







Article

Association of Maternal Observation and Motivation (MOM) Program with m-Health Support on Maternal and Newborn Health

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Citation: Paulsamy, P.; Easwaran, V.; Ashraf, R.; Alshahrani, S.H.; Venkatesan, K.; Qureshi, A.A.; Arrab, M.M.; Prabahaar, K.; Periannan, K.; Vasudevan, R.; et al. Association of Maternal Observation and Motivation (MOM) Program with m-Health Support on Maternal and Newborn Health. *Healthcare* **2021**, *9*, 1629. <https://doi.org/10.3390/healthcare9121629>

Academic Editor:
Veronique Demers-Mathieu

Received: 27 October 2021
Accepted: 21 November 2021
Published: 25 November 2021

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Abstract: Maternal and child nutrition has been a critical component of health, sustainable development, and progress in low- and middle-income countries (LMIC). While a decrement in maternal mortality is an important indicator, simply surviving pregnancy and childbirth does not imply better maternal health. One of the fundamental obligations of nations under international human rights law is to enable women to endure pregnancy and delivery as an aspect of their enjoyment of reproductive and sexual health and rights and to live a dignified life. The aim of this study was to discover the correlation between the Maternal Observation and Motivation (MOM) program and m-Health support for maternal and newborn health. A comparative study was done among 196 pregnant mothers (study group—94; control group—102 mothers) with not less than 20 weeks of gestation. Maternal outcomes such as Hb and weight gain and newborn results such as birth weight and crown–heel length were obtained at baseline and at 28 and 36 weeks of gestation. Other secondary data collected were abortion, stillbirth, low birth weight, major congenital malformations, twin or triplet pregnancies, physical activity, and maternal well-being. The MOM intervention included initial face-to-face education, three in-person visits, and eight virtual health coaching sessions via WhatsApp. The baseline data on Hb of the mothers show that 31 (32.98%) vs. 27 (28.72%) mothers in the study and control group, respectively, had anemia, which improved to 27.66% and 14.98% among study group mothers at 28 and 36 weeks of gestation ($p < 0.001$). The weight gain ($p < 0.001$), level of physical activity ($p < 0.001$), and maternal well-being ($p < 0.01$) also had significant differences after the intervention. Even after controlling for potentially confounding variables, the maternal food practices regression model revealed that birth weight was directly correlated with the consumption of milk ($p < 0.001$), fruits ($p < 0.01$), and green vegetables ($p < 0.05$). As per the physical activity and maternal well-being regression model, the birth weight and crown–heel length were strongly related

with the physical activity and maternal well-being of mothers at 36 weeks of gestation ($p < 0.05$). Combining the MOM intervention with standard antenatal care is a safe and effective way to improve maternal welfare while upholding pregnant mothers' human rights.

Keywords: pregnant mothers; physical activity; maternal well-being; antenatal mothers; newborn outcomes; m-health; low birth weight; small for gestation; gestation age; hemoglobin

1. Background

Pregnancy is a precious event that can influence maternal health and the health of future generations. Nutrition is vital for maternal and child health, and it is well acknowledged that well-balanced nutrition in early life is the foundation for long-term health [1]. Poor maternal nutrition, maternal body composition, metabolism, and placental nutrient supply are key factors that can influence fetal development and have been associated with a poor pregnancy outcomes and fetal genetic potential expression [2].

For maternal, fetal, and newborn health, counseling women to promote awareness of the importance of maternal health prior to conception and in pregnancy and advocating a culturally accepted lifestyle modification in favor of a healthy weight is critical. Although a balanced diet is widely available in today's globalized world, a shift to a high-fat, low-quality diet has resulted in inadequate vitamin and mineral intake during pregnancy [3]. When the required micronutrient intakes are difficult to meet through food alone, supplementation and fortification can be of benefit [4]. The research does not support routine multiple micronutrient supplementations alone [5]; rather, it emphasizes the significance of an individualized approach to identify nutritional deficiencies in individuals, leading to healthy, culturally accepted lifestyle practices prior to conception and in pregnancy and ultimately to better maternal and newborn outcomes [6].

According to the World Health Organization (WHO) guidelines on "antenatal care (ANC) for a positive pregnancy experience" [1], counseling on healthy eating and staying physically active during pregnancy is recommended for pregnant women who want to stay healthy and avoid accumulating too much weight. Pregnant women should take a daily iron and folic acid supplement with 30 to 60 mg of elemental iron and 400 mcg (0.4 mg) of folic acid to avoid maternal anemia, puerperal sepsis, low birth weight, and premature birth. Each pregnant woman should keep her case notes throughout her pregnancy to ensure continuity, quality of treatment, and a positive pregnancy experience. Antenatal care models with at least eight visits are recommended to reduce perinatal mortality and improve pregnant women's experiences. It is proposed that maternal and newborn health-related behaviors be promoted to a broad range of cadres, including lay health workers, auxiliary nurses, nurses, midwives, and doctors [1].

"Every mother and newborn receive quality care during the pregnancy, childbirth, and postnatal period", the WHO envisions [7]. There is evidence that effective intervention strategies for preventing or treating all life-threatening maternal complications are affordable [8]. Optimal adaptation and uptake of existing research findings could alleviate nearly two-thirds of the global maternal and newborn disease burden worldwide [9]. In 2015, almost 303,000 women and adolescent girls died worldwide due to pregnancy and delivery complications [10]. The majority of maternal deaths occur in low-resource settings, and most of them can be avoided [11]; also, almost 2.6 million babies were stillborn in 2015, mostly in low-resource areas [12].

Nevertheless, the association between maternal nutrition and birth outcome is quite complex and influenced by biological, socioeconomic, and demographic factors. Understanding the relationship between maternal nutrition, pregnancy, and birth outcomes may serve as the basis for nutritional interventions. It will improve birth outcomes and the newborn's long-term health, improving quality of life and lowering mortality, morbidity, and healthcare costs [13].

Under the international human rights law, one of the fundamental commitments of nations includes enabling women to survive pregnancy and delivery as part of their enjoyment of sexual and reproductive health and rights and living a life of dignity [14]. The human-rights-based approach promotes health and well-being while preserving dignity and rights and also avoiding substantial morbidity and mortality.

For this, based on a woman's preferences and available possibilities, we need novel, evidence-based methods of antenatal care to accomplish the "Every Woman Every Child" vision and the Global Strategy for Women's, Children's, and Adolescents' Health. Maternal care also provides an opportunity to interact with and support women, families, and communities at a crucial period in a woman's life.

1.1. Significance of the Study

Poor maternal nutrition, resulting in either malnutrition or excessive weight gain, is common and significant in poor perinatal outcomes [15]. Low BMI in early pregnancy augments the risk of both small for gestational age (SGA) babies and preterm birth [16]. A study showed that high BMI increased the risk of preterm birth and also low weight gain, which is associated with SGA and preterm birth [17]. According to randomized control trials (RCTs), it is well proven that intervention improves birth outcomes, especially when given to impoverished women leads to their newborns gain roughly an extra 100 g (95% CI: 56–145) at delivery [18]. The WHO has set a global target to reduce LBW by 30% by 2025 [19].

Iron, folate, and vitamin A deficiency are all linked to anemia and associated with an increased risk of maternal and infant mortality [20]. Anemia also significantly increases the danger of maternal death by a factor of two [21]. In 2017, more than 50 million children had BMIs that were too low as a result of inadequate nutrition during pregnancy [22]. In addition to producing anemia, iron deficiency harms muscular energy usage and, as a result, physical capability and work performance. It also affects the immunological state and, thereby, infection-related morbidity [23]. Folate (vitamin B9) insufficiency has been related to prenatal neural tube abnormalities in addition to anemia [24,25]. Iron–folate acid supplementation substantially decreased self-reported intra-partum hemorrhage in an RCT in rural Nepal [26].

Pre-eclampsia has been related to calcium deficiency [27], and shortages of other vitamins and minerals, such as vitamin E, C, B6, and zinc, have also been suggested to have a role in the condition [28]. Zinc insufficiency is linked to weakened immunity [29–31]. Due to limited access to comprehensive maternal healthcare, women from low-income, rural, and other marginalized backgrounds are more likely to experience pregnancy- and childbirth-related complications [32].

Pregnancy is a time of physical and emotional stress, and psychological symptoms occur at a higher rate in pregnant women, adversely affecting pregnancy and postpartum outcomes [33]. It is, therefore, necessary to routinely screen for psychological symptoms during pregnancy and postpartum.

Mobile health, or "m-Health", technologies are increasingly being used to improve chronic disease management and encourage behavior change [34]. Given that more pregnant women are using smart phones, mobile health provides an opportunity to improve pregnancy health behaviors. Hence, this study was undertaken to find the impact of the Maternal Observation and Motivation (MOM) program with m-Health support on maternal and newborn health.

1.2. Objectives

To test the hypothesis that the Maternal Observation and Motivation (MOM) program with m-Health support during pregnancy would improve maternal and newborn health.

2. Methods

2.1. Design

A comparative study was done to assess the effect of the Maternal Observation and Motivation (MOM) program with m-Health support on maternal and newborn health.

2.2. Participants and Setting

The study participants were pregnant women with gestational age not less than 20 weeks with a viable fetus confirmed by ultrasonogram. The study took place in six villages, 30–40 km from Chennai city and covered a population of 35,000. The eligible samples were 196 pregnant women who met the inclusion criteria and were ready to take part in the study.

2.3. Sample Size and Sampling Process

The non-probability convenient sampling technique selected 196 samples from six villages in the Chennai suburban area. The inclusion criteria were viable fetus, gestational age not less than 20 weeks, no severe illness, written consent for participation, and possession of a smart phone when recruited. The mothers from three villages were allotted to the study group (94 mothers) and those from three other villages were in the control group (102 mothers) for convenience and to avoid contamination. The CONSORT diagram is included in Figure 1.

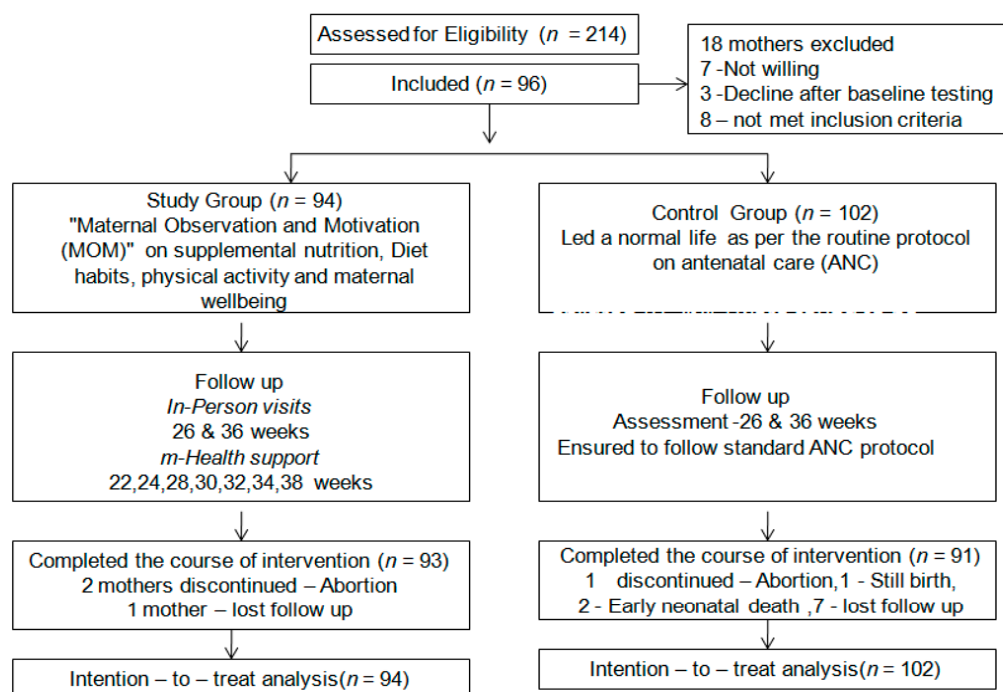


Figure 1. CONSORT flow diagram of the study.

2.4. Data Collection Tools/Instruments

Section A: The sociodemographic characteristics of the participants included age, parity, education, occupation of the mothers, husband's education and occupation.

Section B: Food Frequency Questionnaire (FFQ) was created and used to collect the baseline data on diet history.

Section C: Maternal outcomes such as height (Ht), weight (kg), body mass index (BMI), and hemoglobin (Hb) at baseline, 28 weeks, and 36 weeks were obtained. In addition, the data related to maternal morbidity and mortality, such as spontaneous abortion, induced abortion, stillbirth, or live births, were obtained from a structured checklist.

Section D: Newborn outcomes such as birth weight and crown–heel length were measured to the nearest 0.1 cm using fiberglass tapes (CMS Instruments, London, UK). Secondary data such as low birth weight, small for gestational age, major congenital malformations, and twin or triplet pregnancies were also collected.

Section E: The data were gathered using a self-structured pregnancy physical activity (PA) checklist.

Section F: Maternal well-being was assessed using the World Health Organization-5 Well-Being Index (WHO-5) [35] tool.

2.5. Assessment

The participating pregnant women were followed up monthly at home by one of the investigators or research assistants. Information on specified gastrointestinal adverse effects was collected after four weeks of supplementation and the MOM program. If the mother had minor ailments such as constipation or heartburn, home remedies as per the WHO guidelines were given. If those symptoms persisted or worsened, mothers were referred to the nearby health centers/hospitals. The weight and Hb level in venous blood were assessed using HemoCue (HemoCue AB) at initial contact, 28-, and 36-weeks of gestation. Anemia was defined as having a hemoglobin level less than 11.0 g/mL. All participants in both groups were provided with two 3-day food diaries to quantify intakes and physical activity surveys to ascertain self-reported compliance, monitored by the investigating team.

Pregnancy outcomes were classified as spontaneous abortion (unintended loss of a fetus before 28 weeks' gestation as determined by reported last menstrual period), induced abortion (intentional loss of a fetus before 28 weeks' gestation), stillbirth (birth of a dead fetus after 28 weeks' gestation), or live birth (birth of a fetus with any sign of viability). The birth anthropometry was primarily measured by trained nurses within 72 h of birth. SECA electronic scales (SECA GmbH) were used to measure all birth weights to a precision of 10 g.

The crown–heel length of the newborn was measured using standard procedures using domestically manufactured collapsible length boards that were accurate to 1 mm. Training of the interviewers/research assistants on anthropometric measurements was conducted periodically. Weighing equipment was calibrated monthly with standard weights. Inter-observer and intra-observer variation studies were conducted every month to ensure the quality of these measurements. The data were gathered using a self-structured pregnancy physical activity (PA) checklist.

The duration of each day's physical activity was recorded in the self-monitored diary. The "Fit" app was downloaded on the mothers' smart phones to observe and motivate their PA to calculate the average weekly minutes spent on physical activity. Pregnancy is a time of physical and emotional stress, as well as progressive physiological and psychological changes. Psychological symptoms occur at a higher rate in pregnant women than in non-pregnant women and adversely affect pregnancy and postpartum outcomes. Therefore, the WHO-5, a short-form (five items) tool was used. The five items are as follows: I have felt cheerful and in good spirits; I have felt calm and relaxed; I have felt active and vigorous; I woke up feeling fresh and rested; and my daily life has been filled with things that interest me. Each item is rated on a six-point Likert-type scale of 0–5, with 0 indicating the lack of positive feelings during the preceding 2 weeks and 5 indicating consistent positive feelings. The total raw score, which ranges from 0 to 25, is multiplied by 4 to obtain the final score, with 0 representing the worst possible well-being and 100 representing the best possible well-being [26].

2.6. Intervention

Women in the control group received only the standard antenatal care, and the intervention group received routine antenatal care as well as a the "Maternal Observation

and Motivation (MOM)" program. The MOM program began with a single face-to-face education session conducted for a group of 5–8 antenatal mothers.

This education session was delivered at the first visit and emphasized the importance of nutrition; the effect of anemia and vitamin or mineral deficiency on the mother, the fetus, and the child in later life; the compliance of supplemental medications and nutrition supplement mixes; and the importance of the physical activity and emotional well-being of the mother during pregnancy. Participants were encouraged and were informed about a healthy diet, including adding fresh fruits and vegetables, milk and milk products. The recommended diet provided additional calories, proteins, and micronutrients that approximated the recommended levels.

Under the Integrated Child Development Services (ICDS) program [36], the antenatal (AN) mother receives a supplemental nutrition powder that has the following components in 100 mg: protein (11 g), carbohydrate (55 g), calcium (200 mg), vitamin A (200 mcg), niacin (4 mg), folic acid (15 mcg), fat (3 mg), iron (6 mg), vitamin B1 (300 mcg), vitamin B2 (350 mcg), vitamin C (15 mg), and calories (400 kcals). The AN mother receives 165 g/day as 15 days ration from Anganwadi centers. In addition to the nutritional mix given by the Government of Tamilnadu, all AN women with Hb = 11 g/dL were given 100 tablets of iron (100 mg) and folic acid (0.5 mg) (1 tablet/day) at 18 week gestation or soon after being registered in the study through the mother and child protection card (MCP Card), according to the National Nutritional Anemia Control Program. If the AN woman had an Hb of 9–10.9 g/dL, 2 tablets/day for 100 days were provided, and if Hb was 7.1 to 8.9 g/dL an additional two tablets per day were given and the AN mother was given an iron sucrose injection. Before starting these iron and folic acid supplements, the AN woman was given albendazole 400 mg tablets for anthelmintics treatment. The same protocol was followed in this study too. It was ensured that the control group mothers also followed the same protocol for ethical reasons.

All women in the study group were given 100 tablets of iron (60 mg) and folic acid (0.5 mg) at initial contact according to the National Nutritional Anemia Control Program and the nutritional mix given by the government Tamilnadu [36]. Anemic mothers were given special consideration and followed the above protocol. The information received at the face-to-face education session was reinforced by smart phone, through WhatsApp messages every 2 weeks (sent by the research team). The research assistants did three follow-up, face-to-face, in-person home visits besides those at baseline, 26 weeks, 36 weeks of gestation, and after delivery. Among the four research assistants, three were nurses with master's degrees in Obstetrics and Gynecology and one had a masters in Mental Health Nursing. The research assistants were given training on the assessment of data and counseling of mothers related to MOM and motivating the mothers to comply with the nutrition habits, supplements, regular physical activity, and mental well-being.

The content of the WhatsApp messages was standardized to a specific theme on a 2 week basis with some discourse between the researchers and participants. Individual attention was given to each mother on her concerns about diet, physiological alterations related to pregnancy and its' management, and follow up of nutrition supplementation. Individualized counseling was also given on minor ailments related to pregnancy, and one of the researchers also visited the mothers at least two times during the study period. The virtual meetings occurred eight times during the study period with three in-person visits.

2.7. Ethical Consideration

Official permission to conduct the study and ethical approval were obtained from the Institutional Ethical Committee with ICE/LCN/2021-02 dated 29 January 2021. Consent from the participants was collected before starting the study after explaining the aim of the study, their role, the confidentiality of the information, and their right to depart from the study at any point of data collection. A no-harm certificate was obtained from an obstetrician for the MOM program. The control group mothers were also assured

that they were following the standard antenatal care protocol of the state government. Confidentiality and beneficence were assured throughout the study period.

2.8. Statistical Analysis

The data were processed and analyzed by SPSS version 21.0. Armonk, NY using descriptive and inferential statistics. Analysis of data was done in accordance with intention to treat. Analysis of variance was used to examine the main effects of food practices among the two groups on the Hb level of the mothers. The 't' test was used to compare differences between group means to compare the MOM intervention with the standard program. Multiple regression analysis was used to examine changes in birth weight of the newborn according to maternal food practices, physical activity, and maternal well-being. In regressions, birth measurements and maternal measurements were evaluated as continuous variables. Food practices, physical activity, and maternal well-being scores were analyzed as grouped variables, and $p < 0.05$ was considered statistically significant.

3. Results

Table 1 shows the baseline data of the mothers of the study and control group. In this study, 94 mothers and 102 mothers in the study group and in the control group respectively. The mean age of the mothers was 28.1 ± 4.6 and 27.9 ± 4.8 years, respectively, for the study and control groups. Regarding the parity, 48.9% and 53.92% were primipara mothers in the study and control group. The mean height of the mothers was 144.8 cm with an SD of 6.1 in the study group, whereas it was 147 ± 6.9 cm in the control group. The average BMI was 21.7 ± 3.1 and 21.3 ± 2.9 for the study and control group, respectively. The majority of the mothers had education up to secondary school (65.96% vs. 55.88%) and most of them were not working (77.66% vs. 69.71%). The education status of the husbands was more or less similar in both groups (73.4% vs. 76.47%), and a similar trend was also seen in their occupation status.

The dietary intake of the pregnant mothers was measured using a self-reported FFQ checklist on milk and milk products, green leafy vegetables, and fruits. These data were used for the regression analysis to determine their relationship with the maternal and newborn outcomes. In addition to this, the mothers were given nutritional supplements as per the Government of Tamilnadu.

Table 2 shows the comparison of Hb status among study and control group mothers at different periods of observation. For the study group, the mean Hb was 110.4 with an SD of 3.08 at baseline, 112.7 with an SD of 4.13, and 113.1 with SD of 3.16 at 28 and 36 weeks of gestation at $p < 0.001$ as per repeated ANOVA.

The baseline data on Hb show that 31 (32.98%) vs. 27 (28.72%) of the study and control group had anemia, which was improved to 27.7% and 15.0% among study group mothers at 28 and 36 weeks of gestation. There was a significant dissimilarity in anemia status among the study and control group at the $p < 0.001$ level after intervention. The weight gain among the intervention group also showed a significant disparity at the $p < 0.001$ level. There was a significant variation between physical activity and maternal wellbeing groups at the $p < 0.001$ and $p < 0.01$ levels (Table 3). Similarly, the crown–heel length was 47.6 ± 3.0 vs. 46.8 ± 3.5 cm among the study and control group, respectively.

The newborn outcomes show a significant difference between groups at $p < 0.001$ in crown–heel length and in birth weight and gestational age at birth at $p < 0.01$. The mean birth weight of the study group was slightly higher than that of the control group (2.78 ± 0.56 vs. 2.56 ± 0.49 kg). Similarly, the crown–heel length was 47.6 ± 3.0 vs. 46.8 ± 3.5 cm in the study and control group, respectively.

The birth weight was strongly related with the consumption at 36 weeks of gestation of milk ($p < 0.001$), fruits ($p < 0.01$), and green vegetables (GLV) ($p < 0.05$) even after adjustment for potentially confounding variables such as sex, parity, gestational age at birth, and baseline weight of mothers (Table 4).

Table 1. Baseline characteristics of the pregnant women of both the study and the control group.

Variables	Study (n = 94) (%)	Control (n = 102) (%)
Age (in years) Mean \pm SD	28.14.6	27.9 \pm 4.8
Parity		
Primipara mothers	46 (48.9)	55 (53.9)
Multipara mothers	48 (51.1)	47 (46.1)
Height (cm)	144.8 \pm 6.1	147 \pm 6.9
Weight (kg)	45.8 \pm 4.3	46.1 \pm 3.9
BMI (kg/m ²)	21.7 \pm 3.1	21.3 \pm 2.9
Educational Attainment		
Primary or less	21 (19.7)	19 (18.6)
Up to secondary	62 (66.0)	57 (55.9)
Completed college education	11 (11.7)	26 (25.5)
Occupation		
Semiskilled/unskilled	16 (17.0)	19 (18.6)
Skilled/self-employed	3 (3.2)	5 (4.9)
Professional	2 (2.1)	7 (6.7)
Not working	73 (77.7)	71 (69.1)
Husband's Education		
Primary or less	17 (18.7)	16 (15.7)
Secondary	69 (73.4)	78 (76.5)
Graduate	8 (8.5)	8 (7.8)
Husband's Occupation		
Semi-skilled/unskilled	58 (61.7)	62 (60.8)
Skilled/self-employed	24 (25.5)	27 (26.5)
Professional	4 (4.3)	6 (5.9)
Not working/other	8 (8.5)	7 (6.8)
Dietary Intake		
Milk and Milk Products (other than in coffee/tea)		
1 time/week	43 (45.7)	50 (49.0)
1–6 times/week	31 (33)	37 (36.3)
\geq 7 times/week	20 (21.3)	15 (14.7)
Green Leafy Vegetables (GLV)		
1 time/week	23 (24.5)	27 (26.5)
1–6 times/week	61 (64.9)	58 (56.9)
\geq 7 times/week	10 (10.6)	17 (16.7)
Fruits		
1 time/week	14 (14.9)	19 (18.3)
1–6 times/week	59 (55.5)	62 (60.8)
\geq 7 times/week	21 (22.3)	21 (20.6)

Table 2. Comparison of Hb status among study and control group mothers at different periods of observation.

Maternal Hb Level	Study Group Mean (SD)	Control Group Mean (SD)	t Value p-Value
Hb level at baseline, g/L	110.4 (3.08)	110.1 (2.91)	t = 0.848 p = 0.397 (N.S.)
Hb level at 28 week gestation, g/L	112.7 (4.13)	112.1 (3.99)	t = 0.199 p = 0.843 (N.S.)
Hb level at 36 week gestation, g/L	113.1 (3.16)	112.5 (3.05)	t = 0.985 p = 0.21 (N.S.)
Repeated ANOVA	F = 19.305, p < 0.001	F = 0.633, p = 0.532	

Table 3. The maternal and newborn outcomes among pregnant mothers.

Maternal Outcome Variables	Study Group (n = 94)	Control Group (n = 102)	p
Anemia (Hb < 110 g/L)			
At 28 weeks	26 (27.7%)	31 (30.4%)	0.001
At 36 weeks	14 (15.0%)	19 (18.6%)	
Weight Gain			
At 28 weeks	43.9 ± 6.2	41.8 ± 8.1	
At 36 weeks	47.6 ± 7.4	46.2 ± 6.7	0.001
Physical Activity (min/week)			
Pre-intervention	81 ± 11	86 ± 16	
Post-intervention	131 ± 29	103 ± 17	0.001
Maternal Well-being			
Pre-intervention	54 ± 13	59 ± 18	0.01
Post-intervention	81 ± 19	67 ± 11	
Newborn Outcome Variables			
Birth weight (kg)	2.78 ± 0.56	2.56 ± 0.49	0.01
Crown–heel length (cm)	47.6 ± 3.0	46.8 ± 3.5	0.001
Gestational age at birth (wk)	38.9 (38.6–39.1)	38.6 (38.4–39.0)	0.01

Table 4. Multiple regression analysis of the relationship of the maternal food practices in 36 weeks of gestation with newborn's birth weight.

Dependent Variable	Independent Variables	Milk Product Intake			Green Leafy Vegetables Intake			Fruit Intake		
		R ²	β	P	R ²	β	p	R ²	β	p
Birth weight of newborn (g)	Sex, parity, gestational age at birth	19.8 (0.87)	16.9	<0.001	23.1 (1.63)	6.7	<0.05	22.1 (0.98)	5.8	<0.01
	Sex, parity, gestational age at birth and baseline weight of mother	29.3 (1.8)	17.5	<0.001	23.4 (0.47)	5.1	<0.05	31.6 (0.83)	9.1	<0.05

The newborn's birth weight and crown–heel length was strongly connected with the physical activity at 36 weeks of gestation ($p < 0.001$) after adjusting the predictor variables such as sex; parity; and baseline weight of the mother; and intake of milk products, GLV, and fruits. Maternal well-being also showed a significant influence on the birth weight and crown–heel length of the newborn ($p < 0.05$) (Table 5).

Table 5. Relationship between physical activity and maternal well-being at 36 weeks of gestation with newborn outcomes.

Dependent Variable	Independent Variable	Physical Activity	Maternal Well-being
Birth Weight	P1 (Sex, parity, and baseline weight of mother)	<0.05	<0.05
	P1 and intake of milk products, GLV, and fruits	<0.001	<0.05
Crown–Heel Length	P1 (Sex, parity, and baseline weight of mother)	<0.01	<0.05
	P1 and intake of milk products, GLV, and fruits	<0.05	<0.05

The data on preterm birth (PTM), spontaneous abortion, stillbirth, low birth weight, small for gestational age, major congenital malformations, and twin or triplet pregnancies were obtained from a structured checklist. There were only two spontaneous abortions and four small-for-gestation babies among the study participants (Figure 2).

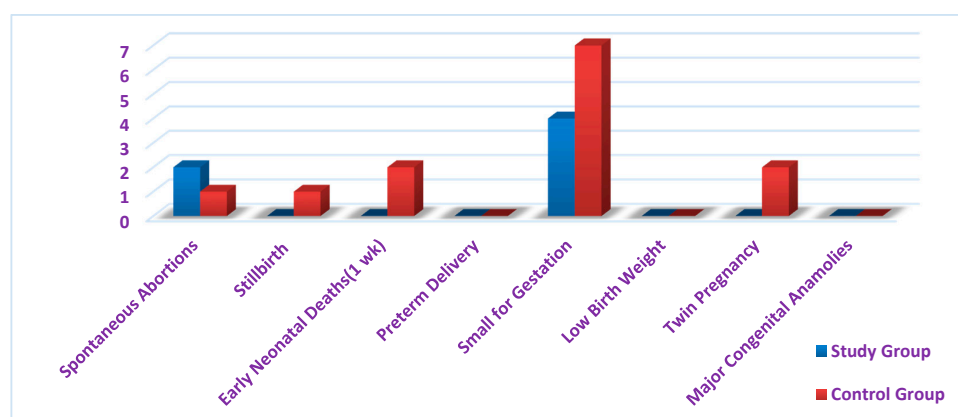


Figure 2. Distribution of secondary variables.

4. Discussion

This study was done to compare the effect of the Maternal Observation and Motivation (MOM) program on maternal outcomes such as weight (kg) and Hb at baseline, 28 weeks, and 36 weeks and newborn outcomes such as birth weight, crown–heel length, and gestational age at birth. The data on preterm birth (PTM), spontaneous abortion, stillbirth, low birth weight, SGA, major congenital malformations, and twin or triplet pregnancies were obtained from a structured checklist. The strengths of our study were that it was community based, and the mothers were continuously observed and motivated by the qualified nurses for their compliance with the intervention as well as to promote their well-being, throughout their pregnancy. In addition, according to the WHO recommendations that pregnant women be followed up at least eight times during their pregnancy, in this project, the mothers had four face-to-face counseling sessions and eight virtual follow-ups with the healthcare professionals through smart phones.

The baseline data on Hb of the mothers show that around 29% of them had anemia, which was improved to 27.7% and 15.0% among study group mothers at 28 and 36 weeks of gestation after the intervention. According to the findings of a study, globally, in 2016, an estimated 35.3 million pregnant women worldwide or 40% were anemic. Among them, 19% of women are affected by iron deficiency [37]. The WHO also says that anemia among pregnant women ranges from 14% in affluent countries to 65–75% in India [38]. Even though anemia is easily curable and avoidable illness, it is strongly linked to pregnancy. Increasing each 1 g/dL of mean hemoglobin (Hb) in late pregnancy reduces the odds of maternal deaths by 29% [39]. Reduced intake, excess demand in multigravida women, altered metabolism, low socioeconomic status, illiteracy, early marriage, and infectious diseases such as hookworm infestations may be the causal factors linked to the occurrence of anemia during pregnancy [40]. Hence, the improved Hb among mothers of this study caused by the MOM intervention enhanced the pregnancy-related outcomes. Thus, nutrition education and counseling during pregnancy is a promising strategy to improve maternal and newborn health.

In addition, inadequate folate levels in the blood before conception and in the first trimester can cause severe fatal neural tube abnormalities. Spina bifida and anencephaly, the two most prevalent kinds of neural tube disorders, affect an estimated 300,000 babies each year [38,41]. Therefore, it is crucial to improve pregnant mothers' Hb and folic acid level to elevate the health status of the fetus and future generations.

According to a few prospective studies on maternal nutrition, after controlling for a variety of covariates, the maternal thinness, as defined by a low mid-upper arm circumference, was linked to all-cause maternal death (up to 42 days postpartum) in Nepal [26] as well as severe hemorrhage and sepsis morbidity in Bangladesh [42]. The study on "Improving Women's Diet Quality Preconceptionally and during Gestation: Effects on Birth Weight and Prevalence of Low Birth Weight" found that there was a significant disparity in anemia status and weight gain among the study and control groups at $p < 0.001$ after

the intervention, which denied the effect of daily snacking with leafy vegetables, fruit, and milk before conception and during pregnancy on the birth weight [43]. Hence, the tailor-made health coach approach of this present study, with the additional emphasis on physical activity and mothers' mental health proved to be effective. There were only two spontaneous abortions and four small-for-gestation babies among the study participants (Figure 2).

As per the concept, the WHO's shift of considering diet quality and promoting healthy eating practices on antenatal care recommends counseling on healthy eating and keeping physically active during pregnancy [44]. Furthermore, under the international human rights law, one of the fundamental commitments of nations include enabling women to survive pregnancy and delivery, as part of their enjoyment of sexual and reproductive health rights, as well as living a life of dignity [14]. Hence, by considering the above facts and providing a nutritious diet, pregnant women need additional support in the form of emotional and social motivation and individualized care during pregnancy.

This study's strong point was that it adopted an individualized approach for pregnant women with in-person interactions and the most novel approach of m-Health support through smart phones. This allowed the investigators to meet the mothers often and give custom-made interactions and resolutions for the women. This was reflected in the study findings on physical activity, maternal well-being, and the outcome variables of the study. There was a significant dissimilarity between physical activity and maternal well-being among groups in the present study at $p < 0.001$ and $p < 0.01$ levels.

Nearly three million annual newborn deaths account for an estimated 44% of all under-five deaths globally. There is solid evidence for various therapies on prevention of this, provided alone or in packages, across both time and place continuums (preconception, pregnancy, birth, and postnatal). While these interventions can prevent 70% of newborn fatalities (and more than one-third of stillbirths) [45], the most challenging issues ahead are overcoming bottlenecks and healthcare system barriers to achieve high coverage and quality at scale. In the present study, with the MOM intervention, the newborn outcomes show significant differences at $p < 0.001$ in crown–heel length, birth weight, and gestational age at birth at $p < 0.01$, respectively. The mean birth weight of the study group was slightly higher than that of the control group (2.780 ± 0.560 vs. 2.560 ± 0.490 kg). Similarly, the crown–heel length was 47.6 ± 3.0 vs. 46.8 ± 3.5 cm among the study and control groups. This could have been because the present study provided individual attention to the antenatal mothers and included regular monitoring and motivation to improve the mothers' physical and mental well-being of the mothers.

According to the maternal food practices regression model, the birth weight was strongly associated with the consumption at 36 weeks of gestation of milk ($p < 0.001$), fruits ($p < 0.01$), and green vegetables ($p < 0.05$) even after adjustment for potentially confounding variables such as gender, parity, gestational age at birth, and baseline weight (Table 4). This gives the insight that consuming the supplements alone will not be enough to improve the birth weight. Consumption of milk and milk products, fresh fruits, vegetables, and green leafy vegetables play a significant role other than nutrition supplementation on the fetal growth and birth weight.

As per the physical activity and maternal well-being regression model, the birth weight and crown–heel length were strongly related with the physical activity and maternal well-being of mothers at 36 weeks of gestation ($p < 0.05$) even after adjustment for potentially confounding variables such as gender; parity; gestational age at birth; and baseline intake of milk products, GLV, and fruits. This finding suggests that the newborn outcome variables such as birth weight and crown–heel length were strongly linked with the mothers' physical activity and maternal well-being of the mothers.

Hence, this multi-component MOM intervention incorporating diet, nutritional supplements, physical activity, and maternal well-being by personal interaction with continuous observation and motivation through m-Health improved the maternal and newborn outcomes significantly. However, among the independent variables, physical activity and

maternal well-being played a significant role in the improvement of newborn outcomes in addition to dietary habits, including intake of milk products, GLV, and fruits.

Our results contrast with the results of RCTs conducted by two prospective studies [38,43] that meagre nutrition supplementation and dietary modification were unsuccessful in bringing the desired changes in the newborn outcome variables such as birth weight, length, and gestational age at birth. Since optimal maternal weight and Hb are the essential components of maternal and newborn care, improving these outcomes by modifying dietary habits and improving physical activity and maternal well-being by continuous monitoring with motivation is sensible for any intervention trials. The interventions including incessant motivation may enhance the compliance of nutrition supplements, dietary modification, adherence to expected physical activity, and improved maternal well-being, which might have improved the maternal and newborn outcomes in study participants.

5. Conclusions

While reducing maternal mortality is an important indicator, simply surviving pregnancy and childbirth does not imply improved maternal health. The burden of maternal morbidity can have long-term consequences for women's health and well-being. Adopting a human rights framework for universal health necessitates the provision of high-quality care not only during pregnancy and labor but also before and after childbirth. It is critical to broaden the focus on mortality to include morbidity to achieve health for all. This MOM intervention involving face-to-face counseling, constant motivation, and observation by m-Health improved compliance, physical activity behavior, and maternal well-being and eventually improved maternal and newborn health. Hence, it is a safe and effective measure to use the MOM intervention with standard antenatal care to improve maternal well-being from the human rights point of view and reduce the disease burden.

Author Contributions: P.P.: Conceptualization, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing—original draft, writing—review and editing. V.E.: data curation, formal analysis, methodology, project administration, resources, validation, writing—review and editing. R.A.: Conceptualization, methodology, project administration, writing—original draft, writing—review and editing. S.H.A.: conceptualization, methodology, project administration, resources, supervision, validation, visualization, writing—review and editing. K.V. (Krishnaraju Venkatesan): conceptualization, formal analysis, funding acquisition, methodology, project administration, resources, software, supervision, validation, visualization, writing—original draft, writing—review and editing. A.A.Q.: conceptualization, data curation, methodology, project administration, validation, writing—original draft, writing—review and editing. M.M.A.: data curation, formal analysis, methodology, project administration, validation, visualization, writing—review and editing. K.P. (Kousalya Prabahar): formal analysis, methodology, project administration, software, supervision, validation, visualization, writing—original draft, writing—review and editing. K.P. (Kalaiselvi Periannan): data curation, formal analysis, methodology, project administration, resources, validation, writing—review and editing. R.V.: conceptualization, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing—review and editing. G.K.: data curation, formal analysis, methodology, project administration, validation, writing—original draft, writing—review and editing. K.C.: conceptualization, investigation, methodology, project administration, supervision, writing—review and editing. E.M.P.: conceptualization, investigation, methodology, project administration, supervision, writing—review and editing. K.V. (Kumar Venkatesan): formal analysis, methodology, project administration, resources, software, validation, writing—review and editing. V.M.: conceptualization, investigation, data curation, project administration, resources, supervision, validation, visualization, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Deanship of Scientific Research at King Khalid University, grant number "RGP 2/186/42".

Institutional Review Board Statement: The Institution Ethical Committee gave an ethical clearance with IEC/LCN/2021-2 dated 29 January 2021.

Informed Consent Statement: Written informed consent was obtained from the participants of the study to publish this paper.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors extend their sincere appreciation to the Deanship of Scientific Research at King Khalid University for funding this study through the Large Research Group Project under grant number “RGP 2/186/42”. We also extend our gratitude to the mothers and families of both the study and control group and the research assistants.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. WHO. Recommendations on Antenatal Care for a Positive Pregnancy Experience. Available online: <https://www.who.int/publications/i/item/9789241549912> (accessed on 27 October 2021).
2. Morrison, J.L.; Regnault, T.R.H. Nutrition in Pregnancy: Optimising Maternal Diet and Fetal Adaptations to Altered Nutrient Supply. *Nutrients* **2016**, *8*, 342. [CrossRef]
3. Preconception Care: Maximizing the Gains for Maternal and Child Health. Available online: https://www.who.int/maternal_child_adolescent/documents/preconception_care_policy_brief.pdf (accessed on 27 October 2021).
4. Tam, E.; Keats, E.C.; Rind, F.; Das, J.K.; Bhutta, A.Z.A. Micronutrient Supplementation and Fortification Interventions on Health and Development Outcomes among Children Under-Five in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. *Nutrients* **2020**, *12*, 289. [CrossRef]
5. Misner, B. Food alone may not provide sufficient micronutrients for preventing deficiency. *J. Int. Soc. Sports Nutr.* **2006**, *3*, 51–55. [CrossRef] [PubMed]
6. Stephenson, J.; Heslehurst, N.; Hall, J.; Schoenaker, D.A.J.M.; Hutchinson, J.; Cade, J.E.; Poston, L.; Barrett, G.; Crozier, S.R.; Barker, M.; et al. Before the beginning: Nutrition and lifestyle in the preconception period and its importance for future health. *Lancet* **2018**, *391*, 1830–1841. [CrossRef]
7. Tunçalp, Ö.; Were, W.M.; MacLennan, C.; Oladapo, O.T.; Gülmezoglu, A.M.; Bahl, R.; Daelmans, B.; Mathai, M.; Say, L.; Kristensen, E.; et al. Quality of care for pregnant women and newborns—The WHO vision. *BJOG Int. J. Obstet. Gynaecol.* **2015**, *122*, 1045–1049. [CrossRef]
8. Campbell, O.M.R.; Graham, W.J.; The Lancet Maternal Survival Series Steering Group. Strategies for reducing maternal mortality: Getting on with what works. *Lancet* **2006**, *368*, 1284–1299. [CrossRef]
9. Fisk, N.M.; McKee, M.; Atun, R. Relative and absolute addressability of global disease burden in maternal and perinatal health by investment in R&D. *Trop. Med. Int. Health* **2011**, *16*, 662–668. [PubMed]
10. Alkema, L.; Chou, D.; Hogan, D.; Zhang, S.; Moller, A.-B.; Gemmill, A.; Fat, D.M.; Boerma, T.; Temmerman, M.; Mathers, C.; et al. Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: A systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. *Lancet* **2016**, *387*, 462–474. [CrossRef]
11. *Maternal Mortality*; Fact Sheet No. 348; World Health Organization: Geneva, Switzerland, 2014; Available online: <http://www.who.int/mediacentre/factsheets/fs348/en/index.html> (accessed on 22 October 2021).
12. Blencowe, H.; Cousens, S.; Jassir, F.B.; Say, L.; Chou, D.; Mathers, C.; Hogan, D.; Shiekh, S.; Qureshi, Z.U.; You, D.; et al. National, regional, and worldwide estimates of stillbirth rates in 2015, with trends from 2000: A systematic analysis. *Lancet* **2016**, *4*, e98–e108. [CrossRef]
13. Imdad, A.; Bhutta, Z.A. Maternal nutrition and birth outcomes: Effect of balanced protein-energy supplementation. *Paediatr. Perinat. Epidemiol.* **2012**, *26* (Suppl. 1), 178–190. [CrossRef]
14. Office of the United Nations High Commissioner for Human Rights (OHCHR). Technical Guidance on the Application of a Human Rights-Based Approach to the Implementation of Policies and Programmes to Reduce Preventable Maternal Morbidity and Mortality. In *Human Rights Council, Twentieth Session*; United Nations General Assembly: New York, NY, USA, 2012; Available online: http://www2.ohchr.org/english/issues/women/docs/A.HRC.21.22_en.pdf (accessed on 11 February 2021).
15. Tang, A.M.; Chung, M.; Dong, K.; Terrin, N.; Edmonds, A.; Assefa, N.; Chetty, T.; Ramlal, R.; Christian, P.; West, K.; et al. *Determining a Global Mid Upper Arm Circumference Cut off to Assess Malnutrition in Pregnant Women*; FHI 360/Food and Nutrition Technical Assistance III Project (FANTA); Washington, DC, USA, 2016; Available online: <http://www.fantaproject.org/sites/default/files/resources/FANTA-MUAC-cutoffs-pregnantwomen-June2016.pdf> (accessed on 4 April 2021).
16. Yu, Z.; Han, S.; Zhu, J.; Sun, X.; Ji, C.; Guo, X. Pre-pregnancy body mass index in relation to infant birth weight and offspring overweight/obesity: A systematic review and meta-analysis. *PLoS ONE* **2013**, *8*, e61627. [CrossRef]
17. Han, Z.; Lutsiv, O.; Mulla, S.; Rosen, A.; Beyene, J.; McDonald, S.D.; Knowledge Synthesis Group. Low gestational weight gain and the risk of preterm birth and low birth weight: A systematic review and meta-analyses. *Acta Obstet. Gynecol. Scand.* **2011**, *90*, 935–954. [CrossRef]

18. WHO; de Benoist, B.; McLean, E.; Egli, I.; Cogswell, M. (Eds.) Worldwide Prevalence of Anaemia 1993–2005. In *WHO Global Database on Anaemia*; World Health Organization (WHO): Geneva, Switzerland, 2008; Available online: http://apps.who.int/iris/bitstream/10665/43894/1/9789241596657_eng.pdf (accessed on 3 March 2021).
19. WHO/UNICEF Discussion Paper: The Extension of the 2025 Maternal, Infant and Young Child Nutrition Targets to 2030. Available online: <https://www.who.int/nutrition/global-target-2025/discussion-paper-extension-targets-2030.pdf> (accessed on 18 February 2021).
20. Soofi, S.; Khan, G.N.; Sadiq, K.; Ariff, S.; Habib, A.; Kureishy, S.; Hussain, I.; Umer, M.; Suhag, Z.; Rizvi, A.; et al. Prevalence and possible factors associated with anaemia, and vitamin B₁₂ and folate deficiencies in women of reproductive age in Pakistan: Analysis of national-level secondary survey data. *BMJ Open* **2017**, *7*, e018007. [[CrossRef](#)] [[PubMed](#)]
21. *Guideline: Daily Iron and Folic Acid Supplementation in Pregnant Women*; World Health Organization: Geneva, Switzerland, 2012. Available online: http://www.who.int/nutrition/publications/micronutrients/guidelines/daily_ifa_supp_pregnant_women/en/ (accessed on 18 March 2021).
22. Levels and Trends in Child Malnutrition. UNICEF/WHO/World Bank Group Joint Child Malnutrition Estimates. Key Findings of the 2018 Edition. 2018. Available online: <http://www.who.int/nutgrowthdb/2018-jme-brochure.pdf?ua=1> (accessed on 24 March 2021).
23. Stevens, G.A.; Finucane, M.M.; De-Regil, L.M.; Paciorek, C.J.; Flaxman, S.R.; Branca, F.; Peña-Rosas, J.R.; Bhutta, Z.A.; Ezzati, M.; on behalf of Nutrition Impact Model Study Group (Anaemia). Global, Regional, and National Trends in Haemoglobin Concentration and Prevalence of Total and Severe Anaemia in Children and Pregnant and Non-Pregnant Women for 1995–2011: A Systematic Analysis of Population-Representative Data. *Lancet Glob. Health* **2013**, *1*. [[CrossRef](#)]
24. Abu-Saad, K.; Fraser, D. Maternal Nutrition and Birth Outcomes. *Epidemiol. Rev.* **2010**, *32*, 5–25. Available online: <https://academic.oup.com/epirev/article-lookup/doi/10.1093/epirev/mxq001> (accessed on 4 April 2021). [[CrossRef](#)] [[PubMed](#)]
25. Akhtar, S.; Ahmed, A.; Randhawa, M.A.; Atukorala, S.; Arlappa, N.; Ismail, T.; Ali, Z. Prevalence of vitamin A deficiency in South Asia: Causes, outcomes, and possible remedies. *J. Health Popul. Nutr.* **2013**, *31*, 413–423. [[CrossRef](#)] [[PubMed](#)]
26. Christian, P.; Khattry, S.K.; Le Clerq, S.C.; Dali, S.M. Effects of prenatal micronutrient supplementation on complications of labor and delivery and puerperal morbidity in rural Nepal. *Int. J. Gynaecol. Obstet.* **2009**, *106*, 3–7. [[CrossRef](#)]
27. Chappell, L.C.; Cluver, C.A.; Kingdom, J.; Tong, S. Pre-eclampsia. *Lancet* **2021**, *398*, 341–354. [[CrossRef](#)]
28. Gernand, A.D.; Schulze, K.J.; Stewart, C.P.; West, K.P., Jr.; Christian, P. Micronutrient deficiencies in pregnancy worldwide: Health effects and prevention. *Nat. Rev. Endocrinol.* **2016**, *12*, 274–289. [[CrossRef](#)]
29. Wessels, I.; Maywald, M.; Rink, L. Zinc as a Gatekeeper of Immune Function. *Nutrients* **2017**, *9*, 1286. [[CrossRef](#)]
30. FAO; IFAD; UNICEF; WFP; WHO. The State of Food Security and Nutrition in the World 2017. Building Resilience for Peace and Food Security. 2017. Available online: <http://www.fao.org/3/a-I7695e.pdf> (accessed on 11 April 2021).
31. Rich Mother, Poor Mother: The Social Determinants of Maternal Death and Disability. Fact Sheet. UNFPA, December 2012. Available online: <https://www.unfpa.org/sites/default/files/resource-pdf/EN-SRH%20fact%20sheet-Poormother.pdf> (accessed on 11 April 2021).
32. Golbasi, Z.; Kelleci, M.; Kisacik, G.; Cetin, A. Prevalence and correlates of depression in pregnancy among Turkish women. *Matern. Child Health J.* **2010**, *14*, 485–491. [[CrossRef](#)] [[PubMed](#)]
33. Bhutta, Z.A.; Berkley, J.A.; Bandsma, R.H.J.; Kerac, M.; Trehan, I.; Briend, A. Severe childhood malnutrition. *Nat. Rev. Dis. Primers* **2017**, *3*, 17067. [[CrossRef](#)]
34. Mahmood, A.; Kedia, S.; Wyant, D.K.; Ahn, S.; Bhuyan, S.S. Use of mobile health applications for health-promoting behaviour among individuals with chronic medical conditions. *Digit. Health* **2019**, *5*, 2055207619882181. [[CrossRef](#)]
35. Topp, C.W.; Østergaard, S.D.; Søndergaard, S.; Bech, P. WHO-5 Well-Being Index: A systematic review of the literature. *Psychosom.* **2015**, *84*, 167–176. [[CrossRef](#)]
36. National Institute of Health and Family Welfare, Government of India. National Nutritional Anemia Prophylaxis Programme. Available online: <http://nihfw.nic.in/ndc-nihfw/html/Programmes/NationalNutritionalAnemia.htm> (accessed on 29 July 2013).
37. Trends in Maternal Mortality: 1990 to 2015: WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division. World Health Organization. 2015. Available online: http://apps.who.int/iris/bitstream/10665/194254/1/9789241565141_eng.pdf?ua=1 (accessed on 1 April 2021).
38. Rao, S.; Yajnik, C.S.; Kanade, A.; Fall, C.H.D.; Margetts, B.M.; Jackson, A.A.; Desai, B. Intake of Micronutrient-Rich Foods in Rural Indian Mothers Is Associated with the Size of Their Babies at Birth: Pune Maternal Nutrition Study. *J. Nutr.* **2001**, *131*, 1217–1224. [[CrossRef](#)] [[PubMed](#)]
39. Murray-Kolb, L.E.; Chen, L.; Chen, P.; Shapiro, M.; Caulfield, L. CHERG Iron Report: Maternal Mortality, Child Mortality, Perinatal Mortality, Child Cognition, and Estimates of Prevalence of Anemia Due to Iron Deficiency. Available online: cherg.org/publications/iron-report.pdf (accessed on 5 February 2014).
40. Chowdhury, H.A.; Ahmed, K.R.; Jebunessa, F.; Akter, J.; Hossain, S. Factors associated with maternal anaemia among pregnant women in Dhaka city. *BMC Womens Health* **2015**, *15*, 77. [[CrossRef](#)] [[PubMed](#)]
41. Folic Acid: Birth Defects Count. Available online: <https://www.cdc.gov/ncbddd/birthdefectscount/basics.html> (accessed on 27 October 2021).

42. Persson, L.Å.; Arifeen, S.; Ekström, E.-C.; Rasmussen, K.M.; Frongillo, E.A.; Yunus, M.; for the MINIMat Study Team. Effects of Prenatal micronutrient and Early Food Supplementation on Maternal Hemoglobin, Birth Weight, and Infant Mortality among—Children in Bangladesh. *JAMA* **2012**, *7*, 2050–2059. [[CrossRef](#)]
43. Potdar, R.D.; Sahariah, S.A.; Gandhi, M.; Kehoe, S.H.; Brown, N.; Sane, H.; Fall, C.H. Improving women’s diet quality preconceptionally and during gestation: Effects on birth weight and prevalence of low birth weight—A randomised controlled efficacy trial in India (Mumbai Maternal Nutrition Project). *Am. J. Clin. Nutr.* **2014**, *100*, 1257–1268. [[CrossRef](#)] [[PubMed](#)]
44. American College of Obstetricians and Gynecologists. Physical activity and exercise during pregnancy and the postpartum period. Committee opinion no. 650. *Obstet. Gynecol* **2015**, *126*, e135–e142. [[CrossRef](#)]
45. Gülmezoglu, A.M.; Lawrie, T.A.; Hezelgrave, N.; Oladapo, O.T.; Souza, J.P.; Gielen, M.; Lawn, J.E.; Bahl, R.; Althabe, F.; Colaci, D.; et al. Interventions to Reduce Maternal and Newborn Morbidity and Mortality. In *Reproductive, Maternal, Newborn, and Child Health: Disease Control Priorities*, 3rd ed.; Black, R.E., Laxminarayan, R., Temmerman, M., Walker, N., Eds.; The International Bank for Reconstruction and Development/The World Bank: Washington, DC, USA, 2016; Volume 2, Chapter 7. Available online: https://www.ncbi.nlm.nih.gov/books/NBK361904/doi:10.1596/978-1-4648-0348-2_ch7 (accessed on 7 September 2021).