Impact of COVID-19 pandemic in breastfeeding consultations on LactApp, a mHealth solution for breastfeeding support.

Running head: Influence of COVID-19 in a mHealth breastfeeding app

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ABSTRACT

Introduction: Breastfeeding is an unquestionable right of mothers and their children; however, it is not a one-woman job. For breastfeeding to succeed, women must have access to appropriate support and guidance. The COVID-19 pandemic and subsequent restriction measures and lockdown to reduce community spread of the disease have negatively impacted breastfeeding support from health services and thus, in mothers' breastfeeding experiences.

Objective: The present study aims to evaluate the impact of COVID-19 pandemic on breastfeeding consultations in LactApp (a mobile app for mHealth focused on breastfeeding support, www.lactapp.com) during the COVID-19 pandemic.

Materials and Methods: We conducted an observational, descriptive, and retrospective study with LactApp data recorded between July 2018 and March 2021 including 9,151,456 queries classified in 48 topics among 137,327 active users. We used Interrupted time series model to evaluate the increase of number of queries consulted and active users due to the COVID-19 pandemic. Wilcoxon test was used to study the increase of certain topics due to the COVID-19 pandemic.

Results: LactApp active users increased by 12,092 users (p-value<0.001) during the COVID-19 outbreak and confinement and queries consulted in LactApp also significantly increased by 10,899 queries per month after the pandemic outbreak. The breastfeeding topics that significantly increased are those related to growth spurts, breastfeeding stages, breastfeeding technique, breast pain and mastitis, problems with infants not gaining weight correctly, hypogalactia, increased milk demand, and relactation. These findings are important to understand the potential of online tools when face-to-face professional support is unavailable.

Conclusions: Critical issues in breastfeeding establishment were highly consulted and significantly increased in the App during the pandemic. We believe that LactApp was a useful tool for breastfeeding support when women could not obtain appropriate support elsewhere. LactApp might be a powerful tool to identify critical issues of breastfeeding and trends in an automatized way.

1. INTRODUCTION

Breastfeeding is an important part of women's reproductive cycle and its practice benefits both mother and child. It is the natural result of pregnancy and childbirth and causes changes in the maternal organism that favours good physical and emotional health, not only during breastfeeding but in women's future life[1-3].

Breastfeeding is an unquestionable right for mothers and their children; however, it is not a one-woman job. Whereas the baby's instinct to nurse is innate, the act of breastfeeding is not always natural, and women need to learn. Women who choose to breastfeed need the support of their families, health professionals and healthcare systems, society, and governments. For breastfeeding to succeed, women must have access to appropriate support and guidance[4].

The COVID-19 pandemic has brought fear and anxiety among countries and has led to restrictive public health measures to reduce the community spread of the disease[5, 6]. These measures affected women's well-being during pregnancy, birth and postnatal care period[7]. A few recent studies have reported that policies aimed at limiting interpersonal contact to reduce SARS-CoV-2 transmission led to negative postpartum experience, poor postpartum mental health and problems with breastfeeding due to lack of in-person breastfeeding support, which caused early cessation of breastfeeding[7-14].

A few studies have reported that during the pandemic women needed support in technical issues such as difficulties with latch, perception of insufficient milk, breast pain, relactation, and reducing supplemental infant formula milk[12, 14].

Under this paradigm, women needed to seek breastfeeding support in technological tools like web pages and mobile applications such as LactApp (https://lactapp.com/). LactApp is an mHealth solution designed for breastfeeding support[15, 16]. LactApp gives mothers customized expert answers to breastfeeding and maternity questions by

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leveraging Artificial Intelligence (IA) technology. Downloaded by over 500,000 users worldwide, since 2018 the App has answered over 16.6 million consultations automatically so far and is available to download in English and Spanish as a free version for mothers and as free or premium version for healthcare professionals (LactApp Medical). Due to the large number of breastfeeding consultations that LactApp receives, it might be a potential tool to identify difficulties, critical points of breastfeeding and changes in women breastfeeding experiences in a semi-automatized way.

The aim of the present study is to evaluate the impact of COVID-19 pandemic on breastfeeding consultations in LactApp.

2. MATERIALS AND METHODS

2.1. LactApp: an mHealth solution for breastfeeding support

LactApp is a free mobile application developed to support breastfeeding. LactApp's performance has been described elsewhere[15, 16], but briefly LactApp 's main functionality is an automated breastfeeding consultation system that works as a self-administered questionnaire based on 48 decision trees that include topics related to breastfeeding, maternity, maternal and child health, built with questions and answers and supported by scientific evidence and up-to-date official health guidelines. The result of the questionnaire leads to more than 2,300 personalized answers that can be reached through more than 76,100 possible paths across the decisions trees, which vary according to the user's and her baby's profile. Personalized answers include messaging to seek for professional medical help when needed.

LactApp also provides functionalities of breastfeeding monitoring, such as child growth tracking functions, child's infant stools and breastfeeding trackers. Other features that

LactApp offers are breastfeeding tests and personalized plans and it is also possible to consult questions through a live chat function, hosted by lactation experts from the LactApp team.

Furthermore, we are developing an IA that is able to understand user queries in the live text-based chat and offer an immediate and personalized response, by effectively providing semi-automated (difficult questions are still replied to by experts) and real-time immediate guidance on the different breastfeeding topics that LactApp covers.

Due to the need to inform users about COVID-19 and lactation compatibility, LactApp included a new decision tree with specific questions and answers about this matter. That information is based on information from official organisations such as WHO and Centre for Disease Control and Prevention (CDC).

2.2. Study design and data collection

We conducted an observational, descriptive, and retrospective study with LactApp data recorded between July 2018 and March 2021 including 9,151,456 queries classified in 48 topics among 137,327 active users.

LactApp's data collection system has been explained previously[15]. Briefly, LactApp collects the e-mail of registered users along with other optional data about age, home city, pregnant or not pregnant, due date, number of children. Also, LactApp collects data about the mother's registered child: baby's date of birth, sex, whether the baby was preterm or not, gestational week born at, and weight and height at birth.

Moreover, LactApp also registers all final answers that the user reached along with the day and time of the query, user identifier, operating system of the mobile phone used and language used in the query.

Additionally, Google Firebase was used to register the number of active users and total queries visited in the app from 2017 to 2021. The data from those platforms are anonymized anonymized and aggregated[17].

2.3. Data analysis

Raw data management and statistical analysis were performed using R v 3.6.2 in R studio environment (v. 1.2.5001). Data of all final answers reached by the users were aggregated quarterly and yearly and by categories of the topic using Microsoft Power BI. The growth of visited queries was evaluated quarterly and yearly.

Interrupted time series analysis was performed to study the impact of the COVID-19 outbreak on the number of queries consulted in LactApp and number of active users. Using Interrupted time series model, we were able to calculate the predicted queries and users that LactApp would have received if the COVID-19 pandemic had not occurred, the real immediate impact on the number of queries and users, and the long-term impact of the pandemic on the number of users and queries.

Shapiro-Wilk test was used to evaluate the normality distribution of the variables. Since variables did not follow a normal distribution, we used a non-parametric Wilcoxon test to compare between the pre-pandemic (from July 2018 to February 2020) and the pandemic period (from March 2020 to March 2021). In order to reduce bias in the comparison due to the increased number of LactApp users during the pandemic period, queries were corrected using queries per unique user ratio. Queries were further aggregated by months; thus the main results of the present study are expressed in monthly queries per user. Live chat consultations classified by topics using IA were aggregated by weeks and therefore the results have been expressed in weekly consultations.

2.4. Ethical considerations

This study followed the Spanish Organic Law 3/2018, of December 5, on the Protection of Personal Data and guarantee of digital rights. Registration in LactApp requires users to accept Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 regarding the protection of individuals with respect to the processing of personal data and the free circulation of these data (General Regulation of Data Protection).

For the present study no user's personal information has been used and the data has been treated completely anonymous.

3. RESULTS

LactApp's active users increased 133% and total queries increased 116% after the COVID-19 outbreak, resulting in a mean of 389,984 breastfeeding consultations per month.

Figure 1 shows the Interrupted time series analysis. This graph plots the actual growth of queries received in LactApp and active users from 2017 to 2021. Moreover, the predicted number of queries and users according to the natural growth over time of LactApp is also plotted to show how the pandemic impacted LactApp's activity since the time point of March 2020 (the beginning of the COVID-19 pandemic in Europe). Table 1 shows the main results of the Interrupted time series model for total queries and active users. As shown, time significantly increased both queries consulted in LactApp (6,919 queries per month, p-value<0.001) and active users (785.3 users per month, p-value<0.001). COVID-19 outbreak and the beginning of confinement in Europe significantly increased active users by 12,092 users (p-value<0.001). And time since the COVID-19 outbreak significantly increased in queries consulted by 10,899 queries per month (p-value=0.003). Thus, after the COVID-19 pandemic, queries positively increased by 3980 each month.

As reported previously[15], the most consulted queries in LactApp are related to breastfeeding technique (12.6%), infant sleep and breastfeeding (8.9%), growth spurts (5.5%), introducing solid foods (5%) and breastfeeding stages (4.9%).

Monthly queries per user significantly increased during the COVID-19 pandemic (pre-pandemic= mean 19.25, pandemic =mean 23.11, p-value=0.02) as shown in Table 1. The breastfeeding topics that significantly increased after COVID-19 outbreak are those related to growth spurts (mean increase of 107%, p-value<0.001), breastfeeding stages (mean increase of 76.8%, p-value=0.01), breastfeeding technique (mean increase of 56%, p-value=0.003), breast pain and mastitis (mean increase of 43.3%, p-value<0-001), mother's disease and breastfeeding (mean increase of 38.5%, p-value=0.05), problems with infants not gaining weight correctly (mean increase of 31.2%, p-value=0.04), hypogalactia and sensation of insufficient milk production (mean increase of 26.4%, p-value<0.001), increased milk demand (mean increase of 21%, p-value<0.001), and relactation (significant mean increase of relactation personalized plan by 15.3%, p-value<0.001).

Whereas monthly queries per user that did not significantly change between the pre-pandemic and pandemic period were related to tandem breastfeeding (p-value=0.29), breastfeeding twins (p-value=0.73) or breastfeeding older infants (p-value=0.98), breastmilk pumping (p-value=0.3,) and breastmilk donation (p-value=0.8), infant care (p-value=0.31) and infant sleep (p-value=0.5), menstruation and fertility (p-value=0.1), pregnancy (p-value=0.78), returning to work (p-value=0.7), mother's health (p-value=0.9), feelings (p-value=0.67) and weaning (p-value=0.62) (Table 1).

Queries about COVID-19 have been highly visited during the pandemic (mean 11,304 queries per month from March 2020 to March 2021) and were in the top 20 most consulted queries in 2020, and the sixth most consulted in the first quarter of 2021. The

most answered question about COVID-19 was about the compatibility of the vaccine with breastfeeding.

One of LactApp 's core functionalities is its automated breastfeeding symptom checker. However, it is also possible to consult breastfeeding questions through an in-app live chat function, answered by breastfeeding experts within the LactApp team. Live chat consultations increased by 28.5% during the outbreak of COVID-19. Furthermore, thanks to LactApp experts' efforts to classify those queries into the different topics covered, (which is required for training IA) were able to assess the impact of such an increase in each of the different topics. Therefore, we can see how LactApp's live chat received significantly more consultations about mastitis and breast pain (mean increase of 105.7%, p-value=0.01) and how to latch on to the breast correctly (mean increase of 88.4, p-value=0.04) (Table 2). Other topics such as breastfeeding basics, infant not gaining weight correctly, introducing solid foods and growth spurts increased by more than 50% during the pandemic, however, that increase was not statistically conclusive due to high dispersion of the weekly consultations in the live chat.

4. DISCUSSION

The COVID-19 pandemic has unquestionably changed our daily life in every aspect. The general restriction measures affected women's well-being during pregnancy, birth and postnatal care period[5]. In-person support from a lactation specialist became restricted and consequently mothers experienced increased levels of stress and isolation[12].

Recent studies have reported that exclusive breastfeeding rates might have decreased during COVID-19 pandemic and lockdown in UK, Italy, US and Canada[7-9, 13, 14, 18, 19]. The reasons for breastfeeding cessation were shorter hospital stays at birth, deficient

professional support throughout the first days of life, worries about the safety of breastfeeding and symptomatology of COVID-19.

Due to the lack of in-person professional support from pediatricians, midwives, lactation experts and lactation support groups, mothers sought breastfeeding support in technological tools such as telehealth services (either phone-only or videoconferencing), chats and texting support via WhatsApp or HouseParty App, online support groups, web pages[8, 20, 21] and breastfeeding apps[22] such as LactApp. Interrupted time series model showed that LactApp active users increased largely during the COVID-19 outbreak and confinement and queries consulted in LactApp also significantly increased monthly after the pandemic outbreak.

Our main results are in concordance with an online survey of the Australian Breastfeeding Association reporting that mothers' main concerns during the pandemic were related to insufficient milk or weight gain, painful breasts, relactation and reducing supplemental infant formula milk. And these concerns were aggravated by the lack of health care access due to fear and unavailability[12]. Our results are also in agreement with Brown and Shenker 2021[14] which reported that the most common reasons for women to stop breastfeeding during the pandemic were insufficient professional support and technical issues such as difficulties with latch, perception of insufficient milk, breast pain and exhaustion[14]. All these toppics were highly consulted in LactApp and significantly more visited during the pandemic compared to the pre-pandemic period. Thus, LactApp could have been a potent tool to support breastfeeding when women had no support from health services. Moreover, since LactApp has been able to detect an increased need for support in this critical topic without asking breastfeeding mothers directly, LactApp might also be a powerful tool to identify trends, difficulties, and critical issues of breastfeeding in an automatized way.

Our results reveal a clear change in breastfeeding consultations due to the COVID-19 pandemic. Our lactation experts that are daily in contact with breastfeeding mothers through the live chat function, also detected a significant change in breastfeeding consultations. This data is not shown in the present work however this knowledge has helped to interpret the main results of this article.

Monthly queries per user about breastfeeding technique significantly increase in the pandemic period compared to pre-pandemic by 56%. The most consulted queries about this topic during the COVID-19 pandemic were about latching, breastfeeding on demand, breastfeeding positions and milk supply. Accordingly, another issue that significantly increased during the pandemic was queries related to infants not gaining weight correctly, monthly queries per user about those topics increased by 31%. Based on the information we obtained from breastfeeding women on the live chat, we believe that this fact could be attributed to the lack of breastfeeding support during the pandemic since mothers did not have professional guidance on a proper latch, optimal milk transfer and breastfeeding on demand which could have led to a deficient breastfeeding technique and poor milk transfer to the child. As a result, monthly queries about user perception of insufficient milk supply also significantly increased by 26%. These results are also in concordance with Brown et al. 2020 study which reported that women either expressed milk or gave formula as a supplement during the pandemic due to the lack of support which led to pain or poor latch[14]. We also believe that queries related to hypogalactia increased due to the perception of women not having enough milk supply, since they did not receive adequate in-person support to correct latching issues, positioning, or even evaluate potential oral complications of the infant such as ankyloglossia. However, further studies are needed to confirm this hypothesis.

Another feature that increased highly in consultations is the personalized relactation plan in the app. Relactation is the process by which a mother reestablishes breastfeeding after reducing milk production or having interrupted it for some time. Based on what breastfeeding women reported to us, mothers needed to search for information about relactation since breastfeeding was not successfully established in the crucial first days because most families were sent home shortly after birth without any further information or guidance. Another reason to search for information about relactation could be that infected mothers with COVID-19 were separated from their children either at birth or in older infants. Also, front-line midwives, nurses and physicians might have also been discouraging mothers to breastfeed during the first COVID-19 outbreak leading to an interruption of breastfeeding.

Monthly consultations per user about mastitis and breast pain also significantly increased by 43% in the self-administered questionnaire and by 105.7% in the live chat. As reported by breastfeeding women in the live chat this could be due to the fact, that most of face-to-face appointments were cancelled, many health care staff were unavailable because of the pandemic and women were afraid to go to a medical centre. This situation led women to seek information about mastitis symptomatology, management, and treatment in LactApp. Accordingly, queries about nipple damage care and breast lumps also significantly increased during the pandemic by 36% and 37%, respectively. These types of consultations are often dealt with in healthcare centers since they cause acute pain and other possible symptoms such as fever. However, as medical centers were unavailable, these consultations might have been transferred to LactApp.

The main limitations of the present study are that LactApp is available worldwide however, most of the users are from Spain (80%) followed by Mexico (4.3%),

Argentina (2.3%), Chile (2.1%), United States (2.1%), Colombia (1.4%), Germany (0.7%), Peru (0.7%), United Kingdom (0.7%), and Uruguay (0.5%). Thus, the results of the present study might be biased by the Spanish COVID-19 restriction measures and lockdown as well as Spanish culture, social habits and healthcare system. Moreover, user profile data and their children's data entry are optional and are not verified, thus the models may include some uncontrolled bias. Another limitation that we detected is that final answers are given according to the user's and their registered child's data, for example, mother's status (pregnant or not pregnant). If the user does not update her status in her user profile, personalized answers given by the decision tree algorithm might not have been corrected. Since we only registered the final answer but not the whole path, some of the results might also have bias.

In conclusion, COVID-19 restrictions negatively impacted breastfeeding support and mothers' breastfeeding experiences. Critical issues in breastfeeding establishment such as inadequate latching, perception of insufficient milk supply, breast pain and poor infant weight gain worsened during the COVID-19 pandemic due to lack of in-person professional guidance. These issues were highly consulted and significantly increased in the App during the pandemic. We believe that LactApp was a useful tool for breastfeeding support when women could not find appropriate support elsewhere. And LactApp might be a powerful tool to identify critical issues of breastfeeding and trends in an automatized way. However, this must be studied in detail in future approaches.

Author contribution:

P.Q.R, D.M.T, L.A.C and A.P.A were responsible for concept and design, methodology
and interpretation of data. P.Q.R and I.G.S extracted the data and performed the
analysis. P.Q.R drafted the manuscript and created tables and figures. All authors
revised and approved the final version of the manuscript.

All authors meet the criteria detailed in Author Instructions

Competing Interests statement:

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Tables

Table 1. Interrupted time series model for LactApp's number of queries and active

users.

	Number of queries		Number of users	
	Coefficient	p-value	Coefficient	p-value
Time	6919	<0.001	785.3	<0.001
COVID-19 outbreak	50562	0.14	12092	<0.001
Time since COVID-19 outbreak	10899	0.003	-263.2	0.15
Intercept	7699	0.65	117.9	0.21

Table 2. Monthly breastfeeding queries per user aggregated by topics before and after

COVID-19 pandemic. Results are expressed in median along with interquartile range

(IQR).

	Pre-pandemic (n= 68242 unique users)		Pandemic (n= 88822 unique users)		p-value
	Median	IQR	Median	IQR	
Breastfeeding complications					
Breast lumps	2.9	0.7	3.09	0.5	0.02
Breast pain and mastitis	3.48	0.4	4.16	0.4	<0.001
Hypogalactia	2.69	0.4	2.90	0.4	<0.001
Sore nipples	3.19	0.99	3.93	0.60	0.001
Breastfeeding technique					
Breast refusal	2.01	0.3	2.37	0.2	0.001
Breastfeeding infants over 6 months	3.11	0.7	3.05	0.5	0.98
Breastfeeding myths	7.58	1.4	6.77	1.1	0.01
Breastfeeding products	5.54	1.1	5.05	1.0	0.02
Breastfeeding stages	2.77	0.2	3.04	2.1	0.01
Breastfeeding technique	8.39	4.1	13.15	1.7	0.003
Breastfeeding twins	2.73	1.5	2.67	1.5	0.73
Increased milk demand	1.96	0.3	2.38	0.2	<0.001
Induced lactation	2.93	2.6	2.42	1.7	0.22
Mixed feeding	6.22	1.2	6.43	1.2	0.41
Relactation	1.90	0.4	2.13	0.6	0.29
Relactation Personalized Plan	1.80	0.3	2.01	0.3	<0.001
Shape and sizes of my breast	3.93	1.0	3.97	0.8	0.7
Tandem breastfeeding	5.17	2.5	5.27	2.3	0.29
The first days of breastfeeding	2.92	0.5	3.34	0.4	<0.001
Weaning	3.22	0.7	3.23	0.5	0.62
Infant care and breastfeeding					
Growth spurts	2.38	0.2	2.58	2.1	<0.001
Infant care	5.20	0.7	5.27	0.5	0.31
Infant does not gain weight	2.59	0.5	2.70	0.4	0.04
Infant poops	4.24	0.5	4.08	0.7	0.2
Infant sleep and breastfeeding	7.59	1	7.42	0.8	0.5
Infant's health	3.1	0.9	2.76	0.5	0.03
Introduction to solid foods	9.32	2.4	8.45	1.4	0.01
Preterm infants	2.51	1.5	2.70	1.0	0.06
Milk pumping					
Handling and storage of breastmilk	9.76	1.3	9.12	1.23	0.01
Health situation and breastfeeding	2.48	1.1	2.33	0.8	0.2
How to express milk	3.49	0.5	3.36	0.4	0.3
Milk donation	5.42	3.5	5.52	3.1	0.81
Women and breastfeeding					
Menstruation and fertility	3.38	0.9	3.62	0.7	0.1
Mother's disease and breastfeeding	2.37	0.88	2.08	1	0.05
Mother's diseases	2.07	0.3	1.94	0.4	0.02
Mother's feelings	3.78	1.0	3.60	0.8	0.67
Pregnancy	4.19	1.2	4.03	0.9	0.78
Returning to work	4.35	0.8	4.31	0.8	0.7
Total queries	*18.23*	*3.9*	*20.57*	*4.0*	*0.02*

Table 3. Weekly breastfeeding consultation in LactApp's live chat. Selected topics were classified with support of the IA. Results are expressed in median along with interquartile range (IQR).

	Pre-pandemic		Pandemic		p-value
	Median	IQR	Median	IQR	
Breast pain and mastitis	6	18	17	20	0.01
Breastfeeding basics	2	6	4	5	0.12
Growth spurts	3	10.5	5	7	0.23
Sensation of insufficient milk supply	1	4	1	3	0.85
Infant not gaining weight correctly	2	6.5	5	5	0.13
Introducing solids	1	3	2	3	0.17
Latching on breast correctly	3	5	4	6	0.04
Relactation	5	3.2	2	4	0.21

Figures

Figure 1. Interrupted time series analysis of the number of queries (a) and active users

(b) of LactApp from 2017 to 2020. Real and Predicted values are plotted since COVID-

19 outbreak. Data was extracted from Google Firebase[17]