



# Predicting mothers' exclusive breastfeeding for the first 6 months: Interface creation study using machine learning technique

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## Abstract

**Background:** Machine learning techniques (MLT) build models to detect complex patterns and solve new problems using big data.

**Aim:** The present study aims to create a prediction interface for mothers breastfeeding exclusively for the first 6 months using MLT.

**Method:** All mothers who had babies aged 6–24 months between 15.09.2021 and 15.12.2021 and to whom the surveys could be delivered were included. 'Personal Information Form' created by the researchers was used as a data collection tool.

Data from 514 mothers participating in the study were used for MLT. Data from 70% of mothers were used for educational purposes, and a prediction model was created. The data obtained from the remaining 30% of the mothers were used for testing.

**Results:** The best MLT algorithm for predicting exclusive breastfeeding for the first 6 months was determined to be the Random Forest Classifier. The top five variables affecting the possibility of mothers breastfeeding exclusively for the first 6 months were as follows: "the mother not having any health problems during pregnancy," "there were no people who negatively affected the mother's morale about breastfeeding," "the amount of water the mother drinks in a day," "thinking that her milk supply is insufficient," "having no problems breastfeeding the baby".

**Conclusions:** Using created prediction model may allow early identification of mothers with a risk of not breastfeeding their babies exclusively for the first 6 months. In this way, mothers in the risk group can be closely monitored in the early period.

## KEYWORDS

breastfeeding, machine learning technique, mothers, prediction model

## 1 | INTRODUCTION

Breast milk is the only physiological food that contains the nutrients the newborn needs in appropriate quantity and quality. Breastfeeding is the healthiest and most effective method of delivering breast milk to babies<sup>1</sup> and is widely encouraged worldwide because it

contributes to the lifelong health of both mother and child. World Health Organization (WHO) recommend exclusive breastfeeding for the first 6 months after birth.<sup>2</sup>

The World Health Assembly set global nutrition targets in 2012, aiming to increase the rate of exclusive breastfeeding for babies aged 0–6 months to at least 50% by 2025.<sup>3</sup> Although breastfeeding is a



common practice in our country, the rate of babies being exclusively breastfed for the first 6 months after birth is low. According to Turkey Population Health Survey (TNSA) 2018 data, only 41% of children under 6 months of age are exclusively breastfed.<sup>4</sup>

Many factors affect mothers' breastfeeding tendencies. They include mother's age and education level,<sup>5</sup> smoking habit,<sup>6</sup> pregnancy being intended and complications during pregnancy,<sup>7</sup> perception of insufficient milk,<sup>8</sup> early return to work for working mothers,<sup>9</sup> early postpartum skin-to-skin contact, and breastfeeding within the first hour.<sup>7</sup> It is important to research why mothers stop breastfeeding or start using formula or supplements in addition to breastfeeding. Early detection of mothers at risk of not breastfeeding their babies exclusively for the first 6 months is an important step in increasing breastfeeding rates.<sup>10</sup>

Artificial intelligence is being widely implemented in various fields due to technological advancements. Machine learning algorithms underlying artificial intelligence technologies can find the best solution for future problems by gaining insight and experience from existing examples.<sup>11</sup> Some examples include the prediction of birth risk based on pregnant women's age, the prediction of postpartum depression based on prenatal data, and the prediction of breast cancer risk based on pre- and post-menopausal status.<sup>12</sup> However, in the literature review conducted, no study determining the act of breastfeeding among prediction studies could be found.

The present study aims to create a prediction interface using machine learning techniques (MLT) for mothers' breastfeeding exclusively for the first 6 months. Studies exist that determine the factors affecting mothers' exclusive breastfeeding of their babies for the first 6 months,<sup>7,9</sup> but not all factors have the same impact. The machine learning technique ranks factors by importance and creates a prediction model based on their impact. This is the original aspect of this research. In addition, the prediction model determined by the machine learning method was transferred to a web interface as part of the study. Using this web interface, health professionals will be able to detect risky mothers early, easily, and in a short time.

## 2 | METHOD

### 2.1 | Research design

Machine learning techniques were used for prediction mothers' breastfeeding exclusively for the first 6 months. Early detection of mothers at risk of not breastfeeding their babies exclusively for the first 6 months is an important step in increasing breastfeeding rates. The machine learning technique ranks factors by importance and creates a prediction model based on their impact.

### 2.2 | Sample

No sample calculation was made in the study. All mothers to whom the surveys could be delivered between 15 September 2021 and 15 December 2021, who met the inclusion criteria and agreed to

participate in the research after being informed were included. Mothers were reached by a simple random sampling method. Power analysis cannot be conducted in machine learning methods. However, it is stated that the acceptable coefficient of accuracy is between 0.70 and 0.90.<sup>13</sup> The fact that the accuracy value of in this study is 72% indicates that the sample size is sufficient.

### 2.3 | Inclusion criteria

- The mother having a baby aged 6–24 months.
- Being able to read and write.

### 2.4 | Exclusion criteria

- Having a health problem that prevents breastfeeding (untreated HIV infection, galactosemia in the baby, etc.)

### 2.5 | Ethical considerations

Before the study was carried out, permission was received from Ethics Committee (2021/008). An informed consent form that provided the participants with information about the study was presented. Participants were free to decline participation and to withdraw at any time.

### 2.6 | Measurement

The "Personal Information Form" created by the researchers was used as the data collection tool in the study.<sup>5–8</sup> The form has 45 questions on the baby and mother's socio-demographic, obstetric, breastfeeding, and baby-feeding details. Among these questions, "the baby's feeding type for the first 6 months" was accepted as the dependent variable. The remaining 44 constituted the independent variables.

### 2.7 | Data collection

Survey created via Google Forms were sent to mothers online because it is a pandemic period. They were shared via authors' profil between 15 September 2021 and 15 December 2021 in Instagram and Facebook, two social media platforms that are very popular among mothers. Were aimed to reach mothers across Türkiye. The system has a preventive feature in refilling the forms filled on the same account. The time to answer the survey is approximately 5–10 min.

### 2.8 | Data analysis

As a result of machine learning, it was concluded that all 44 variables affected the baby's feeding type for the first 6 months (Figure 2).

A prediction model was created by training 70% of the data collected in the study. The remaining 30% was used for testing. Machine learning algorithms eXtreme Gradient Boosting (XGB), Light Gradient Reinforcement Machine Classifier (LGBM), Random Forest Classifier (RF), Extra Trees Classifier (ETC), Logistic Regression (LR) were used to create the prediction model. The basic structure of the prediction model is shown in Figure 1. As shown in the figure, the data set containing information about mothers and their babies was entered into a computer interface designed for the study. This information entered into the interface was converted into numerical values via the program and applied to machine learning method inputs. The data were then trained with XGB, LGBM, RF, ETC, and LR algorithms, respectively, and the performance of each was evaluated. SPSS software package was used for statistical analysis. Python Programming Language and Scikit-Learn Library were used to develop machine learning algorithms. Performance evaluation was performed with cross-validation, sensitivity, and specificity values. Then, the algorithm that provides the highest performance value is included in the interface software. The algorithm chosen here predicted the incoming data.

A computer interface was created based on the prediction model created with machine learning (Figure 2). This interface predicts breastfeeding exclusively for the first 6 months. According to the answers given to the variables, the result "Breast Milk" in the bottom section shows that mothers are more likely to feed exclusively with breast milk for the first 6 months. The "Others" result in the bottom section shows that mothers are less likely to breastfeed exclusively for the first 6 months. The latter indicates a high probability that the mother will give the baby formula and/or supplementary food in addition to or without breast milk for the first 6 months.

### 3 | RESULTS

The study was completed with 514 mothers. Their mean age was  $30.02 \pm 4.21$ . Some descriptive characteristics of the mothers are given in Table 1. Table 2 shows some findings regarding the mothers' pregnancy, birth, and breastfeeding processes.

62.5% of mothers fed their babies exclusively with breast milk for the first 6 months, 30% with breast milk and formula, 2.9% with breast milk, formula, and complementary food, 2.1% with breast milk and complementary food, 2.1% with formula only, and 0.4% with formula and complementary food. The top 25 variables that affect the baby's exclusive breastfeeding for the first 6 months, determined by machine learning, are shown in Figure 3 in order of importance.

## 4 | RESULTS ON MACHINE LEARNING

Data from 514 mothers were used for the machine-learning method. 70% of the data set was used for training and 30% for testing. Prediction models were created using XGB, LGBM, RF, ETC, and LR methods in the training set, and it was determined that the RF algorithm had the best prediction ability with 72% accuracy, 73% sensitivity, and 72% specificity (Table 3). The RF algorithm correctly predicted 49 of 68 data and 51 of 69 data in the test data set.

## 5 | DISCUSSION

A prediction model and computer interface for mothers to give breast milk exclusively to their babies for the first 6 months were developed in this study with the machine learning method. Risk groups can be identified thanks to prediction models and interfaces, and protective measures can be taken before problems occur. The interface developed in the current study may allow identifying mothers who are unlikely to give breast milk exclusively to their babies at an early stage for the first 6 months. These mothers may be addressed as a risk group and provided education and more frequent monitoring. This may increase the rate of babies receiving breast milk exclusively for the first 6 months, contributing to raising healthier generations owing to the benefits of breast milk.

In the present study, the leading factor affecting whether the mother breastfed her baby exclusively was "the mother not having any health problems during pregnancy." Similarly, several previous studies found significantly lower intention to breastfeed and a lower proportion of women starting breastfeeding after birth in women who had health problems during pregnancy, especially in diabetes and obesity<sup>14,15</sup> and hypertension<sup>15</sup> compared to women with a healthy pregnancy. Women may go into labour feeling tired due to health problems they experience during pregnancy. The responsibility to take care of the baby after delivery, added to the ongoing health problems, can cause further distress to the mother. Fatigue may prevent the mother from eating well and sleeping well and may increase her stress. All these can lead to a decrease in both the amount of milk produced and the frequency of breastfeeding. This result is crucial as it shows that mothers who have health problems during pregnancy need more support regarding breastfeeding.

The second most important factor was determined as "the absence of people who negatively affect the mother's morale about breastfeeding." Breastfeeding decisions are constantly considered in the context of environmental factors such as family and friends, media, local and national policies, and cultural and religious norms.<sup>16</sup>

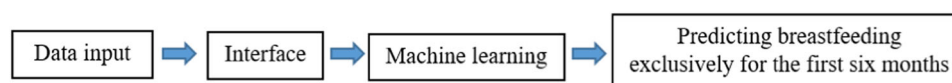


FIGURE 1 The general structure of the prediction model.



1) According to your last menstrual period, at what week was your baby born?  under 37 weeks  37-42 weeks  over 42 weeks

2) Your baby's gender  Girl  Male

3) What is your baby's birth weight?

4) Does your baby have a diagnosed chronic disease?  Yes  No

5) Were you told by your doctor during your pregnancy that there was any problem with your baby?  Yes  No

6) Did your baby have any problems at birth?  Yes  No

7) Did your baby have any problems after birth?  Yes  No

8) Birth Type  Normal Birth  cesarean section

9) In which hospital did you give birth?  State Hospital / City Hospital  Private Hospital  University Hospital

10) Did your baby stay in the neonatal ward after birth?  Yes  No

11) Was skin-to-skin contact (laying the baby naked on the mother's chest) applied with your baby after birth?  Yes  No

12) Did you stay in the same room with your baby during your stay in the hospital after birth?  Yes  No

13) Does your baby use a pacifier?  Yes  No

14) How long did it take for the first breastfeeding after your baby was born?

15) Have you encountered any problems while breastfeeding your baby?  Yes  No

16) Have you thought that your milk supply is insufficient during breastfeeding?  Yes  No

17) Are you currently using milk enhancing drinks or foods?  Yes  No

18) Did you receive breastfeeding training before birth?  Yes  No

19) Have you had breastfeeding experience in the past?  Yes  No

20) Are there/were there people who negatively affected your morale about breastfeeding?  Yes  No

21) Does breastfeeding in crowded places bother you?  Yes  No

22) Your age

23) Your Education Status  postgraduate  High school  College  Middle school  Primary school

24) Are you working in an income-generating job?  Yes, I am working  No I'm not working

25) with your partner  You are living together  you divorced  You are not divorced but you live separately

26) Your family type  Nuclear family  Extended family

27) Your family income  
 Our income is less than our expenses  Our income is more than our expenses  Our income equals our expenses

28) Do you smoke?  Yes  No

29) Do you use alcohol?  Yes  No

30) Do you exercise regularly?  Yes  No

31) On average, how many glasses of water do you drink a day?  
 1-3 cups  4-6 cups  7-9 cups  10-12 cups of water  13 cups or more

32) Do you have any diagnosed psychological illness?  Yes  No

33) Your total number of children including this baby  1  2  3  4  5

34) Are you having trouble taking care of your children?  Yes  No

35) Does your spouse help with the care of your children?  Yes  No

36) Are there other people (other than your spouse) who help care for your children?  Yes  No

37) Do you have any diagnosed chronic diseases?  Yes  No

38) Did you conceive this baby willingly?  Yes  No  Neither yes nor no

39) Did you have regular follow-ups during your pregnancy?  Yes  No

40) Do you have any health problems that occur during pregnancy?  Yes  No

41) Did you have sleep problems during pregnancy?  Yes  No

42) Did you experience psychological problems (depression, anxiety, etc.) during pregnancy?  Yes  No

43) Did you experience psychological problems (depression, anxiety, etc.) after birth?  Yes  No

44) Did you have sleep problems after your baby was born?  Yes  No

**Prediction Result**

**FIGURE 2** Interface for predicting mothers' breastfeeding exclusively for the first 6 months.

Especially environmental factors may cause obstacles to breastfeeding at home, at work, or in hospitals.<sup>17</sup> Studies have found that perceived support, especially from family and friends, significantly affects exclusive breastfeeding in the first month.<sup>16,17</sup> Some other studies suggested that negative reactions from mothers, mothers-in-law, other female family members, and friends are essential obstacles to continuing breastfeeding.<sup>16,18</sup> Similarly, studies from Turkey reported results indicating that the lack of support from family members regarding breastfeeding negatively affects mothers' ability to initiate and continue breastfeeding.<sup>19,20</sup> Of note, however, such obstacles are modifiable with targeted training and practices that can improve breastfeeding.<sup>17</sup>

The third most important factor was "the mother drinking more than 13 glasses of water daily". Breastfeeding mothers experience a water loss of approximately 700 mL per day through milk secretion in the 8th week postpartum. This fluid loss poses a risk of dehydration for women. Therefore, mothers are recommended to increase their water intake as a physiological need to compensate for the fluid lost through milk secretion.<sup>21</sup> However, there is no sufficient evidence that mothers drinking more fluid than they need increases breast milk production.<sup>22</sup> Although further clinical research is required to clarify this information, according to the current research results, explaining the importance of adequate fluid intake to mothers during breastfeeding training may be recommended.

**TABLE 1** Findings on some descriptive characteristics of mothers.

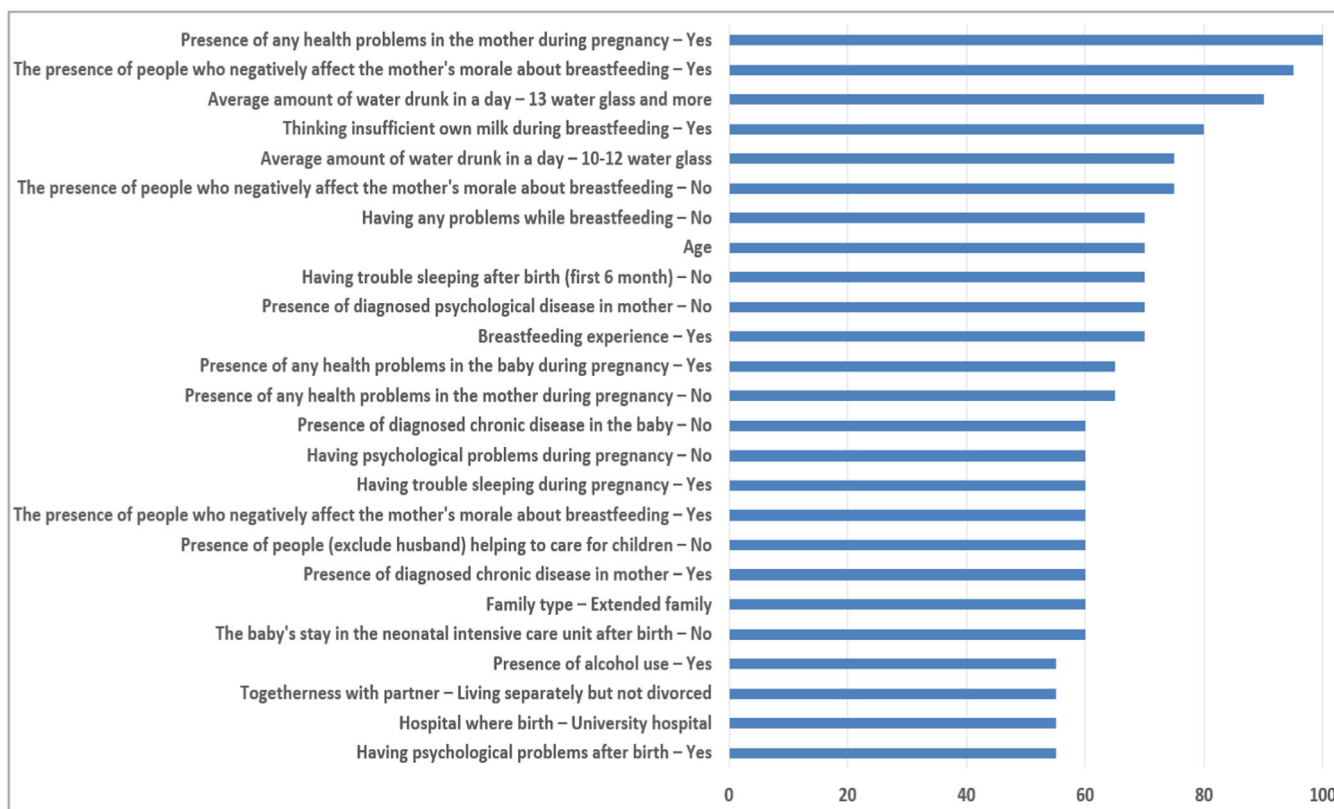
Descriptive characteristics		n (%)
Mother's education level	Primary school	2 (0.4)
	Secondary school	9 (1.8)
	High school	103 (20.1)
	Undergraduate	233 (45.3)
	Postgraduate	167 (32.4)
Mother's employment status	Yes. I am working	239 (46.5)
	No. I'm not working	275 (53.5)
With her husband?	We live together	506 (98.4)
	We are not divorced, but we live separately	4 (0.8)
	We got divorced	4 (0.8)
Family income	Income is less than expenses	97 (18.9)
	Income equals expenses	280 (54.4)
	Income more than expenses	137 (26.7)
Family type	Nuclear family	483 (94.0)
	Extended family	31 (6.0)
Total number of children	1	413 (80.4)
	2	78 (15.1)
	3	21 (4.1)
	4	2 (0.4)
Presence of a diagnosed chronic disease in the mother	Yes	91 (17.7)
	No	423 (82.3)
The presence of a diagnosed psychological condition in the mother	Yes	14 (2.7)
	No	500 (97.3)
Mother's smoking status	I smoke	89 (17.3)
	I don't smoke	425 (82.7)
Mother's alcohol use	I use alcohol	42 (8.2)
	I don't use alcohol	472 (91.8)
<b>TOTAL</b>		<b>514 (100.0)</b>

The fourth most important factor was "thinking that her milk supply is insufficient." It is known that every woman can produce enough milk to raise two babies. Despite this, many women think their milk supply is insufficient.<sup>23</sup> Many studies have shown that the low amount of milk perceived by the mother plays a vital role in breastfeeding cessation.<sup>8,24</sup> In a systematic review,<sup>25</sup> the reason for about 50% of mothers discontinuing breastfeeding was their belief that their milk supply was insufficient. To address this, signs showing

**TABLE 2** Findings regarding mothers' pregnancy, birth, and breastfeeding processes.

Variables		n (%)
Regular follow-up throughout pregnancy	Yes	507 (98.6)
	No	7 (1.4)
Any diagnosed health problems in the mother during pregnancy	Yes	135 (26.3)
	No	379 (73.7)
Sleeping problems in the mother during pregnancy	Yes	280 (54.5)
	No	234 (45.5)
Intended pregnancy	Yes	421 (81.9)
	Neither yes nor no	66 (12.8)
	No	27 (5.3)
Birth type	Normal birth	146 (28.4)
	Cesarean section	368 (71.6)
Time of the first breastfeeding after birth	In the first half-hour	175 (34.0)
	In the first hour	208 (40.5)
	After the first hour	125 (24.3)
	Never breastfed	6 (1.2)
Skin-to-skin contact with the baby after birth	Yes	205 (39.9)
	No	309 (60.1)
Sleep problems in the mother after birth	Yes	378 (73.5)
	No	136 (26.5)
Mother having problems breastfeeding her baby	Yes	391 (76.1)
	No	123 (23.9)
Receiving breastfeeding education before birth	Yes	80 (15.6)
	No	434 (84.4)
The mother having previous breastfeeding experience	Yes	75 (14.6)
	No	439 (85.4)
The mother thinking that her milk supply is insufficient	Yes	267 (52.1)
	No	247 (47.9)
Feeling bothered breastfeeding in a crowd	Yes	245 (47.7)
	No	269 (52.3)
The presence of a person(s) who negatively affect the mother's morale about breastfeeding	Yes	251 (48.8)
	No	263 (51.2)
<b>TOTAL</b>		<b>514 (100.0)</b>

that the baby is getting enough milk can be emphasized during training for mothers who think their milk supply is insufficient. Mothers can be informed about what they can do to increase milk production.



**FIGURE 3** Top 25 variables affecting the baby's exclusive breastfeeding for the first 6 months. \*Since each answer to the questions is evaluated as a different variable in machine learning, different answers to the same questions can be included in the graph.

**TABLE 3** Results of algorithms.

Algorithm	XGB	LGBM	RF	ETC	LR
Accuracy	0.69	0.66	0.72	0.70	0.66
Positive predictive value (precision)	0.69	0.66	0.72	0.71	0.66
Sensitivity (recall)	0.69	0.66	0.73	0.71	0.66
Specificity	0.69	0.66	0.72	0.70	0.66
F1 Score	0.69	0.66	0.73	0.71	0.66

Abbreviations: ETC, Extra Trees Classifier; LGBM, Light Gradient Reinforcement Machine Classifier; LR, Logistic Regression; RF, Random Forest; XGB, eXtreme Gradient Boosting.

The fifth most important factor was "having no problems breastfeeding the baby." Breastfeeding has been described as the most challenging aspect of learning to be a parent. Generally, one in every two new mothers report experiencing early breastfeeding problems.<sup>26</sup> The most common problems mothers experience are painful and cracked nipples,<sup>27</sup> low milk production,<sup>10</sup> and the baby's inability to hold and suck the breast.<sup>28</sup> Therefore, it is essential that professionals assess breastfeeding problems and intervene as necessary at an early stage.

The sixth most important factor was "young maternal age," which negatively affected whether the mother breastfed her baby

exclusively. Similarly, some studies<sup>24,29</sup> reported that the ability to continue breastfeeding for a long time increases as the maternal age increases. This result may be related to the mother's increasing self-confidence with age and her ability to continue breastfeeding more successfully.

The seventh most important factor was "the mother not having sleep problems after birth." Sleep deprivation is a stressor associated with activation of the hypothalamic-pituitary-adrenal axis and is known to inhibit the release of oxytocin and prolactin.<sup>30</sup> Evidence shows that mothers with low sleep efficiency are less likely to initiate breastfeeding than mothers with high sleep efficiency.<sup>31</sup> A study evaluating the relationship between maternal sleep and breastfeeding self-efficacy with 128 mothers in Turkey demonstrated that as mothers' sleep quality increases postpartum, their breastfeeding self-efficacy also increases.<sup>32</sup> Improving postpartum maternal sleep can support breastfeeding by improving the mother's mental and physical health and interaction with the baby.

The eighth factor was "the mother not having a diagnosed psychological disease." Similarly, many studies<sup>14,16,33</sup> have stated that mental health problems such as depression and anxiety in the mother negatively affect breastfeeding results. Maternal depression and anxiety, in particular, are known to have negative effects on all breastfeeding outcomes, including the initiation and continuation of breastfeeding.<sup>33</sup> In systematic review, women with depressive

symptoms or high levels of prenatal anxiety were shown to run the risk of having shorter-lasting exclusive breastfeeding.<sup>34</sup> Depressive symptoms can lead to low self-esteem, lack of self-confidence, and lack of belief that one can exclusively breastfeed the baby. Mothers may, thus, choose to use nutritional supplements in addition to breast milk more frequently. Additionally, these mothers tend to be more easily influenced by the environment. Therefore, it is important that mothers with depressive tendencies and anxiety are especially supported in breastfeeding.<sup>14</sup>

The ninth factor was “the mother's first breastfeeding experience.” This result is consistent with the studies in the literature evaluating the relationship between parity and breastfeeding.<sup>18,35</sup> The fact that multiparous mothers have previous breastfeeding experience increases their likelihood of starting breastfeeding early. It should also be noted that primiparous mothers may experience high levels of perceived stress and, therefore, may need more breastfeeding assistance.<sup>36</sup>

The tenth and eleventh most essential factors were “the baby having any health problems during pregnancy” and “the baby having a diagnosed chronic disease.” If the newborn has a health problem, they may be admitted to the neonatal ward postnatally, causing the mother and baby to be separated. This can also negatively affect breastfeeding. Mothers can start additional supplementary nutrients early, believing that breast milk will not provide adequate growth in low-birth weight babies.<sup>37</sup> Besides, if the baby has a chronic disease such as congenital heart disease, they get tired quickly while breastfeeding and cannot be fed enough, possibly necessitating additional nutritional supplements.<sup>38</sup> Health professionals should not forget that mothers will need more support in breastfeeding if the baby has a health problem.

## 6 | LIMITATIONS

The limitations of the study is that the data was collected online, and the forms were filled out based on the self-reports of the individuals.

## 7 | CONCLUSION AND SUGGESTIONS

Despite the benefits of breastfeeding for both mother and newborn, rates of exclusive breastfeeding for the first 6 months remain an issue that needs improvement in many countries. The prediction model developed in this study for the factors affecting breastfeeding provides healthcare professionals with a new tool for the early detection of mothers at risk for breastfeeding. The information that mothers enter into the interface determines whether they are in the risk group based on whether they have all these factors. This may enable health professionals to develop breastfeeding support strategies adapted to the at-risk population.

Once risky mothers are identified with the developed interface, simply giving breastfeeding advice to mothers will not be enough to encourage them to breastfeed. It is recommended that especially

breastfeeding nurses determine and apply a personalized approach to mothers in the risk group both in the prenatal and postnatal periods. In the machine learning approach, the larger the number of samples, the more realistic results are obtained. Therefore, conducting studies with larger sample sizes may contribute to updating the interface in line with new results.

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## CONFLICT OF INTEREST STATEMENT

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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