ANALYSING THE IMPACT OF THE USE OF DRONE TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT IN IMPROVING HEALTH SERVICES IN GHANA

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Drone has played a major role in supply chain management. The use of drones to deliver supplies to customers has impacted significantly, especially in areas where the targeted participant is remotely located from the source. Unmanned Aerial Vehicle (UAV) or First-Person View (FPV) drones have played a major role in the military, health care, and the business world in improving supply chain management. The use of drones in health care is basically for emergency purposes and also to reach inaccessible areas. This research aimed to provide the first comprehensive analysis of the impact of the introduction of UAVs in Ghana in improving the service pf health care providers. Health care in Ghana is fraught with several challenges, especially in rural areas where accessibility is hard to reach. The research analyses the impact of the use of drone technology in supply chain management in improving health services in Ghana. The quantitative method was adopted for the research. The research concluded that there was a moderately significant correlation between the use of drones and the supply chain within the health service. However, the research indicated that there is a need to widen the coverage of drone technology to increase the acceptability of drone technology nationwide.

Keywords— Unmanned Aerial Vehicle, First Person View, Drone, Supply Chain Management, Health Care Services, and Quadcopter.

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I. INTRODUCTION

According to den Besten, (2021) although the "personal drone" is still in its early stages of development, supply chain organizations in general, and logistics companies in particular, have been employing drones for many years. For example, in 2015 in Lugano, Switzerland, Swiss Post performed drone delivery trials, in which Matternet drones autonomously transported laboratory samples between two hospitals, saving significant time over road transport (den Besten, 2021). Moreover, 70 flights were flown during the trials, with more anticipated in the future (den Besten, 2021). There are numerous instances where drones have impacted supply chain operations. For example, in 2016, DHL Parcel, the world's largest logistics company, completed a three-month test of its third Parcelcopter generation, an autonomous tilt wing vehicle The initiative chalked a successful trial integration of DHL Parcelcopter into the logistics chain. As a result, package delivery by drones is no longer a pipe dream, but a present-day reality. This feature is especially beneficial in regions where contacting the parcel sender or receiver is difficult. Drone package delivery might potentially be a game-changer in areas where severe winter weather occurs, making delivery services easier and more efficient (den Besten, 2021).

According to García-Fernández, Sanz-Ablanedo, and Rodríguez-Pérez (2021), Drones are ready to play a large role in other areas of supply chain operations, such as inventory management, in addition to logistics (Garcia, 2013). Drones are already assisting in the process of monitoring and tracking supplies around the warehouse, which is time-consuming, labour-expensive, energy-inefficient, costly, and unsafe. Drones are now outfitted with technology that allows them to scan any barcode (linear, QR, Matrix, etc.) and send the information to a warehouse management system in real-time (WMS). Drones can provide several evident benefits in this setting, including higher tracking precision and efficiency, as well as improved resource and personnel use and safety (Garfield, 2016).

Very limited studies have been done on the commercial use of drones for collection and delivery (Chitta & Jain, 2019). Few economists have studied the different commercial and civil uses of drones covering a wide range of topics, but only aerial supervision; the few studies in the area of drones make research into the use of drones for packaging minimal (Chitta & Jain, 2019). Kharchenko and Preušov (2012) examined various uses of drones by dividing them into three different groups, namely safety control, scientific research and business. The commercial use of drones was emphasized but the freight delivery/transport was not explained. The authors mainly focused on aerial photography and monitoring options. Kharchenko and Prusov (2012) however, referred to specific requirements necessary for the unmanned aircraft (UAC) or drone station structure (Kharchenko & Prusov, 2012). The following requirements are: unmanned aircraft itself, unmanned aircraft control systems and aerial control stations; onboard software and monitoring systems for unmanned aircraft; communication media (earth and air/earth) for air traffic control and unmanned aircraft payloads. (Pietsch, 2019).

As the usage of drones becomes ever more popular, Kharchenko and Prusov (2012) indicated that there might be difficulties with using airspace and allocated frequency ranges for the control of aircraft and transfer of data from [aircraft] to earth, and vice versa. Competition Unmanned Aircraft System (UAS) frequency use may become a problem that needs to be legally solved, similar to radio frequencies. Kharchenko and Prusov (2012) concluded that in the future, only when technical and administrative obstacles are reduced will the market for drones and Drone systems grow. Tatham (2019) addressed the use of the Unmanned Aerial Vehicles System (UAVS) in drones for aerial monitoring and recognition in areas requiring immediate action. The author quoted M.C. Christopher from the fields of Logistics and Supply Chain Management indicated that "There is broad agreement that delivery time is a key criterion for order-making" (Tatham, 2019). Tatham (2019) believes drones can help areas that have suddenly been hit by a disaster earlier and better quality. Tatham uses the publication to analyse the advantages and losses of manned to unmanned surveillance methods by discussing differences in cost, data quality and other requirements for each aircraft type. The advantages of using UAVS could be greater than the cost of technology development and operation. He said that the costs for UAVS are going to be very costly in the near future (Chitta & Jain, 2019).

According to Rinaudo, (2019), noted that millions of people worldwide, both in developed and developing countries, die each year because patients do not get the medicine need. However, Rinaudo emphasized that the Zipline drone application aims to build the first logistics system in the world to serve all people equally.

Research Objectives:

1. To find out the effects of using drones for medical supplies on health service delivery
2. To find out the challenges of using drone technology in medical supplies in Ghana
3. To compare the performance of drones to the traditional mode of medical delivery in the country.

II. LITERATURE REVIEW

Drones and Healthcare Supply Chain Management

Drones have emerged as a promising technology for improving healthcare supply chain management. According to Lokhande et al. (2018), drones are being utilized in various sectors, including military operations, aid work, and delivery services by companies like Amazon and DHL. The use of drones in the healthcare sector has gained attention due to their potential to overcome logistical challenges and enhance the timely delivery of medical supplies. This information highlights the growing interest in drone technology and its relevance to healthcare supply chain management (Lokhande et al., 2018; Amukele et al., 2017; Claesson et al., 2016).

One of the significant advantages of using drones in the healthcare supply chain is their ability to reach remote and underserved areas. The World Health Organization (WHO) launched the "Fly-To-Save-A-Life" project in Ghana, establishing a medical drone delivery network to provide on-demand delivery of medical supplies to health facilities (WHO,

2019). This initiative demonstrates the potential of drones to improve access to healthcare in regions with limited infrastructure and challenging terrain. The information emphasizes the importance of drones in addressing healthcare disparities and ensuring the timely delivery of critical medical resources (WHO, 2019; Gavi, 2021; World Economic Forum, 2022). Delivery time is a crucial factor in healthcare supply chain management, especially for time-sensitive medical supplies. Tatham (2019) suggests that drones can significantly improve delivery times in areas affected by disasters or emergencies. Compared to traditional transportation methods, drones can navigate quickly and directly to their destination, bypassing traffic congestion and geographical barriers. This efficiency in delivery can have a profound impact on patient outcomes and the overall effectiveness of healthcare services. The information highlights the importance of drones in expediting the delivery of medical supplies, particularly in urgent situations (Tatham, 2019; Chowdhury et al., 2017; Scott, & Andritsos, 2023).

Ensuring the quality and safety of medical supplies during transportation is paramount in healthcare supply chain management. Drones equipped with advanced technology can monitor and track supplies, providing real-time information to warehouse management systems (WMS) (Garfield, Moore, & Adams, 2019). This capability enhances tracking precision, reduces errors, and improves overall supply chain efficiency. Furthermore, the use of drones can minimize risks associated with traditional delivery methods, such as road accidents and theft. These quality and safety benefits make drones a valuable asset in maintaining the integrity of medical supplies and improving patient safety (Garfield, et al., 2019; Rosser et al., 2018; Rao et al., (2024)). The cost-effectiveness and sustainability of healthcare supply chain operations are crucial considerations for healthcare organizations. Garcia (2013) suggests that drones can contribute to cost savings by reducing labour expenses, improving resource utilization, and optimizing inventory management. Additionally, the use of drones can minimize carbon emissions and environmental impact compared to traditional transportation methods. This information highlights the potential economic and environmental benefits of incorporating drones into healthcare supply chain management (Garcia, 2013; Scott, & Andritsos, 2023; Rao et al., (2024)). By leveraging this technology, healthcare organizations can enhance their ability to provide timely and effective healthcare services, particularly in remote and underserved areas.

III. Methods

This study adopts a quantitative research method, which offers a scientific and structured approach for data collection and analysis. It enables comprehensive insights from various stakeholders to address the research questions effectively (Creswell, 2017; Bryman, 2016; Creswell & Plano Clark, 2018; Teddlie & Tashakkori, 2009). The research design is structured to explore and quantify the impact of Unmanned Aerial Vehicles (UAVs) on healthcare logistics in Ghana. It provides a systematic framework for data collection, measurement, and analysis, ensuring the reliability and validity of the results (Creswell, 2017; Yin, 2018; Saunders et al., 2019). The population for this study includes healthcare facilities receiving drone deliveries, healthcare professionals (such as doctors, nurses, and pharmacists), and employees of Zipline Ghana Limited, the company responsible for drone delivery operations. These participants were selected from six Zipline distribution centers: Omenako, Mpanya, Vobsi, Sefwi Wiawso, Kete Krachi, and Anum. A sample size of 160 health professionals and Zipline staff was used to obtain relevant data. Purposive and snowball sampling techniques were employed to identify participants with specialized knowledge and experience in drone healthcare delivery. The data collection involved the use of Google Forms, with survey links distributed through email and shared on professional platforms by initial participants. Zipline also supported the distribution among its employees. This approach helped the researcher to overcome challenges in reaching targeted participants and to gather a broad and representative dataset.

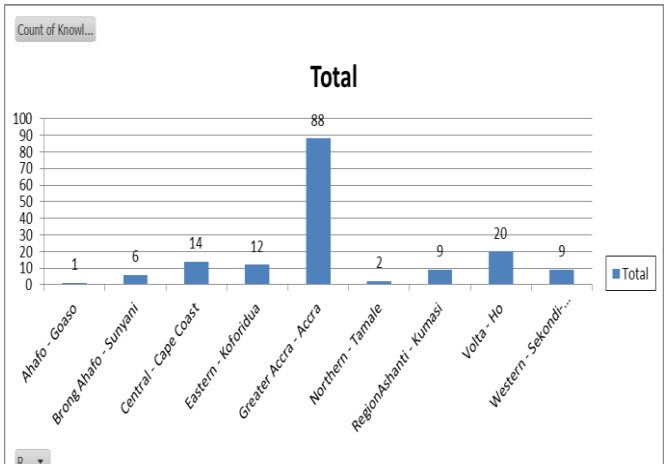
IV. RESULTS

Regional distribution of respondents

Figure 1 illustrates the regional distribution of respondents based on their place of work across different regions in Ghana. From the figure, the indication is that 1 respondent was from Ahafo-Goaso 1, Brong Ahafo – Sunyani 6, Central – Cape Coast 14, Eastern Region Koforidua 12, Greater Accra 88, Northern Region Temale 2, Ashanti Region – Kumasi 9, Volta Region – Ho 20, and Western Region 9. The total number of participants for this research was 161.

The Greater Accra region stands out as having the largest number of respondents, with nearly 88 participants. The region's significant representation reflects the central role of Accra as the nation's capital, home to numerous healthcare facilities and Zipline's drone delivery operations. Following Greater Accra, the Volta region (Ho - 20) shows the second-largest number of respondents, suggesting growing involvement in healthcare supply chains and technology-driven operations. Central Region (Cape Coast - 14) and Eastern (Koforidua - 12) regions both have a moderate number of respondents. Similarly, Western (Sekondi-Takoradi) and Ashanti (Kumasi) regions show moderate involvement, which be attributed to their regional healthcare networks and infrastructure. On the other hand, Brong Ahafo (Sunyani) and Northern (Tamale) regions have the lowest number of respondents, indicating that healthcare workers or facilities in these regions are less involved in UAV operations or related supply chain activities. The chart shows that respondents are heavily concentrated in Greater Accra, with varying levels of participation across other regions. The distribution highlights the centralization of healthcare services and UAV integration in Ghana, particularly in Accra .

Figure 1. Regional distribution of respondents



Perceptions of drone technology in healthcare, particularly in Ghana

Table 1, illustrates the correlation matrix, which provides insights into the relationships between various perceptions of drone technology in healthcare, particularly in Ghana.

There is a significant positive correlation ($r = 0.401$, $p < 0.001$) between personal knowledge of healthcare aerial delivery with drones and the belief that most healthcare practitioners have knowledge in this area. There is a negative correlation ($r = -0.210$, $p = 0.008$) between the belief that most healthcare practitioners have knowledge about aerial delivery and the perception that drone technology has no significant impact on healthcare services. The perception of public awareness of drone technology shows no significant correlation with the other variables except for a significant negative correlation with the impact of drone technology on healthcare ($r = -0.216$, $p = 0.006$). The results indicate a generally positive perception of drone technology in healthcare, particularly among those who are knowledgeable about it .

Table 1: Relationships between various perceptions of drone technology in healthcare, particularly in Ghana

Correlations

		How would you rate your knowledge of Healthcare aerial delivery with drones?	Most healthcare practitioners know healthcare aerial delivery with drones.	The general public is much more aware of drone technology.	Drone technology has a significant impact on healthcare services in Ghana	Drone Technology has no significant impact on healthcare services in Ghana
How would you rate your knowledge of Healthcare aerial delivery with drones?	Pearson Correlation		.401**	.116	.031	.018
	Sig. (2-tailed)		.000	.146	.694	.826
	N		161	160	160	160
Most healthcare practitioners know healthcare aerial delivery with drones.	Pearson Correlation	.401**		.104	.089	-.210**
	Sig. (2-tailed)	.000		.191	.261	.008
	N	161		160	160	160
The general public is much more aware of drone technology.	Pearson Correlation	.116	.104		-.216**	-.098
	Sig. (2-tailed)	.146	.191		.006	.217
	N	160	160		161	161
Drone technology has a significant healthcare services in Ghana	Pearson Correlation	.031	.089	-.216**		-.223**
	Sig. (2-tailed)	.694	.261	.006		.004
	N	160	160	161	161	161
Drone Technology has no significant impact on healthcare services in Ghana	Pearson Correlation	.018	-.210**	-.098	-.223**	1
	Sig. (2-tailed)	.826	.008	.217	.004	
	N	160	160	161	161	161

**. Correlation is significant at the 0.01 level (2-tailed).

Relationships surrounding drone technology in healthcare, particularly regarding its impact, perceived challenges, and opportunities

There is a significant negative correlation ($r = -0.223$, $p = 0.004$) between the perception that drone technology has a significant impact on healthcare services and the belief that it has no significant impact. The correlation between the belief in a significant impact on healthcare and challenges/barriers presented by drone technology is weak and not significant ($r = 0.063$, $p = 0.432$). The correlation between the significant impact of drone technology and its potential advantages is also weak and not significant ($r = -0.023$, $p = 0.769$). The data indicate that perceptions of the impact of drone technology on healthcare services in Ghana are largely independent of perceptions of barriers and opportunities. While there are significant negative correlations between the belief in significant impact and the belief in no significant impact, the other correlations reveal a lack of strong relationships.

Table 2. Relationships surrounding drone technology in healthcare, particularly regarding its impact, perceived challenges, and opportunities

Correlations

		Drone technology has a significant impact on healthcare services in Ghana	Drone Technology has no significant impact on healthcare services in Ghana	Healthcare aerial delivery with drone technology provides challenges or potential barriers.	I have had the opportunity to use, participate or observe the use of healthcare aerial delivery with drones.	Healthcare aerial delivery with drones technology provide great opportunity or advantages.
Drone technology has a significant impact on healthcare services in Ghana	Pearson Correlation	1	-.223**	.063	.042	-.023
	Sig. (2-tailed)		.004	.432	.601	.769
	N	161	161	160	159	160
Drone Technology has no significant impact on healthcare services in Ghana	Pearson Correlation	-.223**	1	.039	.107	-.141
	Sig. (2-tailed)	.004		.628	.180	.074
	N	161	161	160	159	160
Healthcare aerial delivery with drones' technology provides challenges or potential barriers.	Pearson Correlation	.063	.039	1	-.149	-.016
	Sig. (2-tailed)	.432	.628		.060	.836
	N	160	160	161	160	161
I have had the opportunity to use, participate or observe the use of healthcare aerial delivery with drones.	Pearson Correlation	.042	.107	-.149	1	-.063
	Sig. (2-tailed)	.601	.180	.060		.429
	N	159	159	160	160	160
Healthcare aerial delivery with drones' technology provide great opportunity or advantages.	Pearson Correlation	-.023	-.141	-.016	-.063	1
	Sig. (2-tailed)	.769	.074	.836	.429	
	N	160	160	161	160	161

**. Correlation is significant at the 0.01 level (2-tailed).

V. DISCUSSION

The findings contribute to the existing literature by providing insight into how knowledge and perceptions influence beliefs about drone technology in healthcare settings. For instance, the positive correlation between self-rated knowledge and the belief in healthcare practitioners' knowledge aligns with studies by Amukele et al. (2017), which highlight the importance of education and awareness among healthcare professionals regarding emerging technologies like drones. The expectation that knowledgeable practitioners would reject the notion of drones having no impact supports the findings of other studies that emphasize the role of healthcare provider education in the successful adoption of innovative solutions (Rosser et al., 2018). The lack of significant correlations between personal knowledge and perceptions of public awareness regarding drones is consistent with the observations made by Chang and Kim (2019), which suggest that while healthcare professionals

may possess knowledge about drone technology, this does not necessarily translate to an awareness of the public's understanding of the technology. Additionally, the negative correlation between the belief that the public is aware of drone technology and the perception of its significant impact may reflect a disconnect between public perception and the actual effectiveness of drone technology in healthcare, as noted by Wickramasinghe et al. (2020). The weak inverse relationship between the perceived impact of drones and the belief in barriers suggests that overcoming challenges associated with drone technology could be linked to greater acceptance of its benefits. The observation aligns with the literature indicating that addressing logistical and regulatory barriers can enhance the integration of drone technology in healthcare delivery (Rosser et al., 2018).

The lack of significant correlations between perceptions of impact and challenges echoes findings from Wickramasinghe et al. (2020), who noted that while healthcare professionals often recognize the benefits of innovative technologies like drones, they may not perceive and exposure, but these factors may not be strong enough to alter broader beliefs about its utility in healthcare. The findings align with Amukele et al. (2017), which indicated that drones have the potential to revolutionize healthcare delivery by improving access to essential medical supplies, especially in rural and hard-to-reach areas. The data supports the negative correlation observed, where individuals who view drones as impactful tend to disagree with the notion that they have no impact. The literature emphasizes that drones can offer unique solutions in healthcare logistics, ultimately saving lives and reducing delivery times for critical supplies. However, the perception that widening and improving healthcare aerial delivery with drones may enhance healthcare does not show a significant relationship with the belief that drones currently have a significant impact ($r = .075$, $p = .348$). The data reflect a more cautious view, as indicated in literature that points out the infrastructural, regulatory, and cost-related barriers limiting the widespread use of drones (Rosser et al., 2018). Such factors may temper the immediate perception of drones' impact, even as their potential is acknowledged.

Studies by Chang and Kim (2019) suggest that healthcare professionals' openness and positive attitudes toward new technologies, including drones, are crucial for successful implementation. The positive attitude may facilitate the adoption and expansion of drone technology, as noted in other settings where technology acceptance among healthcare workers is pivotal for innovation diffusion. Finally, the lack of a significant correlation between the perceived impact of drones and healthcare professionals' attitudes ($r = -.035$, $p = .663$) underscores insights from Wickramasinghe et al. (2020), which suggest that while professionals may have positive attitudes toward technology, these attitudes do not always translate into perceptions of immediate, significant impact. Structural, logistical, and policy constraints often influence how professionals view the efficacy and integration of such technologies into the healthcare system.

VI. CONCLUSION

The use of drones to improve the supply chain in health care services is very important. The importance of this system is marginalised due to a lack of awareness. Though there is no consensus that the impact of Unmanned Aerial Vehicle on health service may be significant, if the introduction is widened throughout the country this may impact positively on the health service delivery. Also, a large-scale education among professionals and the general public may improve the understanding of the concept, thereby enhancing the understanding and acceptance of UAVs among health practitioners.

While there is a significant belief in the potential of drone technology to improve healthcare, this belief does not necessarily correlate with perceptions of its current impact. However, positive attitudes among healthcare professionals do appear to play a crucial role in shaping perceptions of potential improvements, highlighting the importance of support and advocacy within the healthcare community..

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