

Lhia as A Chatbot for Breastfeeding Education

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Human milk is the most important way to feed and protect newborns as it has the components to ensure human health. Human Milk Banks (HMBs) form a network that offers essential services to ensure that newborns and mothers can take advantage of the benefits of human milk.

Keywords: chatbot ; breastfeeding ; human milk ; co-design ; deep learning ; natural language processing ; milk

1. Breastfeeding Education

Breastfeeding education aims to increase mothers' knowledge and skills in breastfeeding, help them see breastfeeding as normal, and help them develop positive attitudes towards breastfeeding ^[1]. While the audience is usually pregnant or breastfeeding women, it may include fathers ^[2] and others who support the mother who is breastfeeding ^[3]. It can be given in any space or time, as long as it is given with experience and specific knowledge in breastfeeding management ^[4].

Different breastfeeding support strategies can be used, always taking into account the individual needs of each mother during the breastfeeding process, thus seeking to improve their feelings, power capacity and their self-efficacy in breastfeeding ^[4]. The breastfeeding education is an effective strategy to promote exclusive breastfeeding ^[5]. Postnatal home support provided by community health workers increases breastfeeding duration and knowledge ^[6]. Education via mobile text messages and Internet (e.g., smartphone applications) has also been considered an effective tool to promote exclusive breastfeeding. Along with classical support methods, Internet-based tools provide another possible method for promoting positive long-term breastfeeding outcomes ^[7].

2. Human Milk Donation

HM donation is essential to increase the chances of recovery of preterm infants and/or low-birth-weight newborns who are hospitalized in NICU, in addition to providing a healthy development for them. Human milk protects against necrotizing enterocolitis, late onset sepsis, retinopathy of prematurity, bronchopulmonary dysplasia, and aids in neurodevelopment in babies born with ≤ 28 weeks gestation or with a mean birth weight of ≤ 1500 g ^[8].

A difficulty in prematurity is associated with the immaturity of the gastrointestinal tract of the premature newborn. In preterm infants, the development of the gut microbiota is disrupted by events related to prematurity, such as mode of delivery, antenatal and postnatal use of antibiotics, minimal exposure to maternal microbiota, and low intake of HM ^[9]. Human milk is better tolerated by preterm infants than artificial formulas, as it contains immunobiological nutrients that stimulate intestinal maturation and motility ^[10]. The sooner babies start breastfeeding, the greater their chances of survival and healthy growth ^[11].

Every healthy woman who breastfeeds and has more than enough milk for the full development of her baby can be an HM donor, and any donation of HM can help premature newborns ^[12]. Despite the benefits of HM for preterm infants, HM stocks available in HMBs are usually much smaller than the demand for NICU and, with the coronavirus pandemic, the demand for HM for high-risk newborns admitted to NICU increased ^[13]. Therefore, new strategies to encourage HM donation are needed.

3. Conversational Agents

Chatbots are software solutions that can interact with humans through a conversational interface ^[14]. They are also known as talkbots, smartbots, bots, chatterbots and conversational agents. Chatbots tend to communicate with the user and behave like a human being. They are usually connected to messaging services (e.g., Telegram, WhatsApp), web pages and mobile applications. Chatbots may be classified into two types ^[15]: based on rules and AI techniques. Rule-based chatbots use the concept of a state machine, which consists of a rule engine that determines the set of inputs needed to

transition from one state to another. Question and answer structures are pre-defined to enable the chatbot to control conversations; thus, the chatbot only performs pre-established actions ^[16].

AI-based chatbots can understand natural language and not just predefined commands ^[14]. In addition, they manage to maintain different contexts of conversations and provide the user with richer and more engaged conversations ^[17]. This type of chatbot can use AI techniques for Natural Language Understanding (NLU) ^[18]—in particular, in the tasks of intent classification and entity recognition ^[19]—and Natural Language Generation (NLG) ^[20]. Chatbots with a NLU component can analyze natural language by extracting concepts, entities, emotions, keywords, and interpret it into a computer language ^[18]. Chatbots with an NLG component, called generative chatbots (e.g., ChatGPT by OpenIA, Bard by Google, Bing Chat by Microsoft), use a Large Language Model (LLM) to generate responses in a fluid and coherent way for each interaction made by the user ^[21].

4. Internet Interventions in Supporting Breastfeeding

Studies have reported positive outcomes related to the usability and effectiveness of chatbots in healthcare, but the evidence is not yet strong ^[22]. An increasing number of chatbots for healthcare have been developed and studied, including those focused on health education ^[23]. Also, deep/machine learning-based approaches have been used frequently for developing chatbot systems in the health domain ^[24]. However, although chatbots for healthcare are evolving, to the best of our knowledge, little has been achieved specifically using chatbots as an intervention in breastfeeding education and recruitment of donor mothers ^[25].

A first initiative of chatbots for educational support in breastfeeding was Tanya ^[26]. It was a female, multiracial, computer-animated character that was displayed on the computer screen. A pilot study with 15 mothers in the perinatal period demonstrated that Tanya may be helpful in improving rates of exclusive breastfeeding, particularly when there is no adequate healthcare professional support ^[26]. When evaluating the ability of the chatbot to longitudinally maintain continuity of care on postnatal, Zhang et al. ^[27] observed that home use of Tanya may help mothers with stability, reliability, and comfort during breastfeeding.

Yadav et al. ^[28] aimed to understand the potential of chatbots for breastfeeding education in India. They conducted a Wizard of Oz experiment (i.e., a human emulating functionalities of a chatbot) that made participants believe they were chatting with a real chatbot. Results demonstrated that a majority of breastfeeding-related questions can be answered by a chatbot.

In Brazil, a first related effort was performed by Barreto et al. ^[29] when developing and evaluating the *GISSA Chatbot Mamãe-Bebê* (*GISSA chatbot*). This chatbot is concerned with maternal and child health in Brazil, and has a module developed for mothers/caregivers of children under two. The module provides information related to breastfeeding, food introduction, immunization, growth and development milestones. An experimental evaluation with 142 puerperal women using the GISSA chatbot demonstrated good results in relation to its use by the participants regarding simplicity, quality of information, clarity of content, usefulness and satisfaction.

As opposed to the previous proposals, *Lhia* is a tool designed to offer an innovative way to support breastfeeding mothers, through education and, in addition, recruit mothers to donate HM to the HMB. It is proposed for the Brazilian Portuguese language (PT-BR), the official and most spoken language of Brazil, and it is focused on aspects of breastfeeding culture in the Brazilian context. *Lhia* was developed from technical knowledge using a co-design approach, in which experienced health professionals collaborated to build the conversational flow. Moreover, a DL-based NLP pipeline was deployed to enable the chatbot to answer questions related to breastfeeding.

Lhia is proposed as a virtual breastfeeding consultant that uses conversations based on text messages and illustrative images through Telegram and WhatsApp. It was developed using a co-design approach in partnership with the HMB of the University Hospital of the Federal University of Maranhão (HU-UFMA), a center focused on the promotion, protection and support of exclusive breastfeeding, which has been operating for over 20 years in a maternity hospital. *Lhia* allows the identification of different types of problems faced by mothers who breastfeed. It is able to identify when a mother has a problem that could lead to early weaning and thus intervene, by guiding her correctly or indicating the appropriate professional care to ensure successful breastfeeding. Furthermore, *Lhia* provides incentives for HM donation through an active notification mechanism (i.e., it autonomously initiates conversations aimed at recruiting mothers).

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