Findings from a Trial of a Community-Engaged Emergency Referral System in a Remote, Impoverished Setting of Northern Ghana

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Abstract: Although Ghana has a well-organized primary health care system, it lacks policies and guidelines for developing or providing emergency referral services. In 2012, an emergency referral pilot was launched by the Ghana Health Service (GHS) in collaboration with community stakeholders and health workers in one sub-district of the Upper East Region and scaled up in 2013 to a three district trial serving a population of approximately 184,000 over the 2013 to 2015 period. Fielded as a component of a health systems strengthening project, known as the Ghana Essential Health Intervention Program (GEHIP), this plausibility trial was termed the "Sustainable Emergency Referral Care" (SERC) initiative. Monitoring data show that community exposure to SERC was associated with increases volume of emergency referrals, diminished reliance on facilities unstaffed and unequipped to provide surgical care, and increased caseloads at facilities capable of providing appropriate acute care. By organizing this bypassing of substandard points of care, SERC reduced overall facility-based maternal mortality relative to levels observed in facilities located in comparison areas.

Efforts to develop emergency referral services typically focus on the deployment of equipment, without adequate attention to systems planning that includes community engagement, frontline worker triage training, communication systems development, and implementation monitoring. A program launched in northern Ghana used implementation science to develop a system of referral care that addressed these gaps. Strategies that emerged reduced facility-based maternal mortality.

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cateds not yet served by SERC. Qualitative appraisal shows that the strategy is highly regarded in communities that it serves owing to community awareness that SERC operations improved emergency readiness and survival.

Running Head: Community-Engaged Emergency Referral System

Keywords: Ghana, emergency referral, acute care, community-based health care, maternal and child health; implementation science, emergency medical services, Africa

Word count: 5,998

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INTRODUCTION

Considerable child health development progress was achieved during the Millennium Development Goal era in Africa. Despite this MDG progress, maternal and perinatal mortality remain among the leading causes of death, a problem that persists throughout Africa. According to the World Health Organization (WHO), approximately 800 women die from pregnancy or childbirth-related complications every day, [1] of which nearly 99% occur in developing countries, with over half occurring in sub-Saharan Africa where only seven percent of the global population resides. Most maternal deaths are associated with hemorrhaging, unsafe abortions, obstructed labor, infection, or eclampsia --causes that could be prevented if women received timely care during medical emergencies.[2] Nearly all maternal deaths are accompanied by associated neonatal deaths. Even where child health has improved, neonatal mortality has proven to be a challenge to address. Although most neonatal deaths are preventable, if only skilled attendants were present at times of delivery,[3,4] rates remain high even where child health and survival is otherwise improving.

Developing emergency care is therefore a priority activity of most public health systems in Africa. WHO defines three core components of emergency care: care provided in the community, during transportation, and at the health facility [5–7] each incurring corresponding sources of risk that elevate death and disability: (1) delays in seeking care; (2) delays in reaching care; and (3) delays in receiving appropriate care upon arrival at the referral facility.[8] In rural Ghana, these delays are driven by lack of awareness of the importance of emergency care, poor road conditions, scarcity of vehicles, and limited means of communication with consequences that can be fatal tocases in need of acute care interventions. This paper reports results from a trial of solutions to such problems in a rural Sahelian region of Ghana known as the Upper East Region.[9]

CONTEXT

While Ghana has a well-organized, decentralized primary health care system, the country has yet to develop clear emergency referral service guidelines. Moreover, the National Health Insurance Scheme (NHIS) has no provision for covering referral transport costs. In the UER , one of Ghana's most impoverished and remote regions, there is a scarcity of vehicles, poor road networks, impassible terrain, and geographic barriers to reaching health services.[10] forcing patients in urgent need of acute care to resort to walking, bicycles, donkey carts, or motorbikes. Ambulances are typically absent, in disrepair, or located so remotely from communities that they fail to address emergency needs. Even if equipment is available, no organized emergency communication system links one level of care to another to ensure that referrals are successfully executed. Cultural norms can also constrain timely acute care seeking behavior. Moreover, since the NHIS does not cover costs associated with emergency transportation, referral can be prohibitively expensive, further increasing delays in seeking care.

In response to these gaps, the GHS pilot tested an emergency referral scheme in collaboration with community stakeholders and health workers in a sub-district of the UER. Conducted initially as five-month pilot in 2012, the program added 12 sub-districts in July 2013, serving a population of approximately 180,000. The project included a referral strategy informed by the assessment of population needs and health systems capabilities, adequately resourced referral

centers, active collaboration between referral levels and across sectors, formalized communication and transportation arrangements, with specific protocols specified for referrer and receiver and mechanisms for ensuring supervision and accountability, affordable service costs, capacity to monitor effectiveness, and policy support. Known as Sustainable Emergency Referral Care (SERC), the project aimed to develop a community- and sub-district level emergency referral system that would improve survival in rural impoverished Ghanaian communities.

THE SERC PROGRAM

SERC was designed to address access, organizational, and knowledge barriers to emergency care services through the implementation of a low-cost emergency transportation and communication system and community education activities. The program aimed to facilitate rapid transport of patients from their community locations or sub-district health center to higher levels of care. SERC was a component of a health systems development program known as the Ghana Essential Health Intervention Program (GEHIP), and as such, scale-up was led by GEHIP staff based at the Upper East Regional Health Directorate (RHD). By applying the tools and methods of participatory planning,[11] SERC was designed and implemented in collaboration with community members as well as community, sub-district, district and regional health system officials . To solicit stakeholder advice, meetings, focus group discussions, and in-depth interviews were held throughout the planning process with community members, frontline workers and supervisors.[12–14] Research assistants were assigned to each District Health Management Team (DHMT) to support program implementation activities and liaise across levels of the health system.

The transportation system

A fleet of 24 three-wheeled motorcycles known as "*Motorkings*" was procured by the GHS to serve three districts (12 sub-districts) in the UER: Bongo, Builsa North, and Builsa South. Based on driver advice from the pilot phase, structural modifications to *Motorkings* were made to enhance patient safety and comfort. These adjustments involved installation of a welded frame and tarpaulin to provide privacy and protection for patients during transport, extended rearview mirrors to allow maximum visibility, a mattress and safety belt for patients, a seat for an accompanying health worker, and a hook for intravenous drips (Figure 1). To identify vehicles

as ambulances, each was marked with the GHS logo and a red cross. All vehicles were equipped with First Aid kits, a spare tire and jack, and protective rain gear for drivers. Recognizing the importance of vehicle maintenance, vehicles were routinely serviced by staffed mechanics from the Upper East RHD. Spare parts were procured and kept in stock at the RHD to ensure timely repair in the event of breakdowns.

GIS data were used to estimate the optimal placement of ambulance stations and configuration of catchment areas that ensured community access to an ambulance.[15] SERC ambulances were deployed to nine sub-district health centers, 12 community health posts, and three communities that lacked such facilities or community resident nurses. In Ghana, community health service posts function as the first point of care, but only half of the planned locations for these facilities are functional. In the three locations that lacked community facilities, community leaders were engaged to determine an appropriate location for the community-based ambulance station. In all three villages, assemblyman and sub-chief's homes were selected as stations due to their centrality, relative security, and social acceptability for this responsibility.

Forty-eight community-selected volunteers (two per ambulance) were trained to serve as drivers. Drivers varied in age, but were typically literate young adult men. Drivers were trained in basic first aid, infection prevention, defensive driving, basic maintenance, transport policies, communications protocols, and record-keeping. Training was pursued as a collaboration of the RHD's Transport Unit, the *Motorking* vendor, the Drivers Licensing Authority, and the Ghana Red Cross.

The communication system

Prior to SERC, no integrated emergency communication system had been established to link patients to emergency care services at the community and sub-district levels. Therefore, the RHD procured communications equipment to facilitate rapid communication during emergencies. Dual-SIM mobile phones were distributed to health facilities, health workers, and volunteer drivers. In communities that lacked a resident nurse, volunteers were provided emergency phones. This ensured that every community had access to a mobile phone for eliciting rapid referral. Emergency phones were assigned to nurses termed "Community Health

Officers" (CHO) who were either based at community facilities, or in sub-district health centers, or in the Outpatient Department of district hospitals. At the tertiary referral point, the Regional Hospital had a designated phone line in each ward for receiving incoming calls about impending cases.

The community-engagement system

Protocols specified various emergency scenarios in the community or at the facility. Key guidelines included emergency verification by a health worker and alerts to facilities of incoming cases to facilitate preparation and minimize delays. Frontline workers were trained in basic triage procedures. All transited cases were to be accompanied by a health worker. Receiving facilities were required to provide feedback to the referring facility upon discharge, facilitating health work follow up scheduling. Resources and supplies were monitored routinely to assess availability of human resources, equipment, medication, and forms.

Staff and volunteers were equipped with emergency phones and trained in mobile phone use, criteria for ambulance use, protocols, and record-keeping. Quarterly refresher training sessions were held to ensure that knowledge and skills were retained. District and sub-district level supervisors were trained to oversee SERC activities and provide routine monitoring and supervision. Monthly review meetings were held across worker tiers to discuss challenges that arose and system improvements that were needed.

The GHS supported the operating costs of the emergency referral system. Pregnant women and children under five years of age were provided free emergency transport. Normal labor cases were transported free of charge to encourage facility-based delivery. Other ambulance users were charged a nominal cost recovery fee ($2.50 – 5.00 USD), determined by each District Health Management Team (DHMT). In one district, the District Assembly (DA), covered maternal and child referral fuel costs.

Ghanaian cultural groups have well defined systems of social organization and community consensus building that rely upon "durbars," an open forum for discussion matters of collective importance to the community. In concert with these traditions, SERC convened durbars in all ambulance catchment areas to explain the intended use of the ambulance, introduce SERC health

workers and volunteers, and review their roles, and discuss the importance of seeking care during emergencies. An emergency phone number was provided to communities and placed on posters at health facilities and community gathering points. Health workers liaised closely with traditional chiefs and elders as their support was essential.

Health worker feedback was solicited to inform strategies for community education on emergencies. Qualitative appraisal was applied to determine the learning needs of community members regarding emergencies and identified strategies for developing a culturally appropriate community education program with the aim of increasing community capacity to recognize signs and symptoms of emergencies, encourage prompt decision-making to seek care, and increase SERC utilization. Educational materials were developed in consultation with opinion leaders and community members and translated into local languages. Materials included educational flipcharts (for use by health workers); informative songs played on local radio stations and on speaker systems of outpatient hospital wards. Filmed dramas were developed depicting emergency scenarios for projection at evening durbars. Posters displayed in health facilities and meeting points depicted actions to be taken in emergency situations.[16] Discussion of the possible harm to the program that could arise from equipment misuse was integrated into community education sessions.

METHODS

Implementation research was conducted to identify operational challenges and potential solutions. An iterative systems development approach was employed to continuously refine the initiative. Methods included a routine analysis of key process and health indicators, a health worker survey, and qualitative systems appraisal with community members.

Quantitative evaluation of health information data

Monthly SERC monitoring records were completed by volunteers, health staff, and district supervisors, submitted to the RHD where results were visualized to assist supervisors with assessment of referral volume by location and the types of cases associated with referral operations. Monitoring included station specific information on distances traveled, transit times, adherence to protocols, types of emergency, and patient outcomes with technology designed to

integrate SERC monitoring into the routine GHS data system operations known as District Health Information Management System (DHIMS). Educational aids and training sessions were developed to assist regional and district level managers with database usage. Monthly DHIMS data are routinely available for all primary health care service points in Ghana. For the purpose of this analysis, three SERC exposed "treatment" districts provided a basis for assessing the effect of the program relative to comparison district facilities in the Upper West Region and seven districts of the UER. Of the 13 districts of the Upper, Kassena-Nankana East and Municipal Districts were removed from GEHIP because research protocols in operation in these districts were potentially confounding factors in the interpretation of GEHIP and SERC results Communities of the Millennium Village Project in Builsa South were excluded owning to unique financial and logistics support systems of that project.[17]

Utilization of the DHIMS data for SERC evaluation involved comparison of time trend data from SERC facilities with that of facilities located in unexposed districts of the UER applying generalized linear mixed models with an exchangeable covariance structure to account for repeated observations.[18] This basis for inference ensures simultaneous adjustment for autoregressive error in time series models and hierarchical adjustment for multilevel clustering .[19, 20] For each dependent variable of interest, a model of monthly time series data takes the form:

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + \beta_2 t_{ij} + \beta_3 x_{ij} t_{ij} + u_j + \epsilon_{ij}$$

Where

y_{ij} is a DHIMS reported value of outcome y from facility j at time i.

x_{ij} is a dummy variable defining whether facility j is in the SERC area or control group.

t_{ij} is a dummy variable defining whether time i is before or after the start of the SERC intervention.

u_j is a random intercept for facility j.

ϵ_{ij} is a random error term for facility j at time i.

The parameters $\beta_0, \beta_1, \beta_2, \beta_3$ are estimated by maximum likelihood, with β_3 estimating the "difference in difference" association of SERC exposure with the number of events of interest recorded by 14 hospital facilities over 70 months of observation. This approach to evaluation

represents a regression extension of the Heckman (1974) procedure for estimating impact of interventions non-experimental designs [21,22]. Repeated observations within a facility are adjusted by assuming an exchangeable correlation structure.[23, 24] Table 1 reports robust standard errors obtained via the sandwich operator.[25]

A health worker survey

A survey was administered to health workers in December 2013 to assess their perspectives on SERC components and challenges. The survey sampling frame was comprised of all staff based at sub-district and community level health facilities involved in the SERC program, including those who were either affiliated with ambulance stations or responsible for referral operations at ambulance stations, or charged with receiving SERC referrals. This yielded a list of 124 health workers, with a interview response rate of 89% (N=110). Sample loss was due to annual leave of the 14 non-respondents. The questionnaire was pre-tested and revised based on feedback provided. Over a one week period, survey instruments were completed as self-administered questionnaires. Respondents were encouraged to provide candid feedback, and were provided with de-identified forms and blank envelopes to preserve anonymity. Procedures assured respondents of confidentiality so that instruments could be completed without risk that critical comments would incur supervisory concern or reprisal.

Qualitative systems appraisal

A qualitative appraisal was conducted in March 2014 to assess community stakeholder, client, and volunteer experiences with SERC. Focus group discussions (FGDs) and in-depth interviews (IDIs) with community stakeholders assessed the acceptability of the intervention at the community level. IDIs also examined client experiences with SERC, their satisfaction with care, and suggestions for improvement. A total of 16 FGDs and 59 IDIs were conducted. Sixteen FGDs were held with men, women, drivers, and volunteers from SERC intervention sub-districts. Twenty-three IDIs were conducted with chiefs, emergency referral users, and volunteers equipped with emergency phones. To enhance representativeness, different communities were sampled for each focus group category (women, men, community health volunteers). FGD sessions were community-based to enhance discussion. All IDI and FGD were conducted in local languages, Builli and Guruni. Respondents provided written consent, and all interviews were tape-recorded, transcribed, and analyzed using the Nvivo 9 software package.

RESULTS

Findings from time series analysis of key indicators

From July 2013 through June 2015, 1290 cases utilized SERC transport services. The average trip time and distance traveled were 56.6 minutes and 9.92 km respectively. Most referrals were to higher levels of care at sub-district health centers and district hospitals, with a high concentration of care at two facilities that are well staffed and equipped to manage emergencies (Figure 2). The next most common reasons for referral included malaria, anemia, diarrhea, ARIs, and injury. Ninety-eight percent of cases were treated and discharged successfully, while 2% resulted in death.

[Insert Figure 2 here:

The facility focus of SERC-related referral care in three districts of the Upper East Region, 2013-2015]

The referral profile changed as SERC progressed (Figure 3). However, irrespective of the time period, obstetric cases were the predominant type of referral. Consequently, nearly three quarters of cases were female patients. Although inappropriate use of the referral system could not be monitored directly, care for minor situations that are not emergencies tend to be labeled as "other" types of referrals. As Figure 3 shows, the proportion of such cases declined with time, suggesting that the high initial frequency of inappropriate SERC referrals may have diminished as operations progressed.

[Insert Figure 3 here:

The monthly time series in aggregated reasons for referral reported by 359 facilities unexposed and exposed to the SERC system, 2009-2015]

The association of SERC exposure with facility output indicators is presented in Table 1. As the parameters show, the volume of facility-based deliveries increased with passing time, but trends in treatment districts were less than comparison districts. The SERC effect, as estimated by the regression effect in the SERC (DD) row of column (1) was negative, as shown in Figure 4, but not significant. There was nonetheless a shift in the location of delivery care within districts

where SERC was introduced. More deliveries occurred in SERC district acute care ready facilities , displacing delivery care where surgical procedures are not performed (Figure 5), and hospitals staffed and equipped to provide acute care received more referrals where SERC was operative than elsewhere (Table 1, column 4). This relocation of care was associated with a reduction in facility-based maternal mortality (Table 1, column 2), although there was no significant effect on the C-section rate (Table 1, column 3). Of the specific indicators of the volume of acute care episodes, only the volume of care for accidents and maternal emergencies appear to have been affected (columns 2 and 8, Table 1, respectively). The impact of SERC on acute care for accident victims is important, not only for the evidence accorded by Table 1 results, but also because evidence now suggests that accident related morbidity and mortality is rapidly expanding in northern Ghana.[26] Although time series regression results must be interpreted with caution owing to the instability of models and results that are subject to adjustment for autoregressive error, [27] SERC mortality effects are suggested by the relationships demonstrated in Table 1. While these findings merit further investigation, SERC replication and scale-up merits careful review and consideration.

[Insert Figure 4 here:

Time series in the total monthly deliveries for 359 facilities in SERC districts versus comparison districts 2009-2015

[Insert Figure 5 here:

Time series in the total monthly volume of deliveries at Upper East Region by type of facility in districts exposed to SERC versus UER and Upper West Region facilities unexposed to SERC.]

Other monitored information included process indicators such as staff compliance with protocols. Of the cases transported, less than half (49%) were accompanied by referring health workers. Receiving facilities were alerted to incoming cases in only 46% of the referral episodes monitored.

[Insert Table 1 here]

Health worker survey findings

Of the 110 survey respondents, over half were CHOs (56%) while the remainder were clinic-based nurses (25%), midwives (13%), or physician's assistants (6%). Sixty-nine percent of the

respondents worked in community locations, 27% worked in sub-district health centers, and 4% were hospital based. Subsequent to program launching, 74% of the respondents had personally referring cases using SERC's transport service.

Perceived effectiveness and safety of Motorking ambulances. The majority of health workers (66%) considered SERC as 'very effective' in improving the community and sub-district level emergency referral system. Thirty-three percent considered *Motorkings* to be 'somewhat effective.' Most health workers perceived the *Motorking* to be safe, with 26% categorizing the vehicle as 'very safe' and 61% considering it to be 'somewhat safe.'

Driver dedication and availability. Respondents generally perceived drivers to be dedicated to their roles (56% reported finding them 'very dedicated'; 41% found them 'somewhat dedicated,' and only 3% found them 'not at all dedicated'). However, there were instances when health workers were unable to promptly contact volunteer drivers. When asked whether health workers at ambulance stations should be trained on driving *Motorkings* for such instances, the majority of respondents (75%) said 'yes.'

Protocol adherence. Protocol non-compliance was evident for some aspects of care. For instance, referring facilities often failed to call in advance to alert receiving facilities of an incoming case. Moreover, many cases were unaccompanied by a health worker, despite protocol specifications requiring accompaniment. Although surveyed health workers nearly universally affirmed the importance of these procedures, 67% of the referred patients who were interviewed reported that they had been referred without accompaniment. When workers were asked why they were unable to accompany the patient, the most commonly cited reasons were that another health worker accompanied the patient (37%); the respondent was the only staff member at the facility and could not leave their post (35%); or the respondent was attending another client (32%). A few respondents reported that they did not accompany the case because they did not feel comfortable riding in the ambulance (16%) while four percent thought the patient would not benefit from riding with a health worker. Protocols also obligate receiving facilities to provide patient outcome feedback to referring facilities for every case, but this requirement was typically ignored.

Frontline worker perspectives on SERCs. Health workers interviewed were asked to identify the primary challenges to effective emergency referral services. Poor road conditions (95%) was the most commonly reported challenge, followed by lack of driver motivation (59%); cultural practices that delay care seeking, lack of knowledge of the importance of seeking care (40%); poor communications networks (32%); and adverse weather conditions (29%). Less frequently reported responses included client inability to take time away from work or family obligations (20%); the cost or unavailability of fuel (19%); poor communication between health facilities (18%); lack of readily available transport options (13%); or lack of *Motorking* acceptability (12%).

Qualitative appraisal o challenges to effective emergency referral

Qualitative systems appraisal shed light on the acceptability of services and community perspectives on potential areas for improvement. Three main categories of themes emerged during data analysis: community endorsement of SERC; logistical challenges; and interpersonal relationships.

Community endorsement of SERC. Overall, community members strongly endorsed SERC and expressed appreciation for the service. SERC was generally perceived as reliable and reactive with a committed staff supporting the system. For instance, a woman who had used SERC noted that:

> *"It sent me to the clinic to deliver and I did that safely without any bad thing happening to me. I delivered safely. That is the beauty of it.*"

Several users reported that they would recommend SERC services to anyone in need of emergency care. The removal of fees for pregnant women and children under-5 was seen as a key contributor to high SERC uptake. Although some participants preferred four-wheeled ambulances, respondents generally believed that the three-wheeled ambulance was better than the available alternatives such as walking, bicycles, donkey carts or motorbikes:

> *"It has been so beneficial to the pregnant women and the children under-5 because they do not pay when the vehicle is transporting them. In the past, we used to transport pregnant women in donkey carts and on bicycles but today there*

is ready and reliable means of transport for them in emergencies." (Community volunteer during FGD)

Some participants acknowledged that three-wheeled vehicles, such as the *Motorking*, can traverse narrow passages that are inaccessible to four-wheeled vehicles:

"If not for the Motorking, women especially pregnant women and children would have been suffering a lot…. It is able to go to the interior [of communities] to carry cases like the one I told you about with the woman who was in labor and nearly died if not for the sake of the Motorking ambulance." (IDI with community sub-chief)

Perceptions of reduced delays and increased facility-based births as a result of SERC were mentioned by several participants, along with the impression that services were helpful, safe, quick, and life-saving:

"When a woman is in labor and is not quickly sent to the health facility she might deliver. She might also lose either the baby or even herself. Kids like this, once they are weak, they can easily pass on. So the impact I see is that the emergency referral saves lives." (SERC driver during FGD)

Community and household consensus endorsing SERC was uniformly evident in each FGD and IDI, a key determinant of the sustainability of the system.

Logistical challenges. While communities were receptive to SERC services, several logistical challenges were identified. Some intervention areas remained inaccessible due to harsh weather and terrain, especially during the rainy season. These challenges however were perceived to affect all vehicle types. Some communities conveyed interest in overcoming logistical or geographical barriers through collective action or political advocacy. As two FGD respondents suggested:

"I am of the view that the community members can contribute something, however little, and seek assistance from the authorities to work on our routes or roads for us."

"Our youth, if they could help us to repair our roads small, small and when the motors come, they can be running without problems."

Although concerns about roads did not constrain SERC utilization, some participants noted that communities that were remote from an ambulance station often sought alternative means of emergency care, in anticipation of delay. Indeed, this observation is consistent with GIS data analyses showing that communities located far from ambulance stations had lower utilization rates than proximate communities.

Communication challenges. Communication problems introduced further complications. Poor phone networks, that are common in rural Ghana exacerbated service delays. Although this did not compromise care seeking resolve, solutions to communication gaps sometimes involved walking great distances to alert a health worker or volunteer.

P patient perspectives on comfort during transport varied, a problem that was associated with poor road quality. Some described the vehicle as being unstable and uncomfortable; while others described their experience as feeling very safe, with minimal discomfort. Any discomfort, however, did not appear to be severe enough as to deter SERC usage in the event of emergencies:

"There are issues like discomfort, safety and others when you are being transported but as a sick person you do not have those issues in mind when there is an emergency. Anything that can hurriedly get you to the place on time is what you will be looking for. All vehicles have the tendency of falling when transporting people so it will not be fair relating safety issues to the Motorking alone." (Male FGD participant)

"Everyone has his problem and when the vehicle picked me the driver knew that it was a painful thing being in labor so they also became careful with the way they were driving and we got there safely. Now I will not be able to speak for another person but for my experience it was comfortable." (IDI with female user of SERC services)

Community members also expressed support for improving driver's work conditions. There were concerns over drivers being exposed to unfavorable weather and the risk of robbery during

late night service episodes. Although no such incidents were reported, a few drivers worried about night driving:

> *"There are beasts at night and also ghosts. From where I come, there are so many spirits that it is not advisable to move out at night. The people sit protected in the vehicle whiles you are left alone in front. In addition to that you are not supposed to speed the vehicle and you can imagine how exposed you are if someone intends to harm you." (Driver during an FGD)*

Drivers advised SERC to develop roadside repair protocols for addressing unanticipated mechanical problems. Drivers also noted that their personal transportation needs were a challenge, as many drivers have no means of personal transportation home following late night referral episodes. Drivers were provided with two bars of soap monthly, a token of appreciation that was universally perceived as being insufficient. Cash incentives were preferred as a being critical to sustaining driver motivation. Some community members recommended that SERC choose drivers from the ranks of existing community health volunteers, given prevailing volunteer commitment to community health.

Community trust and expectations. Some participants noted instances of mistrust between health staff and drivers. For example, a driver mentioned an episode where the network was down but a health worker accused him of having turned off his phone. In another example, a male FGD participant explained how at times users may misconstrue basic triage practices as health worker neglect:

> *"Some of the pregnant women will be complaining that they came and they are thrown away, they don't care about them. Because there is no understanding between the pregnant women and the midwife when she tells them it's not time for them to deliver and they should wait. Because of that, the women say the workers are not serious, but for me, the way I know about the work I know they are serious."*

Although some patients experienced negative interactions with health workers, many described satisfaction with health staff performance during emergencies:

"We think that the child was saved by the nurses because of the timeliness of our arrival. We were happy when we got into the hands of the nurses." (IDI with female user of the service)

Drivers expressed concern that community respect for their contribution was lacking. Some community members believed that drivers were paid employees rather than volunteers. Dismissive and ungrateful comments were frustrating to some drivers. Although most community members interviewed indicated gratitude for driver services, some complained that drivers operated *Motorkings* at unsafe speeds.

DISCUSSION

Mixed methods implementation research enriched learning about the scalability, acceptability, and potential impact of implementing a community-based emergency referral system in a severely resource-constrained setting. Evidence suggests that SERC strategies can be adapted to the needs of impoverished, remote communities elsewhere in Ghana.

Overall, the SERC system was well receivedby communities and health workers alike as an effective means of reducing acute care risks. A key lesson learned was the importance of people-centered planning for obtaining and sustaining community endorsement and utilization of services. Without engagement of community leaders from the very beginning, program acceptance would have been limited. Focused outreach targeting heads of household and familial gatekeepers is also crucial to ensuring continued support and understanding of services. Moreover, the collaborative role of transportation authorities and vehicle manufacturers in the planning, training, and implementation processes proved vital to program success.

While SERC aimed to improve system functioning based on process evaluation results, the pursuit of such improvements was constrained by resource limitations, poor communication network infrastructure, and impassible roads. Nearly all of health workers consulted in this appraisal expressed a willingness to use emergency radios to offset poor cell phone coverage. However, given limited funds for equipment purchases and lack of locally available communication equipment, use of radio devices could not be implemented, obligating workers to develop improvised solutions when networks were not functioning.

The Motorking was locally available; affordable, and suitable for traversing rough terrain. Nonetheless, Motorking ambulances received mixed review of their comfort and safety attesting to the need to explore additional equipment options. A costing analysis comparing three-wheeled motorcycles ambulances with enhanced "Motorkings" or higher-quality vehicles is warranted. Similarly, determining an appropriate and sustainable incentive and recruitment system for drivers requires investigation of strategies for minimizing turnover, improving motivation, and optimizing efficiency.

Quite apart from equipment considerations, the quality of emergency care services will be limited by the poor state of infrastructure more generally. Several of the community members who were interviewed expressed concern about the status of primary health care facility development and the slow pace of CHPS implementation, high-lighting the fact that launching effective referral care requires a fully functioning primary health care system.

The SERC experience attests to the value of routine monitoring and evidence-based supervision, in conjunction with the provision of refresher training for health staff and volunteers. Lack of accountability mechanisms, supervision and training can precipitate poor protocol adherence.

Feedback mechanisms are needed that foster timely implementation of systems improvements. For instance, after it was discovered that 30 percent of the trip report forms were incomplete, forms were simplified, the format of review meetings was revised, and GIS-based vehicle tracking procedures were instituted to facilitate practical use of data for decision-making. Similarly, the importance of adhering to a routine vehicle maintenance protocol that ensured prompt repairs were found to be crucial for preventing breakdowns and minimizing service disruptions.

Training for quality assurance is important. Although most clientele reported positive experiences with staff involved in facilitating referrals, some patients experienced negative or insensitive comments. While clinical skills are crucial to operations, it is equivalently essential to foster worker patience and understanding of patient's perspectives on the quality of emergency care operations.

Some volunteer drivers perceived community members as being unappreciative of their services. Although FGD participants may have been reluctant to criticize drivers, the general discussion

suggests that drivers were, in fact, appreciated and that participants generally agreed that incentives provided should be increased. Exchanges nonetheless suggest a need for durbars and other means of community engagement that promote awareness of the life saving service and dedication of volunteers.

The fact that remote communities sometimes preferred to find their own means of transport to offset ambulance access delays attests to the need for implementation research investigating mechanisms that such communities use to undertake emergency referral. Such community-based solutions to referral problems may be relevant to operations more generally.

CONCLUSION

The process of planning and implementing emergency health services is often predicated on the need to invest in equipment, communication tools, and clinical triage capabilities. While the broad outlines of a systems perspective on such commitments merits support without challenge, specifics of strategic planning for community engagement components of referral systems requires evidence that only implementation research can convey. The successful implementation of referral services in severely resource constrained settings of Sahelian Africa depends upon systematic investigation of the appropriate equipment for the context, clarification of the appropriate strategies for social engagement in the sustainable deployment of equipment, and trial of all manner of procedural detail in rolling out an effective system of care. How these components of a functioning system interact requires trial, process evaluation, and calibration of strategies in response to findings. In settings such as Sahelian Ghana, where poverty is extreme and system resources are profoundly constrained, the effective operational planning of emergency care is particularly dependent upon implementation research. Implementing SERC in an evidence vacuum would have been a formula for certain failure.

While facility-based care is important, facility focused approaches can fail to achieve their full life-saving potential in the absence of effective referral. Moreover, if receiving facilities are poorly equipped, inadequately staffed, and unable to respond to clinical emergency needs, effective referral is little more than a program for relocating mortality. But SERC time series research attests to the life-saving potential of redirecting referral to facilities where emergencies could be competently managed. Acute care provided in fixed facilities reduced facility-based maternal mortality and accident related death by rechanneling the location of services. SERC in

the future could expand its intervention regimen offsetting strategies for bypassing substandard care facilities with training and capacity building that would enable frontline care providers of the system to more effectively manage emergencies that arise.

Just as SERC success was evidence-dependent, effective scaling up of these results will require systems approaches to effective replication. The transition from pilot to trial clarified training and engagement requirements; replication of SERC elsewhere in Ghana could clarify the practical milestones in establishing a large scale system of referral care. While documentation has been essential to moving SERC forward, effective utilization will require team demonstration, counterpart learning, and systems approaches to knowledge management and operational replication. The success of SERC attests to the importance of translating the districts that have served as the location of a trial into learning localities that can serve as platforms for demonstrating the practical requirements of catalyzing referral system development and reform.

Acknowledgements
Research for this paper was supported by grants to Columbia University from the Doris Duke Charitable Foundation and by grants to the University of Ghana and the Ghana Health Service from the British charity Comic Relief.

Conflict of Interest
The authors declare that there is no conflict of interest.

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Variables:	**Table 1. Difference-in-Difference Estimates of the Impact of SERC on Hospital-Based Health Measures, Upper East and Upper West Regions, Ghana 2009 – 2015[a]**									
	Deliveries (1)	**Maternal Mortality Rate** (2)	**C-section Rate** (3)	**Referrals in** (4)	**Referrals out** (5)	**Pneumonia** (6)	**Other Upper Respiratory Track** (7)	**Septicemia** (8)	**Accidents** (9)	**Diarrheal diseases** (10)
Treatment area	**-52.93***	**0.00353*****	-0.00651	**-12.08****	-6.499	-4.537	**-100.5****	2.555	-15.35	20.96
	(26.18)	(0.000925)	(0.0113)	(4.345)	(3.735)	(8.015)	(37.80)	(25.98)	(8.088)	(36.05)
Time period	**32.55*****	-0.000868	**0.0249****	**-3.050***	**-6.804*****	0.677	35.57	**23.64***	-3.235	18.12
	(9.550)	(0.000682)	(0.00964)	(1.435)	(1.870)	(12.75)	(47.67)	(11.90)	(3.209)	(19.13)
SERC[b]	-4.884	**-0.00352*****	0.00352	**12.27***	1.597	10.99	22.57	35.09	**20.52***	11.71
	(12.76)	(0.000775)	(0.0146)	(5.184)	(3.515)	(12.92)	(49.82)	(41.91)	(9.904)	(33.54)
Constant	**89.73*****	**0.00270*****	**0.117*****	**17.45*****	**12.18*****	**46.96*****	**237.4*****	28.38	**28.17*****	**72.04*****
	(23.81)	(0.000702)	(0.0161)	(4.174)	(3.041)	(14.13)	(58.80)	(30.88)	(6.840)	(14.96)
Observations	861	861	795	361	500	787	748	237	796	804
Number of hospitals	14	14	13	13	14	14	14	10	14	14

a) Robust standard errors in parentheses
b) The SERC Effect (difference in difference) is given by the interaction of treatment area with time period

*** p<0.001, ** p<0.01, * p<0.05

Figure 1: A modified Motorking

Figure 2: A map of the health facility focus of SERC-related referral care in three districts of the Upper East Region,

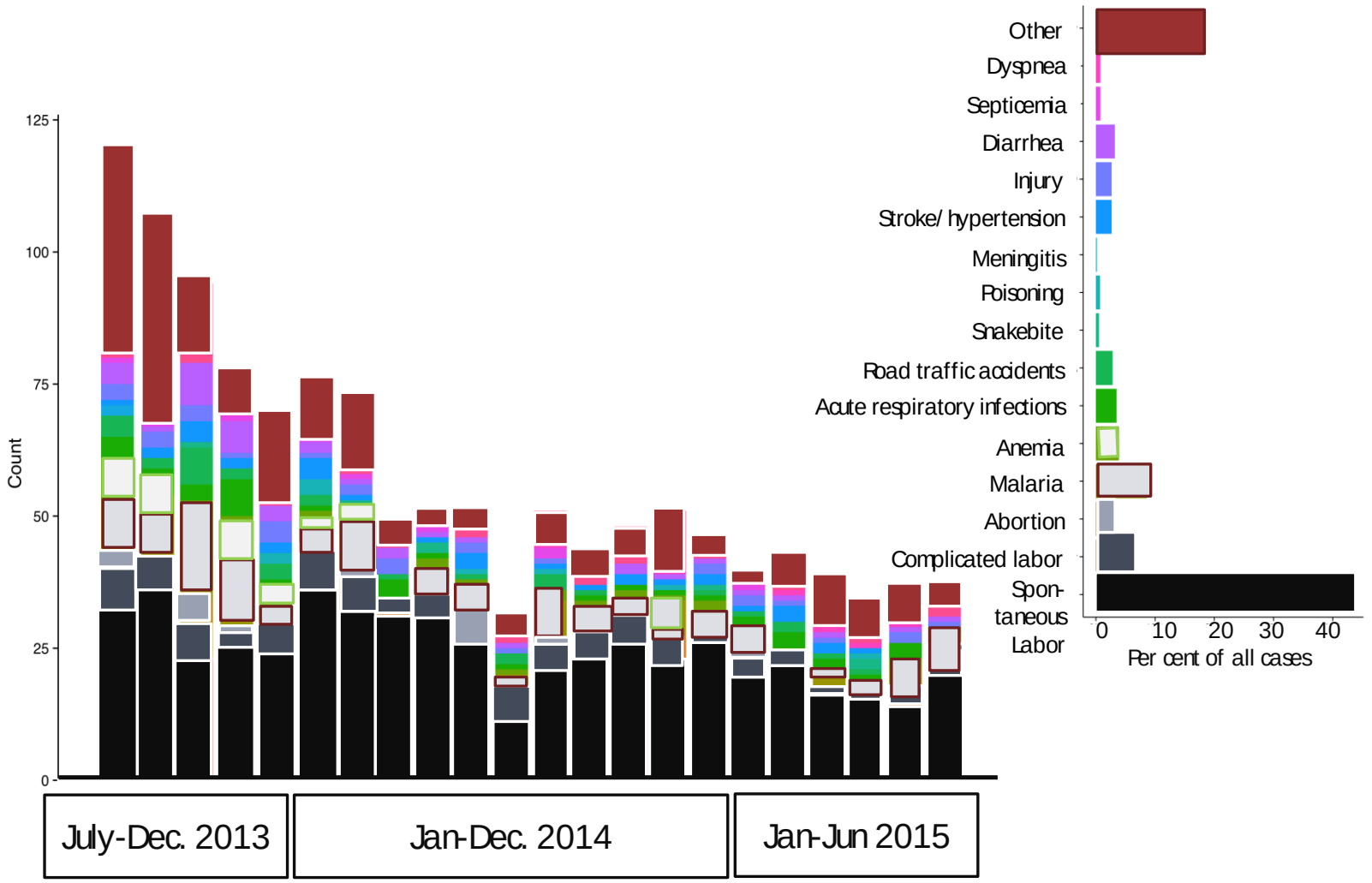

Figure 3: The monthly time series in aggregated reasons for referral reported by 359 facilities unexposed and exposed to the SERC system, 2009-2015

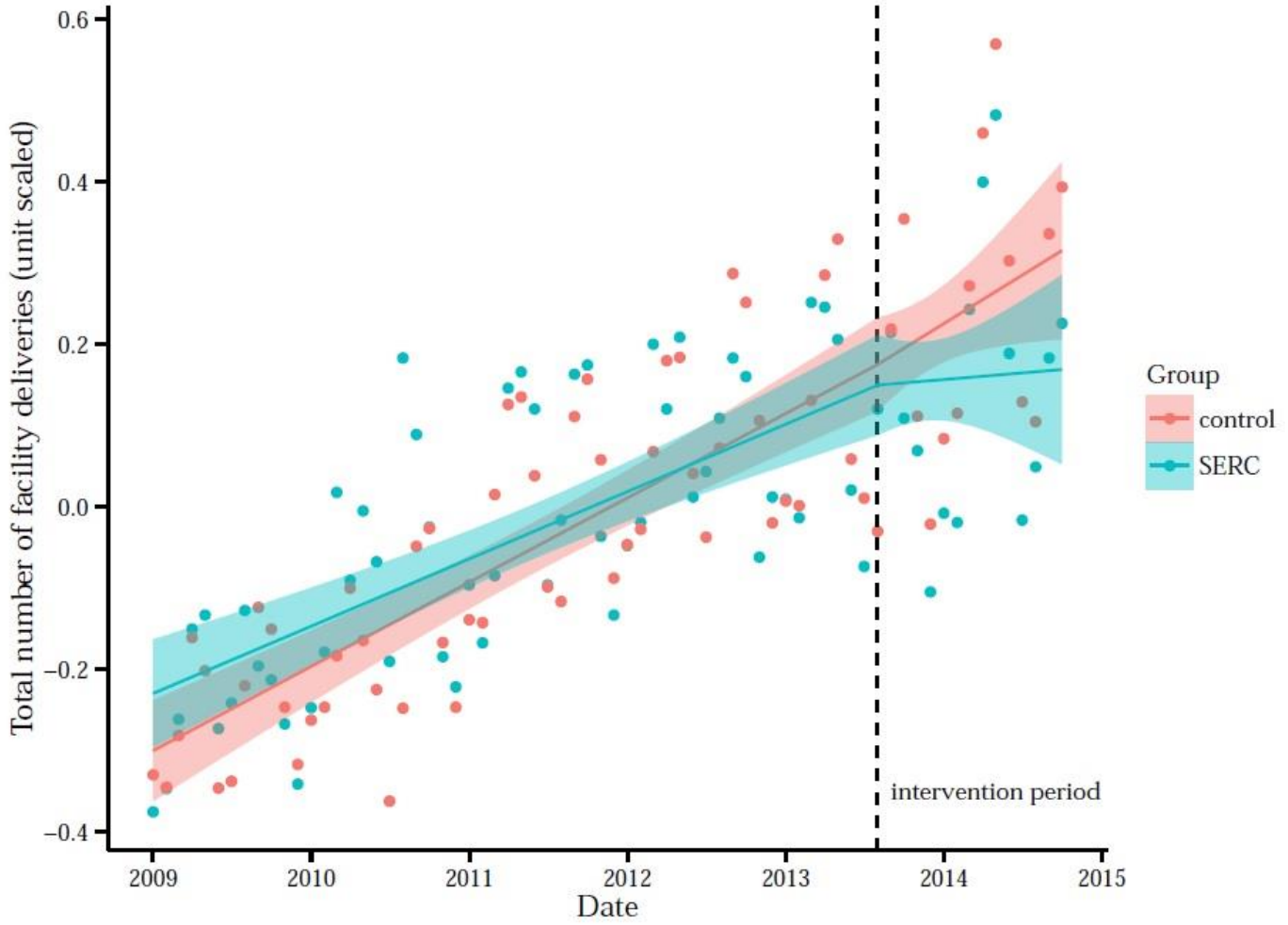

Figure 4: Time series in the total monthly deliveries for 359 facilities in SERC districts versus comparison districts 2009-2015

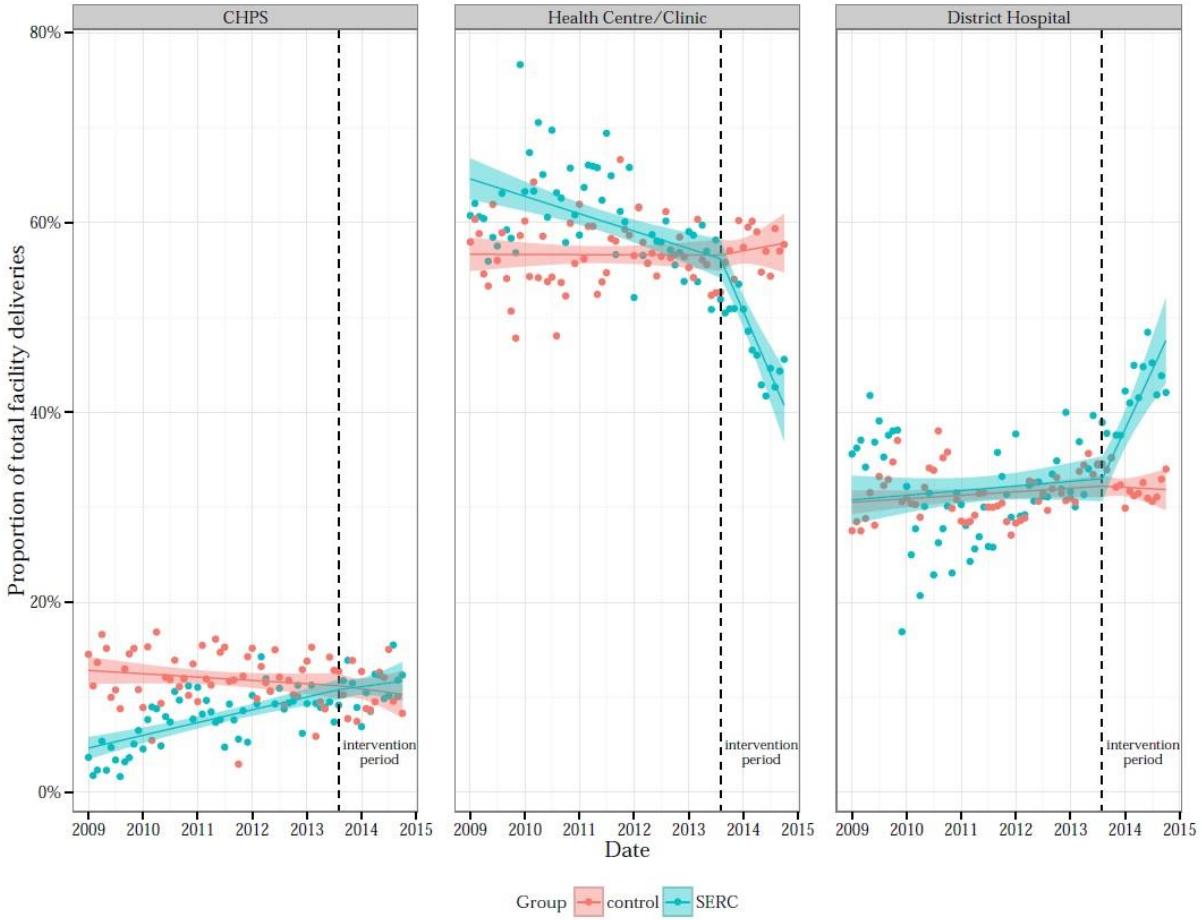

Figure 5: Time series in the total monthly volume of deliveries by type of facility in districts exposed to SERC versus facilities unexposed to SERC.