



A systematic review of digital health tools used for decision support by frontline health workers (FLHWs) in low- and middle- income countries (LMICs)

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Part 0: Front Matter

Abstract

In in low-and middle-income countries (LMIC), where there are very few trained physicians and nurses, community health workers (CHWs) are often the only providers of healthcare to millions of people. Such LMIC are countries that are classified, based on their geographic region and Gross National Income (GNI), as low-middle income by the World Bank Group, the worlds largest development bank. Research has shown digital health tools to be an effective strategy to improve the performance of frontline line health workers. The aim of this review was to systematically examine the literature on digital health tools that are used for decision support in LMIC and describe what we can learn from studies that have used these tools. As part of a larger parent study the following databases were searched: PubMed, Embase, Scopus, CINAHL, Global Health Ovid, Cochrane and Global Idex Medicus, to find ariticles in the following domains: training tools, decision support, data capture, commodity tracking, provider to provider communication, provider to patient communication and alerts, reminders, health information content. These domains were selected based on the World Health Organisation (WHO) framework for classifying digital health interventions. Content from all seven of these domains informed a series of reviews however this review focuses on how digital tools are used to provide decision support to FLHWs. Included studies were conducted in LMIC in Africa, Asia, North America and South America with the most common users of the tools being CHWs. Most tools for FLHW decision-support used in the interventions described in included articles were in either the pilot or prototype phases, and offered maternal and child health care services. Although decision support was the primary digital health function of all these studies, there was considerable variation in the number of digital health functions of each tool with most studies reporting decision support and data capture as their primary and secondary functions respectively. All the studies found their intervention to have beneficial effects on one or more of the following outcomes: beneficiary engagement, provider engagement, health effects and process/outputs. These findings show great potential for the use of decision support digital health tools as a means of improving the outcomes of health systems through; reducing the work load of FLHWs, reducing the costs of health care, improving the efficiency of service delivery and/or improving the overall quality of care.

Key words: Frontline line health workers , low-and middle-income countries, community health workers, digital health tools, decision support

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Part A: Review Protocol

A systematic review of digital health tools used for decision support by frontline health workers (FLHWs) in low- and middle- income countries (LMICs)

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Background to the Protocol

In LMICs frontline health workers (FLHWs) are often the first and only point of call for people in need of health care services.¹ However, despite the essential role that they play, FLHWs are often neglected, remain poorly equipped and receive insufficient training- compromising their abilities and the chance of improving health outcomes.^{1,2} In order to solve this problem governments and private organizations have, for many years, been implementing various digital health projects. With mobile health being a model of health care delivery supported by mobile devices such as mobile phones, tablets, personal digital assistants and wireless infrastructure.³

To learn more about the health tools being used, their functions and their success rates we set out to review available literature. In August 2018 a search began to find studies in LMICs that use digital health tools that fall into one of the six categories described in the WHO's framework for classification of digital health interventions.⁴ These categories are based on the tools function including:

- Training: the provision of material to improve access to continuing healthcare education.⁵
- Decision support: software algorithms that are used to advise health care professionals on the clinical diagnoses of patients.⁶
- Data capture: the use of electronic methods to capture patient data, decrease the cost and increase the efficiency of the data collected.⁷
- Commodity tracking: the use of using ICT to improve ordering and the management and distribution of medicines.⁸
- Provider to provider communication: the use of digital tools to promote the transfer of knowledge between health care professionals; improving the provision of medical advice and patient referrals.⁶
- Provider to patient communication: the use of ICT as a means of communication between patient and health care provider, for example the use of a mobile phone to regularly check in with a patient and encourage compliance for certain chronic diseases.⁹
- Alerts, reminders and health information content: voice or SMS messages sent to patients to schedule or attend an appointment or to remind them to take certain medication.⁶

The following databases were searched: PubMed, Embase, Scopus, CINAHL, Global Health Ovid, Cochrane and Global Index Medicus. Grey Literature was not included in this search due to limited resources. Articles found in all seven of these domains are being used to inform a series of reviews.

Introduction

People in LMICs have less access to healthcare services than those in high income countries.¹⁰ In LMICs frontline health workers are often the first and only point of call for people in need of these services.¹ With a predicted shortage of between 42,600 and 121,300 physicians in the healthcare industry by the end of 2020 their work may become even more crucial.¹¹ However, despite the essential role that they play, FLHWs are often neglected and remain poorly equipped; receiving insufficient training, little supervision, low pay and few opportunities for professional development.^{1,2} As a result, their abilities are limited and opportunities to improve health outcomes are lost.¹

FLHWs form a major part of the health system in many developing countries and are key to reducing preventable deaths and achieving universal health coverage.² Frontline health workers include all types of health workers- nurses, midwives, community health workers, doctors and pharmacists.¹² Common roles of these FLHWs include administrative support, preventive services, health education, rehabilitative care, and chronic disease management.¹³

With mobile phone penetration rates exploding worldwide, even in LMICs¹⁴ – with 85% of adults owning a mobile phone¹⁵ governments and private organizations have, for many years, been implementing various digital health projects aimed at improving the abilities of these FLHWs and strengthening health systems.¹ Digital health tools are digital technologies used for modernising health and care.¹⁶ The most common digital health tools developed have a variety of functions including: education, awareness, data collection, tracking and monitoring, communication, training and decision support.¹⁷ In August 2018 a search began to find studies in LMICs that used digital health tools with the following functions; training, decision support, data capture, commodity tracking, provider to provider communication, provider to patient communication and alerts, reminders, health information content. These domains were selected based on the World Health Organisation (WHO) framework for classifying digital health interventions. Articles found in all seven of these domains informed other papers in this series of reviews. However, this review will focus on digital health tools with decision support functions which provide step-by-step guidelines for FLHWs to assess a patient's condition and/or inform treatment decisions.¹⁸

While studies have consistently demonstrated digital health to improve the quality and coverage of care offered as well as increase provider and beneficiaries access to information, services and skills, there are a limited number of reviews summarizing the findings and drawing conclusions from all these different studies. In the literature review conducted for the purpose of this study (Section B)

I analysed six reviews, four of which differed greatly in their focus, methodology and findings, while two of the reviews had many similarities. Overall these reviews demonstrated positive findings – highlighting the potential of digital health decision support tools. However, several gaps became obvious when studying these reviews: none of them looked specifically at LMICs, most of them were vulnerable to publication bias and they all tended to have a very narrow scope – describing and critically appraising only a very small part of each intervention while providing little to no insight into important information and evidence such as: country of implementation, type of mobile device used, outcome and impact. The purpose of this systematic review (Part C) will be to address these gaps in literature.

Review questions

Through thorough examination of the literature this paper aims to review current studies on decision support digital health tools and determine how decision support digital tools, including mobile phones, have been used by frontline health workers (FLHWs) in low-and middle-income countries (LMICs). The review will specifically explore the following questions:

Main research question

How are digital health tools used for decision making by FLHWs in LMICs?

Subsidiary research questions

1. What are the popular geographic areas for implementation of such programmes?
2. How are these interventions delivered (i.e. type of technology used)?
3. What is the stage of maturity of these digital health tools?
4. Which health services and/or disease and practice areas do these interventions focus on?
5. What evidence exists to support their benefit in terms of processes/output, Outcomes (provider and beneficiary engagement) and impact?

Methodology

Literature search strategy

In August 2018 a search began to find studies in LMICs that used digital health tools with the following functions; training, decision support, data capture, commodity tracking, provider to provider communication, provider to patient communication and alerts, reminders, health information content. These six categories were selected based on the WHO framework for classifying digital health interventions.⁴ Several databases were included as is recommended to ensure maximum sensitivity.¹⁹ The databases searched included: PubMed, Embase, Scopus, CINAHL, Global Health Ovid, Cochrane and Global Index Medicus. Grey Literature and studies not published in English were not included due to limited resources. Two of the search terms selected (FLHW and digital health) were those used by Agarwal et al. (2015) in their systematic review of digital health tools for FLHWs.²⁰ The third search term selected was LMICs as defined and listed by the World Bank. Articles found in all seven of these domains informed other papers in this series of reviews. However, this review will focus on the 33 articles found in the decision support domain.

Table 1. Search terms

Concept 1: mHealth	"Telemedicine"[Mesh] OR "telemedicine"[tw] OR "telehealth"[tw] OR "digital health"[tw] OR "mobile"[tw] OR "Telephone"[Mesh] OR "phone"[tw] OR "phones"[tw] OR "telephone"[tw] OR "telephones"[tw] OR "smartphone"[tw] OR "smartphones"[tw] OR "iphone"[tw] OR "iphones"[tw] OR "android"[tw] OR "androids"[tw] OR "mHealth"[tw] OR "eHealth"[tw] OR "Information Technology"[Mesh] OR "information technology"[tw] OR "information technologies"[tw] OR "communication technology"[tw] OR "communication technologies"[tw] OR ("cellular "[tw] OR "wearable"[tiab] OR "digital"[tiab]) AND ("technology"[tw] OR "technologies"[tw])) OR "portable cellular"[tw] OR "transportable cellular"[tw] OR ((cellular[tw] OR mobile[tw] OR phone[tw] OR smart[tw] OR text[tiab] OR digital[tiab]) AND ("app"[tiab] OR "application"[tiab] OR "applications"[tiab] OR alert[tiab] OR alerts[tiab] OR reminder[tiab] OR reminders[tiab])) OR "mobile device"[tw] OR "mobile devices"[tw] OR "SMS"[tw] OR "short message service"[tw] OR "text message"[tw] OR "text-message"[tw] OR "text messages"[tw] OR "text-messages"[tw] OR "text messaging"[tw] OR "text-messaging"[tw] OR "texting"[tw] OR "textings"[tw] OR "text contact"[tw] OR "text contacts"[tw] OR "interactive voice response"[tw]) AND ("2008/01/01"[PDAT] : "2018/12/31"[PDAT])
Concept 2: Health worker	"community health workers"[MeSH Terms] OR "community health worker"[tw] OR "community health workers"[tw] OR "CHW"[tw] OR "CHWs"[tw] OR "community health aid"[tw] OR "community health aides"[tw] OR "family planning personnel"[tw] OR "midwifery"[MeSH Terms] OR "traditional birth attendant"[tw] OR "traditional birth attendants"[tw] OR "skilled birth attendant"[tw] OR "skilled birth attendants"[tw] OR "frontline worker"[tw] OR "frontline workers"[tw] OR "health worker"[tw] OR "health workers"[tw] OR "lay worker"[tw] OR "lay workers" OR "village health worker"[tw] OR "village health workers"[tw] OR "VHW"[tw] OR "VHWs"[tw] OR "midwife"[tw] OR "midwives"[tw] OR "barefoot doctors"[tw] OR "barefoot doctor"[tw] OR "health auxiliary"[tw] OR "health auxiliaries"[tw] OR "peer health worker"[tw] OR "peer health workers"[tw] OR "medical auxiliary"[tw] OR "medical auxiliaries"[tw] OR "health provider"[tw] OR "health providers"[tw] OR "lay counselor"[tw] OR "lay counselors"[tw] OR "lady health worker"[tw] OR "lady health workers"[tw] OR "LHW"[tw] OR "LHWs"[tw] OR "lay

educator"[tw] OR "lay educators"[tw] OR "Activista"[tw] OR "activistas"[tw] OR "Agente comunitario de salud"[tw] OR "agentes comunitarios de salud"[tw] OR

"Anganwadi"[tw] OR "accredited social health activist"[tw] OR "accredited social health activists"[tw] OR "ASHA"[tw] OR "ASHAs"[tw] OR "Animatrice"[tw] OR "animatrices"[tw] OR "Barangay health worker"[tw] OR "[Barangay Health Workers](#)"[tw] OR

"Basic health worker"[tw] OR "basic health workers"[tw] OR "Brigadista"[tw] OR "brigadistas"[tw] OR "Colaborador voluntario"[tw] OR "[Colaboradores voluntarios](#)"[tw] OR "Community drug distributor"[tw] OR "community drug distributors"[tw] OR "Community health agent"[tw] OR "community health agents"[tw] OR "Community health promoter"[tw] OR "community health promoters"[tw] OR "Community health representative"[tw] OR "community health representatives"[tw] OR "Community health volunteer"[tw] OR "community health volunteers"[tw] OR "Community nutrition worker"[tw] OR "community nutrition volunteers"[tw] OR "Community resource person"[tw] OR "community resource persons"[tw] OR "Female community health volunteer"[tw] OR "female community health volunteers"[tw] OR "Female multipurpose health worker"[tw] OR "female multipurpose health workers"[tw] OR "Health promoter"[tw] OR "health promoters"[tw] OR "Kader"[tw] OR "kaders"[tw] OR "Maternal and child health worker"[tw] OR "maternal and child health workers"[tw] OR "Monitora"[tw] OR "Mother coordinator"[tw] OR "mother coordinators"[tw] OR "**Outreach educator**"[tw] OR "outreach educators"[tw] OR "Promotora"[tw] OR "Promotoras"[tw] OR "Rural health motivator"[tw] OR "rural health motivators"[tw] OR "Shastho shebika"[tw] OR "Shasthya Shebika"[tw] OR "Shasthya Shebikas"[tw] OR "Sevika"[tw] OR "sevikas"[tw] OR "Village health helper"[tw] OR "village health helpers"[tw] OR "Village drug-kit manager"[tw] OR "village drug-kit managers"[tw] OR "Saksham Sahaya"[tw] OR "Saksham Sahayaks"[tw] OR "Raedat"[tw] OR "Raedat Refiat"[tw] OR "Accompagnateurs"[tw] OR "Accompagnateur"[tw] OR "Behvarz"[tw] OR "behvarzan"[tw] OR "Dai"[tw] OR "Dais"[tw] OR "Bidan Kampong"[tw] OR "bidan kampungs"[tw] OR "bidan kampong"[tw] OR "agents de santé"[tw] OR "agent de santé"[tw] AND ("2008/01/01"[PDAT] : "2018/12/31"[PDAT])

**Concept 3:
With LMIC
Filter**

((("community health workers"[MeSH Terms] OR "community health worker"[tw] OR "community health workers"[tw] OR "CHW"[tw] OR "CHWs"[tw] OR "community health aides"[tw] OR "family planning personnel"[tw] OR "midwifery"[MeSH Terms] OR "traditional birth attendant"[tw] OR "traditional birth attendants"[tw] OR "skilled birth attendant"[tw] OR "skilled birth attendants"[tw] OR "frontline worker"[tw] OR "frontline workers"[tw] OR "health worker"[tw] OR "health workers"[tw] OR "lay worker"[tw] OR "lay workers"[All Fields] OR "village health worker"[tw] OR "village health workers"[tw] OR "VHW"[tw] OR "VHWs"[tw] OR "midwife"[tw] OR "midwives"[tw] OR "barefoot doctors"[tw] OR "barefoot doctor"[tw] OR "health auxiliary"[tw] OR "health auxiliaries"[tw] OR "peer health worker"[tw] OR "peer health workers"[tw] OR "medical auxiliary"[tw] OR "medical auxiliaries"[tw] OR "health provider"[tw] OR "health providers"[tw] OR "lay counselor"[tw] OR "lay counselors"[tw] OR "lady health worker"[tw] OR "lady health workers"[tw] OR "LHW"[tw] OR "LHWs"[tw] OR "lay educator"[tw] OR "lay educators"[tw] OR "agentes comunitarios de salud"[tw] OR "Anganwadi"[tw] OR "accredited social health activist"[tw] OR "accredited social health activists"[tw] OR "ASHA"[tw] OR "ASHAs"[tw] OR "Barangay Health Workers"[tw] OR "Basic health worker"[tw] OR "basic health workers"[tw] OR "Brigadista"[tw] OR "brigadistas"[tw] OR "community drug distributors"[tw] OR "Community health agent"[tw] OR "community health agents"[tw] OR "Community health promoter"[tw] OR "community health promoters"[tw] OR "Community health representative"[tw] OR "community health representatives"[tw] OR "Community health volunteer"[tw] OR "community health volunteers"[tw] OR "community resource persons"[tw] OR "Female community health volunteer"[tw] OR "female community health volunteers"[tw] OR "Health promoter"[tw] OR "health promoters"[tw] OR "Kader"[tw] OR "kaders"[tw] OR "mother coordinators"[tw] OR "outreach educators"[tw] OR "Promotora"[tw] OR "Promotoras"[tw] OR "Sevika"[tw] OR "village health helpers"[tw] OR "Raedat"[tw] OR "Accompagnateurs"[tw] OR "Accompagnateur"[tw] OR "Behvarz"[tw] OR "Dai"[tw] OR "Dais"[tw] OR "bidan kampungs"[tw] AND ("2008/01/01"[PDAT] : "2018/12/31"[PDAT])) AND ("Telemedicine"[Mesh] OR "telemedicine"[tw] OR "telehealth"[tw] OR "digital health"[tw] OR "mobile"[tw] OR "Telephone"[Mesh] OR "phone"[tw] OR "phones"[tw] OR "telephone"[tw] OR "telephones"[tw] OR "smartphone"[tw] OR "smartphones"[tw] OR "iphone"[tw] OR "iphones"[tw] OR "android"[tw] OR "androids"[tw] OR "mHealth"[tw] OR "eHealth"[tw] OR "Information Technology"[Mesh] OR "information technology"[tw] OR "information technologies"[tw] OR "communication technology"[tw] OR "communication technologies"[tw] OR ("cellular "[tw] OR "wearable"[tiab] OR "digital"[tiab]) AND ("technology"[tw] OR "technologies"[tw])) OR ((cellular[tw] OR mobile[tw] OR phone[tw] OR smart[tw] OR text[tiab] OR digital[tiab]) AND ("app"[tiab] OR "application"[tiab] OR "applications"[tiab] OR alert[tiab] OR alerts[tiab] OR reminder[tiab] OR reminders[tiab])) OR "mobile device"[tw] OR "mobile devices"[tw] OR "SMS"[tw] OR "short message

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St Lucia[tw] OR Saint Vincent[tw] OR St Vincent[tw] OR Grenadines[tw] OR Samoa[tw] OR Samoan Islands[tw] OR (Navigator[All Fields] AND Island[tw]) OR (Navigator[All Fields] AND Islands[tw]) OR Sao Tome[tw] OR Saudi Arabia[tw] OR Senegal[tw] OR Serbia[tw] OR Montenegro[tw] OR Seychelles[tw] OR Sierra Leone[tw] OR Slovenia[tw] OR Sri Lanka[tw] OR Ceylon[tw] OR Solomon Islands[tw] OR Somalia[tw] OR Sudan[tw] OR Suriname[tw] OR Surinam[tw] OR Swaziland[tw] OR Syria[tw] OR Tajikistan[tw] OR Tadjikistan[tw] OR Tadjikistan[tw] OR Tadjik[tw] OR Tanzania[tw] OR Thailand[tw] OR Togo[tw] OR Togolese Republic[tw] OR Tonga[tw] OR Trinidad[tw] OR Tobago[tw] OR Tunisia[tw] OR Turkey[tw] OR Turkmenistan[tw] OR Turkmen[tw] OR Uganda[tw] OR Ukraine[tw] OR Uruguay[tw] OR USSR[tw] OR Soviet Union[tw] OR Union of Soviet Socialist Republics[tw] OR Uzbekistan[tw] OR Uzbek[All Fields] OR Vanuatu[tw] OR New Hebrides[tw] OR Venezuela[tw] OR Vietnam[tw] OR Viet Nam[tw] OR West Bank[tw] OR Yemen[tw] OR Yugoslavia[tw] OR Zambia[tw] OR Zimbabwe[tw] OR Rhodesia[tw])) OR ("developing countries"[MeSH Terms:noexp] OR "africa"[MeSH Terms:noexp] OR "africa, northern"[MeSH Terms:noexp] OR "africa south of the sahara"[MeSH Terms:noexp] OR "africa, central"[MeSH Terms:noexp] OR "africa, eastern"[MeSH Terms:noexp] OR "africa, southern"[MeSH Terms:noexp] OR "africa, western"[MeSH Terms:noexp] OR "asia"[MeSH Terms:noexp] OR "asia, central"[MeSH Terms:noexp] OR "asia, southeastern"[MeSH Terms:noexp] OR "asia, western"[MeSH Terms:noexp] OR "caribbean region"[MeSH Terms:noexp] OR "west indies"[MeSH Terms:noexp] OR "south america"[MeSH Terms:noexp] OR "latin america"[MeSH Terms:noexp] OR "central america"[MeSH Terms:noexp] OR "afghanistan"[MeSH Terms:noexp] OR "albania"[MeSH Terms:noexp] OR "algeria"[MeSH Terms:noexp] OR "american samoa"[MeSH Terms:noexp] OR "angola"[MeSH Terms:noexp] OR "Antigua and Barbuda"[Mesh:noexp] OR "argentina"[MeSH Terms:noexp] OR "armenia"[MeSH Terms:noexp] OR "azerbaijan"[MeSH Terms:noexp] OR "bahrain"[MeSH Terms:noexp] OR "bangladesh"[MeSH Terms:noexp] OR "barbados"[MeSH Terms:noexp] OR "benin"[MeSH Terms:noexp] OR "republic of belarus"[MeSH Terms:noexp] OR "belize"[MeSH Terms:noexp] OR "bhutan"[MeSH Terms:noexp] OR "bolivia"[MeSH Terms:noexp] OR "bosnia and herzegovina"[MeSH Terms:noexp] OR "botswana"[MeSH Terms:noexp] OR "brazil"[MeSH Terms:noexp] OR "bulgaria"[MeSH Terms:noexp] OR "burkina faso"[MeSH Terms:noexp] OR "burundi"[MeSH Terms:noexp] OR "cambodia"[MeSH Terms:noexp] OR "cameroon"[MeSH Terms:noexp] OR "cabo verde"[MeSH Terms:noexp] OR "central african republic"[MeSH Terms:noexp] OR "chad"[MeSH Terms:noexp] OR "chile"[MeSH Terms:noexp] OR "china"[MeSH Terms:noexp] OR "colombia"[MeSH Terms:noexp] OR "comoros"[MeSH Terms:noexp] OR "congo"[MeSH Terms:noexp] OR "costa rica"[MeSH Terms:noexp] OR "cote d'ivoire"[MeSH Terms:noexp] OR "croatia"[MeSH Terms:noexp] OR "cuba"[MeSH Terms:noexp] OR "cyprus"[MeSH Terms:noexp] OR "czechoslovakia"[MeSH Terms:noexp] OR "czech republic"[MeSH Terms:noexp] OR "slovakia"[MeSH Terms:noexp] OR "djibouti"[MeSH Terms:noexp] OR "Democratic Republic of the Congo"[Mesh:noexp] OR "dominica"[MeSH Terms:noexp] OR "dominican republic"[MeSH Terms:noexp] OR "timor-leste"[MeSH Terms:noexp] OR "ecuador"[MeSH Terms:noexp] OR "egypt"[MeSH Terms:noexp] OR "el salvador"[MeSH Terms:noexp] OR "eritrea"[MeSH Terms:noexp] OR "estonia"[MeSH Terms:noexp] OR "ethiopia"[MeSH Terms:noexp] OR "fiji"[MeSH Terms:noexp] OR "gabon"[MeSH Terms:noexp] OR "gambia"[MeSH Terms:noexp] OR "Georgia (Republic)"[Mesh:noexp] OR "ghana"[MeSH Terms:noexp] OR "greece"[MeSH Terms:noexp] OR "grenada"[MeSH Terms:noexp] OR "guatemala"[MeSH Terms:noexp] OR "guinea"[MeSH Terms:noexp] OR "guinea-bissau"[MeSH Terms:noexp] OR "guam"[MeSH Terms:noexp] OR "guyana"[MeSH Terms:noexp] OR "haiti"[MeSH Terms:noexp] OR "honduras"[MeSH Terms:noexp] OR "hungary"[MeSH Terms:noexp] OR "india"[MeSH Terms:noexp] OR "indonesia"[MeSH Terms:noexp] OR "iran"[MeSH Terms:noexp] OR "iraq"[MeSH Terms:noexp] OR "jamaica"[MeSH Terms:noexp] OR "jordan"[MeSH Terms:noexp] OR "kazakhstan"[MeSH Terms:noexp] OR "kenya"[MeSH Terms:noexp] OR "korea"[MeSH Terms:noexp] OR "kosovo"[MeSH Terms:noexp] OR "kyrgyzstan"[MeSH Terms:noexp] OR "laos"[MeSH Terms:noexp] OR "latvia"[MeSH Terms:noexp] OR "lebanon"[MeSH Terms:noexp] OR "lesotho"[MeSH Terms:noexp] OR "liberia"[MeSH Terms:noexp] OR "libya"[MeSH Terms:noexp] OR "lithuania"[MeSH Terms:noexp] OR "macedonia (republic)"[MeSH Terms:noexp] OR "madagascar"[MeSH Terms:noexp] OR "malaysia"[MeSH Terms:noexp] OR "malawi"[MeSH Terms:noexp] OR "mali"[MeSH Terms:noexp] OR "malta"[MeSH Terms:noexp] OR "mauritania"[MeSH Terms:noexp] OR "mauritius"[MeSH Terms:noexp] OR "mexico"[MeSH Terms:noexp] OR "micronesia"[MeSH Terms:noexp] OR "middle east"[MeSH Terms:noexp] OR "moldova"[MeSH Terms:noexp] OR "mongolia"[MeSH Terms:noexp] OR "montenegro"[MeSH Terms:noexp] OR "morocco"[MeSH Terms:noexp] OR "mozambique"[MeSH Terms:noexp] OR "myanmar"[MeSH Terms:noexp] OR "namibia"[MeSH Terms:noexp] OR "nepal"[MeSH Terms:noexp] OR "netherlands antilles"[MeSH Terms:noexp] OR "new caledonia"[MeSH Terms:noexp] OR "nicaragua"[MeSH Terms:noexp] OR "niger"[MeSH Terms:noexp] OR "nigeria"[MeSH Terms:noexp] OR "oman"[MeSH Terms:noexp] OR "pakistan"[MeSH Terms:noexp] OR "palau"[MeSH Terms:noexp] OR "panama"[MeSH Terms:noexp] OR "papua new guinea"[MeSH Terms:noexp] OR "paraguay"[MeSH Terms:noexp] OR "peru"[MeSH Terms:noexp] OR "philippines"[MeSH Terms:noexp] OR "poland"[MeSH Terms:noexp] OR "portugal"[MeSH Terms:noexp] OR "puerto rico"[MeSH Terms:noexp] OR

"romania"[MeSH Terms:noexp] OR "russia"[MeSH Terms:noexp] OR "Russia (Pre-1917)"[Mesh:noexp] OR "rwanda"[MeSH Terms:noexp] OR "Saint Kitts and Nevis"[Mesh:noexp] OR "saint lucia"[MeSH Terms:noexp] OR "Saint Vincent and the Grenadines"[Mesh:noexp] OR "samoa"[MeSH Terms:noexp] OR "saudi arabia"[MeSH Terms:noexp] OR "senegal"[MeSH Terms:noexp] OR "serbia"[MeSH Terms:noexp] OR "montenegro"[MeSH Terms:noexp] OR "seychelles"[MeSH Terms:noexp] OR "sierra leone"[MeSH Terms:noexp] OR "slovenia"[MeSH Terms:noexp] OR "sri lanka"[MeSH Terms:noexp] OR "somalia"[MeSH Terms:noexp] OR "south africa"[MeSH Terms:noexp] OR "sudan"[MeSH Terms:noexp] OR "suriname"[MeSH Terms:noexp] OR "swaziland"[MeSH Terms:noexp] OR "syria"[MeSH Terms:noexp] OR "tajikistan"[MeSH Terms:noexp] OR "tanzania"[MeSH Terms:noexp] OR "thailand"[MeSH Terms:noexp] OR "togo"[MeSH Terms:noexp] OR "tonga"[MeSH Terms:noexp] OR "Trinidad and Tobago"[Mesh:noexp] OR "tunisia"[MeSH Terms:noexp] OR "turkey"[MeSH Terms:noexp] OR "turkmenistan"[MeSH Terms:noexp] OR "uganda"[MeSH Terms:noexp] OR "ukraine"[MeSH Terms:noexp] OR "uruguay"[MeSH Terms:noexp] OR "ussr"[MeSH Terms:noexp] OR "uzbekistan"[MeSH Terms:noexp] OR "vanuatu"[MeSH Terms:noexp] OR "venezuela"[MeSH Terms:noexp] OR "vietnam"[MeSH Terms:noexp] OR "yemen"[MeSH Terms:noexp] OR "yugoslavia"[MeSH Terms:noexp] OR "zambia"[MeSH Terms:noexp] OR "zimbabwe"[MeSH Terms:noexp])) AND ("2008/01/01"[PDAT] : "2018/12/31"[PDAT])

Article Inclusion Criteria

The criteria for inclusion into the series of systematic reviews were:

(i) publications in English: Although inclusion of only studies published in English holds potential bias as it is possible that studies in other languages may have met the inclusion criteria,²¹ this was done due to the limited language proficiency of the review team.

(ii) publication dates ranging between 2008 and 2018: This series of reviews follows on from a prior review done by Agrawal et al. (2015) on the feasibility and effectiveness of digital health including articles published between 2000- 2013. This review will include research published between 2008-2018.

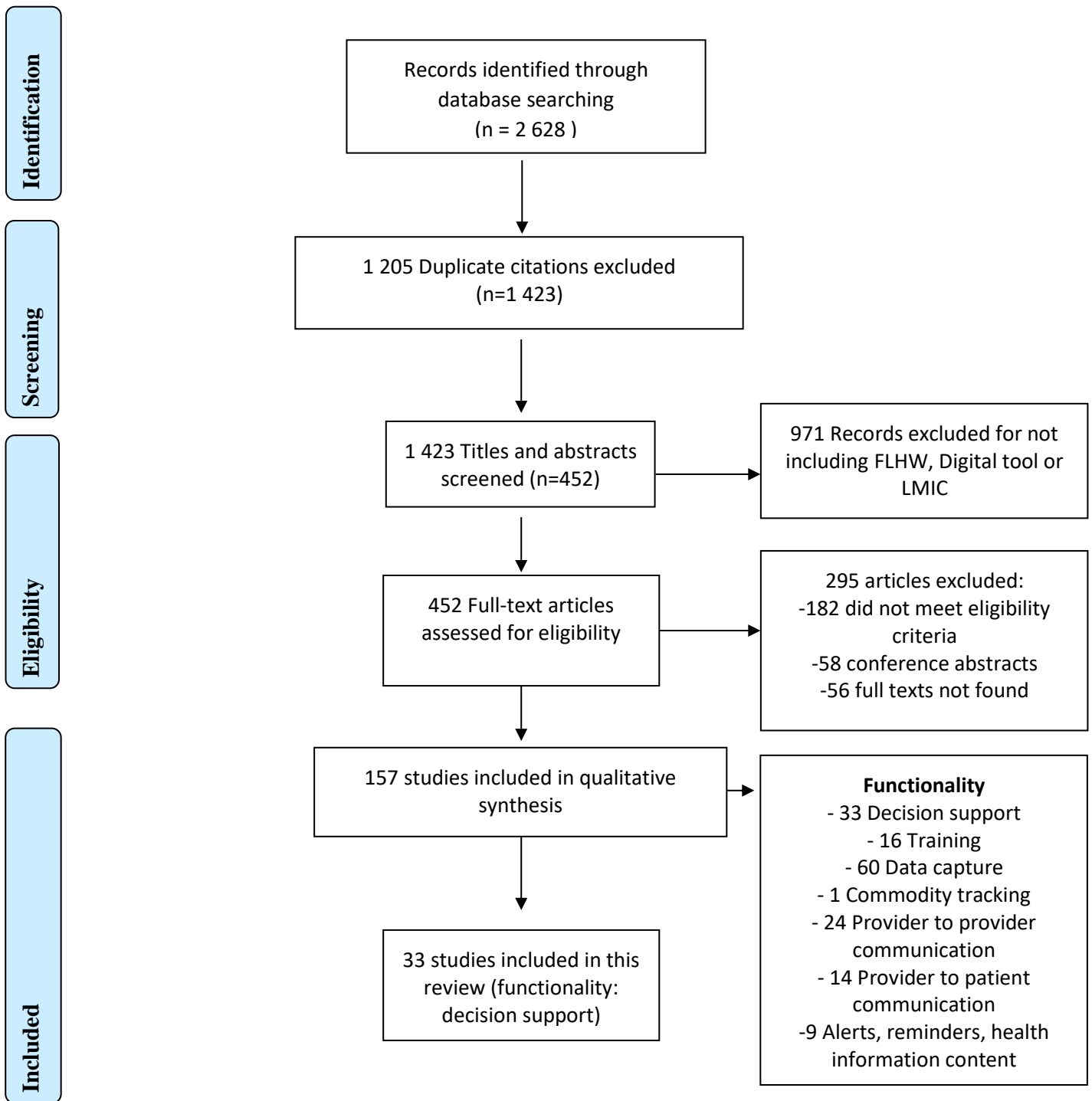
(iii) studies that reported on FLHWs: Frontline health workers are the individuals who provide needed services directly to the population, particularly in rural/ developing areas where there is a shortage of trained physicians. FLHWs include all types of health workers including nurses, midwives and community health workers/volunteers.¹²

(iv) Studies based in low and middle-income countries (LMICs): Countries classified as low-middle income by the World Bank Group. Classifications are made based on geographic region and Gross National Income (GNI).²²

Article Selection

As part of the series of systematic reviews 33 decision support articles were identified by four reviewers. This was done by importing all relevant study references to a computer programme Covidence,²³ from which reviewers were able to co-screen the titles and abstracts of the 1 423 studies identified through the database search. Of these 1 432 articles 971 were then excluded for not including FLHW, digital tool or LMIC. The remaining 452 articles were then co- screened and recorded in a log on Microsoft Excel. Of these articles 295 were excluded (182 for not meeting the eligibility criteria, 57 as they were conference abstracts and 56 as no full texts were found). Remaining were 156 (16 Training tools, 33 Decision support, 60 Data capture, 1 Commodity Tracking, 23 Provider to provider communication, 14 Provider to patient communication and 9 Alerts, reminders, health information content) studies which could be included for qualitative synthesis of the series of systematic reviews.

Figure 1: Literature search strategy - PRISMA diagram ²⁴



Data extraction

During full text screening all the included studies were grouped according to their primary digital health function. For this review only the 33 articles that focused on decision support will be used. Data from the articles to be reviewed will be populated into the data extraction tables (contained in the appendix) which include the following:

Table 1: Intervention Characteristics

1. First author last name
2. Year
3. Title
4. Mobile device
5. Geographic area of implementation of the program
6. Stage of maturity of digital health tool

Table 2: Health Service, Disease and Practice areas

1. First author last name

Health services:

2. Antenatal care
3. Intrapartum care
4. Postnatal care
5. Immunizations
6. Family planning
7. Safe abortion
8. Adolescent health
9. Growth monitoring
10. Water and sanitation
11. Other: Specify

Disease and Practice Areas:

12. Malaria prevention/ treatment
13. TB
14. HIV/ STI
15. Pneumonia
16. Diarrhoea
17. Infant feeding
18. Essential new-born care
19. Other specify

Table 3: Summary of evidence reported

1. First author last name
2. Processes/ Outputs:

3. Outcomes: Beneficiary engagement
4. Outcomes: Provider engagement
5. Impact: Health effects Main conclusion

Data Synthesis

In this review, studies were not excluded based on the type of study design (ie. the studies that were included could be qualitative, quantitative or mixed-method studies), for this reason a meta-analysis will not be possible for this review as not all studies will include quantitative data, the synthesis method used for the purpose of this review will therefore be narrative. Studies will be carefully reviewed, and key information identified, will be used to populate the extraction tables. The findings will then be analysed to identify trends in the data such as cadre of health worker engaged in the intervention, country of implementation and mobile device used. Studies will be appraised by looking at whether evidence exists to support their benefit in terms of processes/output, outcomes (provider and beneficiary engagement) and impact. From the data in the extraction tables findings will be further summarised into sections.

Timeline

This systematic review will begin in November 2018. As part of a larger study, articles have already been identified and data extracted so it is expected that the synthesis process should not take too long.

Part A: Protocol	Subject formulation	
	First draft Sub deadlines: Intro & Background Justification of review. Methodology Inc.	February 5 th 2019
	Edits	March 20 th 2019
Part B: Literature review	Complete scoping review & refining search strategy	April 8 th 2018
	Systemic literature review	April 30 th 2018
Part C: Journal article	Data Extraction	November 30 th 2018
	Synthesis	May 10 th 2019
	Draft	May 30 ^h 2019
	Edits	June 10 th 2019
	Journal article first draft	June 15 th 2019
	Intention to submit	June 30 th 2019
	Final edition	July 25 th 2019
	Submission	August 1 st 2019
	Dissemination	August 30 th 2019

Study Limitations

It is anticipated that the most significant limitation of this review will be that there will be a single reviewer due to resource constraints. To moderate potential bias 10% of the articles will be reviewed by a second reviewer and the before mentioned clear-cut inclusion and exclusion criteria will be used. Another limitation will be the potential for publication bias as this review will not include grey literature due to time constraints. Finally, the inclusion of only studies published in English holds potential bias as it is possible that studies in other languages may have met the inclusion criteria.²⁵

Ethical considerations

No primary research will be conducted in this review, therefore, there is no need for ethical considerations/approval.

Dissemination

This review fulfils the mini-dissertation component of a master's in public health (MPH) degree and will be published in thesis format in the database of the University of Cape Town. As per MPH requirements, a publishable manuscript will also be submitted to relevant journals in order to disseminate the findings.

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Appendix A: Data extraction template 1

First author last name	Year	Title	Mobile device	Geographic area of implementation of the program	Stage of maturity of digital health tool

Appendix B: Data extraction template 2

	Health workers engaged by the program			Beneficiaries engaged by the program		Evaluation Design	Evaluation Methods
First author last name	Name(s) of FLHW cadre	Level of health system of health worker base : 1- Community; 2-Health post; 3. Primary Health Center; 4. Secondary/ tertiary hospital; 5. Other specify	Total health workers using digital tool	Type	Total number of beneficiaries (based on health workers involved)	1. Qualitative, 2. Case study 3.RCT 4. Quasi- 5. Cohort 6. Cross-sectional 7. case-control 8. OTHER Specify	

Appendix C: Data extraction template 3

First author last name	Health Service										Disease and Practice Areas							
	Antenatal care	Intrapartum care	Postnatal care	Immunizations	Family planning	Safe abortion	Adolescent health	Growth monitoring	Water and sanitation	Other: Specify	Malaria prevention/treatment	TB	HIV/STI	Pneumonia	Diarrhoea	Infant feeding	Essential new-born care	Other: Specify

Appendix D: Data extraction template 4

First author last name	Processes/ Outputs:	Outcomes: Beneficiary engagement	Outcomes: Provider engagement	Impact: Health effects	Main conclusion
	1-Beneficiary perceptions of the digital health intervention assessed 2- Provider perceptions of the digital health intervention assessed 3- Technology performance assessed, including message/ call delivery, etc. 4- Other processes assessed: specify	1-Exposure/ engagement with the digital health solution assessed 2- Change in attitudes, intentions described 3- Change in knowledge described 4- Change in practice (preventive, promotive, curative) described	1-Exposure/ engagement with the digital health solution assessed 2-Change in attitudes, intentions described 3- Change in knowledge described 4- Change in practice / service delivery (preventive, promotive, curative) described 5- Available evidence on efficiency gains in service delivery described	1-Describe available evidence linking the digital tool to changes in health outcomes, including infections averted, lives saved 2- Changes in the quality of care described 3- Value for money of the digital health solution as compared to alternatives described	In 1-2 sentences, describe the high-level take-home lesson that was learned

Part B: Literature review

Introduction

Mobile phone penetration rates have increased dramatically worldwide, including in low-middle income countries (LMICs). In January 2018, the Global Digital reports from We Are Social and Hootsuite, two social media management platforms, showed that of the 7.593 billion people in the world 5.135 billion were mobile phone users, that is 68% of the world's population.²⁶ Furthermore these reports revealed that although LMICs have previously had the lowest rates of internet penetration, they are now seeing the fastest growth in internet adoption. This is confirmed by a second source stating the number of internet users in Africa to have increased by more than 20 percent between 2017 and 2018.²⁷

Due to the broad reach of mobile technologies, they have become a significant resource for health service delivery and public health.²⁸ Mobile technology is believed to have the potential to transform health services and the ways in which individuals interact with these services.²⁹ This has been consistently demonstrated by research that has shown mHealth to improve the quality and coverage of care offered as well as increase provider and beneficiaries access to information, services and skills.³⁰

In many LMICs, there are huge shortages of trained physicians this is mainly due to an increase in chronic diseases and conflict and migration/concentration of health care professionals in urban areas.³¹ In these countries frontline health workers (FLHWs) are heavily relied upon and provide the bulk of health care services.¹ However, despite the essential role that they play, FLHWs are often neglected, remain poorly equipped and receive insufficient training- compromising their abilities and the chance of improving health outcomes.^{1,2} In order to solve this problem governments and private organizations have, for many years, been implementing various mHealth projects.

These digital health projects rely on digital tools with a variety of functions including including: education, awareness, data collection, tracking and monitoring, communication, training and decision support.

The systematic review conducted for this dissertation will look specifically at interventions using decision support digital tools in LMICs. A comprehensive literature search has revealed that there is a limited number of systematic reviews that evaluate decision support digital health interventions particularly in LMICs. I will now carefully examine the findings of the most significant of these reviews to determine if any gaps exist in the literature.

Key Concepts

There are a few key concepts that require clarification to understand the content covered in this review. The first of which is:

Front line health workers (FLHWs): Frontline health workers are the individuals who provide required services directly to the population, particularly in LMICs where there is a shortage of trained physicians and nurses. FLHWs include all types of health workers including community health workers, traditional birth attendants, lay workers, village health workers, midwives, health auxiliary workers, peer health workers, medical auxiliary workers, health providers, lay advisors, lay counsellors, lady health workers and lay educators.¹²

Low-middle income countries (LMICs): LMICs are countries that are classified, based on their geographic region and Gross National Income (GNI), as low-middle income ²² by the World Bank Group, the worlds largest development bank.

Mobile health (mHealth): mHealth has been defined as medical and/or public health practice that is supported by mobile devices. This includes mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices.³²

Decision support tools: step-by-step guidelines for FLHWs to assess a patient's condition and/or inform treatment decisions.¹⁸

Clinical decision support system (CDSS): Clinical Decision Support Systems (CDSS) are computer applications designed to aid physicians in making diagnostic and therapeutic decisions. They provide physicians or patients with computer-generated clinical knowledge and patient related information, intelligently filtered or presented at appropriated times, to enhance patient care.³³

Decision support interventions

Study aims/focus

Here below I have analysed six of the most significant reviews on decision support. The major aims of the here studied reviews varied in three of the studies and were similar in the remaining three. One of the reviews with a unique aim was the Martínez-Pérez B, 2014 review - the aim of this review was to summarize current decision support systems available in literature and commercial stores in order to draw conclusions and make recommendations.³⁴ The Dwivedi R, 2005 review also had a unique aim as it sought to identify key challenges which prevent the wide spread adoption of decision support interventions.³⁵ The next three reviews were similar in that they all looked specifically at clinical decision support tools – with the Bright TJ, 2012 review aiming to determine the effect of such tools on clinical outcomes, health care process, workload and efficiency³⁶ and the Kawamoto K, 2005 and Van de Velde S, 2018 reviews similarly aiming to identify the features of the interventions that were critical for improving clinical practice outcomes.^{37,38} The Ibukun-Oluwa O, 2017 review differed in that it focused on interventions on one continent - Africa. This review aimed to find and summarize evidence on the use of digital health tools for point of care decision support by health care workers in Africa.³⁹

Search strategy

While the authors of all six reviews agree that there is a need for a greater body of research into decision support tools, there are also important differences across these papers. These begin with variations in the search strategy and selection criteria.

The Martínez-Pérez B, 2014 review searched four databases (Scopus, IEEE Xplore, Web of Knowledge and PubMed) and Google Play and the App store to identify 92 relevant papers and 192 commercial APPS. The search strategy used was quite narrow making use of only three key words; “mobile, clinical and decision”. Such a narrow search strategy could be seen as limitation as it is possible that the use of synonyms and other relevant key words would have resulted in a far greater literature find.³⁴

In contrast the Dwivedi R, 2005 review searched a far greater number of databases (Business Source, Complete, CINAHL, Cochrane library, MEDLINE, PsycINFO, PubMed, Science Direct and Web of Science) using a broader assortment of key words (m-health, mhealth, mobile health, decision support, decision support system, DSS, feedback, reminder, expert system, evidence based medicine, evidence-based medicine) to identify its 29 selected articles.³⁵ The use of a broader range of search terms makes this study far less vulnerable to bias.

The Bright TJ, 2012 review, similarly to the Martínez-Pérez B, 2014 review, searched only a few databases (MEDLINE, CINAHL, PsycINFO, and Web of Science). The authors also did not state the key words used in this search- risking bias in their findings. However, a possible strength of this review is that it identified and reviewed a far greater number of studies than any of the other 5 reviews (n=148).³⁶

Uniquely, the Kawamoto K, 2005 review did not just search databases (Medline, CINAHL, and the Cochrane) but also hand searched reference lists. A comprehensive list of key words was used to search databases (decision support systems, clinical; decision making, computer-assisted; reminder systems; feedback; guideline adherence; medical informatics; communication; physician's practice patterns; reminders; feedbacks; decision supports; and expert system.) to help identify the 70 articles used in this review.³⁷

Like the previous mentioned review, the Van de Velde S, 2018 review also searched both databases and hand searched reference lists (Central, Medline, Embase, and CINAHL). Important to note – this study also made no mention of the key words used in its search - risking bias. This study identified 66 articles through its search strategy, however, without knowledge on the key words used it is difficult to discern if this is a reliable find.³⁸

The Ibukun-Oluwa O, 2017 review searched four databases (PubMed, CINAHL, Web of Science Core Collection, and Cochrane) and like two of the other reviews it took into consideration grey literature by searching a grey literature electronic database called K4Health. The key words used in this search strategy were; mobile health, decision-making, quality of care, health care workers and Africa. This strategy identified 22 articles.³⁹

Selection criteria and data extraction

Similarly, to the search strategy the selection criteria and data extraction methods for these six reviews also varied.

Analysing the methodology of the Martínez-Pérez B, 2014 review, a red flag is immediately raised as no mention of the data extraction technique is mentioned. This is concerning as without it a reader cannot ensure the reliability of the data-extraction process.⁴⁰ Despite this weakness, this review is strengthened by the use of more than one reviewer (a strategy that limits bias) and the use of clear cut inclusion and exclusion criteria. This review only included studies published in English between the years 2007-2014 that were about one or more mobile clinical decision support application.³⁴ Clearly defined inclusion and exclusion criteria such as these are crucial as they allow articles to be selected in a consistent, reliable, uniform and objective manner.⁴¹

The Dwivedi R, 2005 review analysed is perhaps the review with the weakest methodology as it omits two important sections; the data extraction methods used and the number of reviewers who participated in the study. The omission of this important information negatively effects the reliability of the review. In contrast a possible strength of this review's methods section was the use of clearly defined inclusion and exclusion criteria. Studies included in this review had to be published in English between 2005-2016.³⁵

The remaining Bright TJ, 2012, Kawamoto K, 2005, Van de Velde S, 2018 and Ibukun-Oluwa O, 2017 reviews were more thorough in the reporting of their methodology- with clear descriptions of their data extraction, study selection methods and the number of reviewers used. The Bright TJ, 2012 and Kawamoto K, 2005 reviews were almost identical in methodology as both reviews clearly state that data was extracted by one reviewer and then confirmed by another to limit potential bias/error. An additional strength of these two reviews was the use of specific and clearly defined inclusion and exclusion criteria; with only randomized control trials published in English on clinical decision support tools being included. Furthermore, these reviews were made more reliable by including their data extraction methodology.^{36,37}

The Van de Velde S, 2018 review analysed in this literature was compiled by four reviewers who worked in pairs to select and screen studies and then to exclude studies that did not meet the inclusion criteria. Studies selected for this review had to be randomised controlled trials, non-randomised trials or control trials published in English. Similarly to the Bright TJ, 2012 and Kawamoto K, 2005 reviews this review included a comprehensive description of the data extraction methods used.³⁸

The Ibukun-Oluwa O, 2017 review had broader inclusion criteria; not putting a limit on study design or publication date. Other strengths of this review were the use of more than one reviewer and inclusion of extraction methods. The methods in this review were considerably more reliable than the other reviews analysed.³⁹

Results

Over all these reviews reported on several different findings and outcomes. The Martínez-Pérez B, 2014 review summarized current decision support systems that are available and concluded that the number of digital health applications with clinical decision support functions and their inclusion in clinical practices has increased greatly. Another key finding of this review was that the most common medical fields of these apps were general medicine (21%), drug prescribing (7%), emergencies services tasks (5%) and paediatrics (5%).³⁴

The Dwivedi R, 2005 review which sought to identify key challenges which prevent the wide spread adoption of decision support interventions found mixed results in terms of the potential of decision support tools to empower healthcare providers and improve their relationships with patients. Some of the negative findings included usability issues, issues with acceptability and utility, lack of functionalities and technical issues. This review concluded that the use of digital health decision support tools in a healthcare setting poses many challenges, which must be addressed before their widespread adoption and use.³⁵

The Bright TJ, 2012 review was the first of the three reviews that looked specifically at clinical decision support tools. This review aimed to determine the effect of such tools on clinical outcomes, health care process, workload and efficiency. Sixteen of the studies included in the review assessed morbidity outcomes, twenty-five assessed health care processes and seven assessed workload and efficiency. A Meta-analysis of these studies suggested that clinical decision support systems improved morbidity outcomes (relative risk, 0.88 [95% CI, 0.80 to 0.96]) and improved the rates of ordering/completing recommended preventive care services (OR, 1.42 [CI, 1.27 to 1.58]). However, evidence on the effect of CDSSs on user workload and efficiency outcomes was insufficient. Using a standardized approach the authors evaluated the overall strength of evidence for each outcome as high, moderate, low, or insufficient – in doing so they rated the evidence of improved clinical outcomes as moderate, the evidence of improved health care processes as high and the evidence of improved workload and efficiency outcomes as low.³⁶

The Kawamoto K, 2005 and Van de Velde S, 2018 reviews focused specifically on clinical decision support systems aimed to identify the features of the interventions that were critical for improving clinical practice outcomes. One of these reviews identified four features that significantly improved clinical practice: automatic provision of decision support as part of clinician workflow, provision of recommendations rather than just assessment, provision of decision support at the time and location of decision making and computer-based decision support.³⁷ Of these features identified the second review had only one in common: automatic provision of decision support as part of clinician workflow. Other features that the Van de Velde S, 2018 review identified to improve clinical practice included: displaying clinical decision support on a screen rather than on paper. Providing clinical decision support to both the provider and the patient rather than just the provider and making clinical decision support more patient specific.^{37,38,38}

The Ibukun-Oluwa O, 2017 review analysed aimed to find and summarize evidence on the use of digital health tools for point of care decision support by health care workers in Africa. This review found significant evidence on the use of mobile technology as a clinical decision support system within sub-Saharan Africa. Key findings of this review were that mCDSSs were found to have been used in 11 interventions in sub-Saharan Africa, with predominant focus on lower cadre workers, maternal health and at primary health care level in rural settlements. With few exceptions, most of these interventions were usability or feasibility pilot studies using small sample sizes. These studies reported that even though health workers were generally enthusiastic about mCDSS, they had concerns about its effects on increased workload and altered workflow.³⁹

Limitations/Gaps identified in literature

All but one of these reviews tended to focus on studies conducted in developed settings rather than interventions conducted in LMICs where there is a critical shortage of trained physicians and the need for supporting FLHWs is greatest. The one review that did focus on LMICs only looked at countries in sub-Saharan Africa, omitting other countries such as India where many digital health interventions have been implemented.³⁹

A second common limitation in these reviews was vulnerability to publication bias. Publication bias can be defined as a tendency of authors to preferentially publish studies that have significant results.⁴² Firstly, because several of these studies did not include grey literature³⁴⁻³⁶ and secondly because, although many of these studies used a large variety of databases, only studies published

in English were included.³⁴⁻³⁹ This has the potential to introduce bias as it is possible that studies in other languages/grey literature may have met the inclusion criteria.

Another common limitation was that these studies had a very narrow scope with five out of the six reviews looking solely at studies using clinical decision support tools and only one of the reviews looking at mobile decision support tools used outside of a clinic setting.³⁴ This is a notable shortcoming as in today's context (where there is a shortage of trained physicians in many LMICs and a substantial amount of health care work is carried out by FLHWs outside of the clinic setting) – it is important for us to be looking at other kinds of decision support. Furthermore, half of these reviews only included randomized control trials omitting any other studies that may have had a different study design.¹⁶⁻¹⁸

Conclusion

While studies have consistently demonstrated digital health tools to improve the quality and coverage of care offered as well as increase provider and beneficiaries access to information, services and skills, there are a limited number of reviews summarizing the findings and drawing conclusions from all these different studies. In this literature review I analysed six reviews, four of which differed greatly in their focus, methodology and findings and two of which had many similarities. Overall these reviews did demonstrate positive findings which highlight the potential of digital health decision support tools. However, several gaps in the available literature became evident: no existing review looks specifically at LMICs, most of the existing reviews are vulnerable to publication bias, reviews predominantly focus on decision support tools used in a clinical setting and current reviews tend to have a very narrow scope. The purpose of this systematic review (Part C) will be to address these gaps in literature.

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Part C: Journal article

This article has been prepared for submission to the Journal of Digital Health. Submission Guidelines can be found online at (<https://uk.sagepub.com/en-gb/afr/journal/digital-health#submission-guidelines>) and in the Supplementary material (Part D).

Front Sheet

(as requested by the journal)

1. Article type: Systematic Review

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3. A systematic review of digital tools used for decision support by frontline health workers (FLHWs) in low-and middle-income countries (LMICs)

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5. Abstract (below)

Decision support digital tools, including mobile phones, used by frontline health workers (FLHWs) in low-and middle-income countries (LMICs): A systematic review

Abstract

Objectives: The aim of this review was to systematically examine the literature on digital health tools that are used for decision support in LMIC and describe what we can learn from studies that have used these tools.

Methods: As part of a larger parent study several databases were searched to find articles in the following domains: training tools, decision support, data capture, commodity tracking, provider to provider communication, provider to patient communication and alerts, reminders, health information content. These domains were selected based on the World Health Organisation (WHO) framework for classifying digital health interventions. Content from all seven of these domains informed a series of reviews however this review focuses on decision support digital health tools.

Results: The majority of tools used in the selected studies were in either the pilot or prototype phases. Although decision support was the primary function of all these studies, there was considerable variation in the number of digital health functions of each tool with most studies reporting decision support and data capture as their primary and secondary functions respectively.

Conclusion: All the studies found their intervention to have beneficial effects on one or more of the following outcomes: beneficiary engagement, provider engagement, health effects and process/outputs. These findings show great potential for the use of decision support digital health tools as a means of improving the outcomes of health systems through; reducing the work load of FLHWs, reducing the costs of health care, improving the efficiency of service delivery and/or improving the overall quality of care.

Key words: Frontline line health workers , low-and middle-income countries, community health workers, digital health tools, decision support

Introduction

People in low-and middle-income countries (LMICs) have less access to healthcare services than those in high income countries.¹⁰ In LMICs frontline health workers (FLHWs) are often the first and only point of call for people in need of these services.¹ According to the Bureau of Labour Statistics Occupational Classification system, a standard used by federal agencies to categorize working people into occupational groups,⁴³ there are 26 different types of FLHWs including; community health workers, traditional birth attendants, lay workers, village health workers, midwives, health auxiliary workers, peer health workers, medical auxiliary workers, health providers, lay advisors, lay counsellors, lady health workers and lay educators. Common roles of these FLHWs include administrative support, preventive services, health education, rehabilitative care, and chronic disease management.¹³

FLHWs form a major part of the health system in many developing countries and are key to reducing preventable deaths and achieving universal health coverage.² With a predicted shortage of between 42,600 and 121,300 physicians in the healthcare industry by the end of 2020, the work of FLHWs may become even more crucial.¹¹ However, despite the essential role that they play in providing care and supporting health systems in LMICS, FLHWs are often neglected and remain poorly equipped; receive insufficient training, little supervision, low pay and few opportunities for personal development.^{1,2} As a result, their abilities are compromised and opportunities to improve health outcomes are lost.¹

In January 2018 statistics showed that of the 7.593 billion people in the world 5.135 billion were mobile phone users, that is 68% of the world's population.²⁷ This shows how mobile phone penetration rates are exploding worldwide, even in LMICs.¹⁴ Governments and private organisations have, for many years, been taking advantage of this digital trend by implementing various mHealth projects aimed at improving the abilities of FLHWs and strengthening health systems.¹ The mHealth tools developed have a variety of functions including: education, awareness, data collection, tracking and monitoring, communication, training and decision support.¹⁷ This systematic review will focus on mHealth tools with decision support functions. Decision support functions include step-by-step guidelines for FLHWs to assess a patient's conditions and/or inform treatment decisions.¹⁸

The need for supportive interventions is highest in LMICs where there the shortage of trained physicians and nurses is greatest. Although a number of tools to support the work of FLHWs

exist, there is no systematic review that describes and critically appraises these tools/ interventions specifically in LMIC settings. The purpose of this review is to meet this need.

Methods

Search strategy

In August 2018 a search began to find studies published in English in LMICs that used mHealth tools with the following functions; training, decision support, data capture, commodity tracking, provider to provider communication, provider to patient communication and alerts, reminders, health information content. Several databases were included, as is recommended, to maximise the number of relevant studies found and minimise selection bias.¹⁹ The databases searched included: PubMed, Embase, Scopus, CINAHL, Global Health Ovid, Cochrane and Global Index Medicus. Grey Literature and studies not published in English were not included due to limited resources. Two of the search terms selected (FLHW and mHealth) were those used by Agarwal et al. (2015) in their systematic review of digital health tools for FLHWs.²⁰ The third search term selected was LMICs as defined and listed by the World Bank. Articles found in all seven of these domains informed other papers in this series of reviews. My role in this series of reviews was to extract data from studies in the decision support domain. As a result of this my interest on the topic grew and I decided to continue my research on the topic in the form of my mini dissertation.

See additional file 1 in appendices for more details on search strategy and key words used.

Inclusion and Exclusion Criteria

Studies were included in this systematic review if they met the criteria identified below (Table 1)

Table 1: Inclusion and Exclusion Criteria

	Inclusion	Exclusion
<i>Date of publication</i>	Between 2008-2018	Before 2008 After 2018
<i>Country</i>	Low and middle-income countries	High income countries
<i>Language</i>	English	Other languages
<i>Publication status</i>	Published studies	Grey literature

Defined FLHW	Frontline worker, health worker, community health worker, traditional birth attendants, lay worker, village health worker, midwife, health auxiliary, peer health worker, medical auxiliary, health provider, lay advisor, lay counsellor, lady health worker and lay educator	Undefined
Defined mHealth	Mobile, phone, cell phones, information and communication technology, cellular phone, mobile device, SMS, text message, interactive voice response (IVR)	Undefined

For the purposes of this review, all studies that did not fall into the publication date range, were not in LMICs, were not published in English or did not include an mHealth / digital tool used for the purposes of training FLHWs were excluded.

Rational for inclusion:

(i) publications in English: Although inclusion of only studies published in English holds potential bias as it is possible that studies in other languages may have met the inclusion criteria,²¹ this was done due to the limited language proficiency of the review team.

(ii) publication dates ranging between 2008 and 2018: This series of reviews follows on from a prior review done by Agrawal et al. (2015) on the feasibility and effectiveness of digital health including articles published between 2000- 2013. This review will include research published between 2008-2018.

(iii) studies that reported on FLHWs: Frontline health workers are the individuals who provide needed services directly to the population, particularly in rural/ developing areas where there is a shortage of trained physicians. FLHWs include all types of health workers including nurses, midwives and community health workers/volunteers.¹²

(iv) Studies based in low and middle-income countries (LMICs): Countries classified as low-middle income by the World Bank Group. Classifications are made based on geographic region and Gross National Income (GNI).²²

Article Selection

Data extraction and synthesis

During full text screening all the included studies were grouped according to their primary digital health function. For this review only the 33 articles that focused on decision support were used.

Data from the reviewed articles were used to populate the data extraction tables (contained in the appendix). A second reviewer verified findings by reviewing 10% of studies. Findings were then analysed to identify trends in the data such as cadre of health worker engaged in the intervention, country of implementation, mobile device used. From the data in the extraction tables graphs were made and findings were further summarised into sections.

In this review, studies were not excluded based on the type of study design (ie. the studies that were included could be qualitative, quantitative or mixed-method studies), for this reason a meta-analysis will not be possible for this review as not all studies will include quantitative data, the synthesis method used for the purpose of this review will therefore be narrative.

Results

A total of 2 628 abstracts were found in the database searches, 1205 of which were duplicates. Following this 1423 titles and abstracts were co-screened, of which 971 records were then excluded for not including FLHW, digital tool or LMIC. The remaining 452 articles were then co-screened to assess their eligibility, of these 295 were excluded (182 for not meeting the eligibility criteria, 57 as they were conference abstracts and 56 as no full texts were found). Remaining were 157 (17 Training tools, 33 Decision support, 60 Data capture, 1 Commodity Tracking, 23 Provider to provider communication, 14 Provider to patient communication and 9 Alerts, reminders, health information content) studies which could be included for qualitative synthesis of the original paper (See Figure 1: Prisma Flow diagram which details the search and article selection process (below)). For this review we will be focusing on the 33 studies in the decision support domain. These studies are detailed in Tables 2, 3, and 4

Figure 1: Literature search strategy - PRISMA diagram ²⁴

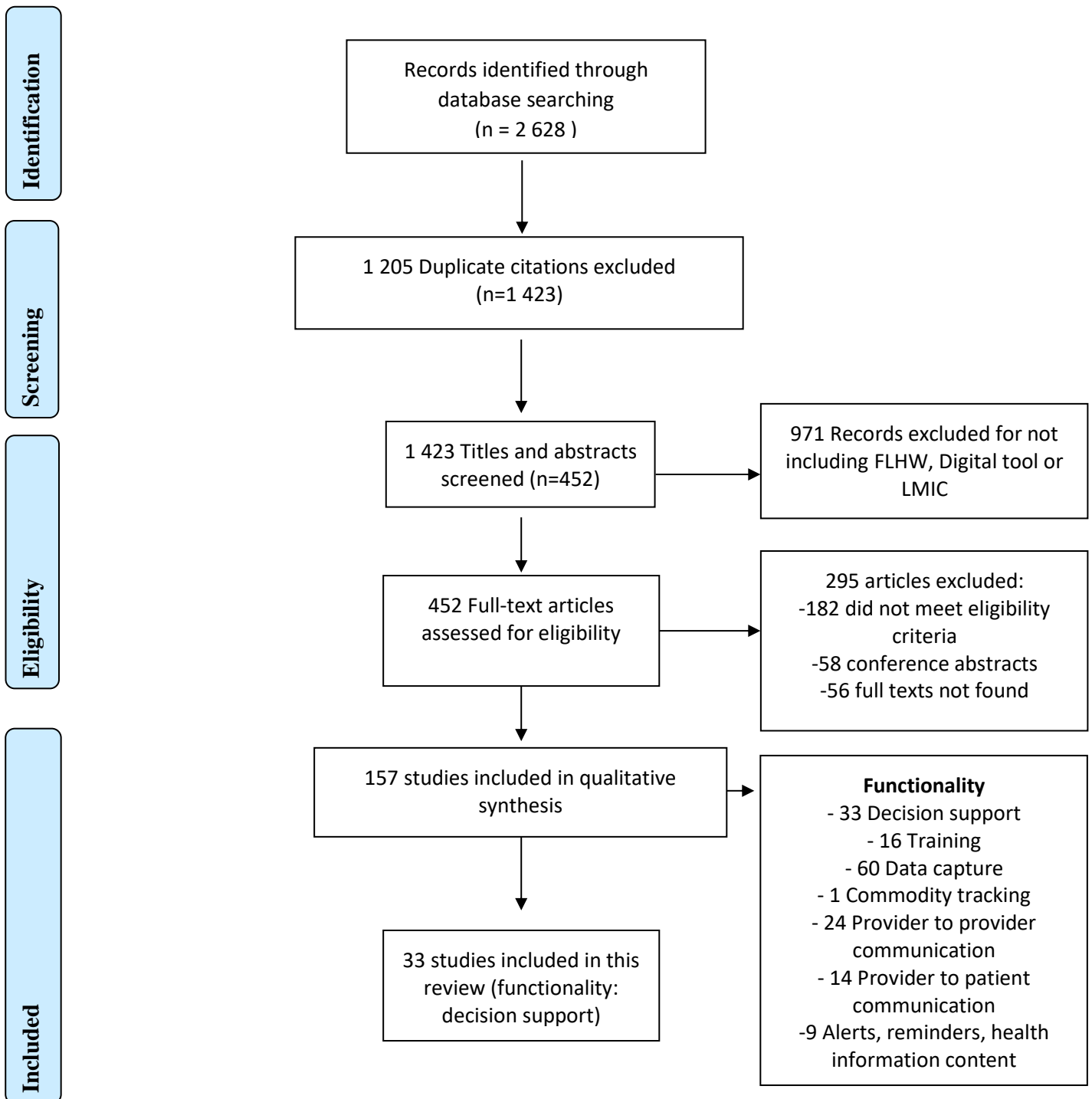


Table 2: Characteristics of included studies

	First author last name	Year	Title	Mobile device	Geographic area of implementation of the program	Stage of maturity of digital health tool
1	Amoakoh	2017	The effect of a clinical decision-making mHealth support system on maternal and neonatal mortality and morbidity in Ghana: study protocol for a cluster randomized controlled trial	Mobile phone (type not specified)	Ghana	NA - it's a protocol study
2	Bakibinga	2017	The role of a decision-support smartphone application in enhancing community health volunteers' effectiveness to improve maternal and new-born outcomes in Nairobi, Kenya: quasi-experimental research protocol	Smart Phone	Kenya	Pilot
3	Balakrishnan	2016	Continuum of Care Services for Maternal and Child Health using mobile technology – a health system strengthening strategy in low- and middle-income countries	Mobile phone (type not specified)	India	Scale up
4	Biemba	2017	A Mobile-Based Community Health Management Information System for Community Health Workers and Their Supervisors in 2 Districts of Zambia	Feature Phone	Zambia	Pilot
5	Black	2009	Mobile Solutions for Front-Line Health Workers in Developing Countries	Health workers own phone (types will vary)	Mozambique and Uganda	Prototype
6	Braun	2016	An evaluation of a family planning mobile job aid for community health workers in Tanzania	Brick Phone	Tanzania	Pilot
7	Coetzee	2017	Community health workers' experiences of using video teaching tools during home visits—A pilot study	Tablets	South Africa	Pilot
8	Ettinger	2016	Building quality mHealth for low resource settings	Smart Phone	South Africa	Prototype
9	Florez-Arango	2011	Performance factors of mobile rich media job aids for community health workers	Mobile phone (type not specified)	Colombia	Pilot
10	Hope	2012	The midwife's assistant: Designing integrated learning tools to scaffold ultrasound practice	Netbook	Uganda	Pre-Prototype
11	Iyengar	2013	Decreasing workload among community health workers using interactive, structured, rich-media guidelines on smartphones	Smart Phone	Colombia	Pilot
12	Keyani	2009	Affordable and Accessible Tele-healthcare to Rural areas of Pakistan through Web and Mobile based Technologies	Mobile phone (type not specified)	Pakistan	Pre-Prototype
13	Long	2017	Design and Implementation of a Community Health Worker HIV Treatment and Prevention Intervention in an HIV Hot Spot Fishing Community in Rakai, Uganda	Smart Phone	Uganda	Pilot
14	Maleka	2016	Developmental Screening—Evaluation of an m-Health Version of the Parents Evaluation Developmental Status Tools	Smart Phone	South Africa	Pilot
15	Martinez	2017	Agile Development of a Smartphone App for Perinatal Monitoring in a Resource-Constrained Setting	Smart Phone	Guatemala	Prototype
16	Maulik	2015	Systematic Medical Appraisal, Referral and Treatment (SMART) Mental Health Programme for providing innovative mental health care in rural communities in India	Mobile phone (type not specified)	India	Prototype
17	McNabb	2015	Assessment of the Quality of Antenatal Care Services Provided by Health Workers Using a Mobile Phone Decision Support Application in Northern Nigeria: A Pre/Post-Intervention study	Brick Phone or a Tablet	Nigeria	Demonstration
18	Megalingam	2013	PULSS: Portable ultrasound scanning system	Mobile phone (type not specified)	India	Prototype
19	Morrison	2013	Mobile Phone Support for Rural Health Workers in Nepal through 'Telemedicine'	NR	Nepal	Pilot
20	Patterson	2018	Diagnosis of epileptic seizures by community health workers using a mobile app: A comparison with physicians and a neurologist	Tablet	India	Scale up
21	Peireis	2016	Systematic medical assessment, referral and treatment for diabetes care in China using lay family health promoters: protocol for the SMART Diabetes cluster randomised controlled trial	Mobile phone (type not specified)	China	NA - it's a protocol study
22	Praveen	2013	A multifaceted strategy using mobile technology to assist rural primary healthcare doctors and frontline health workers in cardiovascular disease risk management: protocol for the SMART Health India cluster randomised controlled trial	Tablets	India	Prototype
23	Praveen	2014	SMART Health India: Development and Field Evaluation of a Mobile Clinical Decision Support System for Cardiovascular Diseases in Rural India	Tablet	India	Prototype
24	Prinja	2017	Impact of m-health application used by community health volunteers on improving utilisation of maternal, new-born and child health care services in a rural area of Uttar Pradesh, India	Feature Phone	India	Pilot
25	Prinja	2016	Impact assessment and cost-effectiveness of m-health application used by community health workers for maternal, new born and child health care services in rural Uttar Pradesh, India: a study protocol	Feature Phone	India	NA - it's a protocol study
26	Qin	2012	Reliability of a Telemedicine System Designed for Rural Kenya	NR	Kenya	Pilot
27	Raghu	2015	Engineering a mobile health tool for resource-poor settings to assess and manage cardiovascular disease risk: SMART health study	Tablet	India	Pilot

28	Ramkumar	2018	Cost and outcome of a community-based paediatric hearing screening programme in rural India with application of tele-audiology for follow-up diagnostic hearing assessment	NR	India	Pilot
29	Soni	2016	High Burden of Unrecognized Atrial Fibrillation in Rural India: An Innovative Community-Based Cross-Sectional Screening Program	Smart Phone	India	Pilot
30	Tian	2015	A Cluster-Randomized, Controlled Trial of a Simplified Multifaceted Management Program for Individuals at High Cardiovascular Risk (SimCard Trial) in Rural Tibet, China, and Haryana, India	Smart Phone	China and India	Demonstration
31	Van Heerden	2017	App-Supported Promotion of Child Growth and Development by Community Health Workers in Kenya: Feasibility and Acceptability Study	Smart Phone	Kenya	Pilot
32	Vélez	2014	A usability study of a mobile health Application for rural Ghanaian midwives	Smart Phone or Tablet	Ghana	Prototype
33	Zurovac	2012	Costs and Cost-Effectiveness of a Mobile Phone Text- Message Reminder Programmes to Improve Health Workers' Adherence to Malaria Guidelines in Kenya	Health workers own phone (types will vary)	Kenya	Demonstration

Table 3: Study designs and reach

First author last name	Name(s) of FLHW cadre	Health workers engaged by the program		Beneficiaries engaged by the program		Evaluation Design	Evaluation Methods
		Level of health system of health worker base : 1- Community; 2-Health post; 3. Primary Health Center; 4. Secondary/ tertiary hospital; 5. Other specify	Total health workers using digital tool	Type	Total number of beneficiaries (based on health workers involved)		
13	Amoakoh	frontline providers of maternal and neonatal health care services	A range of bases	NR	maternal and neonatal participants	NR	3- RCT mixed
27	Bakibinga	Community Health Volunteers	1- Community	NR	The main beneficiaries are pregnant women (over 24 weeks), mothers in the immediate postpartum period and their newborns (up to 28 days old).	NR	4- Quasi- Experimental mixed
22	Balakrishnan	Frontline healthworkers (Accredited Social Health Activists, Anganwadi Workers, Auxilliary Nurse Midwives and Lady Health Supervisors)	1-Community	550	Children and mothers	19,880 pregnancies and 19,888 children were registered and provided the continuum of care services.	4- Quasi experimental Quantitative
28	Biemba	Community health workers and their supervisors	1- Community	40 CHWs and 20 CHW supervisors	All children under 5 years old who presented with suspected malaria, pneumonia, or diarrhea to the CHWs	NR	8- Qualitative Qualitative methods
16	Black	Front Line health workers	NR	NR	NR	NR	NA (it's a paper that presents a model) NA
23	Braun	CHWs	1-Community	25	NR	848 clients	8- Other- Mixed method mixed
2.	Coetzee	CHWs	1	24	Preganant woman and young mothers	NR	1 Qualitative Qualitative methods
14	Ettinger	Community health care workers (CHCW)	1- Community	10	NR	2	1- Qualitative Qualitative methods
11.	Florez-Arango	CHWs	1- Community	50	Human patient simulators in a laboratory setting, not on real patients	1500	3- RCT (A randomized prospective crossover study) mixed
17	Hope	Midwives	1- Primary Health Care	NR	NR	NR	1. Qualitative Qualitative methods
4.	Iyengar	CHWs	Simulation lab in the University of Antioquia	50	Human Patient simulators.	NR	3- RCT Quantitative

15	Keyani	LHWs (Lady Health Workers)	1- Community	NR	People in remote and rural areas of Pakistan	NR	NA (it's a paper that presents a model)	NA
29	Long	CHWs	1- Community	10	Local residence: any persons aged 15 and older years.	771	3-RCT	Quantitative
1.	Maleka	CHWs	3	3	Caregivers (research population)	207	6- Cross sectional	Quantitative
30	Martinez	Lay midwives		21	NR	NR	8- Mixed methods study	mixed
8.	Maulik	ASHAs and doctors	1- Community and 3- Primary Health Centre	NR	NR	NR	8- Mixed methods	mixed
12	McNabb	frontline community health extension workers (CHEWs)	3- Primary Health Centre	152 CHEWs/HCWs and 20 supervisors	ANC clients	266	1. Qualitative	Qualitative methods
18	Megalingam	Community health care workers (CHCW)	1-Community	NA	Pregnant woman	NA	NA (it's a paper that presents a model)	No
6.	Morrison	mid level health workers	2 & 3	24	NR	NR	1- Qualitative	Qualitative methods
7.	Patterson	Nonphysician health workers (NPHWs)	4	13	Individuals with epilepsy or suspected to have epilepsy	101	3- RCT	Quantitative
24	Peireis	Lay family health promoters	1-community	NR	People with T2DM	2000	3-RCT	mixed
19	Praveen	ASHAs and Primary health care providers	1- Community & 3- Primary Health Centre	NR	Adults aged ≥40 years at high cardiovascular disease event risk	Approximately 15,000 people	3- RCT	mixed
20	Praveen	nonphysician health care workers (NPHWs) and primary health center (PHC) physicians.	3- Primary Health Centre	11 NPHWs and 3 PHC Physicians	NA	NA	8-Mixed method study	mixed
5.	Prinja	Accredited social health activists (ASHAs)	1	259	Children, Pregnant woman & New mothers	NR	4- Quasi- Experimental	Quantitative
25	Prinjah	ASHA	1- Community	259	Pregnant woman and mothers	NR	4. Quasi-experimental	Quantitative
3.	Qin	CHWs	1- Community	NR	NR	102	8. Feasibility and acceptability study	Quantitative
32	Ramkumar	Village health workers	1- Community	NR	Children under 5 years of age underwent screening	1335		Quantitative
26	Soni	CHWs	1- Community	NR	NR	354	5- Cohort	Quantitative
21	Tian	CHWs	1- Community	NR	individuals with high cardiovascular risk (aged ≥40 years with self-reported history of coronary heart disease, stroke, diabetes mellitus, and/or measured systolic blood pressure ≥160 mm Hg)	2086	3- RCT	Quantitative
31	Van Heereden	Community Health Volunteers	1-Community	10	Children aged 2-8 years in households in Rarieda.	313	1. Qualitative	Qualitative methods
9.	Vélez	Midwives	3- Primary Health Centre	7	NR	NR	8- descriptive study	mixed
10.	Zurovac	Health workers	2 Health Post	119	Children who visited the health post	NR	8. Secondary analysis	Quantitative

Table 4: Health service, Disease and Practice Area

	First author, last name	Health Service									Disease & practice area							Other specify
		Antenatal care	Intrapartum care	Postnatal care	Immunizations	Family planning	Safe abortion	Adolescent health	Growth monitoring	Water and sanitation	Other: Specify	Malaria prevention / treatment	TB	HIV / STI	Pneumonia	Diarrhoea	Infant feeding	
1	Amoakoh	Yes	Yes	Yes	No	No	No	No	No	No		No	No	No	No	No	No	
2	Bakibinga	Yes	Yes	Yes	No	No	No	No	No	No		No	No	No	No	No	Yes	
3	Balakrishnan	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No		No	No	No	No	Yes	Yes	
4	Biemba	No	No	No	No	No	No	No	No	No		Yes	No	No	Yes	Yes	No	No
5	Black	No	No	No	No	No	No	No	No	No	Respiratory & Pulse rate, gestation age, estimated date of delivery, drug dose, ECG	No	No	No	Yes	No	No	No
6	Braun	No	No	No	No	Yes	No	No	No	No		No	No	No	No	No	No	
7	Coetzee	No	No	No	No	No	No	No	Yes	No		No	No	Yes	No	No	Yes	Alcohol & nutrition
8	Ettinger	No	No	No	No	No	No	No	No	No		No	Yes	No	Yes	No	No	
9	Florez-Arango	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	
10	Hope	Yes	Yes	No	No	No	No	No	No	No		No	No	No	No	No	No	
11	Iyengar	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	Paediatric, adult medical & adult trauma conditions.
12	Keyani	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	
13	Long	No	No	No	No	No	No	No	No	No		No	No	Yes	No	No	No	
14	Maleka	No	No	No	No	No	No	Yes	No	No		No	No	No	No	No	No	
15	Martinez	Yes	Yes	Yes	No	No	No	No	No	No		No	No	No	No	No	No	
16	Maulik	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	Mental health care
17	McNabb	Yes	Yes	Yes	Yes	Yes	No	No	No	No		Yes	No	Yes	No	No	Yes	

18	Megalangam	Yes	No	No	No	No	No	No	Yes	No	Measuring BP, Body temperature, HR	No	No	No	No	No	No	No	
19	Morrison	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	No	
20	Patterson	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	No	Epilepsy
21	Peireis	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	No	Diabetes
22	Praveen	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	No	Cardiovascular disease
23	Praveen	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	No	Cardiovascular disease
24	Prinja	Yes	No	Yes	Yes	No	No	No	No	No		No	No	No	No	No	Yes		
25	Prinjah	Yes	Yes	Yes	Yes	No	No	Yes	No	No		No	No	No	No	No	Yes		
26	Qin	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No		
27	Raghu	No	No	No	No	No	No	No	No	No	Measuring BP, Blood glucose and Cholesterol	No	No	No	No	No	No	No	Cardiovascular disease
28	Ramkumar	No	No	No	No	No	No	No	No	No	Hearing screening	No	No	No	No	No	No		
29	Soni	No	No	No	No	No	No	No	No	No	Screening for atrial fibrillation	No	No	No	No	No	No		
30	Tian	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No	Cardiovascular disease	
31	Van Heerden	No	No	No	No	No	No	No	Yes	No		No	No	No	No	No	No		
32	Vélez	No	No	No	No	No	No	No	No	No		No	No	No	No	No	No		
33	Zurovac	No	No	No	No	No	No	No	No	No		Yes	No	No	No	No	No		

Table 5: Summary of evidence reported

First author last name	Processes/ Outputs:	Outcomes: Beneficiary engagement	Outcomes: Provider engagement	Impact: Health effects
1	1-Beneficiary perceptions of the digital health intervention assessed 2- Provider perceptions of the digital health intervention assessed 3- Technology performance assessed, including message/ call delivery, etc. 4- Other processes assessed: specify	1-Exposure/ engagement with the digital health solution assessed 2- Change in attitudes, intentions described 3- Change in knowledge described 4- Change in practice (preventive, promotive, curative) described	1-Exposure/ engagement with the digital health solution assessed 2-Change in attitudes, intentions described 3- Change in knowledge described 4- Change in practice / service delivery (preventive, promotive, curative) described 5- Available evidence on efficiency gains in service delivery described	1-Describe available evidence linking the digital tool to changes in health outcomes, including infections averted, lives saved 2- Changes in the quality of care described 3- Value for money of the digital health solution as compared to alternatives described
1	-	-	-	-
2	-	-	-	-

3	Balakrishnan	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-Yes, Early initiation of breastfeeding reported to be 14% higher in intervention group compared to control group.	1-No 2-No 3-No 4-No 5-Yes, 50 % of beneficiaries in the intervention group and 29 % of beneficiaries in control group received all three antenatal visits	1-No 2-Yes, Registration of pregnancy, complete 3 antenatal visits, receiving at least 90 iron and folic acid tablets, institutional delivery, early initiation of breastfeeding and post-natal home visits were all higher in the implementation area 3-No
4	Biemba	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
5	Black	-	-	-	-
6	Braun	1-Yes, (98%) were comfortable with CHWs using the mobile phone. (99%) comfortable sharing their personal information. (98%) felt that the mobile job aid was an acceptable tool for FP counselling. 2-Yes, CHWs perceived benefits to service quality, including timelier and more convenient care; better quality of information; increased method choice; & improved privacy, confidentiality & trust with clients. 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-Yes, Many CHWs reported job aid helped them deliver timely care by providing reminders to follow-up with clients and enabling interactions in convenient locations. Also reported providing more in-depth information to their clients.	1-No 2-No 3-No
7	Coetzee	1-No 2-Yes, CHWs deemed the devices and the video content an acceptable and feasible means with which to provide health promotion and education among their clients. 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
8	Ettinger	1-Yes, two community members, who could be prospective patients with Clinical Guide, were interviewed. All were amenable to the idea that a CHCW might use a smartphone to gather information and guide clinical decision-making. 2- Yes, CHCW reported positively about their initial experience with Clinical Guide and its implications for their workflow. 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
9	Florez-Arango	1-No 2-Yes, intervention resulted in statistically significant decreases in overall workload as compared to the control groups workload & frustration. 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-Yes, Intervention reduces errors by an average of 33.15% (p<0.001) and increases protocol compliance 30.18% (p<0.001). 3-No
10	Hope	1-No 2- Yes, all ten of the midwives interviewed were enthusiastic about the help system. 3-No 4- No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
11	Iyengar	1-No 2-Yes, when using the ISRMGs on mobile phones the health workers reported statistically significant decreases in mental demand, frustration, and overall workload as compared to using paper-based job-aids. 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No

12	Keyani	-	-	-	-
13	Long	1-No 2-No 3-No 4- Yes, Scale Performance was assessed- Health scouts completing the MITI evaluation mostly demonstrated beginning proficiency in most domains with a mean composite score of 18.6 of 25 (median 20, range 11-23).	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
14	Maleka	1-No 2-No 3- Yes, outcomes of the smartphone application, operated by a CHW, corresponded closely to the gold standard PEDS tools operated by a health professional. 4- No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
15	Martinez	1-No 2-No 3-Yes, there was a progressive increase in the number of high-quality recordings, progressive increase in number of calls for patient care coordination, and continued use of the system 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
16	Maulik	-	-	-	-
17	McNabb	1-Yes, client satisfaction: as measured by proportion of clients who said they were very satisfied with the ANC services, increased from 75% at baseline to 83% at end line. 2-No 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2- Yes, overall, the quality score increased from 13.33 at baseline to 17.15 at end line (p<0.0001), with the most significant improvements related to health counselling. 3- No
18	Megalingam	1-No 2-No 3-Yes, HR and temperature measured by system was compared to manually measured HR & findings were very similar 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
19	Morrison	1-Yes, overall, mid-level health workers and patients were positive about the intervention 2-Yes, overall, mid-level health workers and patients were positive about the intervention 3-No 4-No	1-No 2-No 3-No 4-No	1-Yes, 16 out of 24 health workers had called a GP. A total of 71 calls were made. Fifty-nine per cent (42) of calls were made between 9am and 5pm, and one doctor usually received out of hours calls 2-No 3-No 4-No 5-No	1-No 2-No 3-No
20	Patterson	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
21	Peireis	-	-	-	-
				5-Yes, the misdiagnosis rate of the NPHW/app combination was is similar to that of local physicians when measured against a neurologist.	

22	Praveen	-	-	-	-
23	Praveen	1-Yes, community participants expressed satisfaction with the convenience & reduced costs 2-Yes, Several ASHAs described initially feeling anxious and some were sceptical however felt better after training. 3-No 4-No	1-No 2-No 3-No 4- Yes, one focus group participant commented on his decision to cease tobacco use and alcohol consumption	1-No 2-No 3-Yes, several ASHAs considered that the training and support provided in this project improved their knowledge & tablet offered mechanism for dissemination of this knowledge to the community. 4-No For the doctors, the tablet appeared to enhance workflow and was viewed as a time-saver.	1-No 2-No 3-Yes, community participants also expressed satisfaction with the convenience and reduced costs
24	Prinjah	-	-	-	-
25	Prinja	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4- Yes, statistically significant increase in coverage IFA supplementation (12.58%), identification and self-reporting of illnesses/complication during pregnancy (13.11%) & after delivery (19.6%) was observed in the intervention area vs. the control area.	1-No 2-No 3-No 4-No 5-No	1-Yes, there was statistically insignificant change in the coverage of institutional delivery and full immunisation. 2-Yes, statistically insignificant change in quality of ANC care such as blood pressure, urine test, weight measurement and blood test during ANC care between the intervention and control areas. 3- No
26	Qin	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5- Yes, telemedicine system was able to provide patients with approximately the same quality of care and advice as if the patient had physically travelled to a clinic to see a nurse.	1-No 2-No 3-No
27	Raghu	1-No 2-Yes, In-depth analysis of user interactions found the CDS tool feasible for use and easily integrable into the workflow of healthcare workers 3-No 4-No	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-Yes, there was a decrease in median completion time with a greater number of procedures performed. This indicated the ASHA's increased familiarity with the process as well as provides evidence for expected or optimal usage and actual usage	1-No 2-No 3-No
28	Ramkumar	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-Yes, of the 1335 children screened, 20 children were referred for tele diagnostic ABR testing due to a refer outcome on the second screening. Of the 20 children, 17 underwent follow-up testing	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3- yes, from the patient perspective, average wage lost by a parent to bring the child for remote ABR via tele-audiology was Rs.95. The average travel cost incurred by a parent to use tele-ABR was Rs.79.
29	Soni	1-No 2-No 3-No 4-Yes, twelve participants screened positive for atrial fibrillation yielding a sample prevalence of 5.1% (95% CI 2.7-8.7). Only one participant had persistent atrial fibrillation throughout all the screenings, and 9 screened positive only once.	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No
30	Tian	1-No 2-No 3-No 4-No	1-No 2-No 3-No 4- Yes, the intervention group had a 25.5% (P<0.001) higher net increase in the primary outcome of the proportion of patient-reported antihypertensive medication use pre- and post-intervention.	1-No 2-No 3-No 4-No 5-No	1-No 2-No 3-No

31	Van Heerden	<p>1-Yes, caregivers described the app as shifting the relationship from feeling harassed by CHVs to experiencing genuine interest from CHVs.</p> <p>2-Yes, CHVs reported feasibility challenges primarily related to infrastructure. The limited battery life of mobile phones combined with the lack of readily available electricity made it difficult to keep the phones charged. CHVs reported initial anxiety as first-time mobile phones users, including concerns about using the IFA app. With time, increased levels of confidence were seen.</p> <p>3-No</p> <p>4-No</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p> <p>4- Yes, increase in self-reported uptake of desired behaviours and practice.</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p> <p>4-No</p> <p>5-No</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p>
32	Vélez	<p>1-No</p> <p>2-Yes, midwives perceived mClinic as useful</p> <p>3-No</p> <p>4- Yes, results show there are usability problems that need to be addressed- e.g., difficulty entering numbers due to small buttons</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p> <p>4-No</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p> <p>4-No</p> <p>5-No</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p>
33	Zurovac	<p>1-No</p> <p>2-No</p> <p>3-No</p> <p>4- Yes, under study conditions, intervention costs were 19,342 USD, the cost of national scale-up would be 97,350 USD. Conclusion is simple text message intervention is effective and inexpensive.</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p> <p>4-No</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p> <p>4-No</p> <p>5-No</p>	<p>1-No</p> <p>2-No</p> <p>3-No</p>

* No means that the study did not report on that form of evidence

Intervention Characteristics

Geographic area of implementation of the program

Just under half of the programmes described in these articles were implemented in Asia (n=15).⁴⁴⁻⁵⁸ 15 of the studies also took place in Africa.⁵⁹⁻⁷³ Two studies were implemented in South America and one in North America.

Mobile device

The technology used in these interventions was predominantly mobile phones (n=22).^{8-10,12-30} Of these twenty-two studies, nine used smart phones^{48,49,60,61,63-65,67,74,75}, three used feature phones^{45,46,66} and one used brick phones.⁵⁹ Seven of these twenty-two studies were less specific and mentioned that a mobile phone was used but did not specify the type.^{44,47,50-52,64,76} Two of the twenty-two studies stated that the health workers own phone would be used.^{68,69} Five studies did not use mobile phones but rather other mobile devices; tablets (n=4)^{53-55,62} and netbooks (n=1).^{3,4} Three of the studies used more than one type of mobile device with one study using both smartphones and/or tablets⁷¹ and two studies using brick phones and/or tablets. Three authors provided no information on what type of mobile device was used in their intervention.^{56,57,72}

Stage of maturity of digital health tool

The majority of digital health tools used in these interventions were in the pilot phase (A phase for testing if an intervention produces desired effects under controlled circumstances.⁷⁷) (n=15)^{45,48,54,56,57,59,61-63,65-67,72,75,76}. Eight interventions used digital health tools that were in the prototype phase (A phase during which, designs are created, and functionality and usability are tested.⁷⁷)^{50,52,53,58,60,69,71,74}. The remaining interventions made use of tools in the demonstration phase (A phase during which an intervention is tested within a small population/area rather than controlled conditions.⁷⁷) (n=3)^{49,68,73}, scale up (A phase in which an intervention is ready to be optimized.⁷⁷) (n=2)^{44,55} and pre-prototype phase (A phase during which hypothesis are built, needs/context are assessed and the intervention is tested for usability/ feasibility and technical stability.⁷⁷) (n=2).^{51,70} Three of the studies were protocol studies so tools were not yet selected/developed/tested.^{45,47,64}

Main Health Services, Disease and Practice Areas of interventions:

Health Services

The most common health service offered by these interventions was maternal and child care (n=23); nine interventions reported offering antenatal care, ^{44,45,50,52,56,65,66,72,75} seven offered intrapartum care ^{44,50,52,65,66,72,75} and seven offered postnatal care. ^{44,45,50,52,65,66,72} Other health services offered by at least one of the thirty-three interventions reviewed include: immunizations (n=4), ^{45,50,66,72} family planning (n=3), ^{50,62,66} adolescent health (n=2), ^{72,74} respiratory & pulse rate (n=1), ⁵⁹ gestation age (n=1), ⁵⁹ estimated date of delivery (n=1), ⁵⁹ drug dose (n=1), ⁵⁹ ECG (n=1) ⁵⁹, measuring blood pressure (n=1) ⁵⁶, measuring body temperature (n=1) ⁵⁶, measuring heart rate (n=1), ⁵⁶ blood glucose and cholesterol (n=1), ⁵⁷ hearing screening (n=1) ⁴⁸ and screening for atrial fibrillation (n=1). ⁴⁹ 16 authors made no mention of health service/services offered. ^{47,49,51-56,58,66-68,71,72,75,76}

Disease and Practice areas

Essential new-born care, ^{44-46,65,73} cardiovascular disease, ^{49,53,54,58} pneumonia, ^{60,66,69} HIV/STI, malaria prevention/ treatment ^{62,67,73} and infant feeding ^{44,62} were among the most commonly reported disease and practice areas in the thirty-three reviewed articles (where n=5, n=4, n=3, n=3, n=3 and n=2 respectively). Besides these other disease and practice areas that were mentioned in at least one of the articles reviewed were TB, ⁵⁴ diarrhoea, ⁶⁶ alcohol & nutrition, ⁶² adult medical and adult trauma conditions, ⁷⁵ mental health care ⁵² and diabetes. ⁴⁷

Summary of evidence reported:

Processes/Outputs

Six of the studies reviewed reported on beneficiaries' perceptions of the digital health intervention. In all six beneficiaries were reported to have positive attitudes towards the intervention, expressing satisfaction with the convenience and reduced cost. ^{53,56,59-61,73} One of these studies reported an increase in client satisfaction from 75% at baseline to 83% at end line. ⁷³ Nine of the articles reported on provider perceptions of the intervention. Perceptions were generally positive, with providers perceiving benefits to their work load and service quality. ^{54,56,59,60,62,70,71,75,76} In two studies health workers described initially feeling anxious and sceptical however, they reported feeling better after training. ^{53,61} In one study FLHW

s reported feasibility challenges primarily related to infrastructure. ⁶¹ Other processes assessed included technology performance with three studies reporting technology to work well. ^{50,63,74}

Outcomes: Beneficiary engagement

Although none of the studies assessed beneficiary's exposure/ engagement with the digital health solution, their change in attitudes/intentions or change in knowledge, six of the studies did described a change in practice (preventive, promotive, curative) following the intervention.

This is an included increased medication use included increased medication use pre- and post-intervention, increased number of follow up appointments, cessation of tobacco use and alcohol consumption and early initiation of breastfeeding. ^{44,45,49,53,57,61}

Outcomes: Provider engagement

Only one of the reviewed articles assessed provider exposure/engagement with the digital health solution reporting that 16 out of the 24 health workers had called a GP and a total of 71 calls were made. ⁵⁶ In one study FLHWs reported on their change in knowledge stating that the training and support provided in the project improved their knowledge and the tablet provided them with a means to share their knowledge with the community. ⁵³ Five studies described gains in service delivery; with one study reporting 21% more beneficiaries receiving all three antenatal visits in the intervention group compared to the control group, ⁴⁴ two studies reported being able to deliver timely care ^{54,59} and two studies reported services to be approximately the same quality as if the patient had physically travelled to a clinic to see a nurse. ^{55,72}

Impact: Health effects

Four of the reviewed studies described changes in the quality of care provided by FLHWs. One study reported that registration of pregnancy, completion of 3 antenatal visits, receiving at least 90 iron and folic acid tablets, institutional delivery, early initiation of breastfeeding and post-natal home visits were all higher in the implementation area. ⁴⁴ Another study reported that the intervention reduced errors by an average of 33.15% and increased protocol compliance by 30.18%. ⁷⁶ The third study reported their most significant improvements were related to health counselling ⁷³ and the last study reported improvement in quality, although found to be insignificant. ⁴⁶

Discussion

Although there have been several studies on decision support tools used in LMICs there has been no comprehensive systematic review. The aim of this review was to systematically examine the literature on digital health tools that are used for decision support in low and middle-income settings and describe what we can learn from studies that have used these tools.

This review identified 33 studies conducted in LMICs, six of which were protocol studies and the remainder of which (27/33) showed great potential for the use of decision support mHealth tools as a means of improving health systems through; reducing the work load of FLHWs, reducing the costs of health care, improving the efficiency of service delivery and/or improving the overall quality of care.

Overall this review showed that the number of studies focusing on decision support mHealth interventions has drastically increased over the past few years (2016-2018).^{44-48,59-67,74} This is likely due to the urgent need to better equip FLHWs who are carrying much of the work load in the health systems in LMICs.¹ We expect that this body of research will continue to grow and remain relevant as it is predicted that LMICs will continue to struggle with shortages of trained physicians in the next few years.¹¹ The interventions used for decision support in these studies predominantly made use of mobile phones (n=22),^{8-10,12-30} with smart phones being the most popular device, this is most likely due to the rapid spread of mobile technology around the globe making mobile phones one of the most accessible and affordable options for the delivery of digital health care services.

From the reviewed studies it is evident that current research efforts have tended to focus on developing decision support interventions for improving maternal and child health (n=23) in LMICs. Very few of the interventions studied in this review focused on other health services such as immunisation, family planning and adolescent health. Perhaps future studies could channel efforts and resources into these services to provide a more comprehensive body of research on health services other than child and maternal health.

Unlike other available literature reviews, studied in Part B of this paper, that tended to focus on more developed countries. The articles reviewed for this study all focused on interventions implemented in LMICs, mainly Asia (n=16)⁴⁴⁻⁵⁸ and Africa (n=15).⁵⁹⁻⁷³ This is important as it is in these countries where shortages of trained physicians are seen and the need for support is greatest. Furthermore, in contrast to other available literature reviews that focus solely on decision support tools used in a clinical setting this review focused on tools used outside of the clinic

setting as in today's context (where there is a shortage of trained physicians in many LMICs and a substantial amount of health care work is carried out by FLHWs outside of the clinic setting) – it is important for us to be looking at other kinds of decision support.

Evidence reported in these studies varied greatly with some studies reporting on processes/outputs, some reporting on outcomes, some reporting on impact and some reporting on more than one of these. Overall, the evidence found, largely highlighted the benefit of decision support tools in supporting FLHWs and enhancing their abilities. Of the studies that reported on beneficiaries and providers' perceptions of the intervention all findings were positive with both providers and beneficiaries having positive attitudes towards the intervention; something that is critical for the success of an intervention. In addition to this following the engagement of providers and beneficiaries with the intervention; positive results were reported with beneficiary's preventative, promotive and curative practices increasing and providers' knowledge and service delivery improving.

The large variation in the evidence reported on makes it difficult to compare these studies. Most of articles were of studies in the pilot phase (n=15)^{45,48,54,56,57,59,61–63,65–67,72,75,76} and therefore provided no evidence on the effectiveness of the tools on a large scale. Both variation in evidence reported on and phase of maturity of the tool are things that future studies could focus on as both are necessary to inform future policy and programmes.

Strengths and Limitations

This review included many studies (n=33) from a variety of LMICs and confirmed that decision support digital health tools hold great potential for improving the abilities of FLHWs and strengthening the health systems of LMICs. However, this review did have several limitations the most significant being that there was predominantly one reviewer. Potential bias was partially moderated by using a second reviewer to review 10% of the articles and clear-cut inclusion and exclusion criteria were developed to try and reduce potential for selection bias. Another limitation was the potential for publication bias as this review did not include grey literature due to time constraints. Finally, the inclusion of only studies published in English holds potential bias as it is possible that studies in other languages may have met the inclusion criteria.

Conclusions

There is a growing pool of evidence supporting the benefits of decision support mHealth tools for improving the abilities of FLHWs in LMICs where there are shortages in trained physicians and nurses. In this review we found that both providers and beneficiaries perceive such tools to be beneficial. In addition to this, we found the results of interventions that used these tools to be positive - with beneficiary's preventative, promotive and curative practices increasing and providers knowledge and service delivery improving. These encouraging findings show the need for further studies and investigation into this growing field. Considering the gaps in research, futures studies should focus on qualitative analysis, to better understand how mHealth tools may be better designed. In addition to this an impact evaluation across studies would provide much needed evidence to inform future studies. The potential of these decision support tools to improve health systems in LMICs is undoubtedly great; however, a stronger evidence base is needed to inform future health policies and programmes.

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Part D: Supplementary Material (as referenced in journal article)

Additional File 1: Literature search strategy

In August 2018 a search began to find studies in LMICs that used digital health tools with the following functions; training, decision support, data capture, commodity tracking, provider to provider communication, provider to patient communication and alerts, reminders, health information content. These six categories were selected based on the WHO framework for classifying digital health interventions.⁴ Several databases were included as is recommended to ensure maximum sensitivity.¹⁹ The databases searched included: PubMed, Embase, Scopus, CINAHL, Global Health Ovid, Cochrane and Global Index Medicus. Grey Literature and studies not published in English were not included due to limited resources. Two of the search terms selected (FLHW and digital health) were those used by Agarwal et al. (2015) in their systematic review of digital health tools for FLHWs.²⁰ The third search term selected was LMICs as defined and listed by the World Bank. Articles found in all seven of these domains informed other papers in this series of reviews. However, this review will focus on the 33 articles found in the decision support domain.

Table 1. Search terms

Concept 1: mHealth	"Telemedicine"[Mesh] OR "telemedicine"[tw] OR "telehealth"[tw] OR "digital health"[tw] OR "mobile"[tw] OR "Telephone"[Mesh] OR "phone"[tw] OR "phones"[tw] OR "telephone"[tw] OR "telephones"[tw] OR "smartphone"[tw] OR "smartphones"[tw] OR "iphone"[tw] OR "iphones"[tw] OR "android"[tw] OR "androids"[tw] OR "mHealth"[tw] OR "eHealth"[tw] OR "Information Technology"[Mesh] OR "information technology"[tw] OR "information technologies"[tw] OR "communication technology"[tw] OR "communication technologies"[tw] OR (("cellular "[tw] OR "wearable"[tiab] OR "digital"[tiab]) AND ("technology"[tw] OR "technologies"[tw])) OR "portable cellular"[tw] OR "transportable cellular"[tw] OR ((cellular[tw] OR mobile[tw] OR phone[tw] OR smart[tw] OR text[tiab] OR digital[tiab]) AND ("app"[tiab] OR "application"[tiab] OR "applications"[tiab] OR alert[tiab] OR alerts[tiab] OR reminder[tiab] OR reminders[tiab])) OR "mobile device"[tw] OR "mobile devices"[tw] OR "SMS"[tw] OR "short message service"[tw] OR "text message"[tw] OR "text-message"[tw] OR "text messages"[tw] OR "text-messages"[tw] OR "text messaging"[tw] OR "text-messaging"[tw] OR "texting"[tw] OR "textings"[tw] OR "text contact"[tw] OR "text contacts"[tw] OR "interactive voice response"[tw]) AND ("2008/01/01"[PDAT] : "2018/12/31"[PDAT])
Concept 2: Health worker	"community health workers"[MeSH Terms] OR "community health worker"[tw] OR "community health workers"[tw] OR "CHW"[tw] OR "CHWs"[tw] OR "community health aid"[tw] OR "community health aides"[tw] OR "family planning personnel"[tw] OR "midwifery"[MeSH Terms] OR "traditional birth attendant"[tw] OR "traditional birth attendants"[tw] OR "skilled birth attendant"[tw] OR "skilled birth attendants"[tw] OR "frontline worker"[tw] OR "frontline workers"[tw] OR "health worker"[tw] OR "health workers"[tw] OR "lay worker"[tw] OR "lay workers" OR "village health worker"[tw] OR "village health workers"[tw] OR "VHW"[tw] OR "VHWs"[tw] OR "midwife"[tw] OR "midwives"[tw] OR "barefoot doctors"[tw] OR "barefoot doctor"[tw] OR "health auxiliary"[tw] OR "health auxiliaries"[tw] OR "peer health worker"[tw] OR "peer health workers"[tw] OR "medical auxiliary"[tw] OR "medical auxiliaries"[tw]

OR "health provider"[tw] OR "health providers"[tw] OR "lay counselor"[tw] OR "lay counselors"[tw] OR "lady health worker"[tw] OR "lady health workers"[tw] OR "LHW"[tw] OR "LHWs"[tw] OR "lay educator"[tw] OR "lay educators"[tw] OR "Activista"[tw] OR "activistas"[tw] OR "Agente comunitario de salud"[tw] OR "agentes comunitarios de salud"[tw] OR

"Anganwadi"[tw] OR "accredited social health activist"[tw] OR "accredited social health activists"[tw] OR "ASHA"[tw] OR "ASHAs"[tw] OR "Animatrice"[tw] OR "animatrices"[tw] OR "Barangay health worker"[tw] OR "[Barangay Health Workers](#)"[tw] OR

"Basic health worker"[tw] OR "basic health workers"[tw] OR "Brigadista"[tw] OR "brigadistas"[tw] OR "Colaborador voluntario"[tw] OR "[Colaboradores voluntarios](#)"[tw] OR "Community drug distributor"[tw] OR "community drug distributors"[tw] OR "Community health agent"[tw] OR "community health agents"[tw] OR "Community health promoter"[tw] OR "community health promoters"[tw] OR "Community health representative"[tw] OR "community health representatives"[tw] OR "Community health volunteer"[tw] OR "community health volunteers"[tw] OR "Community nutrition worker"[tw] OR "community nutrition volunteers"[tw] OR "Community resource person"[tw] OR "community resource persons"[tw] OR "Female community health volunteer"[tw] OR "female community health volunteers"[tw] OR "Female multipurpose health worker"[tw] OR "female multipurpose health workers"[tw] OR "Health promoter"[tw] OR "health promoters"[tw] OR "Kader"[tw] OR "kaders"[tw] OR "Maternal and child health worker"[tw] OR "maternal and child health workers"[tw] OR "Monitora"[tw] OR "Mother coordinator"[tw] OR "mother coordinators"[tw] OR "**Outreach educator**"[tw] OR "outreach educators"[tw] OR "Promotora"[tw] OR "Promotoras"[tw] OR "Rural health motivator"[tw] OR "rural health motivators"[tw] OR "Shastho shebika"[tw] OR "Shasthya Shebika"[tw] OR "Shasthya Shebikas"[tw] OR "Sevika"[tw] OR "sevikas"[tw] OR "Village health helper"[tw] OR "village health helpers"[tw] OR "Village drug-kit manager"[tw] OR "village drug-kit managers"[tw] OR "Saksham Sahaya"[tw] OR "Saksham Sahayaks"[tw] OR "Raedat"[tw] OR "Raedat Refiat"[tw] OR "Accompagnateurs"[tw] OR "Accompagnateur"[tw] OR "Behvarz"[tw] OR "behvarzan"[tw] OR "Dai"[tw] OR "Dais"[tw] OR "Bidan Kampong"[tw] OR "bidan kampungs"[tw] OR "bidan kampong"[tw] OR "agents de santé"[tw] OR "agent de santé"[tw] AND ("2008/01/01"[PDAT] : "2018/12/31"[PDAT])

**Concept 3:
With LMIC
Filter**

((("community health workers"[MeSH Terms] OR "community health worker"[tw] OR "community health workers"[tw] OR "CHW"[tw] OR "CHWs"[tw] OR "community health aides"[tw] OR "family planning personnel"[tw] OR "midwifery"[MeSH Terms] OR "traditional birth attendant"[tw] OR "traditional birth attendants"[tw] OR "skilled birth attendant"[tw] OR "skilled birth attendants"[tw] OR "frontline worker"[tw] OR "frontline workers"[tw] OR "health worker"[tw] OR "health workers"[tw] OR "lay worker"[tw] OR "lay workers"[All Fields] OR "village health worker"[tw] OR "village health workers"[tw] OR "VHW"[tw] OR "VHWs"[tw] OR "midwife"[tw] OR "midwives"[tw] OR "barefoot doctors"[tw] OR "barefoot doctor"[tw] OR "health auxiliary"[tw] OR "health auxiliaries"[tw] OR "peer health worker"[tw] OR "peer health workers"[tw] OR "medical auxiliary"[tw] OR "medical auxiliaries"[tw] OR "health provider"[tw] OR "health providers"[tw] OR "lay counselor"[tw] OR "lay counselors"[tw] OR "lady health worker"[tw] OR "lady health workers"[tw] OR "LHW"[tw] OR "LHWs"[tw] OR "lay educator"[tw] OR "lay educators"[tw] OR "agentes comunitarios de salud"[tw] OR "Anganwadi"[tw] OR "accredited social health activist"[tw] OR "accredited social health activists"[tw] OR "ASHA"[tw] OR "ASHAs"[tw] OR "Barangay Health Workers"[tw] OR "Basic health worker"[tw] OR "basic health workers"[tw] OR "Brigadista"[tw] OR "brigadistas"[tw] OR "community drug distributors"[tw] OR "Community health agent"[tw] OR "community health agents"[tw] OR "Community health promoter"[tw] OR "community health promoters"[tw] OR "Community health representative"[tw] OR "community health representatives"[tw] OR "Community health volunteer"[tw] OR "community health volunteers"[tw] OR "community resource persons"[tw] OR "Female community health volunteer"[tw] OR "female community health volunteers"[tw] OR "Health promoter"[tw] OR "health promoters"[tw] OR "Kader"[tw] OR "kaders"[tw] OR "mother coordinators"[tw] OR "outreach educators"[tw] OR "Promotora"[tw] OR "Promotoras"[tw] OR "Sevika"[tw] OR "village health helpers"[tw] OR "Raedat"[tw] OR "Accompagnateurs"[tw] OR "Accompagnateur"[tw] OR "Behvarz"[tw] OR "Dai"[tw] OR "Dais"[tw] OR "bidan kampungs"[tw] AND ("2008/01/01"[PDAT] : "2018/12/31"[PDAT])) AND ("Telemedicine"[Mesh] OR "telemedicine"[tw] OR "telehealth"[tw] OR "digital health"[tw] OR "mobile"[tw] OR "Telephone"[Mesh] OR "phone"[tw] OR "phones"[tw] OR "telephone"[tw] OR "telephones"[tw] OR "smartphone"[tw] OR "smartphones"[tw] OR "iphone"[tw] OR "iphones"[tw] OR "android"[tw] OR "androids"[tw] OR "mHealth"[tw] OR "eHealth"[tw] OR "Information Technology"[Mesh] OR "information technology"[tw] OR "information technologies"[tw] OR "communication technology"[tw] OR "communication technologies"[tw] OR ("cellular "[tw] OR "wearable"[tiab] OR "digital"[tiab]) AND ("technology"[tw] OR "technologies"[tw])) OR ((cellular[tw] OR mobile[tw] OR phone[tw] OR smart[tw] OR text[tiab] OR digital[tiab]) AND ("app"[tiab] OR

"application"[tiab] OR "applications"[tiab] OR alert[tiab] OR alerts[tiab] OR reminder[tiab] OR reminders[tiab])) OR "mobile device"[tw] OR "mobile devices"[tw] OR "SMS"[tw] OR "short message service"[tw] OR "text message"[tw] OR "text-message"[tw] OR "text messages"[tw] OR "text-messages"[tw] OR "text messaging"[tw] OR "text-messaging"[tw] OR "texting"[tw] OR "interactive voice response"[tw] AND ("2008/01/01"[PDAT] : "2018/12/31"[PDAT])) AND (((("developing country"[tw] OR "developing countries"[tw] OR "developing nation"[tw] OR "developing nations"[tw] OR "developing population"[tw] OR "developing populations"[tw] OR "developing world"[tw] OR "less developed country"[tw] OR "less developed countries"[tw] OR "less developed nation"[tw] OR "less developed nations"[tw] OR "less developed world"[tw] OR "lesser developed countries"[tw] OR "lesser developed nations"[tw] OR "under developed country"[tw] OR "under developed countries"[tw] OR "under developed nations"[tw] OR "under developed world"[tw] OR "underdeveloped country"[tw] OR "underdeveloped countries"[tw] OR "underdeveloped nations"[tw] OR "underdeveloped population"[tw] OR "underdeveloped world"[tw] OR "middle income country"[tw] OR "middle income countries"[tw] OR "middle income nation"[tw] OR "middle income nations"[tw] OR "middle income population"[tw] OR "middle income populations"[tw] OR "low income country"[tw] OR "low income countries"[tw] OR "low income nation"[tw] OR "low income nations"[tw] OR "low income population"[tw] OR "low income populations"[tw] OR "lower income country"[tw] OR "lower income countries"[tw] OR "lower income nations"[tw] OR "lower income population"[tw] OR "lower income populations"[tw] OR "underserved countries"[tw] OR "underserved nations"[tw] OR "underserved population"[tw] OR "underserved populations"[tw] OR "under served population"[tw] OR "under served populations"[tw] OR "deprived countries"[tw] OR "deprived population"[tw] OR "deprived populations"[tw] OR "poor country"[tw] OR "poor countries"[tw] OR "poor nation"[tw] OR "poor nations"[tw] OR "poor population"[tw] OR "poor populations"[tw] OR "poor world"[tw] OR "poorer countries"[tw] OR "poorer nations"[tw] OR "poorer population"[tw] OR "poorer populations"[tw] OR "developing economy"[tw] OR "developing economies"[tw] OR "less developed economy"[tw] OR "less developed economies"[tw] OR "underdeveloped economies"[tw] OR "middle income economies"[tw] OR "low income economy"[tw] OR "low income economies"[tw] OR "low gdp"[tw] OR "low gnp"[tw] OR "low gross domestic"[tw] OR "low gross national"[tw] OR "lower gdp"[tw] OR "lower gross domestic"[tw] OR lmic[tw] OR lmic[s] [tw] OR "third world"[tw] OR "lami country"[tw] OR "lami countries"[tw] OR "transitional country"[tw] OR "transitional countries"[tw]) OR (Africa[tw] OR Asia[tw] OR Caribbean[tw] OR West Indies[tw] OR South America[tw] OR Latin America[tw] OR Central America[tw] OR Afghanistan[tw] OR Albania[tw] OR Algeria[tw] OR Angola[tw] OR Antigua[tw] OR Barbuda[tw] OR Argentina[tw] OR Armenia[tw] OR Armenian[tw] OR Aruba[tw] OR Azerbaijan[tw] OR Bahrain[tw] OR Bangladesh[tw] OR Barbados[tw] OR Benin[tw] OR Byelarus[tw] OR Byelorussian[tw] OR Belarus[tw] OR Belorussian[tw] OR Belorussia[tw] OR Belize[tw] OR Bhutan[tw] OR Bolivia[tw] OR Bosnia[tw] OR Herzegovina[tw] OR Hercegovina[tw] OR Botswana[tw] OR Brasil[tw] OR Brazil[tw] OR Bulgaria[tw] OR Burkina Faso[tw] OR Burkina Faso[tw] OR Upper Volta[tw] OR Burundi[tw] OR Urundi[tw] OR Cambodia[tw] OR Khmer Republic[tw] OR Kampuchea[tw] OR Cameroon[tw] OR Cameroons[tw] OR Cameroon[tw] OR Cape Verde[tw] OR Central African Republic[tw] OR Chad[tw] OR Chile[tw] OR China[tw] OR Colombia[tw] OR Comoros[tw] OR Comoro Islands[tw] OR Comores[tw] OR Mayotte[tw] OR Congo[tw] OR Zaire[tw] OR Costa Rica[tw] OR Cote d'Ivoire[tw] OR Ivory Coast[tw] OR Croatia[tw] OR Cuba[tw] OR Cyprus[tw] OR Czechoslovakia[tw] OR Czech Republic[tw] OR Slovakia[tw] OR Slovak Republic[tw] OR Djibouti[tw] OR 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Additional File 2: Journal Submission Guidelines

Journal of Digital Health

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Content Type	Article Types	Abstract word limit	Main Text Word limit
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Research Articles	Original research, controlled trials, case studies, feasibility and pilot studies, qualitative and quantitative studies	250	N/A
Research Protocols and Study Designs	-	250	N/A
Review Articles	Literature reviews, systematic reviews, market reviews, critical reviews	250	N/A
Educational Pieces	Tutorials on new methods, best practice, user guides, policy and practice	250	N/A
Current topics and opinion pieces	Digests of policy, regulation and legislation	250	1,500
Editorials		N/A	1,000
Essays		250	N/A
Commentaries		250	800
Brief Communications		250	1,500

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DECLARATIONS

Conflicting interests

Funding

Ethical approval

Guarantor

Contributorship

Acknowledgements

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DECLARATIONS

Conflicting interests: MS is an employee of XXX. BF has received grants from XXX.

Funding: This work was supported by the Medical Research Council [grant number XXX].

Ethical approval: The ethics committee of XXXX approved this study (REC number: XXXX)

Guarantor: BF

Contributorship: BF and NP researched literature and conceived the study. MS was involved in protocol development, gaining ethical approval, patient recruitment and data analysis. BF wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript

Acknowledgements: We would like to thank XXX XXXX for his assistance and guidance in this research.

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6.3 Corresponding author contact details

Provide full contact details for the corresponding author including email, mailing address and telephone numbers. Academic affiliations are required for all co-authors. These details should be presented separately to the main text of the article to facilitate anonymous peer review.

You will be asked to provide contact details and academic affiliations for all co-authors via the submission system and identify who is to be the corresponding author. These details must match what appears on your manuscript. At this stage please ensure you have included all the required statements and declarations and uploaded any additional supplementary files (including reporting guidelines where relevant).

6.4 Publication of Twitter handles

As a way of encouraging ongoing discussion within the field, *DIGITAL HEALTH* authors are offered the option of providing their Twitter handle to be published alongside their name and email address within their article. This way *DIGITAL HEALTH* readers who have questions or thoughts regarding your paper can tweet you directly. Providing a Twitter handle for publication is entirely

optional; if you are not comfortable with *DIGITAL HEALTH* promoting your article along with your personal Twitter handle then please do not supply it.

By providing your personal Twitter handle you agree to let *DIGITAL HEALTH* and *SAGE Publications* use it in any posts related to your journal article. You may also be contacted by other Twitter users. *DIGITAL HEALTH* and *SAGE Publications* will have no control over you or your tweets at any time. If you would like guidance on how to promote your article yourself on Twitter or other Social Media channels please visit <https://uk.sagepub.com/en-gb/eur/increase-usage-citation-using-social-media>.

To include your Twitter handle within your article, please provide this within the SAGE Track Submission form when prompted, on the manuscript title page and on the manuscript itself.

Corresponding

author:

Professor Joe Bloggs, Department of Digital Health, University of Digital Health, Digital Health Road,
Digital Health, DHJ 2014, UK

Email: JoeBloggs@email.com

Twitter: @profjoebloggs

6.5 Artwork, figures and other graphics

For guidance on the preparation of illustrations, pictures and graphs in electronic format, please visit SAGE's [Manuscript Submission Guidelines](#).

Photographic illustrations should be rendered with at least 300 dpi; please use CMYK color conversion if possible. Graphs made with Office software such as Microsoft Excel, can be provided in their original format to facilitate conversion into printable format with preserved quality. Any other line graphs/illustrations should preferably be provided in EPS format with a resolution of at least 600 dpi to prevent ragged lines when printed. A figure image should be at least 160 mm in width at the appropriate resolution. For further guidance on how to prepare your digital image see <http://art.cadmus.com/da/index.jsp>.

Graphs and images that are unsuitable may be returned to the author for amendment, causing delay in publication.

6.6 Units of measurement

Units of measurement should be expressed in SI and metric units; older conventional units may be added in parentheses.

6.7 Nomenclature

Use the generic or chemical name of any drug, in lower case; the specific trade name (capitalized) may be given in parentheses after the first text reference.

6.8 Standard abbreviations and symbols

Standard Abbreviations and symbols should be used, then defined in full in the first instance unless they are standard units of measurement. Avoid any use of abbreviations in the article title and abstract.

6.9 Supplementary material

This journal is able to host additional materials online (e.g. datasets, podcasts, videos and images) alongside the full-text of the article. These will be subjected to peer-review alongside the article. For more information please refer to our guidelines on submitting supplementary files, which can be found within our [Manuscript Submission Guidelines](#) page.

6.10 Guidelines for submitting video material as part of an article

Video content can be streamed within the HTML version of your article. If you would like to submit a video as part of your article, please read the below video properties guidelines carefully, ensure that you make a note within your manuscript as to where the video would be placed and upload it under the file type 'Additional Video Content' when you upload your manuscript via the manuscript submission site.

Please note that an audio-visual release form for each individual contributor to the video. This form should be signed, scanned and submitted as 'audio-visual release form'. The form is located [here](#).

Video Properties:

- At least 640 by 480 resolution and at least 20 fps.
- The video compression should be of high quality. The Journal expects compression technology to evolve and so does not wish to be prescriptive over compression types. Today H.264 codec in an MP4 or AVI contained is a good choice. MPEG-1 and MPEG-2 are portable but have lower quality and larger files than the more modern codecs. We expect videos to be able to play on Windows 8 and back, Linux and Mac so propriety formats, such as WMV and FLV are discouraged.

- Note the *DIGITAL HEALTH* Editors-in-Chief reserve the right to request authors to change the compression codec before publication.

Videos should be below the 50MB mark and any video over this amount should provide a short preview to be hosted alongside the full file. Exceptions may be made at the discretion of the Editors-in-Chief.

6.11 Guidelines for submitting a video abstract (Vidab)

A video abstract is a short video introduction to your article, which can be linked to from the Table of Contents on SAGE Journals, promoted via Social Media, and shared directly by you with your own networks. It is intended to be an addition to, rather than replacement of, your text abstract.

For further information regarding video abstracts please see the SAGE Video guidelines: [Video Abstract Guidelines](#).

Please note that an audio-visual release form for each individual contributor to the Vidab. This form should be signed, scanned and submitted as ‘audio-visual release form’. The form is located [here](#).

6.12 Reference style

DIGITAL HEALTH adheres to the SAGE Vancouver reference style. Please review the [guidelines on SAGE Vancouver](#) to ensure your manuscript conforms to this reference style.

If you use [EndNote](#) to manage references, you can download the [SAGE Vancouver output file here](#).

6.13 English language editing services

Authors seeking assistance with English language editing, translation, or figure and manuscript formatting to fit the journal’s specifications should consider using SAGE Language Services. Visit [SAGE Language Services](#) on our Journal Author Gateway for further information.

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7. Submitting your manuscript

7.1 How to submit your manuscript

DIGITAL HEALTH is hosted on SAGE Track, a web based online submission and peer review system powered by ScholarOne™ Manuscripts. Visit <http://mc.manuscriptcentral.com/dhj> to login and submit your article online.

IMPORTANT: Please check whether you already have an account in the system before trying to create a new one. If you have reviewed or authored for the journal in the past year it is likely that you will have had an account created. For further guidance on submitting your manuscript online please visit ScholarOne [Online Help](#).

All papers must be submitted via the online system. If you would like to discuss your paper prior to submission, please refer to the contact details below.

Please note that, in addition to selecting your article type, you will also be asked to select the primary discipline that you believe best matches your paper from the following list:

Clinical Applications and Trials

Engineering, Technology and Health Care

Social Sciences, Public Health and Health Care

This information will be used to select the Editor-in-Chief who is best placed to process your manuscript. Given the multi-disciplinary nature of *DIGITAL HEALTH* content, there will be instances where more than one Editor-in-Chief is involved in deciding the final outcome of a paper. The Editorial Office reserves the right to transfer your paper to another primary discipline for processing.

If you seek advice on the submission process, please contact the Editorial Office at: digitalhealth@sagepub.co.uk.

7.2 Title, keywords and abstracts

Please supply a title, short title, an abstract and keywords to accompany your article. The title, keywords and abstract are key to ensuring readers find your article online through online search engines such as Google. Please refer to the information and guidance on how best to title your article, write your abstract and select your keywords by visiting the SAGE Journal Author Gateway for guidelines on [How to Help Readers Find Your Article Online](#).

Keywords: 2-10 to accompany the abstract. They should, where relevant, be drawn from the MeSH list of Index Medicus and be chosen with a view to useful cross-indexing of the article.

Abstract: The abstract should accurately and concisely reflect the content of the article, and should be limited to 250 words for text articles and 500 words for audio-visual content. Please avoid reference citations and undefined abbreviations in the abstract. Where applicable the abstract should be formatted under the following headings: Objective, Methods, Results, Conclusions.

7.3 Information required for completing your submission

Provide full contact details for the corresponding author including email, mailing address and telephone numbers. Academic affiliations are required for all co-authors. These details should be presented separately to the main text of the article to facilitate anonymous peer review.

You will be asked to provide contact details and academic affiliations for all co-authors via the submission system and identify who is to be the corresponding author. These details must match what appears on your manuscript. At this stage please ensure you have included all the required statements and declarations and uploaded any additional supplementary files (including reporting guidelines where relevant).

7.4 ORCID

As part of our commitment to ensuring an ethical, transparent and fair peer review process SAGE is a supporting member of [ORCID, the Open Researcher and Contributor ID](#). ORCID provides a unique and persistent digital identifier that distinguishes researchers from every other researcher, even those who share the same name, and, through integration in key research workflows such as manuscript and grant submission, supports automated linkages between researchers and their professional activities, ensuring that their work is recognized.

The collection of ORCID IDs from corresponding authors is now part of the submission process of this journal. If you already have an ORCID iD you will be asked to associate that to your submission during the online submission process. We also strongly encourage all co-authors to link their ORCID ID to their accounts in our online peer review platforms. It takes seconds to do: click the link when prompted, sign into your ORCID account and our systems are automatically updated. Your ORCID iD will become part of your accepted publication's metadata, making your work attributable to you and only you. Your ORCID iD is published with your article so that fellow researchers reading your work can link to your ORCID profile and from there link to your other publications.

If you do not already have an ORCID ID please follow this [link](#) to create one or visit our [ORCID homepage](#) to learn more.

7.5 Permissions

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8. How to submit your multimedial material (Video and Audio)

8.1 Video content

DIGITAL HEALTH accepts and reviews videos, which can be published at the article level, as opposed to a component of a text based manuscript. Video content should also include an audio component – be that participants speaking within the video itself or a voiceover. Please note *DIGITAL HEALTH* will not edit video material at any stage during the peer review or production process. Any revisions, requested by the Editors-in-Chief, will need to be made by the author group.

All authors submitting video content to be published as an article within the main journal should include as part of the submission:

- A title page with names and contact details for all authors.
- A structured abstract of no more than 500 words.
- An audio-visual release form for each individual contributor to the video. This form should be signed, scanned and submitted as ‘audio-visual release form’. The form is located [here](#).

Authors of video content are also required to fulfil all of the standards and conventions expected of a text article, such as declaration of conflicting interest, patient consent and funding acknowledgements.

Video Style

The video should open with a white-on-black title page, lasting for a few seconds containing:

- *DIGITAL HEALTH* (<http://DHJ.sagepub.com>).
- The video title.
- The authors and their affiliations.
- Corresponding author contact information.

The video should close with a white-on-black title page, lasting for a few seconds containing:

- *DIGITAL HEALTH* (<http://DHJ.sagepub.com>).
- The video title.
- Acknowledgements, funding, conflict of interest and any relevant ethical statements.
- Corresponding author contact information.

The technical content of the video should be well explained with the use of textual and or audio annotation, as required. Care should be taken to avoid compression artifacts, which impinge on the scientific content of the video; Please be sure to check all graphics carefully after compression, paying particular attention to line graphics – for example graphs with numbered axes.

Video Properties

- At least 640 by 480 resolution and at least 20 fps.
- The video compression should be of high quality. The Journal expects compression technology to evolve and so does not wish to be prescriptive over compression types. Today H.264 codec in an MP4 or AVI contained is a good choice. MPEG-1 and MPEG-2 are portable but have lower quality and larger files than the more modern codecs. We expect videos to be able to play on Windows 8 and back, Linux and Mac so proprietary formats, such as WMV and FLV are discouraged.
- Note the *DIGITAL HEALTH* Editors-in-Chief reserve the right to request authors to change the compression codec before publication.
- Videos should be below the 50MB mark and any video over this amount should provide a short preview to be hosted alongside the full file. Exceptions may be made at the discretion of the Editors-in-Chief.

How to submit your video

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8.2 Audio content

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All authors submitting audio content to be published as an article within the main journal should include as part of the submission:

- A title page with names and contact details for all authors.
- A structured abstract of no more than 500 words.
- An audio-visual release form for each individual contributor to the audio content. This form should be signed, scanned and submitted as 'audio-visual release form'. The form is located [here](#).

Authors of audio content are also required to fulfil all of the standards and conventions expected of a text article, such as declaration of conflicting interest, patient consent and funding acknowledgements.

Podcast best practice

- Be considerate to your listeners. Podcasts play in real-time, so be mindful of your users' attention and move the credits listing to the end of the audio recording.
- Keep your personal discussions personal. Don't expect your listener to continue listening to discussions only relevant to the people creating the podcast.
- Keep it short. Twenty minutes is about the right length for a podcast. Listeners are likely to be listening while exercising, driving or doing something else. Make your content consumable in a time period that fits this use model.
- Deliver valuable, informative, engaging and entertaining content that your listeners can't get from any other media. Repurposing content may have its benefits, but you should strive to be a unique source of information for your market.
- Make it easy for your listeners to find links to content you mention during the podcast by including these in the accompanying abstract.

Podcast Style

The audio content should begin with the following description:

- This podcast has been published in the journal *DIGITAL HEALTH* <http://DHJ.sagepub.com> published by SAGE.
- The podcast title.
- A list of contributors and their affiliations.
- Corresponding author contact information.
- A brief description of the podcast content.

The audio content should end with:

- This podcast (podcast title) has been published in *DIGITAL HEALTH*, an Open Access journal published by SAGE <http://DHJ.sagepub.com>
- Acknowledgements, funding, conflict of interest and any relevant ethical statements.
- Corresponding author contact information.

Audio Properties

- Audio content can be submitted in any of the following formats:
 - asf, avi, flv, mov, mp3, mp4, mpeg, mpg, wav, wma or wmv.
- The file should be no larger than 50MB. If you wish to produce a podcast with a larger file size, please discuss this with the *DIGITAL HEALTH* Editorial Office first.
- The file should be labelled as follows: DHJ followed by volume year, month of submission, an underscore and the leading author's last name.

For example a podcast submitted to *DIGITAL HEALTH* in August 2014 by John Smith would have the file name: DHJ1408_smith.

How to submit your podcast

Audio content should be submitted via ScholarOne™ Manuscripts, a web based online submission and peer review system. Please visit <http://mc.manuscriptcentral.com/DHJ> to login and submit your podcast online.

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9. On acceptance and publication

If your paper is accepted for publication after peer review, you will first be asked to complete the contributor's publishing agreement. Once your manuscript files have been checked for SAGE Production, the corresponding author will be asked to pay the article processing charge (APC) via a payment link. Once the APC has been processed, your article will be prepared for publication and can appear online within an average of 30 days. Please note that no production work will occur on your paper until the APC has been received.

9.1 SAGE Production

Your SAGE Production Editor will keep you informed as to your article's progress throughout the production process. Proofs will be sent by PDF to the corresponding author and should be returned promptly. Authors are reminded to check their proofs carefully to confirm that all author information, including names, affiliations, sequence and contact details are correct, and that Funding and Conflict of Interest statements, if any, are accurate. Please note that if there are any changes to the author list at this stage all authors will be required to complete and sign a form authorizing the change. The PDF of your article will be available for download on the journal website after publication.

We value your feedback to ensure we continue to improve our author service levels. Upon publication, all corresponding authors will receive a brief survey questionnaire on your experience of publishing in *DIGITAL HEALTH* with SAGE.

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One of the many benefits of publishing your research in an open access journal is the speed to publication. With no page count constraints, your article will be published online in a fully citable form with a DOI number as soon as it has completed the production process. At this time it will be completely free to view and download for all.

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10. Further information

Any correspondence, queries or additional requests for information on the Manuscript Submission process should be sent to relevant Editor-in-Chief or the *DIGITAL HEALTH* editorial office as follows:

Manuscript Submission Process: digitalhealth@sagepub.co.uk

Engineering, Technology and Health Care: Professor Theodoros N. Arvanitis, Joint Editor-in-Chief: T.Arvanitis@digitalhealthjournal.co.uk

Public Health, Social Sciences and Health Care: Professor John Powell, Joint Editor-in-Chief: J.Powell@digitalhealthjournal.co.uk

Clinical Trials and Applications: Dr John Hixson, Joint Editor-in-Chief: J.Hixson@digitalhealthjournal.co.uk

All other enquiries: Philippa Stevens, Publishing Editor: philippa.stevens@sagepub.co.uk

Additional File 3: Prisma Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	√
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	√ No registration number
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	√
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	√
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	NA
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	√
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	√
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	√
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	√
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	√
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	√
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	√
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	NA
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Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	√
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	NA
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	√
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	√
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	√
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	NA
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	√
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	√
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	√
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	NA – no funders

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: www.prisma-statement.org.