

Effects of Drone Technology on access to blood and blood components for improved maternal health outcomes in underserved communities in Ghana: A cross sectional study

Florence Haruna

florenceharuna25@gmail.com

Kwame Nkrumah University of Science and Technology

Daniel Opoku

Kwame Nkrumah University of Science and Technology

Peter Agyei-Baffour

Kwame Nkrumah University of Science and Technology

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Abstract

Background

Access to specialized blood components such as fresh frozen plasma and cryoprecipitate is fraught with challenges due to supply-demand imbalances, logistical and transportation constraints in most lower-middle income countries such as Ghana. These barriers have significant implications on maternal health, contributing to preventable deaths and disabilities resulting from postpartum hemorrhage. The study sought to assess how the adoption of medical drone technology (aerial logistics) has improved access to blood and blood components for improved maternal health outcomes in the Eastern region of Ghana.

Methods

A cross sectional study of 16 transfusion facilities was employed to estimate the impact of medical drone technology on blood products access and maternal health outcomes using data from administrative records of the Eastern region Ghana Health Service and Zipline, an unmanned aerial logistics company in Ghana. Descriptive statistics were used to establish associations between blood utilization from the medical drone technology source and other traditional sources, while a difference in difference analysis was conducted to determine pre-post differences between the weighted average of MMR among transfusion facilities served by the aerial logistics company and those not served.

Results

The use of medical drone technology has significantly diversified the range of available blood components (34% drone delivery of whole blood, 40% concentrated red cells (CRC), 18% fresh frozen plasma (FFPs), and 8% Cryoprecipitate), enabling more targeted treatment protocols compared to 90% whole blood and less than 10% were CRC and FFP utilized from other sources. There has been a significant increase in the availability of blood products and a substantial reduction in maternal mortality ratios.

Conclusions

The findings revealed that medical drone technology effectively addresses existing healthcare supply chain gaps with regards to blood distribution. It not only enhances the availability of specialized blood components but also improves maternal health outcomes.

Introduction

Blood transfusion serves as a life-saving clinical intervention, but a stark global disparity exists in the access and availability of this critical resource. Approximately 80% of the world's population has access to only 20% of the global blood supply [1]. This inequity is even more pronounced in low-and middle-income countries (LMICs), where the demand for blood products frequently exceeds the supply. The devastating effects of shortage of blood and blood components, especially on maternal health, has been

a major health challenge especially in LMICs, where maternal mortality has been predominantly caused by post-partum hemorrhage due to shortage of blood and blood components [2].

In 2020, Ghana recorded a maternal mortality ratio of 263 per 100,000 live births. Although there has been a general improvement in the past years (274 in 2017, 273 in 2018, 244 in 2019), it is still far from the global target of less than 70 per 100,000 by 2030 [3][4][5]. This precarious phenomenon mainly informed the government of Ghana to engage Zipline, an unmanned aerial logistics company, to leverage on drone technology to supply timely blood products among others to help address this challenge.

Unmanned Aerial Vehicles (UAVs), commonly known as drones, have demonstrated potential in healthcare logistics. Originally developed for military use, drones are now being employed to deliver medical supplies, including blood products, particularly in hard-to-reach and underserved areas[6]. A case in point is Rwanda, where drone technology reduced blood wastage by 42% and significantly lowered maternal mortality rates associated with postpartum hemorrhage [7]. In a similar vein, Ghana has since 2019 adopted the use of drone technology as part of the efforts to bridge the in-equity gap in blood supply due to logistical challenges and reduce the risk of wastage.

In light of this, our study aimed at examining the effects of drone technology on blood products availability and blood transfusion health outcomes in maternal healthcare in Ghana.

Methods

Study Setting and sampling

This study was conducted among 16 transfusion facilities within the Eastern region of Ghana, the sixth largest region in Ghana with a total population of 2,633,154. As of 2021, the region had 46.3% of its communities being rural with very poor road networks. Also, the region has a number of water bodies like the Volta lake which occupies a stretch of the land. The nature of roads and in-land communities located in the region pose challenges in traditional commuting when accessing health commodities. For instance, the average round trip by road made by the Ghana Health Service - the largest healthcare provider in Ghana - transfusion facilities in the Eastern region to the Eastern Regional Hospital in Koforidua and the National Blood Service in Accra is 2hr 58 min and 4hr 55 min respectively using the shortest routes. This study targeted all public transfusion facilities within the Eastern region who also fell within the catchment area of Zipline Omenako distribution center and have the mandate to render blood transfusion services to the public.

Sampling Method

Ghana Health Service transfusion facilities within the Eastern region were considered for secondary data collection on blood products utilization and health outcomes on blood transfusion cases and management. All Ghana Health Service transfusion facilities within the Eastern region were included in the studies while private and non-transfusion facilities were excluded from the studies.

A combination of blood utilization and deliveries data were gathered from the records of the transfusion facilities and Zipline Omenako station respectively. Additionally, maternal mortality ratio (MMR) data was collected from the District Health Information Management System (DHIMS2) records of the Eastern Regional Health Directorate together with data on live births that were used to compute the weighted average of the former.

Data Collection

Secondary data was collected from the transfusion facilities and Zipline Omenako to understand the relation between the drone technology and clinical outcomes.

Data Analysis

Data was entered and stored in Microsoft Excel and analyzed using STATA V.17.0 (College Station, TX, StataCorp LLC). Blood utilization by the participating facilities were analyzed descriptively. Maternal mortality ratios were weighted with the number of live births for each transfusion facility. Difference in difference analysis was done to determine significance difference between the weighted average of MMR among transfusion facilities served by the drone technology and those not served.

Results

Characteristics of Transfusion Facilities

The 16 transfusion facilities reached out to had an average of 12 medical doctors, 249 nurses and 10 laboratory staff workforce at each of the facilities.

Blood Utilization

Out of the 16 transfusion facilities reached out for blood utilization data, 10 responded. Demand for blood was generally high across all facilities, with a greater proportion consumed from other sources (donor replacement, voluntary donors, etc.) and about 8% consumption from the medical drone technology service whose source is from the National Blood Service as shown in Fig. 1.

From the health facilities laboratory records, approximately 90% of the blood consumed from non-medical drone sources were whole blood and less than 10% were CRC and FFP as shown in Fig. 2.

Following the proportion of blood products consumed from the medical drone technology source, according to its delivery records, 34% on average were whole blood, 40% were CRC, 18% were FFPs, and 8% were Cryoprecipitate as shown by Fig. 3.

A comparison of the trends of weighted average maternal mortality ratio among medical drone served facilities and non-served facilities showed a significant difference ($p = \text{value} < 0.05$) in 2021 as shown in Fig. 4.

Discussion

The advent of drone technology in healthcare logistics has marked a pivotal shift in the availability of blood products and the reduction of maternal mortality ratios, particularly in resource-limited settings. Before medical drones were introduced in Ghana, healthcare facilities faced numerous challenges in procuring blood, echoing similar difficulties encountered in Rwanda. These challenges included prolonged turnaround times to secure blood from centralized sources, logistical limitations in screening blood to golden standards, and the inability to separate blood into its various components like fresh frozen plasma, cryoprecipitate, or platelet concentrate [8].

In the past, the choice of blood products for transfusion was informed by the medical conditions, access and availability of blood products. Heavy reliance on whole blood through the traditional sources confirms a study on how most Saharan healthcare providers relied on whole blood to treat all cases irrespective of the uniqueness of the case, reducing the efficacy of treatment for patients [9]. Organizations such as the World Health Organization and the Ghana National Blood Services, have advocated for healthcare providers to adapt using specific blood components to treat specific cases to optimize care and recovery. Data gathered from non-medical drone sources showed 90.4% annual whole blood utilization, 5.2% CRC, 0.5% FFP between 2016 to 2021. However, the blood products used from the medical drone source paralleled WHO's advocacy (34% on average were whole blood, 40% were CRC, 18% were FFPs, and 8% were Cryoprecipitate within 2019 and 2021). This demonstrates the benefit of the medical drone to make available the different components of blood to promote the use of specific blood products for a specific clinical case. Further substantiating the impact of drones, our study found a significant decline in maternal mortality ratios for transfusion facilities served by medical drones (p -value < 0.06) using difference-in-difference analysis. This result parallels findings in Rwanda, where drone technology contributed to a reduction in maternal mortality due to post-partum hemorrhage [7]. It can be inferred that access and timely delivery of specific blood components by drones plays a pivotal role in addressing emergencies effectively, thereby reducing maternal mortality.

Policy Implication

The study, focused on Eastern Ghana where Zipline's first distribution center is located, offers recommendations for various health system actors. The Ministry of Health (MOH) can bolster the National Blood Service (NBS) with resources to meet blood demand and integrate drone technology for emergency responsiveness and equitable access to componentized blood products. Zipline's role is emphasized as a provider of essential, componentized blood, filling a gap left by transfusion facilities unable to segregate blood. The recommendations aim to make healthcare workstreams in Ghana more agile and robust.

Limitations

The specific causes of maternal mortality were not provided and cannot be solely attributed to postpartum hemorrhage or lack of blood access. Also, the difference-in-difference model was unadjusted

and did not consider other variables such as health education programs organized for pregnant women that might have affected the trend in maternal mortality rate. Again, the study did not consider the different times that the transfusion facilities were operationalized by the medical drone, which could influence the number of blood products they ordered within the study period.

Conclusion/Recommendation

In conclusion, aerial logistics, particularly through drone technology, has emerged as a transformative force in healthcare supply chains. The medical drone services in Ghana have significantly bridged gaps in blood supply, enabling equitable access and timely deliveries even to remote transfusion facilities and thus reducing maternal mortality ratios. These drones not only facilitate quick access to whole blood but also make specialized blood components like fresh frozen plasma and cryoprecipitate readily available, revolutionizing emergency care.

Declarations

Ethics approval and consent to participate

This study was approved by the Ghana Health Service Ethics Review Committee with reference number CHRPE/AP/720/22 and informed consent was obtained for the primary data collection which involved the health workers completing a survey.

Consent for publication

Not applicable

Availability of data and materials

The authors do not have permission to share governmental data.

Competing Interest

We declare that this research manuscript has no conflicts of interest. The study did not receive any form of funding, financial support or sponsorship from any organization, institution or individual. Two of the authors had no form of affiliations or involvement that could be perceived as influencing the research, its findings or the interpretations as represented in this manuscript. However, one author, Florence Haruna, is affiliated to the drone company through employment.

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Authors' contributions

F.H conceptualized research idea and design, led protocol drafting, performed administrative duties, collected research data, performed data analysis and led the manuscript preparation.

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Authors' information

F.H Graduate Student, Health Policy, Management and Economics, Kwame Nkrumah University of Science and Technology

D.O Lecturer, Health Policy, Management and Economics, Kwame Nkrumah University of Science and Technology

P.A.B Head of Department, Health Policy, Management and Economics, Kwame Nkrumah University of Science and Technology

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Figures

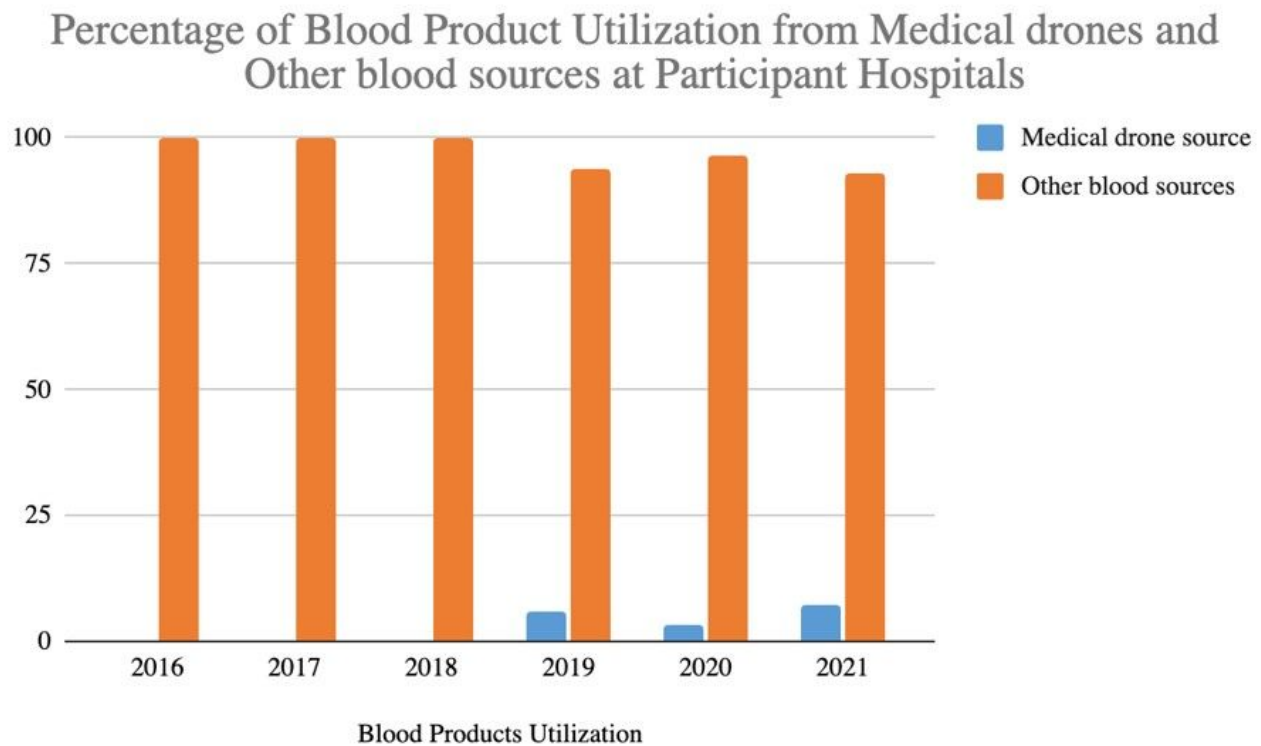


Figure 1

Proportion of blood products utilization from medical drone source and other sources [N=36635][source: health facility laboratory record and Zipline delivery record, 2022]

Percentage of Non-Medical Drone Source of Blood Products Used at Participants Hospitals

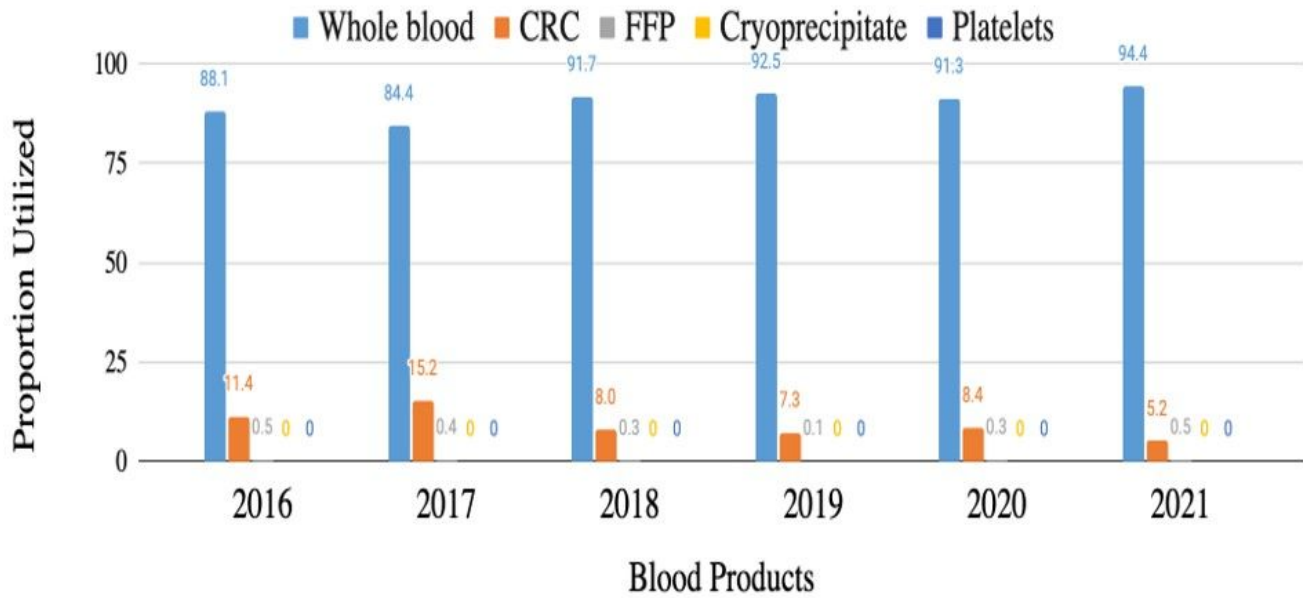


Figure 2

Proportion of specific blood products utilization from other non-Zipline sources [N=35466] [source: health facility laboratory record, 2022]

Percentage of Medical Drone Source of Blood Products Used at Participants Hospitals

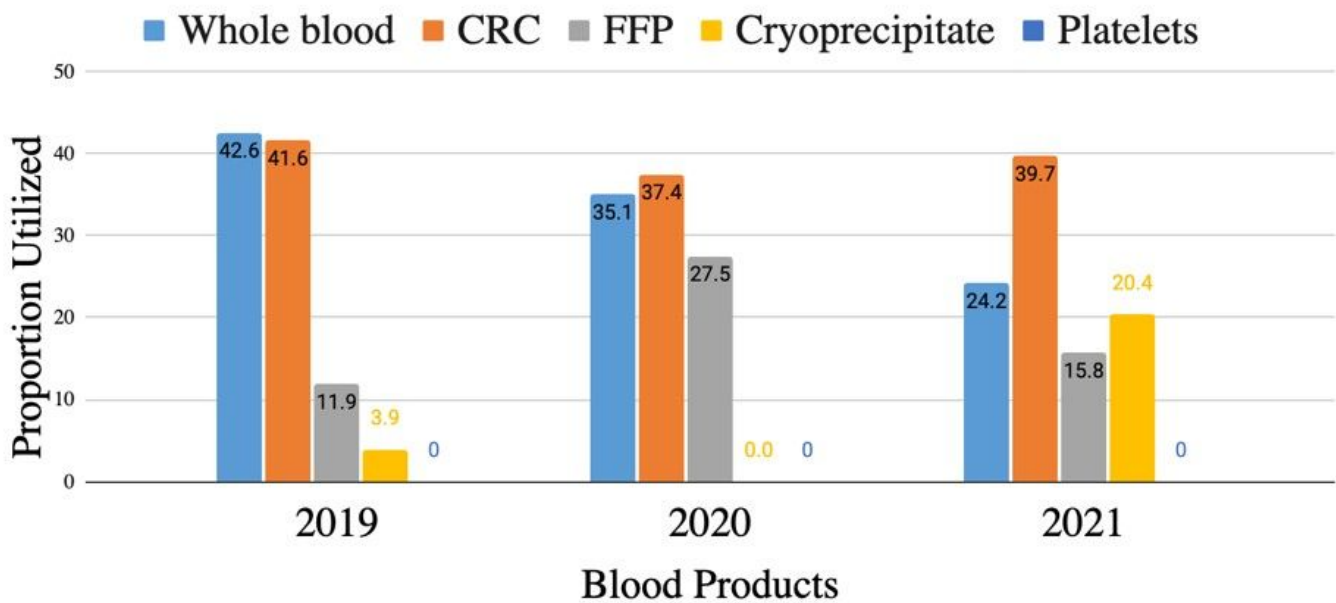


Figure 3

Proportion of specific blood products utilization from medical drone sources [N=1169] [source: Zipline delivery record, 2022]

Weighted Average Trend of Maternal Mortality Ratio(MMR) Between Hospitals Served by Medical Drone Technology Versus Those Not Served

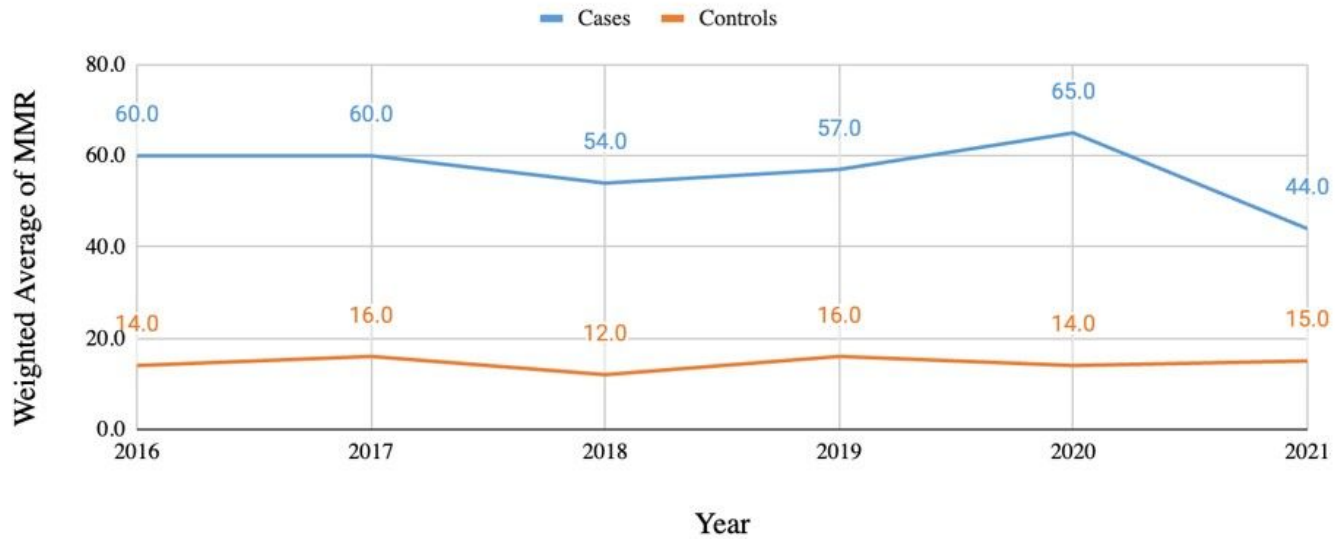


Figure 4

Trends of weighted average of maternal mortality ratio at facilities served by medical drone and those not served (Ca: Cases, Cl: Control). [Difference-in-difference P-value= 0.011, 1] [source: Eastern regional health directorate health record, 2022]