Word count: Abstract (213), Main text (2367)

Abstract

Purpose: Intermittent preventive treatment with sulphadoxine-pyrimethamine for pregnant women (IPTp-SP) coverage remains far below the desirable goal of at least 3 doses before delivery. This study evaluates an innovative intervention using mobile phones as a means to increase the coverage of the third dose of IPTp-SP.

Methods: This study was designed as an open-label pragmatic, two-arm, randomised trial conducted in Burkina Faso. Pregnant women who attended antennal clinic (ANC) visits were included at their first ANC visit and followed until delivery. The intervention consisted of mobile phones used to track directly pregnant women.

Results: In total, 248 pregnant women were included in the study. The proportion of women who received at least three doses of IPTp-SP was 54.6%. In the intervention group, 54.1% of women received at least three doses of IPTp-SP versus 55.1% in the control group, but the difference was not significant (adjusted odds ratio “aOR”, 0.86; 95% confidence interval “95% CI”, 0.49-1.51). Women in the intervention group were likely to timely attend to their ANC visits than women in the control group (aOR, 3.21; 95% CI, 1.91-5.39).

Conclusions: Mobile phones intervention did not increase the proportion of women receiving 3 doses of IPTp-SP; however, it may contribute to improve the rate of timely attendance to ANC visits.

Trial registration: PACTR202106905150440

Keywords: Mobile phones, Intermittent Preventive Treatment of malaria, Sulfadoxine-Pyrimethamine, Antenatal care, Burkina Faso.

List of abbreviations and acronyms

ANC: Antenatal clinic

CI: Confidence interval

CRF: Case report form

IPTp: Intermittent preventive treatment in pregnancy

ITN: Insecticide-treated bed-nets

mHealth: Mobile health

OR: Odd ratio

SD: Standard deviation

SP: Sulfadoxine-pyrimethamine

SSA: sub-Saharan Africa

WHO: World Health Organisation

Introduction

In sub-Saharan Africa (SSA), over 30 million pregnant women are at risk of malaria infection each year [1]. Pregnant women are particularly vulnerable to malaria infection, resulting in negative consequences for the health of the mother and the new-born, mainly maternal anaemia, and low birthweight, and increasing maternal and infant mortality and morbidity [2].

For malaria control in pregnancy, the World Health Organisation (WHO) recommends the use of insecticide-treated bed-nets (ITNs), intermittent preventive treatment with sulfadoxine-pyrimethamine (IPTp-SP) and prompt and effective management of clinical cases [3]. IPTp-SP is a key intervention and highly cost-effective in preventing the harmful consequences of malaria on maternal and foetal outcomes [4]. The administration of SP consisted of at least two doses starting at the second trimester with at least one month interval [3]. However, since October 2012, the policy has been revised, and IPTp has been recommended at each scheduled antenatal clinical care visit (ANC) from the second trimester of gestation, with the aim of ensuring the uptake of at least three IPTp administrations of SP [5]. Several African countries have adopted the latest recommendation. However, the uptake of the intervention is unacceptably low in areas of high-intensity transmission of malaria [6], indicating the need of innovative tools and approaches to increase it.

With a rapid penetration of mobile phones in Africa, mobile health (mHealth) could be used as a potential intervention to promote and enhance health care service utilization. Recent studies showed that mHealth increase the utilization of maternal and child health services, clinic attendance, and promote health-seeking behaviour [7]. Therefore, we aimed to evaluate the impact of mobile phone intervention on the IPTp-SP uptake in Burkina Faso.

Material and methods

Study design

This was a pragmatic two-arms, open-label randomised trial carried out between November 2015 and January 2017 at the health districts of Koudougou and Boulmiougou, Centre and Central-West health regions of Burkina Faso. The 2 arms were composed of the intervention group (mobile phone use) and the control group, which received only the routine ANC visit package.

Study sites

The study took place in the maternity clinics of Kokologo, in the health district of Koudougou (Central-Western Region) and Tanghin Dassouri in the health district of Boulmiougou (Centre Region). These sites were selected by convenience based on the geographical accessibility and their rural (maternity clinic of Kokologo) and semi-rural (maternity clinic of Tanghuin-Dassouri) characteristics. Most of the residents in the study areas are subsistence farmers with 'mooré' being the most popular language. The climate is characterized by a long dry season running from October to May, followed by a single short rainy season. Malaria transmission is perennial, with a peak period of transmission running from June to September.

Sample size

Several studies carried out in Africa have reported that the proportion of women who received a third dose of IPTp-SP was around 35% [8]. In Burkina Faso, data from the Ministry of Health showed that 68.6% of pregnant women received at least 2 doses of IPTp-SP in 2014 (one year before the start of our study). We therefore assumed at 30% the proportion of pregnant women who will receive at least 3 doses of IPTp-SP in a routine situation, and this proportion would increase by at least 60% (an increase from 30% to 48%) in a context of use of the mobile phone to relaunch appointments for ANC visits. Under these assumptions, 230 pregnant women (115 per arm) were sufficient to observe the difference of 18% (48% - 30%) due to the intervention with a power of 80% and a margin of error of 5%.

Study participants

All pregnant women attending the ANC services were screened for participation in the study. Pregnant women were enrolled if they had provided signed/thumb printed informed consent form, had a gestational age at the first ANC < 20 weeks, had access to a mobile phone, had decided to reside in study area throughout the period of the study and had agreed to comply with the study procedures.

Intervention

The mobile phone intervention consisted of making two systematic reminder phone calls for the ANC visits appointment, the first and the second reminder calls one week and a day before the appointment respectively. A standardised short text/voice message was delivered to those unable to be reached out.

Randomisation and masking

Eligible and consenting pregnant women were randomly assigned (1:1) to either the mobile phone intervention or control group. The allocation of the participants to the study arms was done centrally. The principal investigator produced the computer-generated randomization list for each recruiting site. Treatment allocation for each participant was concealed in opaque sealed envelopes that were opened only after recruitment. Study participants were assigned a unique study number linked to the allocated treatment group. Neither study participants nor clinical staff was masked because of the nature of the intervention requiring overt participation.

Outcomes

The primary outcome was the proportion of pregnant women who received at least three doses of IPTp-SP. Secondary outcomes were the proportion of pregnant women who attended at least four ANC visits, the proportion of pregnant women with anaemia (Hb < 11 g/dL) at delivery, the proportion of pregnant women with malaria infection (positive slide) at delivery, prevalence of low birthweight (birthweight < 2500g) and the proportion of women who timely attended to their ANC visits appointment. A woman was considered "regular" in prenatal consultation or “having a timely

attendance" when the date of consultation corresponded to the given appointment date.

Procedures and data collection

At the inclusion, demographic and socio-economic characteristics were collected and recorded in a standardized case report form (CRF). Medical history including the obstetric history and chronic conditions was also collected. Physical and obstetrical examination were performed. IPTp-SP was administered to pregnant women with a gestational age > 13 weeks.

Blood sample by finger prick was collected at inclusion and at delivery for malaria parasitaemia and haemoglobin concentration determination.

At delivery, the new-born was examined, and the Ballard's score assessed to determine the gestational age. A home visit was conducted within a week to women who delivered outside the health facility.

Laboratory tests

Haemoglobin (Hb) level was measured using a Hemo-Control photometer (EKF Diagnostics, Barleben/Magdeburg, Germany) device with 10 µL of blood and anaemia was defined as Hb < 11 g / dL. Malaria infection was determined using the Lambaréné technique [9]. Ten microliters of blood were spread on a rectangular area of 1.8 cm2 (1.8 cm x 1 cm) of a slide. The slide was stained with Giemsa and read at a magnification of 1,000 with an oil immersion lens. A multiplication factor was applied to the average parasitemia per field to determine the number of parasites per mL. The Lambaréné technique detection threshold has been estimated to be 5 parasites per mL.

Ethical statement

The study protocol received approval from the Comité d'Ethique pour la Recherche en Santé (Reference ID 2014-12-142) in Burkina Faso. The study was conducted in accordance with the Declaration of Helsinki, Good Clinical Practice, and applicable national regulations. All study participants provided written informed consent.

Statistical analysis

Data were managed with Microsoft Access 2013 and analysed with STATA software version 13.0 (Stata Corp, College Station, TX). Analyses were performed according to the intention-to-treat population. We first describe the general characteristics of the study population. After then, univariate and multivariate logistic regressions were performed to evaluate the impact of the intervention. Because of the hierarchical structure of the data, we used generalised estimating equations to take into account for within-sites correlation. Results were expressed as odds ratios (ORs) for primary and secondary outcomes with 95% confidence intervals (95% CI). The statistical significance was set at 5%.

Results

A total of 1,569 pregnant women were screened. Of which, 248 were enrolled and data of 26 women were analysed (Figure 1). At enrolment, the mean age of the study participants was 26.2 years, (SD ± 6.3) and 45.8% (99/216) pregnant women with a gestational age < 16 weeks attended the first ANC visit. The study participants' general characteristics were similar between the study groups (Table 1).

The overall proportion of women who received at least three doses of IPTp-SP (the study primary endpoint) was 54.6 % (118/216). The proportion of pregnant women who received at least three doses of IPTp-SP in the intervention group (54.1%, 59/109) was not different from that observed in the control group (55.1%, 59/107) (adjusted Odds Ratio; aOR: 0.86; 95% CI: [0.49 - 1.51]). There was no significant difference between women who attended four ANC visits between the two groups: 93.6% (102/109) in the intervention group versus to 97.2% (104/107) in the control group (aOR: 0.40; 95% CI: [0.10-1.62]). Similarly, there was no difference between the two groups on the secondary outcomes i.e. low birth weight, anaemia and malaria infection at delivery (Table 2). However, women in the intervention group were more likely to timely attend the ANC visit appointments than those in the control group (aOR: 3.21; 95% CI: [1.91-5.39]) (Table 3).

Discussion

Our results failed to depict an improvement in the coverage of the third dose of IPTp-SP, but they showed a timely attendance of ANC visits appointments by pregnant women who were exposed to mobile phones intervention at Kokologo and Tanghin Dassouri, in Burkina Faso.

Low coverage and poor quality of ANC visits are known to be associated with poor pregnancy outcomes such as abortion, abnormalities, stillbirth, preterm birth, low birthweight and anaemia [10]. Evidence of interventions that improve the coverage and the quality of ANC visits is then crucial in SSA, where the lowest rates of ANC visits attendance and IPTp-SP coverage are reported. [11]. The ANC visits are essential to prevent and identify complications during pregnancy, improve maternal and child outcomes [12,13] and especially, prevent malaria and malaria-related illness such as maternal anaemia and placental malaria [12]. In this study, 54.6% of pregnant women had received at least three doses of IPTp-SP. This result is substantially better than previous findings that reported 35% of pregnant women receiving three IPTp-SP doses in most African settings [8,14]. Although the proportion of women who received at least 3 doses of IPTp-SP in our study is higher than those reported by several African studies, it is still low compared to the available potential, since the proportion of women who performed at least four ANC visits was 95.4%. IPTp-SP delivery is closely related to the access of ANC visits. However, we observed an unexpectedly lower proportion of women who received at least three doses of IPTp-SP despite the higher proportion of pregnant women who completed at least four ANC visits. There are then important bottlenecks for high coverage of IPTp-SP that should be considered such as the low socioeconomic status, high parity or unplanned or mistimed pregnancies [15]. There are also social factors among young pregnant women such as adolescents social position, acknowledgment of the pregnancy, health centre as public space who are importantly related to the number of ANC visits [16]. Furthermore, although adopted by most national malaria control programs in SSA, the effective implementation of the new policy of administering at

least 3 doses of IPTp-SP to pregnant women before delivery is not yet generalized in health facilities, especially in peripheral areas.

Specific interventions that are included in the ANC visits package, if pushed to high coverage have significant potential impact across many settings. In areas of high *P falciparum* burden, systematic use of ITNs and/or IPTp-SP could reduce maternal mortality by up to 10%, newborn mortality by up to 20%, and stillbirths by up to 25–30%; detection of pre-eclampsia followed by timely delivery could prevent up to 25% of newborn deaths and stillbirth and over 90% of maternal eclampsia/pre-eclampsia deaths [17]. In our study we failed to establish a significant relationship between the use of mobile phone and the risk of adverse pregnancy outcomes such as low birthweight, anaemia and malaria infection at delivery. However, a cluster-randomized controlled trial that investigated the impact of mobile phones on antenatal care attendance in Zanzibar a semi-autonomous part of the United Republic of Tanzania showed a trend towards more antepartum referrals amongst the intervention group, suggesting that more women with complications were being identified and treated [18].

Worldwide, fewer newborns are dying but they account for a higher share of child deaths and estimates indicate that 14% of all deaths amongst children under five are due to preterm birth complications [19]. As there is an association between few ANC visits and a subsequent preterm birth, regular and timely attendance to antenatal care is essential to improve child survival [20]. In line with the study conducted in Zanzibar [19], we showed that the use of the mobile phones was associated with regular and timely attendance to ANC visits. The proportion of women who timely attend their ANC visits was higher in the intervention group than in the control group. A cross-sectional analysis performed on data of 4,494 mothers included in the Bangladesh Demographic and Health Survey showed that women who use mobile phones are more likely to use ANC and professional delivery services than those who do not [21]. The women may have used their own cell phones during the survey; however, studies found an association between mobile phones ownership

and high socioeconomic level [22], which in turn affects women's ability to use health services [23].

The use of a mHealth intervention has been shown as a cost-effective strategy to promote prenatal health [18,24–27]. However, in this study, there was no significant association between mobile phone intervention and pregnancy adverse outcomes such as low birthweight, maternal anaemia and malaria infection at delivery. Few studies in Sub Saharan Africa assessed the direct effect of the mHealth) intervention on pregnancy outcomes [28,29]. Therefore, more in-depth assessments are needed to explore the public health benefits of such an intervention.

There were some limitations in this study. First, we chose a pragmatic approach and randomised individuals rather than health facilities leading to a potential spillover effect from intervention to the control group. Second, most of the time, women do not have their own mobile phones and depend on someone else, often their husband. Unfortunately, no information on cell phones ownership was collected, so we cannot confirm that secondary outcomes were not confounded in the intervention and control groups. Finally, we did not collect some potential confounder factors (parity, bed net use, iron supplementation) which would have explained the lack of association, but we assumed that factors have been distributed equally between the two study arms thanks to the randomisation. However, we adjusted the analysis for unbalanced factors such as maternal education.

Conclusions

The mothers' mobile phones intervention significantly increased the proportion of women who regularly and timely attend to their ANC visits, but the intervention did not increase the proportion of women receiving at least 3 doses of IPTp-SP. The current evidence remains insufficient to conclusively inform policy decisions and further quality research and cost-effectiveness analyses as well as factors influencing the IPTp-SP intake are required to draw more robust conclusions, particularly for poor-resource settings.

Acknowledgments

We are extremely grateful to all women who took part to the study, the midwives, nurses, and field workers, and the whole study team, including technicians, statisticians, students.,.

Funding

This study was supported by WHO TDR advanced postdoctoral research and training grants in implementation research (WHO reference: 2015/544432-0; Unit reference: B40117). The funders do not play a role in study design, collection, management, data analysis and interpretation. They do not influence the writing of the report and the decision to submit.

Ethics approval and consent to participate

The present study received approval from the Comité d'Ethique pour la Recherche en Santé (Reference ID 2014-12-142). Women were included in the present trial after providing a signed written informed consent.

References

[1] Dellicour S, Tatem AJ, Guerra CA, Snow RW, ter Kuile FO. Quantifying the number of pregnancies at risk of malaria in 2007: a demographic study. PLoS Med 2010;7:e1000221. https://doi.org/10.1371/journal.pmed.1000221.

[2] Guyatt HL, Snow RW. Impact of malaria during pregnancy on low birth weight in sub-Saharan Africa. Clin Microbiol Rev 2004;17:760–9, table of contents. https://doi.org/10.1128/CMR.17.4.760-769.2004.

[3] World Health Organization. A strategic framework for malaria prevention and control during pregnancy in the African region. Report AFR/MAL/04/01. Geneva, WHO 2004:27.

[4] WHO Malaria Policy Advisory Committee and Secretariat. Malaria Policy Advisory Committee to the WHO: conclusions and recommendations of eighth biannual meeting (September

248 2015). Malar J 2016;15:117. https://doi.org/10.1186/s12936-016-1169-x.
249 [5] World Health Organization. WHO policy brief for the implementation of intermittent
250 preventive treatment of malaria in pregnancy using sulfadoxine-pyrimethamine (IPTp-SP) April 2013
251 (rev. January 2014) 2013:13.
252 [6] van Eijk AM, Hill J, Alegana VA, Kirui V, Gething PW, ter Kuile FO, et al. Coverage of
253 malaria protection in pregnant women in sub-Saharan Africa: a synthesis and analysis of national
254 survey data. Lancet Infect Dis 2011;11:190–207. https://doi.org/10.1016/S1473-3099(10)70295-4.
255 [7] Sondaal SFV, Browne JL, Amoakoh-Coleman M, Borgstein A, Miltenburg AS, Verwijs M,
256 et al. Assessing the Effect of mHealth Interventions in Improving Maternal and Neonatal Care in
257 Low- and Middle-Income Countries: A Systematic Review. PloS One 2016;11:e0154664.
258 https://doi.org/10.1371/journal.pone.0154664.
259 [8] Pons-Duran C, Llach M, Sacoor C, Sanz S, Macete E, Arikpo I, et al. Coverage of intermittent
260 preventive treatment of malaria in pregnancy in four sub-Saharan countries: findings from household
261 surveys. Int J Epidemiol 2020. https://doi.org/10.1093/ije/dyaa233.
262 [9] Swysen C, Vekemans J, Bruls M, Oyakhirome S, Drakeley C, Kremsner P, et al. Development
263 of standardized laboratory methods and quality processes for a phase III study of the RTS, S/AS01
264 candidate malaria vaccine. Malar J 2011;10:223. https://doi.org/10.1186/1475-2875-10-223.
265 [10] World Health Organization. WHO recommendations on antenatal care for a positive
266 pregnancy experience (Licence: CC BY-NC-SA 3.0 IGO) 2017:196.
267 [11] van Eijk AM, Hill J, Larsen DA, Webster J, Steketee RW, Eisele TP, et al. Coverage of
268 intermittent preventive treatment and insecticide-treated nets for the control of malaria during
269 pregnancy in sub-Saharan Africa: a synthesis and meta-analysis of national survey data, 2009-11.
270 Lancet Infect Dis 2013;13:1029–42. https://doi.org/10.1016/S1473-3099(13)70199-3.
271 [12] Carroli G, Rooney C, Villar J. How effective is antenatal care in preventing maternal mortality
272 and serious morbidity? An overview of the evidence. Paediatr Perinat Epidemiol 2001;15 Suppl 1:1–

42. https://doi.org/10.1046/j.1365-3016.2001.0150s1001.x.

[13] Tekelab T, Chojenta C, Smith R, Loxton D. The impact of antenatal care on neonatal mortality in sub-Saharan Africa: A systematic review and meta-analysis. PloS One 2019;14:e0222566. https://doi.org/10.1371/journal.pone.0222566.

[14] Accrombessi M, Yovo E, Fievet N, Cottrell G, Agbota G, Gartner A, et al. Effects of Malaria in the First Trimester of Pregnancy on Poor Maternal and Birth Outcomes in Benin. Clin Infect Dis Off Publ Infect Dis Soc Am 2019;69:1385–93. https://doi.org/10.1093/cid/ciy1073.

[15] Magadi MA, Madise NJ, Rodrigues RN. Frequency and timing of antenatal care in Kenya: explaining the variations between women of different communities. Soc Sci Med 1982 2000;51:551–61. https://doi.org/10.1016/s0277-9536(99)00495-5.

[16] Grietens KP, Gies S, Coulibaly SO, Ky C, Somda J, Toomer E, et al. Bottlenecks for High Coverage of Intermittent Preventive Treatment in Pregnancy: The Case of Adolescent Pregnancies in Rural Burkina Faso. PLOS ONE 2010;5:e12013. https://doi.org/10.1371/journal.pone.0012013.

[17] Hodgins S, Tielsch J, Rankin K, Robinson A, Kearns A, Caglia J. A New Look at Care in Pregnancy: Simple, Effective Interventions for Neglected Populations. PloS One 2016;11:e0160562. https://doi.org/10.1371/journal.pone.0160562.

[18] Lund S, Nielsen BB, Hemed M, Boas IM, Said A, Said K, et al. Mobile phones improve antenatal care attendance in Zanzibar: a cluster randomized controlled trial. BMC Pregnancy Childbirth 2014;14:29. https://doi.org/10.1186/1471-2393-14-29.

[19] Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet Lond Engl 2012;379:2151–61. https://doi.org/10.1016/S0140-6736(12)60560-1.

[20] Raatikainen K, Heiskanen N, Heinonen S. Under-attending free antenatal care is associated with adverse pregnancy outcomes. BMC Public Health 2007;7:268. https://doi.org/10.1186/1471-2458-7-268.

298 [21] Tang S, Ghose B, Hoque MR, Hao G, Yaya S. Women Using Mobile Phones for Health
299 Communication Are More Likely to Use Prenatal and Postnatal Services in Bangladesh: Cross-
300 Sectional Study. JMIR MHealth UHealth 2019;7:e10645. https://doi.org/10.2196/10645.
301 [22] Poirier MJP, Bärnighausen T, Harling G, Sié A, Grépin KA. Is the lack of smartphone data
302 skewing wealth indices in low-income settings? Popul Health Metr 2021;19:4.
303 https://doi.org/10.1186/s12963-021-00246-3.
304 [23] Nie J, Unger JA, Thompson S, Hofstee M, Gu J, Mercer MA. Does mobile phone ownership
305 predict better utilization of maternal and newborn health services? a cross-sectional study in Timor-
306 Leste. BMC Pregnancy Childbirth 2016;16:183. https://doi.org/10.1186/s12884-016-0981-1.
307 [24] Lund S, Hemed M, Nielsen BB, Said A, Said K, Makungu MH, et al. Mobile phones as a
308 health communication tool to improve skilled attendance at delivery in Zanzibar: a cluster-
309 randomised controlled trial. BJOG Int J Obstet Gynaecol 2012;119:1256–64.
310 https://doi.org/10.1111/j.1471-0528.2012.03413.x.
311 [25] Andreatta P, Debpuur D, Danquah A, Perosky J. Using cell phones to collect postpartum
312 hemorrhage outcome data in rural Ghana. Int J Gynaecol Obstet Off Organ Int Fed Gynaecol Obstet
313 2011;113:148–51. https://doi.org/10.1016/j.ijgo.2010.11.020.
314 [26] Cormick G, Kim NA, Rodgers A, Gibbons L, Buekens PM, Belizán JM, et al. Interest of
315 pregnant women in the use of SMS (short message service) text messages for the improvement of
316 perinatal and postnatal care. Reprod Health 2012;9:9. https://doi.org/10.1186/1742-4755-9-9.
317 [27] Coleman J, Black V, Thorson AE, Eriksen J. Evaluating the effect of maternal mHealth text
318 messages on uptake of maternal and child health care services in South Africa: a multicentre cohort
319 intervention study. Reprod Health 2020;17:160. https://doi.org/10.1186/s12978-020-01017-3.
320 [28] Daly LM, Horey D, Middleton PF, Boyle FM, Flenady V. The Effect of Mobile App
321 Interventions on Influencing Healthy Maternal Behavior and Improving Perinatal Health Outcomes:
322 Systematic Review. JMIR MHealth UHealth 2018;6:e10012. https://doi.org/10.2196/10012.

[29] Murthy N, Chandrasekharan S, Prakash MP, Ganju A, Peter J, Kaonga N, et al. Effects of an mHealth voice message service (mMitra) on maternal health knowledge and practices of low-income women in India: findings from a pseudo-randomized controlled trial. BMC Public Health 2020;20:820. https://doi.org/10.1186/s12889-020-08965-2.

Legends

Figure 1. Study flowchart. ANC: Antenatal clinical

329 **Table 1:** general characteristics of study participants (N = 216)

Characteristics	Control group (n = 107)	Intervention group (n =109)	All (n=216)
Study site, % (n)			
Kokologo	65.4 (70)	64.2 (70)	64.8 (140)
Tanghin Dassouri	34.6 (37)	35.8 (39)	35.2 (76)
Age, Mean (SD) (year)	26.6 (±6.3)	25.8 (±6.3)	26.2 (±6.3)
< 20	13.1 (14)	22.0 (24)	17.6 (38)
20-30	61.7 (66)	56.0 (61)	58.8 (127)
≥ 30	25.2 (27)	22.0 (24)	23.6 (51)
Marital status, % (n)			
Single	0.9 (1)	2.7 (3)	1.8 (4)
Polygamy	23.4 (25)	27.5 (30)	25.5 (55)
Monogamy	75.7 (81)	69.7 (76)	72.7 (157)
Occupation, % (n)			
Housewife	46.7 (50)	50.5 (55)	48.6 (105)
Farmer	18.7 (20)	14.7 (16)	16.7 (36)
Business	21.5 (23)	22.9 (25)	22.2 (48)
Student	4.7 (5)	5.5 (6)	5.1 (11)
Civil servant	3.7 (4)	0.9 (1)	2.3 (5)
Others	4.7 (5)	5.5 (6)	5.1 (11)
Education, % (n)			
No	58.9 (63)	70.6 (77)	64.8 (140)
Yes	41.1 (44)	29.4 (41)	35.2 (76)
Household income, % (n)			
Low	43.9 (47)	51.4 (56)	47.7 (103)
Average	34.6 (37)	31.2 (34)	32.8 (71)
High	21.5 (23)	17.4 (19)	19.4 (42)
Gestational age (weeks)			
Mean	14.4 (±4.8)	14.6 (±4.6)	14.5 (±4.7)
<16	46.7 (50)	44.9 (49)	45.8 (99)
≥16	53.3 (57)	55.1 (60)	54.2 (117)
Hb level (g/dL) Mean (SD)	10.5 (±1.6)	10.3 (±1.6)	10.4 (±1.6)
<11 g/dL	57.6 (61)	61.7 (66)	59.6 (127)
Malaria infection, % (n)			
No	72.9 (78)	76.1 (83)	74.5 (161)
Yes	27.1 (29)	23.8 (26)	25.5 (55)
Number of IPTp doses, % (n)			
0	4.7 (5)	5.5 (6)	5.1 (11)
1	11.2 (12)	9.2 (10)	10.2 (22)
2	29.0 (31)	31.2 (34)	30.1 (65)
≥3	55.1 (59)	54.1 (59)	54.6 (118)
Number of ANC visit, % (n)			
1-3	2.8 (3)	6.4 (7)	4.6 (10)
≥4	97.2 (104)	93.6 (102)	95.4 (206)

330 Abbreviations: IPTp, Intermittent preventive treatment during pregnancy; Hb, Haemoglobin; ANC,
331 Antenatal care

Table 2: association between mobile phone intervention and primary and secondary outcomes, logistic multilevel mixed model (N=216)

Characteristics	Control	Intervention	Unadjusted OR (95% CI)	adjusted OR* (95% CI)
Primary outcome				
Number IPTp intake during pregnancy£				
≥ 3 doses	59/107 (55.1%)	59/109 (54.1%)	0.96 (0.56-1.64)	0.86 (0.49-1.51)
Secondary outcomes				
At least four ANC visits	104/107 (97.2%)	102/109 (93.6%)	0.42 (0.11-1.67)	0.40 (0.10-1.62)
Anaemia at delivery	33/86 (38.4%)	31/78 (39.7%)	1.06 (0.56-1.98)	1.01 (0.53-1.91)
Malaria infection at delivery	0/81 (0%)	2/76 (2.6%)	-	-
Low birthweight	11/106 (10.4%)	10/104 (9.6%)	0.91 (0.37-2.26)	0.97 (0.39-2.42)

Abbreviations: OR, Odds ratio; IPTp, Intermittent preventive treatment in pregnancy; ANC, Antenatal care, anaemia defined as haemoglobin level <11g/dL. * Adjusted for maternal education and within cluster effect; £ At the first antenatal visit, no intermittent preventive treatment was administered

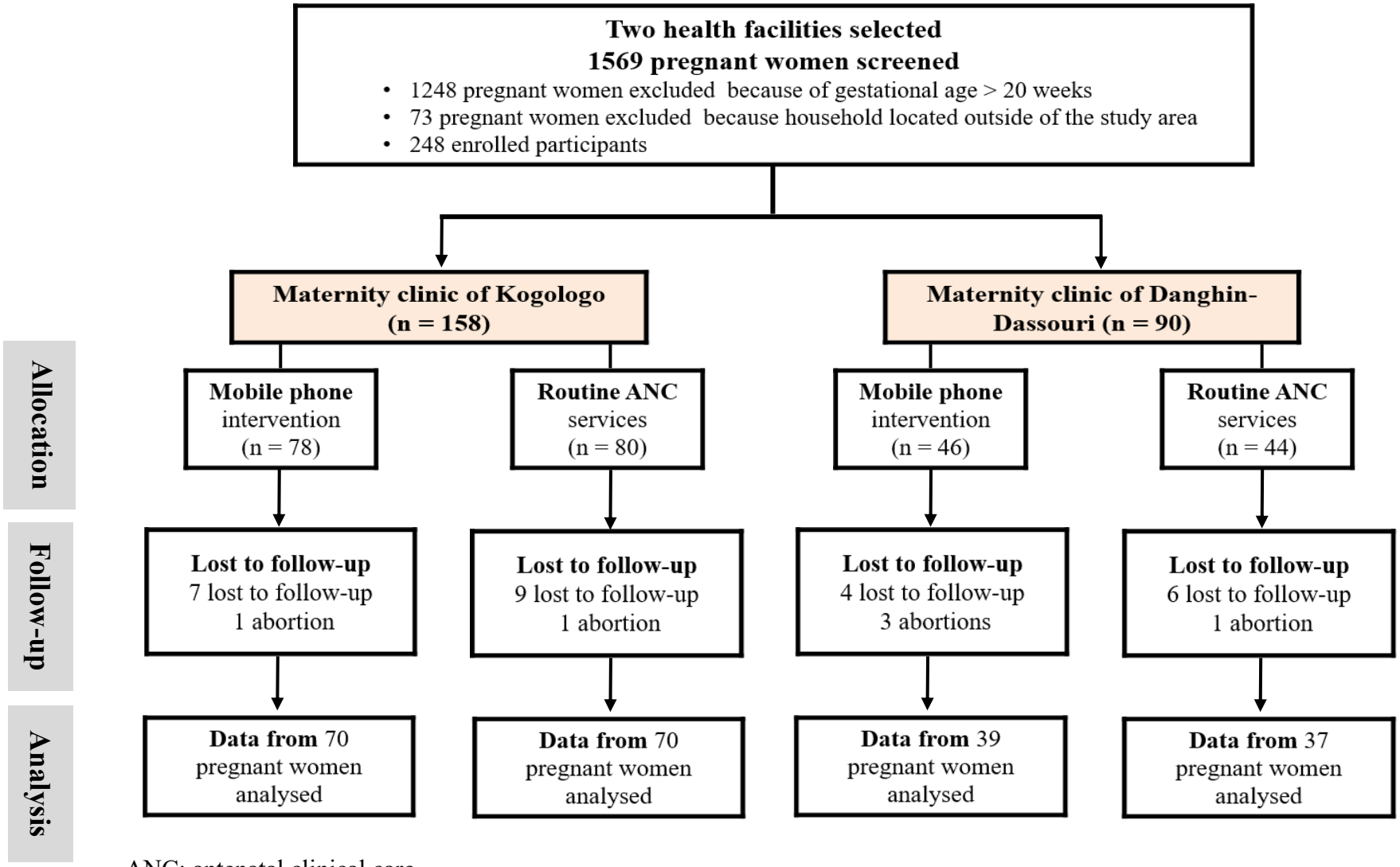
343 **Table 3:** association between mobile phone intervention and regularity in the ANC visit appointment, logistic multilevel mixed regressions

344 (N=216)

Characteristics	Control	Intervention	Unadjusted OR (95% CI)	adjusted OR* (95% CI)
Regularity in the ANC visit appointment				
ANC visit 2	56/106 (52.8%)	84/109 (77.1%)	2.99 (1.67-5.39)	2.91 (1.61-5.26)
ANC visit 3	63/104 (60.6%)	70/101 (69.3%)	1.47 (0.82-2.62)	1.53 (0.84-2.77)
ANC visit 4	41/82 (50.0%)	63/87 (72.4%)	2.62 (1.38-4.97)	2.74 (1.43-5.27)
ANC visit 5	22/42 (52.4%)	37/42 (88.1%)	6.72 (2.21-20.5)	6.63 (2.17-20.2)
Overall ANC visits£	182/334 (54.5%)	254/339 (74.9%)	2.49 (1.80-3.46)	3.21 (1.91-5.39)

Abbreviations: CI, Confidence interval; OR, Odds ratio; ANC, Antenatal care. * Adjusted for maternal education; £ Adjusted for within and inter individual effects

345
346



ANC: antenatal clinical care

Figure 1: study flowchart