The **M**obile Phone **S**olutions for **Im**m**u**nizations Trial (M-SIMU):
A cluster randomized controlled trial in western Kenya

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February 18, 2014

Vaccines save lives

- Vaccines are a cost-effective public health intervention
  - Prevent over 2 million deaths per year (WHO, 2009)

Projected number of future deaths averted by WHO region in cohorts vaccinated during 2011–2020 in 73 low- and lower–middle-income countries.

WHO region	Number of countries	Deaths averted	Percent of total
Africa	37	12,099,594	51.9
Southeast Asia	9	6,365,751	27.3
Eastern Mediterranean	6	2,966,358	12.7
Western Pacific	7	1,267,391	5.4
Europe	8	460,340	2.0
Americas	6	165,979	0.7
Total	73	23,325,413	100.0

Lee. Vaccine 31S (2013) B61– B72

- Yet, low coverage and delays persists across LMICs

Vaccine Delays across 45 LMICs

	BCG	DTP1	DTP3	MCV1
Target (weeks)	0 (0–0)	6 (6–9)	14 (14–17)	39 (39–39)
Coverage at				
4 weeks	49% (30–70)			
8 weeks	69% (48–81)	24% (8–36)		
12 weeks	74% (62–86)	57% (46–70)		
4 months	82% (68–90)	73% (60–83)	10% (4–22)	
5 months	84% (70–90)	80% (64–88)	27% (16–42)	
6 months	85% (73–91)	82% (67–89)	36% (23–54)	
9 months	87% (75–92)	87% (75–92)	59% (43–72)	12% (10–14)
12 months	89% (76–93)	88% (73–92)	65% (49–79)	54% (37–69)
18 months	90% (78–94)	90% (75–94)	72% (52–83)	74% (58–82)
24 months	90% (78–94)	90% (76–94)	74% (53–84)	80% (62–88)
36 months	91% (78–95)	91% (76–95)	76% (56–85)	82% (66–91)
Index				
All countries	84% (73–89)	84% (70–89)	63% (45–72)	74% (58–83)
African region*	83% (72–86)	78% (67–85)	58% (40–68)	67% (56–80)
Americas region†	91% (87–93)	91% (88–93)	75% (55–79)	83% (76–87)

BCG=bacille Calmette-Guérin. DTP=diphtheria, tetanus, and pertussis. MCV=measles-containing virus. *27 countries covered by the WHO Regional Office for Africa. †Nine countries covered by the WHO Regional Office for the Americas.

Table 2: Target ages and median (IQR) for estimated coverage at different ages across 45 countries

Intervention Points for Increasing Immunization Coverage

- Reminders
- Incentives

- Knowledge
- SES
- Forgetfulness
- Perceptions
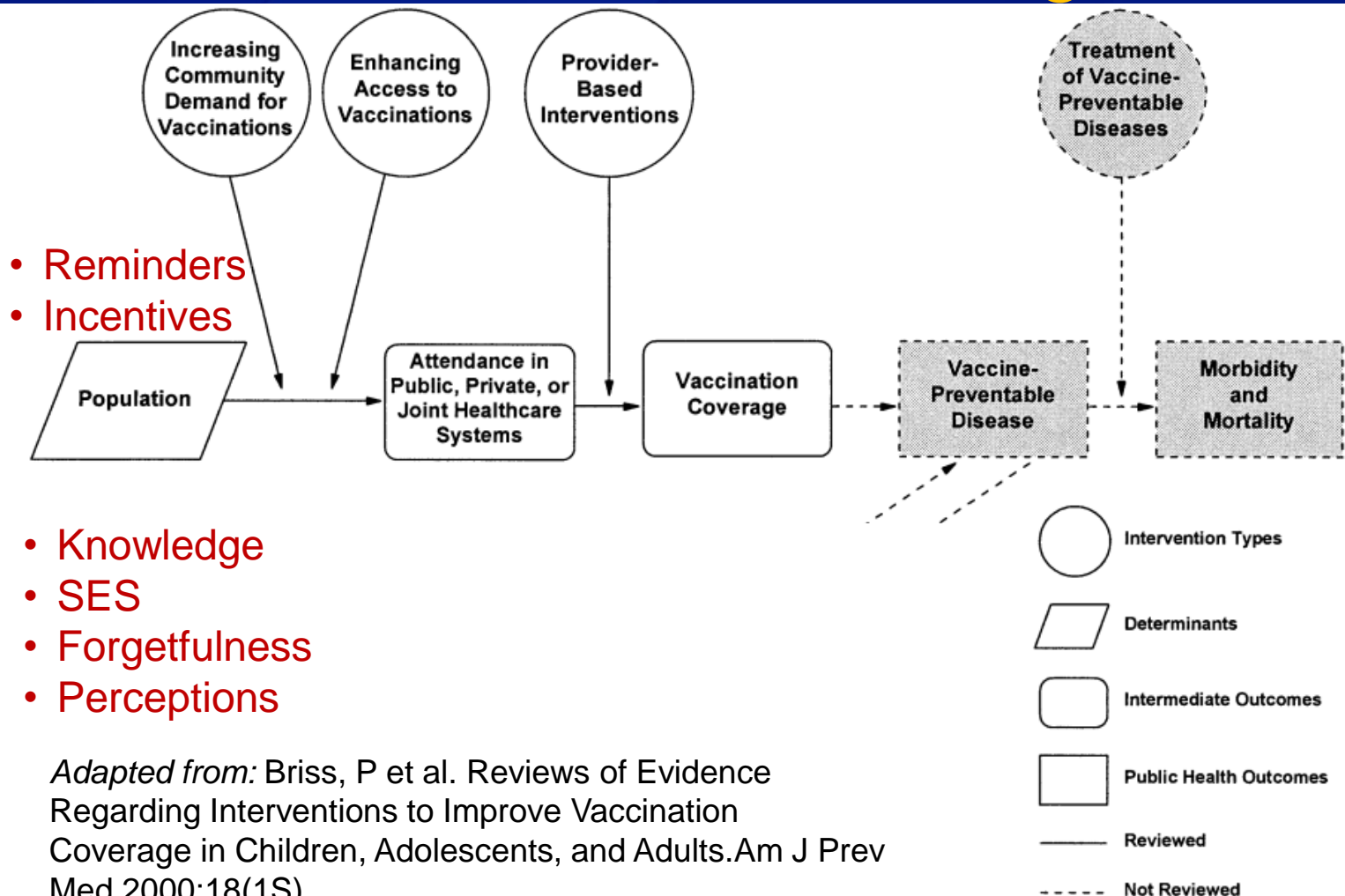
Adapted from: Briss, P et al. Reviews of Evidence Regarding Interventions to Improve Vaccination Coverage in Children, Adolescents, and Adults.Am J Prev Med 2000;18(1S)

RCTs find SMS reminders in Africa work

Author (yr)	Population	SMS reminder	Phone ownership	Result
Lund (2014)	2550 with 1 ANC-Zanzibar	Bi-monthly + voucher	37% own Share?	13% diff. in ≥4 ANC visits
Pop-Eleches (2011)	431 adults on HART-Kenya	Weekly for 48 wks	100%- given phones	13% diff. in ARV adher.
Zurovac (2011)	119 HW Kenya	2 per day for 6 months	≈100% of HW	23.7% diff in correct treatment
Odeny (2012)	1200 adults circumcised-Kenya	Daily for 1 wk	100% own	5.7% diff. in post-op visit
Lund (2012)	2550 with 1 ANC-Zanzibar	Bi-monthly + voucher	37% own Share?	13% diff. in skilled delivery
Mbuagbaw (2012)	200 adults on ART-Cameroon	Weekly for 6 mos	100%	-3.4% diff. in ART adherence. NS
Lester (2010)	538 adults on ART-Kenya	Weekly for 1 yr	86% own 14% share	12% diff. in HART adherence
De Tolly (2011)	2553 adults S. Africa	3 or 10 SMS Motiv. or Info	100%?	OR=1.7 Moti-10 in HIV testing

SMS content and dosage can influence the reminder's effectiveness

- SMS reminders for HIV test results

Table 3. Impact of Dosage and Content on Decision to Test for Human Immunodeficiency Virus			
ANALYSIS	GROUP	ODDS RATIO	P-VALUE
Content	MOTI-3 vs. INFO-3	OR = 0.80; 95% 0.55–1.14	0.233
	MOTI-10 vs. INFO-10	OR = 1.62; 95% 1.10–2.39	0.016
Dosage	INFO-10 vs. INFO-3	OR = 0.88; 95% 0.61–1.25	0.47
	MOTI-10 vs. MOTI-3	OR = 2.322; 95% 1.55–3.50	2.2e-05

de Tolly, K. Telemedicine and E-Health. 2012

- SMS reminders sent to CHW for pediatric malaria treatment
  - "You know as I say food without salt is not tasty so I think they were trying to make us enjoy the message." 5–21.

Jones, C. PLoS ONE. 2012

Incentives enact behavior change

- Monetary or other remunerable good given conditioned on completion of behavior
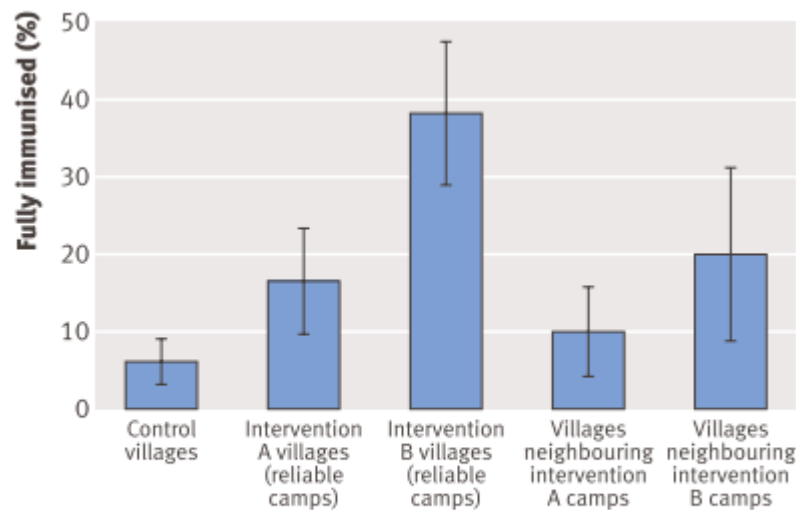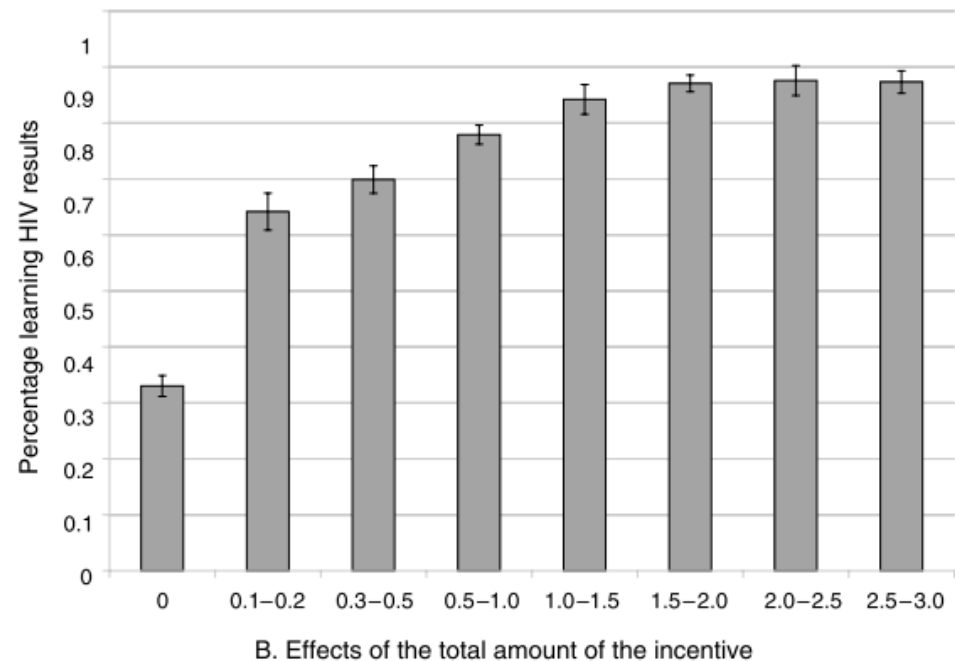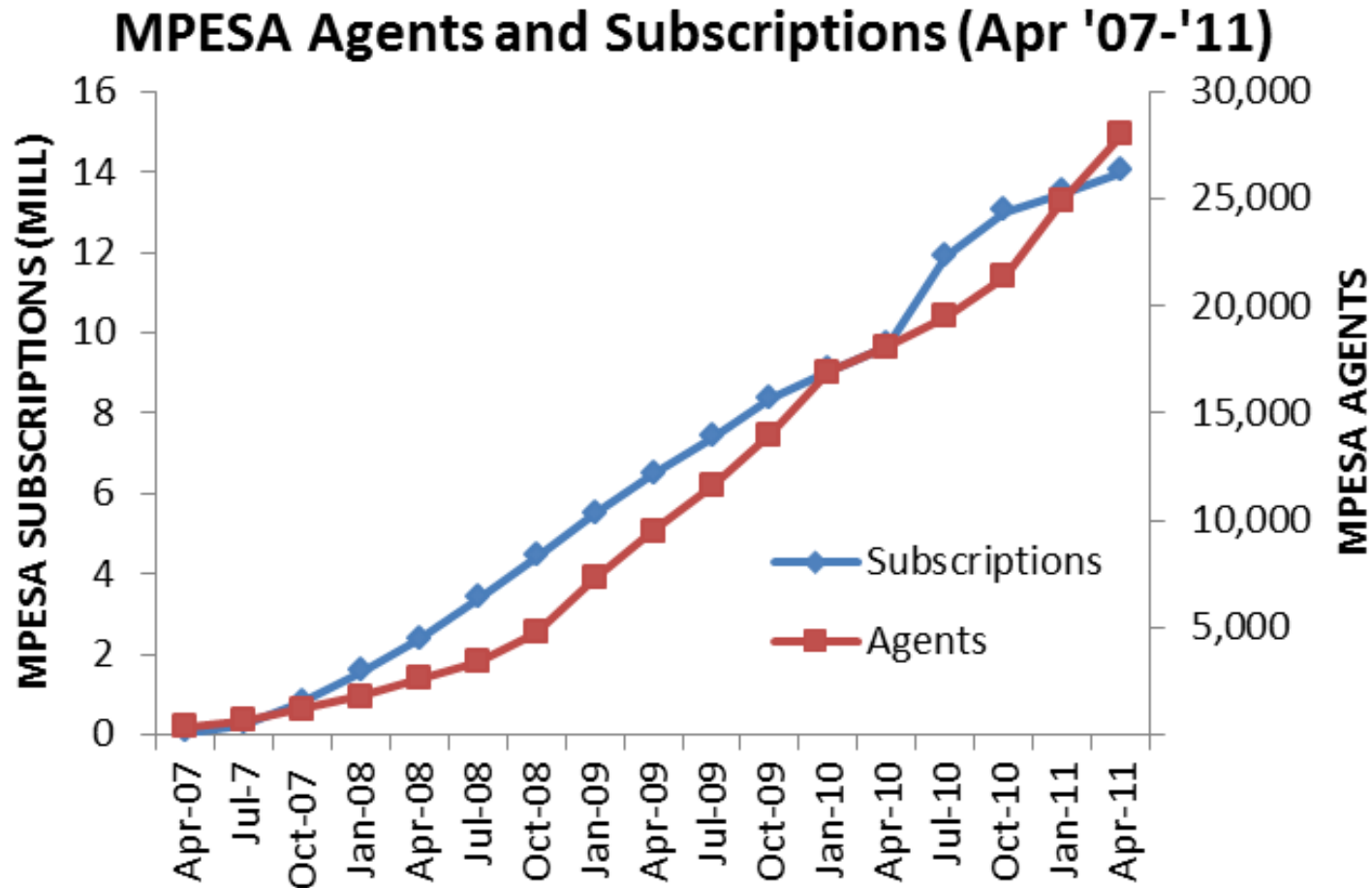- Pushes the tipping point towards health behavior change

Fig 2 | Percentage of children aged 1-3 years fully immunised by treatment status

B. Effects of the total amount of the incentive

The rise of MPESA

MPESA Agents and Subscriptions (Apr '07-'11)

Oh no, a pilot study

- SMS reminders and 150 KSH in either airtime or mobile money for pentavalent vaccination
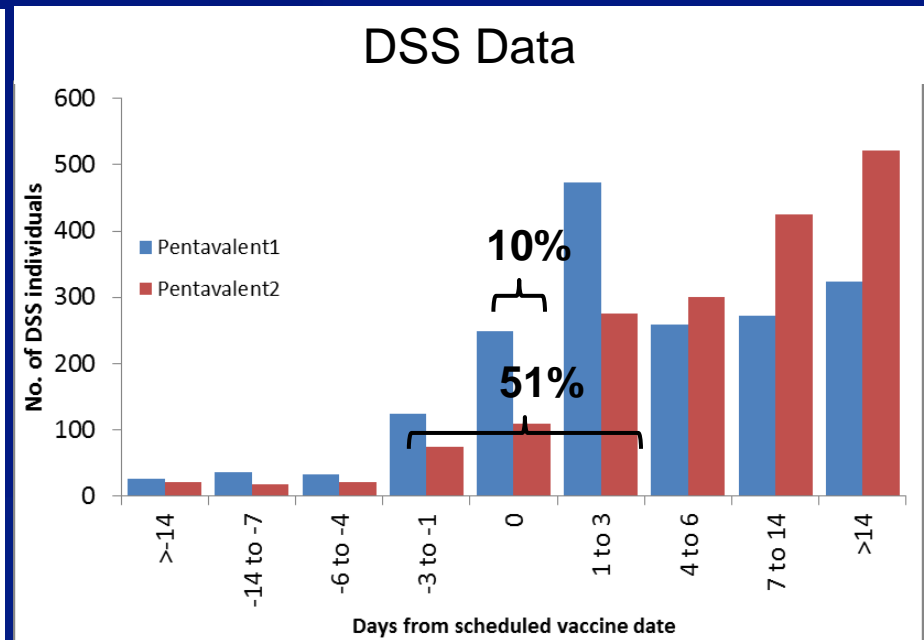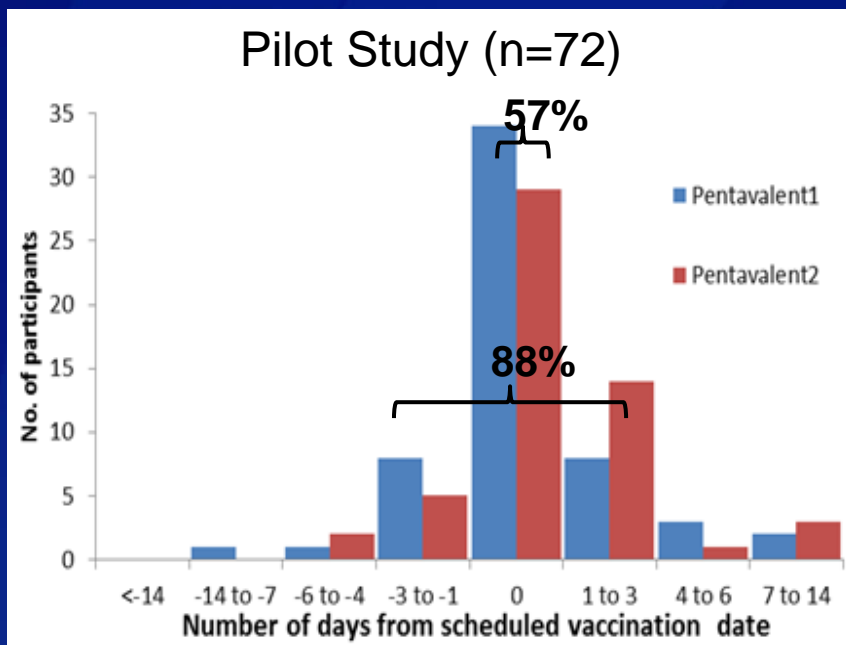
- 62% cashed out same day, 89% ≤ 3 days
- Prefer money over airtime

Wakadha H, et al. *Vaccine*. 2013. 31(6):987-93

M-SIMU Study Design

A cluster randomized controlled trial

Study Area

- 152
  - 1
    e
  - 3
    e
- 24 h
- With
  surv

Phone Ownership OK….. phone access great

Compound A
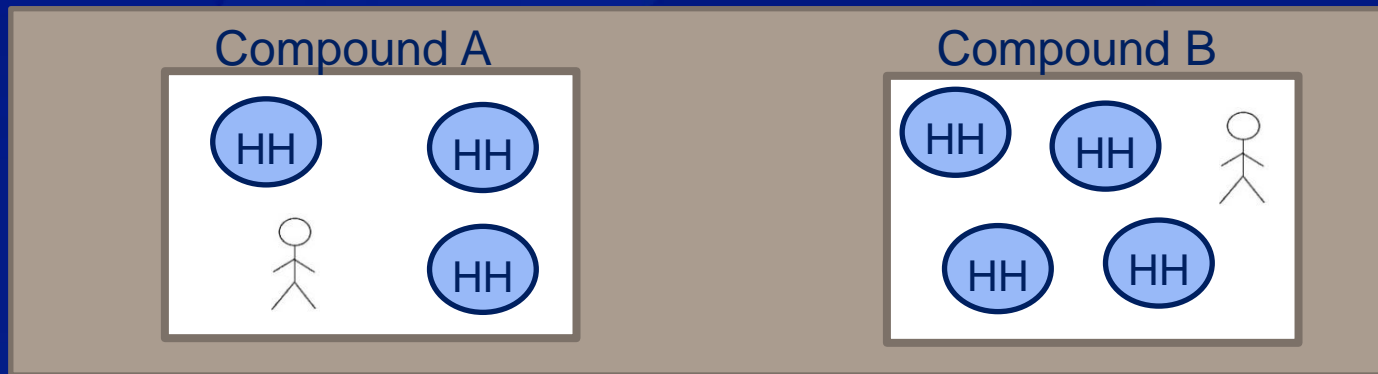
Compound B

Mobile Phone Ownership/Access	N (%)	Cum. %
Mother owns	1751 (55%)	55%
Access at household	1064 (34%)	89%
Access at compound	160 (5%)	94%
None of the above	195 (6%)	

Maternal age, literacy, SES, husband's education, and smaller # of persons in household associated with mother's phone ownership

Kenyan moms receive & send SMS

Receiving SMS by Phone Access

Ownership/ Access	Receive SMS	Do Not Receive SMS
Own	565 (97%)	16 (3%)
Household	171 (51%)	162 (49%)
Compound	12 (26%)	35 (74%)
None	7 (10%)	61 (90%)
Total	**755 (73%)**	**274 (27%)**

Time to receive SMS by phone ownership/access in those that receive SMS

Ownership/ Access	Immediately	<1 day	>1 day
Own	471 (83%)	86 (15%)	8 (1%)
Household	105 (61%)	58 (34%)	8 (5%)
Compound	4 (33%)	7 (58%)	1 (8%)
None	5 (71%)	2 (29%)	0 (0%)
Total	**585(78%)**	**153 (20%)**	**17 (2%)**

Sending SMS by Phone Access

Ownership/ Access	Send SMS	Do Not Send SMS
Own	407 (70%)	175 (30%)
Household	137 (41%)	196 (59%)
Compound	12 (26%)	35 (74%)
None	3 (4%)	65 (96%)
Total	**559 (54%)**	**471 (46%)**

- Median SMS RECEIVED= 5 per wk
- Median SMS SENT= 3 per wk

Mobile Phone Characteristics & 'Literacy'

Phone brought to FGD	N (%)
Yes	27 (90%)
No	3 (10%)
Credit Amount on Phone (Ksh)	
0-0.99	9 (33%)
1-5	11 (40%)
5-20	7 (26%)
Battery Charge on Phone (%)	
0-25	6 (22%)
26-50	1 (4%)
51-75	7 (26%)
76-100	13 (48%)
Remember p/w sent 1 before FGD	
Sent to wrong number	1 (3%)
No	9 (30%)
Yes	20 (67%)
Can open and read SMS	
No, can't open or read	2 (7%)
Yes, with difficulty	1 (3%)
Yes, easily	27 (90%)

- June 2013
- 3 groups of 9-12 mothers

Main Question of RCT

- Can we increase the proportion of infants that are fully vaccinated using SMS reminders and mobile money incentives?

Vaccine	Birth	6 wks	10 wks	14 wks	9 mos
BCG	1				
Pentavalent		1	2	3	
Polio		1	2	3	
Measles					1

Secondary Outcomes

- FIC at 10 months of age
- Pentavalent3 at 24weeks of age
- Measles at 10 and 12 months
- Timeliness of each vaccine dose
- Other health status indicators
- Effect modification of distance to HF and phone ownership with FIC
- Direct costs of intervention

Argument for an RCT

- Gold standard of scientific evidence
  - Minimizes biases
  - Reduces spurious causality

M-SIMU Timeline

July 2011----pilot study

August 2011 ----RCT conceptualization

January 2012---Initial talks with BMGF

May 2012- submitted grant to BMGF

July 2012-----Submit to SSC/ERC

Nov. 2012----BMGF grant received

March 2013---ERC approved

March 2013----TAG group formed

March-Sept. 2013- Community Mobilization-
     village chief, CAB, MOH, DMOH, Health Facilities

Mar-Apr 2013---Baseline Survey

June 2013----Focus groups

Sept 2013---Public Randomization Ceremony
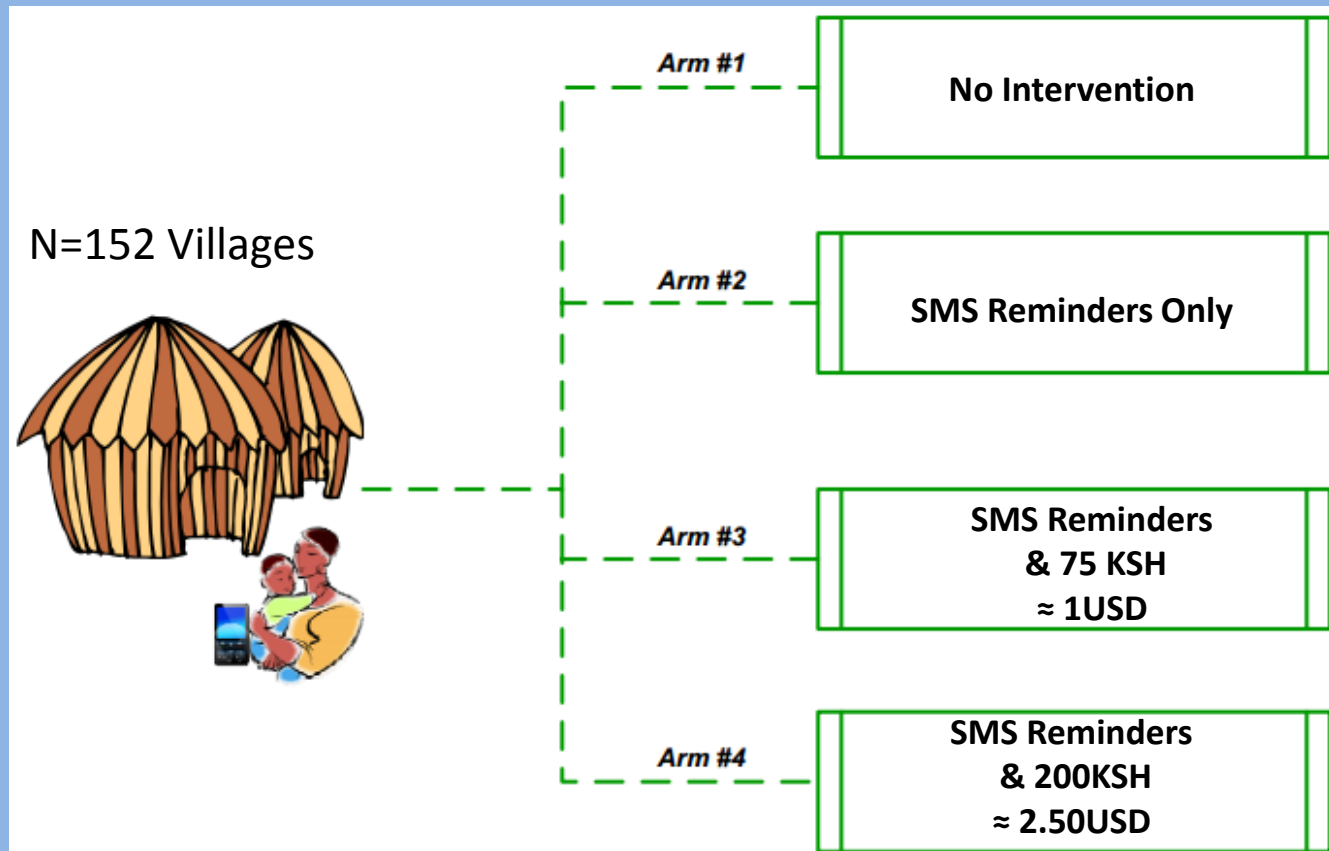
Sept 2013---Enrollment

Aug 2014---End of Enrollment

Aug 2015---End of Follow up

Stakeholders

- Johns Hopkins
- IVAC
- KEMRI/CDC
- MOH and DMOH
- Village Chiefs
- CAB
- The community
- Ethical Review Committees
- Technical Advisory Group
- DSS
- Community Interviewers
- Health Facility Recorders
- Field Supervisors
- Programmers
- Village Reporters

Study arms of Village-RCT

N=152 Villages

Arm #1 — **No Intervention**

Arm #2 — **SMS Reminders Only**

Arm #3 — **SMS Reminders & 75 KSH ≈ 1USD**

Arm #4 — **SMS Reminders & 200KSH ≈ 2.50USD**

- SMS sent 3 days & 1 day before pentavalent and measles dates
- Incentive given if vaccinated within 2 weeks of date
- Interventions for all vaccines but BCG

Decisions on SMS and Incentives

- SMS
  - Content?
  - Timing?
  - Personalized?
  - Phone ownership?

- Incentive
  - Amount?
  - Content?
  - Timing?
  - Phone ownership?
  - Framing the incentive

What FGD mothers want in an SMS

– Date

– Name of vaccine

– Location

– Personalized

– Source

– Importance

– Multiple languages

"I think is good for a parent to know which vaccine the child should get."- #8

"We request that you include importance of the vaccine, that is what can make the mother take her child to clinic."-#1

"I cannot trust it because I do not know where it has come from and how it started. Nowadays messages are sent aimlessly to phones."- #9

"Me I think the problem with that message can be with the person borrowing a phone. Sometimes, she borrows a person's phone, sometimes the husband's. So he can delay with message such that she gets it when it is late." - #8

- CHALLENGES WITH SMS
  - Length
  - Effectiveness vs efficacy
  - Clinic Schedule

<u>3 DAY REMINDER: SMS ARM</u>
"Tell Mama <Baby FName> that Penta-1 vaccine is due this week. <Motivational Message>"-

<u>WELCOME MESSAGE:</u>
Thank you for enrolling your child in the KEMRI/CDC M-SIMU study. You will get periodic reminders for Baby <Baby FNAME>'s vaccinations. The greatest wealth is health.

<u>3 DAY REMINDER: $1 USD Arm</u>
"Tell Mama <Baby FName> that Penta-1 vaccine is due this week. You get 75ksh if Baby vaccinated in next 2 weeks. <Motivational Message>"

SMS Content-Proverbs

- Parallel to pediatric malaria study (Zurovac, 2011)
- Informational, motivational, religious, humorous, local sayings
- Rank individually, then again at FGD

List of Potential Proverbs to encourage mothers to open SMS and bring child for vaccination

#	Phrase	Category
1.	Vaccinations save the lives of Kenyan babies.	Informational
2.	80% of children in this area get vaccinated	Informational
3.	Baby Thomas is happy when healthy	Motivational
4.	It takes a village to raise a child	Motivational
5.	Hope resides in Togetherness	Motivational
6.	When a ripe fruit sees an honest man, it drops	Motivational
7.	Most mothers in your area are getting their children vaccinated, be one of them!	Motivational
8.	If you start early you won't have to see a magician	Local saying
9.	The brain makes the person	Local saying
10.	An antelope is not anyone's goat	Local saying
11.	Do not respond to a mosquito with a hammer. You will hurt yourself	Humorous
12.	A joyful heart is good medicine, But a broken spirit dries up the bones- Philippians 4:6-7	Religious

Top Choices by FGD Participants

	1st Choice	2nd Choice	3rd Choice	Weighted Score
#1 Vaccinations save the lives of Kenyan babies	14(47%)	6 (20%)	2 (7%)	56
#2 Baby Thomas is happy when healthy	6 (20%)	6 (20%)	10 (33%)	40
#11 Most mothers in your area are getting their child vaccinated, be one of them!	4 (13%)	7 (23%)	6 (20%)	32
#8 If you start early, you won't have to see a magician	4 (13%)	2 (7%)	3 (10%)	19
#7 A joyful heart is good medicine, but a broken spirit dries up the bones- Philippians 4:6-7	1 (3%)	3 (10%)	3 (10%)	12
#3 It takes a village to raise a child	1 (3%)	3 (10%)	1 (3%)	10
#12 80% of children in this area get vaccinated		2 (7%)	5 (17%)	9
#4 Hope resides in togetherness		1 (3%)		2

Thoughts on adding the 'proverbs'

- *"These phrases such as 'immunization saves lives', if you send that on a message then I think … that maybe it can encourage a mother to take a child for vaccination." – #1*

- *"Me I chose 'If you start early you won't need to see a magician'. I chose it because taking a child for vaccination prevents some diseases. There are some diseases such as polio, now you know if you start early then you can prevent them."- #5*

Motivational messages in M-SIMU

1. Vaccines save Kenyan babies lives
2. Most <District: Asembo or Gem> babies get vaccinated, be one of them
3. Baby < Baby Fname > is happy when healthy.
4. Vaccines are available now.

"Tell Mama <Baby FName> that Penta-1 vaccine is due this week. <Motivational Message>"-

Randomized for each dose

FGD mothers prefer SMS delivered at 2-3 days
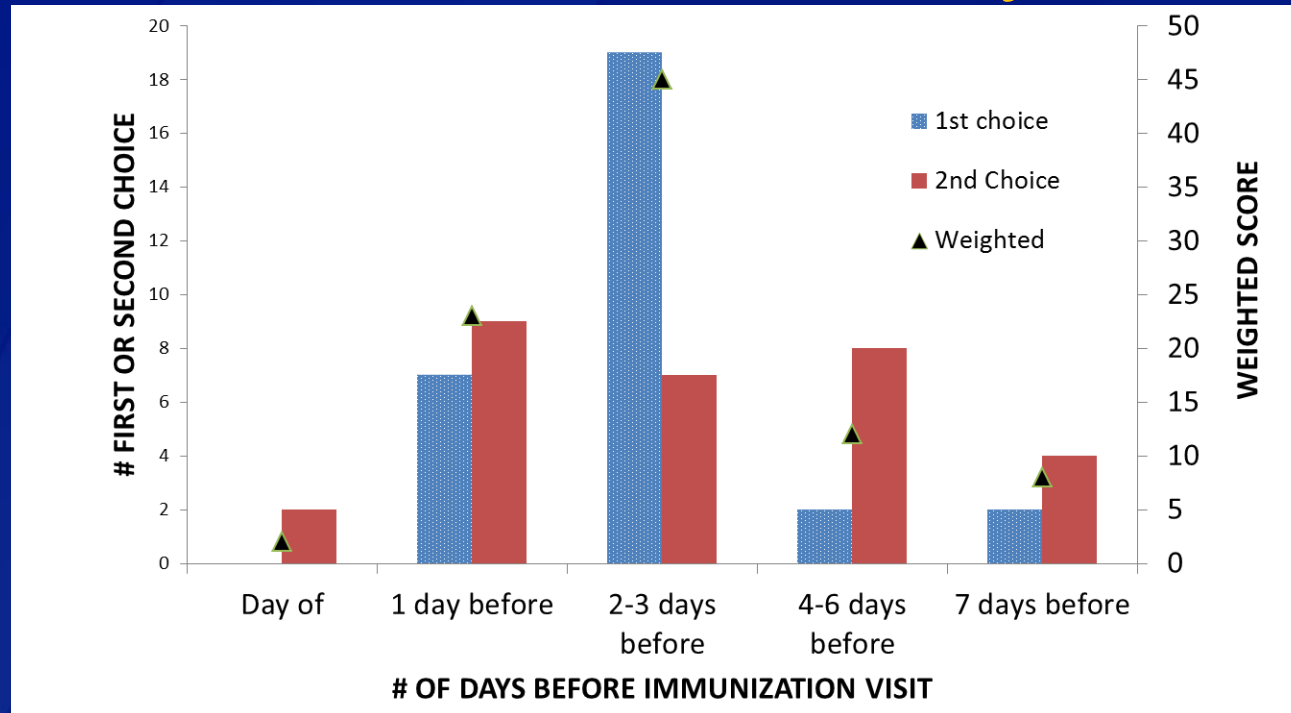
"Me, I chose 2-3 days because I realized they are the best days when I am sent the SMS so that I prepare while knowing the day I should take a child for vaccination. But if I am sent the message 7 days … you know there could be many commitments and then you forget when there are many days to go."- #5

175 KSH will motivate moms to bring infant for vaccination
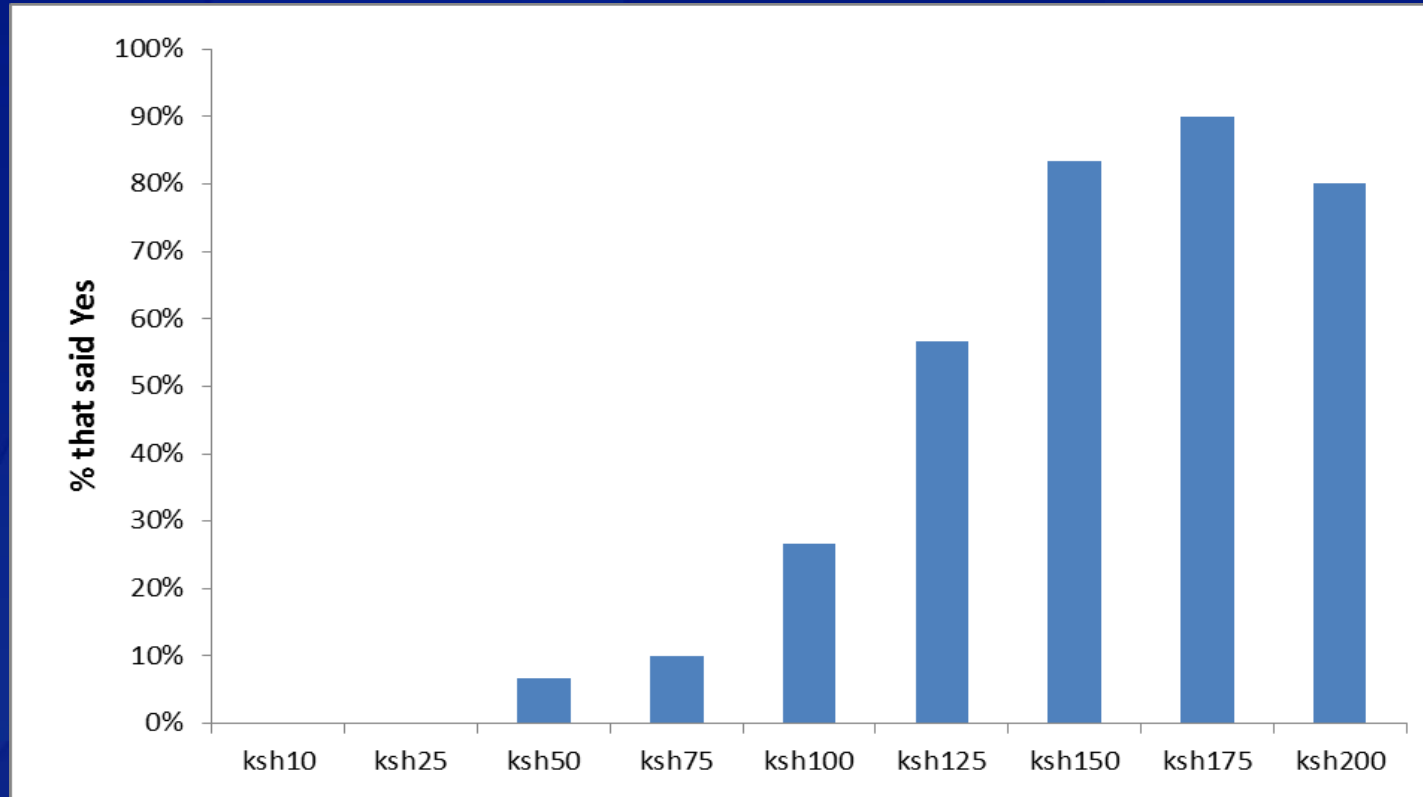
The incentive amounts were presented in the following order: 100ksh, 25, 200, 50, 125, 10, 75, 150, and 175.

Incentives interpreted as transport cost

- *"There are some people who come all the way from Boro and want to come this side. So, if it happens that she is given Ksh. 200.00 that will cater for all round journey plus a surplus of at least Ksh 20.00 to buy the child some sweets."*

- *"Me I say that 50 ksh is just good. The main thing is money. Given that I come from Aringo, even if you give me Ksh. 50.00 I will receive because vaccination is something I must take the baby for. I am the one who likes, so if I get a little money for bus fare, that is your choice to give me that bus fare, it is just good."*

- *"I think as so long as a person is given an amount which is enough for transport it is ok. So, even if you are given Ksh. 50 for fare, you are going to save life of your child."*

CONSORT Study Flow Diagram

Enrollment

Inclusion Criteria

- Mother of infant 0-4 wks
- Resident of village
- Willing to sign informed consent

Exclusion Criteria

− Move in next 6 months
− Received 1st dose of penta
− Attend MSIMU clinic

Target enrollment
152 villages, 2000 total infants

Villages Randomized
1:1:1:1

Allocation

Interventions
1. SMS reminders
2. SMS + 75 Ksh
3. SMS + 200 Ksh

Control
− Receive general health
   related SMS at enrollment

Baseline Assessment

Mobile phone, SES, and demographic questionnaires

Follow-up

¨Document immunization at clinic
¨Follow up at 12 months

Randomization

- Stratified by region
- Restricted by:
  - FIC coverage,
  - Mobile phone ownership,
  - Distance to clinic,
  - Village size

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1) Village Reporter reports new birth to field supervisor through sending a birth notification SMS

2) Community Interviewer Enrolls Mother & Child. Sends Enrollment SMS to RapidSMS

3) "Welcome to Study" SMS sent to Mother's Mobile Phone

4) 1st and 2nd Reminders SMS sent for Vaccine Dose on 3 days and 1 day Before Vaccination Date.

5) Mother and Child go to Health Center for Vaccine Dose

6) Health Facility Recorder sends Notification to RapidSMS that Child was Vaccinated on Time

7) RapidSMS Identifies that a Child was Vaccinated on Time

8) SMS Notifications Sent Out Automatically at the End of Each Day to MPESA

9) MPESA Credit (KSH) sent to Mother's Mobile Phone

10) Mother Receives Cash from MPESA Store

"Rapid SMS" Server at KEMRI/CDC

1) Village Reporter reports new birth to field supervisor through sending a birth notification SMS

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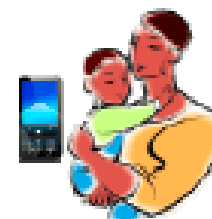
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165 simple Nokia phones provided to village reporters

"Rapid SMS" Server at KEMRI/CDC

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H

10) **Mother Receives Cash from MPESA Store**

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"Rapid SMS" Server at KEMRI/CDC

7) **RapidSMS Identifies that a Child was Vaccinated on Time**

8) **SMS Notifications Sent Out Automatically at the End of Each Day to MPESA**

1) Village Reporter reports new birth to field supervisor through sending a birth notification SMS

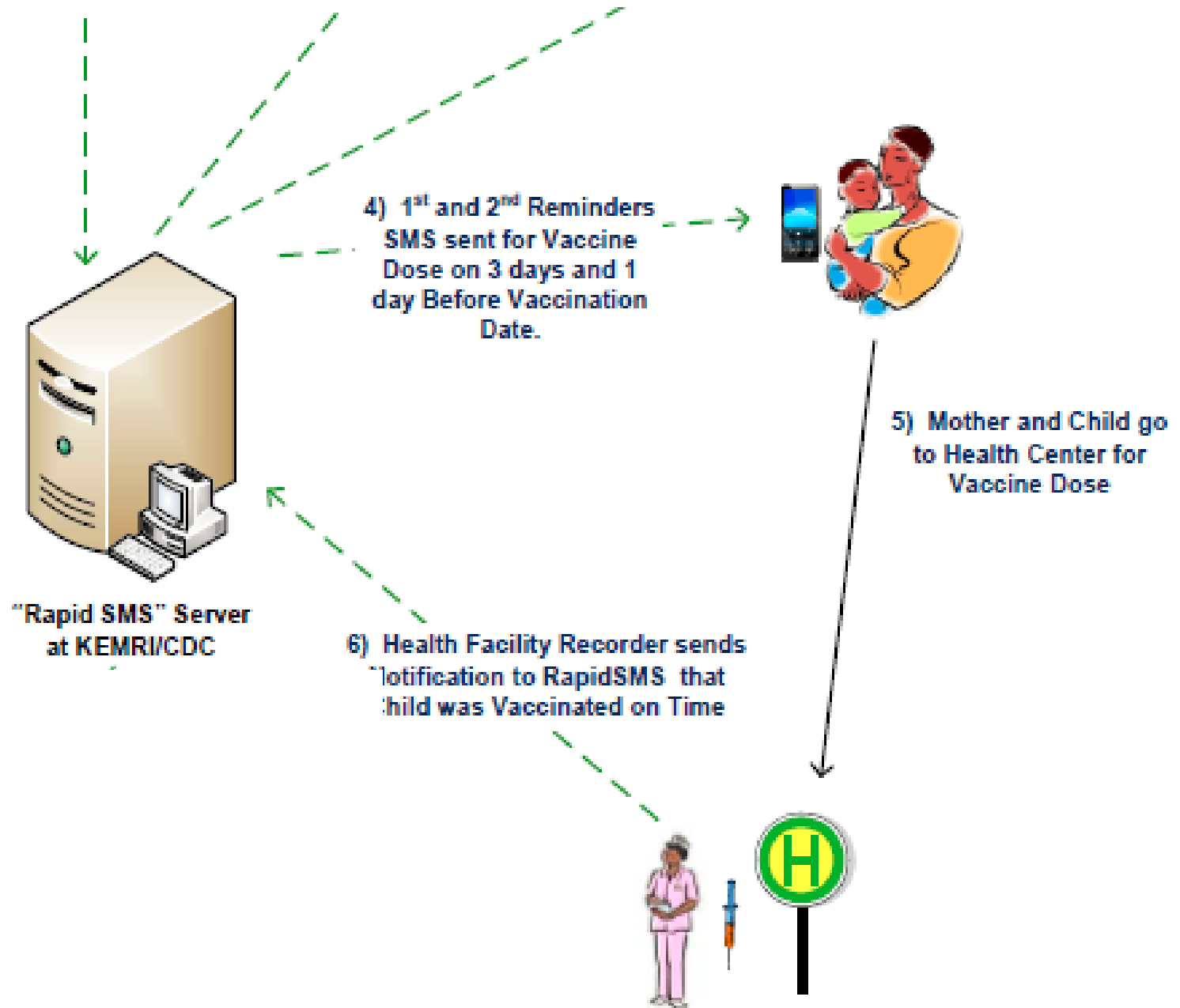2) Community Interviewer Enrolls Mother & Child. Sends Enrollment SMS to RapidSMS

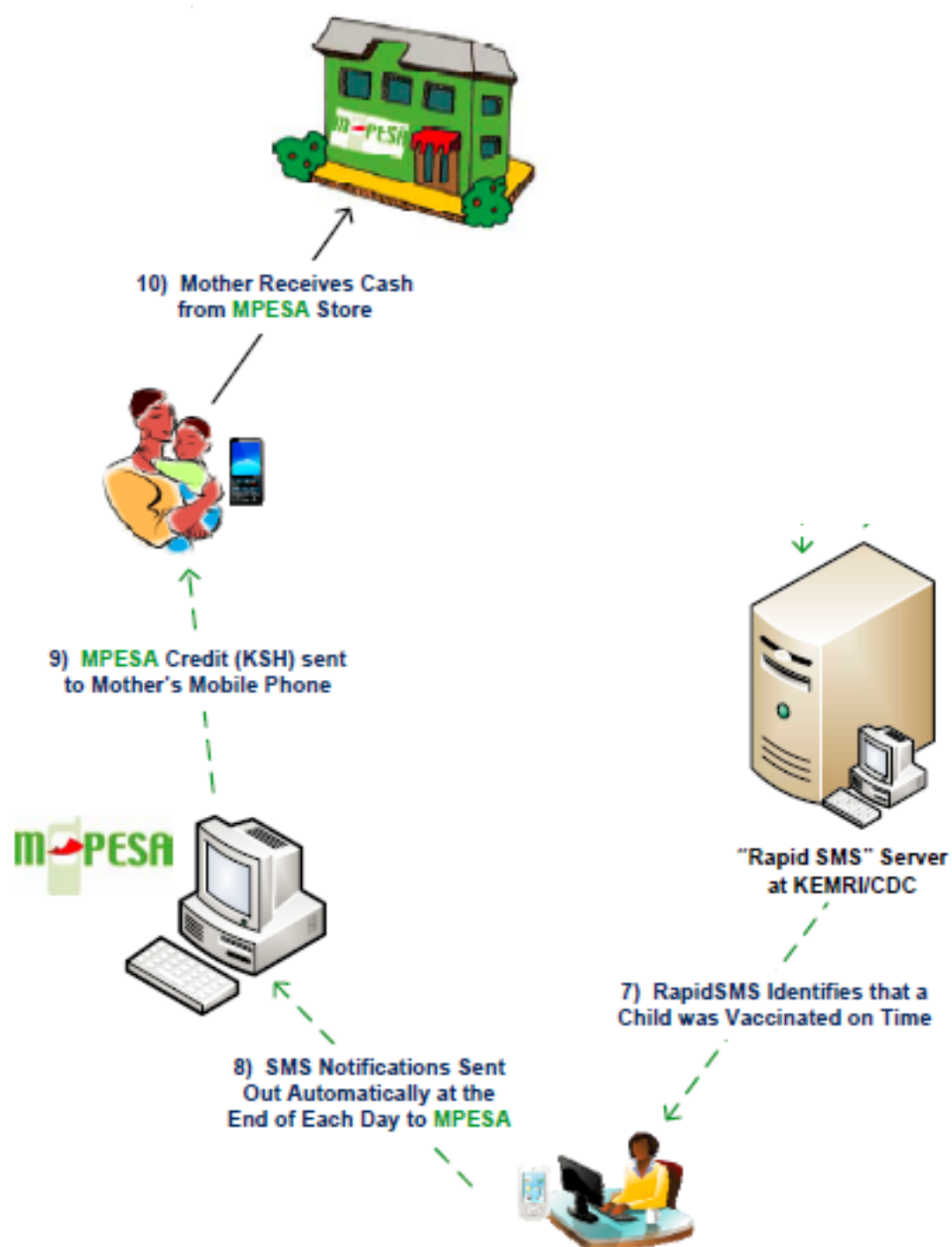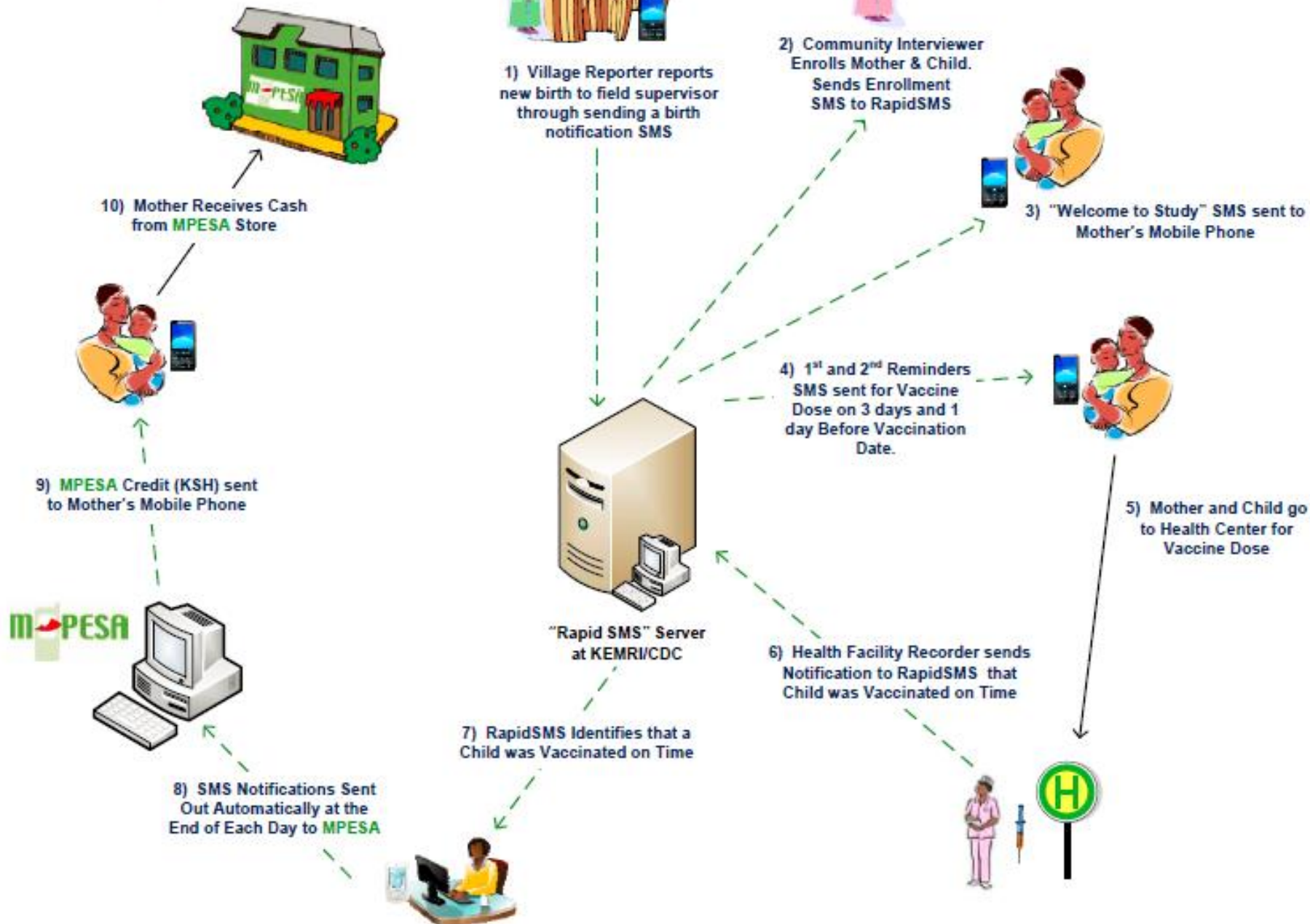3) "Welcome to Study" SMS sent to Mother's Mobile Phone

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"Rapid SMS" Server at KEMRI/CDC

Study Progress

- Enrolled 'Pilot group' October 2013
- Formal enrollment began October 14, 2013
- Close enrollment August 2014
- Complete 12 month follow up August 2015
- mHealth working group presentation October 2015

Challenges and discoveries

- Accurate data entry
- Automating M-PESA delivery is difficult
- Linking data sets
- Village Reporters
  - Timely identification of births
  - Missing and damaged phones

Automating MPESA options

- Mezzanine Tracom
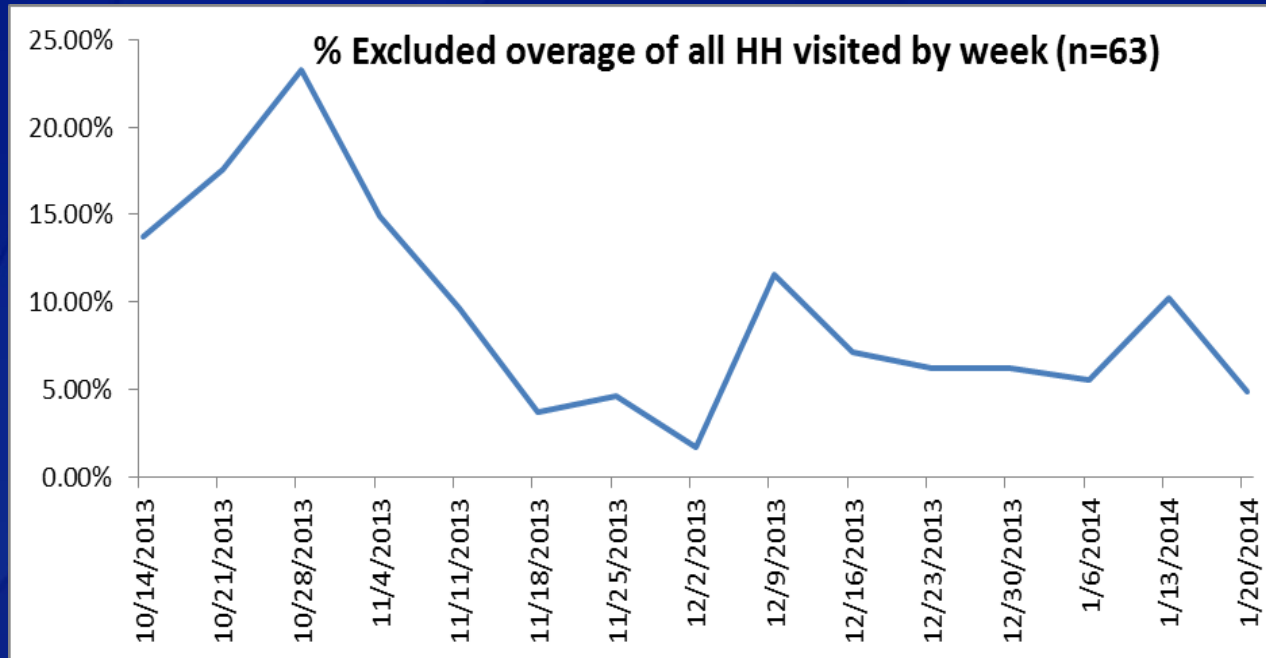- KEMRI Bill Pay
- Frontline
- Me

Multiple 'operating systems' make linking datasets difficult

- Study ID= village# - compound – sequential enrollment#

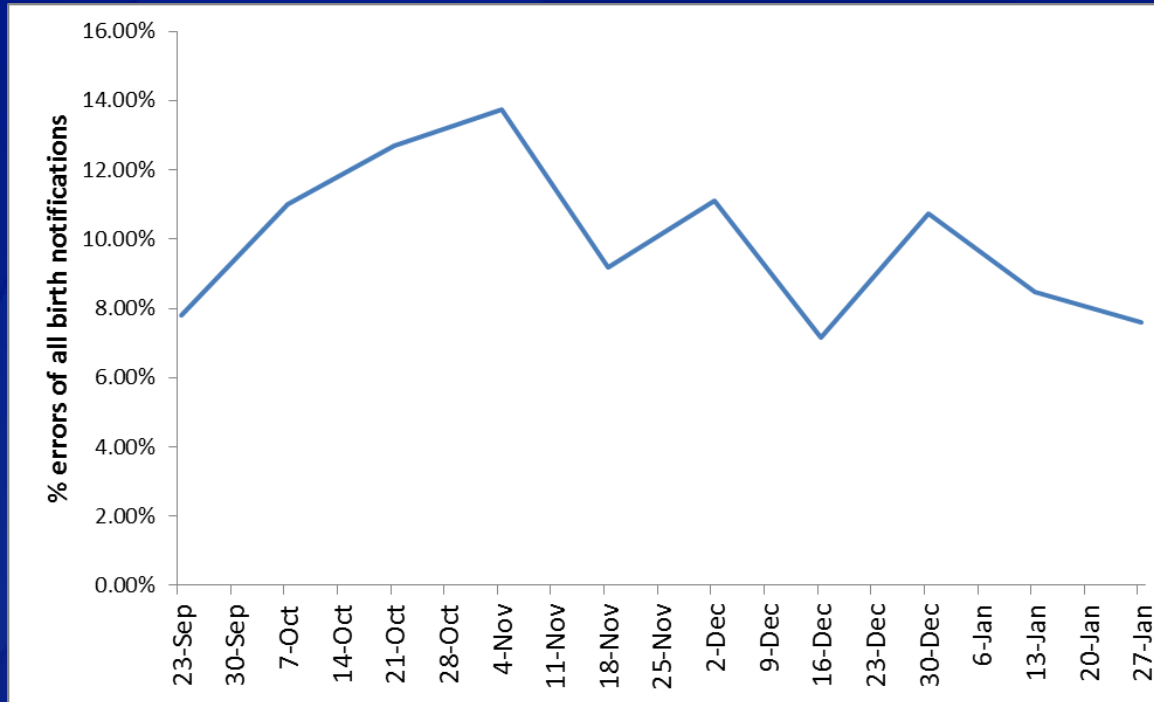- Enrollment and follow up- ODK collect
- Health facility- netbook

Village Reporters to identify births

Timely identification & reporting of births improves with time

% Excluded overage of all HH visited by week (n=63)

Errors in birth notification SMS decreased with time

Format: new village# compound# phone# (optional)

Ex. New 137 22 0725797094

Public Health Significance

- Few interventions can raise routine immunization coverage rapidly
- Provides rigorous evidence for mHealth intervention
- An 'effectiveness' trial
- Cloud registry?
- Paper to mobile birth registry
- Potential cost savings
- Open source programming-CHW

Erokamano

KEMRI/CDC
Benard Ochieng
Danet Opot
David Obor
Frank Odhiambo
Reuben Onkoba
Sammy Khagayi
Jully Awino
Dan Oraro
Joyce Were
The CIs and HFRs

Johns Hopkins
Danny Feikin
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