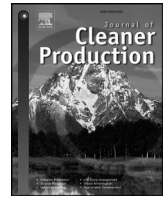




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Artificial intelligence (AI)-enhanced medical drones in the healthcare supply chain (HSC) for sustainability development: A case study

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ABSTRACT

Artificial Intelligence (AI) has attracted extant literature devoted to different subjects, including healthcare. AI studies within healthcare, however, have focused extensively on medical diagnosis, operations, and prescription, to the neglect of supply chain management (SCM). To bridge this research gap, we draw on corporate social responsibility (CSR) as a theoretical lens to explore how an AI-enhanced medical drone application in Ghana's healthcare supply chain (HSC) improves the HSC system and contributes to sustainable development. The data for this study is collated through documentary and an in-depth semi-structured interviews from the world's largest medical drone programme in Ghana. Findings indicate that an AI-enhanced medical drone application in HSC contributes significantly to the host country's HSC and sustainable development goals (SDGs) with particular emphasis on climate (SDGs 3, 8 & 13). The SDGs are achieved through the reduction of carbon emission with carbon and noise-free drones in the delivery of emergency medical products to healthcare centres. Furthermore, by adopting the use of medical drones in the HSC system, society's socio-economic situations are improved through the reduction of mortality rates and may lead to the provision of better social and economic lives for the citizenry. Moreover, the medical drones contribute to the long-term corporate sustainability of the implementing firm.

1. Introduction

Extensive evidence suggests that investment in artificial intelligence technology (AIT) is going to be the solution to sustaining development (SD) worldwide, as it is an important driver of productivity and economic growth (Lega et al., 2013; Moskwa, 2016). For instance, a recent report shows that the sustainability of the US economy and national security hinges on AIT (science and technology report, February 2019)¹; hence, to a large extent, many countries' sustainable development prospects could be tied to AIT investment.

Furthermore, existing evidence suggests that organisations are now positioning themselves to respond to institutional pressures from AIT investment prioritisation (Rakovska and Stratieva, 2018). The urgent drive to invest in AIT, mainly through firms could be motivated by an agency theory perspective – the control of markets through accurate positioning for efficiency (Jensen, 1986) and the extension of firms'

capabilities in an incremental manner (Chang, 1996). This suggests that AIT will continue to be trendy in the coming years, since it offers a competitive advantage within the marketplace and for government institutions pursuing efficiency and SD. Consequently, the AIT investment trend is attracting fast-paced growing attention among the media, organisations, and academics (Lega et al., 2013; PwC, 2018; Rakovska and Stratieva, 2018).

Therefore, it is not surprising that the past two decades have witnessed a significant rise in AIT applications in human endeavours. One prominent area of AI application is within healthcare delivery systems (Ramesh et al., 2016; Hassanzadeh et al., 2019; Jemai et al., 2020), where AI is transforming the sector (PwC, 2018). As a result, extensive studies have been devoted to the discussion of AIT and healthcare delivery; however, the growing literature in this area, indicates that researchers have focused extensively on managing healthcare database, medical diagnosis, operations, and prescriptions (Shiraishi et al., 2011

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¹ <https://www.whitehouse.gov/articles/accelerating-americas-leadership-in-artificial-intelligence/>.

Hamet and Tremblay, 2017; Mavrogiorgou et al., 2019) to the neglect of SCM – an important element in the healthcare delivery. This study bridges this knowledge gap by focusing on the SCM.

Adopting AIT in the HSC system is considered a sure way forward in enhancing efficiency in the supply chain network of medical supplies (Zhang et al., 2017; Klumpp, 2018). An important argument put forth by Lega et al. (2013) is that technology application (such as AI) in supply chain network improves supply chain efficiency by reducing cost and waste. Similarly, Rakovska and Stratieva (2018) argue that AI application in the supply chain system (SCS) improves the structure by facilitating the SC system. Based on the important role that AIT plays in SCM, the present research assesses how an AI-enhanced medical drone application in healthcare SCS impacts sustainable development (SD). We use a medical drone as an example of AI because drones, which are also known as Unmanned Aerial Vehicles, use high levels of AI applications (Giones and Brem, 2017; Mairaj et al., 2019), and as such, offer a classic example of the application of AI in human activities.

We also focus on how medical drone usage in the HSC impacts SD, which is described as development that meets the present, and future generational needs (Petrikova, 2014; Hummel and Argyrou, 2021). This being because drones offer an opportunity to empower citizens to develop and improve their lives and the environment.

We draw on the world's most extensive and significant national medical drone programme, which is in Ghana (Bright, 2019; Lamptey and Serwaa, 2020), as a case study to explore the impact of medical drones in a HSC system geared towards SD. Being the largest and most extensive commercial medical drone programme at a national scale means that it also offers an excellent empirical context from which findings could be used to understand similar programmes in the future.

Our findings indicate that an AI-enhanced medical drone application in HSC contributes significantly to the host country's HSC and sustainable development goals (SDGs) with particular emphasis on climate (SDGs 3, 8 & 13). The SDGs are achieved through the reduction of carbon emission with carbon and noise-free drones in the delivery of emergency medical products to healthcare centres. Furthermore, by adopting the use of medical drones in the HSC system, society's socio-economic situations are improved through the reduction of mortality rates and may lead to the provision of better social and economic lives for the citizenry. Moreover, the medical drones contribute to the long-term corporate sustainability of the implementing firm.

This research contributes to AI, HSC and SDGs in several ways. First, the findings show that contrary to the views held by researchers which suggest that cutting-edge technologies (such as AI) are inappropriate in developing countries due to the infrastructural deficit (Eckaus, 1987; Kaplinsky, 2011), the medical drones that operate with high levels of AI technology are appropriate and applicable in developing country context.

Second, unlike prior studies on AI application in healthcare delivery that focused on medical diagnosis, prescriptions, and operations (Shiraishi et al., 2011; Fazal et al., 2018; Hassanzadeh et al., 2019), this study, for the first time, focused on SCM. Therefore, providing an important dimension to the AI debate in the context of healthcare delivery.

Third, by exploring how AI-enhanced medical drone applications contribute to SDGs, we contribute to the opening of the “black box” of AI (Desouza et al., 2017) in the context of healthcare supply chain management and sustainable development. This will deepen our understanding of the critical role that an AI-enhanced medical drones plays in contributing to numbers 3, 8 and 13 of UN's SDGs.

Fourth, in the wake of the practitioners and researchers (Lega et al., 2013; Rakovska and Stratieva, 2018) calls for the adoption of cutting-edge technology in SC to improve SC systems, this study shows that AI-enhanced medical drones could be one of the solutions to this call.

Finally, the study proves that policymakers around the world would be assured that AI is a worthy cause in supporting the United Nations

(UN) SDGs (Lamichhane et al., 2020) with reference to the numbers 3 (good health and well-being) and 13 (climate action) of the goals.

The remainder of the paper is presented as follows: the next section outlines the study's conceptual foundation. Section three, then, discusses the theoretical framework underpinning the study, whilst sections four and five present the research methodology, results, and discussions. The study's conclusions are drawn in the final section through a summary of the findings, implications, contributions, limitations, and future research suggestions.

2. Conceptual foundation

2.1. Artificial intelligence: definition, history, progress and applications

Artificial Intelligence (AI) is defined as “a system's ability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation” (Kaplan and Haenlein, 2019, 17). Fazal et al. (2018, 246) defined AI as an artificial entity capable of solving problems and learning solutions for new problems.’’ In the main, AI is the ability of machines to carry out tasks by displaying intelligent, human-like behaviour and the ability of machines to behave rationally by observing their environment in order to take actions to achieve sets of objectives (Min, 2010; Russell and Norvig, 2016; Candi and Beltagui, 2019).

AIT is generally accepted as having started with the invention of robots. The term “artificial intelligence” is derived from the Czech word *robota*, meaning biosynthetic machines used as forced labour (Hamet and Tremblay, 2017). Historically, the application of AIT in human activities has been mixed. Some authors trace it to the 15th century (Moran (2006)), while others trace it to the middle of the 20th century (Russell and Norvig, 2009); however, modern-day AI was born in 1956, when researchers and students from Dartmouth College, launched AI at a conference (McCorduck, 2004).

From the 1990s to date, there has been a surge in AI research, adoption, and application in several human activities (Dirican, 2015; Chui, 2017). One area in which the application of AI has increased is in drone usage. There has been a continuous surge in drone usage in human activities (including with medical drones) over the past decade, increasing drones economic market value significantly to the extent that its commercial value is estimated to rise from \$2 to \$127 billion between 2016 and 2020 (Moskwa, 2016). Hence, this speaks to the need for a study into how medical drones improve HSC networks and their impact on sustainable development.

2.2. When AI technology meets supply chain system

Since the inception and popularisation of SCM, it has often been described as planning and controlling the materials, information, cash flows, and logistics activities in an industry (Cooper et al., 1997; Chen et al., 2019). The SCM activities involve several systems categorised into three main areas – manual, semi-manual and technology-based. However, recent advances in technology and the need to be efficient and environmentally friendly has seen a considerable shift away from (semi-) manual systems to advanced technology-based systems (Feng et al., 2018; Rakovska and Stratieva, 2018) to the extent that authors perceive technology-enhanced SCSs such as AI as the only way to ensure environmental sustainability (Klumpp, 2018; Jemai et al., 2020).

In response, several organisations are adopting diverse AIT into their scheme of SCS (Klumpp, 2018; Wang et al., 2019; Jemai et al., 2020). Though AI in SCS is gradually gaining ground, researchers have not paid attention to how this contributes to SD. Hence, exploring this subject area will inform host countries' recognition of the vital role that AIT adoption in healthcare SC offers to their sustainable development goals (SDGs) and the World's SDGs in general.

2.3. Sustainable development (SD): socio-economic and environmental sustainability nexus

SD has become a significant discussion point among world leaders, especially in the last decade, due to the growing disparities in nations' development. Some academics have predicted that sustainability will continue to be a top concern for managers and organisations worldwide (Jerónimo et al., 2019). To the extent that environmental legislation and social pressure groups are now compelling organisations to adopt policies and practices that effectively improve the economic, social, and environmental pillars of sustainability (Jerónimo et al., 2019). Consequently, governments, organisations and institutions around the globe have devised strategies for addressing sustainable development concerns (Hummel and Argyrou, 2021). Notable among them, in recent years, are the SDGs set out by world leaders at the United Nations in 2017 (UN, 2017; Lamichhane et al., 2020).

The goals for SD are multi-faceted and spread across many spheres of human life (Cobbinah et al., 2015; Moore, 2015), including within developing countries (see Karuppiyah et al., 2021). The ultimate purpose of SD is to improve humanity's socio-economic well-being by creating a conducive environment for citizens to develop their full potential and, thus, live productive lives (Moore, 2015). It encompasses an integrated and somewhat intertwined development goal such as protecting the natural environment, promoting education, production, consumption and the well-being of citizens (Addison et al., 2015; Coscieme et al., 2021). Accordingly, sustainable organisational and operational activities are characterised by environmental, social, and economic objectives (Longoni et al., 2019). This implies that SD can be approached from different perspectives depending on the SD agenda focus being pursued (Herath, 2009; Pritchett and Kenny, 2013; Cobbinah et al., 2015). Drawing on the SD concept, we draw on corporate social responsibility (CSR) as the theoretical lens for explaining how AIT adoption in healthcare SCS contributes to SD.

3. Theoretical foundation

The concept of CSR has received divergent views from authors, including Davis (1973), who describes CSR as the firm's consideration of, and response to, issues beyond the narrow economic, technical, and legal requirements of the firm to accomplish social and environmental benefits along with the traditional economic gains and to balance the needs and concerns of various stakeholders fairly. Linking CSR to SD, Watts and Holme (1999) describe CSR as corporate commitment to sustainable economic development, employees and their families, and also to local communities.

Traditionally, CSR is supposed to be voluntary but in recent years, CSR is no longer about volunteerism. It is rather tied to plans to augment a firm's economic prospects. The paradigm shift is premised on the notion that "real" CSR is intended to make profit for shareholders. As such, the suggestion that firms should focus on the society, where they operate, threatens, and weakens the fundamental principles of free enterprise and capitalist ideologies (Chang et al., 2017). Furthermore, opponents of volunteerism of CSR argue that if society deteriorates, an important structure that supports the firm's activities will also deteriorate and that will negatively impact the firm's sustainability (Lee, 2008). This implies that supporting society's well-being is as important as supporting the firm's long-term objectives, existence, and economic prospects (Baumol et al., 1970).

CSR's contrasting views suggest that CSR means different things to corporate managers (Dahlsrud, 2008). Empirical evidence suggests that there is a relationship between CSR and the economic performance of firms (Orlitzky et al., 2003; Tan et al., 2015) and as such, CSR should not only be viewed from just the voluntary perspective but also as a form of corporate well-being for the firm, thus, affecting the long-term objective of the corporation. Nevertheless, the central theme that runs through CSR is that corporations are supposed to bear responsibility for their

impact on stakeholders associated with their activities. Based on the above evidence, we argue that the introduction of medical drones impacts the socio-economic and environmental SD goals for local communities, plus the corporate sustainability of the implementing firm.

4. Methodology

4.1. The case study

The Ghanaian medical drone programme was launched in April 2019, to supplement the existing SCS within the public sector healthcare delivery system (Nyantakyi, 2019). The purpose was to supply emergency and essential medical supplies to healthcare centres across the country (Sigal, 2019). Specifically, the medical drone programme is expected to distribute vaccines, blood, and lifesaving medical supplies to ensure a reduction in death rates relating to childbirth, accidents, and snakebites (Asiedu, 2019). The company executing the medical drone programme is Zipline, a San Francisco-based robotics manufacturer and logistics service provider (Bright, 2019). It is expected that Zipline will do 600 flights a day using four distribution centres across the country (Bright, 2019; The Guardian UK, 2019).

The operations of the drone programme involve several sets of stakeholders, such as healthcare workers and drone operators. The implementation process starts when a healthcare practitioner (e.g., a nurse, doctor, or administrator) places an order using a mobile phone to send a text message to the drone distribution centre, where the designated medical supplies are kept in an ultra-modern storage facility (Nuki, 2018). The requested supplies are then packed into a padded box with a parachute. The box is then given to a drone flight operator, who then fixes it beneath the drone. The flight operator then sets it up, ready to fly when aviation clearance is given. After that, a mobile phone with an app releases the drone to fly to its destination using a military-grade global positioning system (GPS) to navigate along a pre-programmed route at a maximum speed of 75mph (Nuki, 2018).

Approximately 5 min to the drone's destination, a text message is sent from the distribution centre to the receiving healthcare centre. The message directs the healthcare practitioner to move to the location where the supplies will be made. The drone uses onboard sensors to measure the wind's speed and direction to determine the best location for the drop off, before spiralling down to an altitude of 20 ft to release the supplies (Nuki, 2018). When the drone returns to its point of departure, it lowers a hook that clasps onto a cable that drags it down to earth, back onto an inflatable landing pad, in a technique often described as "aircraft carrier meets bouncy castle" (Nuki, 2018). Fig. 1 depicts the actions and key actors participating in this SC.

4.2. Data collection and analysis

Employing both documentary and in-depth semi-structured interview methods, qualitative data was collected from four sets of definitive stakeholders (Mitchell et al., 1997), who were directly involved in the medical drone programme; in particular, from the Ministry of Health, Zipline Ghana, healthcare workers and beneficiaries (including their family members). Hence, this study's philosophical foundation is based on the interpretive domain, which is a philosophical position enshrined in interpreting social roles and actor interaction in the world, as well as their meaning (Saunders et al., 2015; Bryman and Bell, 2015). This philosophical position evades unyielding structural frameworks by adopting a flexible research structure that offers a rigorous approach for capturing enough information through interaction (Bryman, 2015).

Purposive sampling was used to select 17 informants (see Table 1 for a complete breakdown). The purposive sampling technique was used because the target audience could be identified with a specific organisation or government agencies (Bryman, 2012; Saunders et al., 2012, 2015) and therefore, could offer illuminating information (Patton, 2002). The participant number was reached through a saturation point,

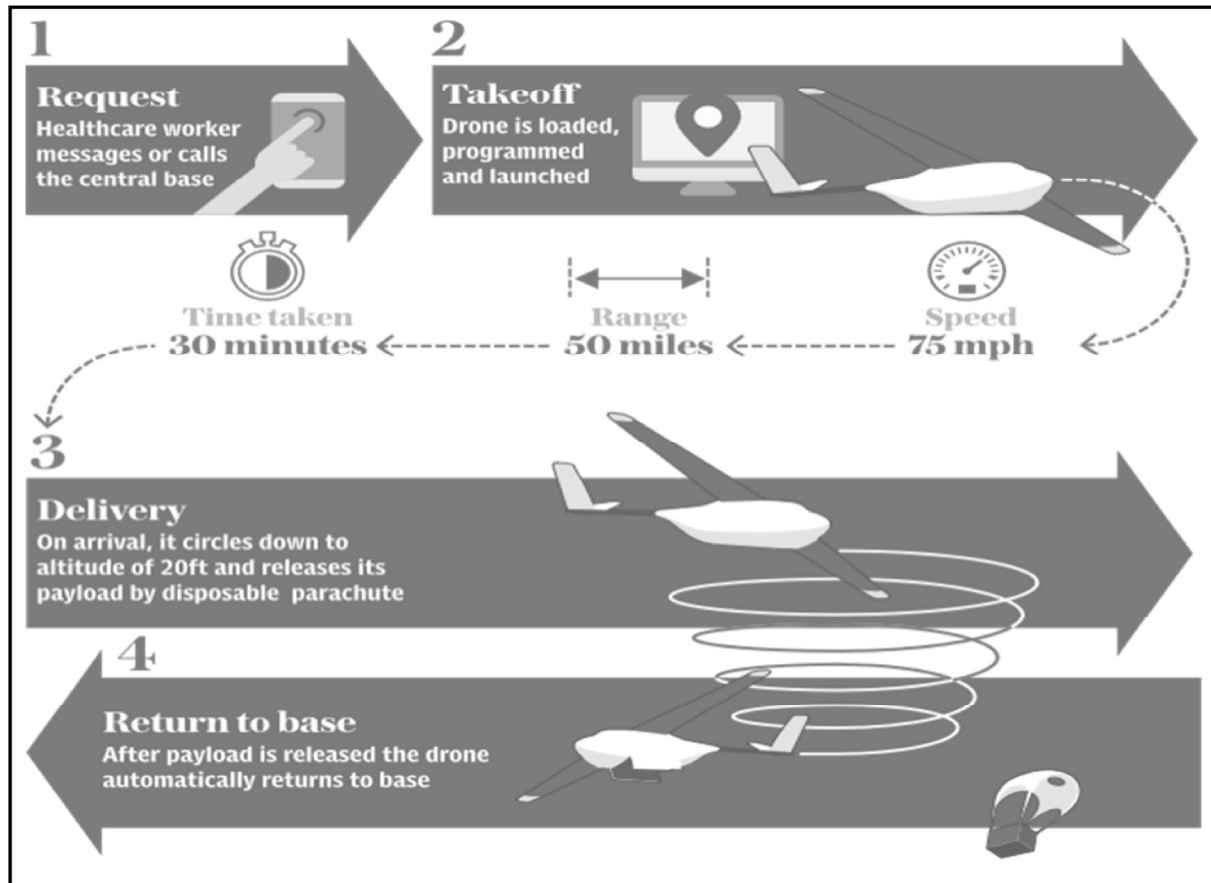


Fig. 1. Operations of drones in medical supplies in Ghana.

Source: Nuki (2018).

with no more emerging information (Morse, 2000; Guest et al., 2006; Silverman, 2013).

Three steps were taken to improve on the data validity: (1) the researchers reviewed the interview question guide several times; (2) the question guide was given to two professors, with a minimum of 15 years of semi-structured interviews usage experience, to review; and (3) the questions were piloted with four participants (one from each set of participating sample groups). Through these various stages, their feedback helped in revising the questions.

Several protocols were followed in the data collection processes, including visits, emails, and phone calls to the participating organisation and agencies. Each interview followed a pre-booking with individuals for a session at their time of convenience. This helped in the creation of a cordial relationship during the interview. The interviews were conducted using various forms, including face-to-face, Zoom on the phone and Skype. They lasted between 13 and 95 min and were conducted by either a professional survey enumerator or one of the researchers. All interviews were either audio recorded only, or audio recorded alongside note-taking. The interviews took place between July to November 2019. Each interview was structured so that the most important questions were asked first. This allowed us to ask probing questions for further elaboration. Upon the interviewees' request, the transcribed data for each interview was sent to its interviewee for review. Based on this, a few additions were made to the data.

The data was analysed using a thematic and inductive approach by adopting the six-staged steps prescribed by Braun and Clarke (2012). The following was observed: First, we familiarised ourselves with the data after transcription and before coding. Second, we uploaded the data into NVivo software for analysis by looking for patterns, as shown in Fig. 2. Third, we identified initial codes by reading through the text line

by line. Themes emerged by the placing of similar codes together into patterns. We did this by highlighting the keywords and phrases revealed by the informants. The fourth phase involved ensuring coherency in the data patterns that fall under each theme. To do this, the researchers reviewed the coded themes severally (Miles and Huberman, 1994). The fifth phase was the mapping of the themes through a "thematic map". This helped the researchers to identify any relationship(s) that exists between the coded themes. The penultimate phase captures the essence of what each theme indicates and decides if any of the themes fit into the overall narrative, including how AIT adoption in healthcare SC impacts SD.

5. Results and discussions

5.1. The medical drone and sustainable development

5.1.1. Socio-economic sustainability

The findings suggest a direct link between social and economic sustainable development and, therefore, these are discussed together. The findings reveal that the medical drone project contributes significantly by saving many lives (ZL1, ZL2, MoH3, HCW1-3, MoH1, MoH2). This is because, since the medical drone's introduction into the SCS in the supply of essential and emergency supplies, requests have been successfully delivered on time, thereby allowing healthcare practitioners to use the supplies on their patients promptly (ZL1, ZL2; HCW4-7). The policy adviser and the public relations officer for the Ministry of Health (MoH1) state that the success and gains from the medical drone programme are that of saving lives and offering sustained support to the livelihood of the ordinary Ghanaian. In addition, ZL2 - aZipline staff member - says:

Table 1
In-depth semi-structured interview respondents' profile.

Organisation/Institution	Informant code	Interview minutes	Interview number
MINISTRY of HEALTH (MoH)	MoH1	45	1
	MoH2	70	1
	MoH3	36	1
	MoH4	30	1
	MoH5	22	1
GHANA HEALTH SERVICE (GHS)	GHS1	95	1
	GHS2	47	1
	GHS3	30	1
	GHS4	25	1
ZIPLINE-GHANA (ZL)	ZL1	65	1
	ZL2	55	1
	ZL3	33	1
	ZL4	25	1
	ZL5	25	1
	ZL6	39	1
	ZL7	20	1
HEALTHCARE WORKERS (HCW)	HCW1	60	1
	HCW2	55	1
	HCW3	70	1
	HCW4	45	1
	HCW5	15	1
	HCW6	22	1
	HCW7	38	1
	HCW8	25	1
	HCW9	27	1
	HCW10	24	1
	HCW11	30	1
	HCW12	35	1
BENEFICIARIES AND FAMILIES (BF)	BF1	35	1
	BF2	28	1
	BF3	15	1
	BF4	25	1
	BF5	13	1
Total			32

Since our launch, we have done over 1000 flights and supplied over 5000 essential various medical supplies. We have had no accidents or problems so far; so, I can say that it has been a success. For the impact, let me start by saying that the government does public policy to improve everybody's lives. That is the essence of governance. So [the drone] is just bringing speed, reliability, and time supplies, and it is only used for essential communities. Yes! We can link very remote communities by providing some emergency supplies, which transform the people's lives. I am excited when I hear the testimonies on YouTube and other social media platforms.

A female ex-patient (BF2), who was interviewed, expresses gratitude to the implementing stakeholders and so states: 'my very existence depended on the medical drone's timely delivery of blood when I was in labour'. HCW2, a healthcare worker, reiterates this point by saying:

There is no price put on the life of a human being ... So that if somebody has flu or a woman has given birth. She is bleeding and in the blink of death, and immediately we [healthcare workers] know that medicines can be made available within a few minutes to save that life. The returns that come to society is enormous [And] ... when medicines are needed in emergencies such as accidents or snake bites in the remotest areas where it can take more than a day to transport [using cars] to these areas; that is when you realise the importance of the [drone] project to the saving of human life.

GHS1 adds:

Medical drones were introduced to complement the medical supply chain system to act more quickly during emergencies, like accidents and surgery. The drone project is precisely delivering that; (resolving emergencies). I will urge you and other academics, and the media to talk positively about this scheme. I feel proud of being associated

with this project as one of the main drivers of the scheme. My team here (GHS) are happy and proud about it [drone].

Not surprisingly, a Ministry of Health representative (MoH2) highlights:

Since the drone project was introduced, we (ministry) have received many positive responses on how lives are being saved, ...I think this is impacting the lives of every Ghanaian. We are very happy about such responses. It means we have done something good, and as you asked, this impacts the lives of ordinary people. (MoH2).

Similarly, also from the Ministry of Health, MoH1 reiterates:

The government is committed to saving lives. The [medical supplies] shortages at the medical store had to be addressed. [and] we have successfully launched and operationalised the drone project. I think Ghana is the winner when it comes to the impact. The stories from people whose lives have been influenced [impacted positively] by the drone project speak volumes of the project's impact on their lives. We have cases of infant mortality, maternal mortality, among others ... they didn't die to contribute to the country and the community they come from.

The president of Ghana, Nana Akufo-Addo, also states that "No one in Ghana should die because they can't access the medicine they need in an emergency," and "That is why Ghana is launching the world's largest drone delivery service a major step towards giving everyone in the country universal access to lifesaving medicine" (as cited by Bright, 2019, 1).

Furthermore, the findings show that saving time by delivering medical supplies on time, eases congestion at the larger hospitals and enables the small clinics and medical centres to operate correctly. Respondents, thus, tell us that referrals to teaching hospitals in the cities have been reduced drastically (HCW1-5; GHS1-2). This point is further elucidated by a Zipline respondent, ZL1, who says:

The smaller hospitals and clinics refer some patients ... and this is because smaller healthcare facilities do not have the drug they need [to treat the patients]. So, now that the medial drone has been introduced, overcrowding at the more prominent hospitals such as 37 [military hospital] has been reduced to a more considerable extent. There is no need to refer someone to Accra [capital city] because there is no blood at Tafo [small village].

This finding also has economic implications, since staff hours are not being lost by the use of vehicles that take longer (i.e., hours and days) to deliver essential and emergency supplies. ZL3, buttress this by adding:

... if you have a place like Ekyi Amanfrom, which is beyond the Afram Plains, which takes longer to reach there, the drones can reach there in less than 30 minutes. Let us say if you are travelling from here [Accra] to Ekyi Amanfrom, just in this scenario you are going to spend four and a half hours Yea!

The timely supply of essential medical needs at medical centres reduces anxiety among healthcare professionals directly treating patients. It is why one healthcare worker says, "For us, the doctors and nurses, we deal directly with patients, so when we need essential supplies, and we do not get it to save a life, we are anxious" (HCW4). With the introduction of the medical drone, healthcare professionals can call the centres to distribute critical medical supplies quickly. "So, when the blood type wanted was confirmed sent through the drone, it was reassuring, and we were very hopeful the baby will survive" (HCW6). Indeed, participants believe that the situation is motivating, and it also provides job satisfaction (HCW6-7). Similarly, patients and their families, for fear of not getting adequate medical treatment, commute for long distances to other hospitals outside their regions. The participants argue that there are intangible costs associated with seeking medical

Nodes					
Name	Sources	References	Created On	Created By	
Sustainability of medical drones	3	3	26/12/2019 05:34	AA	
Socio-economic Sustainability	3	3	26/12/2019 05:41	AA	
Employment of Ghanaians	4	4	26/12/2019 05:43	AA	
Skilled expert from Ghana	5	5	26/12/2019 06:25	AA	
Trained and retraining of medical personnel	4	4	26/12/2019 06:26	AA	
Cost reduction Method	4	4	26/12/2019 05:52	AA	
Reduced cost of transport	4	4	26/12/2019 06:23	AA	
Risk of commuting	5	5	26/12/2019 06:24	AA	
Community ownership	3	3	26/12/2019 05:55	AA	
Chiefs and people durba	4	4	26/12/2019 06:03	AA	
Community level labour	4	4	26/12/2019 06:05	AA	
Integrating drone into medical Supplychain	5	5	26/12/2019 05:56	AA	
cooperation by stakeholders	3	3	26/12/2019 06:34	AA	
Continous sensitisation and education	3	3	26/12/2019 05:58	AA	
Platform for communication	5	5	26/12/2019 06:08	AA	
Bipartisan approach	3	3	26/12/2019 06:11	AA	
Environmental sustainability	4	4	26/12/2019 05:42	AA	
Pollution	5	5	26/12/2019 05:51	AA	
Air pollution CO2 effects	5	6	26/12/2019 06:37	AA	
Sustained Green cover	5	5	26/12/2019 06:00	AA	
Minimal distruction on vegetation	5	6	26/12/2019 06:44	AA	

Fig. 2. Snapshot of Nvivo analysis.

care in other regions, thus, increasing overall frustration (BF1, BF2).

As stated by van Marrewijk and Were (2003), Artiach et al. (2010) and Chang et al. (2017), this offers social empowerment to not only those who are benefiting from the medical drones but also the confidence that non-beneficiaries have in going about their business, knowing that they have the backing of quick emergency supplies when needed. Here, CSR's aspects of empowering the societal subject to improve their lives are evident (Watts and Holme, 1999); and contribute to decent work and economic growth of society enshrined in the SDG number 8 (UN, 2017).

An essential economic SD finding revealed by informants is cost reduction. However, they relate cost reduction to a series of factors. These are non-overstocking, timely delivery of medical supplies, wastage reduction, and reduced overhead costs associated with traditional delivery of medical supplies. For instance, GHS2 - a representative of the Ghana Health Service - asserts that there is a drastic reduction in stock wastage due to expiration. In particular, he says,

You realise that they do not want to run out of stock because of the product going bad. [But] now that they know they have Zipline service, they order just enough because they know that even if they run out of a product, Zipline can supply them until their standard supply comes in. So, they end up not overstocking product. This reduces the overall wastage within the health care system and saves the government money. (GHS2).

Moreover, cost reduction is regarded as crucial economic sustainability for the government and patients (BF1, BF2, MOH2). Ministry of Health representative, MOH2, says:

Overall, the drone helps reduce healthcare costs in the country and, to a more considerable extent, impacts positively on the country's government budget and economic prospects in the long term. People [citizens] do not recognise the overall impact of the (medical) drones on the country's development. If it is sustained for the long-term, I believe it will impact long-term sustainable development.

Another Ministry of Health staff member, MoH1, says that the success and gains from the medical drone programme saves lives and offers sustainable support to the livelihood of the ordinary Ghanaian, in the context of employment. This can be evidenced by how the medical drone programme recruits and assembles a range of personnel, comprising of a diverse calibre of professionals ranging from field engineers to auxiliary staff. Another Ministry of Health representative, MoH3, echoes this view by stating that:

Economically, I think that it [medical drone] has also helped in employing some of our Ghanaian trained engineers, pharmacists and other paramedical staff, including some local people in the [local] community [where healthcare centres are located]. So, economically, I think it is benefitting the nation Ghanaians entirely run the two centres that are in operation with the support of few Rwandans; they have been trained to do the work, and they are doing it excellently.

Furthermore, respondents believe that employment creation by Zipline Ghana will provide sustainable economic development to the citizens employed by Zipline and the overall economic sustainability of the country. This view is premised on the taxation of workers and the trickle-down effects of employment on the programme's employees and

their immediate family. More specifically, a Zipline employee says:

The economic benefits of sustainable development are many, and I think they are like a vicious cycle. If you employ Mr A, the government will tax him. He will also help his family. As you know, this is Africa and that we help each other, so the effects of employment cannot be easily quantified to the employees alone. (ZL2).

Closely related to employment is knowledge transfer, which was started by all the stakeholder group interviewed. Thus, through the medical drones' activities, employees are empowered as they gain soft and hard skills that can be employed in their lives, for both present and future needs of the individual and the society (Petrikova, 2014). Staff from the agencies and organisations, participating in the drone programme, were either sent to the USA or Rwanda to learn the technology and its operation (MoH1, MoH2, MoH3, ZL1, ZL2). The desire was to transfer critical new knowledge from abroad to the programme participants, thus, ensuring that the Ghanaian medical drone services are self-sustaining (MoH2). A Zipline representative, ZL1, explains it as such:

Shortlisted staff were intensively trained for a more extended period before starting the test runs in the two main centres currently operating. We wanted to minimise errors within our operations' timelines; now, these trained persons run the entire medical drone system.

These findings indicate that AIT adoption can unlock economic potential and offer more sustainable economic development to the locals (Baumol et al., 1970; Horváthová, 2010; Tan et al., 2015). By consciously employing locals in medical drone activities, it fulfils the firm's contribution to society's sustainable development (Dahlsrud, 2008) in the context of economic development (Coscime et al., 2021). This may contribute to SDG number 8 (decent work and economic growth) (UN, 2017). This may also impact the participating government agencies and Zipline corporate performance (Orlitzky et al., 2003; Tan et al., 2015).

5.1.2. Environmental sustainability

Apart from the beneficiaries and their families, other participants indicated that the medical drone is environmentally friendly. Three critical areas of environmental sustainability were cited as follows: the reduction of air and noise pollution, as well as carbon emission, plus a reduction in other forms of traditional transportation available to medical SC. In the words of MoH3, a Ministry of Health staff member:

The [medical] drones do not pollute the air ... because it does not use fuel. It uses batteries, and these are pollution-free. I understand that we have not substituted the traditional supply chain system with the [medical] drones. Still, in one way or the other, it is contributing to the reduction of air pollution. This is because the journeys that cars or motorcycles would have gone taking hours, thereby using a lot of fuel, are now being supplied by the drones that use batteries. You might think it's insignificant on a facial value, but I can tell you that it is significant. Assuming every country is doing something similar (reducing air pollution), don't you think global warming problems would have reduced significantly?

Available evidence suggests that rapid industrialisation has resulted in excessive resource exploitation, manifested as a loss of biodiversity, air and water pollution, and resource depletion (Du and Li, 2020; Karupiah et al., 2021). Accordingly, the use of the medical drone in HSC in Ghana does may not only contribute to the reduction of environmental degradation of Ghana, but also the reduction of the ozone depletion in general. Hence, it contributes to environmental sustainability echoed in number 13 (climate action) of UN's SDGs (UN, 2017; Coscime et al., 2021).

Furthermore, a respondent from Zipline states that "the drone's

design is such that they emit a very minimal sound when they are in mid-air and may pass without notice compared to ambulances and other medical supply vehicles currently in the supply chain." (ZL1). Another Zipline representative, ZL3, adds that "the drones currently used in Ghana differ slightly from that of Rwanda [in that] they [the Ghanaian ones] produce minimal sound when even closer [to you]".

Lastly, running on batteries means that carbon emission is reduced drastically, if not avoided altogether. Zipline and GHS respondents believe that medical drones contribute to reducing carbon emissions, not only in the country but worldwide. As a Ghana Health Service representative GHS1 opines:

We [Ghana] are contributing significantly to the reduction of carbon emissions affecting the ozone layer. I believe you are aware that the world's leaders have been meeting over the years to find solutions to global warming affecting the World. There are increasing flooding and droughts around the World, which is why world leaders have been campaigning and making efforts to reduce carbon emissions, so this [medical drone] is our contribution to this call.

This finding implies that adopting green, sustainable, cutting-edge technology like AI-enhanced medical drones in the healthcare SC, impacts the fight against global warming and improves healthcare delivery.

6. Conclusions

Considering the importance of investing in cutting-edge technologies, AI is viewed as driving future industries' creation. Consequently, firms and governments worldwide have made significant efforts to invest in AI; hence, attracting extant literature to its discussions - including on healthcare delivery. The literature on healthcare delivery, however, has focused extensively on medical diagnosis, operations, and prescriptions (Shiraishi et al., 2011; Hamet and Tremblay, 2017), to the neglect of SCM. To bridge this research gap, this study explored how AI-enhanced medical drones' adoption in healthcare SC improves not only the SC of healthcare delivery but also contributes to SD.

The findings indicate that AI-enhanced medical drone application in HSC contributes significantly to the host country's HSC and SDGs by reducing carbon emission with carbon and noise-free drones in the delivery of emergency medical products to healthcare centres. Furthermore, the findings show that by adopting the medical drones in the medical SC system, society's socio-economic situations are improved by reducing the mortality rate and by providing better social and economic lives for the beneficiaries.

Drawing on the findings, it can be argued that the introduction of AIT in the form of the medical drone system, with the existing SC structure, is an action that meets present and future generation needs not only in cities and towns but also in remote rural communities. The evidence of success of medical drone adoption in healthcare SCS in Ghana indicates that cutting-edge technology such as AI is appropriate to SC networks and appropriate in developing countries. This contradicts with existing literature, which posits that advanced technologies are inappropriate in developing countries, due to infrastructural deficits (Emmanuel, 1982; Eckaus, 1987; Kaplinsky, 2011). The results indicates that the environment needed to implement technologies in developing countries are changing. This suggests that the West can also learn from the global south when it comes to technology transfers. On the backdrop of this, it is suggested that developing countries such as those in Africa should take the lead in the implementation of cutting-edge technologies, as this will impact on their efforts towards the achievement of their number 3 and 13 of UN's SDGs.

In the main, providing medical drones that are environmentally friendly, may not only improve on the host country and the world's environmental SDGs, but may also improve the socio-economic conditions of the employees and beneficiaries (Moore, 2015); which also

contributes to the long-term corporate sustainability of the implementing firm (Artiach et al., 2010; Chang et al., 2017).

6.1. Limitations and future research

The main caveat of this research is the use of an in-depth semi-structured interview to solicit informants' views, which implies that our findings may only be valid if their views are correct and well-informed. Nevertheless, we do not have any reason to doubt informants' views since they are the definitive stakeholders directly involved in the medical drone programme. Furthermore, care needs to be taken to generalise the findings since this study used a case study. However, this offers a critical exploratory study that can be used as the basis for further studies. Further quantitative work comparing pre-and post-medical drone healthcare delivery performance would be needed when the programme has lasted for many years.

Declaration of competing interest

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

References

- Artiach, T., Lee, D., Nelson, D., Walker, J., 2010. The determinants of corporate sustainability performance. *Account. Finance* 50 (1), 31–51.
- Addison, T., Niño-Zarazúa, M., Tarp, F., 2015. Aid, social policy and development. *J. Int. Dev.* 27 (8), 1351–1365.
- Asiedu, K.G., 2019. An Ambitious Drone Delivery Health Service in Ghana Is Tackling Key Logistics Challenges. *Quartz Africa*. Available at: <https://qz.com/africa/1604374/ziplines-drone-delivery-launches-in-ghana-with-vaccines/>. (Accessed 19 September 2019). Accessed.
- Baumol, W.J., Likert, R., Wallich, H.C., McGowan, J.J., 1970. A New Rationale for Corporate Social Policy. Heath Lexington Books.
- Braun, V., Clarke, V., 2012. *Thematic analysis*. In: Cooper, H.E., Camic, P.M., Long, D.L., et al. (Eds.), *APA handbook of research methods in psychology*, 1. Foundations, planning, measures, and psychometrics. American Psychological Association, USA.
- Bright, J., 2019. Drone delivery startup Zipline launches UAV medical program in Ghana. *TechCrunch*. Available at: <https://techcrunch.com/2019/04/24/drone-delivery-startup-zipline-launches-uav-medical-program-in-ghana/>. (Accessed 19 September 2019). Accessed.
- Bryman, A., 2012. *Social research methods*, 4th. Oxford University Press Inc., New York USA.
- Bryman, A., 2015. *Social research methods*, 5th Edition. Oxford university press.
- Bryman, A., Bell, E., 2015. *Business Research Methods*, illustrated, annotated. Oxford University Press, Oxford, England.
- Candi, M., Beltagui, A., 2019. Effective use of 3D printing in the innovation process. *Technovation* 80, 63–73.
- Chang, D.-Y., 1996. Applications of the extent analysis method on fuzzy AHP. *Eur. J. Oper. Res.* 95 (3), 649–655.
- Chang, R.-D., Zuo, J., Zhao, Z.-Y., Zillante, G., Gan, X.-L., Soebarto, V., 2017. Evolving theories of sustainability and firms: history, future directions and implications for renewable energy research. *Renew. Sustain. Energy Rev.* 72, 48–56.
- Chen, X., Liu, Z., Zhu, Q., 2019. Performance evaluation of China's high-tech innovation process: analysis based on the innovation value chain. *Technovation* 74–75, 42–53.
- Chui, M., 2017. Artificial Intelligence: the Next Digital Frontier? (47). McKinsey and Company Global Institute.
- Cobbinah, P.B., Erdiaw-Kwasie, O.M., Amoateng, P., 2015. Rethinking sustainable development within the framework of poverty and urbanisation in developing countries. *Environ. Develop.* 13, 18–32.
- Cooper, M.C., Ellram, L.M., Gardner, J.T., Hanks, A.M., 1997. Meshing multiple alliances. *J. Bus. Logist.* 18 (1), 67–89.
- Coscieme, L., Mortensen, L.F., Donohue, I., 2021. Enhance environmental policy coherence to meet the Sustainable Development Goals. *J. Clean. Prod.* 296 (10), 126502.
- Dahlsrud, A., 2008. How corporate social responsibility is defined: an analysis of 37 definitions. *Corp. Soc. Responsib. Environ. Manag.* 15, 1–13.
- Davis, K., 1973. The case for and against business assumption of social responsibilities. *Acad. Manag. J.* 16, 312–322.
- Desouza, K.C., Krishnamurthy, R., Dawson, G.S., 2017. Learning from Public Sector Experimentation with Artificial Intelligence (Brookings). Brookings, Washington, DC. Available at: <https://www.brookings.edu/blog/techtank/2017/06/23/learning-from-public-sector-experimentation-with-artificial-intelligence/>. (Accessed 12 November 2019). Accessed.
- Dirican, C., 2015. The impacts of robotics, Artificial intelligence on business and economics. *Procedia - Soc. Behav. Sci.* 195, 564–573.
- Du, W., Li, M., 2020. Assessing the impact of environmental regulation on pollution abatement and collaborative emissions reduction: micro-evidence from Chinese industrial enterprises. *Environ. Impact Assess. Rev.* 82, 106382.
- Eckaus, R.S., 1987. Appropriate Technology: the Movement Has Only A Few Clothes on. *Issues in Science and Technology*, Winter, pp. 62–71.
- Emmanuel, A., 1982. Appropriate or Under-developed Technology? John Wiley, Chichester, pp. 3–22.
- Fazal, M.I., Patela, M.E., Tye, J., Gupta, Y., 2018. The past, present and future role of artificial intelligence in imaging. *Eur. J. Radiol.* 105, 246–250.
- Feng, M., Valdes, G., Dixit, N., Solberg, T.D., Machine Learning with Radiation Oncology Big Data, 2018. *Machine Learning in Radiation Oncology: Opportunities, Requirements, and Needs*. *Front. Oncol.* <https://doi.org/10.3389/fonc.2018.00110>.
- Giones, F., Brem, A., 2017. From toys to tools: the co-evolution of technological and entrepreneurial developments in the drone industry. *Bus. Horiz.* 60 (6), 875–884.
- Guest, G., Bunce, A., Johnson, L., 2006. How many interviews are enough? An experiment with data saturation and variability. *Field Methods* 18 (1), 59–82.
- Hamet, P., Tremblay, J., 2017. Artificial intelligence in medicine. *Metabolism* 69, S36–S40.
- Hummel, H., Argyrou, A., 2021. Planetary demands: redefining sustainable development and sustainable entrepreneurship. *J. Clean. Prod.* 278 (1), 123804.
- Hassanzadeh, P., Atyabi, F., Dinarvand, R., 2019. The significance of artificial intelligence in drug delivery system design. *Adv. Drug Deliv. Rev.* (151–152), 169–190.
- Herath, D., 2009. The Discourse of Development: has it reached maturity? *Third World Q.* 30 (8), 1449–1464.
- Horváthová, E., 2010. Does environmental performance affect financial performance? A meta-analysis. *Ecol. Econ.* 70 (1), 52–59.
- Jemai, J., Chung, B.D., Sarkar, B., 2020. Environmental effect for a complex green supply-chain management to control waste: a sustainable approach. *J. Clean. Prod.* 277 (20), 122919.
- Jensen, M.C., 1986. Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers. *Am. Econ. Rev.* 76 (2), 323–329.
- Jerónimo, H.M., Henriques, P.H., de Lacerda, T.C., da Silva, F.P., Vieira, P.R., 2019. Going green and sustainable: the influence of green HR practices on the organisational rationale for sustainability. *J. Bus. Res.* 112, 413–421.
- Kaplan, A., Haenlein, M., 2019. Siri, siri in my hand, who is the fairest in the land? On the interpretations, illustrations and implications of artificial intelligence. *Bus. Horiz.* 62 (1), 15–25.
- Kaplinsky, R., 2011. Bottom of the pyramid innovation and pro-poor growth. *IKD Work. Paper* (62), 2–17.
- Karuppiah, K., Sankaranarayanan, B., Ali, S.M., Jabbour, C.J.C., Bhalaji, R.K.A., 2021. Inhibitors to circular economy practices in the leather industry using an integrated approach: implications for sustainable development goals in emerging economies. *Sustain. Prod. Consump.* 27, 1554–1568.
- Klump, M., 2018. Automation and artificial intelligence in business logistics systems: human reactions and collaboration requirements. *Int. J. Logist. Res. Appl.* 21 (3), 224–242.
- Lamprey, E., Serwa, D., 2020. The use of zipline drones technology for COVID-19 samples transportation in Ghana. *HighTech Innov. J.* 1 (2), 67–71.
- Lee, M.D.P., 2008. A review of the theories of corporate social responsibility: its evolutionary path and the road ahead. *Int. J. Manag. Rev.* 10, 53–73.
- Lega, F., Marsilio, M., Villa, S., 2013. An evaluation framework for measuring supply chain performance in the public healthcare sector: evidence from the Italian NHS. *Prod. Plann. Control* 24 (10–11), 931–947.
- Lamichhane, S., Eğilmez, G., Gedik, R., Bhutta, M.K.S., Erenay, B., 2020. Benchmarking OECD countries' sustainable development performance: a goal-specific principal component analysis approach. *J. Clean. Prod.* 125040.
- Longoni, A., Pagell, M., Shevchenko, A., Klassen, R., 2019. Human capital routines and sustainability trade-offs: the influence of conflicting schemas for operations and safety managers. *Int. J. Oper. Prod. Manag.* 39 (5), 690–713.
- Mairaj, A., Baba, A.I., Javaid, A.Y., 2019. Application specific drone simulators: recent advances and challenges. *Simulat. Model. Pract. Theor.* 94, 100–117.
- Mavroggiorgou, A., Kiourtis, A., Touloupou, M., Kapassa, E., Kyriazis, D., 2019. Internet of medical things (IoMT): acquiring and transforming data into HL7 FHIR through 5G network slicing. *Emerg. Sci. J.* 3 (2), 64–77.
- McCorduck, P., Peters, A.K., 2004. *Machines Who Think*, second ed. Ltd, Natick, MA.
- Miles, M.B., Huberman, M., 1994. *Qualitative Data Analysis: A Sourcebook of New Methods*, second ed. Sage Publications, Beverly Hills, CA.
- Mitchell, R.K., Agle, R.B., Wood, J.D., 1997. Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. *Acad. Manag. Rev.* 22 (4), 853–886.
- Min, H., 2010. Artificial intelligence in supply chain management: theory and applications. *Int. J. Logist. Res. Appl.* 13 (1), 13–39.
- Moran, M.E., 2006. The da Vinci robot. *J. Endourol.* 20 (12), 986–990.
- Moore, H.L., 2015. Global prosperity and sustainable development goals. *J. Int. Dev.* 27 (6), 801–815.
- Morse, J.M., 2000. Determining the sample size. *Qual. Health Res.* 10 (1), 3–5.
- Moskwa, W., 2016. World drone market seen nearing \$127 billion in 2020, PwC says. Available at: <https://www.moneyweb.co.za/news/tech/world-drone-market-seen-nearing-127bn-2020-pwc-says/>. (Accessed 11 October 2019). Accessed.
- Nuki, P., 2018. Pointing the Way: How Medical Drones Are Saving Lives in Africa. *The Telegraph*. Available at: <https://www.telegraph.co.uk/global-health/women-and-girls/pointing-way-medical-drones-saving-lives-africa/>. (Accessed 23 November 2019). Accessed.
- Nyantakyi, K., 2019. Ghana medical drone delivery successfully delivers the first package to the Tafo Government Hospital. Available at: <https://www.jbklutse.com/gh>

- ana-medical-drone-delivery-successfully-delivers-to-tafo-hospital/. (Accessed 19 September 2019). Accessed.
- Orlitzky, M., Schmidt, F.L., Rynes, S.L., 2003. Corporate social and financial performance: a meta-analysis. *Organis. Stud.* 24 (3), 403–441.
- Patton, M.Q., 2002. *Qualitative Research and Evaluation Methods*, third ed. Sage Publications, Thousand Oaks, California.
- Petrikova, I., 2014. The short- and long-term effects of development projects: evidence from Ethiopia. *J. Int. Dev.* 26 (8), 1161–1180.
- Pritchett, L., Kenny, C., 2013. *Promoting Millennium Development Ideals: the Risks Of Defining Development Down* - Working Paper 338. Centre for Global Development.
- PwC, 2018. No longer science fiction, AI and robotics are transforming healthcare. Available at: <https://www.pwc.com/gx/en/industries/healthcare/publications/ai-robotics-new-health-transforming-healthcare.html>. (Accessed 21 November 2019). Accessed.
- Rakovska, M.A., Stratieva, S.V., 2018. A taxonomy of healthcare supply chain management practices. *Supply Chain Forum Int. J.* 19 (1), 4–24.
- Ramesh, K., Gupta, S., Ahmed, S., Kakkar, V., 2016. A comprehensive study on design trends and future scope of implantable drug delivery systems. *Int. J. Bio-Sci. Bio-Technol.* 8 (6), 11–20.
- Russell, S.J., Norvig, P., 2009. *Artificial Intelligence: A Modern Approach*, third ed. Prentice-Hall, Upper Saddle River, New Jersey.
- Russell, S.J., Norvig, P., 2016. In: *Global (Ed.)*, *Artificial Intelligence: A Modern Approach*. Pearson Higher, Englewood Cliffs, New Jersey.
- Saunders, M., Lewis, P., Thornhill, A., 2015. *Research Methods for Business Students*. In: Harlow (Ed.), sixth ed. Pearson Education Limited.
- Saunders, M., Lewis, P., Thorntonhill, A., 2012. *Research Methods for Business Students*, 6th. Pearson Education Limited, Harlow, England.
- Shiraishi, J., Li, Q., Appelbaum, D., Doi, K., 2011. Computer-aided diagnosis and artificial intelligence in clinical imaging. *Semin. Nucl. Med.* 449–462.
- Sigal, S., 2019. Ghana's new lifesaving drones: like Uber, but for blood. Available at: <https://www.vox.com/future-perfect/2019/6/4/18647685/medical-drones-ghana-africa-zipline-global-health>. (Accessed 19 September 2019). Accessed.
- Silverman, D., 2013. *Doing Qualitative Research*, fourth ed. Sage Publication, London.
- Tan, Y., Ochoa, J.J., Langston, C., Shen, L., 2015. An empirical study on the relationship between sustainability performance and the business competitiveness of international construction contractors. *J. Clean. Prod.* (93), 273–278.
- The Guardian UK, 2019. Vaccines by air as drone medicine service takes off in Ghana. Available at: <https://www.theguardian.com/global-development/2019/apr/25/medical-delivery-drones-cleared-for-takeoff-in-ghana-zipline>. (Accessed 19 September 2019). Accessed.
- UN, 2017. Sustainable development. The 17 goals. Department of economic and social affairs. Available at: <https://sdgs.un.org/goals>. (Accessed 27 July 2020). Accessed.
- van Marrewijk, M., Wempe, M., 2003. Multiple Levels of Corporate Sustainability. *J. Bus. Ethics* 44 (2), 107–119. <https://doi.org/10.1023/A:1023383229086>.
- Wang, R., Pan, W., Jin, Y., Li, Y., Geng, Y., Gao, C., Chen, C., Wang, H., Na, D., Liao, S., 2019. Artificial intelligence in reproductive medicine. *Reproduction* 159 (4), 139–154. <https://doi.org/10.1530/REP-18-0523>.
- Watts, P., Holme, R., 1999. *Corporate Social Responsibility: Meeting Changing Expectations*. World Business Council for Sustainable Development, Geneva, Switzerland.
- Zhang, H., Jackson, J.K., Chiao, M., 2017. Microfabricated drug delivery devices: design, fabrication, and applications. *Adv. Funct. Mater.* 27 (1703606), 1–31.

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