# Educating parents about the vaccination status of their children: A user-centered mobile application

Lea Seeber [a,b], Tim Conrad [c], Christian Hoppe [a,b,c], Patrick Obermeier [a,b], Xi Chen [a,b], Katharina Karsch [a],
Susann Muehlhans [a,b], Franziska Tief [a,b], Sindy Boettcher [d], Sabine Diedrich [d],
Brunhilde Schweiger [e], Barbara Rath [a,b,f,∗]

[a] Department of Pediatrics, Charité University Medical Center, Augustenburger Platz 1, 13353 Berlin, Germany
[b] Vienna Vaccine Safety Initiative, Berlin, Germany
[c] Department of Mathematics and Computer Sciences, Freie University, Arnimallee 14, 14195 Berlin, Germany
[d] National Reference Center for Poliomyelitis and Enteroviruses, Robert Koch Institute, Seestr. 10, 13353 Berlin, Germany
[e] National Reference Center for Influenza, Robert Koch Institute, Seestr. 10, 13353 Berlin, Germany
[f] The University of Nottingham School of Medicine, Hucknall Road, Nottingham NG51PB, UK

## ARTICLE INFO

## ABSTRACT

Parents are often uncertain about the vaccination status of their children. In times of vaccine hesitancy, vaccination programs could benefit from active patient participation. The Vaccination App (VAccApp) was developed by the Vienna Vaccine Safety Initiative, enabling parents to learn about the vaccination status of their children, including 25 different routine, special indication and travel vaccines listed in the WHO Immunization Certificate of Vaccination (WHO-ICV). Between 2012 and 2014, the VAccApp was validated in a hospital-based quality management program in Berlin, Germany, in collaboration with the Robert Koch Institute. Parents of 178 children were asked to transfer the immunization data of their children from the WHO-ICV into the VAccApp. The respective WHO-ICV was photocopied for independent, professional data entry (gold standard). Demonstrating the status quo in vaccine information reporting, a Recall Group of 278 parents underwent structured interviews for verbal immunization histories, without the respective WHO-ICV. Only 9% of the Recall Group were able to provide a complete vaccination status; on average 39% of the questions were answered correctly. Using the WHO-ICV with the help of the VAccApp resulted in 62% of parents providing a complete vaccination status; on average 95% of the questions were answered correctly. After using the VAccApp, parents were more likely to remember key aspects of the vaccination history. User-friendly mobile applications empower parents to take a closer look at the vaccination record, thereby taking an active role in providing accurate vaccination histories. Parents may become motivated to ask informed questions and to keep vaccinations up-to-date.

## 1. Introduction

The World Health Organization (WHO) recommends that each patient-physician encounter should be utilized to determine the patient's vaccination status (Robert Koch Institute, 2014; Hutchins et al., 1993). In an effort to harmonize vaccination records for international travel, the WHO has issued the *International Certificate of Vaccination or Prophylaxis* (WHO-ICV), sometimes referred to as "the yellow card" (World Health Organization, 2005).

In many European countries, centralized vaccination registries are not available, but parents are maintaining a paper-based vaccination record for their children at home (UNICEF, 2016). In Germany, the WHO-ICV is used as the standard vaccination record, where any routine, special indication and travel vaccines are documented (UNICEF, 2016; National Vaccine Advisory Committee, 2003). Parents rushing their children to the emergency department (ED) however, often forget to bring the WHO-ICV with them (Goldstein et al., 1993). Pediatricians and surgeons may require the information in the acute care situation (Macken et al., 2013; Brown, 2012). In these instances, the parents will be asked to remember which vaccines have been administered to their children

("parental recall") (Williams et al., 2007). The most common answer during verbal immunization histories is that the children have received "the usual vaccines". Further details are often inaccessible (Miles et al., 2013).

The European Centre for Disease Prevention and Control (ECDC) as well as the VENICE project keep track on vaccination rates in different EU member states (VENICE II Consortium, 2012; Lopalco and Carrillo, 2014). According to ECDC, German vaccination rates are lower than in many other European countries (VENICE II Consortium, 2011). A recent global survey of vaccine acceptance around the world revealed that Europe is in fact the WHO region with the lowest vaccine acceptance (Larson et al., 2016). Germany is one of the countries with significant issues in this area. As a result, vaccine-preventable diseases (VPD) are still posing a health risk to children in Germany today. For example, the prevalence of measles infections remained high during the past decade, despite the universal recommendation and availability of measles vaccines (Neuhauser et al., 2014). Disease outbreaks are the consequence (Robert Koch Institute, 2016; Opel et al., 2014).

The combat against VPD would benefit from empowered parents, who are able to provide detailed and accurate vaccination histories and who are in a position to interpret what has been documented in the vaccination record (Sabnis et al., 2003). Scientific studies assessing the ability of lay people to understand and report the content of a WHO-ICV however, are lacking (Maurer et al., 2014).

To enable parents to report accurate vaccination histories, the Vienna Vaccine Safety Initiative (ViVI) has developed a digital vaccine education and empowerment tool (*VAccApp*) to be used on smartphones or tablet computers (MacFadyen, 2014; Norman and Yip, 2012; Seeber et al., 2015). The *VAccApp* was designed to invite parents to take a look at the WHO-ICV and to engage in a virtual dialogue covering all aspects of vaccines administered to their children, thereby making parents an active partner in protecting their family. The development of this educational intervention was informed by the data gathered from a separate group of parents, who tried to remember the vaccination status of their child in the absence of a vaccination record ("Recall Group").

The verbal immunization histories generated awareness of knowledge gaps among parents and additional insight into how parents are remembering different kinds of vaccination events. This feedback was leveraged to create a user-friendly mobile application. The reported validation project was thus designed to assess the *status quo* and to test a practical means for improving the *status quo* using a beta version of the *VAccApp*. We are presenting the results of a validation study testing the *VAccApp* in the typical user-group of parents waiting for their child to be seen at a pediatric emergency room in Berlin, Germany. To the author"s knowledge no similar educational tools have been developed so far. Different applications and text message services for appointment reminders have shown promising results in increasing the vaccination rate among users but did not test the knowledge of parents regarding the vaccination status of their children (Oyo-Ita et al., 2011; Stockwell et al., 2012; Wakadha et al., 2013).

## 2. Methods

### 2.1. Participants

The validation project was conducted from March 2012–August 2014 in the context of quality management (QM) programs at the Charité Department of Pediatrics in collaboration with the Robert Koch Institute in Berlin, Germany, as described previously (Rath et al., 2013; Chen et al., 2014; Karsch et al., 2015; Obermeier et al., 2016; Tief et al., 2016). Infants and children (0–18 years of age) presenting to the ED or hospitalized with suspected vaccine-preventable diseases (e.g. influenza-like illness or infections of the central nervous system) participated in QM programs approved by the institutional review board (IRB, EA24/008/10, EA2/161/11). Their parents were eligible for

*VAccApp* user-testing. Informed consent procedures were waived by the IRB for the purpose of quality improvement.

### 2.2. Standard operating procedure (SOP)

According to the QM SOP, vaccination records were solicited from all patients participating in the QM program. When the WHO-ICV was available, a photocopy was obtained for manual data entry into an anonymized PostgreSQL database, performed by an independent data entry professional, followed by double-entry verification (gold standard).

When vaccination records were *not* available (in approximately 74% of cases) trained QM staff conducted structured interviews, asking the parents about the vaccination status for every VPD separately (i.e. "Was your child ever vaccinated against rotavirus?" — Yes/No/I do not know). After completion of the interview, parents were asked to hand in the WHO-ICV later, for a photocopy and professional data entry ("Recall Group").

From January 2014–August 2014, those parents who were fluent in German and who had brought their WHO-ICV with them, were invited to transfer the information (as they understood it) from the WHO-ICV into the *VAccApp* ("*VAccApp* Group").

Professional data entry from the same vaccination record served as the gold standard for the quality of data obtained with the *VAccApp*. Likewise, the quality of data obtained from verbal immunization histories in the absence of a vaccination record was compared to the gold standard, i.e. professional data entry from a vaccination record later provided by the parents.

Both the structured interview as well as the *VAccApp* solicited the same basic information regarding 25 different vaccine types.

The *VAccApp* also contained a brief pre/post testing feature, assessing potential short-term learning effects resulting from *VAccApp* utilization: Initially, participants were asked to remember off-record, whether their child had ever received any of three commonly used childhood immunizations. The same question was repeated immediately after *VAccApp* utilization. The pre/post testing had to be completed without consulting the WHO-ICV or the *VAccApp*.

After using the *VAccApp*, parents were also invited to provide a feedback regarding the mobile application itself, using a standard instrument, the so-called System Usability Scale (Brooke, 1996; Bangor et al., 2008). The System Usability Score consists of ten statements (e.g. "I felt very confident using the app"), which are judged by the user on a five point Likert scale. Scores are reported ranging from 0 ("worst imaginable") to 100 ("best imaginable") (Brooke, 1996; Bangor et al., 2008).

### 2.3. VAccApp design

The *VAccApp* was designed to help parents understand the vaccination record of their children. The mobile application was developed by ViVI, a Berlin-based vaccine safety think tank and non-profit organization, in collaboration with the School of Design Thinking in Potsdam, Germany (Seeber et al., 2015). Design Thinking is an innovation technique first taught at Stanford University with a strong focus on user-centeredness and interdisciplinary thought processes (MacFadyen, 2014). The visual language of the *VAccApp* is non-threatening and playful, using graphical representations of health care practitioners and vaccine recipients (avatars) keeping the user engaged.

For the purposes of the QM program, the *VAccApp* beta version was provided on *Google Nexus 7 Tablets™* as a mobile application for *Android* systems (Seeber et al., 2015). During the evaluation period, the *VAccApp* remained on the tablet computers provided by QM staff. Parents entered the requested information autonomously and anonymously while waiting for their child to be seen by a doctor.

When using the *VAccApp*, parents were instructed to open the vaccination record and to look up any of the requested information in the