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A Review: Evaluating Nutrition Interventions on Maternal and Infant Health in Low and Middle-Income Countries

Zihan Cui

In Partnership with Polygence Research & Mentorship Organization

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ABSTRACT

Severe nutrition inequalities disproportionately hurt mothers and their children. Different nutrition interventions are conducted to address these inequalities and to improve maternal and infant health, and their efficacy needs examining to maximize impact and cost-effectiveness. This study gives an overview of nutrition interventions by categorizing nutrition interventions to three main types, cash transfer, nutrition supplements, and social and behavior change communication (SBCC), reviewing previous studies based on categories, comparing benefits, and discussing associated social and cultural factors that might affect the efficiency. This study focuses on these three categories of interventions based on the scale of application and global impact. This research will help to provide guidance for improving maternal and infant health and conducting nutrition programs in a real world setting, which will be especially meaningful within a post-pandemic and conflict context.

Keywords: Maternal and infant health, malnourishment, nutrition interventions

1. Introduction

Despite technological advancements and economic prosperity before COVID-19, the 2020 Global Nutrition Report revealed severe nutrition inequalities between countries and populations (Global Nutrition Report, 2020). Climate Change, COVID-19, and rising military conflicts fuel global food and nutrition crises, which disproportionately hurts low and middle-income countries (LMICs). LMIC countries have reduced capacity (relative to high-income countries) to cope with health emergencies and are more likely to suffer related severe economic consequences. In 12 countries that are hit the hardest, mothers suffering from acute malnutrition have increased by 25% since 2020 (UNICEF, 2023). COVID-19 alone increased the number of children under 5 years old with wasting, which means parts of their bodies are progressively weaker, by 9.3

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million and pregnant mothers with anemia by 2.1 million, respectively, from 2020 to 2022. (Osendarp et al., 2021).

The overall global impact of child and maternal health can be measured from 4 metrics: lost productivity due to child mortality, cognitive deficiency or disrupted development of children, productivity loss during mothers, and preventable healthcare spending. These impacts are further exacerbated in LMICs because a greater proportion of the population is involved in manual labor. In Cambodia, for example, the economic burden due to maternal and child malnutrition could amount to $266 million, equal to 1.7% of the local GDP (Moench-Pfanner et al., 2016). These statistics strongly prove that maternal and child nutrition not only affects their families but also has a prolonged effect on the national economies, making it necessary for the whole society to focus on this issue and attempt to improve this phenomenon. A variety of programs from government entities and international aid groups seek to address these issues and this research will evaluate relevant nutritional interventions.

This paper focuses on three types of interventions that impact maternal and children's nutrition, thus improving their overall health. Different interventions attempt to focus on different components of diets, including purchasing power, specific nutrients, and specific behavior that leads to better nourishment. The first type are cash transfers, which could be either conditional or unconditional. Cash transfer may help the families to afford greater food diversity, and get access to healthcare services (Ngamasana et al., 2024). The second type is nutrition supplementation, which could be food-based, macronutrient-based, and micronutrient-based. This type of intervention directly improves food security and dietary diversity (Lassi et al., 2020). The third type is social and behavior change communication (SBCC). This includes contraceptive counseling, breastfeeding counseling, and lifestyle interventions. They promote maternal and infant health by encouraging longer birth intervals, exclusive breastfeeding, and reducing obesity (USAID).

Even though studies have been conducted on these intervention programs in many different regions, most only address one or two types of programs failing to provide a comprehensive overview for governments and organizations that intend to invest in or initiate new programs. This study will examine a) to which extent these interventions reduce maternal and children's malnourishment and resulting outcomes b) the comparison between different types of interventions and c) how socioeconomic and cultural factors affect their effectiveness. By doing this, we hope to provide a guide for governments and organizations to solve maternal and child malnourishment.

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2. Methodology

The study is a review, and examines samples that are published with a theme of nutrition interventions to promote maternal and infant health. Articles included are generally original research published in the English language within the last 10 years (until October 2024) in order to ensure time sensitivity and include the most up to date research. Only research based in LMICs is included, because in these areas the dual crises of maternal and infant health are much more severe. Malnourishment might exist in developed countries, but poor healthcare systems and less developed economies in LMICs make local mothers and infants more susceptible to potential negative outcomes. Moreover, as people living in LMICs are more likely to be involved in manual labor, loss of productivity because of stunting and wasting could more directly impact the local economy. Three categories of interventions were reviewed: cash transfers, food or nutrition-based interventions, and social and behavior change counseling. Social and behavior change counseling included contraceptive counseling, breastfeeding counseling, and lifestyle intervention programs. Other types of interventions may not be covered by these categories, but this research prioritizes those that are most widely applied and have the most robust scientific evidence. The main outcomes indicators used for this review were the extent to which negative consequences associated with malnourishment were reduced, challenges associated with implementation, and analyses of the cost-effectiveness of each category, comparisons between different types, and how social and economic reasons affect the efficacy of different interventions.

3. Interventions

3.1. Cash Transfer

Cash transfer programs directly pay money to an eligible person, usually conducted by private donors, organizations, or governments. There are two types: conditional cash transfer usually targets mothers who are pregnant and whose babies are under 5 years old, while unconditional cash transfer (UCT) gives money to the household. Both of them improved purchasing power and resulted in an improved diet. Beneficiaries either directly used the money to purchase food or funded family businesses and improved financial affordability, thus resulting in greater dietary diversity and food security (Ruati, 2024). For instance, a mother in South Sudan invested a cash transfer to her small restaurant, increasing her earnings by 10-fold and indirectly improving food varieties (Ruati, 2024). It is worth mentioning that an unconditional cash transfer program also improved diets among refugees in humanitarian settings, providing a new solution for aiding refugees.

However, unconditional cash transfer often fails to target children or mothers. In Somalia,

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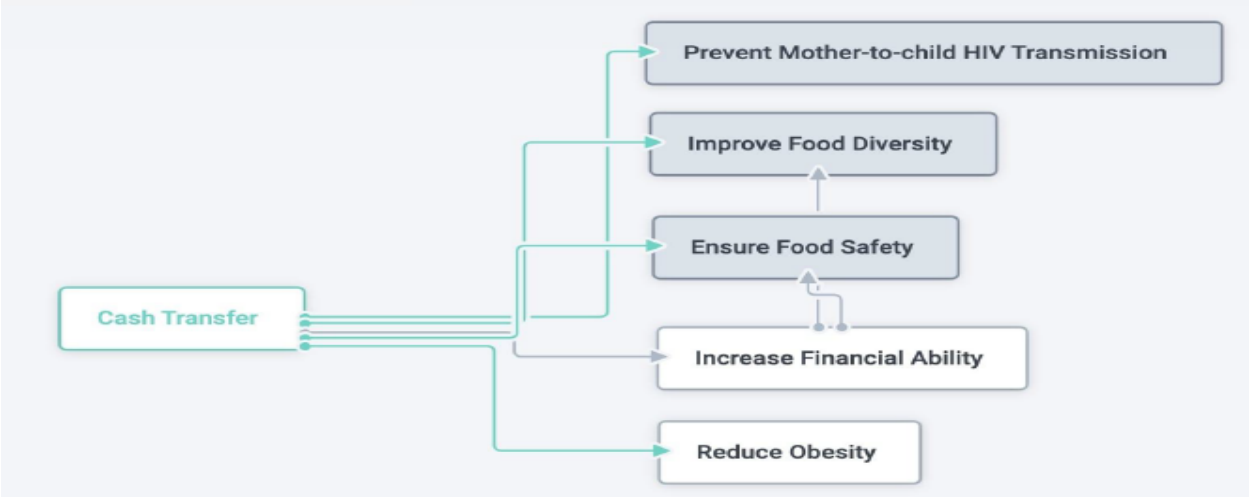
mothers or primary carers of only 61.3% of children were confirmed as cash recipients, and the cash was mainly spent on non-food items (Grijalva-Eternod, 2018). Conditional cash transfers have additional advantages such as making mother-to-child HIV transmission services more affordable (Masiano et al., 2023). This prevention would promote breastfeeding, because mothers who had HIV tended not to breed their children (Seonandan & McKerrow, 2016), and improve access to healthcare services (Rasella et al., 2021). Two studies in Brazil concluded that conditional cash transfer may reduce maternal mortality, with one reporting an 18% decrease (Alves et al., 2023) (Rasella et al., 2021). Fewer statistics point out the relationship between cash transfers and child nourishment. A review conducted in LMICs concluded that CCT only decreased stunting and wasting by 1.4% and 1.3%, respectively (Manley et al., 2022). Original research in India reported a more profound impact, in which CCT reduces the risk of child wasting by 7 percent (Patwardhan, 2023).

The biggest issue concerning the cash transfer program is its limited impact, especially on children. UCT failed to reduce the risk of acute malnourishment among children aged 6-59 months in Somalia (Grijalva-Eternod, 2018). Another study in Myanmar concluded that cash transfer alone couldn’t ameliorate children's stunting, referring to a child who is too short for his or her age because of malnutrition, unless combined with social and behavior change communications (Field & Maffioli, 2019). It is probably because cash receivers lacked recognition that they were malnourished and the awareness to improve food diversity, thus spending most of the cash on non-food items. Providing a social behavior change communication program might give them instructions on allocating the money.

Figure 1.

Interlinkages between cash transfers and maternal health



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3.2. Food or Nutrition-based Supplements

These interventions are usually pills or food and are given to supplement specific kinds of nutrients, which are crucial to infant development during pregnancy. Supplements could be categorized into three kinds: food-based, macro nutrition-based (protein and lipids), and micronutrient-based (iron, calcium, and folic acid).

Food-based supplements

Most food-assisted programs included corn, soy, and oil, which provide three main components in diet: carbohydrates, protein, and lipids. In Guatemala, a food-assisted program, aiming to prevent prenatal obesity, successfully helped mothers to lose weight after delivery (Olney et al., 2018). Mothers whose families received rice, beans, oil, and an additional corn-soy blend for mothers lost 0.50 - 0.65 more kilograms than the control group (Olney et al., 2018). In another similar program conducted in Burundi, corn-soy blend and fortified vegetable oils prevented anemia among women who had delivered in the 3 months preceding the program and had a similar effect on children aged 6–23.9 months (Leroy et al., 2016).

However, food-assisted programs have obvious limitations. In Olney's study, food supplements would not have been so effective if only the mother, instead of the whole family, received rice, beans, and oil, decreasing the cost-effectiveness of this program. In Leryo’s study, no overall program effect among all mothers was found. Another shortage of food supplements is that they are comparatively harder to transport and are more susceptible to contamination and temperature.

Macronutrient-based Supplements

Most trials quantify the efficacy of macronutrient-based supplements by measuring height and weight. There are two types of macronutrient supplementation: energy-protein supplement and lipid nutrient supplement (LNS). Without adequate protein intake, infants may end with fetal death, and suffer from growth restriction and poor mental health (Ota et al., 2012). Lipid is involved in fetal fat mass and growth, and contributes to neurodevelopment in late gestation (Herrera & Ortega-Senovilla, 2014) (Wild & Feingold, 2023).

Energy-protein supplements were often given with Iron-folic acid (IFA) to examine the impact. In a study conducted in Burkina Faso, treatment and control groups both received IFA, and treatment groups were given additional energy-protein supplements (Argaw et al., 2023). The treatment groups showed an increase and an improved growth rate in length-to-age z scores, which indicates that infants are taller, and a 3.18% reduction rate in stunting (Argaw et al., 2023).

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Researchers often compared lipid-based nutrient supplements to other nutrient interventions, such as IFA or multiple-micronutrient supplements (MMN). In Malawi, newborns whose mothers received LNS supplementation had the highest head and arm circumference, compared to the IFA and MMN group. The mean birth weight and newborn length were approximately 50 g and 4 mm larger in the LNS than in the IFA group, even though the difference was not statistically important (Ashorn et al., 2015). In a similar trial conducted in Bangladesh, infants in the LNS group had higher birth weight and higher weight-for-age z scores, and the result was statistically important (Mridha et al., 2016).

However, both supplements are associated with health risks. According to WHO, an excessively high protein supplement has no positive effect on pregnant mothers and an increased risk for gestational-age babies (WHO, 2023). Also, high levels of lipids could narrow blood vessels and increase the risk of heart attack (Cleveland Clinic, 2022).

Micronutrient-based Supplements

WHO highly recommended daily iron and folic acid to reduce the risk of anemia, and calcium supplementation to reduce preeclampsia during pregnancy (WHO, 2024)(WHO, 2023). Because calcium and folic acid supplementation is well established, trials conducted within 10 years sought to understand how dose and additional drugs impact efficacy.

Most trials that studied the relationship between calcium interventions and preeclampsia are older than 2014. A systematic review pointed out that calcium supplementation was associated with a 55% reduction in preeclampsia (Hofmeyr et al., 2018). However, a study in 2019, conducted by the same author, indicated that calcium supplementation, compared with a placebo, did not show a significant reduction in preeclampsia in three places, South Africa, Zimbabwe, and Argentina (Hofmeyr et al., 2019). Another study researched the relationship between calcium supplementation and bone loss: among Mexican women who consumed ≥50%, ≥67%, and ≥75% of pills, respectively, the effect was associated with 17.3%, 21.3%, and 22.1% reductions in bone loss (Ettinger et al., 2014).

Some research compared low-dose calcium supplementation to high-dose one. Two trials conducted in India and Tanzania both showed that low-dose calcium is not inferior to high-dose calcium at the risk of preeclampsia (Dwarkanath et al., 2024). Another study researched how aspirin and calcium supplements combined reduced preeclampsia. This study selected Brazilian mothers who had high blood pressure and revealed that the rate of superimposed preeclampsia was 28.6% lower among women receiving aspirin plus calcium than in the placebo group, even though the difference was not statistically significant (Souza et al., 2014). This study, however, didn't compare aspirin plus calcium to calcium alone and failed to prove whether it was the

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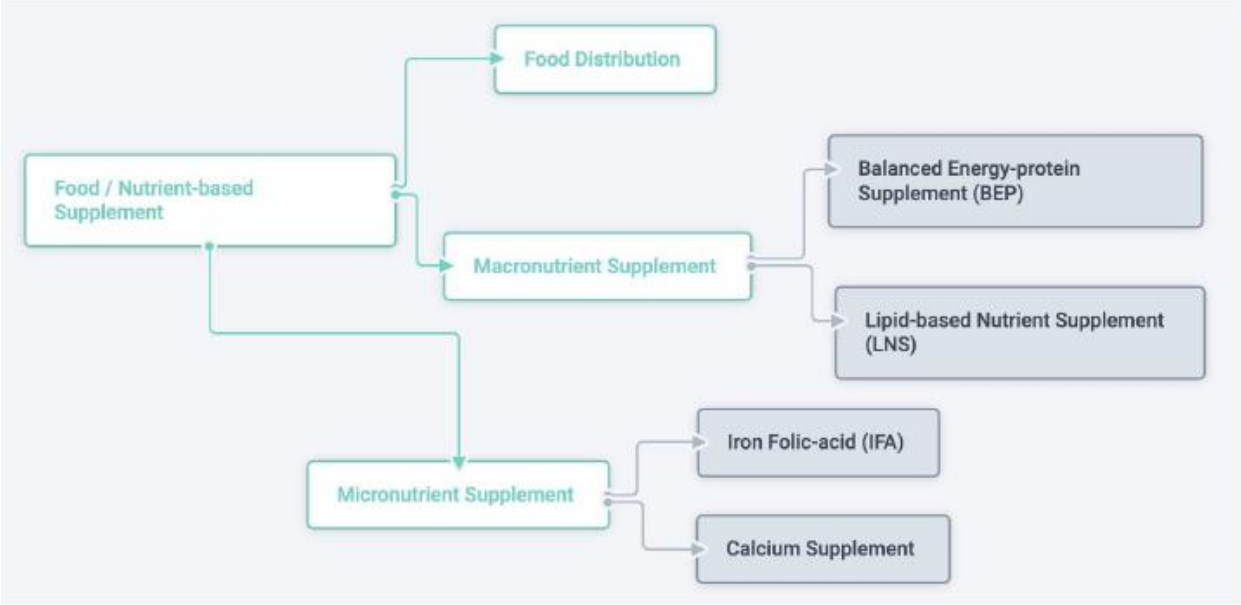
calcium or the aspirin or both of them worked to reduce preeclampsia.

Most trials concerning iron and folic acid (IFA) supplements after 2014 tended to compare the effect of IFA to iron-only or folic acid-only supplements. In a study conducted in Botswana, mothers who received iron only and mothers who only received folic acid had a higher risk of stillbirth, preterm birth, and negative health consequences compared to mothers who received both of them (Carniglia et al., 2022). Similar to calcium supplements, there are also studies comparing the impact of low-dose iron supplements to high-dose supplements. Groups who received 120 mg elemental iron per week resulted in lower height-to-age z-scores, which was slower physical development, and motor composite scores in children, which was inferior cognitive ability, compared with groups who received420 mg elemental iron per week (Hanieh et al., 2017).

Figure 2.

Different Kinds of Food and Nutrient-based Supplement



3.3. Social and Behavior Change Communications

SBCCs provide instructions for pregnant or postnatal mothers, orienting them to behaviors that improve dietary intake, let them recover from the pregnancy better, and feed their children. Breastfeeding Counseling, Contraceptive Counseling, and lifestyle interventions are three common SBCCs. Breastfeeding counseling promotes exclusive breastfeeding (EBF); contraceptive counseling encourages family planning, reducing unintended pregnancy and giving women longer birth intervals, which improves their health; lifestyle interventions are suggestions

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on diets and exercise to keep a normal weight.

Breastfeeding Counseling

Breastfeeding Counseling includes teaching breastfeeding practices, increasing the awareness of the importance of exclusive breastfeeding (EBF), and aims to make mothers initiate the first feeding within one hour after delivery and promote prolonging the exclusive breastfeeding periods to at least 1 year post birth. Breastfeeding Counseling mainly improves infant nutrition and possibly has an impact on maternal health, though the impact varies in different trials.

A longer period of exclusive breastfeeding improves infant health. Exclusive breastfeeding reduces the risk of getting diarrhea and common childhood illnesses (WHO, 2023). Compared to infants who are exclusively fed for 3 or 4 months, infants who are fed for 6 months are less likely to suffer from gastrointestinal infections (Kramer & Kakuma, 2012). Additional benefits for mothers include a more rapid maternal weight loss after delivery, and delayed return of menstrual period (Kramer & Kakuma, 2012).

Most breastfeeding interventions were carried out in addition to existing healthcare services. While all of the interventions significantly increased the likelihood of breastfeeding, they reflected the loopholes within existing healthcare services. In a study conducted in Bangladesh, on average mothers who received additional counseling exclusively fed their children for 60 more days, compared to mothers who only received usual health messages (Khan et al., 2017). Similarly, peer counseling doubled the breastfeeding practice, compared to standard health facility breastfeeding promotion services only (Chola et al., 2015). Another study suggested that personalized maternal nutrition counseling increased the rate of exclusive breastfeeding by 12% (Nikièma et al., 2017). These results reflected that the community should play a bigger role in promoting breastfeeding, as peer and personalized counseling were much more effective than one-size-fits-all breastfeeding education. Organizations and governments should support the community by training professional service providers.

While promoting breastfeeding benefits infants' future growth, these interventions might exert pressure on mothers, which should be avoided during the process. For example, 0.8% and 7.9% mothers in Tanzania gave up exclusive breastfeeding because feeding is painful and they are not producing enough milk, respectively (Maonga et al., 2016). An overstatement of the importance of exclusive breastfeeding might mentally pressure those mothers, and subtly spread a view that mothers should prioritize children to themselves. Another study stated that breastfeeders showed slightly more depression at 3 months postpartum (Alder & Bancroft, 1988). If breastfeeding counseling is carried out without full discretion, those interventions might mentally hurt mothers, further impairing maternal health. Moreover, mother employment seems to be negatively

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associated with EBF, as EBF rate decreased by 58.1% if the mother was employed (Tadesse et al., 2019). This further connects breastfeeding to women's empowerment, presenting a high demand for the planning of breastfeeding counseling.

For mothers who can not breastfeed themselves for a couple of reasons, an emerging program, human milk banks, may help their children. However, current human milk banks target babies with low birthweight, and there is little authoritative guide on the implementation of the program (Fang et al., 2021).

Contraceptive Counseling

Contraceptive counseling increases the awareness of family planning and encourages the use of modern contraceptives. Modern contraceptives reduce unintended pregnancy, saving maternal and infant lives: of 111 million unintended pregnancies in 2019, 35 million ended up with unsafe abortion, 1 million were stillbirths, and 89,000 mothers died (Askew et al., 2023). Modern contraceptives also prolong birth intervals, which reduces risk in the next pregnancy, preventing up to 32% of maternal and 21% of child mortalities in intervals (Mruts et al., 2022). Longer birth intervals allow mothers to recover better since pregnancy and breastfeeding would deplete a mother's protein, energy, and micronutrient reserves (Davanzo et al., 2008). Getting pregnant with a shorter interval is associated with a higher risk of pre-eclampsia, which is high blood pressure during pregnancy, and preterm birth, resulting in higher infant mortality (Davanzo et al., 2008). This is especially dangerous in LMICs, where healthcare services are less accessible and people are more likely to be malnourished (Seferidi et al., 2022).

Instead of being conducted independently, contraceptive counseling or education is often integrated into other healthcare services, including immunization and delivery. In Ethiopia, mothers who received family planning counseling were 25% more likely to use modern contraceptives (Mruts et al., 2022). In India, integration of family planning into maternal healthcare services was positively associated with contraceptive use (Achyut et al., 2016). In Malawi and Liberia, where family planning was integrated with immunization, 14% more Malawi women got access to family planning services, and Liberian women who used contraception increased by as many as 90% (Cooper et al., 2020) (Cooper et al., 2015).

These results showed that integration was quite effective, providing a good template for future practices. However, the integration of multiple healthcare services might pose a higher requirement on staff and add workload, which would be possible barriers to implementation.

Lifestyle interventions

Lifestyle interventions provide instructions on diet and exercise, orienting mothers toward a

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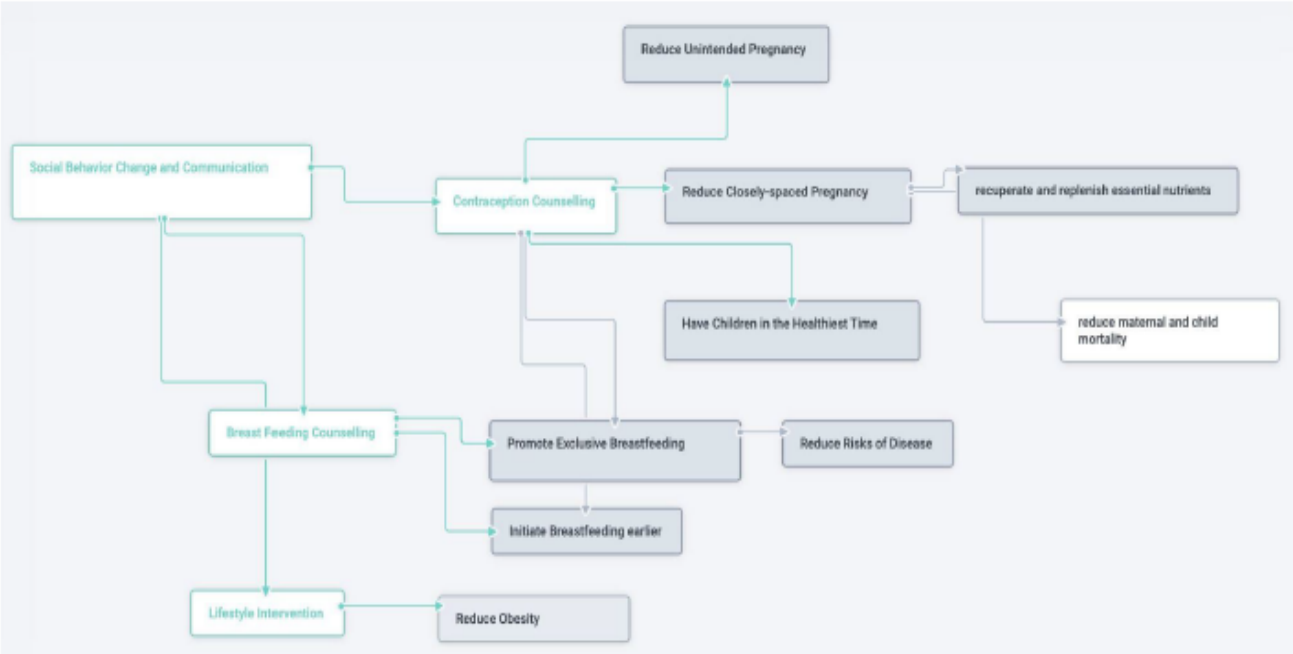
healthier lifestyle. These interventions could be either postnatal or during pregnancy. In Turkey, a lifestyle intervention that lasts for 1 year after delivery significantly improved dietary behavior by adjusting protein, micronutrients, and vegetable intake (Aşcı & Rathfisch, 2016). Another intervention for Chinese pregnant women reduced gestational weight gain and optimized infant weight (Liu et al., 2017).

Lifestyle interventions could be given with cash transfers, which could orient receivers to use the money to improve dietary diversity and maternal and children nutrition, increasing the efficacy of cash transfer.

Figure 3.

Interlinkages between social behavior change communication and maternal health



4. Results & Discussion

4.1. Cash Transfer

Cash transfers increase financial capability in general. But whether cash transfer increases access to healthcare services and better food depends on the knowledge and abilities of the recipients.

Without instructions or guidance on how to use this money, cash transfers alone do not have a significant nutritional impact, and evidence shows that they worked better when combined with SBCC. Cash transfers also create opportunities for community members to buy from local

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producers, helping to reconstruct the local economy. Cash transfers work well in humanitarian settings, serving as an additional option for places where food is hard to transport.

Conditional cash transfers, which targeted mothers who are pregnant or whose children are under 5 years old, may promote better nutritional outcomes overall. This is because the UCTs are more likely to be influenced by gender empowerment. Distribution of unconditional cash transfer is usually decided by male members in Tanzania and Kenya, and they might not consider improving food diversity or sending mothers and children to the hospitals as a necessity (Frumence et al., 2023).

4.2. Food/Nutrient-based Supplementation

Food and nutrient-based supplements are very focused on the physical development of children, including the height, weight, head circumference, and whether they are stunting or wasting. Only micronutrient supplementation, calcium and iron folic-acid supplements, improves maternal health. Some macro supplementation, the lipid-based supplement, is good for infants, but increases risk in maternal heart attacks and obesity. And food-based programs which provide the whole family with food are more effective than programs that only give mothers food.

Food-based programs are also affected by gender empowerment, because in some regions, women ate what was left by men (Cheg et al., 2015). This also has to deal with issues of transportation and preservation, because food easily spoils in places without refrigeration. Issues with adherence to nutrient-based supplements include shame of taking pills, because of community perception of having to take medications for HIV, and the necessity to remember to take the pills (Klemm et al., 2020).

4.3. SBCC

Depending on the type of SBCC, these interventions have different goals: Breastfeeding counseling promotes exclusive breastfeeding (EBF) ; contraceptive counseling encourages family planning, reducing unintended pregnancy and giving women longer birth intervals, which improves their health ; lifestyle interventions or counseling are suggestions on diets and exercise in order to keep a normal weight. Among those counseling, however, breastfeeding counseling could be a double-edged sword, since EBF will hurt mothers who are employed.

Counseling could be carried on via internet and phone calls, which saves the cost and is effective, while in less developed areas people have to go in person counseling. Counseling is more effective when designed to be personalized and conducted face-to-face, which puts a high demand on the knowledge of local workers (Nikièma et al., 2017).

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The access to counseling and its effectiveness is inhibited by religious and cultural factors. Non-muslims mothers are more likely to receive healthcare services such as immunization and antenatal care, during which the counseling is often given to mothers (Kachoria et al., 2022).

Similarly, Chrisitians have higher women empowerment, and are 21% more likely to conduct family planning, compared to Muslims (Hellwig et al., 2024). Traditional beliefs, likewise, affect the rate of exclusive breastfeeding. Traditional beliefs often encourage mothers to feed infants with water or introduce solid food a few months after the birth, and this applies in South Africa, Asia, and Latin America (Lokossou et al., 2021) (Tobing et al., 2019)(Swigart et al., 2017).

Moreover, mothers would stick to traditional practices and disregard health recommendations, because they want to show respect to their mother-in-laws (Lokossou et al., 2021) (Tobing et al., 2019).

Figure 4.

Cultural and Social Factors that Affect the Efficiency of Interventions

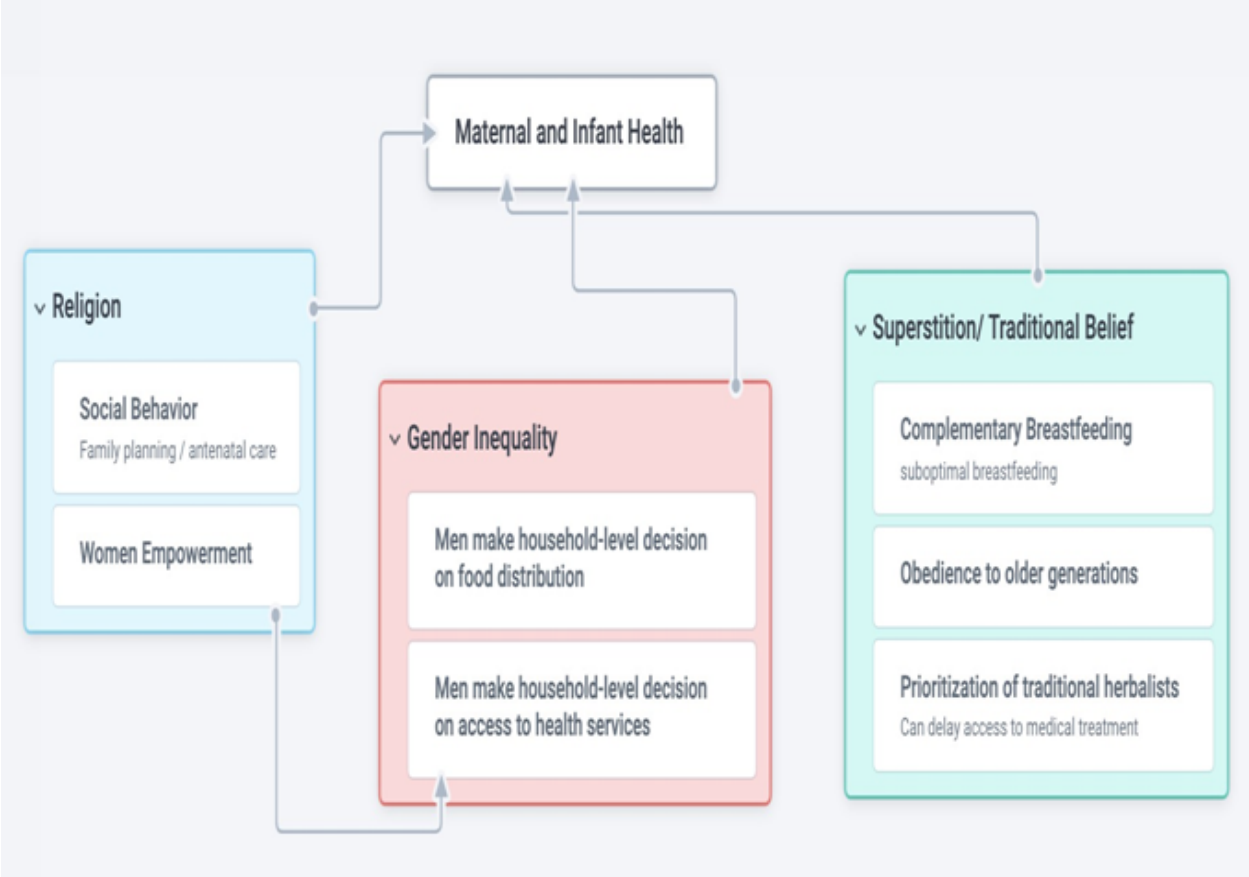

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Figure 5.

Relationship between Different Interventions and Benefits

Types of Interventions	Sub-types	Greater Uptake of Nutrients	Better Pre-pregnancy Health	Better Antenatal Health	Better Infant and children (<= 5 years) Health
Food / Nutrition-based Supplements	/	Yes	No	Yes	Yes
Cash Transfers	/	Sometimes	Sometimes	Sometimes	Sometimes
Social and Behavior Change Communication	Contraceptive Counselling	No	Yes	Yes ..?	Yes
	Breastfeeding Counselling	No	No	Under debate	Yes
	Lifestyle Interventions	Sometimes	No	Yes	Sometimes

5. Conclusion

These three categories of interventions (cash transfer, food or nutrient-based supplements, and Social and Behavior Change Communication) have different focuses on improving maternal and infant health. Cash transfers tend to increase the nutrition of the whole family; food or nutrient-based supplements, except micronutrient supplements which prevent complications of pregnancy, aims to improve the infants' physical development; among social and behavior change communications, contraceptive counseling and lifestyle interventions focus on prenatal health, and leaved indirect benefits on infants, and breastfeeding counseling prioritize children's health.Based on their result, differentiated interventions often have distinctive impacts.

In less developed areas, many people followed traditional lifestyles and received limited education. These groups tended to lack the awareness of the importance of nutrition balances, the intricacies of micronutrient deficiencies, and professionally recommended prenatal practices.

Social and behavior change interventions are especially important for populations not being served by structural education, including ways to breastfeed and how to properly take contraception. Groups which display high frequency of hypertension, anemia, and maternal and infant mortality should consider nutrition supplements.

Even though extensive trials have been carried out to verify the efficacy of interventions, some of those are still up for debate. For example, whether calcium supplementation reduces hypertension and whether exclusive breastfeeding improves prenatal mental health hasn't reached a universal consensus so far.

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During the implementation of the interventions, the cost of transportation, and staff should be carefully considered. The educational level, religious belief, and cultural factors can also affect the adherence to the interventions. Overall, nutrition interventions should be carried out with full consideration, because it would continuously impact pregnant women and their babies.

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