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IMPACT OF DRONE SERVICES ON THE MANAGEMENT OF EMERGENCY MEDICAL SUPPLIES AND PERINATAL OUTCOMES IN THE KASSENA-NANKANA EAST MUNICIPAL OF GHANA.

BY

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DECLARATION

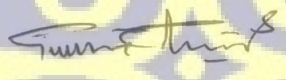
I, Joana Nyamekye Afrifa hereby declare that aside specific references made to this work which have been duly acknowledged, this research is my independent work under the supervision of Dr. Chris Guure. I also declare that this proposal has never been submitted either in whole or part for award of any degree in this university or elsewhere.

Joana Nyamekye Afrifa  24/10/2023

(Principal Investigator) (Signature) Date

Supervisor's Declaration

I hereby declare that the preparation and presentation of the project was supervised in accordance with the guidelines on supervision of dissertation laid down by the School of Public Health, University of Ghana.

Dr. Chris Guure  30/10/2023

(Supervisor) (Signature) Date

DEDICATION

This work is dedicated to my family for their relentless encouragement and contribution towards completing this project.

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ABSTRACT

Background: The medical drone delivery service operated by Zipline started supplying medical products to health institutions in Kassena-Nankana East Municipality (KNEM) of the Upper East Region of Ghana in February, 2020. The availability of the medical drones is expected to, among other things, facilitate the reduction of the perinatal mortality rate in the municipality. There is absence of empirical data measuring the impact of the drone delivery system on perinatal mortality.

Aim: This study investigated the impact of the drone delivery system on emergency medical supplies and perinatal outcomes (i.e. still births and early neonatal deaths) in KNEM.

Method: The study used a retrospective review (research) design, a quantitative methods approach, and a combination of primary and secondary data. Secondary data on yearly perinatal mortality records for 5 drone-serviced health care facilities (from 2016 to 2021) were gathered and analysed. With the aid of self-administered questionnaire to 107 respondent frontline health professionals in KNEM, primary data was gathered on respondents' opinion on factors that may be influencing perinatal mortality (stillbirths and early neonatal deaths) in KNEM before and after drones were introduced, and the impact of drones on emergency medical supplies and perinatal outcomes.

Results: Findings of the study revealed that, from 2016 to 2021, the trend in total cases of perinatal mortality reported by drone-serviced health care facilities in KNEM has been increasing, and is expected/projected to increase beyond 2021, the introduction of drones in February 2020 notwithstanding. Also, despite the introduction of medical drone services the majority of factors that influence perinatal mortality (i.e. stillbirths and early neonatal deaths) in the municipal did not change. In the view of respondents, despite the introduction of medical drone services, the majority of factors associated with still births and early neonatal deaths in

KNEM did not undergo relative changes. The study findings further revealed that drone services in the municipality have had an impact on the management of emergency medical supplies and perinatal outcomes. However, the empirical data on the incidence of perinatal mortality in the municipal and the study findings on trend analysis of perinatal mortality seem to suggest that the impact is insignificant.

Conclusion: The introduction of medical drone services in the municipal has had an impact on emergency medical supply and perinatal outcomes in the area.

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LIST OF ABBREVIATIONS

AED	-	Automated External Defibrillators
AIDS	-	Acquired Immune-deficiency Syndrome
ANC	-	Antenatal care
DHIMS	-	District Health Information Management System
GHS	-	Ghana Health Service
HIV	-	Human Immunodeficiency Virus
KNEM	-	Kassena-Nankana East Municipal
MOH	-	Ministry of Health
NHRCIRB	-	Navrongo Health Research Centre Institutional Review Board

CHAPTER ONE

INTRODUCTION

1.1 Background

Many cutting-edge technologies, particularly those in information and communication, are causing the world to develop quickly (Pulsiri & Vatananan-Thesenvitz, 2018). In the same vein, the world is also confronted with healthcare concerns, such as aging populations, people with disabilities, natural disasters, emerging illnesses, urbanization, and climate change. In places like Sub-Saharan Africa, there is still an ongoing battle with high maternal mortalities and perinatal deaths (Awoonor-williams *et al*., 2018; WHO, 2010). The United Nations, in 2015 launched the Sustainable Development Goals (SDGs). The Goal 3 among these goals (i.e. Good Health and well-being for all at all ages) informs the rights of all persons in having access to quality healthcare system, including Emergency Medical Services (EMS) (United Nations, 2015). Technology and innovation will be an important instrument in achieving the Goal 3 by assisting the life-saving efforts of EMS staff and other healthcare workers in case of an emergency (Pulsiri *et al*., 2019).

Many countries, including Ghana in SSA now struggle to provide adequate EMS coverage through ambulances and the timely saving of lives (Ministry of Health (MOH), 2016; Nimilan *et al*., 2019). Reasons attributed to these difficulties include poor road network systems, hard-to-reach areas, inadequate ambulances, traffic congestion and logistical constraints (Pulsiri *et al*., 2021). The use of medical drones is seen as a potential alternative to support first responders, emergency medical technicians, paramedics, nurses, physicians, and other relevant EMS professionals as part of the pre-hospital EMS. (Konert et al., 2019: Nimilan et al., 2019).

Medical drones can be used to deliver emergency medical supplies such as automated external defibrillators (AED), medicines, pines of blood for transfusion, or vaccines in other to save

lives of patients in hard-to-reach areas. Indeed there are evidences to attest that medical drones played critical roles in delivering AED to cardiac arrest patients (Jones & Despotou, 2019; Pulsiri *et al*., 2021), and carrying of medical supplies to remote areas or during massive casualty incident (Boutilier *et al*., 2017). In addition, drones have been used to take imageries from on-site incidents and the information sent to ambulance dispatch centers and other related partners (Clark *et al*., 2018). The academics in the field of EMS should thus pay attention to scientific study on medical drones as it might lower mortality rate and enhance national well-being. (Balasingam, 2017).

Due to its usefulness, a lot of policy makers and governments are beginning to use it as a support system to the ground ambulances in the health care systems globally (Johnson *et al*., 2021; Pulsiri *et al*., 2021). Researchers have also attempted to present data on the impact of drones on the healthcare systems worldwide, and also in some parts of Africa. For instance, a studies conducted in Rwanda sought to assess the application of drones in healthcare (Balasingam, 2017). The report showed that in Rwanda drone are used to transport blood products and medicine to critical access hospitals and remote regions. A study conducted in Madagascar, Malawi and Senegal also investigated the impact of drones in healthcare delivery systems in these countries (Knoblauch *et al*., 2019). The study concluded that investment in the use of drones fro medical purposes will greatly reduce the economic burden associated with morbidities in the healthcare systems. The use of medical drones will, however, require a sustainable integration into the health systems needs with markets and businesses to locally own and operate the drone delivery systems (Nouvet *et al*., 2019).

Ghana is not left out in this emerging technology to improving access to medical supplies in rural areas. In 2019, the Ghana government launched the medical drone delivery network, under the project name “Fly-To-Save-A-Life” (Ministry of Health [MoH], 2019). The health care drone system is operated and controlled by a US-based Zipline International Inc. in

partnership with the Ghana Health Service. It was estimated that 2,000 health facilities will be served with on-demand medical supplies, such as vaccines, blood products and life-saving medications (MoH, 2019).

The delivery of these essential and crucial items by drone will help to save time wastes and save lives (GHS, 2017). In this regard, Ghana government's desire to close the disproportionate healthcare or medical gap between urban and rural areas is what spurred the adoption of medical drones in the healthcare delivery system in the country (MoH, 2019). The aforementioned is intended to improve Ghanaians' ability to achieve the Universal Health Care by 2030. The drone delivery system is also set to facilitate the achievement of the reduction of maternal mortality ratio to 70 per 100,000 live births by 2030, as stipulated in the Sustainable Development Goals.

Medical drone usage in Ghana will help in improve the overall wellbeing of the people, and also contribute to the improvement of maternal mortality situation in the country. However, there is very limited empirical evidence of the impact of the drone system on perinatal care in Ghana, particularly in the Upper East Region, where there is high rate of perinatal morbidity and mortalities (Awoonor-williams *et al*., 2018). This study will thus investigate the impact of drone system on delivery of emergency medical supplies and perinatal mortality in the Kassena-Nankana East Municipal of the Upper East Region.

1.2 Problem Statement

Every year, an estimated 6 million babies are stillborn (SB) or die within the first seven days of life (early neonatal deaths) (WHO, 2022). These stillbirths and early neonatal deaths, together called perinatal deaths, bear the highest proportion of deaths among children under five years. Perinatal deaths also account for almost twice as many deaths as caused by malaria and HIV/AIDS together. It is accounted that more than 95% of the global perinatal deaths are

reported in Low-and middle-income countries, with West Africa having some of the highest perinatal death rates (Gold et al., 2014; Tavares et al., 2016). Ghana accounts for an estimated stillbirth rate of 22.7 per 1000 birth and neonatal mortality rate of 28.3 per 1000 live births (UNICEF, 2017). Kassena-Nankana East Municipal (KNEM) of the Upper East Region is one of the districts that contributes to the high burden of perinatal mortality in Ghana.

In terms of medical/healthcare research in Ghana, Kassena-Nankana East Municipal is an important municipality because its capital (Navrongo) houses the Navrongo Health Research Centre which maintains the Navrongo Health and Demographic Surveillance System (NHDSS). The municipality also benefits from medical supplies delivered by the health care drone system in Ghana. Data from a study conducted in the KNEM showed that stillbirth rate was 21.2 per 1000 deliveries, and early neonatal deaths (END) was 13.2 per 1000 live births (Saaka & Alhassan, 2021). These represent perinatal mortality rate of 39 deaths per 1000 deliveries. The perinatal death rate recorded in KNEM is found to be a little lower than the national average of 43 deaths per 1000 deliveries (GSS *et al*., 2017).

The availability of the medical drones in the KNEM is expected to facilitate the reduction of the perinatal mortality rate in the district. Whether this reduction has happened or not, the magnitude of it has not been ascertained because of the absence of empirical data measuring the impact of the drone delivery system and perinatal mortality. Earlier studies conducted in some countries reported the strengths, weaknesses, opportunities and the threats of using drones in health care (Balasingam, 2017; Knoblauch et al., 2019). However, these studies failed to measure the actual impact of the drones to the reduction in mortalities such as perinatal mortality.

1.3 Research Questions

The following questions will be answered by the end of the study;

1. What is the trend of perinatal mortality incidence in drone-serviced health facilities in KNEM from 2016 to 2021?

2. What are the factors associated with perinatal mortality before and after the introduction of the medical drone delivery system in KNEM?

3. Are drones significant contributors to perinatal outcome in the KNEM?

1.4 Objectives of Study

Main Objective

This study seeks to assess the impact of medical drone delivery system on perinatal health outcome in KNEM.

Specific Objectives

Specifically, the study will seek:

1. To determine the trend of perinatal mortality incidence in drone-serviced health facilities in KNEM from 2016 to 2021.

2. To determine the factors associated with perinatal mortality before and after the introduction of the medical drone delivery system in KNEM.

3. To determine whether drones are significant contributors to perinatal outcome in KNEM.

1.5 Justification of Study

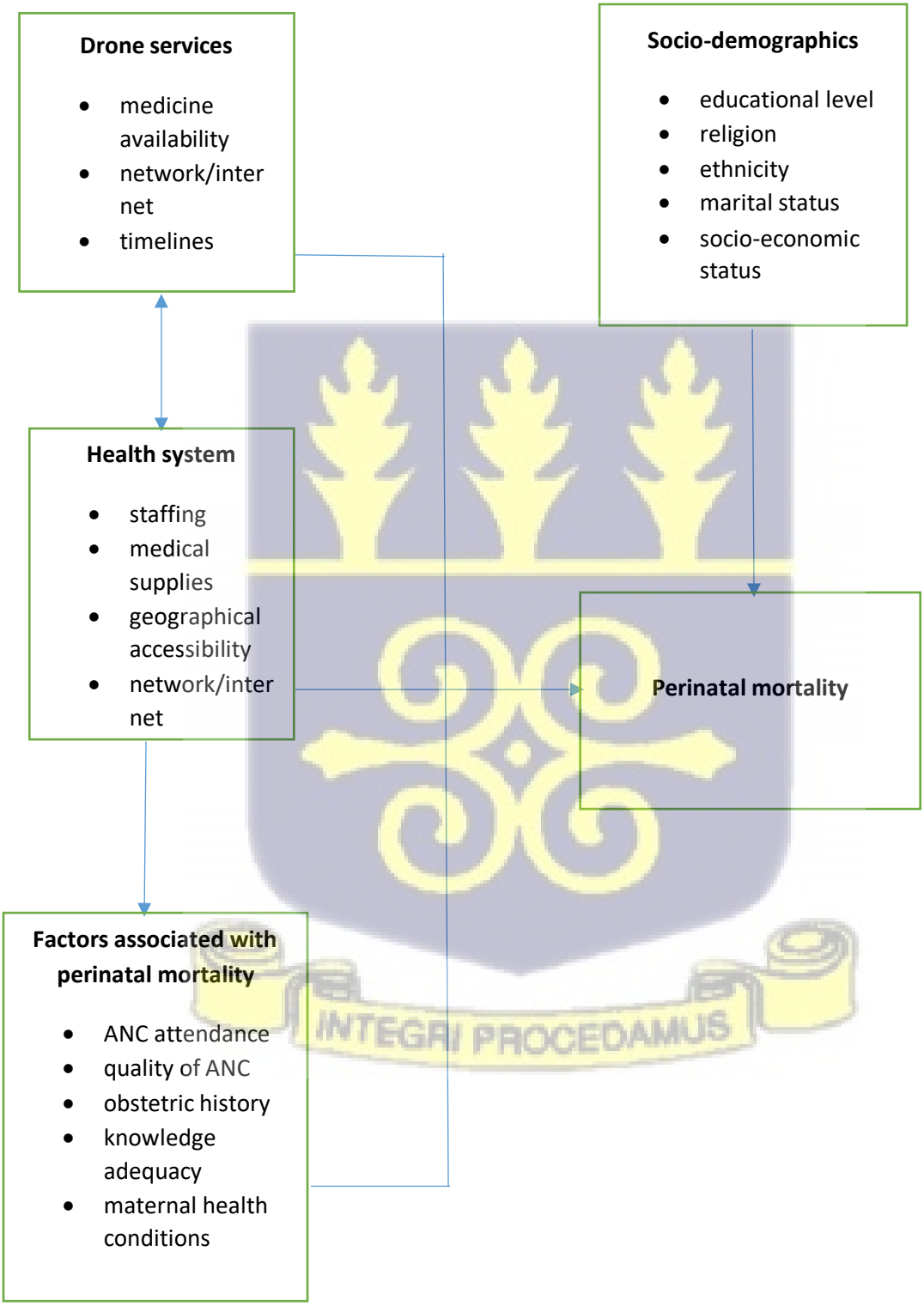
Medical drone's delivery system is an emerging technology that aims at improving the health outcome of people, especially in logistics-constrained environments and hard-to- reach areas. Indeed, such technology will facilitate in the improvement of maternal and perinatal outcome in emergency situations in hospital settings by delivering emergency medicines and blood products. It is therefore important to assess the use of the medical drones in health care system

particularly in places like KNEM, where there is frequent shortage of critical medical supplies and blood products during labour and other medical/surgical interventions.

The rationale for the study is also based on the recent use of drones for health delivery in the municipality. In particular, there is the possibility that the drone supplies in the area may currently beneficial to some specific areas of health service delivery or some particular patients (e.g. OPD patients, pediatric patients, patients in need of vaccines and blood supplies, etc.), but not beneficial/useful to mothers with perinatal issues and related emergencies. However, without evidence from empirical research, it will be difficult for policy decision makers, health practitioners and academics to scientifically establish whether the supplies offered by drones (or the drone operations) significantly benefits or impacts perinatal outcome issues in the area. It is against this background that the study was conducted to establish evidence for advocacy, policy formulation and development.

1.6 The Conceptual Framework

Figure 1.6: A conceptual framework on the study of the impact of drone services on the management of emergency medical supplies and perinatal outcomes in the Kassena-Nankana East Municipal of Ghana



The availability of the medical drones in the KNEM is expected to facilitate the reduction of the perinatal mortality rate in the district. However, it is currently unknown whether this reduction has happened or not and the extent of it. This is partly because the extent of it has not been ascertained through empirical data measuring the impact of the drone delivery system on perinatal mortality. In the conceptual framework shown above, perinatal mortality (dependent variable) in the KNEM is simultaneously dependent on drone services (independent variable) and the availability, effectiveness and efficiency of the services provided by the health system (independent variable) in the hospitals/clinics in the municipality. The factors associated with perinatal mortality (moderator variable) are dependent on both the drone service and health system, and influences/impacts recorded perinatal mortality figures in KNEM. The socio-demographic indicators (control variable) of women with history of perinatal issues in KNEM also impacts the recorded perinatal mortality figures in the Municipality, but is not directly influenced by the drone service system or health system.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the various literature reviewed on the subject of medical drones' delivery systems. Articles were obtained from peered-review journals archived in databases such as PubMed, Scopus, Directory of Open Access Journal (DOAJ), Cumulative Index for Nursing and Allied Health Literature (CINAHL), and Science direct. The chapter is arranged in five sections according to the objectives of the study.

2.2 The Use of Drones to Deliver Medical Supplies and Logistics

Transportation of medical supplies refers to the delivery of medical supplies and logistics such as blood products, blood samples, medical equipment, vaccinations, test kits, and medical help. The most popular means of transporting medical supplies are ground transportation (MedGRT), which includes ambulances and vehicles, and air transportation (MedART), which includes helicopters and airplanes (Zahratul *et al.*, 2020). Drones or unmanned aerial vehicles (UAVs) have been introduced globally as a result of the rapid growth of technology to promote mobility over difficult geographic boundaries, reduce carbon emissions, and maybe even raise the cost-effectiveness of healthcare delivery (Laksham, 2019).

Drones were initially employed in a variety of military activities in the late 1800s and early parts of 1900s (Shaw, 2014). The first non-military use of drones were to assist in damage assessments in the impacted areas after major disasters (Kakaes *et al.*, 2015). They were ideal for such purpose due to their simplicity of use, ability to avoid road closures, and ability to fly over challenging terrain without endangering flight crews.

Drones have since been used to deliver small aid packages to communities that were impacted by major disasters, such as the earthquake that occurred in Haiti in 2010, the hurricane that

struck the northeastern United States, Canada, and the Caribbean in 2012, the category 5 cyclone that struck the islands of Vanuatu in 2015, and the earthquake that occurred in Nepal in 2015 (Howard, 2015; Sharma, 2016). Due to the evidence of the effectiveness of the use drones in major disasters and commerce, the use of drones has transcended into the medical field.

The National Aeronautics and Space Administration (NASA) recently conducted a test employing a drone to transport medical supplies to a small clinic located in rural Virginia (DeAmicis, 2015). This test was the first drone delivery in the United States that was allowed by the federal government. A variety of drugs, including those for diabetes, high blood pressure, and asthma, were included in the supplies. DeAmicis (2015) contend that the testing of the viability of using this cutting-edge technology for such a purpose was a fantastic success, as it was shown to be risk-free and resulted in a significant reduction in the amount of time needed for delivery.

A simulated tuberculosis (TB) test sample was flown by drone from a distant community in Papua New Guinea to a major coastal city in that country (Balasingam, 2017). The mission was carried out by the organization 'Doctors Without Borders' to test the possibilities of using drones in delivering TB medications and samples for testing. Balasingam argued that the use of drones was crucial since the country has a huge TB burden and a rising frequency of multidrug-resistant TB. Drones can help reduce the risk of spreading the disease within the population, especially in rural Papua New Guinea.

Drones have also been put to use in the battle against the human immunodeficiency virus (HIV), which has for a long time been a problem for countries that are considered to be in the third world (Truog *et al*., 2020). In Malawi Africa, a country with one of the highest rates of HIV infections in the world, the United Nations Children's Fund (UNICEF) delivered HIV

testing kits using drones (Truog *et al*., 2020). This facilitated a drastic reduction of the amount of time needed to test infants living in rural areas. This allowed UNICEF to better serve the needs of the country's population.

In a systematic review and meta-analysis study conducted by Zahratul *et al.* (2020) to assess the drone use for medical products transportation in maternal healthcare. The study reviewed only three articles after screening 244 relevant publications. The study showed that drones were used to deliver blood products and blood samples. The study showed that there was stability of blood products during the transportation, and there was no systematic difference in the results from drone delivered blood samples and terrestrial means of delivery of blood samples. A study by Amukele *et al.* (2016) also indicated that drones were used to transport blood products.

The efficacy and efficiency of patient treatment are significantly impacted by the hospital's internal distribution of commodities (Volland *et al*., 2016). However, due to clinical, material, and information operations, healthcare logistics are very different from logistics in other industries (Moons et al., 2018). Moons *et al.,* (2018) further argued that internal hospital delivery does really involve a wide range of logistic processes, each subject to a separate set of guidelines, practices, and routes. In order to enable intra-hospital logistics of diagnostic samples and supplies, contemporary hospitals must have an effective infrastructure and operational organization. A study by Silvestri *et al*. (2022) assessed the design of a service for hospital internal transport of urgent health logistics. The study reported that drones were effective mode of transport of medical commodities like pharmaceutical products.

In the era of COVID-19 pandemic, health officials and medical facilities in several countries employed the use of technology, such the drone delivery system, to facilitate the delivery of urgent medical logistics and equipment for attending to clients in an emergency. A systematic literature review by Apotele and Ayamga (2021) assessed the intricacies of medical drones in

healthcare delivery in the era of COVID-19. The study included 17 articles from 69 relevant articles found on the subject in Africa. The study found that medical supplies such as first aid kits, medical aids and human body parts, and personal protective equipment were transported using drones.

Mark (2017) report in a pilot study on the use of medical drones for delivery of medical products between two Lugano hospitals, the Ospedale Civico and Ospedale Italiano. These two hospitals are 1.3km apart. Both hospitals had Laboratories, however, the laboratory at Ospedale Italiano closes at 5pm and does not open during the weekends. This prompted the hospital authorities to adopt drone delivery measure to ensure that there is always transport available to convey blood samples from the Ospedale Italiano hospital to Ospedale Civico laboratory for testing. The results from the tests is also delivered back to the source hospital using the same drones.

2.3 Use of drones for healthcare services in Kassena-Nankana East Municipal

The medical drone delivery service operated by Zipline started supplying medical products to health institutions in KNEM in February, 2020 (Navrongo War Memorial Hospital, 2020). The Zipline station that supplies KNEM is at Vobsi, a community near Walewale in North East Region. Some of the medical items usually ordered include blood products, anti-snake serum injection, anti-rabies serum injection, amoxycillin + clauvunic acid injection, artesunate injection, oxytocin injection, ciprofloxacin infusion/tablet, dextrose in sodium chloride intravenous infusion, metronidazole tablet, Sodium chloride infusion, Ringer's lactate infusion, ampicillin injection and lidoacaine HCL injection (Navrongo War Memorial Hospital, 2020).

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At War Memorial Hospital, the pharmacist and the laboratory technician are the authorized persons who place orders for supplies from Zipline, whilst community health officers do same

at the Community-based Health Planning and Services (CHPS) level. Orders are placed via phone calls, Whatsapp and text messages. Delivery takes place within 30 to 45 minutes depending on the location of the health facility. The drones are able to deliver the medical products to the individual health facilities upon request. There are points on the premises of War Memorial Hospital and drone serviced CHPS compounds designated as drop points, where the drones drop off requested medical items. Global positioning System (GPS) coordinates of all the drop points are stored by Zipline, and the drone is programmed before take-off to drop specific requested medical products at those GPS coordinates.

2.4 Perinatal mortality and perinatal period

According to Dessu and Dawit (2020) perinatal mortality refers to to the loss of a fetus at or after a gestation period of 28 weeks or death occurring in the first seven days of early life. WHO (2006) indicated that the perinatal period commences from 28 completed gestation weeks and ends seven days after birth.

2.5 Factors associated with perinatal mortality (i.e stillbirth and early neonatal death)

Several factors influence stillbirths and early neonatal deaths. Saleem *et al*. (2018) repotted that factors that influence stillbirth include maternal age, maternal education, gestation age and prematurity, poverty, birth weight, parental care, previous stillbirth and parity. Halim *et al*. (2018) and Newtonray *et al*. (2017) indicated that antepartum factors influence still birth. The antepartum factors include: eclampsia infections, growth restriction of fetus, smoking during pregnancy, prenatal hemorrhage and obesity of pregnant women. Khanan *et al*. (2018) indicated that intrapartum factors like preterm delivery, complications during the delivery period and time taken to get to the health facility also influence stillbirth.

Chomba et al. (2017) and Belliza et al. (2018) reported that the factors that influence neonatal mortality include antenatal care, birth order and birth interval, maternal sepsis, eclampsia,multiple gestations, obstructed labour, parity, maternal age and education. A WHO (2006) report pointed out that stillbirths and early neonatal deaths ocuur as a result of poverty in maternal homes, absence of care of newborn, bad hygienic conditions during delivery and early hours after birth, improper management of pregnancy complications and insufficient care during the period of pregnancy.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the various research methods used in this study. The chapter describes the study design and approach, the study area, including the study population. The chapter also shows the sampling technique, the data collection processes, data analysis and the ethical considerations for the study.

3.2 Study design and approach

This study employed a retrospective review design and quantitative methods approach. The retrospective design was conducted on the perinatal mortality situation of five health facilities that frequently use drone services in the Kassena-Nankana East Municipal. The health facilities are: War Memorial Hospital, Nayagnia CHPS, Vunania CHPS, Wuru CHPS, and Korania CHPS. Information gathered indicates that, though all health care facilities in KNEM are officially entitled to the supply of medical products by the drone service operated by Zipline, a few haven't yet placed their first orders since February 2020. Of the health facilities which are on record to have ordered medical products from drones, some do it at a low frequently rate. The 5 afore-mentioned health care facilities per the records are the most frequent users/patrons of the Zipline medical drone delivery service, and because the study is about the impact of drone services on perinatal outcomes, those facilities were selected for inclusion in the study. In addition, a self-administered questionnaire was used to gather quantitative data on the perceptions or views of health professionals in KNEM on factors that influence perinatal outcomes (stillbirth, early neonatal deaths) before and after the introduction of drones, and the impact of drones on emergency medical supplies and perinatal outcomes. Perception deals with one's awareness, understanding, interpretation, impression and knowledge of a situation or a phenomenon. Perception is subjective and it varies from one person to another. This is due to

how perceptual systems are structured and how individuals "see" things in terms of knowledge, experience and beliefs. Because the respondents are health professionals in KNEM, their perceptions represent informed opinions, informed by their knowledge and experience in the health sector, and those perceptions thus can collectively pass as a form of an assessment of drone impact on perinatal outcomes in KNEM.

3.3 Study setting

The Kassena-Nankana East Municipal is among the fifteen (15) municipalities and districts in the Upper East Region of Ghana. The total population is 130,593 (Ghana Health Service, 2018). The municipality lies within the Guinea Savanna woodlands. The administrative capital of the municipality is Navrongo. The municipal share boundaries with Bongo District and Bolgatanga Municipal to the East; West Mamprusi municipal to the South; Builsa South District, Builsa North Municipal and Kassena-Nankana West District to the West; and Burkina Faso to the North. The total land area of the Municipality is 865 square kilometres (Ghana Districts, 2022).

There are two main ethnic groups in the area, the Kassena and the Nankani. The municipality is mostly patriarchal with male dominance which allows the practice of polygamy. The settlement is mainly dispersed with extended family units living together in compound houses and headed by males.

The municipality is endowed with a good number of healthcare facilities and institutions. Notable among them are the War Memorial Hospital (the municipal hospital) and Navrongo Health Research Centre. The Municipality is divided into eight sub municipals with at least one health Centre in each sub municipal and several Community-based Health Planning and

Services (CHPS) compounds. There are also a few mission Clinics and private health facilities operating in the area (Kumbeni et al., 2019).

Figure 3.3: District Map of Kassena-Nankana East Municipality

Source: Ghana Statistical Service, GSS

3.4 Study Populations for objectives one, two and three

The study population for objective one aspect of the study is all pregnant women in the 5 drone-serviced health facility areas of Kassena-Nankana Municipal who attained 7 completed weeks

of gestation within the period of January, 2016 to December, 2021. The population for objectives two and three aspects were all health care professionals in the Kassena-Nankana East Municipal.

3.4.1 Inclusion Criteria

For the purpose of this study, all data on perinatal deaths, that is death occurring after the 28th week of gestation before birth and within seven days after birth that the mothers delivered within KNEM health facilities that receive medical logistics and medicines from drones were included in the study.

In addition, data on the views of health professionals on factors that influence perinatal outcomes and the effects of drone services on perinatal health issues in the municipal were also included in the study.

3.4.2 Exclusion Criteria

The study excluded data on perinatal deaths that were referred from other health facilities that do not use drone services. It was assumed that the mothers did not receive any form of support or exposure to the drone services in case of emergency.

3.5 Sampling Method

3.5.1 Sampling Method for objective one

Purposive and institutional sampling techniques were employed for objective one. The District Health Directorate of KNEM was purposively selected because it has a unit (-the district health information management system) that keeps records of all perinatal mortalities in the various health facilities in the Municipal. Five health facilities were purposively selected using the

frequency of use of the medical drones. The data on yearly records of perinatal mortality incidence in the five facilities were gathered for the period of 2016 to 2021.

3.5.2 Sampling Method for objectives two and three

For objectives 2 and 3, purposive sampling was used to gather quantitative data from respondent health professionals. The health professionals entailed staff of the drone-serviced health facilities, staff of the municipal health directorate, or personnel who have direct dealings with maternal health issues in drone-serviced health facilities in the Kassena-Nankana East Municipal. Different categories of health professionals were interviewed. The total sample size of the different categories of health professionals interviewed were 107. The specific number of respondents interviewed for each category are: medical officers – 2, pharmacists – 1, midwives - 39, nurses - 43, health assistant - 3, laboratory technologist -1, physician assistants -2, and community health officers -16.

3.6 Data Collection

3.6.1 Data Collection for objective 1

For objective 1, numerical data records on the incidence of perinatal mortality (i.e. still births and early neonatal deaths) for 5 drone-serviced health facilities in the municipality was gathered. The data was extracted from the District Health Information Management System (DHIMS) at the Reproductive and Child Health Unit of the KNEM Health Directorate. All the data on the yearly perinatal mortality incidence from January 2016 to December 2021, in the selected drone serviced health facilities, was obtained for the study.

3.6.2 Data collection for objectives 2 and 3

For objectives 2 and 3, a structured questionnaire was used to gather quantitative data from respondent health professionals. The questionnaire was used to illicit information on factors

that influenced perinatal outcomes (stillbirth, early neonatal deaths) before and after the introduction of drones in health service system of the municipal. Socio-demographic data on respondents, impact of drones on emergency medical services and the extent of impact of drone services on perinatal outcomes in the municipal were also gathered.

In designing the questionnaire, a number of questions are formulated using a Likert Scale, where an item is presented in a declarative sentence, followed by response options that indicate varying degrees of agreement with or endorsement of the statements (DeVellis, 1991). A five (5)-point Likert scale was employed. The response options provided under each declarative statement in the questionnaire aspect pertaining to factors that influence perinatal outcomes are: (1) strongly agree, (2) agree, (3) neutral, (4) disagree and (5) strongly disagree. For the questionnaire aspects on effect of drones on emergency medical services and effect of drone supply services on perinatal outcomes in the municipal, the response options provided are: (1) 'not at all' (2) 'a little' (3) 'moderately' (4) 'quite a bit' and (5) 'extremely'.

3.7 Data Handling and Safety

Various mechanisms were used to safeguard the data. The questionnaire was pre-coded to protect the identity of respondents. Unauthorized persons were not allowed to have access to the data collected. The gathered data entered into the software for data analysis have been locked in a folder after analysis.

3.8 Statistical Method and Analysis

For objective 1, the data from DHIMS was extracted into Microsoft Excel and checked for errors. The data was then exported into Statistical Package for Social Sciences (SPSS version 25) for analysis. Descriptive statistics particularly line graph was used to analyze the trend of the perinatal mortality incidence from 2016 to 2021 in the five selected drone-serviced health facilities.

For objective 2, simple proportions were used to describe categorical data at univariate level and presented in frequency and percentage distributions in tables.

For objective 3, the main outcome variables were (i) emergency medical supplies management, and (ii) perinatal outcomes. Simple proportions were used to describe categorical data at univariate level and presented in frequency and percentage distributions in tables. Correlation analysis was conducted to investigate the association, if any, between socio-demographic characteristics of respondents (gender, age, education level, occupation) and the scores reported for the statements regarding impact of drones on the management of emergency medical supplies, and perinatal outcomes (dependent variables).

3.9 Ethical Consideration

The study proposal was submitted for ethics clearance from the Navrongo Health Research Centre Institutional Review Board (NHRCIRB). Also, permissions were sought from the Regional Director of health services as well as the Kassena-Nankana Municipal Director of health services whose municipality would participate in the research before initiating the study. In addition, participation in the study was voluntary. Oral consent was used to invite participants into the study. The rational for the study, the study procedures, the risks and benefits of participation, voluntariness of participation and the rights to withdraw was shared with potential participants (medical officers, pharmacists, dispensing technicians, midwives, nurses, health administrators, laboratory technicians, physician assistants, and community health officers) to enable them to make informed decisions as to whether to participate in the research or not. Finally, permission was sought from medical superintendents and community health officers in-charge of facilities participating before interacting with their staff.

CHAPTER FOUR

MONITORING AND EVALUATION ISSUES OF THE STUDY

4.1 Brief Description of the Study

The medical drone delivery service operated by Zipline started supplying emergency medical products to health institutions in Kassena-Nankana East Municipality (KNEM) of the Upper East Region of Ghana in February, 2020. The availability of the medical drones is expected to, among other things, facilitate the reduction of the perinatal mortality rate in the municipality. There is absence of empirical data measuring the impact of the drone delivery system on perinatal mortality. This study investigated the impact of the drones on perinatal mortality outcome in KNEM.

4.2 Impact Evaluation

Whenever a new project, program, policy or intervention (like the inauguration of the Zipline drone delivery service) is implemented, it invariably produces certain impacts or changes, which could be positive or negative, intended or unintended, direct or indirect, short-term or long-term.

The purpose of an impact evaluation is to assess the changes or outcomes produced by an intervention that can be attributed to just the intervention, but not to other factors.

This study is therefore an impact evaluation; to evaluate the impact of drone services on the management of emergency medical supplies and perinatal outcomes in KNEM.

In this study, the intervention/program/project is the installation and operationalisation of the medical drone delivery station by Zipline (in partnership with the Ministry of Health/Ghana Health Service) at Vobsi, near Walewale in the North East Region of Ghana. The outcome of interest is perinatal mortality in KNEM, where health care facilities are regularly supplied with medical products by Zipline drones. Several factors influence perinatal outcomes; the study

therefore sought to measure the impact of drone service delivery on addressing or mitigating the individual factors known to be associated with perinatal mortality (i.e. still births and early neonatal deaths), as a way of estimating its likely influence on perinatal outcomes.

4.3 Objectives, Indicators, and Means of Measurement

Table 4.3: Definition of indicators and measurement

OBJECTIVES	INDICATORS	MEANS OF MEASUREMENT
1. To determine the trend of perinatal mortality incidence in drone-serviced health facilities in KNEM from 2016 to 2021	1. Data from District Health Information Management System (GHS) on annual recorded/reported perinatal mortality in drone-serviced health care facilities in KNEM from 2016 to 2021	Observation, structured questionnaire
2. To determine the factors associated with perinatal mortality before and after the introduction of the medical drone delivery system in KNEM	1. Collated responses of frontline health workers in KNEM to self-administered questionnaire on factors associated with perinatal mortality before and after drone introduction	Observation, structured questionnaire
3. To determine whether drones are significant contributors to perinatal outcome in KNEM	1. Data from District Health Information Management System (GHS) on annual recorded/reported perinatal mortality in drone-serviced health care facilities in KNEM from 2016 to 2021 2. Collated responses of frontline health workers in KNEM to self-administered questionnaire on their views about impact of drones on perinatal outcome	Observation, structured questionnaire

CHAPTER FIVE

RESULTS

5.1 Trend of perinatal mortality from 2016 to 2021

The trend of perinatal mortality is presented in counts of all perinatal mortalities that were reported by 5 drone-serviced health care facilities in the Kassena Nankana East Municipality of the Upper East Region. The trend is shown in table 5.1 and figure 5.1.

From Table 5.1, the mean annual reported perinatal mortality count in the 5 healthcare facilities is 64.5, with a standard deviation of 15.2. From table 5.1 and figure 5.1 above, it can be observed that, of the five drone-serviced health facilities, War Memorial Hospital reported the highest total count of perinatal mortality over the six-year period (383), followed by Nayagnia CHPS (3) and Wuru CHPS (1). Vunania CHPS and Korania CHPS did not record any cases of perinatal mortality over the years analysed. The combined total perinatal mortality incidence for the five health facilities over the six-year period was 387. The year that saw the lowest reported perinatal mortality was 2018 (46) and the year that saw the highest figures of reported perinatal mortality were 2017 (81) and 2020 (81).

Zipline started delivering emergency medical products by drones to health care facilities in KNEM in the first quarter of 2020 (February, 2020). From table 5.1 and figure 5.1, at the end of 2019, the total reported perinatal mortalities in the five health institutions was 66. If the supply of emergency medical products by Zipline drones was to have a marked impact on perinatal mortalities in KNEM, then at the end of 2020 the total reported perinatal mortality cases should have fallen below the 66 recorded in 2019. But per the data, this didn't happen. Perinatal mortality for 2020 rather went up to 81 cases, which represents a 22.7% increase above that recorded for 2019. However, at the end of 2021, reported perinatal mortalities

reduced from the 81 cases in 2020 to 65 cases, which is still higher than the figure reported for 2016 (48) and 2018 (46) when Zipline drone services were unavailable in KNEM.

Table 5.1: Perinatal mortalities reported by 5 health facilities in the Kassena Nankana East Municipal from 2016 to 2021.

Health facility	Perinatal mortality incidence in drone-serviced health care facilities KNEM from 2016 to 2021						Total	Mean	Standard deviation
	2016	2017	2018	2019	2020	2021			
War Memorial	46	79	46	66	81	65	383	64.5	15.2
Nayagnia CHPS	1	2	0	0	0	0	3		
Vunania CHPS	0	0	0	0	0	0	0		
Wuru CHPS	1	0	0	0	0	0	1		
Korania CHPS	0	0	0	0	0	0	0		
Total	48	81	46	66	81	65	387		

Source: DHIMS of KNEM, 2023

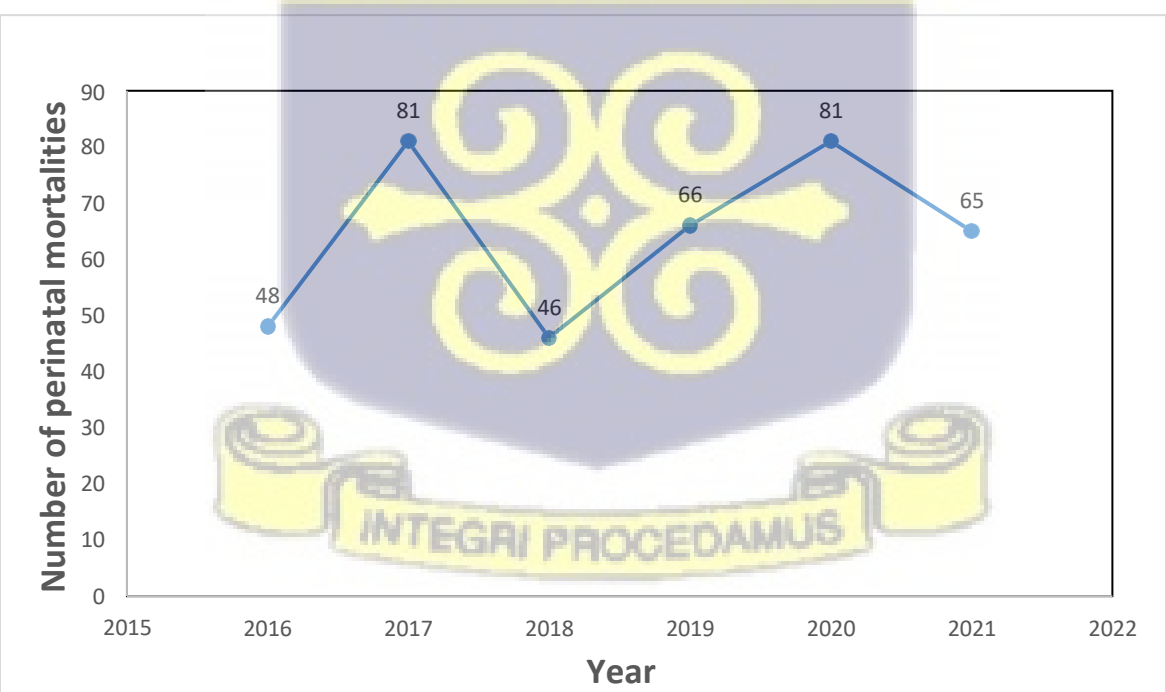

Fig 5.1: Five-year trend of perinatal mortality in 5 healthcare institutions in the Kassena Nankana East Municipal, 2016 – 2021

Like shown below, a trendline can be added to the chart in Fig. 5.1 to show the general pattern or overall direction of the data of perinatal mortality incidence in KNEM over the six-year period (ignoring statistical errors and minor exceptions), and also forecast the expected future trend. When this is done (as shown in Fig. 5.1.1 below) it will be seen that reported perinatal mortality incidences in the 5 healthcare institutions in KNEM has been gradually increasing from 2016 to 2021, and that trend is expected to continue into the future.

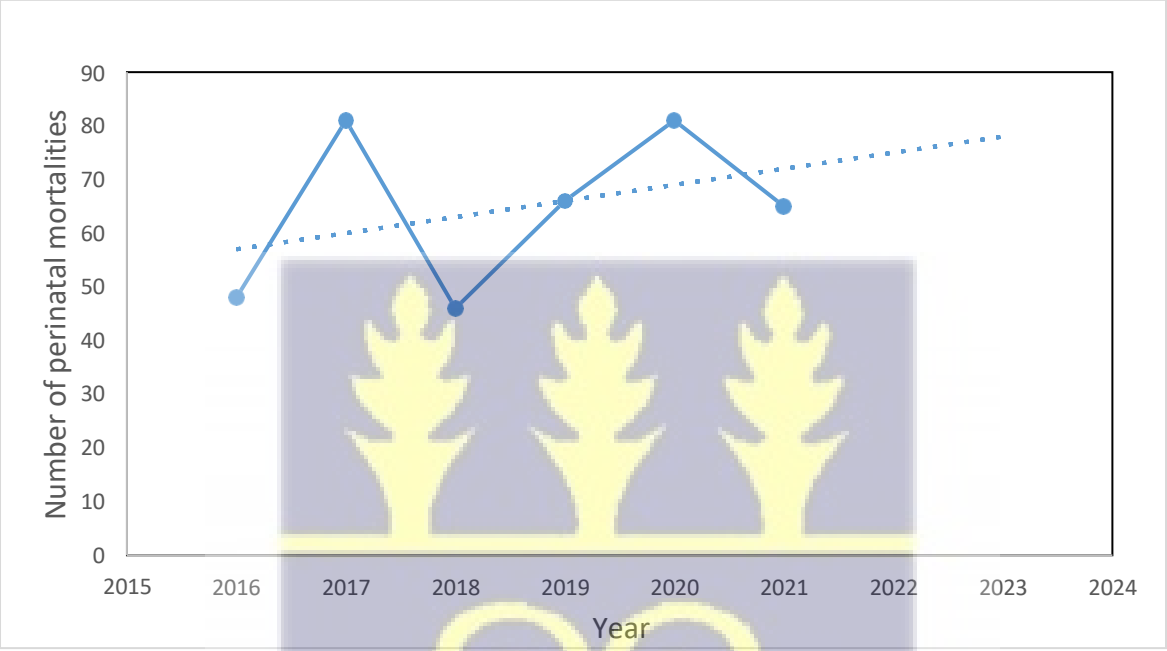

Fig 5.1.1: Trendline of perinatal mortality in 5 healthcare institutions in the Kassena Nankana East Municipal, 2016 – 2021

5.2 Socio-Demographic Characteristics of Respondents

The demographic profiles of sampled respondents of the study (their gender, age, education level and occupation) was collected. The table below (table 5.2) shows the socio-demographic distribution of the respondents.

The total sample size of different categories of health professionals that filled out the survey questionnaire was 107, comprising 23 males (21.5%) and 84 females (78.5%).

From Table 5.2, The categories of health professionals and specific number of respondents for each category was: physicians/medical doctors – 2 (1.9%), midwives – 39 (36.4%), nurses – 43 (40.2%), community health officers – 16 (15.0%), pharmacist – 1 (0.9%), laboratory technologist - 1 (0.9%), physician assistants - 2 (1.9%), and health assistants – 3 (2.8%). Nurses formed the majority of respondents (40.2%), followed closely by midwives (36.4%) and community health officers (15.0%) in that order. From Table 4.2.1, the largest proportion of respondents was between the ages of 25 and 34 representing 53.3%. 29.9% of the respondents were between the ages of 35 and 44. 10.3% of the respondents were between the ages of 18 and 24. 4.7% of the respondents were between the ages of 45 to 54. Only 2 respondents were above 55 years. From the same table, 101 respondents representing 94.4% had either a first degree, HND or Diploma as their highest academic qualification. 3 of the respondents representing 2.8% had a master's degree or PhD as their highest qualification, whilst 3 respondents representing 2.8% reported a secondary school certificate as their highest academic qualification.

Table 5.2: Socio-demographic distribution of respondents

Variable	Categories	Frequency	Percent (%)
Gender	Male	23	21.5
	Female	84	78.5
Age			
	18-24	11	10.3
	25-34	57	53.3
	35-44	32	29.9
	45-54	5	4.7
	55 and above	2	1.9
Education level			
	High Tertiary (Masters or PhD)	3	2.8
	Tertiary (1st degree, HND or Diploma)	101	94.4
	Secondary	3	2.8
Occupation (Job title)			
	Physician	2	1.9
	Midwife	39	36.4
	Nurse	43	40.2
	Community Health Officer	16	15.0
	Pharmacist	1	0.9
	Laboratory Technologist	1	0.9
	Physician Assistant	2	1.9
	Health Assistant	3	2.8

Source: Field Data, 2023

5.3 Respondents' involvement in Maternal Healthcare, Awareness of Stillbirths and Early Neonatal Deaths, and Awareness of Drone Technology Usage in KNEM

The respondents were asked a series of questions related to their involvement in maternal healthcare emergencies/cases (question 1 in table 5.3), their awareness of stillbirths and early neonatal deaths (question 2, 3 and 4), and their awareness of drone technology usage in KNEM (question 5 and 6). The questions asked, and the responses given by the respondents are summarised in table 5.3.

When the respondents were asked whether or not they were directly involved in maternal health issues in the health care institutions where they work (as shown in Table 5.3 below), 65 of them representing 60.7% responded "Yes", whilst 42 representing 39.3% responded "No". This means that the majority of the respondents had a role or work schedule directly involving maternal health issues, in their places of work.

63 respondents representing 58.9% answered "Yes" when asked whether they had ever witnessed stillbirths or early neonatal deaths in their locality, community or health facility. 44 respondents representing 41.1% responded "No" to the same question. When respondents were asked whether they had ever been informed about stillbirth or early neonatal death incidence in their area or health facility, 78 representing 72.9% responded "Yes", whilst 29 representing 27.1% responded "No".

When respondents when asked to indicate (to the best of their memory) when they heard about or witnessed a stillbirth or early neonatal death in their locality or health facility, 28% said before 2020, 39.3% said after 2020, and 32.7% responded "I do not remember".

Survey participants were asked whether they had heard about drone technology. 104 representing 97.2% of respondents answered "Yes" whilst 3 representing 2.8% answered "No". When the respondents were further asked whether they were aware that for some time now in KNEM drones were being used to deliver emergency medical supplies, 102 respondents representing 95.3% answered "Yes" whilst 5 respondents representing 4.7% answered "No". From this we can infer that the knowledge/awareness among health workers of the use of drones to deliver emergency medical supplies in KNEM is very high.

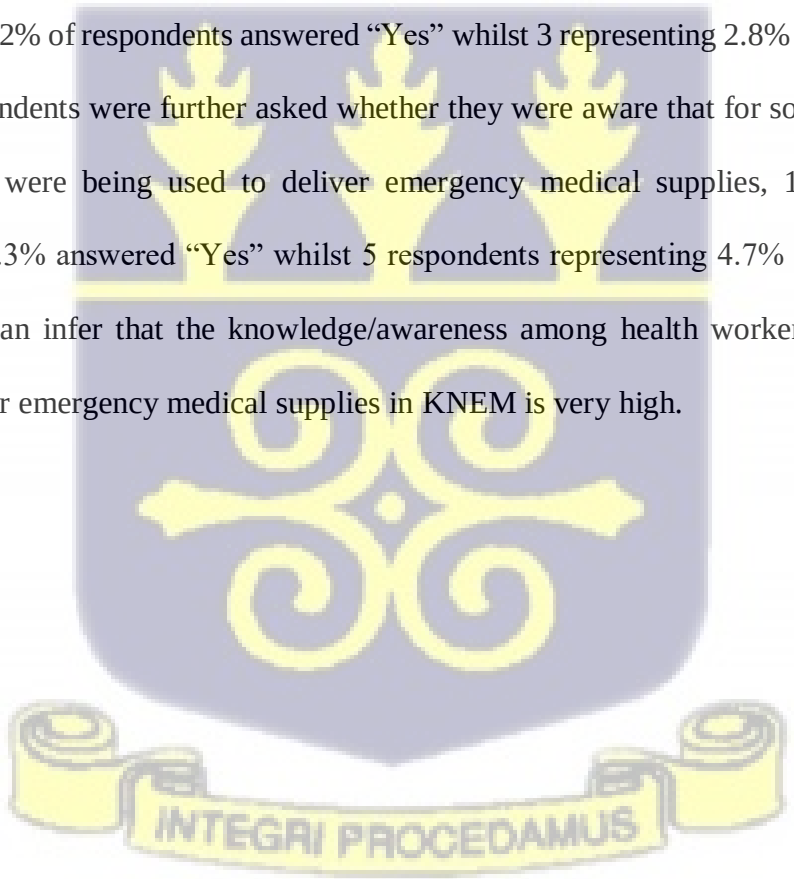

Table 5.3: Summary of responses to questions related to involvement in maternal healthcare, awareness of stillbirths and early neonatal deaths, and awareness of drone technology usage

	QUESTIONS	RESPONSES		
1.	Are you directly involved in maternal health issues?	Yes	No	
		65 (60.7%)	42 (39.3%)	
2.	Have you ever witnessed stillbirths or early neonatal deaths in your locality or health facility?	Yes	No	
		63 (58.9%)	44 (41.1%)	
3.	Have you ever been informed about stillbirth or early neonatal death incidence in your area or health facility?	Yes	No	
		78 (72.9%)	29 (27.1%)	
4.	To the best of your memory, when did you hear about or witness a stillbirth or early neonatal death in your locality or health facility?	Before 2020 (over 3yrs ago)	After 2020	I do not remember
		30 (28.0%)	42 (39.3%)	45 (32.7%)
5.	Have you heard about drone technology?	Yes	No	
		104 (97.2%)	3 (2.8%)	
6.	Are you aware that the use of drone technology to deliver emergency medical supplies in KNEM has been in progress for some time now?	Yes	No	
		102 (95.3%)	5 (4.7%)	

Source: Field Data, 2023

5.4 Factors that may have influenced Stillbirths in KNEM Before and After the Introduction of Drone Supplies in the area in February, 2020

In this section of the questionnaire, the respondents were asked to indicate the extent with which they agreed or disagreed with statements about factors (twenty factors in all) that may have influenced stillbirths or the health condition and total well-being of fetus of pregnant women with 28 completed weeks (or 7 completed months) of gestation (i) before the introduction of emergency medical supplies through drones in February, 2020 and (ii) after February 2020, when emergency medicine was being supplied to health facilities in KNEM by

drone. The response options provided under each declarative statement in the questionnaire were a 5-point Likert scale: (1) strongly agree, (2) agree, (3) neutral, (4) disagree and (5) strongly disagree. For the purposes of analysis of results, the 5-point Likert scale was reduced to a 3-point Likert scale: (1) Agree (comprising both strongly agree and slightly agree), (2) Neutral (neither agree nor disagree), and Disagree (comprising both slightly disagree and strongly disagree). Frequency and percentages have been used to highlight the answers of the respondents to questions on each factor.

From Table 5.4 below, it is observed that 42.1% of respondents strongly agreed that maternal age younger than 20 or older than 35 influenced stillbirths before the introduction of drones supplies, while 23.4% of respondents slightly agreed to this statement. The rest of the respondents were either neutral, slightly disagreed or strongly disagreed to the same statement. Putting the percentages of those who strongly agreed and slightly agreed together, we see that the majority of respondents (65.5%) agreed to the statement. Majority of those same respondents (52.4%) agreed that maternal age younger than 20 or older than 35, influenced stillbirths even after the introduction of drones supplies in KNEM in February 2020. Thus in the opinion of the respondents, the introduction of drones had not changed the fact that maternal age younger than 20 or older than 35 influenced stillbirths in KNEM.

A careful review of table 5.4 shows that, respondents registered similar majority opinions (for both before and after drone introduction) on the following additional 15 out of 20 stillbirth influencing factors, like they did for maternal age: lower maternal education, gestational age and prematurity, access and patronage of antenatal care services, poverty, previous history of stillbirths, antepartum hemorrhage, hypertension, suspected sepsis, eclampsia corticosteroids, antibiotics, type of delivery attendant, place of delivery, mode of delivery, obstructed labour, and household living conditions.

For stillbirth influencing factors such as low birth weight, antenatal corticosteroids, and hospitalisation, we observe from table 5.4 that, the majority of respondents agreed that they influenced stillbirths before drone introduction in February 2020, but majority of those same respondents disagreed that those three factors influenced stillbirths after drone introduction. For the stillbirth influencing factor 'sleeping position during birth', though majority of respondents agreed that it influenced stillbirths before drone introduction, there wasn't a clear majority decision concerning the situation after drone introduction.

Table 5.4: A tabular presentation of respondents' perception of factors that may have influenced stillbirths in KNEM before and after the introduction of emergency medical supplies by drones in February, 2020.

	Statement	Period	Responses				
			Strongly agree	Slightly agree	Neither agree nor disagree	Slightly disagree	Strongly disagree
1.	Maternal age younger than 20 or older than 35 influenced stillbirths	BeforeFebruary,2020	45 (42.1%)	25 (23.4%)	13 (12.1%)	10 (9.3%)	14 (13.1%)
		After February, 2020	31 (29.0%)	25 (23.4%)	16 (15.0%)	21 (19.6%)	14 (13.1%)
2.	Lower maternal education was associated with stillbirths	Before February, 2020	30 (28.0%)	35 (32.7%)	11 (10.3%)	18 (12.1%)	13 (12.1%)
		After February, 2020	28 (26.2%)	27 (25.2%)	14 (13.1%)	24 (22.4%)	14 (13.1%)
3.	Gestational age and prematurity was associated with still births	Before February, 2020	43 (40.2%)	33 (30.8%)	11 (10.3%)	10 (9.3%)	10 (9.3%)
		After February, 2020	42 (39.3%)	19 (17.8%)	12 (11.2%)	22 (20.6%)	11 (10.3%)
4.	Pregnant women's' access and patronage of antenatal care services influenced perinatal outcomes	Before February, 2020	40 (37.4%)	35 (32.7%)	8 (7.5%)	7 (6.5%)	17 (15.9%)
		After February, 2020	30 (28.0%)	33 (30.8%)	8 (7.5%)	16 (15.0%)	20 (18.7%)
5.	Poverty influenced stillbirths	Before February, 2020	37 (34.6%)	41 (38.3%)	10 (9.3%)	6 (5.6%)	13 (12.1%)
		After February, 2020	30 (28.0%)	30 (28.0%)	8 (7.5%)	25 (23.4%)	14 (13.1%)
6.	Low birth weight was associated with still births	Before February, 2020	23 (21.5%)	38 (35.5%)	17 (15.9%)	11 (10.3%)	18 (16.8%)
		After February, 2020	24 (22.4%)	22 (20.6%)	13 (12.1%)	20 (18.7%)	28 (26.2%)
7.	Previous history of still birth influenced probability of still births	Before February, 2020	21 (19.6%)	42 (39.3%)	17 (15.9%)	17 (15.9%)	10 (9.3%)
		After February, 2020	19 (17.8%)	31 (29.0%)	16 (15.0)	25 (23.4%)	16 (15.0%)
8.	Antepartum hemorrhage was associated with still births	Before February, 2020	39 (36.4%)	31 (29.0%)	12 (11.2%)	7 (6.5%)	18 (16.8%)
		After February, 2020	34 (31.8%)	22 (20.6%)	9 (8.4%)	16 (15.0%)	26 (24.3%)
9.	Hypertension influenced still births	Before February, 2020	53 (49.5%)	27 (25.2%)	9 (8.4%)	9 (8.4%)	9 (8.4%)
		After February, 2020	35 (32.7%)	22 (20.6%)	10 (9.3%)	20 (18.7%)	20 (18.7%)
10.	Suspected sepsis influenced still births	Before February, 2020	38 (35.5%)	48 (44.9%)	7 (6.5%)	9 (8.4%)	5 (4.7%)
		After February, 2020	41 (38.3%)	24 (22.4%)	9 (8.4%)	20 (18.7%)	13 (12.1%)
11.	Eclampsia Corticosteroids influenced still births in the municipal	Before February, 2020	39 (36.4%)	37 (34.6%)	15 (14.0%)	9 (8.4%)	7 (6.5%)
		After February, 2020	25 (23.4%)	27 (25.2%)	15 (14.0%)	25 (23.4%)	15 (14.0%)
12.	Antenatal Corticosteroids influenced still births	Before February, 2020	23 (21.5%)	43 (40.2%)	18 (16.8%)	9 (8.4%)	14 (13.1%)
		After February, 2020	19 (17.8%)	24 (22.4%)	20 (18.7%)	29 (27.1%)	15 (14.0%)
13.	Hospitalization influenced still births in the area	Before February, 2020	9 (8.4%)	38 (35.5%)	16 (15.0%)	17 (15.9%)	27 (25.2%)
		After February, 2020	17 (15.9%)	16 (15.0%)	20 (18.7%)	26 (24.3%)	28 (26.2%)
14.	Antibiotics were associated with stillbirths	Before February, 2020	16 (15.0%)	26 (24.3%)	20 (18.7%)	18 (16.8%)	27 (25.2%)
		After February, 2020	14 (13.1%)	19 (17.8%)	18 (16.8%)	20 (18.7%)	36 (33.6%)
15.	Type of delivery attendant (eg. TBA, Nurse, Physician, Family member, self) influenced still births	Before February, 2020	33 (30.8%)	34 (31.8%)	8 (7.5%)	16 (15.0%)	16 (15.0%)
		After February, 2020	23 (21.5%)	32 (29.9%)	10 (9.3%)	21 (19.6%)	21 (19.6%)
16.	Place of delivery (hospital, clinic/health center or home) influenced still births	Before February, 2020	39 (36.4%)	34 (31.8%)	7 (6.5%)	11 (10.3%)	15 (14.0%)
		After February, 2020	27 (25.2%)	20 (18.7%)	14 (13.1%)	18 (16.8%)	28 (26.2%)
17.	Sleeping position (or 'lie') of maternal women (transverse, Oblique, Breech, vertical) during birth influenced still births	Before February, 2020	26 (24.3%)	39 (36.4%)	13 (12.1%)	17 (15.9%)	12 (11.2%)
		After February, 2020	20 (18.7%)	27 (25.2%)	13 (12.1%)	17 (15.9%)	30 (28.0%)
18.	Still birth was associated with mode of delivery (thus, vaginal, vaginal assisted, and caesarean delivery)	Before February, 2020	22 (20.6%)	37 (34.6%)	11 (10.3%)	19 (17.8%)	18 (16.8%)
		After February, 2020	20 (18.7%)	27 (25.2%)	17 (15.9%)	22 (20.6%)	21 (19.6%)
19.	Obstructed labour influenced still births	Before February, 2020	39 (36.4%)	41 (38.3%)	4 (3.7%)	12 (11.2%)	11 (10.3%)
		After February, 2020	31 (29.0%)	18 (16.8%)	17 (15.9%)	18 (16.8%)	23 (21.5%)
20.	Household living conditions (i.e nutrition, sanitation, drinking water quality etc) influenced unborn foetus	Before February, 2020	44 (41.1%)	36 (33.6%)	7 (6.5%)	12 (11.2%)	8 (7.5%)
		After February, 2020	34 (31.8%)	29 (27.1%)	9 (8.4%)	15 (14.0%)	19 (17.8%)

Source: Field Data, 2023

5.5 Remarks on Effect of Drone Intervention on Relative Change of Factors Influencing Still Births in KNEM before and after February, 2020

An analysis of table 5.5 below reveals that, only three of the 20 factors that could influence still birth outcomes in the municipal underwent relative changes from the period before drone introduction in February 2020 and the period after the intervention was introduced. This implies that the relative change of factors influencing still births in KNEM, over the period under review is minimal, because the majority of factors remain unchanged.

A critical assessment of the few factors that relative changes (per opinion of respondents) were identified reveal that there is possibility that changes could have been attributed to the drone intervention or some other reasons.

Table 5.5: A tabular summary of remarks on effect of drone intervention on relative change of factors influencing stillbirths in KNEM before and after February, 2020

	STATEMENT	PERIOD	OPINION OF MAJORITY OF RESPONDENTS	RELATIVE CHANGE OF INFLUENCING FACTOR
1.	Maternal age younger than 20 or older than 35 influenced stillbirths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
2.	Lower maternal education was associated with stillbirths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
3.	Gestational age and prematurity was associated with still births	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
4.	Pregnant women's' access and patronage of antenatal care services influenced perinatal outcomes	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
5.	Poverty influenced stillbirths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
6.	Low birth weight was associated with still births	Before February, 2020	Agreed	Yes
		After February, 2020	Disagreed	
7.	Previous history of still birth influenced probability of still births	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
8.	Antepartum hemorrhage was associated with still births	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
9.	Hypertension influenced still births	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
10.	Suspected sepsis influenced still births	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
11.	Eclampsia Corticosteroids influenced still births in the municipal	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
12.	Antenatal Corticosteroids influenced still births	Before February, 2020	Agreed	Yes
		After February, 2020	Disagreed	
13.	Hospitalization influenced still births in the area	Before February, 2020	Agreed	Yes
		After February, 2020	Disagreed	
14.	Antibiotics were associated with stillbirths	Before February, 2020	Disagreed	No
		After February, 2020	Disagreed	
15.	Type of delivery attendant (eg. TBA, Nurse, Physician, Family member, self) influenced still births	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
16.	Place of delivery (hospital, clinic/health center or home) influenced still births	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
17.	Sleeping position (or 'lie') of maternal women (transverse, Oblique, Breech, vertical) during birth influenced still births	Before February, 2020	Agreed	No
		After February, 2020	No majority decision	
18.	Still birth was associated with mode of delivery (thus, vaginal, vaginal assisted, and caesarean delivery)	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
19.	Obstructed labour influenced still births	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
20.	Household living conditions (i.e. nutrition, sanitation, drinking water quality etc) influenced unborn foetus	Before February, 2020	Agreed	No
		After February, 2020	Agreed	

Source: Field Data, 2023

5.6 Factors that may have Influenced Early Neonatal Deaths in KNEM Before and After the Introduction of Drone Supplies in February, 2020

In this section of the questionnaire, the respondents were asked to indicate the extent with which they agreed or disagreed with statements about factors (fifteen factors in all) that may have influenced early neonatal deaths in the KNEM (i) before the introduction of emergency medical supplies through drones in February, 2020 and (ii) after February 2020, when emergency medicine was being supplied to health facilities in KNEM by drone. The response options provided under each declarative statement in the questionnaire were a 5-point Likert scale: (1) strongly agree, (2) agree, (3) neutral, (4) disagree and (5) strongly disagree. For the purposes of analysis of results, the 5-point Likert scale was reduced to a 3-point Likert scale: (1) Agree (comprising both strongly agree and slightly agree), (2) Neutral (neither agree nor disagree), and Disagree (comprising both slightly disagree and strongly disagree). Frequency and percentages have been used to highlight the responses of the study participants to questions on each factor.

From Table 5.6 below, 58.8% of respondents agreed to the statement that, "before drone services were introduced in the municipal, maternal age influenced early neonatal deaths (thus, death of newborn within at most 7 days of life). When those same respondents were asked what they thought of the statement that, "after drone services were introduced in the municipal, maternal age influenced early neonatal deaths (thus, death of newborn within at most 7 days of life)", 43.9% of them agreed, 40.2% disagreed and 15.9% were neutral to the statement. By comparing and contrasting the responses, we can conclude that the majority of respondents believed that maternal age influenced early neonatal deaths in KNEM, and the introduction of drone services has not significantly changed that.

A careful review of table 5.6 reveals that, respondents registered similar majority opinions (for both before and after drone introduction) on the following additional 10 out of 15 early neonatal

death influencing factors, like they did for maternal age: lower maternal education, eclampsia, low birth weight, access and patronage of antenatal care services, obstructed labour, birth order and birth interval, suspected sepsis, antepartum hemorrhage, congenital anomalies, and premature births.

For early neonatal death influencing factors such as multiple gestations, hospitalisation of newborns, giving antibiotics to newborns, and bag and mask resuscitation, we observe from table 5.6 that, the majority of respondents agreed that they influenced early neonatal deaths before drone introduction in February 2020, but majority of those same respondents disagreed that those four factors influenced early neonatal deaths after drone introduction.

Table 5.6: A tabular presentation of respondents' perception of factors that may have influenced early neonatal deaths in KNEM before and after the introduction of emergency medical supplies by drones in February, 2020.

	Statement	Period	Responses				
			Strongly agree	Slightly agree	Neither agree nor disagree	Slightly disagree	Strongly disagree
1.	Maternal age influenced early neonatal deaths (thus, death of newborn within at most 7 days of life)	Before February, 2020	27 (25.2%)	36 (33.6%)	22 (20.6%)	6 (5.6%)	16 (15.0%)
		After February, 2020	24 (22.4%)	23 (21.5%)	17 (15.9%)	16 (15.0%)	27 (25.2%)
2.	Lower maternal education influenced early neonatal deaths	Before February, 2020	34 (31.8%)	41 (38.3%)	10 (9.3%)	17 (15.9%)	12 (11.2%)
		After February, 2020	27 (25.2%)	30 (28.0%)	15 (14.0%)	17 (15.9%)	18 (16.8%)
3.	Eclampsia influenced early neonatal deaths	Before February, 2020	43 (40.2%)	37 (34.6%)	11 (10.3%)	11 (10.3%)	5 (4.7%)
		After February, 2020	23 (21.5%)	28 (26.2%)	20 (18.7%)	13 (12.1%)	23 (21.5%)
4.	Low birth weight influenced early neonatal deaths	Before February, 2020	42 (39.3%)	32 (29.9%)	16 (15.0%)	7 (6.5%)	9 (8.4%)
		After February, 2020	24 (22.4%)	29 (27.1%)	17 (15.9%)	21 (19.6%)	16 (15.0%)
5.	Multiple gestations influenced early neonatal deaths	Before February, 2020	29 (27.1%)	41 (38.3%)	13 (12.1%)	16 (15.0%)	8 (7.5%)
		After February, 2020	15 (14.0%)	26 (24.3%)	22 (20.6%)	18 (16.8%)	26 (24.3%)
6.	Lack of access and inadequate patronage of antenatal care influenced early neonatal deaths	Before February, 2020	63 (58.9%)	17 (15.9%)	13 (12.1%)	8 (7.5%)	6 (5.6%)
		After February, 2020	46 (43.0%)	23 (21.5%)	6 (5.6%)	17 (15.9%)	15 (14.0%)
7.	Obstructed labour influenced perinatal deaths	Before February, 2020	51 (47.7%)	27 (25.2%)	14 (13.1%)	6 (5.6%)	9 (8.4%)
		After February, 2020	29 (27.1%)	28 (26.2%)	11 (10.3%)	18 (16.8%)	21 (19.6%)
8.	Birth order and birth interval (eg. 2nd birth < 2years interval, 3rd/later birth < 2years interval, etc) influenced early neonatal deaths	Before February, 2020	21 (19.6%)	36 (33.6%)	24 (22.4%)	11 (10.3%)	15 (14.0%)
		After February, 2020	11 (10.3%)	35 (32.7%)	17 (15.9%)	18 (16.8%)	26 (24.3%)
9.	Suspected maternal sepsis influenced early neonatal deaths	Before February, 2020	42 (39.3%)	38 (35%)	11 (10.3%)	10 (9.3%)	6 (5.6%)
		After February, 2020	29 (27.1%)	30 (28.0%)	12 (11.2%)	14 (13.1%)	22 (20.6%)
10.	Antepartum hemorrhage was associated with early neonatal deaths	Before February, 2020	39 (36.4%)	36 (33.6%)	17 (15.9%)	8 (7.5%)	7 (6.5%)
		After February, 2020	32 (29.9%)	24 (22.4%)	13 (12.1%)	16 (15.0%)	22 (20.6%)
11.	Congenital anomalies influenced early neonatal deaths	Before February, 2020	56 (52.3%)	28 (26.2%)	10 (9.3%)	7 (6.5%)	6 (5.6%)
		After February, 2020	31 (29.0%)	27 (25.2%)	15 (14.0%)	12 (11.2%)	22 (20.6%)
12.	Hospitalization of newborns was associated with early neonatal deaths	Before February, 2020	14 (13.1%)	36 (33.6%)	18 (16.8%)	11 (10.3%)	28 (26.2%)
		After February, 2020	14 (13.1%)	18 (16.8%)	20 (18.7%)	16 (15.0%)	39 (36.4%)
13.	Giving of antibiotics to the newborns was associated with early neonatal deaths	Before February, 2020	25 (23.4%)	26 (24.3%)	10 (9.3%)	18 (16.8%)	28 (26.2%)
		After February, 2020	16 (15.0%)	23 (21.5%)	14 (13.1%)	16 (15.0%)	37 (34.6%)
14.	Bag and mask resuscitation was associated with early neonatal deaths	Before February, 2020	22 (20.6%)	25 (23.4%)	18 (16.8%)	12 (11.2%)	30 (28.0%)
		After February, 2020	13 (12.1%)	22 (20.6%)	17 (15.9%)	17 (15.9%)	38 (35.5%)
15.	Before drone services were introduced, premature births was associated with early neonatal deaths	Before February, 2020	39 (36.4%)	31 (29.0%)	11 (10.3%)	15 (14.0%)	11 (10.3%)
		After February, 2020	24 (22.4%)	26 (24.3%)	11 (10.3%)	20 (18.7%)	26 (24.3%)

Source: Field Data, 2023

5.7 Remarks on Effect of Drone Intervention on Relative Change of Factors Influencing Early Neonatal in KNEM before and after February, 2020

An analysis of table 5.7 below reveals that, only four of the 15 factors that could influence early neonatal death outcomes in the municipal underwent relative changes from the period before drone introduction in February 2020 and the period after the intervention was introduced. This implies that the relative change of factors influencing early neonatal death in KNEM, over the period under review is minimal, because the majority of factors remain unchanged.

A critical assessment of the few factors that relative changes (per opinion of respondents) were identified reveal that there is possibility that changes could have been attributed to the drone intervention or some other reasons.

Table 5.7: A tabular summary of remarks on effect of drone intervention on relative change of factors influencing early neonatal in KNEM.

	STATEMENT	PERIOD	OPINION OF MAJORITY OF RESPONDENTS	RELATIVE CHANGE OF INFLUENCING FACTORS
1.	Maternal age influenced early neonatal deaths (thus, death of newborn within at most 7 days of life)	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
2.	Lower maternal education influenced early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
3.	Eclampsia influenced early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
4.	Low birth weight influenced early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
5.	Multiple gestations influenced early neonatal deaths	Before February, 2020	Agreed	Yes
		After February, 2020	Disagreed	
6.	Lack of access and inadequate patronage of antenatal care influenced early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
7.	Obstructed labour influenced perinatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
8.	Birth order and birth interval (eg. 2nd birth < 2years interval, 3rd/later birth < 2years interval, etc) influenced early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
9.	Suspected maternal sepsis influenced early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
10.	Antepartum hemorrhage was associated with early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
11.	Congenital anomalies influenced early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	
12.	Hospitalization of newborns was associated with early neonatal deaths	Before February, 2020	Agreed	Yes
		After February, 2020	Disagreed	
13.	Giving of antibiotics to the newborns was associated with early neonatal deaths	Before February, 2020	Agreed	Yes
		After February, 2020	Disagreed	
14.	Bag and mask resuscitation was associated with early neonatal deaths	Before February, 2020	Agreed	Yes
		After February, 2020	Disagreed	
15.	Before drone services were introduced, premature births was associated with early neonatal deaths	Before February, 2020	Agreed	No
		After February, 2020	Agreed	

Source: Field Data, 2023

5.8 Impact of drones on emergency medical supplies and perinatal outcomes

Respondents were asked to rate the extent to which they believed that, (i) Drone services in the municipal has had an impact on the management of emergency medical supplies, and (ii) The use of drone services in the delivery of medical supplies (such as blood samples, medicines, anti-snake bites, vaccines, etc) has impacted perinatal outcomes in the municipal. The response options provided under each declarative statement in the questionnaire were a 5-point Likert scale: (1) Not at all, (2) A little, (3) Moderately, (4) Quite a bit and (5) Extremely. For the purposes of analysis of results, the 5-point Likert scale was reduced/compressed to a 3-point Likert scale: (1) Low (comprising not at all and a little), (2) Moderate, and (3) High (comprising quite a bit and extremely).

The results in table 5.8 indicate that, majority of the respondents (50.5%) held a very high view that, drone services in the municipal has had an impact on the management of emergency medical supplies, 32.7% held a moderate view and 16.8% reported a low view. From the table above, we also observe that 66.4% of respondents held a very high view that the use of drone services in the delivery of medical supplies (such as blood samples, medicines, anti-snake bites, vaccines, etc) has impacted perinatal outcomes in the municipal, 20.6% reported a moderate view while only 13% held a low view.

Table 5.8. Response of study participants to statements on impact of drones on the management of emergency medical supplies and perinatal outcomes.

	IMPACT OF DRONES	Not at all	A little	Moderately	Quite a bit	Extremely
1.	Drone services in the municipal has had an impact on the management of emergency medical supplies	3 (2.8%)	15 (14.0%)	35 (32.7%)	14 (13.1%)	40 (37.4%)
2.	The use of drone services in the delivery of medical supplies (such as blood samples, medicines, anti-snake bites, vaccines, etc) has impacted perinatal outcomes in the municipal	4 (3.7%)	10 (9.3%)	22 (20.6%)	23 (21.5%)	48 (44.9%)

Source: Field data, 2023

5.9. Relationship between socio-demographic characteristics of respondents (independent variables) and the scores reported for the statements regarding impact of drones on the management of emergency medical supplies, and perinatal outcomes (dependent variables)

As shown in Table 5.9 below, there is no significant relationship between gender, age, and occupation of respondents and their scores on the statement that "drone services in the municipal has had an impact on the management of emergency medical supplies" ($p > 0.05$). There was however a significant relationship between the educational level of respondents and scores reported for the same statement ($p < 0.05$). Also, there is no significant relationship between the gender, age and occupation of respondents and their views on the statement, "the use of drone services in the delivery of medical supplies (such as blood samples, medicines, anti-snake bites, vaccines, etc.) has impacted perinatal outcomes in the municipal" ($p > 0.05$). There was however a significant relationship between the education level of the respondents and their views on the same statement ($p < 0.05$).

Table 5.9: A table showing Pearson correlation coefficients between independent and dependent variables

Independent variables	Dependent variables			
	Drone services in the municipal has had an impact on the management of emergency medical supplies		The use of drone services in the delivery of medical supplies (such as blood samples, medicines, anti-snake bites, vaccines, etc) has impacted perinatal outcomes in the municipal	
	Pearson correlation	*p*-value (significance of relationship)	Pearson correlation	*p*-value (significance of relationship)
Gender	-0.006	0.952	0.150	0.122
Age	0.047	0.632	-0.130	0.183
Education level	0.199*	0.040	0.203*	0.036
Occupation	-0.020	0.840	0.022	0.825

*. Correlation is significant at the 0.05 level (2-tailed)

CHAPTER SIX

DISCUSSIONS

6.1 Discussion of Results

The study sought to assess the impact of medical drone delivery system on the management of emergency medical supplies and perinatal outcomes in KNEM. To recap, the first objective was to ascertain the trend of perinatal mortality incidence in drone-serviced health facilities in KNEM from 2016 to 2021. The second objective was to determine the factors associated with perinatal mortality before and after the introduction of the medical drone delivery system in KNEM. The third and final objective was to determine whether drones were significant contributors to perinatal outcome in KNEM.

The gathered and analysed data for the research had two sources, primary and secondary. The primary source of data was obtained with the aid of self-administered questionnaire to frontline health workers in health care facilities in KNEM. The secondary data sources include data extracted from the District Health Information Management System (DHIMS) software of KNEM on reported cases of perinatal mortalities in five drone-serviced healthcare institutions in the municipality, and also published academic articles. Mays and Pope (2000) and Patton (2001) argued that, triangulation of sources generates deeper understanding of the phenomena being studied or investigated.

The usage of Zipline drones to deliver emergency medical supplies has been noted to have made significant, positive impact on the emergency health delivery system of Ghana (Demuyakor, J., 2020). Though this assertion may probably be true for KNEM as well, the empirical data on reported incidences of perinatal mortality in 5 drone-serviced health care facilities in KNEM shows that, the delivery of emergency medical supplies by Zipline drones from February 2020 onwards, has not produced any marked, direct positive impact or effect on

perinatal outcomes in KNEM. This is evidenced by the insignificant impact on reported cases of perinatal mortalities. The explanation for this could be that, a positive impact on emergency health delivery system through the use of Zipline drones, did not necessarily mean, imply or result in a significant, positive impact on perinatal outcomes evidenced by the reduction in reported perinatal mortality incidences in drone-serviced health care facilities in KNEM. The only way the services provided by Zipline drones can have a significant effect or impact on perinatal outcomes in KNEM, is if the emergency medical supplies delivered by the drones addresses, mitigates or abates the factors associated with stillbirths and early neonatal deaths in KNEM.

The results of the study indicated a very high degree of awareness among respondents of the use of drones to deliver emergency medical supplies in KNEM (95.3% of respondents aware). The study also detected a significant correlation between the education level of the respondents and their views on statements relating to the impact of drone services on the management of emergency medical supplies, and that involving the impact of drone usage on perinatal outcomes in KNEM. However, the combined/collective influence of the gender, age, education level and occupation of respondents on their scored views on those same statements was found to be insignificant.

An analysis of the tabular summary of respondents' perception about factors that may have influenced stillbirths in KNEM before and after the introduction of emergency medical supplies by drones in February, 2020 reveals that, only three of the 20 factors that could influence still birth outcomes in the municipal underwent relative changes from the period before drone introduction in February 2020 and the period after the intervention was introduced. Factors associated with still births which did not undergo relative changes (per the view of the respondents) include maternal age, lower maternal education, gestational age and prematurity, access and patronage of antenatal care, poverty, previous history of still birth, antepartum

hemorrhage, hypertension, suspected sepsis, eclampsia corticosteroids, antibiotics, type of delivery attendant, place of delivery, mode of delivery, obstructed labour, household living conditions, and sleeping position during birth. Factors influencing still births which underwent relative changes (per the view of the respondents) include low birth weight, antenatal corticosteroids, and hospitalisation.

This implies that the relative change of factors influencing still births in KNEM, over the period under review was minimal, because the majority of factors remain unchanged (i.e. the introduction of drones did not result in a significant impact on majority of influencing factors). A critical assessment of the few factors that relative changes (per opinion of respondents) were identified reveal that, there is a possibility that changes could have been attributed to the drone intervention or some other reasons.

Another analysis of the tabular summary of respondents' perception about factors that may have influenced early neonatal deaths in KNEM before and after the introduction of emergency medical supplies by drones in February, 2020 reveals that, only four of the 15 factors that could influence early neonatal death outcomes in the municipal underwent relative changes from the period before drone introduction in February 2020, and the period after the intervention was introduced. Factors associated with early neonatal deaths which did not undergo relative changes include maternal age, lower maternal education, eclampsia, low birth weight, lack of access and inadequate patronage of antenatal care, obstructed labour, birth order and birth interval, suspected maternal sepsis, antepartum hemorrhage, congenital anomalies, premature births. Factors which influence early neonatal deaths which underwent relative changes (per the view of the respondents) are multiple gestations, hospitalisation of newborns, giving of antibiotics to newborns, bag and mask resuscitation.

This implies that the relative change of factors influencing early neonatal death in KNEM, over the period under review was minimal, because the majority of factors remain unchanged. A

critical assessment of the few factors that relative changes (per opinion of respondents) were identified reveal that there is possibility that changes could have been attributed to the drone intervention or some other reasons.

The respondents could be right because, looking at the issue of still births for example, it is difficult to see how the use of drones can address factors associated with still births like poverty, lower maternal education and poor household living conditions-these are individual, socio-economic problems that require targeted socio-economic interventions to solve.

The respondents in the study unanimously agreed that, the introduction of drones to deliver emergency medical supplies to health care facilities in KNEM had not significantly impacted the vast majority of factors known to be associated with still births and early neonatal deaths. This could explain why the trend of reported perinatal mortality cases in the 5 healthcare institutions in KNEM has been gradually increasing from 2016 to 2021, and that trend is expected/projected to continue into the future, the introduction of drones in February 2020 notwithstanding.

The results indicate that, majority of the respondents (50.5%) held a very high view that, drone services in the municipal has had an impact on the management of emergency medical supplies. This view is supported by literature on the influence of drone services on emergency health services in Ghana (Demuyakor, J., 2020).

The responses of study participants to the statement, "the use of drone services in the delivery of medical supplies has impacted perinatal outcomes in the municipal" (as indicated in table 5.8.3) showed that, 66.4% of respondents held a very high view that the use of drone services in the delivery of medical supplies (such as blood samples, medicines, anti-snake bites, vaccines, etc) has impacted perinatal outcomes in the municipal; 20.6% reported a moderate view while only 13% held a low view. The opinion of the majority of respondents to this

statement, is however not corroborated by the empirical data on perinatal mortality sourced from the District Health Information Management System (DHIMS).

6.2 Limitations of the Study

There are currently 44 healthcare facilities in KNEM. Because Zipline medical drone delivery service is a new initiative, as at the time of commencement of this research only 5 of the 44 healthcare facilities were regularly patronizing the drone service. Also, records available from the DHIMS showed that 9 of the 44 facilities accounted for all the recorded perinatal mortality cases in the municipal between 2016 and 2021. Because of the afore-mentioned factors and time constraints, the study did not employ other methodologies like a quasi-experimental study design (which will have required 24 data points minimum rather than the 5 available), or a mixed method approaches entailing both quantitative and qualitative approaches, and this limits the ability of the study to generate findings that increase the depth of understanding of the subject matter of the impact of medical drone delivery system on perinatal outcomes.

The study setting was limited to just KNEM, so the key findings of the study hold true for KNEM but may not necessarily be the case for other districts, municipalities and metropolitan settings in Ghana. There is the need for a similar study to be replicated in other health jurisdictions.

The sample size for the collection of primary data was limited to 107 respondents, which is small. For various reasons the study was not able to obtain the responses of some of the respondents who agreed to participate, in time for inclusion to increase the sample size thereby improving the validity of the findings.

The study, due to a lack of data and time constraints, was not able to investigate the details of the drugs and other emergency medical items/products routinely being supplied by the drone service, and whether those emergency medical products can address, or are meant to address some or any of the factors influencing perinatal outcomes specifically.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

7.1 CONCLUSION

The key findings of this study include the following:

1. There is a high degree of awareness among respondent health workers in the Kassena-Nankana East Municipality of Ghana on the use of drones to supply emergency medical products.
2. The study detected a significant correlation between the education level of the respondents and their views on statements relating to the impact of drone services on the management of emergency medical supplies, and that involving the impact of drone usage on perinatal outcomes in KNEM.
3. Majority of the respondents in the survey held a very high view that, drone services in the municipality has had an impact on the management of emergency medical supplies.
4. An analysis of empirical data on reported incidences of perinatal mortality (still birth and early neonatal death) in health care facilities in KNEM from 2016 to 2021 indicates that, the trend in total reported cases per year from 2016 to 2021 has been increasing, and is expected/projected to increase beyond 2021. The introduction of drone services in February 2020 appears not to have made any significant impact on the reported annual perinatal mortalities in drone-serviced health care institutions in the municipality.
5. Respondents surveyed in the study were of the unanimous opinion that, the introduction of drones to deliver emergency medical supplies to health care facilities in KNEM had not resulted in relative changes in the vast majority of factors known to be associated with still births and early neonatal deaths. Relative changes occurred for a few factors

(3 out of 20 related to still births, and 4 out of 15 related to early neonatal deaths). A critical assessment of the few factors that changes were identified reveal the possibility that changes can be attributed to some other reasons than drone intervention. This could explain why the trend of reported perinatal mortality cases in healthcare institutions in KNEM has been gradually increasing from 2016 to 2021, and that trend is expected/projected to continue into the future, the introduction of drones in February 2020 notwithstanding.

6. The responses of study participants to the statement, "the use of drone services in the delivery of medical supplies has impacted perinatal outcomes in the municipal," showed that, 66.4% of respondents held a very high view that the use of drone services in the delivery of medical supplies (such as blood samples, medicines, anti-snake bites, vaccines, etc) has impacted perinatal outcomes in the municipal. The opinion of the majority of respondents to this statement, is however not corroborated by the empirical data on perinatal mortality sourced from the District Health Information Management System (DHIMS).

7.2 RECOMMENDATIONS

1. There is the need for further research to be conducted on what medical products are supplied by the drones, and whether they are meant to address/mitigate, or can potentially address/mitigate some of the risk factors associated with still births and early neonatal deaths in KNEM.
2. The Government, and Non-Governmental Organisations (NGOs) operating in KNEM should implement policy measures that empowers women economically to improve the socio-economic condition of households, as a way of dealing with modifiable risk factors associated with perinatal outcomes (which are socio-economic in nature).

3. The provision of antenatal care services in hospitals, clinics and CHPS compounds in the municipality should be strengthened, and the education of maternal mothers should be enhanced through regular sensitization campaigns in the municipality.
4. This study can/should be replicated in other jurisdictions where medical drone delivery services occur, to know the situation in those areas as well.

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APPENDICES

Appendix 1

INFORMED CONSENT FORM

Title of Study: IMPACT OF DRONE SERVICES ON THE MANAGEMENT OF EMERGENCY MEDICAL SUPPLIES AND PERINATAL OUTCOMES IN THE KASSENA-NANKANA EAST MUNICIPAL OF GHANA.

Investigators:

- Joana Nyamekye Afrifa
- Dr. Chris Guure

This Informed Consent Form has two parts:

- Information Sheet (to share information about the research with participants)
- Certificate of Consent (for signatures if you agree to take part)

Participant will be given a copy of the full Informed Consent Form.

PART I: Information Sheet

Introduction

Hi my name is ……..., a research assistant currently pursuing MSc in Public Health Monitoring and Evaluation at the School of Public Health, University of Ghana. We are doing a research study on impact of drone services on the management of emergency medical supplies and perinatal health outcomes in order to fully understand how the services of the drones have helped or is helping to combat perinatal mortalities. You have been randomly selected to be part of this research study. You do not have to decide today whether or not you will participate in the research study. Before you decide, you can talk to anyone you feel comfortable with about the research.

I will now proceed to give you more information about this research study. If there is anything that you do not understand, please ask me to stop as we go through the information and I will take time to explain. You can also ask questions even after I have finished going over this information with you.

Purpose of Study

The purpose of this study is to assess the effect of the use of drones on perinatal health outcome in the Kassena Nankana East Municipal.

Description of the Study Procedures

If you agree to be in this study, you will be asked to complete survey with about 60 questions. I will go through each question one-by-one with you. You will give me a response before continuing on to the next question. This may take up to an hour of your time depending on how quickly we both go through the survey. Completion of this survey is all that is required from you. Upon completing the survey with all information gathered, your participation for this study is concluded.

Risks/Discomforts of Being in this Study

There are no reasonable foreseeable (or expected) risks.

Benefits of Being in the Study

There is no direct benefit to you for participating in the study.

Confidentiality

This study is anonymous. We will not be collecting or retaining any information about your identity. We will not include any information in any report we may publish that would make it possible to identify you.

Payments

You will not receive reimbursement for your time in participating in this study.

Right to Refuse or Withdraw

Your participation in this research is entirely up to you and is voluntary. It is your choice whether to participate or not. You may refuse to take part in the study at any time without affecting your relationship with the investigators of this study. Your decision will not result in any loss or benefits to which you are otherwise entitled. You have the right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

Right to Ask Questions and Report Concerns

You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. If you have any further questions about the study, feel free to contact the PI Joana Nyamekye Afrifa at joananyamekyeafrifa@gmail.com/jnafrifa@st.ug.edu.gh or by telephone at 0248276561. You could also contact Dr. Chris Guure (Supervisor) at cbguure@ug.edu.gh. If you have any other concerns about your rights as a research participant that has not been answered by the investigators, you may contact Navrongo Health Research Centre Institutional Review Board Administrator at 0591152102 or email at nadia.anuseh@navrongo-hrc.org.

Alternatively, concerns can be reported by completing a Participant Complaint Form, which can be found at the Navrongo Health Research Centre Institutional Review Board office.

Certificate of Consent

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Print Name of Participant: _____

Signature of Participant: _____

Date: _____

Day/month/year

If No formal Education

A literate witness must sign (if possible, this person should be selected by the participant and should have no connection to the research team). Participants who have no formal education should include their thumbprint as well.

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness:_____ **Thumbprint of participant**

Signature of witness: _____

Date: _____

Day/month/year

Statement by the researcher/person reading consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands this consent form.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

Print Name of Researcher/person reading the consent: _____
Signature of Researcher/person reading the consent: _____

Date:_____

Day/month/year

SURVEY QUESTIONNAIRE

This research is being undertaken to assess the perspectives of health professional on: 1. factors that may have influenced perinatal outcomes before and after the introduction of drone medical supply services in Kassena-Nankana East Municipal and 2. extent to which drone services in the municipal influenced emergency medical supplies and perinatal outcomes. It is my belief that you will provide very helpful answers to the questions below. Thank you in advance for your contribution to this research study. Please respond to the following by either writing in the blank space provided or ticking the appropriate box.

SECTION A: Demographic Information

Biographic data from health professionals (i.e. Nurses, Community health officers, medical doctors, etc)

1. Gender Male [ ] Female [ ]

2. Age 18-24[ ] 25-34[ ] 35-44[ ] 45-54 [ ] 55 and above [ ]

3. Educational level:

   High tertiary (Masters or PhD) [ ] Tertiary (First degree or HND) [ ]
   Secondary [ ] Primary [ ]
   Other (Please specify)…….. No education [ ]

   Professional qualification ……..

4. Occupation (You could tick more than one depending on your occupational situation)
   Physician [ ] midwife [ ] Nurse [ ] Community health officer [ ]
   Health research scientist [ ] Pharmacist [ ] Health administrator [ ]
   Laboratory technologist [ ] Physician assistant [ ] Anesthetist [ ]
   Other (kindly specify) ……

SECTION B: Involvement in maternal healthcare emergencies/cases

1. Are you directly involved in maternal health issues?
   Yes ( ) No ( )
   If yes, kindly indicate the community or health facility …….

SECTION C: Awareness of stillbirths and early neonatal deaths

2. Have you ever witnessed stillbirths or early neonatal deaths in your locality, community or health facility? Yes ( ) No ( )
3. Have you ever been informed about the stillbirth or early neonatal death incidence in your area or health facility? Yes ( ) No ( )
   If you responded yes to question 2 or 3, kindly answer the question below
4. To the best of your memory, when did you hear about or witness a stillbirth or early neonatal death even in your locality of health facility?
   Before 2020 (thus over 3years ago) ( ), After 2020 ( ), I do not remember ( )

SECTION D: Awareness of drone technology usage in Kassena Nankana East Municipal

1. Have you heard about drone technology?
   Yes ( ) No ( )

2. Are you aware that the use of drone technology to deliver emergency medical supplies in the Kassena Nankana East municipal has been in progress for some time now? Yes ( ) No ( )

SECTION E: FACTORS THAT MAY HAVE INFLUECED PERINATAL OUTCOMES IN THE KASSENA NANKANA EAST MUNICIPAL BEFORE AND AFTER THE INTRODUCTION OF DRONE SUPPLIES IN THE AREA IN FEBRUARY, 2020

For each statement in the table below, kindly tick one option to indicate the extent to which you agree or disagree with the following statements about factors that may have influenced still births or the health condition and total well-being of fetus of pregnant women with 28 completed weeks (or 7 completed months) of gestation, before drone services were introduced in KNEM

No.	Statement **(Before the introduction of drone supplies in health care system of KNEM in February, 2020)**	Strongly agree	Slightly agree	Neither agree nor disagree	Slightly disagree	Strongly disagree
1	Maternal age younger than 20 or older than 35 influenced still births before the introduction of drone supplies in the municipal					
2	Lower maternal education was associated with still births before introduction of drone supplies in the municipal					
3	Gestational age and prematurity was associated with still births before introduction of drone supplies in the municipal					
4	Before drone services were introduced, one of the factors that influenced perinatal outcomes is pregnant women's' access and patronage of antenatal care services					
5	Poverty influenced stillbirths before drone supplies were introduced					
6	Low birth weight was associated with still births before drone service introduction					

7	Previous history of still birth influenced still births before drone service introduction					
8	Antepartum hemorrhage was associated with still births before drone introduction					
9	Hypertension influenced still births before introduction of drone supplies					
10	Suspected sepsis influenced still births before drone supplies were introduced					
11	Eclampsia Corticosteroids influenced still births in the municipal before introduction of drone supplies					
12	Antenatal Corticosteroids influenced still births before drone introduction					
13	Hospitalization influenced still births in the area before introduction of drone supplies					
14	Antibiotics were associated with still births before drone supplies were introduced					
15	Type of delivery attendant (eg. TBA, Nurse, Physician, Family member, self) influenced still births before introduction of drone supplies in the area					
16	Place of delivery (hospital, clinic/health center or home) influenced still births before drone introduction					
17	Sleeping position (or 'lie') of maternal women (transverse, Oblique, Breech, vertical) during birth influenced still births before drones were introduced					
18	Still birth was associated with mode of delivery (thus, vaginal, vaginal assisted, and caesarean delivery) before introduction of drone supplies					
19	Obstructed labour influenced still births before drone introduction					

20	Household living conditions (i.e nutrition, sanitation, drinking water quality etc) influenced unborn foetus before drone supplies were introduced					

For each statement in the table below, kindly tick one option to indicate the extent to which you agree or disagree with the following statements about factors that may have influenced still births or the health condition and total well-being of fetus of pregnant women with 28 completed weeks (or 7 completed months) of gestation, after drone medical supplies were introduced in KNEM (in 2020).

No.	Statement **[After the introduction of drone supplies in health care system of KNEM (i.e. after February, 2020)]**	Strongly agree	Slightly agree	Neither agree nor disagree	Slightly disagree	Strongly disagree
1	Maternal age younger than 20 or older than 35 influenced still births after the introduction of drone supplies in the municipal					
2	Lower maternal education was associated with still births after the introduction of drone supplies in the municipal					
3	Gestational age and prematurity was associated with still births after the introduction of drone supplies in the municipal					
4	After drone services were introduced, one of the factors that influenced perinatal outcomes is pregnant women's' access and patronage of antenatal care services					

5	Poverty influenced stillbirths after drone supplies were introduced					
6	Low birth weight was associated with still births after drone service introduction					
7	After drone medical supplies were introduced in the area, previous history of still birth influenced still births					
8	Antepartum hemorrhage was associated with still births after introduction of medical drone supplies					
9	Hypertension influenced still births after introduction of drone supplies					
10	Suspected maternal sepsis influenced still births after drone supplies were introduced					
11	Eclampsia Corticosteroids influenced still births in the municipal after introduction of drone supplies					
12	Antenatal Corticosteroids influenced still births after drone introduction					
13	Hospitalization influenced still births in the area after introduction of drone supplies					
14	Antibiotics were associated with still births after drone supplies were introduced					
15	Type of delivery attendant (eg. TBA, Nurse, Physician, Family member, self) influenced still births after introduction of drone supplies in the area					
16	Place of delivery (hospital, clinic/health center or home) influenced still births after drone introduction					

17	Sleeping position (or 'lie') of maternal women (transverse, Oblique, Breech, vertical) during birth influenced still births after drones were introduced					
18	Still birth was associated with mode of delivery (thus, vaginal, vaginal assisted, and caesarean delivery) after the introduction of drone supplies					
19	Obstructed labour influenced still births after the introduction of medical drone supplies					
20	Household living conditions (i.e nutrition, sanitation, income, drinking water quality etc) influenced condition of unborn foetus before drone supplies were introduced					

For each statement in the table below, kindly tick one option to indicate the extent to which you agree or disagree with the following statements about factors that may have influenced early neonatal deaths in the Kassena Nankana East Municipal before the introduction of drone medical supplies to the area in February, 2020.

NO.	Statement **(Before the introduction of drone supplies in health care system of KNEM in February, 2020)**	**Strongly agree**	**Slightly agree**	**Neither agree nor disagree**	**Slightly disagree**	**Strongly disagree**
1	Before drone services were introduced in the municipal, maternal age influenced early neonatal deaths (thus, death of newborn within at most 7 days of life)					
2	Lower maternal education influenced early neonatal deaths before introduction of medical drone supplies in the municipal					
3	Eclampsia influenced early neonatal deaths before drone supplies were introduced in the area					

4	Low birth weight influenced early neonatal deaths before drone introduction in the municipal					
5	Multiple gestations influenced early neonatal deaths before drone introduction					
6	Lack of access and inadequate patronage of antenatal care influenced early neonatal deaths before drone services were introduced					
7	Before drone services were introduced in the area, obstructed labour influenced perinatal deaths					
8	Birth order and birth interval (eg. 2nd birth < 2years interval, 3rd/later birth < 2years interval, etc) influenced early neonatal deaths before drone supplies were introduced					
9	Suspected maternal sepsis influenced early neonatal deaths before introduction of drone supplies					
10	Antepartum hemorrhage was associated with early neonatal deaths before drone introduction					
11	Congenital anomalies influenced early neonatal deaths before drone introduction					
12	Hospitalization of newborns was associated with early neonatal deaths before drones were introduced					
13	Giving of antibiotics to the newborns was associated with early neonatal deaths before drones supplies were introduced					
14	Bag and mask resuscitation was associated with early neonatal deaths before drone service introduction					
15	Before drone services were introduced, premature births was associated with early neonatal deaths					

For each statement in the table below, kindly tick one option to indicate the extent to which you agree or disagree with the following statements about factors that may have influenced early neonatal deaths in the Kassena Nankana East Municipal after the introduction of drone medical supplies to the area in February, 2020.

NO.	Statement **(After the introduction of drone supplies in health care system of KNEM in February, 2020)**	Strongly agree	Slightly agree	Neither agree nor disagree	Slightly disagree	Strongly disagree
1	After drone services were introduced in the municipal, maternal age influenced early neonatal deaths (thus, death of newborn within at most 7 days of life)					
2	Lower maternal education influenced early neonatal deaths after introduction of medical drone supplies in the municipal					
3	Eclampsia influenced early neonatal deaths after drone supplies were introduced in the area					
4	Low birth weight influenced early neonatal deaths after drone introduction in the municipal					
5	Multiple gestations influenced early neonatal deaths after drone introduction					
6	Lack of access and inadequate patronage of antenatal care influenced early neonatal deaths after drone services were introduced					
7	After drone services were introduced in the area, obstructed labour influenced perinatal deaths					
8	Birth order and birth interval (eg. 2nd birth < 2years interval, 3rd/later birth < 2years interval, etc) influenced early neonatal deaths after drone supplies were introduced					

9	Suspected maternal sepsis influenced early neonatal deaths after introduction of drone supplies					
10	Antepartum hemorrhage was associated with early neonatal deaths after drone introduction					
11	Congenital anomalies influenced early neonatal deaths after drone introduction					
12	Hospitalization of newborns was associated with early neonatal deaths after drones were introduced					
13	Giving of antibiotics to the newborns was associated with early neonatal deaths after drones supplies were introduced					
14	Bag and mask resuscitation was associated with early neonatal deaths after drone service introduction					
15	After drone services were introduced, premature births was associated with early neonatal deaths					

SECTION E: IMPACT OF DRONES ON EMERGENCY MEDICAL SUPPLIES AND PERINATAL OUTCOMES

IMPACT OF DRONES	Not at all	A little	Moderately	Quite a bit	Extremely
Drone services in the municipal has had an impact on the management of emergency medical supplies					
The use of drone services in the delivery of medical supplies (such as blood samples, medicines, anti-snake bites, vaccines, etc) has impacted perinatal outcomes in the municipal					

OUR CORE VALUES
1. People Centered
2. Professionalism
3. Team work
4. Innovation
5. Discipline
6. Integrity

My Ref: Drone Services /04/2023
Your Ref:

Navrongo Health Research Centre
Institutional Review Board
Ghana Health Services
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Mob: +233 591192102
E-mail: irb@navrongo-hrc.org
26th April 2023

Miss Joan Nyamekye Afrifa,
Navrongo Health Research Centre
P.O Box 114
Navrongo-Upper East Region

ETHICS APPROVAL ID: NHRCIRB512

Dear Miss Afrifa,

Approval of Protocol titled "Impact of Drone services on the management of emergency medical supplies and perinatal outcomes In the Kassena-Nankana East Municipal of Ghana"

I write to inform you that the Navrongo Health Research Centre Institutional Review Board (NHRCIRB) has reviewed your protocol and is happy to grant you approval.The following documents were reviewed and approved;

- Study Protocol version 2 dated 24/3/2023
- Participant Information Sheet and Informed Consent Form version 2 dated 24/3/2023
- Trend in perinatal mortality incidence questionnaire version 2 dated 24/3/2023
- Questionnaire (quantitative survey of respondent health professionals) version 2 dated 24/3/2023
- Influence of drone supplies on perinatal outcome questionnaire version 2 dated 24/3/2023,
- CV of Investigators (Miss Joan Nyamekye Afrifa, Dr Chris Guure)

Please, note that any amendment to these approved documents must receive prior NHRCIRB approval before implementation. This approval expires on 25th **April 2024.**

The Board wishes you all the best in your study.

Sincerely,

Dr Nana Akosua Ansah
(Vice-Chair, NHRCIRB)

Cc: The Director, NHRC - Navrongo