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**“I want you to find a bold and innovative way to do everything exactly the same way it’s been done for 25 years.”**

## **The Evidence Gap**

- **Is there evidence to show that mHealth strategies lead to improved health?**
- **How strong is that evidence?**

# mHealth is not monolithic:

*This impacts -- evaluation, indicators, business models, opportunities and strategies for scale.*



## Education and Awareness

Messaging in support of public health and behavioral change campaigns.



## Diagnostic and Treatment Support

Mobile phones to support provider decisions and as a point-of-care device.



## Disease and Epidemic Outbreak Tracking

Sending and receiving data on disease incidence, outbreaks and public health emergencies.



## Supply Chain Management

Using mobile solution to improve stock-outs and combat counterfeiting.



## Remote Data Collection

Collecting real-time patient data with mobile applications.



## Remote Monitoring

Maintaining care giver appointments or ensuring medication regime adherence.



## Healthcare Worker Communication and Training

Connecting health workers with sources of information.

# mHEALTH: A Health Systems Catalyst

EFFECTIVE  
COVERAGE

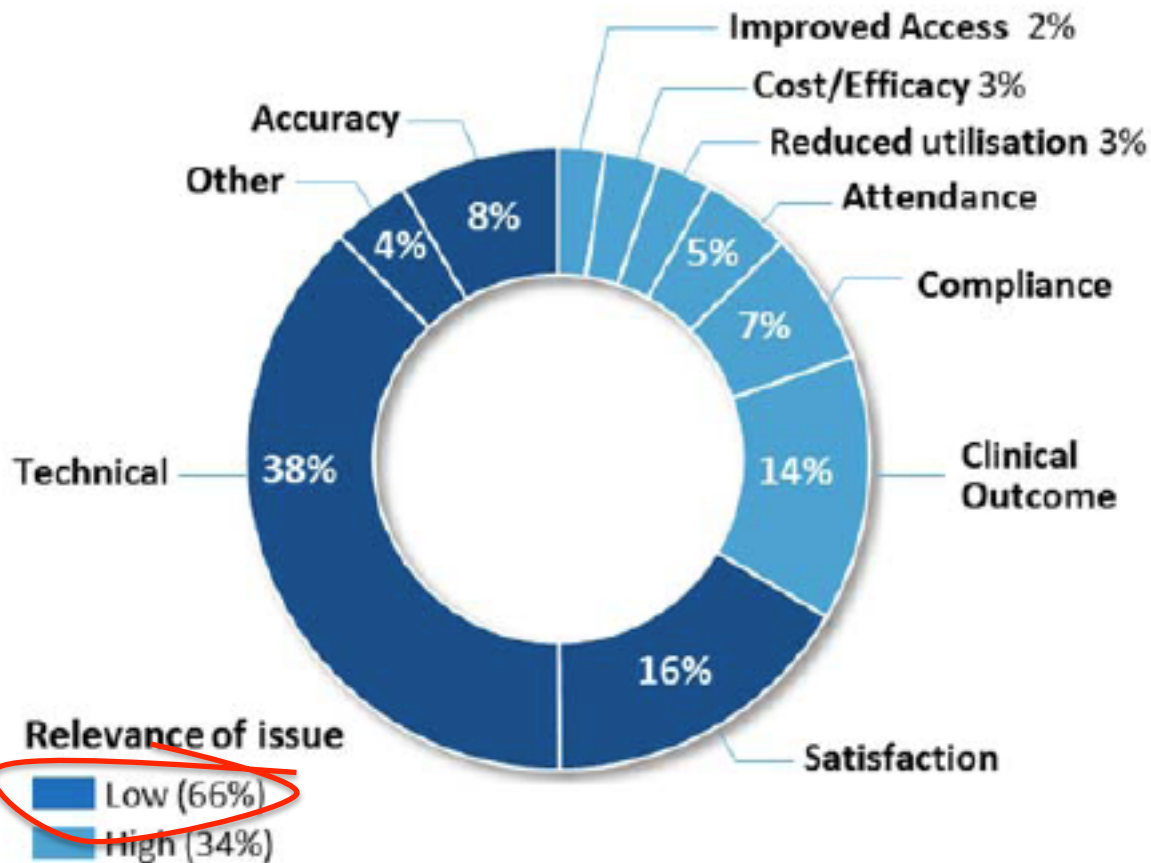


Shift focus from “Does mHealth work?” to “Does mHealth *optimize* what we know works ?”



INTERVENTION  
OF KNOWN  
EFFICACY

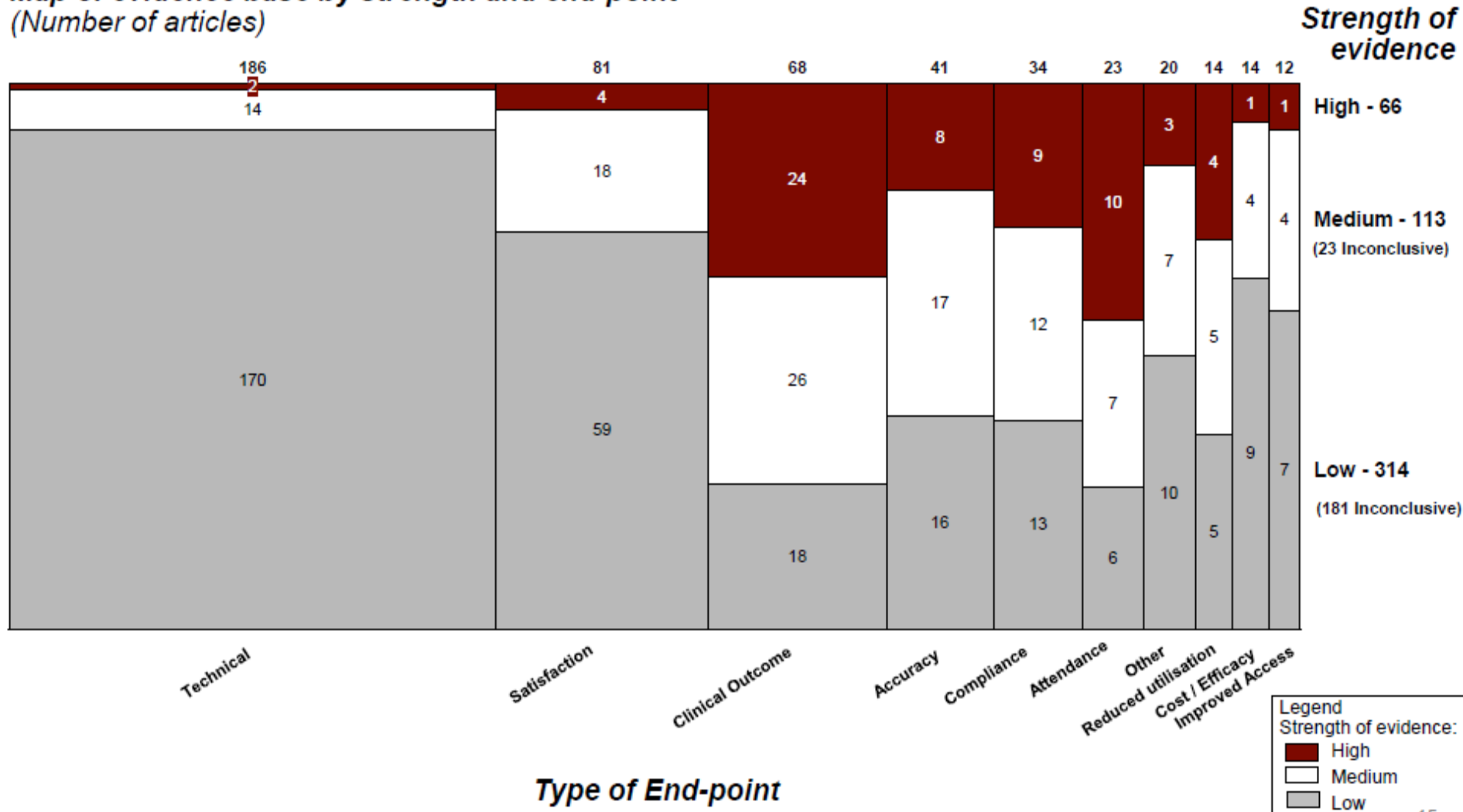
## Distribution of issues examined in Mobile Health research between 2000 and 2010





# 2011: < 13% of primary evidence = High Strength 41% “inconclusive”

**Map of evidence base by strength and end-point**  
(Number of articles)





# Scaling Up mHealth: Where Is the Evidence?

Mark Tomlinson<sup>1\*</sup>, Mary Jane Rotheram-Borus<sup>2</sup>, Leslie Swartz<sup>3</sup>, Alexander C. Tsai<sup>4,5</sup>

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## What Is the Problem?

There are over 6 billion mobile phone subscribers and 75% of the world has access to a mobile phone [1]. Service and care providers, researchers, and national governments are excited at the opportunities mobile health has to offer in terms of improving access to health care, engagement and delivery, and health outcomes [2]. Interventions categorized under the rubric “mobile health” or “mHealth”—broadly defined as medical and public health practice supported by mobile devices [2]—span a variety of applications ranging from the use of mobile phones to improve point of service data collection [3], care delivery [4], and patient communication [5] to the use of alternative wireless devices for real-time medication monitoring and adherence support [6].

A recent World Bank report tracked more than 500 mHealth studies, and many donor agencies are lining up to support the “scaling up” of mHealth interventions [7]. Yet, after completion of these 500 pilot studies, we know almost nothing about the likely uptake, best strategies for engagement, efficacy, or effectiveness of these initiatives. Currently, mHealth interventions lack a foundation of basic evidence [8], let alone a foundation that would permit evidence-based scale up. For example, in Uganda in 2008 and 2009 approximately 23 of 36 mHealth initiatives did not move beyond the pilot phase [9]. The current enthusiasm notwithstanding, the scatter-shot approach to piloting mHealth projects in the absence of a concomitant programmatic implementation and evaluation strategy may dampen opportunities to truly capitalize on the technology. This article discusses a number of points pertinent to developing a more robust evidence base for the scale up of mHealth interventions.

The issues raised are relevant to... and method

Industry/ mHealth s concern. A in South A for scale up low- and i MICs). Ma industry r researchers, i [10]. It is li a quite dif scale up i share, rath comes, at i growing in inantly mo some cauti code of pr ships will li evolution i discuss late the expens public heal

In some magical ap global pub advantages good evide promise is that mobile technologies may solve one of the most difficult problems facing global health efforts—that of structural barriers to access. Travel, especially to remote areas in LAMICs, is expensive,

reminders to improve attendance at health care appointments [13,14]. Yet, none of the studies included in these reviews was conducted in resource-limited settings.

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**Abbreviations:** EBI, evidence-based intervention; LAMIC, low- and middle-income country; mHealth, mobile health; MOST, Multiphase Optimization Strategy.

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**Provenance:** Not commissioned; externally peer reviewed.

## Summary Points

- Despite hundreds of mHealth pilot studies, there has been insufficient programmatic evidence to inform implementation and scale-up of mHealth.
- We discuss what constitutes appropriate research evidence to inform scale up.
- Potential innovative research designs such as multi-factorial strategies, randomized controlled trials, and data farming may provide this evidence base.
- We make a number of recommendations about evidence, interoperability, and the role of governments, private enterprise, and researchers in relation to the scale up of mHealth.

The Essay section contains opinion pieces on topics of broad interest to a general medical audience.



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Letter to the Editor

Hype for mHealth: More “y” or “o” on the horizon?

ARTICLE INFO

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ABSTRACT

Objective: Efforts in the domain of mobile health, or mHealth, have been criticized for the unfettered proliferation of pilots and a lack of a rigorous evidence base to support these strategies. In this letter, we present the response of a group of researchers to these criticisms.

**Results:** We identified 215 unique mHealth studies that were registered in the [clinicaltrials.gov](http://clinicaltrials.gov) database, of which 8.4% ( $n=18$ ) were observational in nature while the remaining 91.6% ( $n=197$ ) were interventional. Of the 215 studies, 81.8% ( $n=176$ ) studies used a classical randomized trial design and 40 new studies were added to the database between May and November 2012 alone. Based on these results, we posit that the field is entering a new ‘era’ where a body of rigorous evaluation of mHealth strategies is rapidly accumulating.

Over the past decade, a growing ‘mHealth’ movement has been exploring and identifying opportunities to improve the delivery of, and access to, health services and information. There are currently 6 billion mobile phone subscriptions permeating 87% of the world’s population, fueling the interest in mHealth solutions as a sea changer for global health [1]. A broad ecosystem has emerged around using mobile technologies to catalyze healthcare, across the economic spectrum, from sophisticated high-income settings to rural populations where basic health needs are often unmet. Technologies used in this space range from simple voice-only phones to highly sophisticated portable computing devices, resulting in a breadth of solutions being developed and tested globally. At the core of most mHealth strategies lies a mix of conventional approaches that optimize processes and meaningful data utilization, to novel systems that depend on emergent sensor technologies to provide diagnostic insights

and personalize care. mHealth can be used to incentivize action, improve timeliness of data collection and utilization, improve access to and communication with clients, provide information on-demand, improve adherence, reduce attrition to clinical follow-up, and document system-client interactions to improve accountability by identifying and acting on missed contacts. There is widespread recognition of the potential inherent in these technologies, across development investors, national governments, global health agencies and the telecommunications sector.

The first ‘era of mHealth’ has been characterized by a global proliferation of proof-of-concept projects. A number of foundations, government agencies and telecommunication operators (e.g., the Bill and Melinda Gates Foundation, USAID, and Vodafone, among others) have provided seed funding mechanisms to help stimulate innovation and experimentation over the past five years. Hundreds of projects,



# PRISMA 2009 Flow Diagram

$n^1 = \text{Original search} + \text{updated search} + \text{trial registries}$

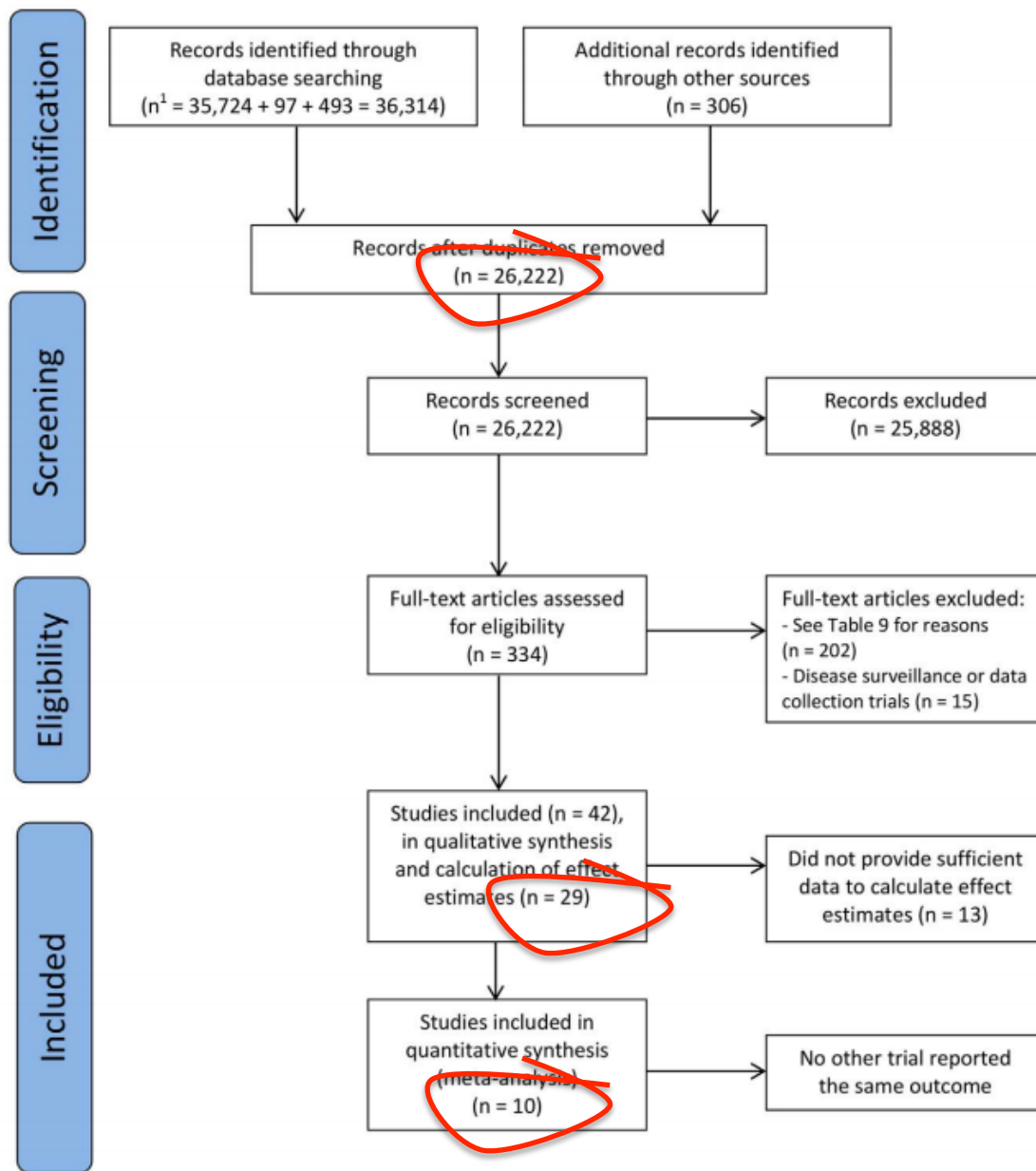


Figure 1. PRISMA 2009 flow diagram. doi:10.1371/journal.pmed.1001363.g001

## The Effectiveness of Mobile-Health Technologies to Improve Health Care Service Delivery Processes: A Systematic Review and Meta-Analysis

Caroline Free<sup>1\*</sup>, Gemma Phillips<sup>1</sup>, Louise Watson<sup>2</sup>, Leandro Galli<sup>1</sup>, Lambert Felix<sup>3</sup>, Phil Edwards<sup>4</sup>, Vikram Patel<sup>5</sup>, Andy Haines<sup>2</sup>

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### Abstract

**Background:** Mobile health interventions could have beneficial effects on health care delivery processes. We aimed to conduct a systematic review of controlled trials of mobile technology interventions to improve health care delivery processes.

**Methods and Findings:** We searched for all controlled trials of mobile technology based health interventions using MEDLINE, EMBASE, PsycINFO, Global Health, Web of Science, Cochrane Library, UK NHS HTA (Jan 1990–Sept 2010). Two authors independently extracted data on allocation concealment, allocation sequence, blinding, completeness of follow-up, and measures of effect. We calculated effect estimates and we used random effects meta-analysis to give pooled estimates. We identified 42 trials. None of the trials had low risk of bias. Seven trials of health care provider support reported 25 outcomes regarding appropriate disease management, of which 11 showed statistically significant benefits. One trial reported a statistically significant improvement in nurse/surgeon communication using mobile phones. Two trials reported statistically significant reductions in correct diagnoses using mobile technology photos compared to gold standard. The pooled effect on appointment attendance using text message (short message service or SMS) reminders versus no reminder was increased, with a relative risk (RR) of 1.06 (95% CI 1.05–1.07,  $I^2 = 6\%$ ). The pooled effects on the number of cancelled appointments was not significantly increased RR 1.08 (95% CI 0.89–1.30). There was no difference in attendance using SMS reminders versus other reminders (RR 0.98, 95% CI 0.94–1.02, respectively). To address the limitation of the older search, we also reviewed more recent literature.

**Conclusions:** The results for health care provider support interventions on diagnosis and management outcomes are generally consistent with modest benefits. Trials using mobile technology-based photos reported reductions in correct diagnoses when compared to the gold standard. SMS appointment reminders have modest benefits and may be appropriate for implementation. High quality trials measuring clinical outcomes are needed.

Please see later in the article for the Editors' Summary.

**Citation:** Free C, Phillips G, Watson L, Galli L, Felix L, et al. (2013) The Effectiveness of Mobile-Health Technologies to Improve Health Care Service Delivery Processes: A Systematic Review and Meta-Analysis. *PLoS Med* 10(1): e1001363. doi:10.1371/journal.pmed.1001363

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**Competing interests:** VP is a member of the Editorial Board of PLOS Medicine. The authors have declared that no other competing interests exist.

**Abbreviations:** ECG, electrocardiogram; m-Health, mobile-health; MMS, multimedia message; PDA, personal digital assistant; RR, relative risk; SMS, short message service

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# **mHealth Technical Evidence Review Group for RMNCH**

## **“m-TERG”**

*“Providing governments and implementing agencies objective, evidence-based guidance for the selection and scale of mHealth strategies across the reproductive, maternal, newborn and child health continuum”*

## Two Initial Areas Selected

*Do mHealth strategies:*

PROVIDER  
ADHERENCE

- *improve provider adherence to care and treatment guidelines ?*

STOCKOUTS

- *reduce stockouts of essential maternal health drugs and commodities?*

## **Bridging the Evidence Gap - Methods**

- 1. Document Search “beyond the peer-reviewed”:  
articles, reports, blogs, presentations using extended  
strategy, ‘sleuthing’ references and links**
- 2. Included documents which describe:**
  - **Implementation of an mHealth intervention**
  - **Systematic Evaluation Methodology**
- 3. Tag document using WHO mTERG taxonomy**
- 4. Grade document quality using WHO mTERG  
instrument**
- 5. Summary / Synthesis of overall direction, magnitude  
and consistency of effect**

# Grading quality of evidence

- A flexible approach that allows the grading of reporting and methodology for varied study designs
- **Domain 1:** Reporting and Methodology – This is indicative of the quality of methodological rigor employed by the studies under consideration, as well as the reporting standards that have been adhered to.
- **Domain 2:** Essential mHealth criteria – Classifies the studies under consideration based on the quality of information presented about the mHealth intervention.

## Two Initial Areas Selected

*Do mHealth strategies:*

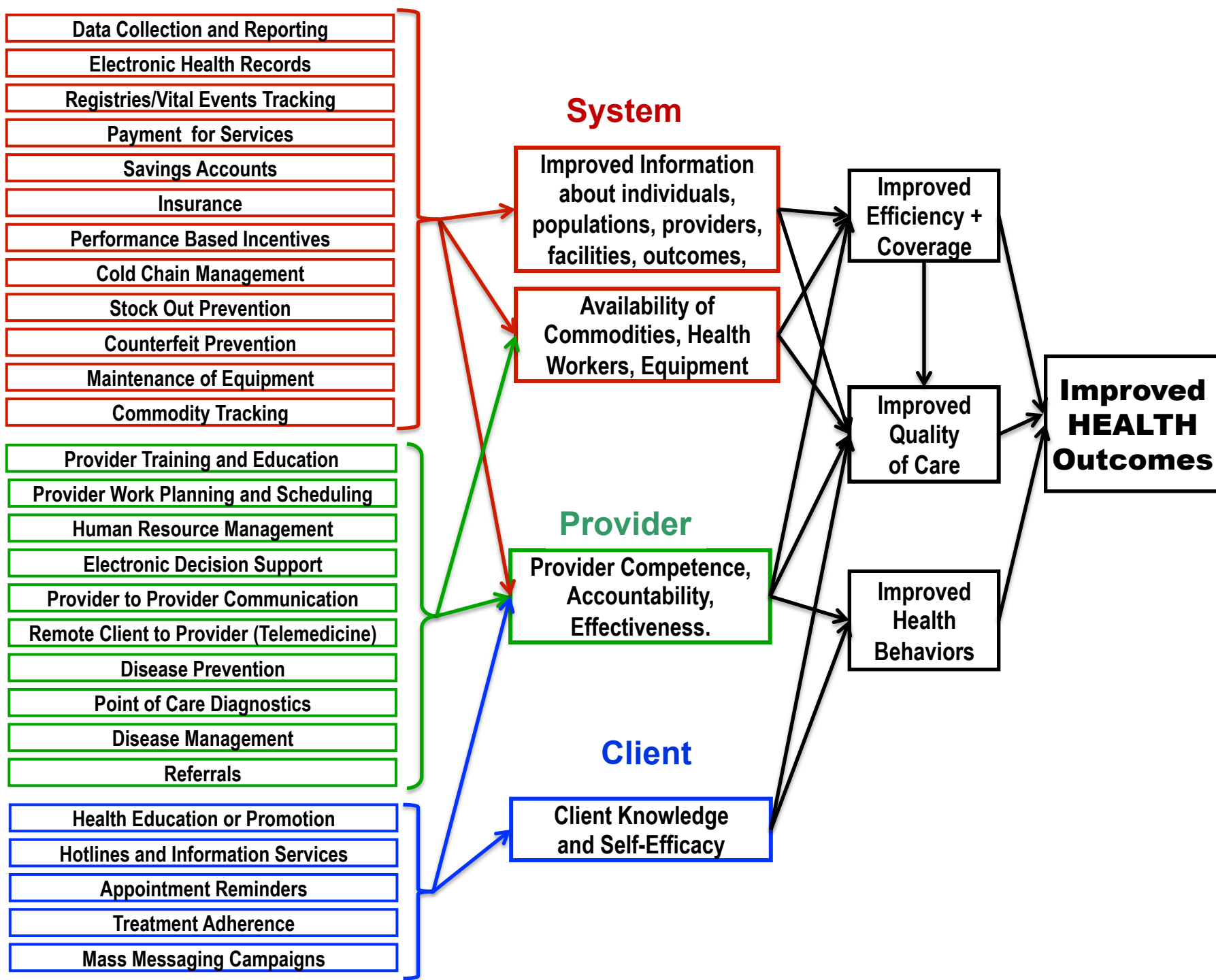
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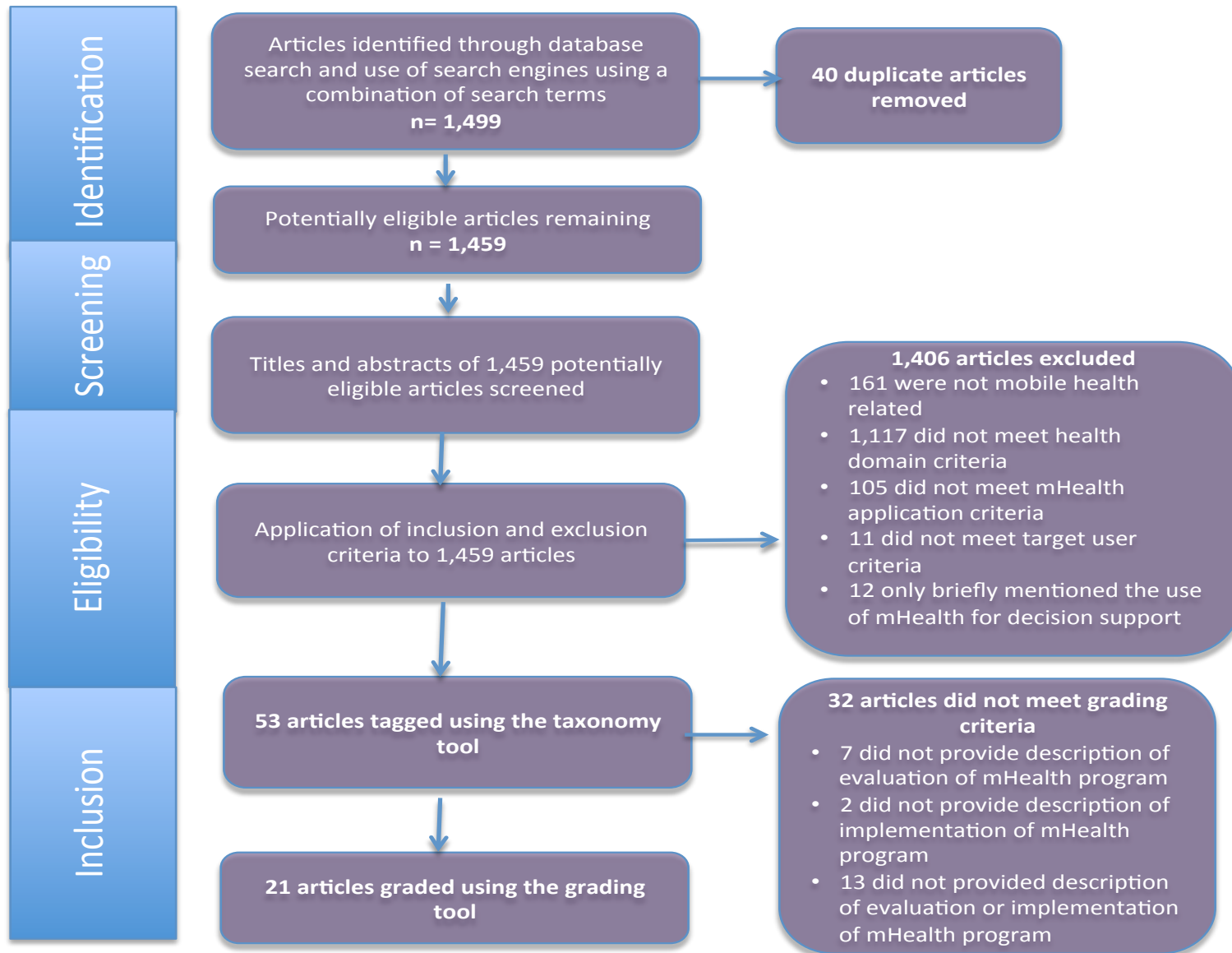




# Search Strategy

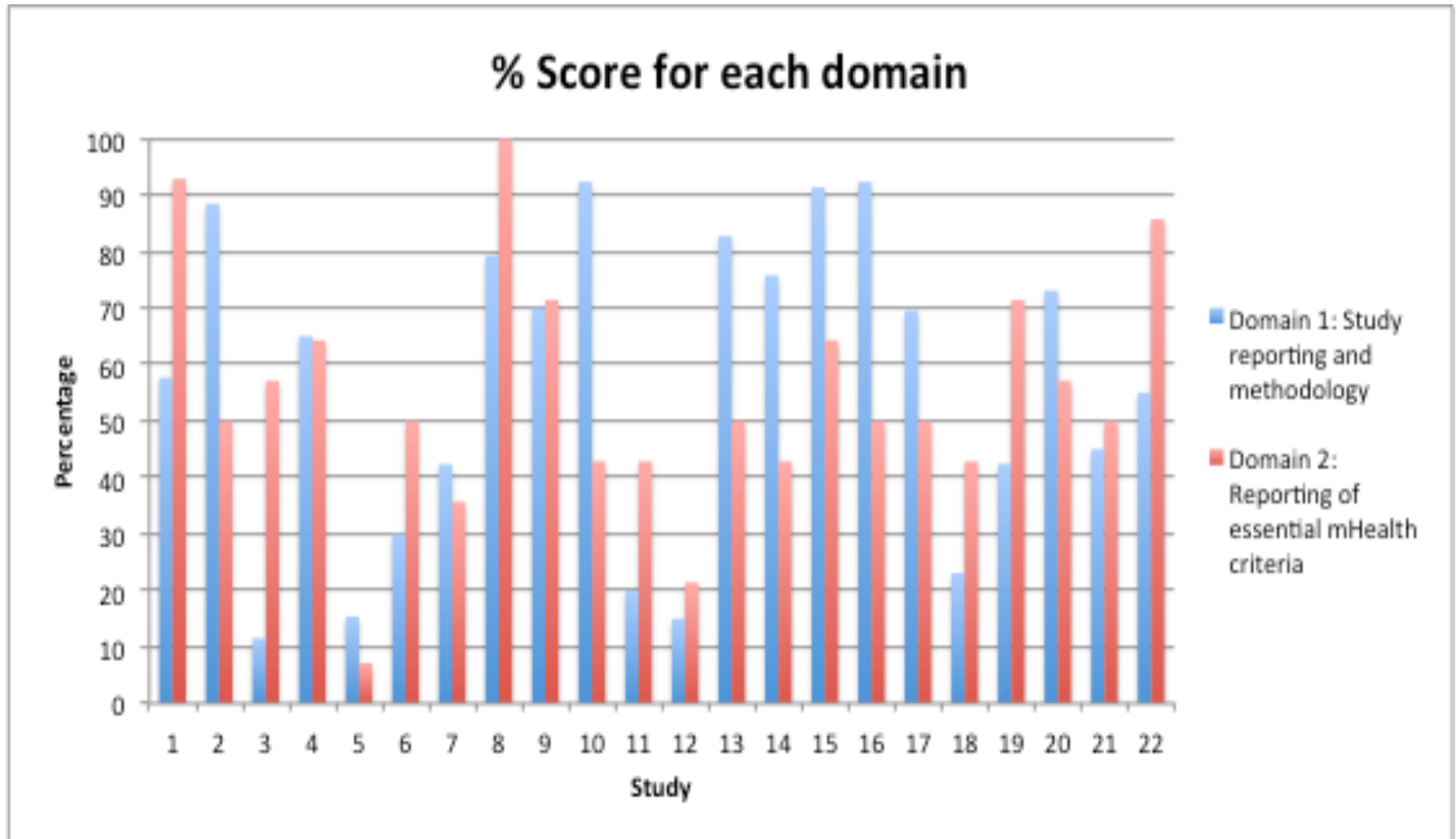
PROVIDER  
ADHERENCE

mHealth for  
maternal health  
*bridging the gaps*



# Quality of Information

PROVIDER  
ADHERENCE



**Completeness of description of methodology**

**Completeness of description of technology, intervention**

## Can mHealth strategies be used to improve provider adherence to care and treatment guidelines?

- Domain 1 score ranged from 5 to 37 points out of a maximum 47-point score (11 to 79%)m suggesting large variations in quality and methodology of reporting
- Only three of the 21 graded studies achieved a score >75% for Domain 2 (essential mHealth criteria), which indicates that most studies do not adequately describe the mHealth intervention they are reporting on.

Authors	Type of study	Findings	Grade scores for strength of evidence (%)	
			Domain 1: Reporting and Methodology	Domain 2: Reporting of essential mHealth criteria
<a href="#">DeRenzi et al</a>	Non-Experimental: quantitative	<ul style="list-style-type: none"> <li>The investigation in rural Tanzania suggests that e-IMCI is almost as fast as the common practice and potentially improves care by increasing adherence to the IMCI protocols.</li> <li>Additionally, the authors found clinicians could quickly be trained to use e-IMCI and were very enthusiastic about using it in the future.</li> </ul>	58%	93%
<a href="#">Zurovac et al</a>	Experimental: quantitative	<ul style="list-style-type: none"> <li>The study found that for health workers who received the SMS reminders, correct management of pediatric malaria increased by almost 25% at both 6 months and 12 months--an increase 2.5 times higher than more complex methods of improving protocol adherence.</li> </ul>	88%	50%
<a href="#">Bogan et al</a>	Non-Experimental: mixed methods	<ul style="list-style-type: none"> <li>CHWs were able to use <u>CommCare</u> quickly and easily and indeed is based on the specific functions they request, rather than making a product that tries to do it all.</li> <li>The authors found many unexpected problems (like battery swapping) and some things we would expect to be problems (such as phone literacy or learning to navigate the program) were not.</li> <li>Perhaps the most important lesson learned is to form a true partnership with the users throughout the design process.</li> </ul>	21%	50%
<a href="#">Chib</a>	Experimental: mixed methods	<ul style="list-style-type: none"> <li>The study found that results on midwives' knowledge of standard delivery procedures were mixed.</li> <li>The intervention group's knowledge scores were significantly higher for two questions (p=0.01 and p=0.06) but lower for one question (p=0.03). However, <a href="#">Chib</a> concluded that the demonstrated potential for knowledge improvement suggests that introducing targeted messages about standard procedures delivered by mobile phone could be effective.</li> </ul>	79%	100%
<a href="#">DeRenzi et al (2)</a>	Non-Experimental: qualitative	<ul style="list-style-type: none"> <li>The results suggest that electronic implementations of protocols such as IMCI can reduce training time and improve adherence to the protocol.</li> <li>They also highlight several important challenges including varying levels of education, language and expertise, which could be most adequately addressed by implementing novel intelligent user interfaces and systems.</li> </ul>	61%	71%
<a href="#">Florez-Arango et al</a>	Experimental: quantitative	<ul style="list-style-type: none"> <li>The automated guidelines increased protocol adherence by an average of 30.18% (p&lt;0.001) and reduced errors by an average of 33.15% (p=0.001) overall.</li> <li>The authors concluded that the IMCI tool effectively simplified a complex set of guidelines, reduced the health workers' cognitive workload, and eliminated the need to recall specific guidelines or patient information during patient visits while providing a high level of clinical care.</li> </ul>	92%	43%



- **The studies that were methodologically sound showed significant improvement of HW performance when using mHealth**

***Examples:***

- In South Africa, Rhode and colleagues randomized 24 primary care nurses to be trained in IMCI using traditional paper-based guidelines, and concluded that nurses who used the IMCI decision-support tool were significantly more likely to make an accurate diagnosis ( $p < 0.001$ ).
  - In rural Kenya, Zurovac et al randomized outpatient health workers with mobile phones to receive text message reminders about national pediatric malaria guidelines to improve and sustain protocol adherence. For health workers who received the SMS reminders, correct management of pediatric malaria increased by almost 25% at both 6 months and 12 months
- **The use of mHealth varied: e-training, peer to peer, SMS reminders, decision support**

## Two Initial Areas Selected

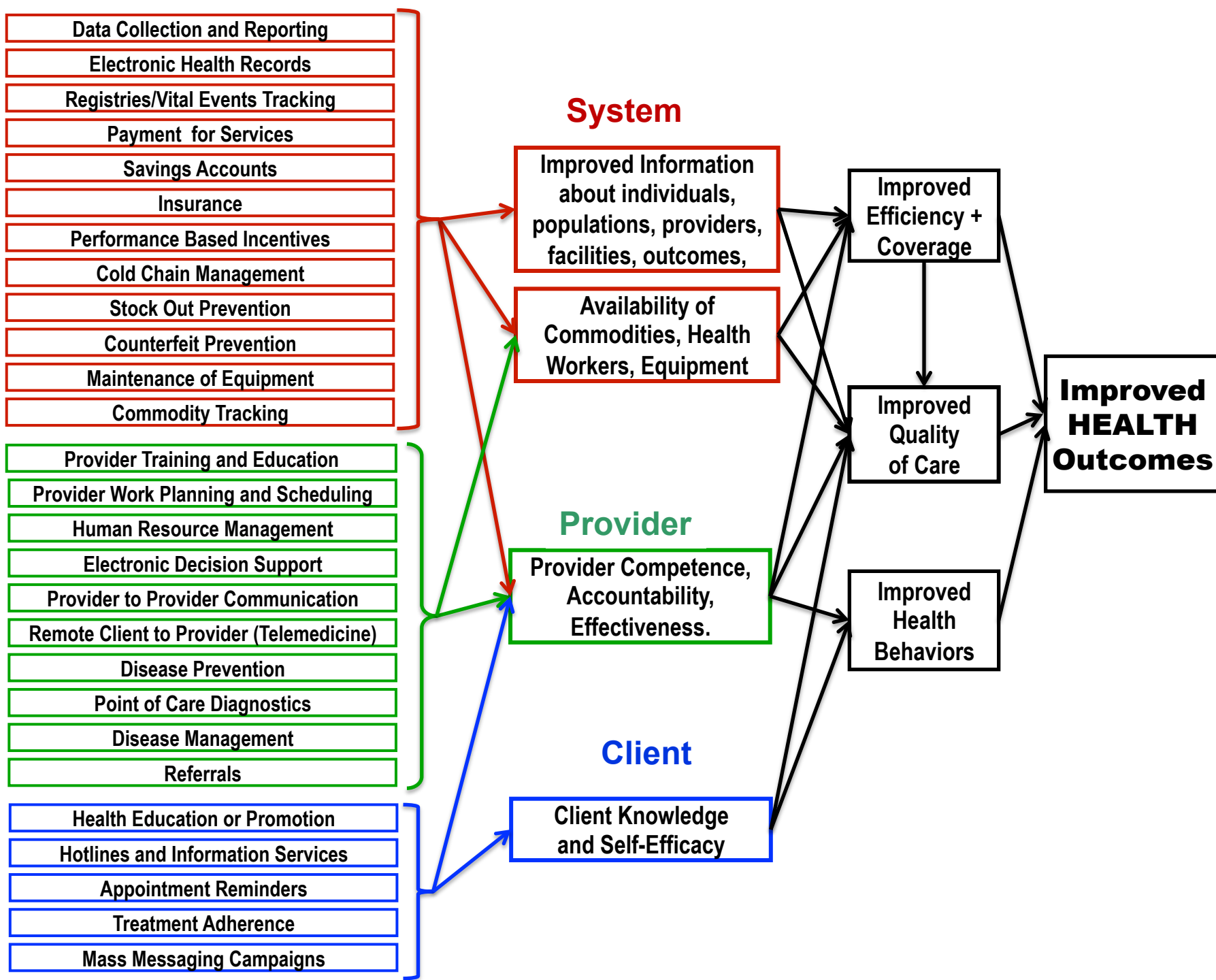
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**STOCKOUTS**

- Data Collection and Reporting**
- Electronic Health Records
- Registries/Vital Events Tracking
- Payment for Services
- Savings Accounts
- Insurance
- Performance Based Incentives
- Cold Chain Management
- Stock Out Prevention**
- Counterfeit Prevention**
- Maintenance of Equipment
- Commodity Tracking**

**System**

Improved Information about individuals, populations, providers, facilities, outcomes,

**Availability of Commodities, Health Workers, Equipment**

- Provider Training and Education
- Provider Work Planning and Scheduling
- Human Resource Management
- Electronic Decision Support
- Provider to Provider Communication**
- Remote Client to Provider (Telemedicine)
- Disease Prevention
- Point of Care Diagnostics
- Disease Management
- Referrals

**Provider**

Provider Competence, Accountability, Effectiveness.

- Health Education or Promotion
- Hotlines and Information Services
- Appointment Reminders
- Treatment Adherence
- Mass Messaging Campaigns

**Client**

Client Knowledge and Self-Efficacy

**Improved Efficiency + Coverage**

**Improved Quality of Care**

**Improved HEALTH Outcomes**

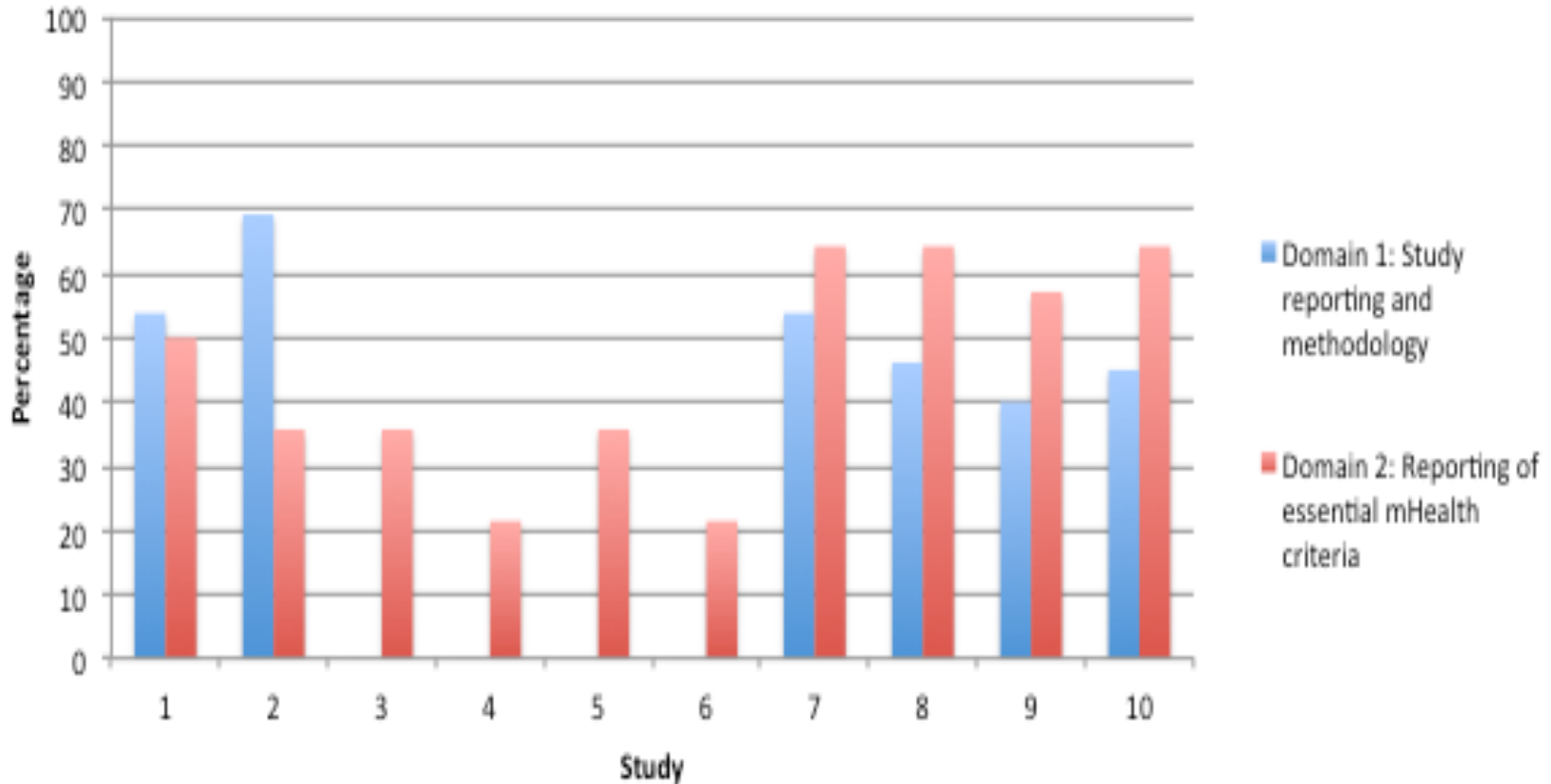
Improved Health Behaviors

# Search Strategy

## STOCKOUTS



### % Score for each domain



**Completeness of description of methodology**

**Completeness of description of technology, intervention**



Author/ mHealth Program	Type of study	Findings	Grade scores for strength of evidence (%)	
			Domain 1	Domain 2
<b>Barrington et al</b>	Experimental: Quantitative	<ul style="list-style-type: none"> <li>Proportion of health facilities that reported no stock-outs of <math>\geq 1</math> anti-malarial drug fell from 78% to 26% over 21 weeks of follow-up.</li> <li>In one district, stock-outs were eliminated by week 8.</li> </ul>	54%	50%
<b>Githinji et al</b>	Experimental: Quantitative	<ul style="list-style-type: none"> <li>79% of the stock-out parameters were accurately reported.</li> <li>Over 26 weeks, percentage of facilities reporting stock-out of <u>Artemether-Lumefantrine</u> reduced by 38%.</li> <li>Of the 176 stock-out alerts, district managers initiated redistribution of stocks in response to 44% alerts.</li> </ul>	69%	36%
<b>Banks</b>	Case Study (News service)	<ul style="list-style-type: none"> <li>FrontlineSMS was used to validate, consolidate, and transmit stock-out data to <u>Ushahidi- a software</u> that displays crowd-sourced information on an online map.</li> <li>Bigger “hotspots” represented greater number of drug stock-outs and allowed collation of stock out information</li> </ul>	0	21%
<b>mTrac</b>	Case study	<ul style="list-style-type: none"> <li>57 districts in Uganda have received <u>mTrac</u> training</li> <li>1000 are submitting stock-outs data</li> </ul>	0	35%
<b>cStock</b>	Experimental: Quantitative (Webinar presentation)	<ul style="list-style-type: none"> <li>Piloted in 6 districts in Malawi</li> <li>94% Health Surveillance <u>Assistants</u>(HSAs) use cStock to request drugs from local facilities.</li> <li>Reporting rates for cStock remained over 80% during 5 months of follow-up.</li> </ul>	0	21%
<b>Asimwe et al</b>	Experimental: Quantitative and qualitative	<ul style="list-style-type: none"> <li>Study suggests that SMS-based stock-outs reporting can improve timeliness in the flow of data</li> </ul>	53%	64%
<b>Rui Xue</b>	Case Study	<ul style="list-style-type: none"> <li>Study suggests that the inventory system in Uganda optimized ordering of stocks</li> </ul>	46%	64%
<b>Shao et al</b>	Non-Experimental	<ul style="list-style-type: none"> <li>Mobile-based data collection can potentially improve visualization of data in a web-interface and has applications to prevention of stock-outs</li> </ul>	45%	64%
<b>Supply Chains for CCM</b>	Program Report	<ul style="list-style-type: none"> <li>Supply Chain for Community Case management (SC4CCM) aims to improve availability of CCM products at the lowest level of the supply chain in Rwanda.</li> </ul>	40%	57%
<b>PBS</b>	News report	<ul style="list-style-type: none"> <li>By using mobile technology, health workers are able to send a text message about their drug supply needs</li> <li>This system can potentially reduce stock-out of drugs</li> </ul>	0	21%

## The Evidence Gap

- Overall, a majority of the evidence was anecdotal and the evidence to suggest effectiveness of use of mHealth strategies to prevent stock-outs is weak
- A number of projects are being currently implemented but have limited published results on effectiveness

## The Evidence Gap - Overall

- Across both domains, there are many interventions but most are incompletely described
- Almost none have design that allow rigorous evaluation
- Almost none have control groups
- It is impossible to compare or combine study results due to lack of standardization
- The nature of the exact interventions differs
- Differing indicators make meta-analyses difficult