

## DEVELOPING A COHORT WEB APPLICATION: REAL-TIME MONITORING OF BREASTFEEDING INDICATORS

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### Abstract

Investing in the development of methodologies for timely intervention in breastfeeding practices that provide improved indicators and prolong breastfeeding duration positively impacts the health of women and children. **Aim:** To develop children cohort data capture interface of a national reference institution for high foetal, neonatal and child risk from birth, covering all hospitalisation up to the second year of life for real-time monitoring of breastfeeding indicators and prevalence. **Methods:** Four primary criteria were considered: data security (specific permissions for different profiles and encryption of sensitive data), researcher time streamlining, data quality and construction of data export auxiliary tools. **Results:** A web-based tool for data collection using a mobile device or computer was developed. The tool successfully allowed the ongoing collection for a defined population cohort of measures related to breastfeeding: maternal factors, child-related factors, health service issues, pacifier use, introduction of fluids and other processed foods, as well as breastfeeding practice. **Conclusion:** The developed product enables the validated extraction and collation of data from existing electronic records and other sources for the monitoring of breastfeeding practices. Such data can be used to refine guidelines and individual behaviour to maximise the benefits of breastfeeding and avoid early weaning.

**Keywords:** telehealth; web application; nursing; breastfeeding; cohort; Brazil

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### Introduction

Breastfeeding brings short, medium, and long term benefits, and is considered an investment for the future by promoting the health of women and children, thereby supporting human capital development and economic return for the nation.<sup>1</sup> Improved breastfeeding rates can impact the morbidity and mortality of mothers and children, potentially save the lives over 800,000 children and 20,000 women worldwide annually.<sup>2</sup> Thus, the investment in the development of methodologies that allow prompt intervention in breastfeeding behaviour, to ensure a higher prevalence and longer duration would be valuable and positively impact the health of women and children.

Monitoring and assessment are some of the components of the National Policy for the Promotion, Protection and Support of Breastfeeding (BF) in Brazil, aimed at following-up the status of national BF indicators and Policy-related interventions, as well as encouraging and supporting related

research.<sup>3</sup> The latest national prevalence survey was conducted over 10 years ago, and cross-sectional data are limited to the sixth month only.<sup>4</sup>

The monitoring of BF indicators in Brazil is the responsibility of the health facility (hospital, primary health unit, and maternity hospitals).<sup>3</sup> To date, Brazil has not invested in establishing strategies that allow near-time follow-up and monitoring of the child's feeding practice for the first two years of life, especially for the first six months, during which time exclusive BF is recommended for all children.<sup>5</sup>

Therefore, a study was designed to investigate the prevalence and duration of breastfeeding and their relationship with determinants in the first two years of life. A cohort of children born at the National Institute of Women, Children and Adolescents Health Fernandes Figueira (IFF/FIOCRUZ) was followed. This national reference institution for foetal, neonatal, and child high risk was chosen because of its vocation for teaching and research, its level of

excellence, and the volume of annual records of hospital visits, admissions, and newborn profiles with significant variability in risk exposures. The IFF/FIOCRUZ is equipped with a Human Milk Bank, and it is a National Referral Center for the Brazilian Network of Human Milk Banks and a Global Referral Center for 23 cooperating countries.

A major goal of this longitudinal study was to maintain data continuity and avoid participant dropout and associated data losses, albeit temporary. To minimise this, a combination of monitoring strategies, directly and indirectly related to obtaining information for the study,<sup>6</sup> and proper follow-up of participants were employed to ensure sufficient and reliable information to identify and classify incident outcomes of interest.<sup>7</sup>

Given the need to collect and manage large volumes of data in a prospective longitudinal study on breastfeeding, and the enormous challenge of preventing follow-up losses, we considered the development of a tool that would allow cohort follow-up. It was anticipated that this would serve as a monitoring prototype for the institution, with the potential to be applied in state reference centres throughout the national human milk bank network.

Thus, this study describes the development of a web-based application that facilitates the capture of data from a study cohort, and allows near-time monitoring of breastfeeding indicators, its prevalence, and duration. The data include foetal, neonatal and child risk information from birth, covering all hospitalisation up to the second year of life.

## Methods

This applied research involved the development of a web application for data capture of breastfeeding practice on a mobile device or computer. The application was initially developed a doctoral thesis<sup>8</sup> with a proposal for later implementation at a reference service.

The planning and development of the application involved a nurse, a system's analyst and a team of four experts. Collectively the experts (nurse, paediatrician, Human Milk Bank Network (Rede Brasileira de Bancos de Leite Humano: rBLH) coordinator, and epidemiologist) had recognised experience in the area of breastfeeding, human milk, and epidemiology. The team reviewed the proposed technological solution, critiquing the approach to facilitating participant adherence over time, to improve the questionnaire, and to assess the relevance and appropriateness of the questions against the proposed objective.

Three steps were required to build the software: i) data entry structuring, ii) computational application building, and iii) pre-test application, and pilot study to adjust application execution problems.

*Data entry structuring.* The application was structured into five questionnaires related to the theme, as per the forms

created especially for this study, i) the participants' profile characterisation questionnaire (newborns and their mothers; with baseline information on prenatal care, childbirth and immediate postpartum care; related to the child, health service use and breastfeeding); ii) follow-up questionnaire for each hospitalisation (information regarding participants, health service used, pacifier use, and feeding practice record); iii) questionnaire for first consultation after hospital discharge (information regarding mother, child, pacifier use and breastfeeding); iv) the monthly follow-up up to six months (information regarding mother, child, pacifier use, readmission and breastfeeding); and (v) early weaning questionnaire. Details about participants, setting, and procedures have been published elsewhere.<sup>9</sup>

*Computational application building.* A responsive web application was developed using a Bootstrap framework.<sup>10</sup> This is a serverless architecture where the application incorporates third-party "Backend as a Service" (BaaS Firebase)<sup>11</sup> services and includes custom code run in managed, ephemeral containers on a "Functions as a Service" (FaaS) platform.<sup>12</sup>

*Pre-test application and pilot study.* To adjust the application's data capture interface a pilot of the data collection instrument was performed with 20 volunteer nursing mothers with a social and functional profile similar to the target population.

After the pilot study, a three-stage data capture process was implemented for the study. Data were captured for a birth cohort of all children born in the institution between March 2017 to October 2018, excluding those with contraindications to breastfeeding (HIV, HTLV, inability to feed themselves orally, and incompatibility with life).<sup>9</sup> The first stage occurred in the maternity ward with individual interviews and data extraction from medical records. In the second stage, the mothers were interviewed during the first consultation after hospital discharge. In the third stage, telephone interviews were conducted at each month of the child's life (up to six months, and then at 24 months of life) to obtain information about the children's feeding practice. The application was used at all stages of follow-up by a previously trained team (leading researcher and research assistant staff).

## Results

A web-based tool was developed for data collection using a mobile device or computer. The tool is an organised breastfeeding monitoring system for mothers and their children up to two years of age. Identification and assessment forms (based on three main pillars: security, quality, and low-cost infrastructure (webserver)) are provided to capture data for each health system encounter. It has been using Bootstrap and Firebase Progressive Web Application technologies to support non-relational data storage and application hosting.

During development, the demands of different collection

stages and departments (maternity, neonatal and neurosurgical intensive care units, neonatal care follow-up outpatient clinics and the Human Milk Bank) were considered. The platform was designed to be, flexible, to facilitate input from these multiple data sources (data extraction from medical records, plus face-to-face interaction and telephone interviews with mothers). Interviews were conducted using the application to gather information from the mothers of 1,003 newborn cohorts.

At each data collection point, several attempts were made to contact the participating mothers, thus ensuring follow-up contacts within the specified timeframe in order to avoid follow-up losses and secure adherence and bonding with the research team. The application's home screen (Figure 1a) informs when each child completes a month, and year of birthday.

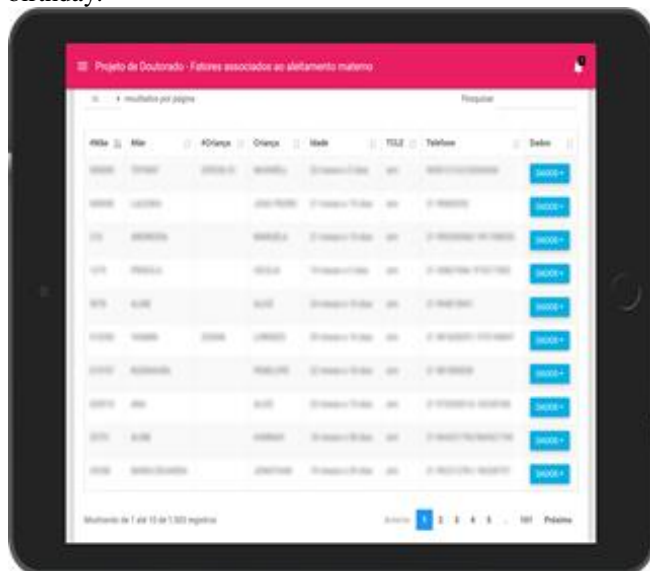


Figure 1 (a). Main page with access to all newborn forms.

The data collected were imbalanced, and 75 mothers (7.5%) were lost to follow-up,<sup>9</sup> which ensured internal validity for this longitudinal study. Proper follow-up of participants is necessary to ensure that sufficient and reliable information is obtained for the identification and classification of incident outcomes of interest in the study.<sup>6,7</sup>

The tool was demonstrated to be successful in several aspects, based upon the experience of the leading researcher and research assistant staff as implementers and users. For example, the tool enabled the monitoring of all low and high-risk children in the cohort for up to two years of age, providing insight in 'near time' of the prevalence of breastfeeding and breastfeeding practices, supporting timely intervention to prevent premature discontinuation of breastfeeding. In addition, use of the tool was found to be intuitive, being easy to understand and fill out for any trained professional, and facilitated data collection and minimised loss to follow-up by highlighting best time to conduct telephone interviews with mothers. It also ensured

confidentiality through different levels of user access authorisation. Finally, reports of data-based information could be compiled and exported in interchangeable formats for different statistical software, always respecting the arrangement of rows and columns. This feature allowed, for example, ongoing near time estimate of the prevalence of breastfeeding; functions as a complementary strategy in maintaining cohort adherence; allows automatic recording of data between screens; and favours the streamlining of different times (completion, data processing, typing, linking, face-to-face interviewing and time of researchers and women in the various data capture contexts).

When recruiting a mother and their newborn for follow-up, the admission form was completed (Figure 1-b) with questions on identification, date of birth, date of admission and discharge, address, and telephone number. In this screen,

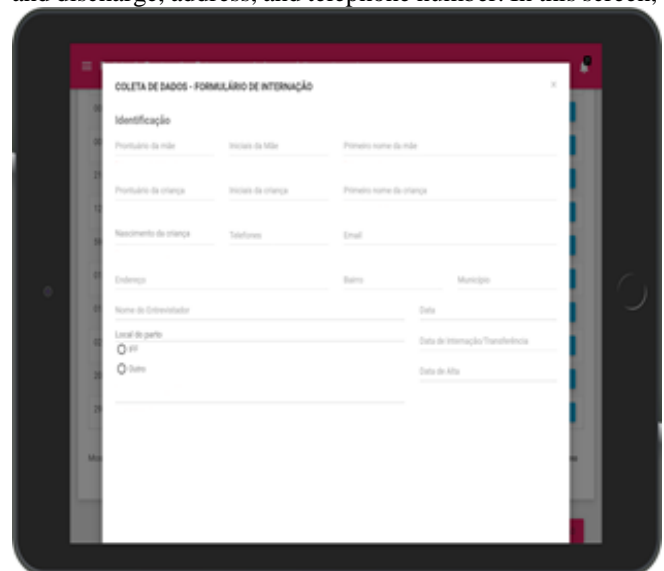
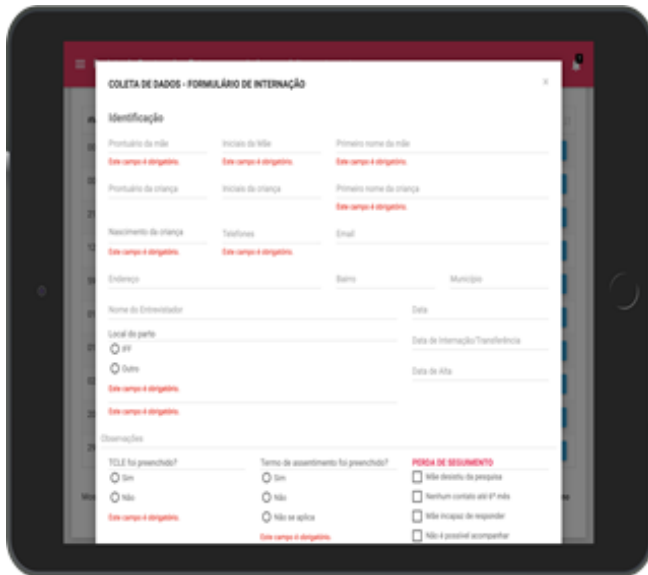


Figure 1 (b) - Application Screenshot: Admission Form.

the nurse/researcher entered answers from the different blocks of questions regarding maternal factors, factors related to the child, the health service, the use of nipples or industrialised liquid foods, and breastfeeding habits. The transition between screens allowed automatic saving. The application had a feature that automatically recorded the interview date and participant identification with a key code, allowing simultaneous collection of data from different sources by more than one research assistant. In addition, the data were structured and stored non-relationally, allowing constant development of the form and permitting quick action for any necessary changes in the follow-up of children. By establishing 'required fields' (Figure 1c) the system prevented advancing forward before completing the field. A red alert showed the need to answer the question before proceeding to the next block. This measure formed a part of the quality control process. In addition, the reason for loss to follow-up could be recorded (bottom right, Figure 1c), choosing from: mother gave up on the research, no contact



**Figure 1 (c).** Validation and required fields.

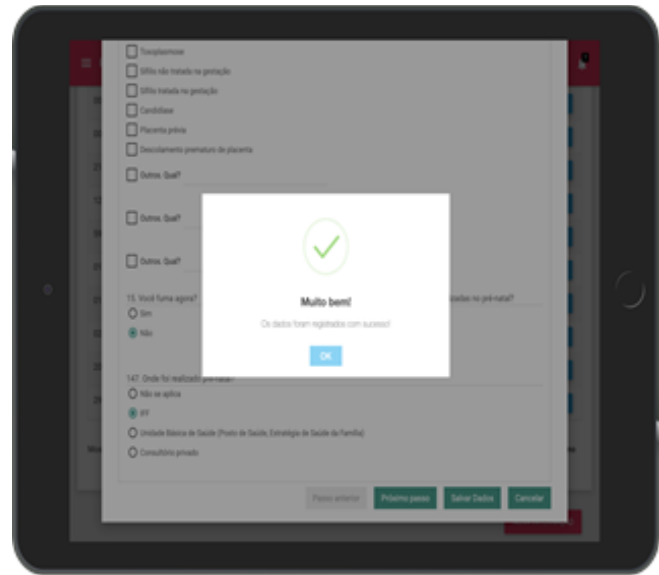
made up to 6 months, mother unable to answer, or not possible to follow-up.

After completing any form, it was necessary to press the SAVE key to store the responses in the database (Figure 1d). Each new interview involved selecting a new form that automatically became available. Viewing spreadsheets and reports required exporting of the stored data, as described earlier.

## Discussion

This study describes the successful development and application of a tool by which to monitor breastfeeding performance and habits of mothers and their newborns and illustrates the main benefits of the application. As a monitoring tool, the developed system supports tracking of feeding practice from birth to two years of a child's life. The benefits included: adherence to protocols for data collection, guaranteeing confidentiality and security levels; timely data capture; flexibility to use on different electronic devices; use of different data sources; adherence to protocols for data collection, and supporting quality data collection and analysis. The application facilitated near time knowledge of breastfeeding indicators, and thereby timely interventions to prevent early interruption of breastfeeding. Further investments are required to encourage monitoring of breastfeeding indicators in other spheres.

Increasingly mobile device apps are being used for health research, service delivery, and public health surveillance through aiding community data collection.<sup>13</sup> Studies have shown fewer errors when collecting data using questionnaires on mobile devices versus paper.<sup>6,14</sup> As a surveillance system the tool identifies breast feeding related sentinel events impacting mothers and newborn quality of care. Although there were no studies on the development of



**Figure 1 (d).** Automatic saving of data in the passage for each question block.

this type of data collection application in this context,<sup>15</sup> the creation and computerisation of this meaningfully supports breastfeeding follow-up and, especially, allows timely interventions, to discourage premature interruption of exclusive breastfeeding.

The product uses serverless technologies that remove the burden of infrastructure, and accelerate the development process by allowing time to create the leanest data collection forms and create field versions. Computerised data collection can also reduce human errors during data entry, contributing to better data quality and increased credibility of survey results.<sup>16</sup> One improvement proposed by the team involves the creation of an alert system to issue notification from the beginning of the follow-up contact period until the end of this period.

This study is one of the few on the development of this kind of application for data capture and monitoring of health indicators, especially breastfeeding in Latin America, and one of the first to develop an organised system for monitoring breastfeeding and its determinants in Brazil.

The main limitations of the application are its Internet dependence and lack of integration with the institution's medical records system. The use of the application is limited to the hospital context by the need to check information regarding hospitalisations.

## Conclusion

The breastfeeding monitoring application offers more rapid insight regarding current breastfeeding habits, and is important to allow meaningful, accurate, and timely planning of short-term actions to improve breastfeeding outcomes. The architecture of this technological solution proved to be effective and efficient in managing high volume data from

different sources, in ensuring quality and security during all stages, and in offering expected functionalities for prospective observational studies and is an essential contribution as an organised system for monitoring breastfeeding from birth to up to two years of age.

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