the app page is moved to the questionnaire page and user is required to answer the simple questions (Figure 3 (b)). If the rate of the TBW is low and the baby is dangerous with dehydration symptoms, the mobile app warns the user and then instructs the actions that user should take. For example, if the condition of the baby is very serious, the app decides and instructs to take the baby to a hospital. At the same time, it encourages to rehydrate the baby with the ORS.

In addition, this application gathers users' data with the position information and detect the distribution and the epidemic status of children with dehydration symptoms. By showing these data to hospitals, the doctors can analyse the infection situations of the entire regions (Figure 4).



Figure 4: Application UI Design for Hospital

### 3. RESULTS AND DISCUSSION

In this proposal we made a design of a pacifier type hardware to encourage parents' behavior and developed a system of applications and dashboards.

### 4. CONCLUSIONS

This study proposes a smart pacifier to help dehydrated babies. We made a design of a pacifier hardware as a sensor that can estimate the moisture content of a baby. In addition, we developed the application and its dashboard that induces proper behavior when baby's vomiting.

Future works include a pilot study to validate the hydration detection method and the utility of recommended actions. This includes a test on whether the pacifier sensor can accurately detect dehydration symptoms. After that, clinical trials can be held in hospitals to test the effectiveness of the system, before the product is distributed to the public.

### REFERENCES

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