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The ability and safety of community-based health workers to safely initiate lifesaving therapies for pre-eclampsia in Ogun State, Nigeria: An analysis of 260 community treatments with $MgSO_4$ and/or methyldopa

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ABSTRACT

Objectives: To evaluate community-based health workers' ability to identify cases of hypertension in pregnancy, safely deliver methyldopa and magnesium sulphate and make referrals when appropriate.
Study design: This was part of Nigeria Community-Level Interventions for Pre-eclampsia (CLIP) cluster randomized controlled trial (NCT01911494). Community-based Health Workers (CHW) recruited pregnant women from five Local Government Areas (clusters) and used mobile health aid for clinical assessment of pre-eclampsia. Main outcome measures: The primary outcome was the number of adverse events that occurred after the administration of magnesium sulphate and/or methyldopa to pregnant women by CHWs.
Findings: Of 8790 women receiving mobile health-guided care, community-based health workers in Nigeria provided 309 women with hypertension (4.2% of delivered women), and safely administered 142 doses of intramuscular magnesium sulphate. Community Heath Extension Workers (CHEWs) and nurses gave fifty-two and sixty-seven doses of intramuscular magnesium sulphate respectively, twenty-three doses were given by other health care workers (midwives, community health officers, health assistants). The high rate of administration by nurses can be explained by turf protection as well as their seniority within the health system. Also, CHEWs and nurses gave 124 doses of oral methyldopa and 126 urgent referrals were completed. There were no complications related to administration of treatment or referral.

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Interpretation: These findings demonstrate the ability of community-based health workers to safely administer methyldopa and intramuscular magnesium sulphate. The use of task-sharing, therefore, could drastically reduce the three delays (triage, transport and treatment) associated with high maternal mortality and morbidity in rural communities in low- and middle-income countries.

1. Introduction

Nigeria has one of the highest maternal mortality ratios (MMR) in the world with an estimated 814 maternal deaths per 100 000 live births in 2015 [1]. In the same year, India and Nigeria were responsible for over one third of all maternal deaths worldwide. Pregnancy hypertension is common and its incidence in south-western Nigeria was found to be as high as 10.2 [2]. Pre-eclampsia, and its complications, often occur in rural communities where there are inadequate resources available for emergency obstetric care [3–5]. The appropriate management of pre-eclampsia, which is typically available only in hospital settings, involves supportive care with frequent maternal and foetal surveillance, anti-hypertensives, seizure prophylaxis, and timely delivery [6–11]. Magnesium sulphate ($MgSO_4$) is the anticonvulsant of choice and is presently included in Nigeria's essential medicines list as the first line drug in the management of pre-eclampsia and eclampsia [12,13]. Ten centres in Nigeria participated in the 1995 multicentre Collaborative Eclampsia Trial where magnesium was proven to be effective in the treatment of eclampsia, despite this, its use in the country remains limited [13,14]. Some barriers to the adoption of $MgSO_4$ are poor dissemination of international guidelines, insufficient health worker training, the perceived need for intensive patient monitoring, stock outs and a lack of adequate manpower [14–16].

Many low- and middle-income countries (LMIC) utilize task-sharing to optimize the delivery of key effective maternal and newborn interventions [17]. This involves delegating responsibilities previously reserved for highly trained health workers to existing or new cadres of health workers with either less or narrowly tailored training [18,19]. These health workers can be useful in bridging the gap between recipients and providers and thus, reduce delays [17]. In Nigeria, community-based health workers are the first point of contact in the health system and provide a range of services in the home and at primary health centres (PHC). There is evidence to suggest that trained community-based health workers had good understanding of the features of pre-eclampsia, could identify women at risk, and initiate care [20].

The Community Level Interventions for Pre-eclampsia (CLIP) study employed task-sharing to community-based health workers in Nigeria to identify and provide emergency treatment for pre-eclampsia prior to referral. This paper aims to assess the ability of community-based health workers to safely initiate lifesaving therapies ($MgSO_4$ and methyldopa) for women with pre-eclampsia with the aid of an mHealth decision-aid, at primary health centres in Ogun State, Nigeria.

2. Methods

2.1. Study setting

This study was conducted in Ogun State, Nigeria from March 01, 2014 to January 31, 2016. Ogun State is populated mainly by the Yoruba ethnic group, roughly 50% of the population live in rural areas, and are served by a mix of public and private health care facilities. Of Ogun State's twenty Local Government Areas (LGAs), ten were chosen for participation in the CLIP cluster randomized controlled trial (NCT01911494) [21]. Five of the ten LGAs were randomly chosen as intervention clusters (i.e. Remo North, Ogun Waterside, Odeda, Ijebu Northeast, and Yewa South), and within each cluster, five to seven wards were selected on the basis of ease of access into the community given the large size of the clusters.

2.2. Clinical intervention

The Community-based Health Workers (CHW), who implemented the CLIP study, were nurses, midwives, community health extension workers (CHEW), and health assistants (HAs), all of whom normally provide care at the community-level in Nigeria. The implementation itself involved clinical assessment of pregnant woman based on demographics, symptoms and signs to identify likely cases of hypertensive disorders of pregnancy (HDP) and if the condition was severe, initiate treatment and referral. This process was guided by a mobile health application, PIERS on the Move (POM) [22]. The POM treatment algorithm was based on the miniPIERS (Pre-eclampsia Integrated Estimate of RiSk) model that was predictive of adverse maternal outcome and perinatal death among women with HDPs in LMIC [22]. In brief, there were seven CLIP 'triggers' for action that resulted in recommendations to administer 750 mg oral methyldopa (for severe hypertension), 10 mg intramuscular $MgSO_4$ (for presumed pre-eclampsia), and attend the nearest comprehensive emergency obstetric care (CEmOC) facility urgently (for women with severe complications such as stroke) or 24 h (for non-severe hypertension). Successful use of this mobile application by minimally trained community-based health workers has previously been demonstrated [23].

A two-day training was provided for community-based health workers, at conveniently-located health centres, with refresher trainings provided every six months. Each community-based health worker was provided a transport allowance to encourage participation. Training facilitators were consultant obstetricians, medical officers, and nurses. Strategies used for training included didactic lectures, group work, case studies, role play, and practical demonstrations; importantly, pre- and post-tests were administered, and direct observations undertaken, to ensure that community-based health workers trained had adequate knowledge and skills. A 'train-the-trainer' model was used, where lead community-based health workers would train others in the facility who were not present on the initial day of training. In the training sessions, community-based health workers were provided information on: (i) the HDPs, focussing on the warning symptoms and signs of pre-eclampsia with the aid of pictograms; (ii) measurement of blood pressure at antenatal and postnatal visits using a low-cost, simple-to-use, semi-automated handheld blood pressure device validated for use in pre-eclampsia [24,25] (i.e., the Microlife 3AS1-2 and then the Microlife Vital Sign Alert (VSA) after January 23, 2015); (iii) dipstick measurement of proteinuria, (iv) entry of basic demographic and pregnancy information into an electronic platform; (v) how to follow recommendations provided by POM; (vi) administration of oral methyldopa and/or intramuscular $MgSO_4$, and (vi) counselling women about the need for referral [23].

This training supplemented health workers' professional qualifications. Nurses had completed a three-year program at various nursing schools throughout Nigeria, and midwives completed an additional year and half maternity-focused training. CHEWs hold a Diploma in community health, having completed a three-year program, primarily at Schools of Health Technology. The CHEW curriculum is focused on community diagnosis and treatment of minor ailments and diseases in preparation for community outreach and assistance at PHCs, including monitoring of labour and delivery; only a few classes in the CHEW curriculum relate to the HDPs. The skills acquired include history taking, physical examination, vital sign monitoring, and administration of oral medications and intramuscular injections. Some nurses and CHEWs had also completed an additional one-year advanced course in primary

health to become community health officers (CHO) (n = 11). HAs are a lower cadre of community-based health workers whose skill set is more limited, consisting of taking vital signs, collecting preliminary clinical and pregnancy history.

2.3. Study participants and data collection

All women aged 15–49 years, who resided in the study area, and were identified as pregnant during routine antenatal care at a public PHC were eligible for participation in the CLIP trial. All eligible women who gave verbal and written consent were included in the study. Community-based health care workers used the POM application on a mobile android device to collect demographic information and record blood pressure, proteinuria, and other PIERS parameters data during routine antenatal clinics.

2.4. Ethical approval

Ethical approval for this study was obtained from the Health Research and Ethics Committee of Olabisi Onabanjo University Teaching Hospital, Sagamu, Nigeria (as the in-country co-ordinating centre) and the Clinical Research Ethics Board of the University of British Columbia, Vancouver, Canada (as the central co-ordinating site) (H12-03497). All women and community-based health workers provided written informed consent for participation prior to enrolment.

2.5. Outcomes

This piece of process evaluation addressed the fidelity (how closely health workers followed the protocol and intervention as intended e.g. adherence to the recommended schedule of antenatal visits: 4-weekly during pregnancy until 28 weeks, fortnightly from 28 to 35 weeks and weekly thereafter, within 24 h of birth, and on approximately days 3, 7, and 14 after delivery), dose (how much of the clinical intervention was delivered), and reach (the number of recipients of the intervention) of the CLIP intervention [26].

2.6. Statistical analysis

The aim of this analysis was to describe the ability of community-based health workers to administer life-saving emergency therapy in the study area from March 01, 2014 to January 31, 2016. Ability is assessed by the following proxies: acceptance rates and number of adverse events related to treatment. Means and standard deviations are presented for continuous variables.

2.7. Role of the funding source

The funder had no role in designing the study, data collection and analysis, the decision to publish, or the preparation of this manuscript. The corresponding author had full access to all the data in the study and final responsibility for the decision to submit for publication.

3. Results

In the 29 participating wards in five clusters, 170 (57.8%) community-based health workers were trained: 83 (48.8%) CHEWs, 14 (8·2%) HAs, and 73 (42·9%) nurses. Twenty-five of the nurses had additional qualification as midwives. The most common reason why community-based health workers were not trained were personnel logistics at the health facility, unwillingness to take up additional responsibility, and turf protection among nurses and lower cadre health workers.

These community-based health workers enrolled 8790 pregnant women (Table 1) during routine antenatal care at public PHCs. These women received an average of three visits per pregnancy, the majority of these visits were antepartum (78.7%); however, 27.5% of pregnancies received at least one postpartum visit. Few women (30.6%) received four or more antenatal visits, and even fewer received the newly recommended eight visits (4.7%).

Table 1
Number of visits per pregnancy.

	Total pregnancies (N = 8790) mean (sd)/n (%)
Total visits*	32 703
Visits per pregnancy	3·7 [± 2·8]
Reach	
Total number of antenatal visits	25 745
(% of all visits)	(78·7%)
Pregnancies with at least one antenatal visit	8680
(% of all pregnancies)	(98·7%)
Fidelity	
Antenatal visits per pregnancy	3·0 [± 2·2]
Pregnancies with ≥ 4 antenatal visits	2693
(% of total pregnancies with antenatal visits)	(31·0%)
Pregnancies with a visit every 4 weeks	1721
(% of total pregnancies with at least two visits and expected to have delivered by end of trial Jan 09, 2016)	(24.5%)
Total number of postpartum visits	6956
(% of total visits)	(21·3%)
Pregnancies with at least one postpartum visit	2416
(% of total pregnancies with at least two visits and expected to have delivered by end of trial Jan 09, 2016 (7016))	(34.4%)
Postpartum visits per pregnancy	2·9
(for all those with postpartum visits (2416))	[± 1·2]
Postpartum visits per pregnancy	1·0
(for all those expected to be postpartum by the end of the trial)	[± 1·6]
Pregnancies with ≥ 4 antenatal visits and at least one postpartum visit	1043
(for all those expected to be postpartum by the end of the trial)	(14·9%)

* *All visits in this analysis include, at a minimum, completed blood pressure measurements or emergency condition(s).*

3.1. Community-level treatment of pre-eclampsia with $MgSO_4$ and methyldopa

The total number of study visits at PHCs with $MgSO_4$ recommended was 154 (0·5% of total visits), 139 visits recommended methyldopa (0·4% of total visits), all whom also received $MgSO_4$. The vast majority of these pregnancies were recommended treatment as a result of severe systolic hypertension (an average systolic blood pressure ≥ 160 mmHg): 85·7% of visits with a recommendation for $MgSO_4$ and 89·9% of visits with a recommendation for methyldopa (Table 2). All women who were provided treatment were also recommended referral within four hours to the nearest CEmOC facility.

3.2. Acceptance of $MgSO_4$ and methyldopa treatment

Out of the 139 visits with methyldopa recommended, 124 (89·2%) accepted this treatment. Similarly, there was a high rate of acceptance for $MgSO_4$, of the 154 $MgSO_4$ recommendations, 136 (88·3%) accepted. Seventy-four percent (n = 127) of those recommended urgent referral, within four hours, accepted (Table 3). The most common reason for refusal of transport was permissions not obtained from husband or decision-maker (n = 17.52% of refusal responses). In the study period, 67 (49·3%) visits resulted in administration of $MgSO_4$ by nurses, 52 (38·2%) by CHEWs, 21 by midwives (15·4%), 1 (0·7%) by CHO and a HA provided $MgSO_4$ on only one occasion (0·7%).

Table 2
$MgSO_4$ and methyldopa treatment recommendations.

	Total visits with $MgSO_4$ recommended (N = 154)
Total visits with a miniPIERS risk ≥ 25%*	5 (3·2%)
Visits with a miniPIERS risk ≥ 25%* that triggered treatment	5 (3·2%)
Total visits with severe systolic hypertension †	132 (85·7%)
Total visits with severe diastolic hypertension †	76 (49·4%)
Visits with severe diastolic hypertension that triggered treatment†,‡	55 (35·7%)
Total visits with signs of recent seizure reported	9 (5·8%)
Total visits with signs of recent seizure confirmed	0 (0%)
Total visits with signs of recent stroke reported	0 (0%)
Total visits that reported ¥vaginal bleeding + non-severe systolic hypertension	0 (0%)
	Total visits with methyldopa recommended (N = 139)
Severe systolic hypertension	125 (89·9%)
Total visits with severe diastolic hypertension†	71 (50·1%)
Visits with severe diastolic hypertension that triggered treatment†,‡	50 (36·0%)

Triggers are not mutually exclusive.
Severe systolic hypertension is defined as an average systolic blood pressure ≥160.†
Non-severe systolic hypertension is defined as average systolic blood pressure ≥140.
Severe diastolic hypertension is defined as average diastolic blood pressure ≥110.†
After December 18th, 2015 MgSO4 was not recommended for any women known to be prior to 20 weeks gestation.

¥ *Antepartum bleeding of a spoonful or greater.*

* *A miniPIERS score is determined by a predictive model for adverse outcome in pregnant/postpartum women with hypertension, a score of ≥25% indicates a likelihood of adverse outcome of ≥25%.*

‡ *Diastolic blood pressure was a trigger for treatment only after January 23, 2015.*

Table 3
Acceptance of $MgSO_4$ and methyldopa.

Dose	Total (N = 32 703)	Accepted	Refused	Missing
Visits with $MgSO_4$ recommended	154 (0·5%)	136 (88·3%)	16 (10·%4)	2 (1·3%)
Visits with methyldopa recommended	139 (0·4%)	124 (89·2%)	12 (8·6%)	3 (2·2%)
Visits with four-hour referral recommended	171 (0·5%)	126 (73·7%)	41 (24·0%)	4 (2·3%)

3.3. The safety of community-level administration of $MgSO_4$, methyldopa, and referral

There were no adverse events related to the administration of $MgSO_4$ or methyldopa in the study period. There was one injury in transport to a CEmOC facility, after thorough review of this case, it was confirmed that the woman suffered a minor injury to her arm due to seizures during transport in a poorly maintained vehicle; therefore, the injury was unlikely related to the community management of pre-eclampsia. There were no cases of serious unexpected events related to any of the treatments provided. In addition, there were no reported instances of mistreatment or overtreatment resulting in magnesium toxicity. There were also no reports of infection or hematoma at injection sites (Table 4). Sixty-five percent (n = 89) of pregnancies with $MgSO_4$ administered received a subsequent visit at some time during pregnancy or the first 42 days postpartum by a community-based health worker. Fifty-eight percent (n = 79) of women who received methyldopa had a subsequent visit at some point by a community-based health worker.

Table 4
Adverse events related to community treatment with $MgSO_4$, methyldopa, and referral.

	Visits with $MgSO_4$ administered (N = 136)
Follow-up visits after treatment with $MgSO_4$	89 (65·4%)
Visits with $MgSO_4$ and an adverse event	0 (0%)
Visits with a hematoma	0 (0%)
Visits with an infection at injection site	0 (0%)
	Visits with methyldopa administered (N = 124)
Follow-up visits after treatment with methyldopa	79 (58·1%)
	Visits with four-hour referral accepted (N = 126)
Visits with injury reported during this referral	0 (0%)
Visits with injury confirmed during this referral	0 (0%)

4. Discussion

In the CLIP Trial, community-based health workers were able to use the POM application to recognize women at risk of pre-eclampsia and eclampsia and to provide appropriate treatment and referral.

There is considerable evidence regarding the treatment of pre-eclampsia and eclampsia by nurses, whereas the literature is far more limited regarding lay community-based health workers. There is a general consensus that it is within the scope of nurses and midwives to administer antihypertensives for severe hypertension in pregnancy; however, WHO did not recommend this task be performed by community-based health workers [17]. WHO has also recommended that nurses administer a loading dose of $MgSO_4$ for prevention and treatment of eclampsia prior to referral [17]. It is important to note that this is recommended in the context of targeted monitoring and evaluation. Studies carried out in Nigeria have demonstrated the ability of trained community-based health workers to triage and initiate pre-eclampsia treatment [27,28]. This has led to a change in national policy such that community-based health workers are authorized to administer a loading dose of $MgSO_4$ before referral [28]. Although some studies have suggested that community-based health workers in LMIC could be employed to provide timely care to women with pre-eclampsia, there is currently no existing systematic review on the treatment of pre-eclampsia and eclampsia by community-based health workers [29]. A systematic review of tested dosing regimens of magnesium sulphate for managing pre-eclampsia and eclampsia demonstrated the necessity for further studies to determine if a $MgSO_4$ loading dose could be safely administered in the community [30].

Pubmed was searched for relevant literature with the following key words: "community health workers", "preeclampsia", "eclampsia", "magnesium sulphate", "low- and middle-income countries".

To our knowledge, this is the first study in a LMIC to assess the ability of community-based health workers to initiate life saving therapies for pre-eclampsia with the assistance of an mHealth platform. Similar studies that examined the ability of CHEWs to provide $MgSO_4$ in Nigeria did not include use of mHealth [27,28]. Moreover, the ability of the community-based health workers to safely administer antihypertensives

was not assessed in previous studies.

4.1. Implications of all the available evidence

The findings from the CLIP study in Nigeria are far-reaching and could improve the health of pregnant women with pre-eclampsia. Task-sharing of emergency lifesaving treatments with the aid of mHealth may contribute to a significant reduction in maternal morbidity and mortality.

In this study, women deemed to be at-risk were provided evidence-based treatment and referred by community-based health workers. There were no adverse events associated with this treatment. There was high level of acceptance among women who were recommended methyldopa (89·2%) for severe hypertension. The rate of acceptance for $MgSO_4$ was similarly high (88·3%), despite the invasive nature of intramuscular treatment. These results suggest that community providers, if properly trained, can safely and appropriately administer $MgSO_4$ and methyldopa to women with pre-eclampsia. These findings support previous studies that demonstrated the ability of minimally trained health workers to safely administer $MgSO_4$ [27,28]. The ability of community-based health workers to safely initiate emergency treatment at primary health centres could lead to a reduction of morbidity and mortality associated with the hypertensive disorders of pregnancy.

In a study conducted in five PHCs in Kano State, community-based health workers were trained to detect severe pre-eclampsia/eclampsia, administer 10 mg of $MgSO_4$ intramuscularly, treat any serious $MgSO_4$-related reactions with calcium gluconate, and refer to facilities for ongoing management. Among women with severe pre-eclampsia/eclampsia, more from study PHCs failed to attend facilities for ongoing care (90%) compared with those in control PHCs (56%) [26]. No adverse outcomes or toxicity was reported in association with PHC-administration of $MgSO_4$ in the study [27]. In the CLIP study, 73.7% of the women accepted recommendation for referral which may suggest a higher acceptance of referral compared with the previous study conducted in Kano State. This difference may be the consequence of extensive targeted training of health workers [19]. Additionally, health care providers resided in the communities in which they worked; this may have contributed to the higher level of adherence to recommendations and a higher rate of follow-up post-treatment as they are trusted members of their communities. This high rate of follow-up indicates an ability to ensure safety and efficacy beyond immediate treatment at the community-level.

This study illustrates the potential benefits to be gained through appropriate and careful task-sharing for maternal health interventions. Further evidence regarding effectiveness is required before the administration of $MgSO_4$ and oral antihypertensives by lay health workers is included in international guidelines, such as WHO's recommendations for optimizing health workers' roles to improve access to key maternal and newborn health interventions [17].

Community-based health workers can serve as a bridge to the health facility in resource constrained settings. This study has shown that when properly trained, these providers can make appropriate decisions regarding treatment and referral of women with pre-eclampsia. Early detection, through regular high-quality antenatal care [31], and the provision of lifesaving therapies at the community-level may reduce maternal and perinatal morbidities and mortalities associated with pre-eclampsia. It is important to note that there may be cases of turf protection among the community-based health workers- some nurses and midwives may feel that CHEWs and other lower CHWs should not be empowered to 'treat' obstetric cases such as pre-eclampsia [19].

The CLIP trials in India, Pakistan and Mozambique were not a cost-effective approach to reducing adverse maternal and perinatal outcomes as implemented; however, when women received at least eight home-based visits from community-based health workers, there was a cost-effective reduction in a composite of maternal and perinatal mortality and morbidity, driven primarily by perinatal mortality [32].

4.2. Limitations of the study

This study did not measure outcomes such as the reduction of maternal mortality.

The CLIP intervention did not reduce adverse pregnancy outcomes in the CLIP trials in India, Pakistan and Mozambique (adjusted OR 1·17, 95% CI 0·90–1·51; p = 0·24) [33–36]. The CLIP trial was initiated in Ogun State, Nigeria on 1 March 2015, and closed on 31 January 2016. Considerable logistical challenges in data-entry from paper forms to electronic database for the surveillance process led to the difficult decision to halt the clinical research trial. The data gathered by the way of the mobile device was of high quality and integrity. This was done by mutual consent with the local research team and under the aegis of the local and institutional research and ethics board.

Fetal outcomes were not available for women who received treatment and/or referral as part of the CLIP trial, therefore, we cannot extrapolate the perinatal impact of these interventions. In addition, data regarding respiratory depression were not collected following treatment with $MgSO_4$, nevertheless, existing evidence indicates this is not a grave concern with an occurrence of only 1.3% [37].

5. Conclusion

These findings confirm the ability of community-based health workers to safely administer methyldopa and intramuscular magnesium sulphate. The use of task-sharing, therefore, could reduce the three delays (triage, transport and treatment) associated with high maternal mortality and morbidity in rural communities in low- and middle-income countries. There is a need for further studies among community-based health workers in other similar settings. A systematic review of these studies may thus justify this as an international recommendation.

Author contributions

MV, AAA*, AAA and CN drafted the manuscript; LL, DT managed the data; LM, BP, AHS, HLN, SD, SS, ZB, OO, EJ, OS, DA, provided manuscript review and input; OA, OAD, JS supervised and led study conduct; PvD conceptualized the study.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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