Technology-Based Innovative Solutions for Improving Perinatal Care Utilization: A Network Meta-Analysis

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Protocol

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Abstract

Background: Technology-based interventions (TBIs) are widely being tested to integrate into the existing health system to increase preventative healthcare utilizations. Despite an uptake of TBIs, evidence remains inconclusive regarding its effectiveness due to a lack of comprehensive and concrete evaluations. This study aims to evaluate the impact and effectiveness of TBIs in improving antenatal visits, postnatal visits, and delivery care services in LMICs using Bayesian network meta-analysis.

Methods: To identify the relevant studies, we will perform a comprehensive search of electronic databases and grey literatures with no language or publication date restriction. We will include experimental studies if they assess effectiveness of TBIs on improving perinatal care utilization among pregnant women. The primary outcomes are antenatal visits, postnatal visits, and delivery care. Two reviewers will independently identify eligible study and perform data extraction and quality assessment. We will use Bayesian meta-analysis to summarize the effect size of individual interventions for each outcome separately. In addition, Bayesian network meta-analyses will be used to pool the direct and indirect effects of all possible comparisons and to provide a hierarchy of all interventions for our primary outcomes. Furthermore, we will assess publication bias and certainty of evidence by GRADE approach for NMA.

Discussion: The findings of this review will fill the gaps in evidence by synthesizing the impact of TBIs on a comprehensive range of reported outcomes in antenatal, postnatal, and delivery care. Furthermore, our meta-analyses will further guide policymakers or stakeholders on the potential use of TBIs in given contexts.

Systematic review registration: PROSPERO Protocol ID CRD42019137331

Background

In 2017, an estimated 295,000 women died from complications related to pregnancy, childbirth, or postnatal period[1]. Out of total global maternal and neonatal deaths, 99% occurs in low- and middle-income countries (LMICs)[2]. The greatest barrier to reduce maternal and neonatal mortality and morbidity is attributed to the low coverage of essential pregnancy-related health services such as antenatal care (ANC) visits, post-natal care (PNC) visits, and delivery care in LMICs. Approximately 50% pregnant women in LMICs received the four mandatory antenatal consultations as recommended by the World Health Organization (WHO)[3]. Providing essential health services to pregnant women is complex in resource-limited settings as integrated and multiple interventions are required throughout the antenatal, delivery, and postnatal processes.

Since the adoption of eHealth resolution by the WHO in 2005, a surge of technology-based interventions (TBIs) in public health has taken place. eHealth incorporates categories such as telehealth, electronic health records, eLearning, mHealth (mobile health), social media, and big data. Such interventions are widely being employed to increase utilization of preventative healthcare, such as ANC, PNC, and delivery

care, at both individual- and community-levels. As a result, TBIs are a potential promise to providing improvement in timeliness, accessibility, and affordability of healthcare services in resource-limited settings. Furthermore, women's access to digital- technology health interventions including mHealth have been shown gender-transformation women's decision-making, social status and access to health resources, and a greater number of male participations in health areas[4-6] . The engagement of male partners supports women's decision that is identified as an important mechanism to progress in maternal and newborn health (MNH)[7]. TBIs have also potentiality to make more responsive health services.

Despite technology-based interventions, evidence remains inconclusive due to a lack of comprehensive and concrete evaluations. This uncertainty raises a question of the role in targeting strategies in implementing TBIs in healthcare utilization. Current literature is limited to evidence from pilot projects, systematic and/or pooled reviews assessing the impact of mHealth in improving continuum of care in LMICs[8-15], or identifying barriers to its uptake through stakeholder interviews[16]. These studies assessed an isolated range of interventions (such as mHealth only) or a limited range of outcomes (such as uptake of health services and skilled birth attendance rates). To date no one assess this complex interaction and TBIs over the dynamic antenatal-delivery-postnatal pathway. This systematic review and network meta-analysis aims to fill this gap through synthesizing available evidence on the effectiveness of TBIs in improving a comprehensive range of outcomes in ANC, PNC, and delivery care. Furthermore, our study will evaluate the impact of sociodemographic, country and regional factors, which will provide further information to policymakers on the potential use of TBIs in given contexts.

Review questions

1) What is the effectiveness of single and complex TBIs on antenatal, postnatal, and delivery care services among women with a comprehensive range of outcomes?

2) How do TBIs interact and produce causal outcomes through the antenatal-delivery-postnatal pathway?

3) Do these new technology-based solutions promote engagement of woman only or woman with their partners and family?

Objectives

This review aims to explore the impact of TBIs in improving ANC visits, PNC visits, and delivery care services in LMICs using Bayesian network meta-analysis. Additionally, the study will assess the role of these TBIs in promoting engagement of woman only or woman with their partners and family over the dynamic antenatal-delivery-postnatal pathway.

Methods

The review protocol was registered in the PROSPERO database (PROSPERO ID: CRD42019137331). This protocol adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) 2015 guideline for preparing protocols of systematic reviews and network meta-analysis[17] (additional file PRISMA-P). We will report the study findings according to the PRISMA for Network Meta-Analysis (PRISMA-NMA) guideline[18].

Study eligibility criteria

The study eligibility criteria are defined in the following PICOS framework (P-Participants/study population, I-interventions, C-Comparator, O-Outcomes, and S-Study design/settings). We will include studies if the study meets the following criteria:

1) Population:

We will include studies if the study population is pregnant women aged 10-49 years.

2) Intervention:

All types of TBIs (e.g., eHealth intervention, mHealth intervention, and telehealth intervention) will be considered for this review.

3) Comparison:

We will include studies if the study compares the effectiveness of any form of technology-based healthcare interventions with usual care or non-TBIs. We will also include a study if it compares different form of TBIs.

4) Outcome:

We intend to include studies that reported perinatal healthcare utilization such as ANC visits, institutional delivery, skilled birth attendance at the time of delivery, proportion of birth preparedness, proportion of post-natal care utilization both for mother and newborn. We will also include studies if they reported any adverse maternal and birth outcomes that occurred during the perinatal period.

5) Types of study:

We will consider all randomized controlled trials (RCTs), cluster RCTs, quasi RCTs, and quasi experimental studies (controlled before and after studies) in this review. We will exclude qualitative studies, case

studies, cross-sectional studies, review studies, discussion papers, case reports, commentaries, editorials, expert opinions, and ongoing research with insufficient PICOS information.

6) Settings:

We will include studies conducted in low-and middle-income countries (LMICs) based on World Bank categories. A country will be categorized as a low- or middle-income country based on the World Bank country income category at the time of the study.

Outcome variables

- ## Primary outcome variables:

number of ANC visits from skilled health provider, institutional delivery, and skilled birth attendance at the time of delivery, birth preparedness, number of PNC visits from skilled provider for both mother and newborn.

- ## Secondary outcome variables:

(a) Health outcomes due to poor care: number of maternal and early neonatal deaths, proportion of women with gestational diabetes and hypertension, low birth weight, and preterm births.

(b) Other outcomes: reported increases in women' access to digital and mobile technologies, engagement of men and/or significant others in care pathway; impact on gender equality and any adverse outcomes.

Search strategy

We will search the following eight electronic databases: British Nursing Index, CINAHL PLUS, Cochrane Library, EMBASE, POPLINE, PsycINFO, PubMed, and Web of Science. We will also check the reference lists of included articles and relevant systematic review studies including reference snowballing, citation tracking, grey literature searching and handsearching in key journals. Search terms will consist of Medical Subject Headings, title/abstract, text words and other relevant field tag depending on the databases. We will also search WHO's international Clinical Trials Registry Platform, ClinicalTrials.gov, and the Cochrane Central Register of Controlled Trials, using appropriate search terms, as presented in Table 1. The search will not be limited by publication status, date or language of production.

Table 1
Keywords used in electronic search strategy

SL	Query
1.	expectant mother OR pregnant women OR pregnant mother OR pregnancy
2.	computer OR tablet OR phone OR mobile OR mobile phone OR mobile device OR smartphone OR smart-phone OR cell phone OR cellphone OR cellular phone OR web OR website OR Internet OR online OR on-line OR technology OR digital technology OR mobile technology OR health technology OR wireless technology OR wireless device OR iPhone OR i-Phone OR iPad OR i-Pad OR iPod OR i-Pod
3.	SMS OR short message service OR short messaging OR mobile phone messaging OR MMS OR multimedia message service OR multi-media message OR SMS advice OR SMS reminder OR text message OR text messaging OR texting
4.	mobile call OR mobile calling OR mobile communication OR voice call OR voice calling OR voice message OR video conference
5.	mobile applications OR mobile apps OR mobile app OR smartphone app OR app OR apps OR email OR e-mail OR personal digital assistant OR PDA
6.	#2 OR #3 OR #4 OR #5
7.	eHealth OR e-Health OR electronic health OR digital health OR telehealth OR telemedicine OR telecommunication OR mHealth OR m-Health OR mobile health OR mobile medicine OR mcare OR m-care OR mobile care OR mHealth messaging OR mobile telehealth OR mobile telehealth care OR m-Edu OR medu OR m-education OR mobile education OR mLearning OR eLearning
8.	#6 AND #7
9.	#1 AND #8

Selection of the study

Following the search strategy, all articles extracted from the eight electronic databases will be stored in EndNote and duplicates will be identified and excluded. After removing the duplicates, the combined articles will be screened through Rayyan QCRI tool. In the first stage, two reviewers will independently screen titles and abstracts based on the inclusion and exclusion criteria. In the second stage of screening, both reviewers will then independently review full texts of selected studies to assess eligibility. Any discrepancies between the reviewers at the two stages will be resolved through discussion.

Data extraction

A coding framework will be developed and piloted prior to undertaking data extraction for all included studies using EPPI Reviewer 4 software. For eligible studies, two reviewers will independently extract data on author information, year of publication, survey year, country, region, settings, study design, type of intervention, sample size, frequency/rate of ANC visits, institutional delivery, skilled birth attendance, and post-natal care visits by different household, individuals or health provider characteristics. Inter-coder reliability will be tested to ensure moderate agreement, until Cohen's kappa reaches 0.41 or above[19], and the review team are satisfied that screeners are making consistent decisions. Disagreements will be solved through discussion. When the information is unclear or full-text articles not available, we will contact the corresponding or co-authors to collect our required information. For articles written in languages other than English (Spanish, Chinese, German, Italian and others), data will be extracted with the assistance of colleagues who are native speakers in these languages.

Missing data

If the study does not contain sufficient data such as means and standard deviations to calculate effect size estimates, the authors will be contacted for further information. If sufficient data cannot be obtained, the study will be excluded from the meta-analysis but presented in a narrative synthesis. In cases where data is missing due to attrition rates of more than 20%, the studies will be included with sensitivity analysis conducted to measure its impact on analysis. In studies with results of both 'intention to treat' and 'as treated' analysis presented, the 'intention to treat' will always be preferred.

Study quality assessment

We will use the Cochrane Collaboration's Tool to assess the study quality[20]. The tool consists of the following domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, and other bias. Non-randomized studies will be coded using Risk of Bias in Non-randomized Studies - of Interventions (ROBINS-I)[21]. We will classify the studies having high, low and unclear risk of bias based on their guideline[20]. The quality of interventions will be assessed based on the degree of implementation fidelity (adherence, intervention complexity, facilitation strategies, quality of intervention delivered, quality of delivery, and participant responsiveness)[22]. Additionally, we will assess certainty of evidence by Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach for our primary outcomes[23]. Two reviewers will independently assess the study quality, which will be cross-checked by two other authors. Any discrepancy will be solved through discussion.

Data Synthesis

Pairwise meta-analysis

To summarize the effect size of individual interventions for each outcome separately, we will use Bayesian fixed- or random-effects meta-analysis depending on the extent of heterogeneity, as well as based on the clinical and methodological heterogeneity. For dichotomous outcome variables, odds ratio (OR), relative risk (RR), or hazard ratios (HR) with 95% confidence interval (CI) will be utilized as the effect size in the meta-analysis. For continuous outcome variables, standardized mean difference (SMD) with standard deviation will be considered in the meta-analysis. The relative risk (RR) is used as the common measure in trials, observational, or even in cross-sectional studies. Consistent with previous study[24], we will treat ORs equal to RRs when the incidence of outcome is not common (<10%) in the study population. Otherwise, we will convert ORs into RRs according to Zhang proposed methodology[24]. We will directly consider RRs when the study reported hazard ratios and/or incidence rate ratios. If the RR or OR is unavailable, we will estimate unadjusted RR from raw data.

Assessing heterogeneity

Regarding the assessment for heterogeneity in the included studies, we will calculate the chi-square statistic and I^2 statistic. We will follow the Cochrane guideline for classifying heterogeneity[25]. If there is no heterogeneity ($P>0.05$, $I^2 < 25\%$), a fixed effect model will be performed[26]. Otherwise, a random effects model will be used to obtain the pooled effect size for each intervention. We will perform subgroup analysis to estimate pooled effect size for each intervention by country, region, age group, year of publication, year of implementation of the intervention, place of residence (urban/rural), measurement of outcomes, quality of study women with conditions (such as HIV/AIDS, cancer, preeclampsia or other severe/chronic diseases, and so on depending on the availability of sufficient information. Subgroup analysis will be performed using Bayesian meta-regression. Publication bias will be assessed using funnel plots and Egger's test[27].

Network meta-analysis

In the first stage of analysis, network plots will be developed to show the direct comparison between treatment arms. After that, the contribution plots will be developed to show the influence and contribution of each direct comparison to the whole network. For Bayesian network meta-analysis, we will develop algorithm in Bayesian framework based on log scale of effect size and estimate the posterior distribution of the treatment effect size. Bayesian network meta-analysis will be utilized to rank the interventions on the basis of their effectiveness for each outcome. To pool the direct and indirect or different indirect outcomes simultaneously, we will use Bayesian network meta-analysis.

Bayesian network meta-analysis will be based on sampling from the posterior distribution over the parameters using Gibbs Monte Carlo, a Markov chain Monte Carlo (MCMC) method. In MCMC algorithm, we will use 40,000 or more iterations with three chains, 500 sample burn-in, and 10 thinning due to reduce autocorrelation. Vague priors, such as $N(0, 10^6)$ for the study-specific baseline and treatment effect

coefficients will be used to insure estimates of effect sizes and precision. Surface under the cumulative ranking curve (SUCRA) will be used for presenting the results. The SUCRA value will be presented as the percentage of the area under the curve, denoting the higher the SUCRA value reflected the better the treatment method. Gelman-Rubin diagnostic statistics and potential scale reduction factor (PSRF) will be used to check the convergence of the model[28]. Furthermore, we will perform the inconsistency analysis to assess disagreement between direct and indirect evidence which can suggest that the transitivity assumption might not be hold. The inconsistency factors in the closed loop will be assessed by the common method[29]. Inconsistency analysis will be presented as a funnel plot. Data management will be performed in Stata version 16.1/MP and analysis will be performed in R (version 3.6.4), and JAGS version 4.2.0.

Abbreviations

ANC, antenatal care; CEDIL, Centre of Excellence for Development Impact and Learning; CI, Confidence interval; eLearning, electronic learning; eHealth, Electronic health; GRADE, Grading of Recommendations, Assessment, Development and Evaluations; HR, Hazard ratio; JAGS, Just Another Gibbs Sampler; LMICs, low- and middle-income countries; MCMC, Markov chain Monte Carlo; mHealth, Mobile health; MNH, Maternal and newborn health; OECD, Organization for Economic Co-operation and Development; OR, Odds ratio; PNC, post-natal care; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis; PRISMA-P, Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols; PRISMA-NMA, PRISMA for Network Meta-Analysis; PSRF, Potential scale reduction factor; RCT, randomized controlled trial; ROBINS-I, Risk of Bias in Non-randomized Studies - of Interventions; RR, Relative risk; SMD, Standardized mean difference; SUCRA, Surface under the cumulative ranking curve; UNESCO, United Nations Educational, Scientific and Cultural Organization; UNFPA, United Nations Population Fund; UNWOMEN, United Nations Entity for Gender Equality and the Empowerment of Women; WHO, World Health Organization;

Declarations

Ethical Approval and Consent to participate

This study does not require ethical approval or consent to participate as the study will use data from the published studies.

Consent for publication

Agree to publish the paper

Availability of data and materials

Data sharing is not possible at this stage since no datasets were prepared for analysis.

Competing interests

MOR, MMR, MSR, EO, JJ, MAA, ML, MRI, HT declare no competing of interests.

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Authors’ contribution

Rahman MO, Rahman MM, and Ota E developed the study concept. Rahman MO wrote the first draft together with Rahman MS and Islam MR. Rahman MM, Jung J, Alam MA, Lohan M,Ota E, and Taniguchi H critically reviewed the drafts. All authors have approved the final draft of the study.

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