Review

DOI: 10.5582/bst.2018.01070

Interventions integrating non-communicable disease prevention and reproductive, maternal, newborn, and child health: A systematic review

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Summary **Reproductive, maternal, newborn, and child health (RMNCH) care services could be critical entry points for preventing non-communicable diseases in women and children. In high-income countries, non-communicable diseases screening has been integrated into both the medical and public health systems. To integrate these services in low- and middle-income countries, it is necessary to closely examine its effectiveness and feasibility. In this systematic review, we evaluated the effectiveness of integrating gestational and non-gestational non-communicable diseases interventions and RMNCH care among women and children in low- and middle-income countries. This systematic review included randomized and quasi-randomized controlled trials published from 2000 to 2015. Participants included reproductive-age women, children < 5 years old, and RMNCH care providers. The included interventions comprised packaged care/services that integrated RMNCH services with non-communicable disease care. The outcomes were maternal and/or infant mortality and complications, as well as health care service coverage. We analyzed six studies from 7,949 retrieved articles. Yoga exercise ($p < 0.01$) and nutritional improvements ($p < 0.05$) were effective in reducing gestational hypertension and diabetes. Additionally, integrating cervical cancer and RMNCH services was useful for identifying potential cervical cancer cases. Interventions that integrate non-communicable disease care/screening and RMNCH care may positively impact the health of women and children in low- and middle-income countries. However, as primary evidence is scarce, further research on the effectiveness of integrating non-communicable disease prevention and RMNCH care is warranted. (*Review Registration*: PROSPERO International prospective register of systematic reviews (CRD42015023425).)**

Keywords: Systematic review, maternal health, low- and middle-income countries, noncommunicable diseases

1. Introduction

The health of women and children is identified as an international priority issue in the Sustainable Development Goals (*1*). Women tend to be more vulnerable due to increased risk exposure and poor access to care, and more than half of all non-communicable disease (NCD)-related deaths were estimated to occur in women (*2*). Furthermore, among women, the major cause of death is NCDs; these account for nearly 65% of deaths in women (*3*), with cardiovascular disease being the number one cause of death in this population (*4*). Some NCDs specifically affect women and adolescent girls, such as breast and cervical cancers (*5*). These cancers are largely treatable in developed countries, but women in resource-limited settings have fewer treatment options (*6-8*).

In addition, reproductive-age women have particular

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NCD risks (*e.g.*, obesity, hypertension, and cancers), and certain NCDs (*e.g.*, diabetes) are often accelerated during pregnancy and childbirth. Gestational hypertension may affect the mother's womb and lead to eclamptic attack and placental abruption, as well as growth retardation of the fetus. Further, gestational diabetes, which affects one-fourth of pregnant women (*2*), may cause stillbirth, premature labor, difficult delivery, or neonatal hypoglycemia. Finally, poor maternal health may further result in chronic conditions of their child, such as asthma, heart disease, and diabetes (*9*).

Reproductive, maternal, newborn, and child health (RMNCH) care services could be critical entry points for NCD prevention among women and children in resource-limited settings (*5*). These services do not only prevent gestational NCDs but also NCDs throughout the lifetime of the woman. This is because nearly 80% of pregnant women have at least one antenatal visit and most children are vaccinated, while their access to additional health care is largely limited in low- and middle-income countries (*10*). Typical RMNCH care in these countries includes antenatal care, birth attendance, postnatal care, vaccination for children, and family planning. One previous study revealed that, during the antenatal care, up to 45% of gestational NCDs could be prevented through proper assessment and education (*11*). Moreover, treating gestational diabetes can reduce the number of newborn deaths (*11*), and congenital heart disease can be successfully treated if adequate postnatal care is provided (*12*). In addition, preeclampsia may increase the risk of cardiovascular disease by two to four times (*13*), and preventing gestational diabetes may prevent the development of type 2 diabetes in the future (*14*). Therefore, the World Health Organization (WHO), other international health authorities, and academia recommend that healthcare for NCDs should be provided as part of an integrated approach for RMNCH services (*2,5,15*).

Integrating health care services is considered an effective approach. It promotes the use of multiple services and reduces the costs of each service (*16*). By integrating NCD care and RMNCH, both health services could be efficiently delivered; subsequently, this may help prevent the development of NCDs, especially during the perinatal period. In high-income countries, NCD care has been integrated into both the medical and public health services (*e.g.*, cervical and breast cancer screening services) (*17*). This has effectively reduced the incidences of NCDs (*18*). In low- and middle-income countries, integrating health care services is also expected to be highly effective for NCDs. However, no prior systematic review article or protocol is available in this area, and the current integration status in these countries is unclear. Analyzing the effectiveness of integration can reveal further opportunities for intervention and offer insights for tailoring interventions. Furthermore, it is necessary to closely examine the effectiveness and feasibility of NCD screening and treatment before adopting them as part of the health system, which can be expensive. In addition, integrating NCD care into regular RMNCH services might reduce the overall health care costs.

Therefore, in this review, we first aimed to quantitatively synthesize evidence regarding the effectiveness of integrating NCD interventions and RMNCH care services in low- and middle-income countries. Subsequently, we aimed to evaluate the impact of such integrations on the health outcomes and access to services for women and children.

2. Methods

We conducted a systematic review following the guidelines of the Cochrane Collaboration (*19*) and the four phases indicated in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (*20*). We developed the systematic review based on the PRISMA checklist and registered the protocol for this systematic review at the PROSPERO international prospective register of systematic reviews on June 17, 2016 (registration number: CRD42015023425; available at *http://www.crd.york.ac.uk/PROSPERO*).

2.1. *Study Inclusion Criteria*

This review included randomized controlled trials and non-randomized intervention studies, which might provide evidence on the effects of interventions that cannot be randomized or adequately studied in randomized trials (*19*). We selected only peer-reviewed journal articles and reports from international organizations as publication types. We included studies in any language if they had English abstracts. Furthermore, we included studies only if they were conducted in low- and middle-income countries, as defined by the World Bank (*21*). We excluded non-intervention studies, such as case series, case reports, and qualitative studies, and those conducted in high-income countries from this review.

2.2. *Participants*

Participants of the interventions included women of reproductive age, defined as those aged 15-49 years according to the WHO; mothers; children < 5 years old; and RMNCH care service providers from low- and middle-income countries. We excluded studies that were conducted specifically in populations with an underlying disease or condition, such as in HIV-positive women, which would complicate the generalizability of our findings to a wider population.

2.3. *Interventions and Controls*

The included interventions comprised packaged care/services that integrated RMNCH services with NCD care. We focused on the following four NCD types: cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes. We distinguished gestational and non-gestational NCDs, since gestational NCDs are often temporal and caused by pregnancy-induced changes in the hormonal levels. Anemia, domestic violence, depression, and diseases related to oral health are also often considered as NCDs (*22-24*), however, as the most frequently used WHO definition of NCDs includes cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes (*22*), we only focused on these four types in this study. We considered studies in which RMNCH and NCD care were not integrated as the controls for this review.

2.4. *Outcomes*

We included studies with outcomes of maternal and/or infant mortality and complications, as well as health care service coverage, in this review.

2.5. *Search Strategy*

We used the following bibliographic databases to search for relevant articles: PubMed/Medline, POPLINE, EBSCO/CINAHL, BiblioMap, and ISI Web of Science. We reviewed relevant internet sources from the WHO library database and Google Scholar for additional gray literature. Finally, we identified additional studies using the snowball method by reviewing the reference lists of the retrieved articles. The publication period was set to 2000-2015 to ensure that enough studies were retrieved.

We conducted the literature search by using appropriate key words, accepted Medical Subject Headings words, and combinations thereof. One search approach involved using broad search terms (*e.g.*, mothers OR women OR female OR adolescent OR pregnant women) combined with intervention-specific search terms such as disease names (cardiovascular diseases OR cancer OR respiration disorders OR diabetes) and NCD risk factors (tobacco use OR smoking OR diet OR nutrition OR alcohol). To supplement the search, we also reviewed reports published by agencies, including the WHO, UNICEF, and the World Bank. Again, we conducted a further snowballing search through hand-searching or by searching for references from the initially identified studies.

2.6. *Data Collection and Analysis*

2.6.1. *Selection of studies*

The study selection process is summarized in Figure 1. The first and second authors independently extracted data and screened the quality and content of the identified studies. We evaluated the titles and abstracts of the study articles for relevance and compliance with the selection criteria based on the research setting, study design, and reported outcomes. We then classified the articles as included, excluded, uncertain, or duplicate; all potentially included or uncertain studies were confirmed, and any disagreements were resolved by consensus.

2.6.2. *Data extraction and management*

The first author extracted the features of each study (*e.g.*, study design, setting, participants, components of intervention, related NCDs, and main outcomes) and entered them into a standardized form. The second author checked all data for accuracy and completeness. To resolve any discrepancies, the two authors discussed until they reached an agreement.

2.6.3. *Risk of bias in the included studies*

The first and second authors assessed the quality of the trials. For randomized controlled trials, the risk of bias was evaluated using the "risk of bias" tool presented in the Cochrane Handbook for Systematic Reviews of Interventions (*19*). Specifically, we assessed the risk of bias in the following seven domains: sequence generation, allocation concealment, blinding of participants and outcome assessors, incomplete outcome data, selective outcome reporting, and other potential threats to validity. To assess non-randomized intervention studies, we used "a Cochrane risk of bias assessment tool: for non-randomized studies of interventions (ACROBAT-NRSI)" (*25*). For non-randomized intervention studies, we evaluated the risk of bias using the following seven domains: confounding, selection of participants, intervention measurements, departures from intended interventions, missing data, outcome measurement, and selective outcome reporting. In addition, for non-randomized intervention studies, we assessed the overall risk of bias following the results of the seven domains. We resolved all discrepancies by consensus.

2.6.4. *Analysis*

We analyzed the results only narratively because the outcome measurements and interventions differed among the selected studies. First, we summarized the included study interventions according to the related NCDs, settings, study design, participants, intervention components, outcomes, and quantitative results. Second, we stratified the studies according to the NCD type integrated with RMNCH care and provided narrative descriptions for each NCD type.

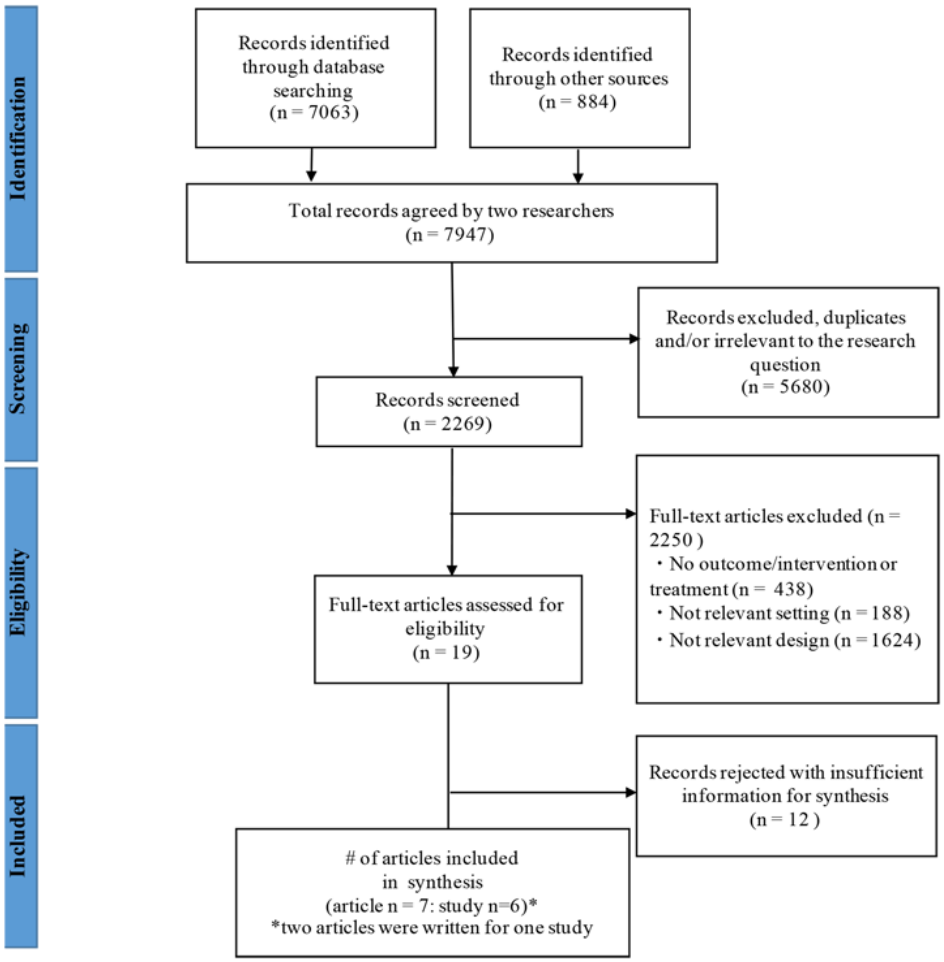

Figure 1. Diagram of information flow through phases of systematic review.

3. Results

A total of 7,947 articles were obtained from the following sources: PubMed (*n* = 7,063), CINAHL (*n* = 353), CENTRAL (*n* = 295), Web of Science (*n* = 167), PsycINFO (*n* = 62), POPLINE (*n* = 4), and Scopus (*n* = 3). After the initial screening, we included 2,269 studies, because the other studies were duplicates and/or irrelevant to the research questions. Of these studies, we excluded a further 2,250 because they had no outcome/intervention or treatment (*n* = 438), irrelevant setting (*n* = 188), or irrelevant design (*n* = 1624). Subsequently, we evaluated the remaining 19 studies for eligibility by reviewing the full-text articles. Among them, we included two randomized controlled studies (three published articles) and four non-randomized interventions (*26-32*), which were all written in English and had been published in peer-reviewed journals, in the final analysis. For randomized controlled trial studies, we initially selected three articles. However, we integrated those written by Jayashree *et al*. and Rakhshani *et al*. into the same category (*i.e*., the Jayashree-Rakhshani study), because both articles involved the same intervention study (*27, 32*).

3.1. *Risk of Bias Assessment*

Table 1 shows the risks of bias for the two randomized controlled trial studies. Both assessed studies lacked information related to the blinding during data collection or implementation. All other biases were "low" in the selected studies. However, high attrition bias was observed in the Jayashree-Rakhshani study, because the dropout rate was almost 35% of the randomized participants in the intervention group (*27,32*).

Table 2 shows the risk of bias in the four non-randomized intervention studies. The overall risks of bias were "moderate" in the studies by Moon et al. and Aalami et al. (*26,30*), and "serious" for the studies by Plotkin et al. and Luo et al (*29,31*). In Plotkin's study, we assessed the "bias due to missing data" as "serious" because 40% of the participants were not provided all interventions. As for Luo's study, we assessed the "bias in selection of participants" as "serious" because the allocation of the intervention and control groups was not indicated.

Table 1. Risk of bias in the included randomized controlled trials

Risk of bias	Jayashree 2013, Rakhshani 2012	Kasawara 2013
Random sequence generation	Low	Low
Allocation concealment	Low	Low
Blinding of participants and personnel	Low	Low
Blinding of outcome assessment	Unclear	Unclear
Incomplete outcome data	High	Low
Selective reporting	Low	Low
Other bias	Low	Low

Table 2. Risk of bias in the included non-randomized intervention studies

Risk of bias	Aalami 2016	Luo 2014	Moon 2012	Plotkin 2014
Bias due to confounding	Moderate	Moderate	Moderate	Low
Bias in selection of participants into the study	Moderate	Serious	Moderate	Low
Bias in measurement of interventions	Moderate	No information	Moderate	Low
Bias due to departures from intended interventions	Low	Low	Low	Low
Bias due to missing data	Low	Low	Low	Serious
Bias in measurement of outcomes	Moderate	Moderate	Low	Low
Bias in selection of the reported results	Moderate	Moderate	Moderate	Moderate
Overall risk of bias	Moderate	Serious	Moderate	Serious

3.2. *Randomized Controlled Trials Integrating RMNCH Care and NCD Interventions*

We included two randomized controlled studies, conducted by Jayashree-Rakhshani in India and Kasawara in Brazil (Table 3) (*27,28*). The study interventions focused on gestational hypertension and diabetes. We did not identify any interventions with a focus on NCDs in general, women-specific cancers, or pediatric NCDs. The total number of participants was 184, including both the intervention and control groups. Both studies involved high-risk pregnant women and physical exercise interventions (*i.e.*, yoga intervention in Jayashree-Rakhshani's study and bicycle exercises in Kasawara's study).

3.3. *Non-randomized Controlled Trials Integrating RMNCH and NCD Care*

We identified four non-randomized controlled trials in this review (Table 3). These studies were conducted by Aalami et al. in Iran, Luo et al. in China, Moon et al. in Mozambique, and Plotkin et al. in Tanzania (26,29-31). The study interventions focused on gestational diabetes and cervical cancer. We were unable to identify studies that focused on NCDs in general or pediatric NCDs. All the selected studies were intervention studies; however, control groups were only identified in the studies by Luo et al. and Aalami et al (*26,29*). In the remaining two studies, the researchers evaluated the implementation and intervention of a health care program, without a separate control group (*30,31*).

3.4. *Integration of RMNCH Care according to the NCD Type*

As indicated in Table 4, we divided the identified studies into three categories according to the type of NCD care that was integrated with the RMNCH care. Of note, the studies on cardiovascular disease and diabetes focused only on gestational hypertension or diabetes, and not on cardiovascular disease or diabetes as a general chronic disease. Cervical cancer was the only cancer that was linked with RMNCH care in the selected studies. Most of the health care interventions for NCDs occurred during the mothers' pregnancy period, except for cervical cancer, which was integrated into the RMNCH service (*i.e.*, during family planning and HIV tests) before or after the pregnancy period.

3.5. *Effectiveness of Integrating NCD Interventions and RMNCH Care on Maternal Health*

3.5.1. *Gestational NCDs*

Four studies evaluated the integration between gestational hypertension and RMNCH care (*26-29*). In the studies by Jayashree-Rakhshani and Kasawara, a physical exercise intervention was implemented for pregnant women. In the studies by Aalami et al. and Luo et al., the intervention involved breathing techniques and nutritional management, respectively. The effectiveness of these interventions on maternal health differed. The progressive muscular relaxation ($p < 0.01$) and breathing interventions ($p < 0.01$) significantly reduced blood pressure in one study (*26*). The incidence of preeclampsia was significantly reduced by exercise intervention in the Jayashree-Rakhshani study (absolute risk reduction, 21%) and by nutrition management intervention ($p < 0.05$) (*27,29,32*). However, we did not observe significant

Table 3. Characteristics of the included interventions that integrated non-communicable disease interventions and maternal, newborn, and child health care services

Related non-communicable diseases	Author/country	Study design	Participants	Intervention	Outcomes
Gestational hypertension (cardiovascular disease)/ gestational diabetes	Jayashree *et al*. 2013 andRakhshani *et al*. 2012/India (*27,32*)	RCT	Women with high-risk pregnancy at 12 weeks' gestation (n = 68; 30 interventions and 38 controls). The inclusion criteria were as follows: high-risk obstetric history, twin pregnancies, maternal age < 20 or > 35 years, obesity (BMI > 30), and genetic history of pregnancy complications.	The yoga group received standard care plus 1-hour yoga sessions 3 times a week from the beginning of the 13th week to the end of the 28th week of gestation. The control group received standard care plus 30-minute walks every morning and evening within the same period. The yoga classes were conducted by well-trained certified yoga therapists. Three categories of yoga interventions were offered to the study group: 1) breathing exercises, 2) yoga postures, and 3) meditative exercises. The latter included visualization, guided imagery, and sound resonance techniques. Subjects were asked to visualize the fetus in the uterus, umbilical cord, and placenta.	Platelet count, uric acid level, gestational hypertension, preeclampsia, and intrauterine growth restriction
Gestational hypertension (cardiovascular disease)	Kasawara *et al*. 2013/Brazil (*28*)	RCT	Pregnant women with chronic hypertension and/or previous preeclampsia, considered at high risk of preeclampsia development (n = 116; 58 interventions and 58 controls)	Participants were divided into two groups: (1) a study group that performed physical exercise with a stationary bicycle once a week for 30 minutes with controlled intensity (i.e., heart rate 20% above resting values) under professional supervision and (2) a control group that was not engaged in any physical exercise. Women in the study group performed 9.24 (± 7.03) physical exercise sessions.	Maternal outcomes: admission to the ICU and morbid conditions due to complications. Infant outcomes: birth weight, Apgar score, admission to ICU, and infant morbidity.
Gestational hypertension (cardiovascular disease)	Aalami *et al*. 2016/Iran (*26*)	Non-randomized intervention study	Pregnant women after 20 weeks of gestational age with systolic BP ≥ 135 mmHg or diastolic BP ≥ 85 mmHg (n = 60; assigned to a progressive muscular relaxation group, breathing control exercises group, or control group)	Progressive muscular relaxation and breathing control exercises were administered to two experimental groups in person once a week and by instructions given on a CD for the remaining days for 4 weeks. Participants were followed-up regarding continuation of exercises by phone calls. The symptoms of severe preeclampsia were evaluated by phone calls and at the beginning of each personal class. In the personal classes, necessary explanations about performing exercises after the primary interventions and controlling blood pressure were provided. Blood pressure was evaluated before and after the interventions in the intervention group and before and after 15 minutes of waiting without any special intervention in the control group.	Systolic blood pressure, diastolic blood pressure
Gestational hypertension (cardiovascular disease)/ gestational diabetes	Luo et al. 2014/ China (*29*)	Non-randomized intervention study	Pregnant women (n = 276; 131 in the intervention group and 145 in the control group)	Women in the intervention group received individualized nutritional management in addition to routine prenatal care. They received monthly obstetric visits up to week 28, biweekly visits from week 28 to week 36, and weekly visits until the end of pregnancy. The total energy intake was modified according to the progression of pregnancy every 4 weeks with energy requirements being individually estimated according to each mother's BMI, weight, and obstetric condition.Women in the control and intervention groups received the same initial information regarding the purpose and content of this study.	Gestational diabetes, gestational weight gain, birth weight, Apgar score, and incidence of pregnancy complications
Cervical cancer	Moon *et al*. 2012/Mozambique (*30*)	Evaluation study of health care program implementation	Screened women (n = 4651)	Cervical cancer screening was nested into family planning clinics using VIA by maternal child health nurses. During the examination, women were evaluated for clinical signs of sexually transmitted infections and other gynecologic pathologies. A cotton swab was then applied, and excess mucus was removed prior to applying 5% acetic acid. After 1 minute, the findings were reported as positive or negative for possible squamous intraepithelial lesions. Women with lesions involving >75% of the transformation zone, endocervical involvement, or suspected invasive cancer were referred to hospital for loop electrosurgical excision procedure, biopsy, or surgery.	Cervical cancer screening
Cervical cancer	Plotkin *et al*. 2014/Tanzania (*31*)	Evaluation study of health care program implementation, analysis of the 2010–2013 data	Screened women (n = 24,966) collected from routine client level service delivery data from 21 government health facilities	Integrated HIV testing into cervical cancer screening with VIA. Providers working at the onsite HIV CTCs at facilities received a 1-day orientation on cervical cancer screening, emphasizing the importance of referral for HIV-infected women. Cervical cancer screening and HIV testing were provided during the same visit and in the same location. Cervical cancer screening was offered at the RCH clinic at least twice a week. Family planning services were offered through the RCH and were available every day when cervical cancer screening was offered. If a client was reactive to an HIV test administered during the screening, she was referred to the onsite HIV CTC.	Acceptance of the HIV test by clients and the number and proportion of women being offered the HIV test

BMI, body mass index; ICU, intensive care unit; RCT, randomized controlled trial; CD, compact disc; BP, blood pressure; VIA, visual inspection with acetic acid; HIV, human immunodeficiency virus; CTC, care and treatment center; RCH, reproductive and child health.

Table 4. Main findings regarding maternal and child health outcomes stratified by the non-communicable disease types

Related non-communicable diseases	Related study	Main findings for mothers	Main findings for children
Gestational hypertension (cardiovascular disease)	Jayashree-Rakhshani/ India (*27*)	• Significantly fewer women in the yoga group ($n = 3$) developed gestational hypertension/preeclampsia than those in the control group ($n = 12$; absolute risk reduction, 21%). • No significant difference in platelet count in the intervention group • No significant difference in the increase in uric acid level in both groups • No significant differences of eclampsia between the intervention and control groups	• Significantly fewer SGA newborns were born in the yoga group ($p = 0.03$). • Significantly fewer babies with low 1-minute and 5-minute Apgar scores were born in the yoga group ($p = 0.01$ and $p = 0.04$).
	Kasawara/Brazil (*28*)	• No significant difference in preeclampsia and other maternal morbidity incidences between the groups	• No significant difference in birth weight, Apgar scores, or other incidences of neonatal morbidity between the groups.
	Aalami/Iran (*26*)	• After 4 weeks of intervention, significant differences in BP in the progressive muscular relaxation group ($p < 0.001$ for systolic BP and $p = 0.001$ for diastolic BP) and breathing in the control group ($p = 0.004$ for systolic BP and $p = 0.047$ for diastolic BP)	
	Luo/China (*29*)	• Significant difference in the preeclampsia incidence rate: 3.1% (intervention) *vs*. 11% (control) $p < 0.05$ No significant difference in the incidences of preterm labor ($p = 0.736$) and premature membranes rupture	• No significant differences in birth weight, infant length, gestational age, and major congenital anomalies between the groups.
Gestational diabetes	Jayashree-Rakhshani/ India (*27*)	• Significantly fewer gestational diabetes cases in the intervention group (3.4%) than in the control group (20.0%) ($p = 0.05$)	• Significantly fewer cases of intra-uterine growth restriction in the intervention group (6.9%) than the control group (25.8%) ($p = 0.05$).
	Luo/China (*29*)	• Significant difference in gestational diabetes: 3.8% (intervention) *vs*. 14.5% (control) ($p = 0.002$)	• No significant differences in birth weight, infant length, and gestational age between the groups. • Significant difference in macrosomia ($p = 0.026$).
Cervical cancer	Moon/Mozambique (*30*)	• Significant difference in gestational weight gain: 7.58 kg (intervention) *vs*. 12.57 kg (control) ($p < 0.01$) • VIA was judged positive for squamous intraepithelial lesions in 8% of women ($n = 380$). • About 4% of these women had lesions requiring referral to hospital; 14 of them were examined at the hospital, but their records were inadequate to judge the outcomes. • Among the screened women, 2714 either had knowledge of their HIV status prior to the VIA or were subsequently sent for HIV testing; 583 of these women were found to be HIV positive. About 96% of women eligible for cryotherapy received treatment on the day of the VIA screen, as compared with only 53% in the first quarter of the year.	
	Plotkin/Tanzania (*31*)	• Approximately 26% were referred from HIV care and treatment clinics. • Among women of unknown HIV status ($n = 18,539$), 60% were offered an HIV test. • Of those offered testing, 94% of women accepted the testing.	

SGA, small for gestational age; BP, blood pressure; VIA, visual inspection with acetic acid; HIV, human immunodeficiency virus.

differences in the blood pressure levels and incidence of preeclampsia in the physical intervention study by Kasawara et al (*28*). Further, we observed significant differences in the incidence of eclampsia, platelet count, and uric acid levels in the Jayashree-Rakhshani study (*27,32*).

Studies by Jayashree-Rakhshani's and Luo's evaluated the integration of gestational diabetes and RMNCH care. According to these studies, exercise intervention significantly reduced the incidence of gestational diabetes ($p = 0.05$) (*27,32*). Moreover, nutritional management intervention significantly reduced the incidences of gestational diabetes ($p < 0.01$) and gestational weight gain ($p < 0.01$) (*29*).

3.5.2. *Cancer*

Two studies evaluated the integration of cervical cancer and RMNCH care. Those studies aimed to examine the feasibility of cervical cancer screening by visual inspection with acetic acid (*30,31*). However, no clear maternal health outcome was reported in those studies, because the researchers were more focused on the uptake of the screening service. According to Moon et al., the incidences of positive cervical cancer cases (8.0%) were comparable to those of similar interventions (range, 3.8-12.7%) (*30*). Among the women screened for cervical cancer in Moon et al. and Plotkin et al.'s studies, those with unknown HIV status were also tested for HIV (58% and 47% of screened women, respectively), and 21% and 26% were identified as HIV positive, respectively (*30,31*).

3.6. *Effectiveness of Integrating NCD Interventions and RMNCH Care on Child Health*

In the yoga intervention group in the study by Jayashree-Rakhshani, significantly fewer babies were born with low 1-minute and 5-minute Apgar scores ($p = 0.01$ and $p = 0.04$, respectively), and significantly fewer fetuses had intra-uterine growth restriction (*27,32*). In Kasawara *et al*.'s bicycle exercise intervention, no significant difference was observed in the fetus/newborn outcomes (*i.e.*, birth weight and Apgar scores) compared with those in the control group (*28*). Moreover, in the study by Luo *et al*., no significant difference was observed in the birth weight and infant length in the nutritional management intervention (*29*).

4. Discussion

This is the first systematic review to examine the effectiveness of integrating gestational and non-gestational non-communicable disease interventions and antenatal care among women and children in low- and middle-income countries. We demonstrated some new and important findings. First, the included studies focused only on gestational hypertension and diabetes, and on cervical cancer. Second, among the interventions integrating NCD and RMNCH care, yoga exercise and nutritional improvements were effective in reducing gestational hypertension and diabetes. Third, studies that linked cervical cancer and RMNCH care revealed positive impacts on the uptake of cervical cancer screening services and on identifying potential cervical cancer cases. However, in this systematic review, we included only two randomized controlled trials, and we were unable to conduct a meta-analysis for these studies because the nature of the interventions differed between the studies (*i.e*., yoga *vs*. bicycle exercise) and because of the small sample sizes. Thus, more concrete data are needed to fully understand the effectiveness of integrating NCD interventions and RMNCH care in low- and middle-income countries.

According to this review, yoga and nutritional improvements were effective in reducing gestational hypertension as well as gestational diabetes. These interventions would not incur high costs and, therefore, would be feasible in low- and middle-income countries. However, the results of this review are not fully generalizable, owing to the insufficient quality and sample size. Thus, further intervention studies are needed to confirm our findings.

Furthermore, the integration of cervical cancer screening and RMNCH care showed a positive impact on the uptake of cervical cancer screening services and on identifying potential cervical cancer cases. In general, integrating cervical cancer screening into the regular RMNCH services is considered costly in low- and middle-income countries. However, using visual inspection with acetic acid would be affordable in these countries and would help improve the health indicators (*33*). With further evidence, the integration of cervical cancer screening and RMNCH care could be accelerated.

In this review, we did not identify any studies that linked RMNCH care and breast cancer, which has the highest mortality rate among all cancers in women in resource-limited settings (*i.e.*, low- and middle-income countries) (*34*). Breast cancer screening using mammography/ultrasound is considered effective, but is not realistic in resource-limited settings. Therefore, it is important to examine the affordability of other possible screening methods (*e.g*., palpation or methods that target only high-risk groups) and the effectiveness of integrating these methods with RMNCH programs.

In addition, we did not identify any studies that integrated pediatric NCD and RMNCH care. Respiratory disease (*e.g*., pediatric asthma) is a key cause of mortality in children of low-income countries (*35*). Therefore, the child mortality rate would theoretically improve by integrating respiratory disease care into the regular health care for pediatric patients. Studies on preventing passive smoking among women

have been conducted in a resource-limited setting, but the intervention was not linked with RMNCH care (*36,37*). Thus, further research is required to examine the effectiveness of integrating respiratory disease and RMNCH care on child health indicators.

Recommendations for Integrating NCD and RMNCH Services To plan a strategy for integrating NCD and RMNCH care services, gestational NCD and other NCD care services should be considered separately. Gestational NCD care services could be integrated into pre-pregnancy or antenatal care through the exercise or nutritional interventions that were suggested as effective in this review. Other NCD care services, including screening for cervical or breast cancer, could be integrated into the postnatal care or family planning services. By integrating these services, health workers can provide different services at the same time and at a low cost, thereby avoiding overlooking many common health problems of women. However, such integration may result in the focus of the service being diluted (*38*). Therefore, health workers need to be allocated and trained adequately, and continuous monitoring is required to assess whether the care can be provided to all women with the same effect (*16*). Moreover, to maximize the effects of integration, the potential challenges need to be examined in detail.

Limitation The main limitation of this study was that the lack of randomized studies, which might have obscured the actual results of the systematic review. Further evidence is needed to determine the effectiveness of integrating NCD interventions and RMNCH care.

5. Conclusions

Interventions that integrate NCDs and RMNCH care appear effective in reducing gestational hypertension and diabetes in low- and middle-income countries. Furthermore, integrating cervical cancer screening and RMNCH care showed a positive impact for identifying suspected cervical cancer cases. However, primary evidence remains scarce, and further research is required to conclude the effectiveness of integrating NCD interventions and RMNCH care services.

Funding This research was supported by Kyushu University.

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(Received April 17, 2018; Revised April 23, 2018; Accepted April 24, 2018)