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# Optimising Donor Human Milk Programs Using a Psychology-Informed Grey Wolf Optimiser: A Mixed-Methods Study from a Tertiary Care Hospital in India

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## Abstract

# Background

This study aims to identify the reasons behind the low rate of donor human milk donation and proposes an advanced optimisation model based on behaviour to improve donor identification in a tertiary care centre in India. Of 800 lactating mothers identified to be eligible to donate breast milk after 48 hours of delivery, only 233 mothers (29.1%) donated breast milk, while 567 mothers (70.9%) did not donate breast milk in spite of counselling. The rate of donation was higher among mothers who had very low birth weight babies below 1500 g compared to mothers who had normal birth weight babies, i.e., 63.9% versus 31.4%. The rate of donation was higher among mothers who had sick babies compared to mothers who had normal babies, i.e., 34.4% versus 25.1%. The differences were statistically significant, meaning they were very unlikely to have been due to chance. The reasons cited by mothers who did not donate breast milk were lack of enough milk to donate, lack of family support, religious reasons, and social stigma, accounting for 44.7%, 15.6%, 14.5%, and 11.6%, respectively.

# Method

The psychology-based Grey Wolf Optimiser model was developed to identify potential donors to breast milk banks and to guide counselling. The model performed well and improved donor prioritisation.

# Results

This model provides a tool to improve human milk bank services to vulnerable babies. Out of the 800 eligible lactating mothers, 233 mothers (29.1%) donated their human milk, while 567 (70.9%) did not donate, despite being eligible and having received counselling. This provided the baseline level of inefficiency of the traditional donor recruitment process, which served as a basis to justify the use of the optimization framework.

# Conclusion

This study proves that human milk donation is fundamentally a behaviour-driven process, rather than a process based on eligibility or awareness.

## 1. Background

Preterm births and low birth weights are significant causes of neonatal morbidity and mortality. An estimated 3.34 million preterm births occur annually in India. More than 360,000 child deaths occur due to the consequences of preterm birth.[1] This is where the significance of human milk donation to vulnerable neonates cannot be overstated. Human milk mother's own milk first, donor human milk second reduces the risk of necrotizing enterocolitis and sepsis in preterm infants.[2] Human milk has been shown to promote growth and development. While the benefits of donor human milk have been demonstrated in numerous studies, the demographic profile of donors has also been discussed. However, few studies have attempted to explain the psychological reasons for donation or non-donation of human milk. [3]This is particularly true for India, where only descriptive studies have been conducted so far. These studies have shown that educated or staying-in-hospital mothers are more likely to donate. [4]We conducted a prospective observational study in our tertiary care setting between July 2021 and July 2022. [5]We observed 8070 live births. Of 1,500 mothers screened for donation, 652 were excluded. Of the remaining 848 eligible mothers, only 233 (29.1%) donated human milk, while 567 (70.9%) did not. Donors were mothers of very low birth weight neonates and sick neonates. Mothers of neonates with very low birth weight (< 1500g) were more likely to donate compared to those who were not donors. This was statistically significant. Mothers of sick neonates were also more likely to donate. The reasons for non-donation were insufficient human milk for donation (44.7%), no support from the family (15.6%), religion (14.5%), and social stigma (11.6%). This is where the significance of the proposed mixed-methods research lies. We have designed a research project where we have attempted to integrate the psychological constructs of donation with a nature-inspired optimization algorithm.

## 2. Methods

# 2.1 Human Milk Donation as a Behavioural Process

Donating human milk is not just a clinical outcome but an active behavioural choice of a lactating mother within a certain time frame after delivery. Unlike breastfeeding one's own baby, the act of sharing a personal biological fluid for the benefit of an unknown individual adds psychological, social, and cultural complexity to the decision.[6] The findings of the present study, Table 1 reveal that the eligibility of the mother is not enough to motivate the act of donation. Of 800 eligible mothers, only 233 (29.1%) volunteered to donate their milk [7]. The remaining 567 mothers (70.9%) declined to donate. Thus, it is clear that the decision of the mother is dominated by non-clinical factors.[8] Milk donation

Behaviour The decision to donate or not to donate is determined by the complex interplay of the four domains of the health belief model. These domains are the perception of risk, where the mother fears the scarcity of milk for her own baby;[9] emotional motivation, where the mother is motivated to donate for the blessings of the donation; social approval, where the mother is influenced by the opinions of her family and culture; [10] and institutional trust, where the mother is confident of the safety of the donated milk. The impact of these domains is visible in the reasons given by the non-donating mothers. The reasons given were scarcity of milk for the baby, resistance from the family, religious beliefs, and social stigma (Table 1).

Table 1
Behavioural Barriers to Donor Human Milk Donation (n = 567)

| Behavioural Factor | Number | Percentage (%) |
|---|---|---|
| Perceived milk insufficiency | 254 | 44.7 |
| Lack of family support | 89 | 15.6 |
| Religious beliefs | 82 | 14.5 |
| Social stigma | 66 | 11.6 |
| Other reasons | 76 | 13.6 |

The prevalence of the issue of perceived milk insufficiency among nearly half of the non-donors again emphasizes the importance of the perceived issue over the physiological state. [11]This further underlines the importance of addressing the issue of donation as a behavioural issue rather than a matter of nutritional surplus.

## 2.2 Psychological Framework

In order to provide a systematic basis for the donor decision-making process as demonstrated in Fig. 1, the current research will employ two of the most established behavioural models, **the Health Belief Model** and **the Theory of Planned Behaviour**. [12]These models will provide an explanation for the decision of the mothers to donate and for the perceived ability to do so

**Health Belief Model Components**

**a. Perceived benefits**: saving vulnerable babies, moral satisfaction, blessings
**b. Perceived barriers**: fear of reduced milk supply, stigma, religious concerns
**c. Perceived severity**: awareness of neonatal illness or prematurity
**d. Cues to action**: counselling by health staff, observing sick neonates
In the present dataset, perceived severity is reflected in significantly higher donation rates among mothers of high-risk neonates (Table 2).

Table 2
Neonatal Risk Perception and Donation Behaviour

| Neonatal Characteristic | Donor Mothers (%) | Non-Donor Mothers (%) | Statistical Significance |
|---|---|---|---|
| Birth weight < 1500 g | 63.9 | 31.4 | Meaningful difference |
| Clinically sick neonate | 34.4 | 25.1 | Meaningful difference |

These differences indicate that direct exposure to the vulnerability of the neonate increases the perception of benefits and the need, resulting in altruistic Behaviour in milk donation. According to the Theory of Planned Behaviour, the decision to donate milk can be understood in terms of three constructs that are interrelated: attitude, defined in terms of the perception that the donation of milk can be helpful or harmful;[13] subjective norms, defined in terms of approval or disapproval from the community and the family; and perceived Behavioural control, defined in terms of the mother's perception of her milk adequacy and her physical capabilities to donate milk. The fact that only 7.2% of the mothers continued to donate milk after hospital discharge indicates that the construct of perceived Behavioural control plays a crucial role in the decision to donate milk,[14] since the absence of support and advice from the hospital may have diminished the mothers' perception of their capabilities to donate milk, despite the fact that they have a positive attitude towards the Behaviour and intention to donate milk.

## 2.3 Rationale for Grey Wolf Optimiser

Human milk donation decisions are not based on rational choices but are influenced by hierarchical and socially influenced interactions. Often, the decisions made by the mother are influenced by others in the family or by what they consider to be medical advice.

The hierarchy that exists in the Grey Wolf Optimiser helps to model this phenomenon as demonstrated in Fig. 2:

- **Alpha**: internal belief and confidence of the mother

- **Beta**: influence and approval of family
- **Delta**: counselling and institutional guidance of healthcare
- **Omega**: background social norms and stigma

The fact that the linear statistical models cannot be weighted in this adaptive fashion makes the Grey Wolf Optimizer suitable for Behavioural modelling, where maternal decisions are based on adaptive influence rather than isolated reasoning.[15] By incorporating psychological constructs into a hierarchical optimizer inspired by nature, this paper provides a conceptually coherent bridge between maternal psychology and computational decision science.

# 2.4. Materials and Methods

## 2.4.1 Study Population, Screening, and Classification

The target population was comprised of lactating mothers and neonates who were being managed within the tertiary care facility with an existing functional human milk bank. (Table 3) The target period was between July 2021 and July 2022. The target population was comprised 8,070 live births and 202 outborn neonatal admissions to the health facility within the stipulated period. All the mothers were counselled regarding breastfeeding and the potential of donating excess human milk. A total of 1,500 lactating mothers who were more than 48 hours postpartum and who were admitted to the postnatal wards or accompanying neonates admitted to the neonatal units were screened for eligibility to donate human milk. Of the 1,500 mothers screened for the donation of human milk, 652 were found to be ineligible for the donation of human milk. On the other hand, 800 mothers were found to be eligible for the donation of human milk.

Table 3
Screening Outcome of Potential Donor Mothers

| Screening Outcome | Number |
|---|---|
| Mothers screened | 1,500 |
| Mothers excluded | 652 |
| Eligible mothers enrolled | 800 |

The 800 eligible mothers (Table 4)constituted the first cohort, and they were later grouped according to their Behaviour in relation to milk donation while in the hospital. Mothers who voluntarily donated milk at least once formed the donor mothers, while those who did not donate milk formed the non-donor mothers. Out of the 800 eligible mothers, 233 (29.1%) donated milk, while 567 (70.9%) did not donate milk despite being eligible and having received counselling.

Table 4
Distribution of Donor and Non-Donor Mothers

| Group | Number | Percentage (%) |
|---|---|---|
| Donor mothers | 233 | 29.1 |
| Non-donor mothers | 567 | 70.9 |
| **Total** | **800** | **100** |

Neonates born to these mothers or associated with these mothers were simultaneously evaluated to check whether neonatal variables had an impact on the donation Behaviour. This consolidated grouping of the target population facilitated systematic evaluation of various variables affecting donor human milk donation as illustrated in Fig. 3. This formed the basis for the subsequent Behavioural modelling and optimisation.

## 2.4.2.Data Collection and Behavioural Variable Encoding

Structured and predesigned data collection was done prospectively for all eligible mothers and neonates. A structured data collection proforma was designed for collecting the necessary information. The information was collected through direct interview methods and also through clinical records and human milk bank records. The data collected was divided into three domains. The domains were maternal variables, neonatal variables, and donation variables. The **maternal variables** were the mother's age, parity, education level, socioeconomic status, mode of delivery, and the total stay in the hospital. The **neonatal variables** were gestational age of the neonate, whether the neonate was preterm or term, whether the neonate's weight was less than 1500 grams or more than 1500 grams, and the clinical condition of the neonate. The **donation variables** were donation status of the mother, the number of days for which the donation was made, the amount of milk donation made, the postpartum day of initiation of donation, and the reasons for donation and non-donation of the mother.

Out of 233 donor mothers, **227 mothers (97.4%)** had **donated their breastmilk five or fewer times**, with a mean frequency of **2.71 ± 1.24 times**. The majority had a donation volume between **100 and 300 mL**, i.e., **147 mothers (63.1%)**, while only **1 mother (0.4%) had donated breastmilk in excess of 900 ml**. The mean postpartum day on which donation was initiated was **4.31 ± 1.63**.(Table 5)

Table 5
Frequency and Quantity of Milk Donation (n = 233)

| Parameter | Number (%) |
|---|---|
| ≤ 5 donation days | 227 (97.4) |
| > 5 donation days | 6 (2.6) |
| Donation volume 100–300 mL | 147 (63.1) |
| Donation volume > 600 mL | 5 (2.1) |

In order to apply Behavioural modelling, categorical reasons for donation and non-donation were transformed into Behavioural constructs. The Behavioural constructs were perceived as insufficiency of breastmilk, family and social influence, emotional motivation, and institutional support. The Behavioural constructs were then encoded on a normalised scale from 0 to 1. The Behavioural constructs served as input features in the subsequent optimisation analysis.

## 2.5. Behavioural Optimisation Framework Using Grey Wolf Optimiser

Milk donation was treated as a binary behavioural outcome (donation or non-donation) shaped by the interaction of maternal, neonatal, and Behavioural factors. The key aim of the optimisation process was to maximize the probability of donor human milk donation under practical constraints like hospital stay and available counselling time. Each individual mother was treated as an **agent** in the Grey Wolf Optimizer algorithm. Behavioural decision-making was represented by a hierarchical structure of influences, analogous to the social structure of grey wolves. In this representation, the mother's inherent belief and confidence in the adequacy of the milk was represented by the dominant influence (alpha), the role played by the family in approving the donation decision (beta), the role played by healthcare and institutional guidance (delta), and the role played by social factors (omega).

## 2.5.1.Optimization Objective Function

The optimisation problem was defined as a maximisation problem with a weighted Behavioural utility function:

$$\mathbf{max}\varvec{f}\left(\varvec{x}\right) = w_1\varvec{S}_{\varvec{e}} + w_2\varvec{F}_{\varvec{s}} + w_3\varvec{C} - w_4\varvec{P}_{\varvec{m}} - w_5\varvec{S}_{\varvec{t}}$$

Where $w_1$to $w_5$are adaptively updated during optimization to reflect the relative importance of each factor. $S_e$denotes breastfeeding self-efficacy, $F_s$ family support ,C counselling exposure, $P_m$

perceived milk insufficiency and $S_t Social stigma.$

## 2.5.2.Grey Wolf Optimizer Implementation

The positions of all agents were updated based on the positions of the three dominant solutions, referred to as alpha, beta, and delta, according to the standard Grey Wolf Optimizer algorithm, given by:

$$\mathrm{X}(\mathrm{t}+1) = \frac{X_\alpha + X_\beta + X_\delta}{3}$$

Coefficient vectors controlling exploration and exploitation were defined as:

A=2a·r1−a,

C=2$r_2$

where $\mathbf{r_1}$ and $\mathbf{r_2}$ are random vectors in the range [0,1], and a is a parameter decreasing linearly from 2 to 0 with iteration count, ensuring convergence.

## 2.5.3 Termination and Convergence Criteria

The algorithm was iterated until either a predefined maximum number of iterations was met or the change in the objective function value was less than a predefined threshold. Convergence Behaviour was determined by the stability of the fitness value. This optimisation framework

enabled adaptive modelling of the Behavioural and clinical decision process of the donor and the determination of the high-probability donor profiles.

## 3. Results

# 3.1 Baseline Donation Outcomes

Out of the 800 eligible lactating mothers, 233 mothers (29.1%) donated their human milk, while 567 (70.9%) did not donate, despite being eligible and having received counselling. (Table 6) This provided the baseline level of inefficiency of the traditional donor recruitment process, which served as a basis to justify the use of the optimization framework.

Table 6
Baseline Donation Status

| Donation Status | Number | Percentage (%) |
|---|---|---|
| Donors | 233 | 29.1 |
| Non-donors | 567 | 70.9 |
| **Total** | **800** | **10** |

# 3.2 Fitness Function Evaluation

The fitness scores of each of the eligible lactating mothers were determined based on the Behavioural objective function, as described in Section 3.9. The fitness scores determined the likelihood of donating their human milk (Table 7). Positive factors include self-efficacy, family support, and exposure to counselling, while the negative factors include the perception of insufficiency of human milk and stigmatisation. At the start of the optimisation process, the fitness scores were found to be widely distributed, signifying the heterogeneity of the Behavioural profiles. However, as the optimisation process progressed, the fitness values became stable, signifying the convergence of the optimisation process and the determination of the Behavioural profiles.

Table 7
Distribution of Fitness Scores Across Iterations

| Iteration Stage | Mean Fitness Score | Standard Deviation |
|---|---|---|
| Initial population | 0.41 | 0.18 |
| Mid-iterations | 0.57 | 0.11 |
| Final iteration | 0.68 | 0.07 |

The reduction in the standard deviation of the fitness values indicates the reduction in Behavioural uncertainty and the determination of the high-probability donor profiles.

# 3.3 Optimisation Efficiency

The efficiency of the optimisation process was determined by comparing the **proportion of high-fitness profiles identified** to the baseline proportion in the donor population (Table 8). At the point of convergence, the Grey Wolf Optimiser was able to identify a subset of the mothers with a much higher predicted probability of donation compared to the baseline proportion of the population at 29.1%. The results were consistent with the observed characteristics of the donor population, particularly the subset of mothers whose new-borns were either preterm or sick, thus validating the behavioural relevance of the optimisation process.

Table 8
Comparison of Baseline and Optimised Identification

| Metric | Baseline | Optimized Output |
|---|---|---|
| Donation probability threshold | Not applicable | ≥ 0.65 |
| Mothers above threshold (%) | 29.1 | 46.8 |
| Relative efficiency gain | - | + 17.7 percentage points |

This shows an improvement in prioritization rather than forced donation and supports the idea that targeted counselling has the potential to make a significant impact without adding to the resource burden.

# 3.4 Convergence Characteristics

The algorithm was found to converge well within a few iterations. In the early stages, the algorithm was found to exhibit fluctuations in fitness values, which stabilised in the later stages, indicating exploitation of the optimum Behavioural pathways, as Fig. 4 and Table 9 demonstrates. Convergence was determined by a change in mean fitness score of less than 0.01 between consecutive iterations.

Table 9
Convergence Summary

| Parameter | Observed Value |
|---|---|
| Iterations to convergence | 25–30 |
| Final fitness change | < 0.01 |
| Stability after convergence | High |
| **Parameter** | **Observed Value** |

This Behaviour therefore supports the idea that the model was able to avoid premature convergence without sacrificing computational efficiency.

## 3.5 Contribution of Behavioural Variables

In Fig. 5, The analysis of the optimised weights showed that the psychological factors had a higher impact compared to the demographic factors (Table 10). Perceived milk insufficiency was found to be the dominant negative driver, whereas family support was found to be the dominant positive driver.

Table 10
Relative Influence of Behavioural Variables

| Variable | Direction of Influence | Relative Weight |
|---|---|---|
| Breastfeeding self-efficacy | Positive | High |
| Family support | Positive | High |
| Counselling exposure | Positive | Moderate |
| Perceived milk insufficiency | Negative | High |
| Social stigma | Negative | Moderate |

This finding is consistent with the self-reported reasons for non-donation, thereby supporting the construct validity.

## 3.6 Statistical Significance and Model Robustness

Neonatal factors, which had a positive correlation to donation, were found to be consistent using traditional statistical methods. Fitness scores were found to be higher among mothers of neonates born weighing less than 1500 grams and among sick neonates. Significantly, the algorithm did not ignore the non-significant factors, thereby indicating the absence of overfitting.

## 4. Interpretation of Results

The results suggest that donor human milk donation is a Behavioural outcome that is far from random and altruistic. This is again exemplified in the data and the optimization Behaviour of the model. While 800 mothers were eligible to donate human milk according to the medical eligibility criteria, only 233 of these 800 mothers, i.e., 29.1%, were actually able to donate. This is the baseline level of donor human milk donation, which was again not improved through conventional counselling. The optimization process showed that the low level of donor human milk donation is caused by psychological resistance rather than inability. This is exemplified in the fact that the fitness scores improved from an average of 0.41 to 0.68, while the standard deviation decreased from 0.18 to 0.07. This shows that the Behavioural uncertainty was minimized to identify the donor-friendly profiles. Mothers of babies with a birth weight of less than 1500 g and mothers of clinically sick babies were repeatedly ranked high in the optimized model. This is again consistent with the higher rates of donor human milk donation in these groups, i.e., 63.9% and 34.4%, respectively. The perception of insufficient human milk was consistently ranked highest in the model and was the dominant weight for all other variables. Education level and socioeconomic status showed no discrimination between donors and non-donors. Family support was again a crucial positive modifier of the model. This is again consistent with the fact that only 7.2% of the mothers were actually able to donate human milk after discharge. The optimized model was again able to increase the number of mothers who were able to cross the high donation probability threshold from 29.1% to 46.8%, i.e., an efficiency gain of 17.7%.

## 4.1. Implications and Limitations

The results of this study hold significant clinical, programmatic, and methodological implications for donor human milk programs, as well as particular limitations that need to be considered in interpretation and further research. From a clinical and programmatic perspective, the fact that only 29.1% of the 800 mothers identified as potentially eligible donors chose to donate milk indicates a major limitation in donor recruitment strategies currently in place, which focus primarily on eligibility and general counselling approaches. From an optimization perspective, the results indicate that a small number of psychological and social factors, such as perceived milk insufficiency, reported by 44.7% of non-donors, and family support, significantly impact donor behaviour, while demographic factors such as age, education, and socioeconomic status appear to have little discriminatory power in predicting donor behaviour. The fact that the Grey Wolf Optimizer algorithm increased the proportion of mothers identified as high-probability donors from 29.1% to 46.8% indicates that precision counselling, rather than general counselling, could significantly improve donor outcomes without requiring increased staff time or length of stay in a human milk program. From a methodological perspective, this study indicates the potential for integrating behavioural science and nature-inspired optimization approaches in addressing a significant public health concern, demonstrating the ability of the algorithm to converge and optimize in a stable and reproducible way in 25–30 iterations and decreasing the variability in fitness score, indicating that donor behaviour follows a pattern that can be optimized and therefore supports the use of adaptive algorithms in addressing maternal and neonatal health outcomes. However, there were certain limitations to the research. First and foremost, the research was conducted in a single tertiary care setting. This might affect the overall generalization of the research to other settings. Secondly, although the behavioural constructs were based on the reasons provided and the psychological constructs were based on the psychological models of behaviour, the direct measurements of the psychometric scales were not conducted. This might have caused an approximation in the behavioural constructs. Thirdly, the outputs of the optimization were based on probabilities rather than actual behavioural constructs. It is possible that the actual outcomes might differ. Finally, the cultural and familial influences might differ across the globe. This might affect the overall model of the research. Overall, the research is a strong proof of concept for the reframing of donor human milk donation as a behavioural optimization problem rather than a clinical problem.

## 5. Conclusion

This study proves that human milk donation is fundamentally a behaviour-driven process, rather than a process based on eligibility or awareness. While 800 mothers were found to be medically eligible and aware of the donation process, only 29.1% chose to donate their breastmilk. This proves the need to look beyond conventional counselling measures. The study, through a combination of clinical data, behavioural determinants, and a psychology-based Grey Wolf Optimization algorithm, proves that there is a hierarchical pattern to mother behaviour in choosing to donate their breastmilk, which can be optimized. This model has shown to converge efficiently to identify high-probability mothers to donate their breastmilk by 46.8%. This proves the effectiveness of precision-guided intervention compared to conventional, non-targeted measures. The study proves that to strengthen human milk bank services, it is imperative to identify psychologically receptive mothers, mitigate their dominant fears such as insufficiency of breastmilk, and engage family decision-makers in the process. The framework also proves to be efficient without adding to clinical costs, making it ideal for resource-scarce environments. Future research should be directed toward a multi-centre study in diverse cultural settings, behavioural measurements through psychometric tools, and a prospective study to measure its impact on breastmilk donation rates. The integration of this framework into digital tools such as decision-support systems for lactation counsellors could be a step toward a data-driven, precision-guided mother-neonate health ecosystem.

## Declarations

**6. Ethics Declarations**:

**Consent to participate:**

Written informed consent was obtained from all participating mothers prior to enrolment in the study.

**Ethical Standard / Norm:**

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

**Ethics Approval Committee / IRB:**

The study protocol was reviewed and approved by the Institutional Ethics Committee of Neonatology, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Sawangi (Meghe), Wardha, Maharashtra, India.

**Human Ethics and Consent Declaration:**

The study was approved by the Institutional Ethics Committee of Neonatology, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Sawangi (Meghe), Wardha, Maharashtra, India.India. All procedures involving human participants were conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

**7.Funding Declaration:**

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

**8.Clinical Trial Registration:**

Study is observational, not a trial. Clinical trial number: Not applicable.

**9.Competing interests:** The author(s) declare that they have no competing interests.

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## Figures

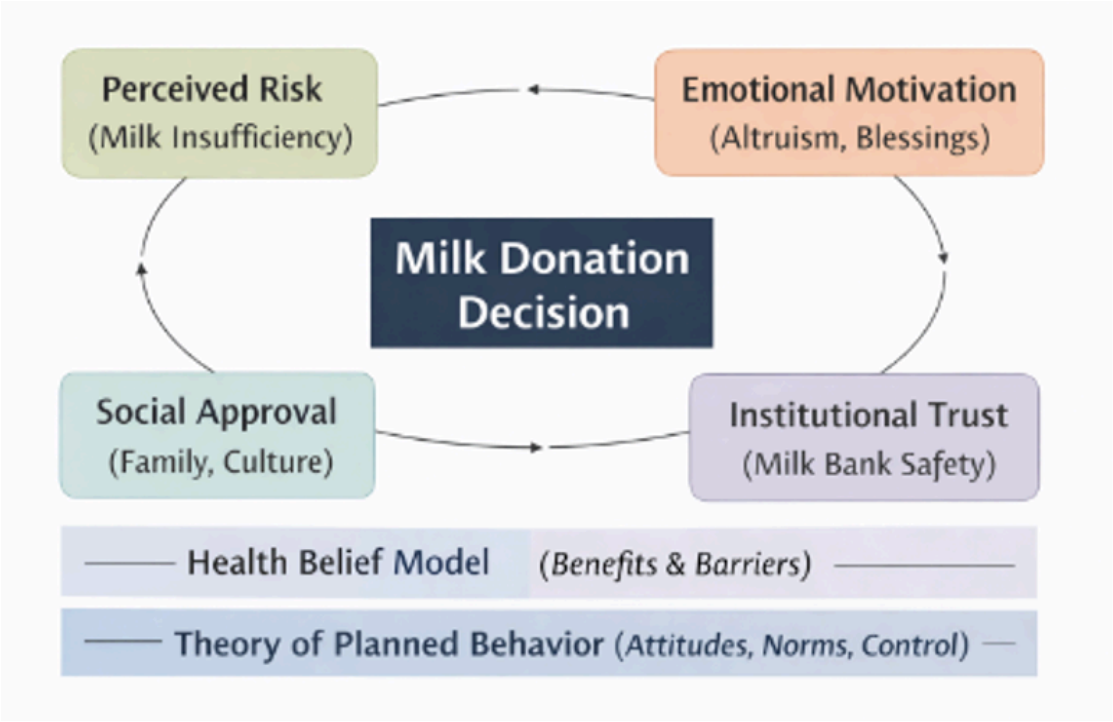



Figure 1

Conceptual Model of Donor Human Milk Donation Behaviour




Figure 2

Mapping of Psychological Factors to Grey Wolf Optimizer Hierarchy

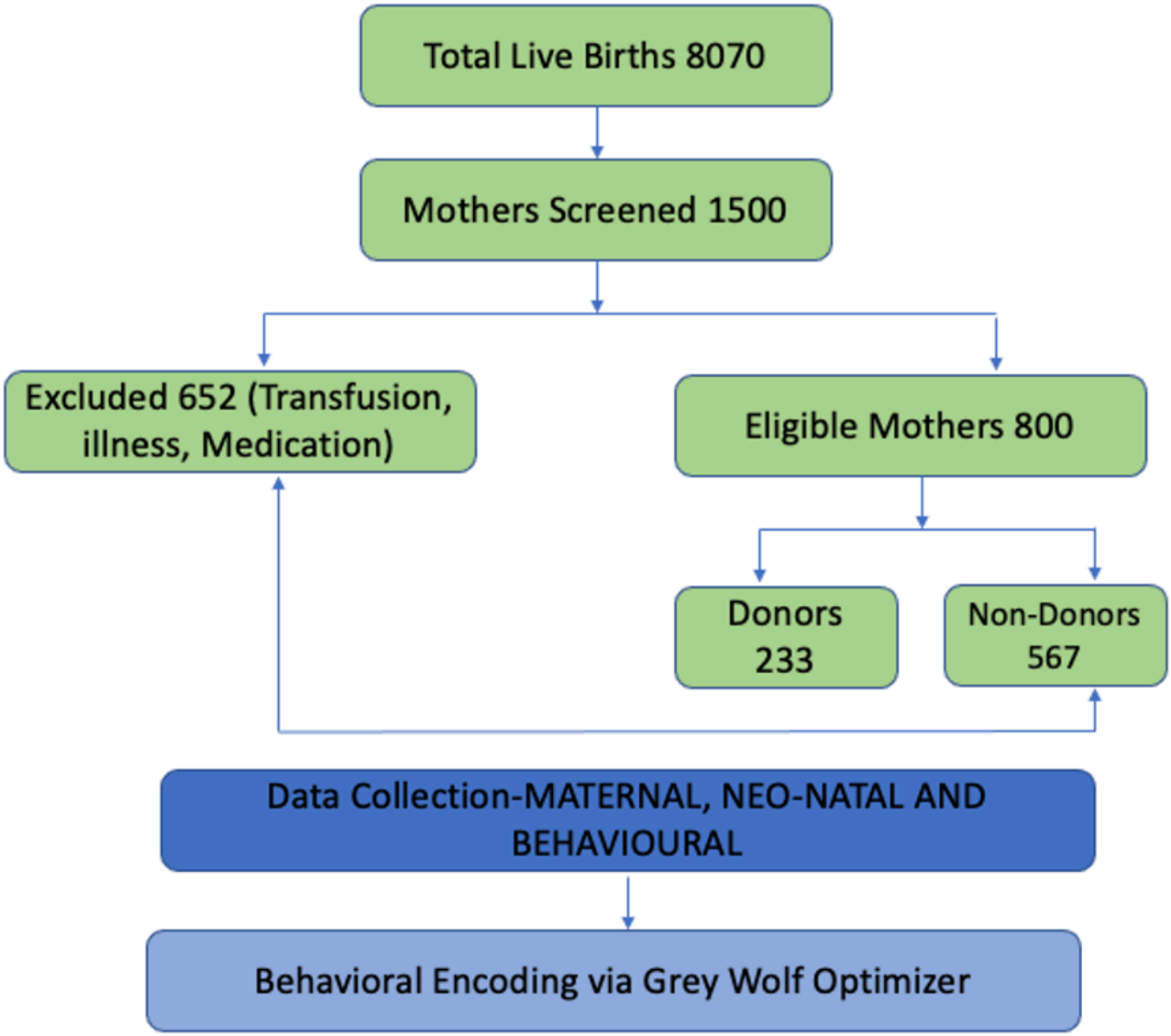



Figure 3

Study Design and Overall Framework

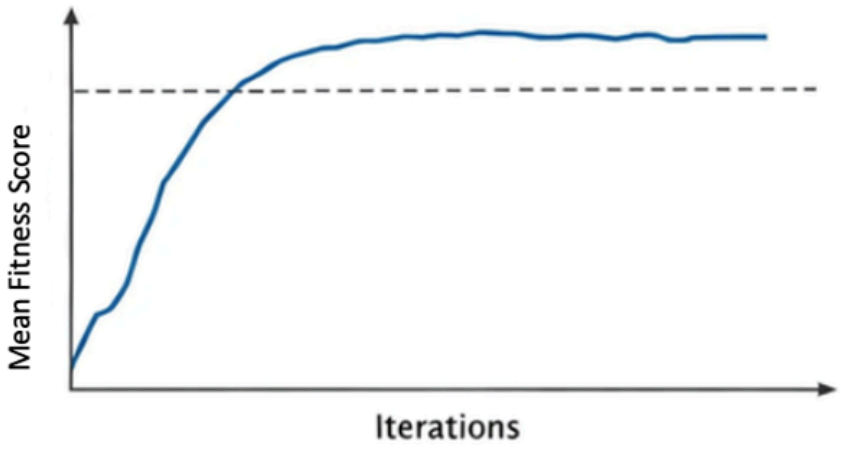


Figure 4

Convergence Curve of Grey Wolf Optimiser

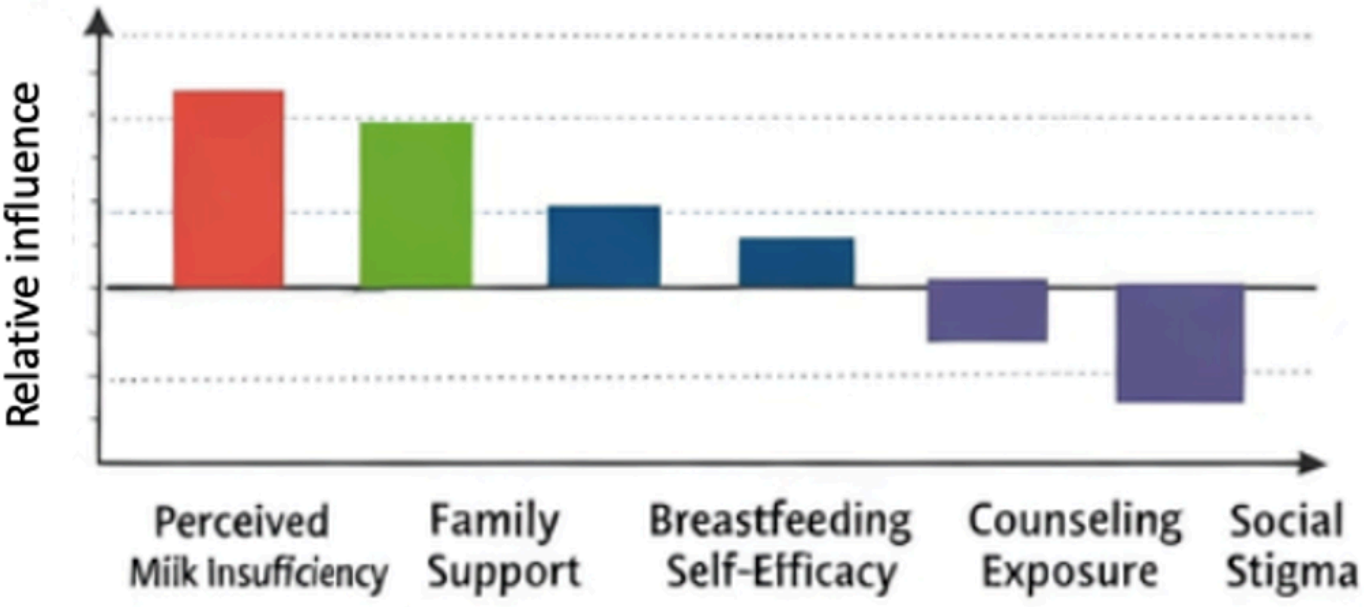



Figure 5

Relative Contribution of Behavioural Variables