Technology in Society 66 (2021) 101624

Contents lists available at ScienceDirect

Technology in Society

journal homepage: www.elsevier.com/locate/techsoc

Intricacies of medical drones in healthcare delivery: Implications for Africa

Albert Apotele Nyaaba [a], Matthew Ayamga [b,*]

[a] Youth Harvest Foundation, P. O. Box 656, Bolgatanga, Ghana
[b] Business Management and Organization (BMO) and Information Technology (INF) Chair Groups, Wageningen University & Research, P.O. Box 8130, 6700 EW, Wageningen, the Netherlands

ARTICLE INFO

Keywords:
Drones
Medical supplies
Aerial delivery
Health emergencies
Transport
Africa

ABSTRACT

Unmanned aerial vehicles, also known as drones, can play a critical role in delivering health care. In this paper, we reviewed the literature to ascertain (1) the various medical supplies delivered by drones, (2) the challenges to the successful use of medical drones and (3) the potential benefits of medical drones. Implications for the African context is then provided. In achieving this objective, we employed a systematic literature review methodology and defined search strings, searched for relevant literature from PubMed, Scopus and Web of Science databases following a review protocol. The snowball technique was similarly used to search for other papers as well. A total of 17 out of 69 papers were included in the review after screening and applying a quality appraisal criterion. The results indicate that blood, AEDs, drugs, vaccines, and laboratory test samples etc were identified as part of the medical supplies aerially delivered by drones. Regulations, cost, misuse (evasion of people's privacy) and psychological effect on people who experienced drones used for bombing are part of the challenges that could result from using the technology for delivery of medical supplies. The benefits derived from drones range from reducing response times during health emergencies thus helping to save more lives, to being environmentally friendly as the CO_2 emissions levels are lower than conventional delivery by trucks and cars. In conclusion, drone technology has opened a new phase for the health sector and to sustain this technological innovation in Africa, there is the need for inclusive innovation to make drones safer and acceptable. This could be achieved by developing the needed policy framework with the regulators, providing other health resources to complement the use of drones, embarking on sensitizations on the usefulness of drones through cultural underpinnings of rural communities about drones and training the needed health personnel to handle dispatches of medical supplies with drones.

1. Introduction

Drones have proven to have exciting potential for increasing the capacity and efficiency of the healthcare systems [1,2]. In this paper, drones are understood as any unmanned aerial vehicle that is remotely piloted [3,4]; which have been generally acclaimed for their capacity to evade many of the challenges to healthcare delivery that hitherto impeded access to healthcare services, particularly in hard-to-reach areas or underserved environment [5]. For instance, the transfer of blood and other medical supplies from a designated medical facility to remote areas or villages can be costly and time-consuming [6]. Again, about 60% of Rwanda's national blood supply is delivered outside the capital Kigali via drones and about half of that blood is used for women suffering from postpartum haemorrhage [7–9].

Interestingly, a drone can identify with precision the scene an accident occurred, the number of injured persons, and the scale of the event before the arrival of emergency services [10]. In this case, drones provide first-hand information about an accident scene thus enabling improved urgent medical services, faster response time and reduced transportation costs [8,9]. The current drive for sustainable medical delivery via innovation is borne out of the Coronavirus (COVID-19) pandemic. The drive is aimed at minimising human interaction to reduce the spread of the virus [11]. Drones are, therefore, technological tools that can enable medical personnel to perform their task more efficiently, effectively, and ultimately save more lives [3,12].

The public view of drones plays a crucial role in accepting their usage particularly when drones are used during emergencies or in rescue missions to save lives as witnessed by people [13]. Even so, the knowledge and context of usage determine how the public perceives drones [14,15]. In the healthcare domain [16–18], point to the

* Corresponding author.
E-mail addresses: matthew.ayamga@wur.nl, ayamgamatthew@gmail.com (M. Ayamga).

https://doi.org/10.1016/j.techsoc.2021.101624
Received 16 March 2021; Received in revised form 19 May 2021; Accepted 29 May 2021
Available online 9 June 2021

promising opportunities that drones can bring to the medical-transportation system. What is therefore the implications for adopting drones for health care delivery in the African context particularly for rural or hard to reach communities?

Answering this question, we first presented a systematic literature review (SLR) of the relevant studies on aerial delivery of medical supplies. The research questions (RQs) to be addressed by the SLR are*: (a) what are the medical supplies aerially delivered by drones? (b) what are the challenges or potential barriers of aerial delivery with drones? (c) what are the potential benefits of medical drones?* Drawing from the findings of the SLR, we provided the implications for the implementation of delivery drones in the health care sector in the African context.

The outcome of this paper could serve as a resource for (a) the various industries within the medical transport ecosystem to plan and consider the appropriate digital technologies for adoption, or the appropriate sustainable medical supply transport systems to be employed and (b) governments, stakeholders, and development practitioners to provide the needed policies, investments, education, and capacity building that could help in mitigating or reducing the hurdles surrounding drones for health care delivery.

The rest of the sections of this paper is as follows: section 2 presents the theoretical background, section 3 presents the methodology, section 4 presents the results, and discussion is done in section 5. The paper concludes in section 6.

2. Theoretical background

The global market size of drone package delivery is projected to reach USD 7388.2 million by 2027, with 14 key companies profiled in the market from the US, South Africa, Israel, Canada, and Germany [19]. Amid the Covid-19 pandemic, the drone delivery market is expected to make substantial gains through the aerial delivery of medical and food supplies worldwide.

Drones are changing the conventional delivery systems focusing on aerial delivery systems that can release packages in a downward direction [20]. The drive for delivery drones is a direct response to the growing demand for fast and efficient logistics within urban cities. The health system is not left out as the industry players' attention is on precision delivery with an efficient cost perspective than conventional delivery systems [21].

The initial discourse on aerial delivery of medical supplies in Africa, specifically the decision of the government of Ghana in 2017 to contract the US company Zipline to deliver emergency medical supplies to hard-to-reach communities, had two key points of contention. The first point was that the government should rather solve the existing problems (provision of beds, drugs and the needed personnel) within the health sector instead of drones. On the other hand, the government argues that the conventional delivery of medical supplies could not be fast enough to save lives in an emergency (focus on blood transfusion etc). The second point of contention had to do with the cost of the contract with Zipline. This was justifiable with the intent to leverage technology to improve the supply chain of critical medical supplies, reduce waste and save lives [22].

Amid the Covid-19 pandemic, doctors and medical facilities in Rwanda and Ghana used an app to order blood, vaccines and vital COVID-19 tests and samples, which are aerially delivered in minutes [23]. The US has also approved Zipline and other companies to deliver medical and food suppliers in some states [19]. The discourse now is on fast, cost-efficiency and precision delivery systems in an integrated supply chain [24].

3. Methodology

3.1. Systematic literature review (SLR)

The guide to conducting SLR given by Ref. [25], which conforms with PRISMA guideline, is followed to answer the RQs. The steps followed include (1) purpose of the literature review, (2) protocol and training, (3) searching for literature, (4) screening for inclusion, (5) quality appraisal (screening for exclusion), (6) data extraction, (7) synthesis of studies (analysis) and (8) writing the review. The first five steps are presented in this section whilst the remaining steps are presented in the subsequent sections.

3.1.1. Purpose of the literature review

We aim to summarise the relevant studies on the socio-technical debate on drone delivery of medical supplies based on the RQs asked.

3.1.2. Protocol and training

In guiding the SLR process, we designed a review protocol which we followed in ensuring consistency. This is detailed and presented in Fig. 1; the SLR protocol followed to answer our research questions (RQs).

3.1.3. Searching for literature

We defined the search strings *"((Aerial package delivery) OR (drone package delivery) OR (Unmanned aerial package delivery)) AND ((aerial medical supplies delivery) OR (drone medical supplies delivery) OR (Unmanned aerial vehicle medical supplies delivery))"* with refining limiting to papers written in the English language and the time frame of publication ranges 2016–2020. This string was applied to Scopus, Web of Science and PubMed databases to retrieve the relevant studies for the SLR. The search string was modified to suit each database while maintaining the keywords. We also employed the snowball technique to find other papers that were not captured by the search string results.

3.1.4. Inclusion and exclusion criteria

The criteria considered for including studies for further assessment based on the outcome of search string were (a) papers within the past five years (2016–2020), (b) papers written in the English language, (c) title and abstract that relate to keywords in the search string and (d) papers, not SLR. All other papers were excluded, including duplicates following the criteria. With this, we arrived at a total of (17) included papers, see Table 2 (a summary of the search outcome and the included papers), which was further screened for quality based on the RQs. To achieve this quality assessment, we defined a quality checklist [26]. The quality assessment contains questions asked about the included papers (see Table 1) and we coded the response to each question in the quality checklist with either; one (1) for a 'Yes' response, half (0.5) for a 'Somewhat' response and zero (0) for a 'No' response.

4. Results

Following the quality assessment for the included studies, the outcome revealed the lowest score of 5.5 and the highest score of 9.5. In the appendix section, a detailed summary of the quality assessment of the included papers is found in Table 4. Also, the appendix section includes the summary of all the included studies and the extracted thematic topics; authorship, year of publication, title, journal, and the research questions answered (see Table 5). Table 3 below presents the summary of the included papers per the research question answered.

4.1. What are the medical supplies aerially delivered by drones?

In this section, we present the medical supplies delivered by drones. These are categorized into (1) first aid kits, (2) medical aids and human body parts, (3) personal protective equipment, and (4) others in the order of urgency. Though the medical supplies elaborated in the subsections below are vital, they are a limited asset to health care systems especially in developing countries due to the poor transport facilities (bad roads networks and limited ambulance services). The urgent need to deliver critical medical supplies, therefore, relies on the level of the health emergency and the geographical location.

4.1.1. First aid kits - (most urgent)

First aid use is a recommendation that could be administered in case of an accident by bystanders before paramedics arrive at the scene which could occur at any location in a country. First aid delivery by a drone in response to an emergency constitutes the most urgent medical aid delivered by a drone [27]. The first aid kit contains different medical supplies that a drone can carry to an emergency scene. Some of the medical supplies could include medications, antibiotics, blood samples [28]. Sudden health emergencies like heart attacks could also occur at any given time particularly now that Africa is faced with the double burden of diseases [29] characterized by increasing prevalence of chronic non-communicable diseases (NCD) such as heart disease, stroke, cancer, diabetes and chronic lung and the battle to deal with infectious diseases such as COVID-19, Ebola, HIV/AIDS, Hepatitis,malaria etc[30,31].

In such cases, drones provide faster delivery of medical devices like automated external defibrillators (AEDs) which could be used to provide first aid before the response team arrives [8,9,32,33].

4.1.2. Medical aids and human body parts - (urgent)

Blood is primarily the aerial delivery product by drones because doctors often require blood samples to complete diagnosis. Under such circumstances, drones are the option as they can deliver faster than the conventional transportation system [34]. Most often, transfusion is required during accidents and other medical situations; blood is vital. As an urgent need, blood is also required in health emergencies such as pregnancy-related complications and cases like severe anaemia, hypoglycemia, and brain involvement [8,9]. Rwanda who pioneered the use of drone to aerially deliver blood to save the lives of most women who suffer from postpartum haemorrhage is a typical example [8,9]. As such, drones come in handy to help health care providers in rural communities assist pregnant women during labour. Blood supply with drones paved the way for expansion to include medical supplies like vaccines [35].

The delivery of antivenom by drones (for snake and dog bites) saves the lives of people bitten by such animals [8,9,34,36,37] especially in Africa where snake and dog bites are not uncommon. Interestingly, drones are not only used for delivering medical supplies but also human body parts like the kidney as well [36,37].

4.1.3. Personal protective equipment - (need)

In the era of the COVID-19 pandemic, drones can help in easy social distance inspection in public places in an automatic way. As many governments in Africa found it rather challenging ensuring citizens observed social distance protocol during the COVID-19 pandemic. Drones could also deliver Personal Protective Equipment (PPEs) to prevent the spread of the virus [38]. The drones deliver PPEs (gloves, facemasks etc.) to emergency scenes and health facilities in some countries [39].

4.1.4. Others – (normal)

Medical supplies that are not often classified as urgent need but delivered by drones are drugs and contraceptives for women [34]. Other supplies include pathology specimens, laboratory test samples, HIV therapies, and condoms [8,9,36,37].

4.2. What are the challenges or potential barriers to aerial delivery with drones?

Regulations could always be a bottleneck that may hinder aerial delivery by drones considering the misuse of drones which has damaged its reputation [34]. Because many countries are yet to establish drone regulations, it is difficult to acquire legal permission to fly a medical drone with the aviation authorities [37]. On one hand, unless drone users demonstrate that they can operate the drone well and avoid collisions with other flying objects or properties on the ground, regulatory obstacles (not permitting usage) would be difficult to overcome [35]. On the other hand, regulators are largely concerned about how drones can avoid or minimise risks relating to technical and privacy-related usage [40]. So, as much as we want technology (drone) to deliver medical supply efficiently, effectively and save more lives, lives and properties must be protected. The use of drones should not also result in the evasion of people's privacy, otherwise, issues of human rights will be violated, and this could have some implications.

Another challenge is that in the past drones were used for war by aerially dropping bombs, and this has left a perception in the minds of individuals in such war zone countries. In such countries, once a drone is seen flying it does not matter what the supply is, it brings back painful memories of death, trauma etc. This creates fear and panic [34]. This ultimately could lead to protest against the use of drones in such countries.

In the public health sector, except for trained professionals, not everyone is familiar with administering an AED to a patient before the arrival of paramedics, therefore, aerial delivery of AEDs to an emergency scene could initially increase stress as bystanders might struggle to operate the AEDs on the patient [32]. Similarly, it can be challenging to fly a drone unless trained. Also, current delivery drones are unable to carry heavy objects and fly long-range [37]. This means that delivery drones might not be able to carry along trained personnel and this makes it difficult in accidents situations, where there are no trained health professionals.

Though drones provide great potential benefits, in some settings, others believe it would be appropriate to invest in improving the conventional transport system than drones [35]. When using drones for public benefit, there is always this enthusiastic response, yet stakeholders have raised concerns regarding value for money, privacy, and security [41].

4.3. What are the potential benefits of medical drones?

One of the incredible potential drones offer to the medical field is that they come in handy in recent times, to help track the hosts of Plasmodium knowlesi malaria that indicates a potentially greater risk of infection to human beings considering how many hosts are infected [34]. Moreover, drones improve response time and increase delivery efficiency [8,9,27,34]. Furthermore, the delivery of AEDs by drones to an emergency scene amid Covid-19 helps prevent infection as continuous chest compressions (CCC) and early defibrillation are relevant without mouth-to-mouth ventilation [39]. Drone-delivered AEDs have the potential to improve survival for patients in out-of-hospital cardiac arrest (OHCA) survival, as they have a favourable response time compared to others [33]. The [42] study found that it was possible to autonomously transport and deliver an AED using a drone in out-of-sight flights with much better response time than the emergency medical services (EMS). In this regard, when the public is informed and gets involved in experiments about drones delivering medical supplies, they turn to appropriate technological innovation.

Developing countries particularly those in Africa have been known to be leapfrogging when it comes to technological adoption [36]. The adoption of drones in the medical sector in Africa is an example of the term 'leapfrogging', which alludes to the way developing countries skip the gradual process of technological evolution and adoption seen in developed countries and leapfrog over these gradual steps to the rapid adoption of novel devices and systems [36]. A major key strength of the adoption of drones is that their delivery means can decrease travel time for diagnosis and treatment and are a cost-effective alternative to road transport in difficult terrains [37]. From the perspective of cost, the financial benefits of utilising a drone within a remote medical emergency response can only be achieved if the system is used extensively enough to outweigh the capital costs [40]; p. 15). According to Ref. [43], recent improvements in cost efficiency, reliability, and speed of service of drone systems have motivated the development of many optimisation models that consider their use for deliveries.

It is also of great interest to know that drones played an essential role during lockdowns amid Covid-19 as they help deliver medical and food supplies to people at homes and health facilities [44]. What is more essential about drones is their sustainable enhancement of the environment. They do so as the energy consumption of drones per kilometre is lower than conventional deliveries by trucks and cars. In that sense, this helps reduce the carbon dioxide emission levels in the environments [45].

5. Discussion

5.1. Reflections of the results

The use of drones to deliver blood for emergency cases to rural health facilities paved the way to include other crucial medical supplies like vaccines, drugs, test samples etc. in recent times. The aerial delivery of such critical medical supplies has disrupted the health care delivery systems in the African context, supporting the concept of "leapfrogging of technology adoption" in this age of digital or smart technologies.

In Africa and specifically Ghana, we have experienced some of the inefficiencies in the delivery of primary health care services to rural communities with regards to emergency need for such critical medical supplies as blood, vaccines (for snakes, deadly scorpions, and immunisation purposes), and laboratory sample for testing etc. Some situations have reportedly resulted in avoidable deaths, complications and demotivating people from visiting health facilities due to delay in reaching care (distance to hospital, availability of transport, poor road and infrastructure) or delay in receiving adequate health care (lack of medical supplies, inadequate trained staff etc) as explained by the three-delay model [46]. This contributes to maternal and child mortality. Meanwhile, health facility delivery is taunted as one of the best ways to reduce child and maternal mortality [47]. More importantly, most rural health facilities are not well-resourced to enable blood samples diagnosis. So, when an individual is in critical condition, blood samples are taken to a well-resourced laboratory for testing, which could take a day or two depending on the location of such facility and the nature of the road system. In this regard, one benefit of drones could be to deliver such sample results in a manner of minutes if not hours and aid the diagnosis and subsequent treatment.

The manifold benefits of drones to the health care domain cannot be overemphasized. However, medical drones akin to other types of aircrafts are subject to formal regulations [4], which implies that governments' interests in implementing drones in the health care domain would have to develop the needed regulations to support the use of medical drones within the airspace of respective countries. More so, adopting medical drones would mean employing new staff or training selected health professionals to handle dispatches since operating a drone require certain skills. In the recent study of Ref. [4], they indicated that some individuals and businesses that procured drones did not find it easy to obtain permission to use the drones either because there are no regulations in place or lack of skilled personnel to handle drone-related matters. Public acceptance of medical drones could come through awareness-creation, involving the appropriate stakeholders in developing regulations, and education about drone technology.

5.2. Contribution to the existing literature

The contribution of this paper to the literature is in two folds. First, it contributes to the growing body of knowledge on aerial delivery of medical supplies by systematically collecting and analysing the intricacies of drones in the medical sector and the related socio-technical impact. Secondly, this paper draws from the increasing literature on drones and healthcare delivery and discusses the implication of drones for Africa. By so doing, it serves as a resource for the actors in the medical domain. Extant studies have also made efforts and contributed to the literature. The study of [48] contributes to the state of public knowledge on commercial drones whilst [49] also provides a socio-technical perspective of drones with a focus on Sub-Sahara Africa.

5.3. Threats to validity mitigation approach to SLR

Threats to an SLR study's validity relate to publication and selection bias, data extraction, and classification [50]. To avoid or minimise the threat of publication bias, we applied a quality assessment criterion adopted and modified from Ref. [26] to ascertain the quality of the papers before analysis. As indicated, the least score of the quality results was 5.5, and hence, we did not exclude any paper. The threat of selection bias was covered by defining the study inclusion/exclusion criteria after screening the selected primary studies. The study team discussed the selection criteria to ensure their quality. The data extraction validity is also critical because it can directly influence the results. To validate the extraction process, a research team member also extracted a few papers to check the extraction process. The synthesis of results was carried out as objective as possible while keeping the study aligned with differences between concepts and abstractions. Original articles were used as the reference regarding uncertainty about the synthesis. There is the possibility of missing some interesting papers after applying our inclusion criteria. However, 17 included papers are a reasonable amount of input data for addressing our RQs, considering the studies on aerial deliveries of medical supplies by drones in health care delivery.

6. Conclusion and implications for Africa

In this SLR, we have presented and discussed the answers to our RQs with blood, AEDs, drugs, vaccines, and laboratory test samples identified as the medical supplies aerially delivered by drones. Regulations, cost, misuse (weaponizing a drone, not for military purposes) and psychological effect on people who experienced drones used for dropping bombs are part of the challenges resulting from using the technology for delivery. Drone technology has opened a new phase for the health sector. To sustain this innovation, there is the need for inclusive innovation by creating public awareness about the technology, training the needed health personnel on how to handle dispatches of medical supplies with drones, and developing the needed policy framework with the regulators to make the use of medical drones safer and acceptable.

In the African context, the implementation of medical drones will set to revolutionize the health care delivery systems particularly for rural communities that are hard to reach during health emergencies due to poor road infrastructure. Obviously, this will improve access to primary health care on one hand, and on the other, the initial cost of implementation of medical drones is usually high and this implies that the adoption of medical drones are a long-term goal that will eventually make up for the implementation cost. In this regard, a greater number of the population will be served, and more lives saved than before because of delivery delays of critical medical supplies during an emergency by conventional delivery by trucks.

Another aspect to consider is that African governments should not be carried away by technology adoption or catchup but pay equal attention to other areas that need improvements in the health sector. For instance, equipping hospitals and other health facilities with the necessary resources (beds, ambulances, adequately trained health workers, medical equipment etc) and better renumeration package for health workers are equally important and will complement the use of medical drones.

Furthermore, regulating medical drones calls for multi-disciplinary collaborations between the public and private sectors, whereby the private sector will proactively show how they are going to use medical drones in support of governments' efforts to improve access to health care delivery. On the other hand, regulators are expected to liaise with the necessary stakeholders in developing or amending existing regulations for the delivery of medical supplies with drones. The development of enabling regulations for medical drones serves two purposes. First, it prevents unauthorized organizations and individuals from using

medical drones for other purposes. Secondly, the regulators can follow the development of the approved institutions for using medical drones to ascertain issues and challenges faced in the usage. In this way, they can solve the regulatory-related issues and challenges which will further enhance the aerial delivery of medical supplies.

Lastly, education programmes and awareness of medical drones should be initiated following the cultural underpinnings of rural communities [12] to make people accept drone aided health services. This is particularly important because Ghana among other African countries was able to reduce maternal and child mortality rates following the bold initiatives such as National Health Insurance policy which provides free maternal health services and Community-Based Health Planning Services (CPHS) with aggressive social and behavioural change communication programmes. These changed the narrative for maternal and child health outcomes in Ghana. This was not the case in the past where women specifically rural women prefer to deliver at home through the support of traditional birth attendants instead of health facility delivery.

Authors' contributions

Conception and design of study: AAN; Systematic literature review: AAN and MA; Drafting the manuscript: MA and AAN; revising the manuscript critically for important intellectual content; MA and AAN. All authors have read and approved the final manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

None.

Acknowledgement

None.

Appendix

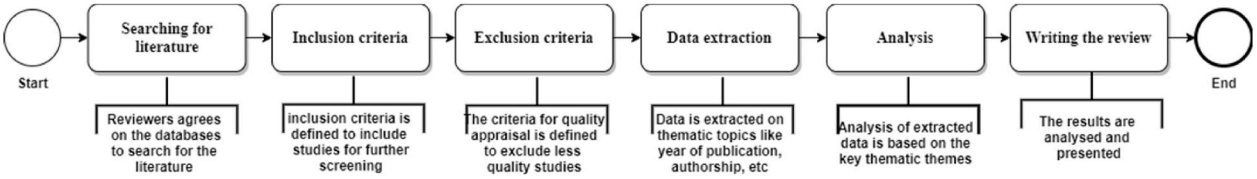

Fig. 1. The systematic literature review protocol followed in answering the research questions.

Table 1
Questions asked in assessing the quality of included papers for the review

Category	Q#[a]	Questions
Clarity	Q1	Is the study aim stated clearly?
	Q2	Is the reporting clear and systematic?
	Q3	Are the findings presented?
Generalizability of a study	Q4	Is the study independent of a domain?
	Q5	Is the scope of drone technology comprehensive relating to the study aim?
Coherency of results	Q6	Is the study clear in describing which RQs are analysed?
	Q7	Are the sources of information clearly stated?
	Q8	Are study questions clear and coherent?
Completeness	Q9	Are all the research questions addressed?
	Q10	Is the conclusion given in accordance to study goals?

[a] Quality criterion ID.

Table 2
The outcome of search results and the number of included studies

Database Searched	Initial studies found	Studies included
PubMed	16	11
Scopus	8	2
Web of Science	36	3
Other[b]	9	1
Total	**69**	**17**

[b] Employed the snowball technique to find other studies.

Table 3
The summary of included studies and the research questions answered per study.

Included study	Research question answered
[34]	RQ1: What are the medical supplies aerially delivered by drones?
[8,9]	
[27]	
[28,39]	
[32]	
[33]	
[36]	
[37]	
[35]	
[34]	RQ2: What are the challenges or potential barriers of aerial delivery with drones?
[32]	
[37]	
[35]	
[40]	
[41]	
[34]	RQ3: What are the potential benefits of medical drones?
[8,9]	
[27,39]	
[32]	
[33]	
[36]	
[42]	
[37]	
[43]	
[44]	
[51]	
[40]	
[45]	

Table 4
The summary of the score results of the questions asked in the quality assessment of included studies

PAPER	CLARITY			GENERALITY		COHERENCY			COMPLETENESS		CLARITY TOTAL	GENERALITY TOTAL	COHERENCY TOTAL	COMPLETENESS TOTAL	TOTAL
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10					
1	1	0.5	1	0	0.5	1	0.5	0	0.5	1	2.5	0.5	1.5	1.5	6
2	1	1	1	0	1	0.5	1	0.5	1	1	3	1	2	2	8
3	1	1	1	0.5	1	1	1	1	1	1	3	1.5	3	2	9.5
4	1	1	1	0	0.5	1	1	1	1	0.5	3	0.5	3	1.5	8
5	1	0.5	0.5	0	0.5	1	1	0	0.5	0.5	2	0.5	2	1	5.5
6	1	1	1	0	1	1	1	1	1	1	3	1	3	2	9
7	1	1	1	0	0.5	1	1	1	1	1	3	0.5	3	2	8.5
8	1	0.5	1	0	0.5	1	0.5	0	0.5	1	2.5	0.5	1.5	1.5	6
9	1	0.5	1	0	1	0.5	1	0.5	0.5	1	2.5	1	2	1.5	7
10	1	1	1	0	0.5	1	1	1	0.5	1	3	0.5	3	1.5	8
11	1	1	1	0	1	1	1	1	1	1	3	1	3	2	9
12	1	1	1	0	0.5	1	0.5	0.5	1	1	3	0.5	2	2	7.5
13	1	1	1	0	0.5	1	1	0.5	1	0.5	3	0.5	2.5	1.5	7.5
14	1	1	1	0	0.5	1	1	0.5	0.5	1	3	0.5	2.5	1.5	7.5
15	1	1	1	0	0.5	0.5	1	0.5	0.5	1	3	0.5	2	1.5	7
16	1	1	1	0	1	1	1	1	1	1	3	1	3	2	9
17	1	1	1	0	0.5	0.5	1	1	1	1	3	0.5	2.5	2	8

Table 5
A summary of included studies and data extracted from them.

NUMBER	AUTHORSHIP	PUBLICATION REFERENCE NUMBER	TITLE	JOURNAL	RQ1	RQ2	RQ3
1	Sachan, D.	[34]	The age of drones: what might it mean for health?	Lancet	*	*	*
2	Ling, G., & Draghic, N.	[8,9]	Aerial drones for blood delivery	Transfusion	*	–	*
3	Fakhrulddin, S. S., Gharghan, S. K., Al-Naji, A., & Chahl, J.	[27]	An advanced first aid system based on an unmanned aerial vehicles and a wireless body area sensor network for elderly persons in outdoor environments	Sensors	*	–	*
4		[28]			*	–	–

(continued on next page)

Table 5 (*continued*)

NUMBER	AUTHORSHIP	PUBLICATION REFERENCE NUMBER	TITLE	JOURNAL	RQ1	RQ2	RQ3
	Srivastava, M., Suvarna, S., Srivastava, A., & Bharathiraja, S.		Automated emergency paramedical response system.	Health Information Science and Systems			
5	van Veelen, M. J., Kaufmann, M., Brugger, H., & Strapazzon, G.	[39]	Drone delivery of AED's and personal protective equipment in the era of SARS-CoV-2.	Resuscitation	*	–	*
6	Sanfridsson, J., Sparrevik, J., Hollenberg, J., Nordberg, P., Djärv, T., Ringh, M., ... & Claesson, A.	[32]	Drone delivery of an automated external defibrillator–a mixed-method simulation study of bystander experience.	Scandinavian journal of trauma, resuscitation and emergency medicine	*	*	*
7	Boutilier, J. J., Brooks, S. C., Janmohamed, A., Byers, A., Buick, J. E., Zhan, C., ... & Chan, T. C.	[33]	Optimising a drone network to deliver automated external defibrillators.	Circulation	*	–	*
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Albert Apotele Nyaaba (M. Phil) is a public health and development practitioner. He is currently the project officer for a COVID-19 study in the Upper East Region, Ghana funded by Plan International and JugendPartnersChaft with Youth Harvest Foundation Ghana (YHFG). He implemented child protection project funded by Global Affairs Canada through UNICEF with YHFG, a Non-Governmental Organization, NGO as the project officer. He is now engaged in health intervention design, project implementation, proposal writing and research work. He holds M.Phil. in Population and Health from University of Cape Coast, Dip in Education, University of Education Winneba and, Bsc. Community Nutrition, University for Development Studies all in Ghana. He is also a certified Project management professional. His research interest are on health system research, maternal and child health, nutrition and sexual and reproductive health. He can be reached through albertnyaaba13@yahoo.com, albert.nyaaba@harvestmail.org, and +233245992602.

Matthew Ayamga (MSc) is a PhD candidate at the Business Management and Organization (BMO) and Information Technology (INF) Chair Groups of Wageningen University and Research in the Netherlands. He holds MSc degree in Management, Economics and Consumer studies from the same university in 2019. Matthew received his BSc degree in Actuarial Science from the University for Development Students in Ghana. From 2015 to 2017, he was the market and research officer for Dumong's System, a software development company in Ghana. His research interest is in the area of business analysis, UAVs for agriculture and health care delivery, business models for digital agri-business ecosystems and information systems. He can be reached through E-mail: matthew.ayamga@wur.nl or ayamgmatthew@gmail.com, Phone: +31 622724914.