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Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study

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Abstract

Unmanned aerial vehicles (UAVs) also known as drones have significant potential in the healthcare field. Ethical and practical concerns, challenges, and complexities of using drones for specific and diverse healthcare purposes have been minimally explored to date. This thesis aims to document, and advance awareness of diverse context-specific concerns, challenges, and complexities encountered by individuals working on the front lines of drones for health projects. It draws on original qualitative research and data from semi-structured interviews (N = 16) with drones for health program managers and field staff in nine countries. Directed thematic analysis was used to analyze interviews and identify key ethical and practical concerns, challenges, and complexities experienced by participants in their work with drones for health projects. This thesis shows how the key ethical and practical concerns, challenges, and complexities are interrelated. Concerns and challenges can be mitigated through the development of appropriate guidelines and regulations and community engagement initiatives.

Keywords

Keywords: drones; unmanned aerial vehicle; health; healthcare; delivery of healthcare; drones for health; ethics; practical challenges; community engagement; stakeholder participation; informed consent; collective consent; guidelines

Summary for Lay Audience

The use of unmanned aerial vehicles (UAVs) also known as drones is now expanding into the healthcare field. Drones are being used to deliver medical supplies, biological samples, live vector, and for mapping. The implementation of new health technologies in healthcare can potentially raise new ethical and practical concerns, challenges, and complexities. It is important to identify and understand these concerns, challenges, and complexities prior to introducing these technologies so that those introducing these health technologies are better prepared to mitigate any potential issues. Recognizing how local customs and cultures shape concerns, challenges, and complexities is especially important when these health technologies are being introduced at the global level. Currently, there exists limited literature that describe the challenges of implementing drones in the context of healthcare delivery.

This thesis aims to document and advance awareness of diverse context-specific concerns, challenges, and complexities encountered by individuals working on the front lines of drones for health. It does so based on interviews with 16 individuals from nine countries that have experiencing introducing drones for healthcare programs. The interviews provide these individuals with the opportunity to describe their experiences of introducing drones for healthcare programs. Through the analysis of these interviews key ethical and practical concerns, challenges, and complexities were identified. This thesis outlines how key ethical and practical concerns, challenges, and complexities are interrelated. It also proposes that concerns and challenges can be mitigated through the development of appropriate guidelines and regulations and community engagement initiatives that are created with appropriate stakeholders and communities that are impacted by these drones for health projects.

Co-Authorship Statement

This thesis is comprised of one manuscript, which has been accepted for publication in the peer-reviewed journal, *Drones*.

Chapter 4

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This chapter was co-authored with my supervisor, committee member, and the founder of WeRobotics, the organization we collaborated with. As the first author, I was primarily responsible for the conception of the work, literature review, data collection, data analysis and interpretation, and drafting of the manuscript. E.N., L.D., and P.M. was involved in the conception of the work. E.N. conducted interviews that happened in Spanish. E.N. and L.D. were consulted throughout the formal analysis of the interviews. All authors reviewed and edited the paper.

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Thesis Topic Selection and Declaration of Academic Achievement

The topic for this thesis arose from working with Dr. Elysée Nouvet. Through consultation with Drs. Elysee Nouvet (Supervisor and Co-PI), Lorie Donelle (Committee Member), and Patrick Meier (WeRobotics Founder), I was able to develop a research project that examined the ethical and practical challenges, concerns, and complexities of introducing drones for health programs in various country settings. I was responsible for the interpretive analysis presented in the following thesis.

All content presented in this document was written and completed by Vyshnave Jeyabalan, acknowledging the contribution of Dr. Elysee Nouvet who helped develop research documents (letter of information and consent, interview guide, codebook etc), conducted interviews, and guided my analysis.

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Chapter 1

1 Introduction

Unmanned aerial vehicles (UAVs) also known as unmanned aerial systems (UASs) or drones are aircraft that do not have an onboard human pilot. Initially, drones were exclusively used for military purposes (Kindervater, 2016). Since their first appearance in World War I, the development of drones has expanded significantly to include a range of recreational and commercial activities. These include search and rescue (Claesson et al., 2017a); package delivery (Hern, 2016); surveying and mapping (Jegillos, 2017); journalism (The New York Times, 2018); policing (Gault, 2020); construction and infrastructure inspection (Li & Liu, 2018; Microdrones, n.d.); precision agriculture (Kesteloo, 2019); wireless coverage provision (Harnett et al., 2008); environmental monitoring (Cohen, 2007); waste management (Leizer, 2018); mining (Suh & Choi, 2017); and inspection and insurance (Lamb, 2016).

The integration of drones into health systems represents an area of massive potential for drones (Claesson et al., 2016; Claesson et al., 2017b; Drone Delivery Canada, 2018; Fornace, Drakeley, William, Espino, & Cox, 2014; Gardner, 2016; González, Vazquez, González, Buhse & Arias-Estrada, 2017; Harnett, Doarn, Rosen, Hannaford, Broderick, 2008; Healthcare IT News Australia, 2018; Katariya et al., 2018; Latimer, McCoy, & Sayre, 2018; Médecins Sans Frontières, 2014; Merchant & Groeneveld, 2017; Nouvet et al., 2019; Rosen, 2017; Shakhatreh, 2018; Stahl, Timmermans, & Flick, 2017; UN's Children Fund, 2017; Van de Voorde et al., 2017). The importance of drones supporting healthcare services may be particularly significant in rural and underserved areas. The definition of rural area varies based on how countries characterize rural areas (United Nations, n.d.). However, normative use of the term defines rural areas as areas that are not urban in nature—they are not inhabited at “urban density levels” and these levels are country-specific (Moreno, 2017; United Nations, n.d.). Underserved areas refer to geographical areas that have limited access to quality healthcare services and healthcare providers; these are areas where the relatively poor reside (World Health Organization,

2010). Half the world's population lives in rural areas, but only 23% of health workers in the world work in these areas. In other words, the shortage in health workers is twice as high in rural areas as compared to urban areas, based on the International Labour Office, Social Protection Department's statistics of 174 countries (Scheil-Adlung, 2015). Additionally, 56% of the world's rural population does not have access to health coverage; the global deficit in rural health coverage is 2.5 times higher compared to urban areas **(**Scheil-Adlung, 2015). These statistics underscore how underserved rural communities are and the need for improved healthcare in these areas.

Drones are not the first technology with significant potential to increase health coverage to underserved rural populations. Telemedicine provides one strategy to address this issue by enabling patients to obtain medical expertise through the use of information technologies and telecommunications (Finn & Wright, 2012). Telemedicine has developed to include healthcare services such as teleconsultation and telesurgery (Wootton, Craig & Patterson, 2006). However, telemedicine presents serious limitations when it comes to any transport-contingent elements of healthcare. Until now, the delivery of medical supplies and biosamples for diagnostic or treatment purposes, such as blood, to these remote communities relies on traditional transportation methods such as by foot, aircraft, or automobiles (Health Canada, 2014; Rosen, 2017). Access using these methods can be difficult and time-consuming since some rural communities are in hard to reach areas. These communities may, for example, be located far from local hospitals, lack or have poor ground transport infrastructures, or be in mountainous areas (Gardner, 2016; Health Canada, 2014; Rosen, 2017). Drones have the potential to circumvent this problem, as they have the ability to fly to these areas to transport the necessary medical supplies and other resources. For example, in Canada, Drone Delivery Canada has partnered with Moose Cree First Nation communities living in remote areas of Northern Ontario to deliver goods such as medical supplies (Drone Delivery Canada, 2018).

The potential for drones to support health systems extends beyond rural areas. Drones hold significant promise to support infectious disease control and public health emergency response. The use of drones has further expanded since the COVID-19 pandemic: drones

are used to spray disinfecting chemical in public spaces; to issue public health announcements reminding individuals to maintain the recommended six feet distance from their fellow citizens; to transport medical supplies, such as PPE, vaccines, samples and blood to hospitals in need of these supplies; and to deliver medications, masks, and sanitizers to elders living in remote communities (Bailey, 2020; Glaser, 2020; MacFarland, 2020; Phillips, 2020; Reuters, 2020; Sherwood, 2020; Wood, 2020; Yang & Reuter 2020). During this COVID-19 pandemic, it could be seen how drone technology can be quickly adopted and serve a multitude of purposes.

1.1 Study Aim

While many have commented on the potential promise and impact of drones for health, little to date has been published about actual processes, lived experiences, and observed impacts of such integration. This thesis makes a contribution to that knowledge gap. It is based on results from an original qualitative study consisting of interviews (N = 16) with individuals on the front lines of introducing drones for health into rural communities in varying countries. The goals of this study are to:

1. Deepen understanding of the ethical and practical challenges that front line staff face when introducing drones to local communities for health-related purposes. What are the differences and similarities in their reported experiences?
2. Document and understand the rationale for strategies those involved with drones for health used to facilitate the introduction of drones for health programs. What are the differences and similarities in their reported experiences?
3. Identify best practices as seen by practitioners for introducing drones for health to communities, with the goal of supporting future decision-making or health system integration practices related to the use of drones for healthcare.

This study aims to advance understanding of the ethical and practical complexities of introducing drones for health in diverse international settings. It includes both theoretical and practical goals. This project responds to calls for the development of what Peckham & Sinha (2018) call “drone theory in global health”: more critical engagement with the social,

political, and ethical meanings and practical implications of the biomedical drone in global health supposed problem-solving. There exists only very limited empirical evidence to date on ethical and practical hopes, concerns, or challenges related to the use of drones for health in resource-limited or resource-richer settings.

This thesis takes as a premise that what qualifies as practical and ethical drone usage in healthcare contexts cannot be defined abstractly. Such parameters need to be determined in consultation with those interacting with drones. This thesis was developed in dialogue with industry partner WeRobotics, a key player in supporting the expansion of drones for development in the world. It is responsive to a call to deepen the understanding of drones for health implementation processes identified by WeRobotics co-director and -founder, Patrick Meier. It reflects in its methodology conviction that it is only by speaking with those on the front lines of implementing drones for healthcare that we can learn about different contextual particularities for such drone use, identify best practices, and develop guidance to inform future decision-making or health system integration practices related to the use of drones for healthcare. While this project gathers insights only from stakeholders implementing drones, it does begin the work of documenting and synthesizing learning from a sample group of those stakeholders about the ethical and practical realities of integrating drones for health in particular contexts.

This connects to the practical intended contribution of this thesis. Best practice guidelines have not been developed for the use of drones in non-emergency health systems; this project aims to support evidence-informed efforts to develop such guidelines. Industry partner, WeRobotics is currently using best practice guidelines developed for drone use in humanitarian context—this best practice guideline is not specific to drone use in the healthcare-context (UAV Code, n.d.; WeRobotics, 2018). The lines of enquiry in this project were developed in dialogue with co-director of WeRobotics, Patrick Meier, and incorporate WeRobotics' interest in clarifying best practices for working with rural communities in the development of drones for health programs. Through co-design with WeRobotics from the outset, this study and its findings are positioned to provide evidence-

informed drone users' understandings of best practices that can serve to inform and guide implementation of drones for health programs in communities throughout the world.

Though regulatory frameworks and toolkits are being developed to guide the operations of drones, they are neither extensive nor specific to drone use in the context of healthcare (Federal Aviation Administration, 2019a; Federal Aviation Administration 2019b; Government of Canada, 2019). Additionally, toolkits that were developed by the Federal Aviation Administration, such as community engagement toolkits, were not specific to drone use in healthcare (Federal Aviation Administration, 2019a). Instead, these toolkits focus on drone safety, and 'do's' and 'don'ts' during drone flights for recreation, hurricane, and wildfire use (Federal Aviation Administration, 2019a).

This study is the first exploratory study of its kind. The findings from this study are intended as grounding for a larger multi-sited study of values informing adoption or resistance to drones for healthcare and will include exploration of target populations' perceptions of drones for health programs.

1.2 Theoretical Framework

1.2.1 Global Health Ethics

This research takes a global health ethics framework as its theoretical point of departure. Global health is defined as:

> "an area for study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide. Global health emphasises transnational health issues, determinants, and solutions; involves many disciplines within and beyond the health sciences and promotes inter- disciplinary collaboration; and is a synthesis of population-based prevention with individual-level clinical care" (Koplan et al., 2008).

The multitude of overlapping crises that threaten the health of many individuals resulted in the development of global health ethics (Pinto & Upshur, 2013). Global health ethics, a

new and emerging field, is the process of applying ethical analysis to various global health issues (Pinto & Upshur, 2013; Stapleton et al., 2014). Ethical analysis helps evaluate the different courses of action taken to mitigate global health issues and their social consequences; anticipating the social implications of these actions will mitigate any potential risks and consequences that stakeholders need to bear as a result of these global health initiatives (Benatar, Daar, & Singer, 2003; Pinto & Upshur, 2013). Ethical analysis brings a critical perspective to global health work that encourages reflection and deliberation about social justice, fairness, professional duties, duties to others, and power imbalances (Pinto & Upshur, 2013). Global health ethics may attend to any number of interrelated issues at once, taking into consideration, for example, how human rights, economic opportunities, good governance, and peace and development play a role in global health issues (Benatar, Daar, & Singer, 2003). Ultimately, a global health ethics lens is guided by a goal of reducing risks of doing harm and encouraging individuals to do their best in the context they are working in (Pinto & Upshur, 2013).

Global health origins date back to tropical medicine and international health which are a result of colonialism and the industrial revolution, respectively (Pinto & Upshur, 2013). These fields of medicine served elite political and commercial interests; normalizing the authority and expertise of privileged groups, while often pushing aside as irrelevant or irrational indigenous, racialized, or poor populations' knowledges or health-seeking practices (Pinto & Upshur, 2013). Tropical medicine and international health operated to deny the value and importance of local knowledges as well as non-specialized populations' inputs on healthcare program design (Pinto & Upshur, 2013). Global health ethics falls within critical global health approaches. It is mindful of the historical past of global health, and advocates for awareness of how this legacy of colonialism and imperialism impacts relationships between those leading global health efforts, and the populations these claim or aim to serve (Godard et al., 2018; Pinto & Upshur, 2013). Moving beyond such normative inequalities between the knowledge/expertise/authority of some, over local, non-professional, or indigenous knowledges, requires ensuring methods used in research actively seek ways to bring historically under-represented perspectives to bear on global

health policy and practice. While there is no doubt individuals from the host community or receiving end of drones for health projects must be involved moving forward in elucidating the practical and ethical complexities of drone technologies in the space of global health, this project does initiate consideration of under-represented perspectives by foregrounding experiences of individuals involved with drones primarily in the Global South, and based on work in and with populations in underserved rural areas.

Global health addresses a wide scope of complex issues and challenges—this means that ethical issues require inter-professional, trans-disciplinary, and transcultural understanding (Godard et al., 2018; Pinto & Upshur, 2013). Public health ethics and bioethics have provided principles and frameworks that helps guide the thinking and understanding of global health ethics (Pinto & Upshur, 2013). For example, the principles of bioethics include autonomy, beneficence, non-maleficence, and justice (Pinto & Upshur, 2013). These principles provide an ethical framework for conducting health research involving humans—these principles are used as benchmarks by research ethics committees influencing medical research internationally (Pinto & Upshur, 2013; Stapleton et al., 2014). These principles then lend themselves to the understanding of normative global health ethics (Stapleton et al., 2014). Additionally, according to Benatar et al. (2003), there are seven underlying values global ethics is built on: 1) respect for all human life; 2) human rights, responsibilities and needs; 3) equity; 4) freedom; 5) democracy; 6) environmental ethics and most importantly; 7) solidarity. These values inform an individual's understanding of the morality of global health (Benatar, Daar, & Singer, 2003; Pinto & Upshur, 2013).

Of these values, solidarity is recognized as very valuable to global health and global health ethics because it promotes mutual caring, encouraging individuals to foster the above-mentioned values and question indignities, violations of human rights, inequities, lack of freedom, undemocratic regimes, and damage to the environment (Benatar, Daar, & Singer, 2003; Pinto & Upshur, 2013). Solidarity is fostered when communities are mobilized, there is capacity building of local organizations and civil societies, and power imbalances are bridged (Pinto & Upshur, 2013). Centering global health initiatives around community

engagement is one way to foster solidarity (Pinto & Upshur, 2013). This involves upholding community self-determination respecting community customs and codes of practices, ensuring that these initiatives are of social value to the local community, and sharing outcomes and results of the initiative to communities (Pinto & Upshur, 2013).

The Global West attempts to systematize global health ethics through the development of ethical frameworks (Godard et al., 2018; Pinto & Upshur, 2013). However, global health ethics must rely on tactile modes of knowing; global health practitioners need to integrate themselves within the communities they are working in, to experience and contextualize the ethical issues that may arise from global health initiatives. Developing these modes of knowing requires engaging with communities and those who benefit from innovation in global health instead of passively conforming to existing guidelines (Godard et al., 2018). Engaging with communities allows public health practitioners to better contextualize the moral reasoning of global health initiatives (Benatar, Daar, & Singer, 2003; Godard et al., 2018; Pinto & Upshur, 2013). What is considered "right" is neither self-evident nor universal (Pinto & Upshur, 2013). Ethical debates emerge because of the contexts they occur in; different individuals, communities, and organizations have different concepts of what is "right" (Benatar, Daar, & Singer, 2003; Godard et al., 2018; Pinto & Upshur, 2013). People in different countries hold different values and/or place different weights on common values meaning that there may be more than one way to address global health-related ethical challenges (Godard et al., 2018; World Health Organization, 2015). Ethical standards, therefore, may not be universal (Pinto & Upshur, 2013; World Health Organization, 2015).

Ultimately, global health ethics aims to reduce health inequalities by critically evaluating global health initiatives' social consequences with an ethical lens. Global health ethics is currently at its infancy, however, reflections surrounding ethical issues in global health should be deepened to better identify strategies to manage competing ethical responsibilities while promoting the implementation of global health initiatives (Godard et al., 2018).

1.3 Thesis Outline

This thesis includes five stand-alone chapters, including the present chapter which serves as an introduction to the research question and its significance, as well as the below brief description of subsequent chapters.

Chapter two presents an overview to help better understand this research topic. This overview provides a background on current uses of drones in the healthcare sector. Additionally, it provides a background of ethical and practical concerns related to the use of drones in healthcare identified in the literature. This chapters highlights some of the gaps in the literature that this research attempts to address.

Chapter three includes a description of the methods utilized to conduct this study. It describes how participants were recruited and how semi-structured interview guides were developed. It goes into detail about how the data collected from the study were analyzed.

Chapter four is the main findings chapter and comprises a published academic article (published in August 2020). It describes the key themes identified in the 16 interviews conducted for this study based on directed and thematic analysis. It provides a description of the participants, who participated in the study, and the kinds of drones for healthcare projects they are involved in. This chapter summarizes indirect benefits, direct benefits, concerns, ethical challenges, and practical challenges related to the implementation of these drones from health projects. Chapter four includes by necessity, given it is formatted as a self-contained manuscript for a journal submission, methodology, and discussion sections, and as such creates some repetition within the thesis.

Chapter five is the final chapter of this thesis. This chapter briefly summarizes the study's key findings and their significance within drones for health scholarship. Specifically, the results of this study are unpacked in relation to the literature described in chapter two, and with the attentiveness to local knowledge, power relations, and issues of equity and justice that constitute the trademark considerations with analysis informed by a global health ethics framework. Key implications of the study's findings for the development of a global

guidance document are outlined. Finally, this chapter describes the limitation of this study and provides future research suggestions that could advance the findings and application of this study.

Chapter 2

2 Background

This chapter presents an overview of the current uses of drones for healthcare and the ethical and practical concerns identified in the literature relevant to using drones for healthcare. This background aims to situate the significance of this project within broader discussions of expanded drone uses, and highlights gaps in current literature about the use of drones in healthcare. Section 2.1 is an extension of a scoping review I co-authored focused exclusively on applications of drones for health within the North American context (Hiebert, Nouvet, Jeyabalan & Donelle, 2020).

2.1 Drones for Healthcare Delivery

To identify challenges, opportunities, and ethics of drones for healthcare delivery it is important to understand the current uses of drones for healthcare delivery. Gaining a better insight on what drones are being used for, where it is being used, and what it transports can inform future trends for drones in healthcare and the potential context-specific challenges and opportunities associated with the use of drones. In addition, recognizing the current use of drones in healthcare delivery will illustrate the rapid growth of this technology in healthcare and the urgent need to identify best practices, and develop guidance to inform future decision-making or health system integration practices related to the use of drones for healthcare.

2.1.1 Medical Transport System and Patient Care

Madagascar, Malawi, and Senegal have conducted drone test flights to successfully deliver medical samples in a timely and efficient manner for diagnosing and treating medical issues such as tuberculosis and HIV (Knoblauch et al., 2019). In North America, drones were used to deliver critical medications to an underserved, rural Appalachian region in Virginia—the pharmacist received a package containing medications from the drone, and then distributed the medication to the patients (Gardner, 2016). This was an efficient way to deliver healthcare to a region that is in a mountainous area and experiences frequent

heavy snowfalls in the winter (Gardner, 2016). In 2016, the drone company Zipline, started performing commercial tests to use drones to deliver blood from Rwanda's capital city to local hospitals (Ling & Draghic, 2019). The drones were able to deliver blood in 15 minutes, whereas it normally takes four hours by road; this can save many lives especially during life-threatening emergencies (Ling & Draghic, 2019). Drones have also been tested to deliver other medical supplies such as oxytocin for maternal health, human organs, and essential medicines, and contraception for women (Knoblauch et al., 2019; Laksham, 2019; Scalea et al., 2019). Furthermore, studies have shown that drones delivering automatic external defibrillator (AED) can reach a victim approximately 19 minutes faster than the emergency medical services (EMS), improving patient survival and recovery rates (Claesson et al., 2016; Claesson et al., 2017b; Latimer, McCoy, & Sayre, 2018; Merchant & Groeneveld, 2017; Van de Voorde et al., 2017). Additionally, Harnett et al. (2008) overcame the barrier of absent wireless networks in a battlefield by using a drone to establish a wireless communication network so that surgeons can perform telesurgery (Harnett et al., 2008). The ability to deliver medical supplies in emergency and non-emergency situations, assess the likelihood of an infectious disease outbreak, and perform diagnostic testing using drones allows healthcare professionals to remotely provide care (Subbaro & Paul, 2015).

2.1.2 Laboratory Diagnostic Testing

As mentioned above, the use of drones expedites the process of delivering biological samples to laboratories in order to diagnose patients in a timely manner (Knoblauch et al., 2019). In addition, pre-processing the samples en-route during drone transportation helps preserve the viability of the biological samples (Katariya et al., 2018). Katariya et al. (2018) programmed drones to do a simple flip maneuver demonstrating that samples could be mixed during drone flights. Priye et al. (2016) developed a portable biochemical analysis platform that creates a "lab-on-a-drone", where polymerase chain reaction and centrifugation can be performed using drones. These drone functions further expedites testing processes, ensures that samples are preserved, and improves access to lab services.

2.1.3 Public Health

Drones have been used for public health surveillance to monitor the epidemiology of health problems. For example, drones were used to obtain spatial information in order to integrate human and macaque, species of Old World monkeys, movement and vector bionomics to understand the epidemiology of zoonotic malaria (Fornace, Drakeley, William, Espino, & Cox, 2014). Additionally, drones have been used to monitor wildfires so that the wildfires can be assessed and managed (Cohen, 2007; Levine et al., 2004). Furthermore, a study used drones to assist paramedics with assessing and identifying hazards of mass-casualty environments to prepare paramedics when they arrive on scene (Jain 2018a; Jain 2018b). Furthermore, drones have been used for emergency response such as search and rescue and backcountry emergencies (Clark, Ford & Tabish, 2019; Van Tilburg, 2017) While such use of drones can provide important epidemiological support within health systems, it also raises ethical concerns which will be discussed in greater detail below.

2.2 Ethical and Practical Concerns Related to the Expanded Use of Drones in the Literature

Many have expressed concerns about the expanded use of these drone technologies in society. These include concerns about the impacts of drone use for different purposes on privacy, individual and population safety, dual uses of drones, obtain affected populations' consent for drone use, as well as limited regulations and guidelines in general. A majority of these concerns are expressed in the literature vis a vis the use of drones outside healthcare usages. There are only a few identified concerns that pertain specific to drone use in health (Peckham & Sinha, 2019). In the face of limited scholarly exploration of ethical and practical challenges and concerns of using drones for health, these more general concerns about drone uses are nevertheless important to pay attention to, as these signal areas of potential concerns that may arise when using drones for healthcare purposes.

2.2.1 Privacy Concerns

At present, privacy represents a significant ethical issue with drone use. Privacy concerns have emerged due to the drone's ability to capture real-time aerial and thermal images and videos; drones capture videos and images of patients, public and private spaces, and civilians inhabiting these spaces (Abrahamsen, 2015; Finn & Wright, 2016; Gevaert, Sliuzas, Persello, & Vosselman, 2018). In general, drones are capable of identifying and tracking individuals, thereby infringing an individual's privacy of location and information (Finn, Wright, & Friedewald, 2013). For example, data collected by drones can be analyzed to inappropriately detect an individual's behaviour, expose their habits, and organizations may use this information to penalize the individual—this may include infringement of individuals' freedom, public shaming, and fining individuals (Gevaert, Sliuzas, Persello, & Vosselman, 2018; Righetti, Vallati, & Anastasi, 2018). This can potentially impact the privacy of data and images, as individuals may not be aware that drones are monitoring them (Finn, Wright, & Friedewald, 2013). Drones' ability in many instances to record and stream videos and images to a large number of people could potentially make it challenging to protect patient privacy and confidentiality (Abrahamsen, 2015). Finally, drones can infringe the privacy of space as it can record images and videos of an individual's private spaces including capturing images inside homes, offices, and backyards (Abrahamsen, 2015; Dayananda, Gomes, & Straub, 2017; Finn, Wright, & Friedewald, 2013). These videos obtained by drones need to be anonymized and treated as part of a patient's medical records for confidentiality and privacy purposes (Abrahamsen, 2015).

Like other health technologies, the use of drones in healthcare to record information, visual or other, does raise questions of who owns the data, who has access to the data, and whether it is necessary to record this information (Abrahamseon, 2015; Demster, 2012). As part of figuring out the ethical and practical best practices for the integration of drones in health systems, it will be important to consider for each use context how such recording is perceived and understood: whether it is a source of concern (or not) to diverse stakeholders; whether the data recorded is necessary to provide care; whether there are ways to using

drones without recording data; and how best to obtain informed consent from those whose information is being recorded by these drones.

Whether drones present privacy concerns will vary from context to context. This contextual nature of drone use is exemplified in a recent study conducted in Eastern Africa aimed to evaluate the societal impacts of using drones for informal settlement mapping (Gevaert, Sliuzas, Persello, & Vosselman, 2018). In this study, researchers found that community members were concerned about their privacy in relation to drones taking images of private spaces and what is happening in these private spaces, and also how this data will be used (Gevaert, Sliuzas, Persello, & Vosselman, 2018). Furthermore, the local laws and social norms affected what each community identified as sensitive and private in the images captured by drones emphasizing the importance of local contexts on individual's perception of privacy (Gevaert, Sliuzas, Persello, & Vosselman, 2018).

Likewise, the purpose of drone use and its function impacts an organization's and its members' perception of privacy (Finn & Wright, 2016). Finn and Wright (2016) used self-reports to understand the concerns of industry representatives, regulators, and civil society organizations regarding privacy, data protection, and other ethical issues that arise from the use of general civil drone operations. In this study, 62% of drone manufacturers and operators indicated that privacy and data protection issues were not relevant to them since the drones did not "focus on people on the ground and that any incidental capture of images of members of the public was often limited to 'the tops of their heads'" (Finn & Wright, 2016, p. 581). For the manufacturers and operators, privacy and data protection were reported as not relevant concerns in their understanding of what the drones "see". At the same time, Finn and Wright (2016) observed that the majority of the drone operators, drone designers, and manufacturers stated that they did not know whether the drones they used captured images—without this knowledge it is highly unlikely that these stakeholders considered privacy issues that may arise from collecting data. However, most of the drones being discussed in this study did capture images that were stored or transferred to other organizations. This study may indicate one of two possibilities, both problematic. It may indicate limited awareness of potential ethical issues related to the use of drones within the

industry. Alternatively, individuals may be reporting that drones pose little to no risks to individual privacy to over-emphasize the benefits and minimize potential social concerns or risks of these technologies to investors or other decision-makers (e.g. governments). The present study provides an opportunity to further explore how prevalent concerns with privacy may be for implementers around the world, and whether or not the presence or absence of concerns is based in a clear consideration of ethical risks and obligations within particular settings.

Drones operators need to consider the payload, data ownership, and who will be impacted on the ground to better understand the potential harms of drones and what they can do to mitigate it (Finn & Wright, 2016). If individuals do not understand how drones operate, they will not be capable of identifying the ethical concerns that emerge from drone use. Gevaert et al (2018) have noted that in order for civilians to protect their privacy, they must understand that the drones are collecting their data. If individuals become aware of how drones function, then they can be proactive and take the appropriate precautions to protect their privacy (Gevaert, Sliuzas, Persello, & Vosselman, 2018).

2.2.2 Safety Concerns

The introduction of civil drones presents many safety concerns; data safety, human safety, and flight safety (Boucher, 2016; Claesson et al., 2016; Damon, 2017 Moskowitz, Siegel-Richman, Hertner, & Schroeppel, 2018; Righetti, Vallati, & Anastasi, 2018). As above, drones can collect sensitive and personal information that citizens are unwilling to share—putting their personal safety at risk (Righetti, Vallati, & Anastasi, 2018). Since it is also difficult to identify who is using the drone and for what purpose, there are concerns that this anonymity could lead to criminal misuse. such as monitoring an individuals' private spaces and stalking victims (Boucher, 2016). Furthermore, since drones are vulnerable to hijacks and attacks by malicious users, an individual's personal data could be stolen and their privacy could be violated (Righetti, Vallati, & Anastasi, 2018). Additionally, incorrect medical deliveries can be made by drones, thereby putting patient privacy at risk (Claesson et al., 2016). These incidences of drone hijacking and losing medical supplies means that

there is a potential that patient samples can be hijacked, lost, or destroyed during drone deliveries—this further puts patients' privacy and safety at risk. Therefore, the ability of drones to collect sensitive data gives rise to data safety concerns.

Drones are capable of causing harm to physical harm. For example, A child suffered from ocular globe rupture after being hit by the propeller of a remote-controlled drone (Moskowitz, Siegel-Richman, Hertner, & Schroeppel, 2018). In addition, there are flight safety concerns due to an increasing rate of small drone collisions that result from a lack of clear flight regulations and standards for operations (Damon, 2017).

2.2.3 Mistrust Related to Drone Use

Utilizing drones in some contexts can further cause tension and mistrust between the state and its members. Drones are being tested in areas that have long histories of colonial surveillance where unmanned and manned vehicles have been used for reconnaissance, war, surveillance, and scientific research (Kindervater, 2016; Peckham & Sinha, 2019). These collective colonial and postcolonial memories can inform citizens' responses to contemporary health campaigns (Peckham & Sinha, 2019). This needs to be taken into consideration, especially though not exclusively where drones for health programs are being deployed in parallel with the deployment of military drones (Peckham & Sinha, 2019; Laksham, 2019). First- or second-hand knowledges of drones being used for military or other non-humanitarian purposes can potentially re-traumatize and even exacerbate the mistrust citizens have of drones as healthcare technologies (Sachan, 2016; Peckham & Sinha, 2019).

2.2.4 Consent and Drones for Healthcare Projects

The literature highlights that obtaining informed consent raises ethical issue for drone use. Individuals may be unaware that drones are monitoring them, meaning that they are being recorded without their consent (Finn, Wright, & Friedewald, 2013). In some situations, patients and bystanders may lack the capacity to consent since they are underage, unconscious, or severely injured (Abrahamsen, 2015). This means it may be difficult to

obtain informed consent from individuals (Abrahamsen, 2015). The National Telecommunications and Information Administration (NTIA), an organization responsible for advising the President of the United States on telecommunications and information policy, recommends that individuals should be notified about drone data collection practices through privacy policies (National Telecommunications and Information Administration, n.d.; National Telecommunications and Information Administration, 2016; Winkler et al., 2018). However, this strategy has been criticized to be inappropriate since privacy policies are inaccessible due to the language used in the policies and where it is posted (Winkler et al., 2018). Additionally, these privacy policies imply informed consent—depending strictly on these privacy policies to obtain informed consent is problematic (Winkler et al., 2018).

Cawthorne and Wynsberghe (2020) developed an ethical framework for the design, development, implementation, and evaluation of drones employed for healthcare purposes. This ethical framework was developed around one of the four key principles in medical bioethics, autonomy, which states that individuals have the right to make their own informed choice (Beauchamp & Childress, 2009; Cawthorne & Wynsberghe, 2020). The authors stated that individuals need to provide informed consent to allow drone operations to occur; this means they need to be informed about the healthcare drone operation, the reason for drone use, and the potential risks and benefits (Cawthorne & Wynsberghe, 2020). Cawthorne & Wynsberghe (2020) suggested that organizations should determine the minimum number of individuals that need to disapprove using drones for healthcare purposes in order to halt these projects. Alternatively, like traditional healthcare projects, drones for health projects can forgo individual consent if government officials and technology developers give consent-by-proxy (Cawthorne & Wynsberghe, 2020).

The need for consent is further complicated when drones are used in research projects as they can collect data on humans both advertently and inadvertently (Resnik & Eliott, 2019). The need for informed consent depends on whether these drone projects fall into non-human subjects research, exempt human subjects research, or non-exempt human subjects research categories (Resnik & Eliott, 2019). Obtaining informed consent for drone projects

could be onerous or even impossible due to the indefinite number of individuals that need to be contacted (Abrahamsen, 2015; Resnik & Eliott, 2019). Due to the practical challenges of obtaining informed consent, drone projects are likely conducted without consent from individuals (Resnik & Eliott, 2019).

2.2.5 Lack of Regulations and Guidelines

It is important to note that there are limited guidelines available describing how to employ drones responsibly and ethically in the context of healthcare delivery (UAV Code, n.d.). Currently, organizations such as WeRobotics are relying on guidelines created for the humanitarian context when initiating projects that use drones for healthcare (WeRobotics, 2018). This guideline describes data protection, community engagement, effective partnerships, and conflict sensitivity in the context of humanitarian drone use (UAViators, 2016). Examples of suggestions in the guidelines include the following: establish a Standard Operation Procedures, consider solution for privacy and ethical sensitives when collecting data, consider risks caused to the environment, identify appropriate community representative for community engagement, define terms and duration of partnership when collaborating with companies or organizations, etc (UAViators, 2016). However, this guideline does not include healthcare specific considerations to facilitate responsible and ethical drone use specifically for these healthcare projects (UAViators, 2016). Instead these guidelines make specific recommendation for the use of drones for humanitarian deployment (UAViators, 2016). For example, it mentions how to develop effective partnerships for disaster response preparedness missions (UAViators, 2016). In addition, data protection guidelines are tailored based on whether drones are used in response to natural disasters or armed conflicts (UAViators, 2016). This guideline does not make recommendations for the use of drones for healthcare programs. This is significant as regulations and negotiating rights to fly drones are a common barrier to initiating and accelerating healthcare-related drone projects (Amukele, 2019; Peckham & Sinha, 2019). Currently, flight requests for flying drones for healthcare applications are being done on an exception basis due to the lack of clear drone flight regulations in many countries (Yang & Reuter 2020). This raises concerns that companies are using places such as Africa to test

drones for healthcare since it does not have rigorous regulatory requirements without really considering the impact drones have on broader infrastructures in these countries (Peckham & Sinha, 2019).

2.3 Summary and Identified Gaps

There is an ever-growing interest in using drones for healthcare delivery, from public health to delivering medical supplies. With this growing interest in the use of drones for healthcare, there is an urgent need to develop evidence-informed recommendations to guide the use of drones for healthcare projects. Drones are unique healthcare technologies, and their uses and perceptions are far from uniform. More careful studies of drones' uses and actual and potential implication in particular settings can begin to outline how drones are affecting healthcare delivery, transforming practices of global health, redefining the roles of healthcare workers, and changing current forms of health management governance (Peckham & Sinha, 2019). Such research can, in the words of Peckham and Sinha (2019), contribute to a "global drone theory", and ensure that as these technologies undergo expanded usage within healthcare, so does the ability of users and scholars to identify and query the practical, ethical, and contextually particular impacts of this expansion.

Current scholarship outlining ethical concerns related to the introduction of drones in public life and governance is limited and has not focused in particular for the most part on drones used for healthcare purposes (Peckham & Sinha, 2019). So, for example, many have raised potential privacy and safety concerns, but these mainly relate to the use of drones in settings other than healthcare. More research needs to be done to explore how drones can impact patient privacy in the healthcare sector and how this differs between varying cultures. It is important to also understand how privacy is compromised based on different uses of drones (medical transport system, laboratory diagnostic testing, public health, and telemedicine) within healthcare. The privacy concerns that arise due to carrying a vaccine to a community are different from the privacy concerns that arise from carrying patients' biological samples. Understanding how these context-specific factors affect real and perceived privacy concerns allows stakeholders to implement contextually and culturally

relevant strategies to protect patient privacy. The present study provides an opportunity to document and understand organizations' and implementers' understanding of potential privacy, data, and safety concerns related to the use drones for particular healthcare purposes, involving working with and flying over particular populations and locations, around the world.

The literature highlights that obtaining informed consent in the context of drone use for healthcare is complicated. It is unclear at present the extent to which consent is obtained in drones for health programs in distinct settings. A study suggested that drone operations could be conducted through consent-by-proxy from government officials and technology developers once the technology is tested and fit to be used. This means consent should be sought when drones are being tested. However, it is unclear what the expectation is regarding obtaining informed consent outside of research settings both from those running programs and from populations being impacted by them. It may also be challenging to contact individuals for informed consent due to the nature of drones for health projects impacting an indefinite number of people. While this study is focuses exclusively on implementers of drones for healthcare, and thus is not gathering the crucial perspective of host populations, it can nevertheless advance understanding of differences and potential contextual particularities, as well as challenges or strategies used to navigate the complexities of consent with respect to drones for health.

It is clear from the literature that the lack of regulations regarding the operations of drones is a barrier to implementing drones for healthcare delivery. In addition, there are no best practice guidelines available to support the ethical use of drones in the context of healthcare.

This study has been developed in response to these gaps in the literature and guidance related to the use of drones for health. It involved original qualitative research with managers and front line staff working with drones for health projects. Some of the challenges that emerged in interviews with these individuals echo concerns, challenges, and ethical complexities of drone use signaled in the literature. Additional context-specific

concerns, complexities, and challenges also surfaced as a result of the in-depth one-on-one interviews with implementers at the core of this study. Connections between this study's findings and the literature reviewed above will be made in chapter five, including recommendations. These include recommendations are made at the end of this study to help draft guidelines and a global guidance document to help mitigate key challenges emphasized by front line staff.

Chapter 3

3 Methods

This qualitative study involved original data collection through semi-structured in-depth interviews with individuals working on the front lines of drones for health programs (program managers, drone operators, and other field staff) in varying countries and Flying labs[1] (N = 16). Qualitative research allows for an in-dept understanding of individual's lived experiences that could inductively generate theories to understand the phenomenon at hand (Waller, Farquharson & Dempsey, 2016) As a multi-sited comparative perception study, it replicates an approach commonly used in program design and quality improvement in the healthcare and humanitarian aid sector (Benton, Sangaramoorthy, & Kalofonos, 2017; Nouvet, Abu-Sada, DeLaat, Wang, & Schwartz, 2016; Nouvet & Schwartz, 2017; Nouvet, Chan, & Schwartz, 2018; Nouvet et al., 2019; Posega, 2014; Reeves et al., 2014). Perception studies are often used in healthcare to understand how front line health staff, patients, policy-makers and community view healthcare delivery; these studies provide insight about the satisfaction, perceived advantages and disadvantages, and perceived importance of health programs (Alrashdi & Al Qasmi, 2012; Papadaki & Dvorsky. 2018; Tabler, Scammon, Kim, Farrell, & Tomoaia- Cotisel, 2014). Studying stakeholder perceptions of health programs is useful in: understanding whether specific health programs are working as intended; identifying unanticipated impacts or meanings of programs; and what modifications are needed to improve them in the eyes of those using and implementing the health program. Those directly involved in the implementation of health programs are more connected to the projects and can provide a description of their lived experiences of introducing such programs opposed to experts or individuals unfamiliar with the day to day operations of these projects. This perception

[1] Flying Lab are local knowledge hubs that are developed and supported by WeRobotics to accelerate the positive impact of projects in a sustainable manner; it increases economical and individual capacity at the local level. Flying Labs train local partners on how to use robotic technology responsibly and effectively to implement social good solutions (WeRobotics, n.d.b).

study gives insight into how drones are perceived in various country settings; this will have an important role in informing evidence-based guidance for context-specific implementation of drones for healthcare. This study involved co-investigators from Western University and WeRobotics, the leader in the set-up and training of Flying Labs and a leader in the development of humanitarian and aid UAV best practice (WeRobotics, n.d.a). A copy of the MoU can be found in **Appendix A**. Below is a more detailed summary of the methodological approach for this qualitative study.

3.1 Participant Recruitment and Sample Details

This study used purposive and snowball sampling to recruit participants. The minimum inclusion criterion for participation was involvement with introducing drones to communities specifically for healthcare purposes. In addition, potential participants had to be willing to discuss their experiences doing so within the particularity of the projects with which they were involved: decision-making processes about where to work, how they engaged communities, what challenges they faced, and how they mitigated said challenges.

Initially, recruitment focused on individuals involved with drones for health programs in association with Flying Labs. Patrick Meier introduced Vyshnave Jeyabalan to various Flying Lab coordinators that were part of active or recently active health-related programs through e-mail, with an invitation to identify program managers, technical support, community engagement agents, or any other pertinent individuals with drones of health experience in the past year, who could also be invited to participate in the study. With limited responses to participation invitations, three months into recruitment, recruitment strategy was expanded to include individuals working with drones for health programs outside the Flying Lab network. Study investigators approached their established network of contacts to identify potential participants. This second phase of recruitment relied on the dissemination of a recruitment poster through a monthly newsletter that was circulated by

the Unmanned Aerial Vehicles for Payload Delivery Working Group[2]. Recruitment poster can be found in **Appendix B**. Vyshnave Jeyabalan then contacted potential participants via e-mail and sent them an invitation to participate in the research study.

This specific participant inclusion identified key informants who can help maximize the potential impact of the research. Since this study utilized snowball sampling, investigators requested participants to introduce them to colleagues working in similar capacities either in that country or in another country context that might be receptive to an invitation to participate. This allowed the investigators to use the knowledge gained from the interview to request the participant to introduce them to specific individuals who were involved in implementing drones in communities for healthcare use. This gave investigators the opportunity to recruit participants that can best speak about the research topic.

Vyshnave Jeyabalan sent an email with the letter of information (LOI) and consent form when inviting individuals to participate in research. The letter of information and consent form can be found in **Appendix C**. Participants were given an opportunity to read the LOI and sign the consent form prior to the interview. Participants also had an opportunity at the beginning of the interview to read the LOI, ask questions, and sign the consent form. Signed consent forms were stored in Western's OneDrive that can only be accessed by Vyshnave Jeyabalan, Elysée Nouvet, and Lorie Donelle.

There were challenges in the recruitment process. Given the focus of recruitment was on individuals working in the field with drones, many were hard to reach through phone or email. It was also tricky to schedule interviews given many of these individuals worked in areas with low internet connectivity. Feasibility was increased by the small sample size (nevertheless sufficient for detailed and context-specific data sought), and by Elysée Nouvet's established network of contacts in the drones for health program community. An

[2] "The Unmanned Aerial Vehicles for Payload Delivery Working Group (UPDWG) is a global community of stakeholders interested in the development, advancement and application of drones for use in public health and supply chain systems" (UPDWG, n.d.).

additional limitation of this study was that given this project utilized a snowball sampling strategy, no Europe projects were referred to us by the participants from this study, so no projects from this geographical area were included in the study.

3.2 Interview Procedure

The semi-structured interview guide used to learn about front line staff's experiences were informed by key ethical complexities identified in the literature and aimed to address some of the gaps in the literature. The interview guide was developed by Vyshnave Jeyabalan in dialogue with the co-investigators (Nouvet, Donelle, Meier). The interview was organized into four parts: 1) General Context; 2) Working with the Community; 3) Community Engagement; and 4) Additional Ethical and Practical Challenges. The first part of the interview asked questions such as "Tell me a bit about the first project on which you worked in [COUNTRY] that involved using drones for some healthcare related purpose" and "Did you or those with whom you were working have any concerns about introducing drones in this community (security, safety, viability, economics, sustainability)?". These questions provided information about the details of the project such as timeline of drones for health projects and who was involved in the decision-making process. Additionally, it helped identify some of the concerns related to these projects. The next part of the interview asked questions such as "Can you describe to me what was involved in introducing this drone-mediated healthcare program to the community?" and "Who did you contact and meet with?". Through community-related questions, it was possible to delve into participants' perception of host community responses to the programs, as well as document concerns, questions, or preferred processes for introduction of these drones for health programs brought to their attention by the community members with whom they worked with. Questions about the participants' experience of introducing drones provided the opportunity to obtain detailed insight into the processes and actors involved in obtaining permissions for such projects in specific settings. The third part of the interview focused on participants' perception of community engagement and how stakeholders were engaged. This section included questions such as "What does community engagement mean to you?" and "Are community members involved in evaluating the program?" The final part of the

interview further explored participants' experience by asking participants to elaborate on the ethical and practical challenges they faced during the implementation of drones for health projects. These questions asked participants to reflect on the privacy of health information, general privacy, and safety protocols related to or used in their projects. The full semi-structured interview guide can be found in **Appendix D**.

Interviews lasted between 20 and 140 minutes, with an average interview duration of 78 minutes. Interviews were digitally recorded with the consent of the participants. Interviews were transcribed verbatim and, where necessary, translated from Spanish and Nepali into English. Vyshnave Jeyabalan and Elysée Nouvet conducted interviews via Skype, Viber, or phone. Elysée Nouvet is fluent in English, French, and Spanish, and has a working knowledge of Nepali. Participants were given the option of being interviewed in English, French, Spanish, or Nepali. Western graduate student Ishor Sharma assisted with interviews that required a Nepali translator.

3.3 Analysis

The interview data was analyzed using directed thematic and interpretive description methods (Maguire & Delahunt, 2017; Nouvet et al., 2019; Thorne, 2016). Interpretive description is a qualitative methodology that was initially borne due to the need to conduct applied qualitative research to gain an understanding of complex experiential clinical phenomena in the nursing field (Thorne, 2016). Interpretive description allows researchers to do applied research based on actual real-world question (Thorne, 2016). The advantage of using interpretive description is that the study design can be modified according to the context, situation, and intent of the study, and the analysis can be put back into the context of the practice field (i.e. considering the social, political, and ideological complexities) (Thorne, 2016). The goal of directed thematic analysis is to identify key themes in the data that will help interpret the research data; the themes allows researchers to identify implicit and explicit meanings based on the interview data (Maguire & Delahunt, 2017; Nouvet et al., 2019).

Interviews were coded using NVivo 12.0 (QSR) software based on a coding framework. NVivo software supports accuracy, transparency, and the opportunity for auditing qualitative data analysis (Welsh, 2002). In this case, NVivo was used for thematic analysis, "a form of pattern recognition used in content analysis whereby themes (or codes) that emerge from the data become the categories for analysis", further tailored to the study's research objectives through a combination of directed and interpretive approaches (Maguire & Delahunt, 2017; Nouvet et al., 2019; Roberts, Dowell & Nile, 2019; Thorne, 2016; 42–43]. Vyshnave Jeyabalan established an initial set of codes based on the research questions (directed thematic analysis approach). The usability of this codebook was tested through initial coding of four interview transcriptions. Towards ensuring this testing was robust, and to ensure that the codes indicated were appropriately named and well suited to the content of the interviews, Vyshnave Jeyabalan and Elysée Nouvet engaged in parallel and independent coding of the same four interview transcriptions. Vyshnave Jeyabalan and Elysée Nouvet developed the codebook with an openness to renaming codes or adding additional ones as needed. In doing so, both adopted, in addition to the directed thematic approach to data analysis, an interpretive description approach. Interpretive description seeks to advance understanding of a phenomenon by illuminating its "characteristics, patterns and structure" while being attentive to nuances and differences (Thorne, Kirkham & O'Flynn-Magee, 2004). With this in mind, Vyshnave Jeyabalan and Elysée Nouvet remained alert in their coding of the same first four interviews independently to implied potential meanings of participant statements, in addition to explicit descriptions of, for example, challenges or evaluations of "good" practice. Codes were added as necessary to the initial set of codes, to capture additional themes. Vyshnave Jeyabalan and Elysée Nouvet then compared the key themes they had identified, and, where differences existed in the naming of themes or their thoughts on their relationship to other themes, these differences were discussed, and consensus sought on key emerging themes. When consensus could not be reached, Vyshnave Jeyabalan and Elysée Nouvet consulted with co-investigator Lorie Donelle to reach consensus. Vyshnave Jeyabalan coded the remaining interviews based on the resulting coding framework. Minor changes (i.e. change in theme names or addition of emerging themes) were made to the codebook in an iterative

process. Elysée Nouvet and Lorie Donelle were consulted throughout the analysis process to increase coding accuracy. Elysée Nouvet performed an audit of the final codebook, to ensure coding completeness and accuracy.

3.4 Ethics

Ethics approval for the study was obtained from the Western University Non-Medical Research Ethics Board (**Appendix E and Appendix F**). Transcripts of de-identified interviews are stored digitally and be both password protected and encrypted. All audio recordings of interviews were deleted following verification of transcription accuracy. All data are stored on the secured Western University server, OneDrive, which only investigators will have access to. Electronic devices allowing access to this server are also protected by password allowing traceability of access to data by the investigators. No nominal information or individual data on participants was shared with third parties.

Chapter 4

4 Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study

This chapter consists of an article that has been accepted and published in the peer-reviewed journal, *Drones* in the Special Issue (https://www.mdpi.com/journal/drones/special_issues/medicine). The certificate of acceptance for this manuscript could be found in Appendix G. We did receive permission from the journal to include this article as a chapter in the thesis.

Jeyabalan, V., Nouvet E., Meier, P., and Donelle, L. (2020). Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study. *Drones, 4*, 1-20.

4.1 Abstract

Unmanned aerial vehicles (UAVs), also known as drones, have significant potential in the healthcare field. Ethical and practical concerns, challenges, and complexities of using drones for specific and diverse healthcare purposes have been minimally explored to date. This paper aims to document and advance awareness of diverse context-specific concerns, challenges, and complexities encountered by individuals working on the front lines of drones for health. It draws on original qualitative research and data from semi-structured interviews (N = 16) with drones for health program managers and field staff in nine countries. Directed thematic analysis was used to analyze interviews and identify key ethical and practical concerns, challenges, and complexities experienced by participants in their work with drones for health projects. While some concerns, challenges, and complexities described by study participants were more technical in nature, for example, those related to drone technology and approval processes, the majority were not. The bulk of context-specific concerns and challenges identified by participants, we propose, could be mitigated through community engagement initiatives.

Keywords: drones; unmanned aerial vehicle; health; healthcare; delivery of health; care; drones for health; ethics; practical challenges; community engagement; stakeholder participation

4.2 Introduction

The integration of unmanned aerial vehicles (UAVs), also known as drones, into health systems represents an area of massive potential [1–18]. Half the world population lives in rural areas, defined in diverse ways across countries, but characterized by non-urban density population [19,20]. Many of these areas are underserved when it comes to healthcare. The health worker shortage is twice as high in rural areas compared to urban areas based on the International Labor Office, Social Protection Department statistics of 174 countries [21]. Additionally, 56% of the rural population do not have access to rights-based health coverage; as compared to the average of 38% without legal health coverage worldwide [22].

Until now, the delivery of medical supplies and blood to rural, underserved communities has relied on traditional transportation methods, such as by foot, aircraft, or automobiles [11,14]. These methods are limited, especially in settings located far from local hospitals, with poor or non-existent ground transport infrastructures, or presenting other challenges to rapid transport, such as mountains [6,11,14]. Drones have the potential to circumvent such limitations. Drones have been used to deliver medications to mobile clinics in the rural and underserved and mountainous Appalachian region of southwest Virginia [6]. Drones are delivering blood from Rwanda's capital city to local hospitals, cutting down delivery time from four hours to merely 15 min [14]. In Canada, Drone Delivery Canada has partnered with Moose Cree First Nation communities living in remote areas of Northern Ontario to deliver goods, such as medical supplies [4]. Studies have shown that automatic external defibrillator (AED) delivered by drones can reach individuals in cardiac arrest approximately 19 min faster than the emergency medical services (EMS), improving patient survival and recovery rates [2,3,10,12,18]. Drones are being used to expedite the process of getting biological samples for diagnostic purposes to laboratories, reducing risks of biological samples becoming non-viable in the process of transportation [8,11,14,23,24], and there are many potential uses of for drones for telemedicine are in expansion [1,25].

The potential for drones to support health systems extends beyond rural areas. Drones hold significant promise to support infectious disease control and public health emergency response. Drone use has further expanded in the course of the COVID-19 pandemic, which is ongoing as we write. Supporting infection control and response initiatives in several jurisdictions, drones have been used during the pandemic to: spray disinfecting chemical in public spaces; issue public health announcements reminding individuals to maintain the recommended six feet distance from their fellow citizens; to transport medical supplies, such as PPE, vaccines, samples and blood to hospitals in need of these supplies; and to deliver medications, masks, and sanitizers to elders living in remote communities [26–29].

The use of drones is relatively new in the healthcare context, with the result that there has been little exploration and documentation of challenges or concerns for drone usage in healthcare settings [30]. The study on which the present article is based had as its objective: to understand the concerns, challenges and complexities of implementing drones for health projects as perceived by individuals involved in introducing and implementing these projects. In doing so, this study responds to calls for the development of a "drone theory in global health", which calls a need for critical engagement with the social, political, and ethical meanings and implications of the biomedical drone in global health supposed problem-solving [30]. Ultimately, our hope is that findings from this study can serve to advance awareness of diverse context-specific concerns, challenges, and complexities that can be anticipated, and potentially, mitigated by parties involved with implementing and using drones for health delivery.

4.3 Methods

This article draws on results from a qualitative perceptions study involving semi-structured in-depth interviews with individuals (N = 16) from nine countries working on the front lines of drones for health programs. Qualitative research is well suited to gaining detailed insight on experiences, relationships within, and the functioning of healthcare initiatives [31,32]. This multi-sited comparative perception of healthcare study replicates an approach commonly used in program design and quality improvement in the healthcare and humanitarian aid sector [13,33–35]. Perception studies are often used in healthcare to understand how This chapter composes of an article that has been accepted and published in the peer-reviewed journal, *Drones.* The certificate of acceptance for this manuscript could be found in **Appendix G**. We did receive permission from the journal to include this article as a chapter in the thesis health staff, patients, policy-makers and communities view healthcare initiatives, providing insight about the satisfaction, perceived advantages and disadvantages, and perceived importance of health programs [36–38].

4.3.1 Recruitment and Sampling

Recruitment involved purposive and snowball methods. Eligibility criteria for participation required that potential participants: (1) work in a role that involved responsibility for introducing and implementing drones for health programs; (2) be willing and able to participate in a one-hour individual virtual interview. Uncertain about the demographic of individuals in these roles around the world, we were committed to seeking a balance of men and women in our sample, but also aware, through our contacts to the sector, that more men than women may be involved with the field implementation side of drones for health projects at this juncture. Initially, recruitment focused on individuals involved with drones for health programs in association with Flying Labs, a global network that supports context-appropriate application and expansion of drones around the world [39]. Country coordinators for Flying Labs with active or recently active health-related programs were contacted through their publicly available contact information, with an invitation to identify program managers, technical support, community engagement agents, or any other pertinent individuals with drones of health experience in the past year, whom we could invite to participate in the study. With limited responses to our requests, three months into recruitment, we expanded the strategy to include individuals working with drones for health programs outside the Flying Lab network. This second phase of recruitment relied on the dissemination of a recruitment poster through a monthly newsletter that was circulated by the Unmanned Aerial Vehicles (UAV) network. Snowball sampling was also used, as participants were asked if they had colleagues working in similar capacities either in that country or in another country context that might be receptive to an invitation to participate.

4.3.2 Data Collection

Interviews were conducted between June 2019 and February 2020 by conventional phone or Skype by two members of the study team (VJ and EN) in English, Spanish or Nepali. A translator was present to assist in interviews conducted in Nepali, as neither interviewer

is fluent in Nepali. Interviews lasted between 20 and 140 min, and an average of 78 min. Interviews were digitally recorded with participants' consent.

4.3.3 Data Analysis

Interviews were transcribed verbatim, and where necessary, translated into English before being uploaded to NVivo 12 (QSR). NVivo software supports accuracy, transparency, and the opportunity for auditing qualitative data analysis [40]. In this case, we used NVivo for thematic analysis, "a form of pattern recognition used in content analysis whereby themes (or codes) that emerge from the data become the categories for analysis", further tailored to our research objectives through a combination of directed and interpretive approaches [13,41–43]. The first author established an initial set of codes based on the research questions (directed thematic analysis approach). Towards ensuring a codebook suited to the content of the interviews, as well as the goals of the study, two members of the study team then independently coded four interviews to identify additional themes, introducing the interpretive description approach [42]. Interpretive description seeks to advance understanding of a phenomenon by illuminating its "characteristics, patterns and structure" while being attentive to nuances and differences [42]. Resulting codes identified by VJ and EN were compared [44]. Discrepancies were discussed and resolved in dialogue with a third member of the study team (LD). The coding framework derived from this process formed the basis for subsequent analysis in NVivo led by VJ. Minor changes (i.e., changes in theme names or addition of emerging themes) were made to the codebook in an iterative process. EN performed an audit of the final codebook, to ensure coding completeness and accuracy.

4.3.4 Ethics

This study received approval from the Western University's Research Ethics Board (protocol approval #113823).

4.4 Results

4.4.1 Overview of Participants and Project Details

Sixteen participants (N = 16), including 11 men and 5 women, volunteered and were included in the study. Most participants were in leadership positions (n = 11), others were advisors (n = 2), technical staff (n = 1), or researchers (n = 2). Participants were involved in drone projects in 9 different countries and projects that can be categorized into five different sub-regions defined by the United Nations (UN). The number of countries that fall under each sub-region and the number of individuals interviewed are summarized in Table 1.

Table 1: Description of United Nation sub-regions and a number of countries where participants implemented drones for health projects.

United Nation Region	Number of Countries	Number of Individuals
Latin America and the Caribbean	2	2
Melanesia	1	2
Northern America	1	2
Southern Asia	1	4
Sub-Saharan Africa	4	6

Drones for health projects is a broad umbrella term we are using here to refer to the use of drones for health-related purposes. In those projects discussed by participants, these purposes included: delivery of biological samples (n = 8), live mosquito vectors (n = 2), and medical supplies (n = 10); geographic mapping (n = 2); and environmental and disaster monitoring (n = 3). Biological sample delivery involved the transport of blood and sputum samples from community health centers to laboratories or district hospitals for laboratory diagnostic testing in order to identify, diagnose, and treat patients for diseases, such as tuberculosis and HIV. Drones were used to deliver medications and vaccines to local pharmacies and automatic external defibrillators to help patients in cardiac arrest. Drones delivered live vector, such as genetically modified mosquitos to

reduce dengue burden. Furthermore, drones were used to map certain locations in order to better understand the hazards caused by flooding. Table 2 includes a summary of the different uses and need cases for drones discussed by study participants.

Table 2: Participant-identified drone needs and actual use.

UN Region	Drone Need	Drone Use
Latin America and the Caribbean (n = 2)	• Improve access to healthcare services and medical supplies in remote communities • Reduce the disease burden	• Biological Sample Delivery • Medical Supply Delivery
Melanesia* (n = 2)	• Understand the health risks, hazards, and safety concerns related to flooding • Reduce the disease burden	• Mapping • Live vector delivery
Northern America (n = 2)	• Improve access to healthcare services in remote communities	• Medical Supply Delivery
Southern Asia (n = 4)	• Improve access to healthcare services in remote communities • Reduce the disease burden	• Biological sample and medical supply delivery
Sub-Saharan Africa (n = 6)	• Improve access to healthcare services and medical supplies in remote communities	• Biological sample and medical supply delivery

* Delivery occurred within the same island

At the time of interview, most participants were involved in projects conducting pilot flights to test the feasibility of implementing drones for health projects (n = 15). One participant was involved in a project that already integrated drones into the country's regular supply chain for healthcare delivery. When the interviews took place, the projects have been executed between seven months and three years.

4.4.2 Benefits of the Drone Project

Participants' accounts of the drones for health projects revealed various benefits to these projects in participants' eyes; some of these were explicit, and others emerged implicitly. These included direct benefits, such as better access to healthcare, enhanced health services, reduced costs to patients, reduced waiting times—all improving healthcare outcomes. Additionally, drones for health projects have indirect benefits that were not the primary objective of the project. This included building local capacity, potentially solving other issues, providing infrastructure to support and continue similar drone projects, mitigating existing risks, and motivating individuals.

4.4.2.1 Direct Benefits

Direct benefits of drones for health projects described by participants included maps for communities (n = 2), reduced delivery times (n = 10), and reduced healthcare-associated costs to patients (n = 2). Most of the projects aim to improve access to healthcare (n = 14). Drones for health projects have provided maps to communities in order to understand environmental hazards and fill in gaps within existing geographical data, allowing governments and organizations to more efficiently help communities prepare for and prevent such hazards (n = 2). Participants reported that drone delivery is more efficient compared to traditional healthcare delivery methods (i.e., automobile, by foot, and boat) (n = 9), especially in communities with either limited or no road infrastructure (n = 10). Transportation time was also enhanced with drone use in communities that experience severe weather, such as thunderstorms and strong winds (n = 7). In some instances, the difference between drone delivery and traditional delivery could be up to six hours (n = 1). Medication, and medical supplies were delivered in a timely manner (n = 5), with one participant noting this being important to protecting the integrity of the products. Consequently, individuals were able to be efficiently diagnosed and treated, which improved their health outcomes. For example, automatic external defibrillator delivered by drones could reach cardiac arrest patients 9 to 10 min faster than emergency medical services—this is crucial as cardiac arrest survival rate decreases 7 to 10 percent per

delayed minute (n = 1). One participant said that in remote communities, individuals seeking diagnostic testing may need to travel upwards of 10 h to do so. Such travel time and accompanying costs (e.g., lost work time, transportation costs) could be a barrier for accessing healthcare for some. The use of drones to collect and deliver biological samples for diagnosis was cited as a benefit for patients in particular (n = 3). In fact, one study participant mentioned that a full house of people arrived at the local health center once they found out they could have their samples tested locally instead of having to go to the main village. Drones are able to "solve the gap, solve the problem of remoteness" (Participant 06). Additionally, drones enable health teams to test samples in hospitals with more sophisticated technology (n = 4) than what is available at local community health centers, supporting quicker and also potentially more accurate turnaround of results (n = 8). These drones for health projects were described by participants as aiming to reduce the disease burden of prevalent diseases, such as tuberculosis, dengue, and HIV (n = 7). A participant described that their team completed 200 hundred drone flights and delivered 2000 patient samples, helping them identify and treat dozens of tuberculosis cases that might otherwise have gone undetected and untreated (n = 2). Many participants felt strongly that drones for health projects represent efficient strategies to strengthen disease identification, treatment, and diagnosis (n = 8). Ultimately, the message from participants was that drones for health projects have the potential to improve healthcare outcomes by improving accessibility, reducing delivery times, and reducing costs to patients.

4.4.2.2 Indirect Benefits

Participant accounts included a description of several indirect benefits deriving from these drones for health projects. These included mitigating existing risks associated to travelling on unsafe roads; building local capacity; providing demographic information to improve other non-health-related services; introducing infrastructure, such as drone guidelines to support and continue similar health-related drone projects; and motivating individuals. These indirect benefits can potentially have long-term e*ff*ects, such as providing individuals with skills, improve well-being, and creating legal documents, such as

guidelines for future drone use—this results in sustainable positive changes in these communities.

Participants mentioned that drones for health projects minimized the need to travel dangerous roads (n = 4). Many of the drones for health projects described by participants involved local community members, university students, or health workers (n = 8). This involvement allowed these individuals to learn new skills (n = 8) and in some cases, earn additional income if their involvement was remunerated (n = 2). Some of the work completed through drones for health projects, such as creating geographical maps, was described as bringing benefits to communities beyond the projects, allowing governments to better serve their communities (n = 2). For example, in one country, the government used the information provided by drone teams to implement sewing programs for women.

Drones for health projects have resulted in countries modifying or developing drone guidelines that are now being adopted for purposes beyond health (n = 4). Participants are hoping to use drone technology to motivate youth to go to university and explore how they can solve their country's problems using innovative solutions (n = 2). Drones for health projects teams have developed committees positioned to involve various stakeholders in future drones for health projects (n = 3). In one instance, such a committee emerged to help convince the government to approve the first drones for health projects. In another country, a team funded a national drone steering committee to mobilize stakeholders (governments and organizations) that have interest in drone projects with the goal of drawing on this structure and its members for future drone projects, health-related or otherwise. Finally, participants said that the drones for health projects piqued interest in neighboring communities and even other countries (n = 4).

4.4.3 Concerns Surrounding the Implementation of Drones for Health Projects

The use of drones for healthcare gives rise to various concerns. These concerns have either been raised by participants themselves, or brought to their attention by community members, elected officials, healthcare staff, security personnel, or civil aviation organizations during

community engagement initiatives. The primary concerns that were raised included issues of privacy, security, safety, and the long-term sustainability of the drones for health projects. Project-specific concerns were also identified by several participants; these concerns are specific to the implementation of drones for health in particular communities. The parameters of these concerns are described in greater detail below, along with participants' attempts to mitigate these for the projects they led or supported. See Table S1 in the supplementary file for exemplary quotes corresponding to key concerns, practical challenges, and ethical complexities identified by participants can be found in a table.

4.4.3.1 Privacy and Security Concerns

Participants reported privacy concerns expressed by community members arising from real or rumored capacities of drones capturing pictures or videos of private and public spaces and/or individuals in these communities (n = 11). Related to such worries in some cases were concerns that drones would be used for spying and policing people, their land, or resources, such as for gold mining (n = 5), as well as concerns related to the ownership and protection of drone-generated visual data (n = 5). Several participants had heard concerns that drones could lead to pictures and videos being taken for sale to people outside the country, for example, for tourism profit purposes, or exploited for mining purposes (n = 5).

A few participants said that during community sensitization where the project was being introduced, the army and police raised security concerns related to drone use and were opposed to having cameras attached to the drones (n = 3). These concerns resulted in the army and police restricting where teams could fly the drones (i.e., not over army camps) (n = 3). However, most drone projects participants were involved in did not have cameras attached to their drones (n = 9).

In those projects where the above concerns were raised (n = 11), participants eased individuals' privacy and security concerns by explaining and assuring them during

community sensitization that the drones did not have cameras attached to them (n = 8). If they did use a camera, the participant explained how the data would be utilized (n = 3). To mitigate these concerns, participants and their teams also followed instructions provided by police and security, or guidelines and regulations the country has implemented for drone use (n = 4).

4.4.3.2 Safety Concerns

Concern for the physical safety of individuals, properties, and animals was brought up in several drones for health project settings (n = 12). Worry that the drone would crash into people and things during takeoff, landing, flight, or during unloading of deliveries was a common concern heard by participants (n = 10). Four participants described that there were concerns about individuals damaging the drone by throwing rocks at it (n = 4). There was also worry that in the future, drones could be used locally for purposes beyond health, such as biological warfare or war, putting community safety at risk (n = 3).

Several participants stated that they managed safety concerns by taking safety precautions, such as asking individuals to keep their distance from the drone and having discussions about safety and answering questions about safety during community sensitizations (n = 10).

4.4.3.3 The Importance of Context

Three participants underlined that some concerns were context-specific. For example, one participant described a community's initial distrust of the drone project in which they were involved and connected this distrust to past and ongoing examples of outsiders coming into the region only when wanting to exploit natural resources, and in the eyes of the community, act with disregard for the local populations. Another participant mentioned that one community was particularly concerned about where the drone was flying, as they did not want it to fly over a nearby refugee camp (n = 1). The leadership team in this community had pointed out to the drone team that the people at the refugee camp may be

traumatized already, and that flying drones over the camp may further negatively affect the individuals.

In another setting, a participant was struck by associations in some community members' minds between drones and beliefs about magic and Satanism. In this case, the participant was unclear what histories or contextual factors might have been at the root of these associations. Regardless, this was unique to a single setting in their experience and serves to reinforce that concerns and community responses to drones for health programs are far from universal: these vary within, but also across different communities. Participants reported being sensitive to the ways concerns connect to local communities' economic activities, cultural beliefs, experiences with outsiders, histories of exploitation in some cases, and adapting project plans or communications where necessary (e.g., not flying near the refugee camp; clarifying the project was not connected to mining interests) in response to such context-specific concerns.

4.4.4 Practical Challenges of Implementing Drones for Health Projects

Participants identified the practical challenges they faced during the implementation and introduction of drones for health projects. These challenges were reported as limitations to the successful execution of these projects and were perceived by participants as impacting the ability to integrate these drones for healthcare delivery in the future. Key challenges identified include skepticism of drone technology, lack of resources, inability to access appropriate stakeholders, technical challenges, and lack of guidelines and regulations.

4.4.4.1 Skepticism of Drone Technology

Half the participants identified that community members, and elected officials were initially uninterested or skeptical about their drones for health projects and were hesitant to support it.

Different participants provided different interpretations of why community members and elected officials were hesitant. These included not understanding the drone technology;

thinking that drones were replacing other health-related services in their community; and skepticism of whether the project was going to be unsuccessful (n = 6). The elected officials were not keen on changing policies and guidelines to accelerate the implementation of the projects (n = 1). Additionally, a few participants speculated that some community members did not participate in community engagement activities that introduced the drone projects to communities because the community members were not generally interested in this project or felt that the drone use case did not pertain to their medical needs (n = 2).

However, after successfully demonstrating and generating evidence that their pilot project worked, some participants reported observing a shift in attitudes (n = 3). Observing the drones at work, and perhaps also observing and growing to trust the team, typically in these participants' experience skeptical stakeholders grew to support the projects they initially doubted (n = 3). Preparedness for such skepticism is important, given skepticism of drones for health projects can act as a barrier to implementation, for example, by translating into difficulties obtaining official approvals, or diminishing engaged communities' acceptance to a project.

4.4.4.2 Lack of Resources

Several study participants reported a lack of resources as a barrier to implementing drones for health projects (n = 9). Resources identified as lacking for optimal operations of particular projects included time, staff, and overall funding. In some regions, the lack of electricity or material resources, such as a refrigerator to store biosamples or medical supplies, represented important barriers to implementing the drones for health projects in a particular area. A number of participants pointed out that many different stakeholders, including themselves, were impacted by time constraints. In the assessment of these participants, time constraints for the execution of a drone project impacted community engagement in particular, and opportunities to optimize drone testing. For example, some participants described having limited or no opportunity to fly drones, due to technical

issues, weather conditions, or needing to spend a majority of their time gaining approvals to conduct the project instead of actually executing the project (n = 6).

Two participants described time as a limitation faced by health workers and lab technicians. Such specialists, integral to the integration of certain projects within existing testing or diagnostic infrastructure, already faced heavy workloads. It was clear to at least two participants that enthusiasm and engagement with new drones for health initiatives was tempered amongst such specialists by an understanding that these projects implied additional responsibilities being added onto their existing heavy workloads. Time constraints on limited yet essential human resources available to move projects forward and ensure their smooth operation could and did in some cases, impact achievement of project objectives. Additionally, seven participants mentioned a lack of individuals with appropriate expertise to quickly come onto projects as supervisors, technicians, and pilots (n = 7). However, this was not a major barrier in participants' eyes. Participants reported being able to train and rely on community members and community health workers to support projects. Little to no incentives were provided to community members working with drones for health projects. This lack of remuneration was not flagged as a concern by any of the participants. In a minority of projects, drone teams recruited. Two participants described time as a limitation faced by health workers and lab technicians. Such specialists, integral to the integration of certain projects within existing testing or diagnostic infrastructure, already faced heavy workloads. It was clear to at least two participants that enthusiasm and engagement with new drones for health initiatives was tempered amongst such specialists by an understanding that these projects implied additional responsibilities being added onto their existing heavy workloads. In a minority of projects, drone teams recruited individuals with the appropriate skills or expertise to support field implementation from outside the project's context (n = 4).

A handful of participants mentioned the high costs associated with drone technology and the human resources required to execute drone for health projects (n = 3). Many more participants mentioned that the scope of their project was constrained by the limited budget, and worried about the future of these projects once funding of the pilot project

ended (n = 10). Some participants (n = 4) explained that this worry was not only theirs: communities involved in pilots wanted to see these projects expand to all health facilities and other communities. No solutions were identified by participants to address these various resource limitations, which posed practical challenges to implementing, sustaining, and scaling drones for health projects to other communities.

4.4.4.3 Technical Challenges

Almost all participants faced technical challenges during the implementation of their drones for health projects. These related primarily to drone technology (n = 14), weather conditions (n = 7), and geography/topography (n = 3). Drone technology challenges included network issues (n = 4), GPS problems (n = 3), flying drones autonomously (n = 3), and precision landing (n = 4). Some participants (n = 3) pointed out that drones' short battery life limits flight distances, a problem exacerbated at higher altitudes. It was also brought to attention that drones need to be controlled for temperature and humidity when transporting samples (n = 3). Some technical issues resulted in drone crashes (n = 8).

Three participants described how the topography of flight paths could make it challenging to fly and operate the drone (n = 3). Additionally, the large size of some villages created challenges to the collection of GPS coordinates to fly the drone in and out of the village for one drone team. Weather conditions could and did pose a major challenge in participants' experience. Current drones in use cannot operate in certain weather conditions like severe wind and thunderstorms (n = 7).

Three participants mentioned that technical challenges have either caused a loss of drones and samples or raised concerns of loss of drones and samples. Almost a third of the participants (n = 5) admitted that the pilot project with which they had worked had not successfully completed its objectives, due to technical challenges.

A minority of participants reported being able to successfully overcome technical challenges by taking a back-up drone with them (n = 1), or having technicians and engineers troubleshoot the problem (n = 2). Study participants acknowledged that drone

technology is new and evolving (n = 3), and more work needs to be done to expand their effective and reliable use for health projects. Several participants called for further fine-tuning and testing of the technology outside the context of projects, in order to resolve any technical issues (n = 7).

4.4.4.4 Lack of Guidelines and Regulations

Several participants mentioned limited or non-existent guidelines and regulations for drone use in the countries where they worked as a challenge (n = 6). In the absence of these reference points, some participants reported that they and their teams were unsure how to appropriately execute their drones for health projects (n = 3). Some countries had guidelines and regulations for drone use, but these were not specific to drones employed for health purposes, limiting their utility as frameworks for drones for health projects (n = 2). Participants noted that these general drone guidelines did not address health-related safety and privacy issues and standard operation procedures for transporting medical supplies and biological samples (n = 2). Additionally, general drone guidelines in some national settings defined limitations on the radiofrequency employed by drones, their altitude and distance, and their cargo weight in ways participants saw as incompatible with the mission of drones for health projects (n = 4).

Some participants found that the lack of appropriate healthcare-related guidelines made it time-consuming for them to adapt existing guidelines and get approvals to conduct the project (n = 2). On the other hand, a participant described that a country with no drone regulations made it easy for them to implement the drones for health projects as they had the flexibility to develop principles of operations that could facilitate the project execution (n = 1).

To overcome these challenges, participants adapted the general drone guidelines to better accommodate the drones for health projects (n = 2). Two participants explicitly called for healthcare-specific drone guidelines (n = 2). As a matter of fact, countries have further developed their drone regulations after the introduction of drones for health projects (n =

4). Participants recognized that governments are learning during this process as guidelines are evolving (n = 2).

Many participants reported that collaboration with stakeholders such as, for example, national and local government, the ministry of health, telecommunication regulatory agency, and civil aviation is required to develop drone regulations to conduct these drones for health projects (n = 4). Guidelines can also be developed by learning from other countries which successfully implemented these drones for health projects (n = 1). Not only is it challenging to execute these projects without the appropriate guidelines, but it also makes it difficult to sustain the project as there are no regulations governing the management and execution of drones for health projects (n = 2).

4.4.4.5 Inability to Access Appropriate Stakeholders

Several participants pointed out that they faced challenges contacting appropriate community stakeholders at the outset of projects (n = 11). Two participants said they were able to communicate with local community members only after arriving at the local community (n = 2). The lack of phone lines or cellular networks in some areas made it difficult to inform community leaders of a project prior to their physical arrival (n = 2). One participant reported that a lack of clear social hierarchy and leadership in one community made it particularly difficult to know how to initiate engagement with the community, as they typically approached elected or traditional leaders for permission to speak to the broader community. Some participants noted low attendance at some of their project's community information sessions, attributing this low turnout to their failure to figure out how to properly communicate to communities, organizations, and leaders about the community sensitization (n = 3). It was observed by many participants that local community members were usually at school, away from the community, busy with household chores, or at work when community engagement activities, such as information sessions or flight demonstrations took place (n = 6). Several participants noted it was especially hard to engage male community members because they were the ones usually away for work (n = 5).

The large population size of some of the communities positioned to host drone for health projects made it hard for participants and their teams to know to what extent invitations and attendance of community engagement activities were effective and inclusive (n = 3). This was further exacerbated if information sessions were held in more central villages, but aimed to include populations from surrounding villages (n = 1). To mitigate limitation to formal community engagement, a significant number of study participants reported that their teams relied on children, women, elected officials, or traditional leaders to relay the information about the project.

This shows how teams conduct engagement initiatives expecting individuals who attend these initiatives to further spread awareness about these projects within the community. Aside from community engagement activities, a participant identified that they faced difficulty hiring local youth to join the project as most of them moved from the remote village for work (n = 1). Additionally, two participants mentioned that it was hard to coordinate meetings with non-governmental and governmental organizations to execute this project because they are busy (n = 3). One participant recommended overcoming these challenges by being flexible to change the meeting date to best-fit everyone's schedule (n = 1), having used this strategy themselves successfully.

4.4.5 Ethical Complexities in Implementing Drones for Health Projects

Participants' accounts brought to light several ethical complexities that merit consideration when initiating drone for health projects. These include complexities of consent, host communities' perceived limited understanding of drones for health project, the fit of project goals with community priorities, and the need for transparency and honesty in project management.

4.4.5.1 Complexities of Informed Consent

Providing individuals residing in remote communities with the opportunity to provide their informed consent to the introduction of drones for health projects in their midst is

important, as it promotes individual autonomy, and prevents individuals from feeling a project is being imposed without respect for their preference. Obtaining consent from communities and residents in communities, especially when working in remote areas where drone teams will be perceived without a doubt as outsiders, supports good or ethical practices of community engagement and implementation. However, participants' reports of consent practices underlined these as clear sites for potential ethical complexity. For example, one participant mentioned that they were unsure whether executing the drones for health projects without community sensitization and with just the consent from the traditional leader was appropriate (n = 1). Different approaches were taken in different contexts: Collective consent was sought in some locations and cases (n = 7), while individual consent from community members was sought in others (n = 6).

There were inconsistent consent practices within and between drones for health projects (n = 5). For example, consent practices were different in rural and urban settings within the same country, in one participant's account. Some participants mentioned that in rural settings, their normal practice was to ask community representatives if it was acceptable to make use of private lands (n = 3); while other participants described their normal practice as involving obtaining consent from the landowner instead (n = 3). The impacts of these different practices, in terms of community perceptions of the drone projects, was unclear to participants. Inconsistent consent practices could undermine individuals' autonomy or respect for local cultures.

Many projects relied on obtaining collective consents from representatives in the village to conduct and present these drones for health projects in the communities (n = 7). This harbored its own ethical complexities. Participants described sometimes getting help from community representative to convince community members who were hesitant in providing informed consent (n = 3). In one scenario described by Participant 08, the team was unable to obtain permission from community members to land the drones on private properties. The public health officials suggested the team get help from the ward councilors to convince the community members to cooperate with the team. Participant 08 proceeded with this plan, but felt uncomfortable given they suspected community

members felt unable to refuse a recommendation from their ward councilor. A few other participants explicitly stated that individuals usually do not disagree with the elected or traditional representatives (n = 3).

4.4.5.2 Individual's Perceived Limited Understanding of Drones for Health Projects

A facet of obtaining informed consent is ensuring that local community members, government, and non-government organizations fully understand the nature of the drones for health projects.

In fact, many of the above-mentioned concerns stem, according to many of this study's participants, from limited awareness and understanding of drones for health projects. Such limited awareness has, in several instances, according to participants, led to rumors and miscommunication, causing individuals to fear drones or resist the implementation of drones (n = 9). These included rumors and misunderstandings that drones would be used for mining (n = 3), surveillance (n = 5), policing (n = 2), or military reconnaissance (n = 2). Some participants explained that such rumors and misunderstanding stemmed from individuals' real and perceived experiences of drone use. For example, in some settings, community members were aware of their government's plan to use drones to police the border, or seen drones dropping missiles in movies. In one instance, there was a misunderstanding that drones were being introduced with a plan to replace existing health services (n = 1). Such concerns, participants reported, could be further amplified when these drones for healthcare projects were implemented by foreigners. In at least one case, this distrust was based on a community's past experience of hosting a project whose team had never followed up to share the results of the project. More often, distrust was connected to a colonial history that involved foreigners stealing their lands or otherwise harming them (n = 3). Another rumor participants had heard was that foreigners were sucking the blood out of community members with witchcraft-like (drone) technology (n = 2).

In addition to these misunderstandings, participants worried that community members and elected officials may not actually understand the "spectrum of harms and benefits the drones might cause" (Participant 08) (n = 4). Participants hypothesized that limited understanding originated in either the fact that stakeholders were unfamiliar with drones being used for healthcare (n = 4), or had heard rumors spreading about the project (n = 9), or did not have the literacy skills to fully grasp the idea of using drones for healthcare (n = 1). Several participants mentioned that they were quite certain community members might not fully understand the complexities of the drone technology and the implications drones may potentially have on their safety and privacy (n = 5). Some study participants asserted that any limited understanding they observed did not surprise them, as it was difficult for them to fully understand the consequences of their own drones for health projects before actually executing the project (n = 3).

A majority of participants emphasized the need and importance for community sensitization to help individuals better understand these drones for health projects (n = 9).

Participants indicated that they were able to clarify any misunderstanding through community sensitization, where they explained the drone project, answered questions, and allowed community members to interact with the drone technology (n = 9).

4.4.5.3 Aligning with Community Priorities

It has been brought to light through several participants' description of the drones for health projects that these projects sometimes do not necessarily meet the needs of the local community (n = 7). Communities do not want studies and trials; they want solutions to their problems (n = 1). However, almost all drones for health projects in which our study participants were involved were generating evidence and testing the feasibility of drones for healthcare (n = 15), rather than transforming health realities in these communities. For example, a participant mentioned that though their project identified the cause of the flooding in the community, the drones were not actually fixing this problem (n = 1). A point made by a couple of participants was that drones are sophisticated technologies that

do not, however, solve more basic problems impacting day to day life in communities (n = 2), such as access to food.

It is important to consider the ethical implications of allocating resources to implementing these expensive drone programs instead of allocating resources to other areas that might better address community health needs. Currently, drones for health projects are focusing on one use case or even one disease, and a participant reported that this worried some individuals in these communities as it does not address what they regarded as their most urgent health problems (n = 1).

Several participants reported being approached by individuals and organizations with requests to expand the drone use case (n = 5). A participant mentioned that they included additional use cases, such as sending medicines in addition to vaccines based on one community's needs and requests (n = 1). By consulting with local communities, participants were better able to tailor the drones for health projects to meet the needs of the in a more meaningful and impactful way (n = 2).

4.4.5.4 Transparency and Honesty in Project Management

Study participants insisted it was important for them to be honest with local communities about what to expect from the drones for health projects (n = 5). In some settings, participants had been unable to successfully conduct promised pilot flights, due to technical issues (n = 3). Participants involved in these projects recognized that, by not fulfilling their plans, communities were left feeling disappointed and were not given the opportunity to better understand the drone project.

Participants acknowledged the importance of being honest with community members about what the drone technology could and could not achieve (n = 5). Clear upfront communication about the parameters of drones for health projects was recommended as the key to managing expectations about project outcomes, especially where projects are feasibility tests and project timelines are short. As one participant noted, if they

overpromised and underdelivered, then it would make it harder for them to operate again in that community (n = 1).

4.5 Discussion

Drones have the potential to transform healthcare landscapes. They are being used for a wide and expanding range of purposes, from biological sample delivery, live vector delivery, and medical supplies delivery, to mapping, disaster monitoring, and environmental monitoring. This study provides a unique snapshot into the perceived benefits, challenges, and complexities of using drones for health, in the eyes of those on the front lines of this rapidly evolving technology.

Participants highlighted both direct and indirect benefits of using drones for healthcare purposes, especially within rural settings with limited road infrastructure and access to healthcare. Direct benefits described included: better access to healthcare; enhanced health services; reduced costs to patients; and reduced waiting times. All of these were framed by participants as ultimately improving healthcare outcomes. Indirect benefits cited included: building local capacity; potentially solving other issues; providing infrastructure to support and continue similar drone projects; mitigating existing risks, such as the need to travel dangerous roads; and motivating individuals (and in particular youth) to think of innovative ways to use drone technology to solve local issues.

In terms of challenges experienced in the process of introducing drones for healthcare purposes in a range of settings, these were both practical and ethical. Participants described having to navigate skepticism of the project amongst community members and government officials. What emerges from accounts of this challenge is a reminder that introducing changes in health systems requires much conversation, explanation, and collaboration with the populations who supposedly stand to benefit from these interventions. Community engagement is viewed as an ethical and practical imperative when implementing any new information and communication technology [45–47]. Many drone companies and organizations have recognized the need to engage with local community members whether it is through hosting community engagement initiatives about drones

or developing drone software that enables local community members to fly drones [30]. However, there are current gaps in the literature describing community engagement practices for the use of drones in the healthcare context [48,49]. Good community engagement takes time, and will be uniquely articulated to local population needs, concerns, and preferences. If community engagement processes are to be authentically integrated within the use of drones for healthcare programs, timelines for these programs may need to be more flexible, in accordance with never wholly predictable processes, norms, and ideals of community engagement in specific contexts.

Several participants experienced practical challenges of limited time, money, or human resources to implement the drones for health projects in a manner that was fully satisfactory to them. Where experienced, these limitations on resources impacted time allocated for drone demonstrations, community engagement more generally, and the ability to resolve technological issues. Regulations and negotiating rights to fly is a common barrier to initiating and accelerating healthcare-related drone projects [30]. Likewise, many participants also noted that the drone projects with which they were involved experienced slowdowns linked to a lack of healthcare-specific drone guidelines in the jurisdiction where they were operating. This lack of regulatory framework made it harder to gain approvals from governments and civil aviation to execute these drones for health projects. Beyond these contextual challenges, participants described many technical challenges associated with the technology. These impacted their ability to complete pilot flights and projects in a timely manner.

It is important to note that like most new technologies, drones may lend themselves to function creep [50]. The term “function creep” refers to when technology is used in ways other than what it was originally intended to be used for [50,51]. These changes usually result in increased surveillance and control, which are unacceptable [50,51]. This is especially concerning since there is a history of using drones for policing, surveillance, and military purposes [52,53]. Many concerns surrounding these projects were brought to attention through participants’ account of their experiences. These included privacy, security, safety, sustainability, and context-specific concerns. These real and perceived

concerns may be because drones are being tested in areas that have long histories of colonial surveillance where unmanned and manned vehicles have been used for reconnaissance, war, and scientific research [30]. These collective colonial and postcolonial memories inform citizens' response to contemporary health campaigns [30]. This needs to be taken into consideration, since biomedical drones are being deployed in parallel with the deployment of military drones [30]. These medical drones can be mistaken for military drones by civilians causing them to have anxiety and post-traumatic stress, especially if deployed in countries that have a history of being attacked by military drones [54]. This exacerbates the mistrust citizens have of these humanitarian interventions [30].

By looking closely at the concerns raised by community members and stakeholders, it can be seen that the majority of these concerns stem from community members' limited understanding of projects. These misunderstandings need to be understood and corrected in order to facilitate individuals' understanding of the benefits and consequences of projects. It is ethically and practically crucial that individuals on the "host" end of drones for health projects be given the opportunity to voice their (mis)understandings, often sources of concerns, prior to the roll-out of projects. If individuals do not understand drones for health project, they cannot critically evaluate the project and assess for themselves its benefits and risks.

Likewise, it is important for individuals in communities hosting these projects to understand and help define projects' potential benefits. Understanding these benefits can help garner their interest, collaboration with, and confidence in these projects. It would be unethical to implement these drones for health projects based on the consent provided by individuals who have not considered the risks and fully understand the nature of these drones for health projects. There is no doubt that it may be challenging for drone teams to correctly identify and disclose these risks and benefits of drones, due to the novelty of this technology [55]. Still, it is important that project coordinators and field staff make efforts to identify and address any misconceptions related to drones for health projects. In addition to clearly explaining what projects and the drones involved will and will not be doing, project coordinators and field staff should be prepared to provide communities

hosting these new projects with the opportunity to identify how drone teams can operate in ways to mitigate community rumors and concerns. Drones for health program teams cannot be confident they are serving the interests of their target populations if they do so in the absence of clear, context-appropriate sharing of information and dialogue about the project with community members.

Current practices reported by participants in this study indicate there remains room for improvement in this area. Processes for seeking informed consent for new drones for health programs are not consistent between and within projects. Inconsistent consent processes have the potential to undermine respect for individuals' autonomy and culture. Drone teams need to consider the power imbalances between community leaders and those they represent, and try to understand what norms of decision-making are in specific settings, They must seek to understand what such norms and dynamics mean for consent processes. Community leaders may hold more power than community members allowing them to influence and even make decisions on behalf of the rest of the community [56–58]. This unequal symbolic power relations may cause ethical tensions between community-level consent and individual-level consent impacting an individual's ability to make decisions for themselves [59]. In order to do this kind of work, it is ethical to ensure that drone projects meet the needs of the communities by consulting with community members. This could also provide an opportunity for participants and their teams to be transparent about what drones could achieve and manage stakeholder expectation.

Practical challenges, ethical complexities, and contextual particularities overlap and need to be considered in tandem. Participants reported they and their teams were able to resolve or address many of these ethical complexities and practical challenges by collaborating and involving stakeholders, such as community members, elected officials, healthcare staff, security personnel, or civil aviation organizations.

For future drone projects, it is recommended to use evidence generated from this project to draft a global guidance document on key practical, ethical and legal considerations for the implementation of drone for health projects. Such a document should be developed in

collaboration with key stakeholders, such as drone teams, private sector, and governments. We also suggest that drone teams collaborate with involved communities' elected and traditional leaders to identify local needs and create context-specific guidelines based on the global guidance drafted based on the findings from this study. Guidelines and the global guidance will then have to be re-evaluated and adapted based on needs and gaps identified by stakeholders that emerge after the implementation of these guidelines in these local contexts (Figure 1).

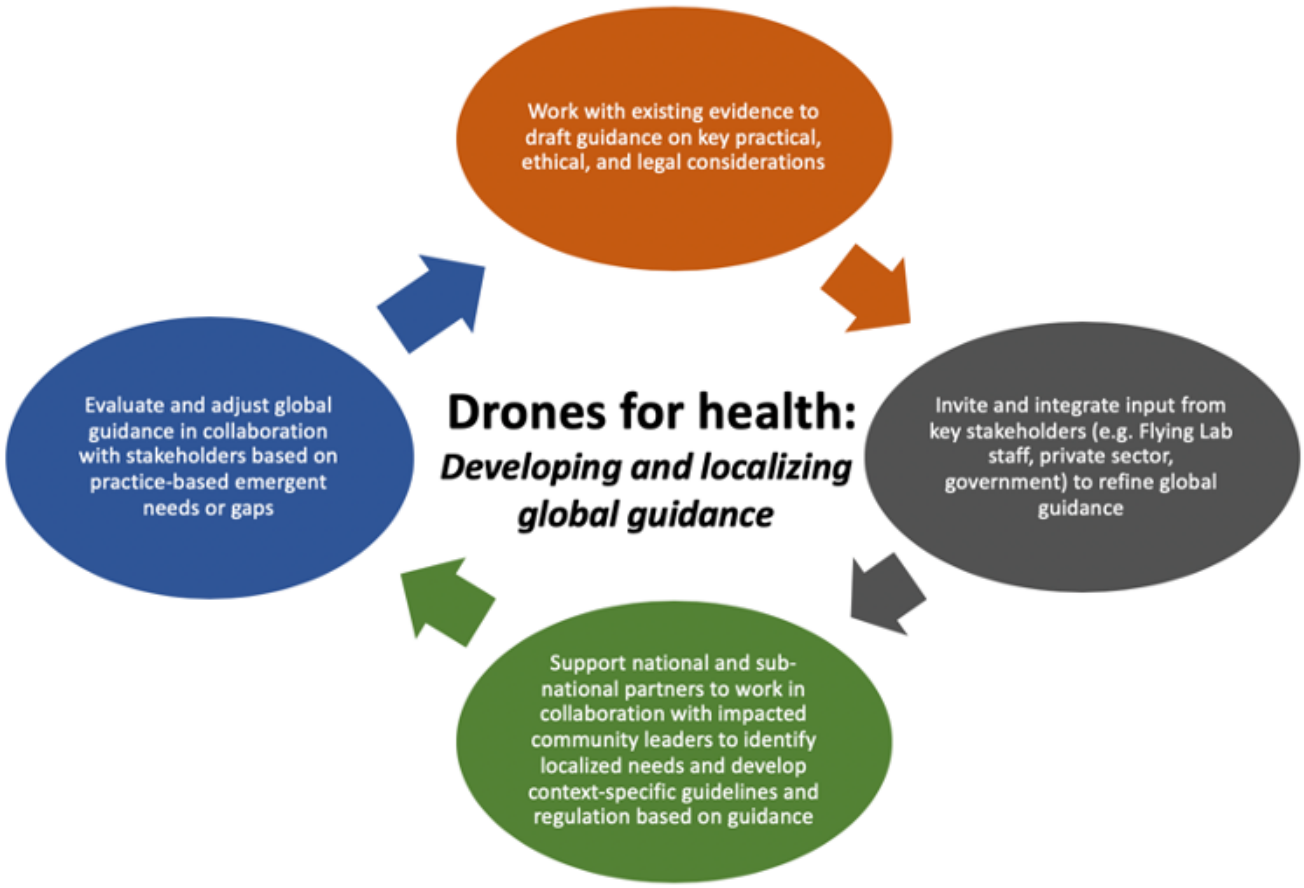

Figure 1. Developing and localizing global guidance.

Global guidance should include guidance on developing consistent context-appropriate consent processes. This will ensure that informed consent processes are consistent within and between projects. Drone teams need to identify how to obtain consent while respecting local customs and values, recognizing that collective consent is preferred and ethically acceptable in some sub-national settings and countries [60,61]. However, obtaining informed consent for drones for health projects may be onerous and even impossible, due to the indefinite number of people affected by such programs [62]. Alternatively, individual consent can be replaced by consent-by-proxy from governments and drone technology developers if these drones for health projects are categorized as public health initiatives instead of research projects [55,63,64].

Global guidance can underline the core importance of community engagement. Such engagement is key, as participants asserted, to identifying, understanding, but also importantly learning how to mitigate any context-specific concerns in ways that are satisfactory ideally to engaged community members. Community engagement is also important in terms of laying the groundwork for drones for health projects to be truly localized eventually: maybe eventually funded, but certainly developed and staffed at the local level. Guidance could outline a framework for organizing community engagement initiatives that are context-appropriate, and cautious to respect local cultural and social norms.

It is evident from participants' accounts that there is a need for healthcare-specific drone regulations that include health-specific cargo weight and flight distance allowances, in addition to other jurisdiction-specific rules pertaining to the delivery of health materials. Global guidance may also underline the importance of such regulatory supports and their development at the local level.

4.6 Conclusion

In conclusion, this study aims to bridge this gap in the literature by providing a summary of the ethical and practical challenges faced by front line staff who introduce drones for healthcare projects to communities. By presenting the ethical and practical challenges

of these drones for health projects and how participants and their drone teams overcame these challenges, this paper provides an initial framework that could guide the introduction and implementation of future drones for health projects. In doing so, this paper contributes to the "drone theory in global health", which calls a need for more critical engagement with the social, political, and ethical meanings and implications of the biomedical drone in global health supposed problem-solving [30]. Developing drone theory requires advancing evidence of the implications and complexities of drone use in practice and in specific contexts. This study's findings can inform emergent evidence-based elaboration of why and how drones represent meaningful new technologies on the landscape within the global health landscape.

Beyond what drones mean in specific settings, we hope and intend this study's findings to be of use in the short term. Practically speaking, it is our hope recommendations for addressing various challenges identified by participants in this paper will be of use to another drone for health teams, as they undertake other drones for health projects. There exists no global guidance to orient drones for health projects. The ethical and social implications of those drones for health projects described in this article could be used as a starting point to develop such guidance, which may serve as an important tool to facilitate the execution of future drones for health projects.

4.7 Study Limitations

It is important to note that almost all the drones for health projects discussed by participants were short-term proof of concept projects. Hopefully, practical and ethical challenges outlined by participants, and implementers' abilities to respond to population concerns, can be mitigated in future through more experience-based preparedness and resourcing for diverse community engagement and trust-building processes in diverse settings. Further research is needed to determine whether the ethical and practical concerns, challenges, and complexities identified in these pilot projects persist once projects become more permanent programs within health systems.

This study did not include drones for health projects from Europe. This is the result of our recruitment and sampling strategy, which took as its point of departure Flying Labs that are located in low- and middle-income country contexts. Towards developing global guidance and drone theory, further research is needed to ensure greater cross-country and region representation.

Finally, this study did not explore differences in concerns, including perceived potential risks to privacy and safety, for example, associated with rural versus urban missions. The majority of projects described by participants, in accordance with operations of Flying Labs and the participants recruited through the UAV Network, were working in a rural and remote setting. Further research would be merited to explore such potential differences.

Supplementary Materials: The following are available online at http://www.mdpi.com/2504-446X/4/3/44/s1. Table S1. Exemplary quotes corresponding to key concerns, practical challenges, and ethical complexities.

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4.9 Supplementary File

Table S1. Exemplary quotes corresponding to key concerns, practical challenges, and ethical complexities.

Theme	Example Quotes
Privacy and Security Concerns	"…Some of [the people from the communities] saw it in the movies—on the movies like action movies like using for shooting or like you know bomb explosions, for spying. Some people asked questions like, if doing something else apart from the drone supporting specimens and the medical supplies. So, it was a bit tough to explain that to the community." Participant 05
	"…People were more worried about issues like privacy, were wondering maybe were worried that maybe we would have cameras on drones and maybe they would be taking pictures and stuff like that." Participant 12
	"Their concerns are like, if they did not know the project yet but before they see the drone flying, that may be a problem if they do not know the project. But if they are aware there is a project using the drone, there is no problem because they may think the drone is suspecting or spying their land or resources or shooting the people, their kids. They may shoot the drone, or they may throw the drones like if they are not aware of the existence of the project." Participant 05
Safety Concerns	"The biggest concern of course worrying about safety; the drone crashing on people, on property." Participant 10
	"I think we just wanted to make sure that the drones were as safe as possible. To make sure that nothing happens. Because in general our goal is to try and improve health service delivery and the health of

	people, so naturally, we don't want—in trying to do that or testing some technology to achieve that in the process, we are able to—I mean we end up you know injuring people or something like that. So, we just felt that it was necessary to take all precautions to make sure that was safe." Participant 12
	"My negative worry about using drone in Madagascar is about what—spy or in some problem of war or some problem of biological war, that's my concern of using drones because that's bad; that's my main worry." Participant 06
The importance of context	"...The only thing we got was to stay away from the refugee camp very close to where we were planning to fly. And we were told by everyone to stay away from there because these are people coming from you know war torn areas in Africa and they will panic if they see a drone fly over their heads so it's best to just avoid the area completely instead of causing panic there." Participant 10
	"Mining is one of the concerns in here, because some—not much, but some people from other municipalities might think that drones could be used to transport- a means of transport of gold from one field of extraction to one location..." Participant 06
	"…I think in the urban centers, the people were more worried about issues like privacy, were wondering maybe were worried that maybe we would have cameras on drones and maybe they would be taking pictures and stuff like that. So, we were focusing on that aspect because it was like a recurring theme in the urban setting, whereas in the in the rural setting that was not the issue at all. They were more worried about that some people may not fully understand how it works and they may associate it with maybe some magic or satanism or things

	like that. Especially that we're also talking about the drones cutting images to blood. Blood is the effervescent product." Participant 12
Skepticism of Drone Technology	"…The first time it was very difficult for [district health officers] to understand because they had not seen any examples. So, when they draft the letter of support for first time, it was very generic. So, we try to talk to them to write some specific details, but they were quite hesitant because they have not seen how the technology actually work in the field. In the first time, it was quite difficult, but now in the second time, they have seen how the technology works and what the technology is. So now in the second time, the draft—the letter of support is drafted in a more like positive way and they have mentioned some good things about the impact the technology have created in the society." Participant 03 "Yeah I think some of the community members were skeptical. You know I think—although I'm going to be hesitant to comment here because it was a period of time that town of Caledon where there was a change that had taken place and their dispatch just stopped. So, once we— now the drone project, there was some that said "well look they're taking away our EMS response and they're giving us drone like we're sort of an experimental area." Participant 07
Lack of Resources	"And then you have a limited amount of funding, limited amount of time to get your project down, so you're not going to spend like 6 months in a community making sure everybody is reached just to do 5 days of flights." Participant 10 "You know the normal reaction would be like 'okay, okay, okay, okay, hold your horses, you know, I'm busy. I have people here in the clinic.' They would not say they don't have time to deal with the drones, they

	would just push back a bit. They would say "we have a lot of stuff on our hands right now,' you know." Participant 04 "We have only shown the drone, but we haven't given the full information like what is drone, how can we collect the sample, suspected cases. how is patient, how can we collect the sample from that patient, after collecting sample how health workers enroll, how drone take it , after taking, how it is examined in our GeneXpert machine, what will be the result, that result is again transported by drone to the health facilities. After coming to health facilities how we inform to the patient, after informing, how we enroll and treatment after treatment how do we cure and complete them. If we would have been able to show them [stepwise what the drone does] then that would have been much better. As it was a short time period project, all making videos, giving orientations, program implementation, all thing we have to do, so it is little bit not sufficient." Participant 14 "It is important to give a training for the community health workers, because they are the community—I mean like community health workers in the village, if we fly the drone for example to the village, we don't like have as many technicians to go to the field, so at least we have the community health workers to receive the supplies or to send the specimens in the drone. So, it's important." Participant 05
Technical Challenges	"…We did not succeed on the flight test of the drones. We always failed on the test—on the flight test, so we did not progress to the training of the community health workers because of that situation. But if the drone works well, so even the members of the DrOTS team should have been trained from this." Participant 05

	"…This 15% loss was mainly due to weather issues. That is, as you know when the drone does not arrive. It doesn't meet the flight plan for different reasons, due to storm issues, weather issues, so the drone returns to its base." Participant 13
	"Occasionally, I worry about that. I worry about that because the flat and the topography in here made me worry because if the wind and the weather are not good at all, that might affect to the explosion were the loss of the drone and part of the distance and remoteness and that's the worry to get the loss of samples with this." Participant 06
Lack of Guidelines and Regulations	"But [existing guideline] is not applicable or suitable for our drone project because we have to carry sputum and medication, which weight more than 2 kg and have to travel more than 4 km. We have to give services to those who are far from the health service sites. 4 km wasn't sufficient. Therefore, we could not follow that guideline and we modify it and implemented it." Participant 14
	"No, actually in the Ministry of Home Affairs, previously, before we started this drones in health, there were only very broad guidelines about use of drones, so it was not very specific on what type of drones we were able to fly or what frequency we were able to take. So, there were not guidelines." Participant 08
	"But now, few months back they came with new regulations. And as per the new regulation, if it is small drone, they don't need to go to home ministry, they can get a letter of permission from the district office; that means from the local level. Now the home ministry, the now trust the local level and if it's a small drone or up to 2 kg then the local level themselves can issue the permission. But if it is a bigger

	drone like what we are using then only the home—central level ministry will be involved. So over time they are also learning and revising the terms and conditions." Participant 03
Inability to Access Appropriate Stakeholders	"Yes, we have selected the school level student because in every house there are some students so that if the student will understand about that importance then they will make understand to their families, their relatives so that it would be understand by all people, so we are focused only school level also. And in that orientation, we are giving orientation to teacher also so that if student not understand teacher will help them understand and if teacher doesn't understand then district level will help them." Participant 09 "So, if you invite everyone from the community, it's not possible because it's a huge number of people that you need to explain to. So, what we did was we invited the local leader of each community. So now in [COUNTRY], we have this smallest administrative unit, they are called wards. So we invited the ward chairperson and ward vice chairperson. And through these people we try to convey our information to the community." Participant 03
Complexities of Informed Consent	"For rural villages, we don't actually give it out to each community because when they give permission, it's a collective permission whereby the village head speaks for each of the households, which are present in the community unless somebody speaks out and says that it's a no…and if it was a urban setting, we have one consent form, which is for each household where it asks 'Is it okay if we do this, fly over your property? Are you comfortable with that?'" Participant 01 "We need to have an engagement of the authority, because you know in Africa—I'm not going to say everywhere, but the person trusts to the

	authority. When the authority agrees to something, there are more person[s] who will agree. That's why we think that to obtain an engagement of the allowance of the authority, it will be more helpful." Participant 15 "One thing is that maybe they couldn't say no to [the ward heads], so because of that also [community members] agreed." Participant 08
Perceived Individual's Limited Understanding of Drones for Health Project	**"**The difficulties about introducing the drones was some misconception about the drone's purpose, in regard of some rumour and somethings in the village such as gold mining. Gold mining was the one that caused many rumours in the village. People thought that we were there to drone for mapping of a mine and something underground and that was the main difficulties and challenge we met as. Because the region where we have been, there was some company from abroad to extract gold in there, and people get confused about who we are regarding to those company exploiting gold in some regions." Participant 06 "…I go and talk to all of these communities, the one thing that I feel is the people that we are talking to, they are so innocent…and almost 50% or even more people who participate in community engagement workshop, they are usually illiterate. So, these illiterate people like they are so innocent that they don't understand technology so they cannot think about anything negative or they cannot foresee privacy and this kind of things. So, they are very innocent and if you explain them something in a good way, then they easily trust on you." Participant 03 "There is room for doubts, there is room for concern, and there's just a normal lack of information right so all we do—the importance that we see is making sure that everyone who sees it, everyone who engages with it, everyone who knows about it has the right information about

	the mission of the drone, has the right information about the nature of the drone, has the right information about what the drone does, what it does not do, and so on and so forth. So that's in a way, creates awareness into what is the service on and what it is doing to kind of alleviate any potential misconception of this new technology that is being used, so that's why it's important" Participant 16 **"**Some were concerned about some people, you know, maybe thinking that there is some involvement of magic or Satanism or any supernatural powers in the operations of the drones." Participant 12 "Actually, it's so new to everyone even including us. That people haven't yet understood what all this spectrum of harms and benefits the drones might cause. Because of this thing also I think even the municipality people aren't still aware about what harms also it can cause. Because of this, I think they aren't raising many questions on drones because they don't even know what it can do and what it can't do. So at the moment when I was working on the project, I think everyone was very curious and excited, but now if you go back to those people now and ask them, I'm sure they still have many concerns now—few concerns about this project because they now understood a little bit how easy it is or how hard it is." Participant 08 "Then doing this community sensitization, that's a direct extension because the less familiar people are with drones, the more work you have to put in to making sure they know what they are getting themselves into when they say "yes I would like a drone show up in my community." Participant 10
Aligning with community priorities	"…Drone might not be responding directly or immediately to what they need. And with regards of the importance and emergency of

	human needs, like those people who are struggling or finding out what to eat everyday...their priority is to hunt food and to sustain their livelihood, rather than seeing a device flying on the sky, which doesn't bring food to them. And that's quite difficult for people." Participant 06
	"The project was only about tuberculosis, and some people thought that with another diseases when our medical team said "you only treat tuberculosis" because that is the only disease that we have authorization from the Ministry of Health, and some people were kind of panicked, because they cannot have the treatment for their diseases, so it was a very difficult to face that situation in the community." Participant 05
	"I think we have to remember that sometimes as researchers or even as medical people, we think we know best. But the community knows best, so involving them early is always—is always a good thing. So, I think that we have to learn some of that; learn how to do that better in our research. We're not very good at it." Participant 11
Transparency and honesty in project management	"And it was a bit difficult to have the information because the drone did not fly to them and during the sensitization they know that we are using drones to transport the things but until we conducted the perception study – when we did the study with them and they said like "we are excited to see the drones, and the drone is not coming yet", so we can see like from the perception that some people are upset and disappointed." (Participant 05)
	"…You go in front of [the communities] and then you start talking about hi-fi technology and they have very basic health problems…in their community. So, I find that very difficult time and again. So what I

	do to avoid that situation is I try to be very honest from my side when I deliver the details of the work that we are trying to do because in this project like we don't tell that—when we give the presentation, we don't tell that the drones is going to solve all the healthcare problems. What we just tell is like it's just another means of transport like jeep or a motorbike, because in the monsoon and when you have bad roads motorbike and jeeps they cannot travel, so if you send a drone, it becomes faster. So, rather than telling like it completely changes everything, you have to be very honest and when you become very honest and tell the details of your project, then you don't feel like cheating the community. So, yeah that's how we do it." Participant 03

5 Discussion and Recommendations

5.1 Discussion

Drone use is expanding within the healthcare setting. Drones are being used for various purposes from medical supply delivery to telemedicine. In the projects that have been explored in this study, the uses included biological sample delivery, live vector delivery, and medical supplies delivery, to mapping, disaster monitoring, and environmental monitoring. With drone technology's potential to revolutionize the landscape of healthcare, especially in the context of under-served remote and rural areas, it is important to consider the ethical and practical implications of implementing this technology.

There is an urgent need to develop evidence-informed recommendations to guide the implementation of drone technologies for healthcare delivery; these recommendations need to take into consideration the social, political, and ethical implications of this technology (Peckham & Sinha, 2019). This study attempts to respond to that call by understanding the real and perceived benefits, challenges, and ethical complexities faced by those on the front line of implementing drones for health projects in local communities.

The challenges described by participants in this study were numerous. These included: skepticism of drone technology; lack of resources; technical challenges; lack of guidelines and regulations; inability to access appropriate stakeholders; complexities of informed consent; perceived individual's limited understanding; aligning with community priorities and; transparency and honesty in project management. Many of these challenges were ethical and practical challenges. Indeed, what emerges through the findings from this study is that the line between ethical and practical challenges is often unclear: it was in the face of practical issues such as lack of guideline and regulations and inability to access appropriate stakeholders, that there emerged ethical questions, such as do drones for health programs require informed consent? Is it appropriate to obtain collective consent instead of individual consent? How does power relationships play a role in obtaining collective consent? Can these power relationships coerce individuals to agree to participate in these drones for health programs?

Participants' accounts highlight that they mitigated many of the challenges they faced by tailoring their methods of informing, involving, and communicating with communities that they worked. This is not novel as a strategy, but it is worth highlighting. The importance of community engagement for successful drones for health interventions has been noted in the literature (Healthcare IT News Australia, 2018; Stahl, Timmermans, & Flick, 2017; UN's Children Fund, 2017). Community engagement represents for many an ethical and practical imperative when implementing new information and communication technology (ICT) in any setting (Alvial-Palavicino, Garrido-Echverria, Jimenez-Estevez, Reyes & Palma-Behnke, 2011; Gomez, Reed, & Chae, 2013; Heeks, 2017). It is important for stakeholders (i.e. drone developers, drone operators, governments, not-for-profit organizations healthcare professionals, policy-makers, and local community members) to be involved in identifying the impact technology has on individuals, the potential consequences of the use of technology, perceptions of technology, the uncertainty of outcomes, and how the technology affects humans' roles in society (Heeks, 2017; Peckham & Sinha, 2018). Engaging with communities is important to nuancing ethics of global health initiatives for specific contexts (Benatar et al., 2003; Godard et al., 2018; Pinto & Upshur, 2013). Community engagement allows for capacity building, enhanced health outcomes, shared benefits, improved understanding of local cultures and values, effective stewardship of public resources, and improved public trust and acceptance (Council for International Organizations of Medical Science, 2016; Emmanuel, Wendler, Killen & Grady, 2004; Nuffield Council on Bioethics, 2002; Solomon, Gusmano & Maschke, 2016). By doing so community engagement aims to empower local stakeholders, democratize knowledge production, and reduce power inequalities (Council for International Organizations of Medical Science, 2016; Emmanuel, Wendler, Killen & Grady, 2004; Nuffield Council on Bioethics, 2002; Reynolds & Sariola, 2018; Solomon, Gusmano & Maschke, 2016). The value of community engagement holds true for all health technologies, and this is no different for drones.

Many drone companies and organizations have recognized the need to engage with local community members whether it is through hosting community engagement events about

drones or developing drone software that enables local community members to fly drones (Peckham & Sinha, 2019). For example, WeRobotics aims to improve community engagement by localizing humanitarian drones; they have developed local knowledge hubs called Flying Labs that increases economical and individual capacity at the local level (WeRobotics, n.d.b). By building local capacity, WeRobotics is promoting technological self-reliance instead of a short-term solution resulting in a sustainable project (Peckham & Sinha, 2019; WeRobotics, n.d.b). Despite these various initiatives, there are current gaps in the literature describing community engagement practices for the introduction and use of drones in the healthcare context (Federal Aviation Administration, 2019a; UAViators, 2016). Several complexities of engaging communities emerge in this study. Key amongst these complexities and unpacked below, is the matter of who to engage when introducing a drone for health program?

In this study, participants reported that they approached traditional or elected leaders in order to get approval to conduct the project; this is to respect the local community's culture. In addition to getting approvals, approaching community gatekeepers also had other benefits such as building trust with local community members and gaining acceptance of the project from the community gatekeepers. These results reflect those of Kass and Hyder (2001) who conducted a survey that indicated that one-third of researchers from the United States doing international research sought approval from a village leader to do their research. In many non-Western cultures and communities, it is a norm for family members or community leaders to play a significant role in individuals' decision-making (Marshall, 2007; Marshall 2005). In fact, collective consent is endorsed and preferred to individual consent in some of these communities (Hudson, 2009; Canadian Institute of Health Research et al., 2018). Respecting local customs and cultures by seeking approval from the appropriate community leaders to implement drones for health projects is normatively considered to be the ethical way to implement public health initiatives (Canadian Institute of Health Research et al., 2018; Council for International Organizations of Medical Sciences & World Health Organization, 2016; Hudson et al., n.d.; National Health and Medical Research Council, 2018; Nuffield Council on Bioethics, 2007). The question

arises though on whether seeking consent only from community leaders or household leaders is appropriate and acceptable in drone for health program implementation. Certainly, this merits further consideration.

Global health ethics pays attention to the power imbalances between public health practitioners and local community members (Pinto & Upshur, 2013). This includes the need for global health ethics to focus on the power imbalances within communities themselves such as those between community gatekeepers and members (Brear, 2018; Powers, n.d.; Kuponiyi, 2008; United Nations Centre for Human Settlements (Habitat) Nairobi, 1988). Working with traditional and elected leaders presents its own ethical challenges related to the power imbalance between community gatekeepers and community members. Community leaders have the moral obligation to make decisions with the best interest of the community and to protect their community members (Tindana et al., 2011; Vreeman et al., 2012). This means that these community leaders and even health staff in the community may "nudge" community members to agree to participate in drones for health projects to improve the individuals' health outcomes. The act of nudging does not align with the principle of informed consent (Chwang, 2015; Ploug & Holm, 2015; Simkulet 2018a; Simkulet, 2017). Nudging does not provide individuals with the whole truth, can result in undue influence or coercion, manipulate individuals by exploiting their cognitive biases, and takes advantage of the power imbalance between the individuals and the messenger (Blumenthal-Barby & Burroughs, 2012; Chwang, 2015; Ploug & Holm, 2015; Simkulet 2018a; Simkulet, 2017).

Community leaders may hold more power than others in the community allowing them to influence and even make decisions on behalf of the rest of the community (Powers, n.d.; Kuponiyi, 2008; United Nations Centre for Human Settlements (Habitat) Nairobi, 1988). Community leaders could exercise their symbolic power to convince community members to participate in the drones for health projects, which in certain situations feel like coercion (Brear, 2018; Graboyes, 2010). Even if individuals in these communities claim to make autonomous decisions that are separate from those of the community gatekeepers, it is difficult to understand individual agency since this symbolic power is insidious (Brear,

2018; Molyneux et al., 2005; Tindana et al., 2006). Third-party coercion by community leaders and health staff through nudging and power imbalances can render invalid an individual's consent to participate in these initiatives even though the team or organization that is introducing the project did not themselves participate in the coercion (Millum, 2014; O'Neil, 2018). Community members may not be able to explicitly disagree with the community gatekeepers and instead may provide silent refusals where they do not explicitly convey their decisions to avoid conflicts and safeguard the relationships in their collectivistic society (Kamuya et al., 2015). Silent refusals reinforce hierarchies and complex power relations in decision-making that already exist in these communities (Kamuya et al., 2015). This impacts community members' ability to provide true consent to participate in drones for health projects. Though working with community leaders and other gatekeepers is both beneficial and respectful, it also poses ethical challenges related to the power imbalance between these community gatekeepers and members. Teams should learn more about the decision-making process in the local community to understand how power is distributed and how much individuals are impacted by the power dynamics within the communities. This could help teams understand the moral obligations traditional leaders and third-parties have and develop strategies to relieve third party pressure to gain true informed consent from individuals.

Respecting local customs and values is understood to be very important in both global health and global health research (Canadian Institute of Health Research et al., 2018; Council for International Organizations of Medical Sciences & World Health Organization, 2016; Hudson et al., n.d.; National Health and Medical Research Council, 2018; Nuffield Council on Bioethics, 2007; Pinto & Upshur, 2013). This also accords with the observation made in this study that understanding and operating within local communities' culture and religion is key to successfully implementing drones for health projects. By respecting local cultures and religions, global health practitioners can foster solidarity, a key value of global health work and ethics (Benatar et al., 2003; Pinto & Upshur, 2013). At the same time, risks of certain inequalities being deepened if consultations fail to grant decision-making power to anyone but leaders in an affected

population must be considered. Teams responsible for introducing drones for health should seek to understand how individuals in communities where they are working make decisions and whether these decisions truly reflect their wishes. It is important to understand the particularities of local cultures and religions as local cultures and religions have the ability to influence individuals' health, moral decision-making, and community structures (Chatters, 2000; Dutta, 2014; Miller, 2014). Doing this groundwork to understand local cultural norms will also help global health practitioners develop strategies to mitigate problems that arise due to nudging and coercion while respecting the local customs and codes of practices. No assumptions can be made about universal best practices for obtaining consent in communities where drones for health programs are being introduced. It is clear from this study that implementing teams are often facing time pressures, and do not include cultural experts such as local anthropologists, to support their understanding and navigation of local decision-making and ethical or belief systems. Integrating such trained individuals or cultural navigators into drones for health teams could be considered by teams moving forward.

Connected to challenges based on limited familiarity with target populations' cultural norms, one of the challenges that emerges in this study's data has to do with obtaining informed consent from individuals in the community to implement these drones for health projects. Obtaining informed consent was described by participants as both a practical and ethical challenge. Echoing Resnik and Eliott (2019), some participants acknowledged that obtaining informed consent could be cumbersome and even impossible due to the large number of people that are affected by the drones for health projects. The findings from this study are also consistent with Resnik and Eliott's (2019) findings as participants reported challenges with contacting local community members as local community members were at work, not in town, or were busy when participants went to the community to introduce the drones for health projects.

Individual consent is normatively understood in medical and research ethics as an enactment of a core respect for persons (Canadian Institute of Health Research et al., 2018; Council for International Organizations of Medical Sciences & World Health

Organization, 2016; World Medical Association, 2018). Such conceptions of decision-making and choice, however, if enshrined in best practice guidelines for the introduction of drones for health programs, could be seen as culturally insensitive in these collectivistic societies that place importance on decision-making that benefits the group as a whole (Hanssen, 2004; Oguz, 2003). It is unclear to what extent failing to obtain individual consent for drones for health programs should be considered ethically problematic.

Obtaining consent was also an ethical challenge since teams were using different consent practices within and between projects—this undermines an individual's autonomy, one of the key principles of global health ethics (Beauchamp & Childress, 2009). While some individuals were given the opportunity to understand the project and accept both the risks and benefits of the project, others were not. Given that people leading really similar drone public health projects categorize it differently (research project versus public health initiatives), there appears a need for more discussion as to how these innovative drone technology projects should be categorized in order to better determine teams' responsibilities to engage in individual informed consent processes. If drones for health programs are categorized as public health initiatives instead of research projects, then there may be exceptions to obtaining individuals' consent. Obtaining informed consent from individuals for many public health interventions is not always expected or required, and it may not always be feasible, or appropriate (Berg, 2012; Nuffield Council on Bioethics, 2007; Public Health Ontario, 2012). Furthermore, there are ethical concerns related to respecting an individual's autonomy as it may undermine the benefits to the greater society (Berg, 2012; Cawthorne & Wynsberghe, 2020; Public Health Ontario, 2012). To determine whether informed consent is required for public health initiatives, some of the following issues must be considered: whether the intervention is applied at the community or individual level; whether the intervention involves routine surveillance activity or non-routine surveillance activity; and whether the intervention impedes an individual's autonomy or poses minimal risks to individuals (Berg, 2012; Nuffield Council on Bioethics, 2007; Public Health Ontario, 2012). Determining the necessity of consent for public health interventions is rarely straightforward and requires stakeholders to accurately

define the public health intervention and understand how it impacts individuals and the population as a whole (Berg, 2012; Nuffield Council on Bioethics, 2007; Public Health Ontario, 2012).

If informed consent is not required, it is still important to share information about the intervention to the general public (Berg, 2012; Public Health Ontario, 2012). Disclosing information about the public health initiative is crucial in protecting individuals' autonomy as it may provide them an opportunity to opt-out or seek alternative care if possible (Berg, 2012). Information disclosure about the public health intervention may improve individuals' compliance with health intervention, increase individuals' trust, and allow individuals to prepare and take steps to minimize possible breach of confidentiality (Berg, 2012; Mann et al., 2016). Democratic, transparent decision-making procedures can help balance the interest of individuals and communities (Nuffield Council on Bioethics, 2007). In certain cases, it has been recognized that community engagement or community consultation can act in lieu of individual's informed consent (Berg, 2012; Public Health Ontario, 2012; Resnik & Eliott, 2019). Ideally, the use of community engagement processes provides some opportunity for communities to be involved during the decision-making process of public health interventions (Berg, 2012; Public Health Ontario, 2012).

5.2 Closing Remarks

This study shows various ethical and practical challenges of introducing drones for healthcare projects into diverse communities around the world. Its qualitative methods support the observation made by Godard et al. (2019) stating that global health ethics must rely on tactile modes of knowing which involves engaging with communities, instead of passively conforming to existing guidelines. The findings from this thesis suggests that the prescriptive key principles that currently govern global health ethics and even global health research ethics may need to be tailored and adapted to the community these global health practitioners are working in.

Global health ethics aims to use a critical perspective to reflect on the global health work being done in order to identify and mitigate the social implications of these actions and any

potential risks and consequences that stakeholders need to bear as a result of these global health initiatives (Benatar et al., 2003; Pinto & Upshur, 2013). The experiences shared by drone implementers in the context of this study indicate that community engagement is key to elucidating the cultural, social, political, and ethical complexities of particular contexts that may impact the adoption of the drone technology for healthcare. Ethical drone implementation, where what constitutes ethical implementation is defined in partnership with stakeholders in implementation settings, requires identifying perceived benefits, risks, and challenges for varying settings (Nouvet et al., 2019). Identifying these contextual differences is crucial for facilitating the context-appropriate implementation of this technology, building trust with, and gaining acceptance from community members to use drones for healthcare delivery. It is only in dialogue with impacted populations that drone implementers can understand how this technology may or may not challenge human dignity and integrity, what impact it will have on the distribution of healthcare in the eyes of local stakeholders, how these programs may challenge relevant laws, and whether it contests religious, social, or cultural conviction (Hofmann, 2005). By involving communities in this process, ethical and social values can be elicited into the health technology assessment process. If done thoughtfully, and with an eye to including a range of representatives from impacted populations, doing so would enact respect for diverse societal values, but also increase legitimacy and breadth of perspectives when identifying and selecting new technologies (Bombard, Abelson, Simeonov & Gauvin, 2011; Pichon-Riviere, Soto, Augustovski, Garcia-Marti & Sampietro-Colom, 2017). Furthermore, by developing drones for health programs that are informed by local communities' culture and faith can improve community members' acceptance of the project, and thereby, the success of the project.

5.3 Recommendations

As noted in Chapter 2, there exists no guidance to support the ethical use of drones for health. Towards contributing to the development of such guidance, a number of recommendations derived from analysis of challenges identified by participants in this study are presented below.

1. Given that people leading really similar drone public health projects categorize it differently (research project versus public health initiatives, there appears a need for more discussion as to how these innovative drone technology projects should be categorized in order to better determine teams' responsibilities to engage in individual informed consent processes. A document could be produced that explicitly outline the activities that require consent so that all teams are consistent with their informed consent process.
2. If informed consent is needed, a protocol should be developed by drone teams in collaboration with stakeholders such as government officials, local research ethics board, non-governmental organizations, and traditional leaders to support informed consent processes. It may make sense for teams working on drone for health projects to develop a workshop to train community gatekeepers so that they are able to inform and seek consent from local community members about the drones for health projects. This will minimize the disruption caused by the teams going into communities and may increase the awareness of the program as the community gatekeepers will have more contact with the local community members compared to drone teams.
3. Teams should learn more about the decision-making process in the local community to understand how power is distributed and how much individuals are impacted by the power dynamics within the communities. This could help teams understand the moral obligations traditional leaders and third-parties have and develop strategies to relieve third party pressure to gain true informed consent from individuals.
4. Teams may have limited understanding related to norms of community decision-making. To make teams more culturally competent, teams could include individuals from local communities in their team to navigate the local culture and religion.
5. It is important that individuals entering communities to introduce drones for health projects stay alert to responses that are not clear expressions of approval and consent. Where there is silence, or a response "do what you want", or any other

lack of clear signal the community is onboard cannot be taken as a satisfactory replacement for community acceptance and further discussion may be needed.

6 Conclusion

6.1 Conclusion

Peckham and Sinha describe that there is an urgent need to develop a "drone theory in global health" to better understand the social, political, and ethical implications of this technology (Peckham & Sinha, 2019). This study responds to that call. It provides a unique snapshot of the ethical and practical challenges faced by front line staff who introduce drones for health projects to communities in rural and underserved areas. By presenting the ethical and practical challenges of these drones for health projects and how participants and their drone teams overcame these challenges, this thesis provides an initial series of considerations that can support the development of global guidance for the introduction and implementation of future drones for health projects.

This study emphasizes the need to stray away from passively following existing guidelines and the need to work with communities to contextualize the moral reasoning of global health ethics at the local level. An important contribution of this thesis is its surfacing of a lack of clarity and consistency in implementers' approaches to the issue of community and individual informed consent for drone for health projects. Brought to attention in this thesis for the first time in the context of drones for health, to the best of my knowledge, is the question of whether informed consent is required for public health initiatives. Indeed, the need or lack of need for informed consent hinges on participants' and their drone teams' categorization of these drones for health projects as research or public health initiatives. This thesis opens up a discussion that merits further consideration and inter-sectoral deliberation on the appropriateness of informed consent in the context these drones for health projects are taking place in. Informed consent is based on the Global West's ethical principle of autonomy, which can be seen as culturally insensitive in some of these communities. This highlights the need to reconsider how to adapt current principles of global health ethics to align with the moral values of the community these projects are being implemented in. This will ensure that the local community's customs and values are respected by drone teams.

In some communities, collective consent is preferred to an individual's informed consent. However, the power inequalities between community gatekeepers and community members may lead to nudging and third-party coercion. Collective consent could inadvertently reinforce hierarchies and power imbalance that already exist in these communities. Drone teams need to identify strategies to address these issues and manage competing ethical responsibilities of respecting local customs while also respecting individual autonomy.

This thesis emphasizes the need for community engagement as it provides local communities an opportunity to be the champions of these drones for health projects. Community engagement is both an ethical and practical imperative of doing global health work. Participants themselves have reported that they were able to overcome some of the ethical and practical challenges they faced by utilizing community engagement initiatives. Informing, involving, and collaborating with local communities provides an opportunity for drone teams to describe the projects to the communities, answer any questions they have, and tailor these projects to the needs of the community. Community engagement can inform drone teams on how to ethically implement these drones for health projects. Community engagement not only improves acceptance of the project, but also makes it easier in the future to transfer the ownership of the project to the local communities.

Due to the novelty of this technology in the healthcare context, most of the drones for health projects that were explored in this thesis were in the pilot stage of the project where stakeholders were testing the feasibility of implementing drones for healthcare delivery. This was a limitation as the ethical and practical concerns described in this study by participants were limited to those that occurred during the pilot phase. Future studies should explore the ethical and practical concerns, challenges, and complexities that arise in other stages of the drones for health projects to better understand the various social and ethical implications of these drones for health projects.

Drone technology is outpacing the FAA's attempt to integrate drones into the national airspace system (Damon, 2017). It has been identified both by this study and prior literature

that regulations and negotiating rights to fly is a common barrier to initiating and accelerating healthcare-related drone projects (Amukele, 2019; Peckham & Sinha, 2019). However, the lack of flight regulations is not the only issue participants are facing, participants reported that the lack of guidelines specific to the use of drones in the healthcare context is also a problem. In fact, existing literature itself highlights limited guidelines available describing the use of drones in the context of healthcare delivery to employ drones responsibly and ethically (UAV Code, n.d.). Due to this, organizations such as WeRobotics relying on adapt guidelines created for the humanitarian context when initiating projects that use drones for healthcare (WeRobotics, 2018).

For future projects, it is recommended to use evidence generated from this study to draft a global guidance document on key practical, ethical, and legal considerations for the implementation of drones for healthcare projects. This global guidance should be developed in collaboration with key stakeholders such as drone teams, private sectors, and government. We also recommend that drone teams work with elected and traditional community leaders to further tailor this global guidance to develop context-specific guidelines that meet the needs of the local community. The guidelines and the global guidance developed based on the findings from this study will need to be re-evaluated and adapted on an ongoing basis to meet the needs and gaps identified by stakeholders that emerge after the implementation of these guidelines in these local contexts.

Global guidance should include guidance on developing consistent context-appropriate consent processes. This will ensure that informed consent processes are consistent within and between projects. Additionally, global guidance can underline the core importance of community engagement. Such engagement is key, as participants asserted, to identifying, understanding, but also importantly learning how to mitigate any context-specific concerns in ways that are satisfactory ideally to engaged community members. Guidance could outline a framework for organizing community engagement initiatives that are context-appropriate, and cautious to respect local cultural and social norms. Finally, global guidance may also underline the importance of regulatory supports such as the need for healthcare-specific drone regulations and their development at the local level.

There is no doubt that a further step must be to study the extent to which challenges and strategies identified by those on the front lines of implementing drones for health resonate with the communities in which they are doing so. It is only through such gathering and analysis of perspectives, that we can advance awareness of ethical and social implications of drones for health projects. Identifying similarities and differences in challenges and complexities faced in distinct settings by those on the front lines of these technologies, whether as drone operators, project managers, community leaders, or community members in non-leadership positions, that the industry, countries, and potentially sub-national entities such as communities or regional authorities can develop ethical guidelines and regulations that are realistic and effective.

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Appendices

Appendix A: Memorandum of Understanding between: WeRobotics and The University of Western Ontario, Canada ("Western University")

Western Research

Memorandum of Understanding

BETWEEN:

WeRobotics

and

The University of Western Ontario, Canada
("Western University")

This is a Memorandum of Understanding ("MOU") with an effective date of March 15, 2019

WeRobotics and The University of Western Ontario ("Western University) wish to pursue cooperative relations between the two institutions in research and education through mutual cooperation, agree as follows:

Scope: Area and Method of Cooperation

The participating parties will cooperate on the following research collaboration:

Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study.

This project aims to:

a. Deepen understanding of the context-specific practical and ethical challenges that front-line staff face when using drones in communities for health-related purposes.
b. Develop, pilot, and disseminate, in partnership with WeRobotics, the first ever open access comparative analysis of stakeholders' experiences of drones used for healthcare programs.
c. Ultimately, support context-attentive and ethical use of drones in healthcare, by creating a set of materials researchers, ethicists, regulators, civil society leaders, and policymakers can consult to better understand, discuss, prepare for, and navigate the use of drones for healthcare.

Responsibilities

Western University will assume all costs associated with data collection, data analysis, and the preparation of the eventual findings report. WeRobotics will identify and e-introduce co-PIs of the study (E Nouvet and V Jeyabalan) to Flying Labs® coordinators. Patrick Meier, founder of WeRobotics, will also be invited to provide his input and insights on early analysis of interview data collected, though is under no obligation to do so.

Terms of each activity shall be discussed and agreed upon in writing by both parties prior to the initiation of the particular activity.

Western Research

Dissemination of Results and Authorship

The participating parties agree that any public dissemination of results will be contingent upon mutual agreement between Western University and WeRobotics. This agreement will be in writing and undertaken prior to the initiation of any such activity.

In the event of a publication, co-authorship will be extended to the project committee at Western University and Dr. Patrick Meier of WeRobotics. Additional co-authorship will be subject to approval by both parties.

Principles

WeRobotics and Western University acknowledge to the other that each subscribe to a policy of non-discrimination, which requires its employees not to discriminate on the basis of race, sex, sexual orientation, age, ethnicity, religion, or national origin. The parties shall abide by these principles in the administration of this Memorandum of Understanding and neither party shall impose criteria to the participants that would violate these principles of non-discrimination.

Terms of Cooperation

Length of Agreement
This Memorandum of Understanding will remain in force for a period of two years, beginning on March 15, 2019 and ending on March 15, 2021, subject to adherence to the terms of cooperation.

Accountability
An activity report shall be submitted to each of the institutions' designated representatives, as defined below. In addition, an activity report will be appended to this MOU.

Amendments
Any amendment to the MOU will require the written approval of each party.

Termination
Either party reserves the right to terminate this Memorandum of Understanding upon thirty days written notice. Any activity that has already commenced shall be completed to the best of both parties' abilities.

Communication
The Parties can publish or announce, in any form of media, this MOU and the relationship existing between the two Parties.

Nothing in this MOU shall be deemed to authorize the public use by either party of the other's trademarks, logos, or member names in marketing materials or other media, or the disclosure of confidential information to third parties, unless specifically agreed to as part of a subsequent written agreement.

Western Research

Designated Representatives

WeRobotics Representative: Dr. Patrick Meier

Western University's Representative: Dr. Elysée Nouvet

Signatures

Two signed originals of this Memorandum of Understanding will be produced, one to reside with each party.

For: **The University of Western Ontario**

[redacted]

Name: Mark Daley
Title: Associate VP Research

Date:

[redacted]

Name: Dr. Elysée Nouvet
Title: Assistant Professor

March 21, 2019.

Date:

For: **WeRobotics**

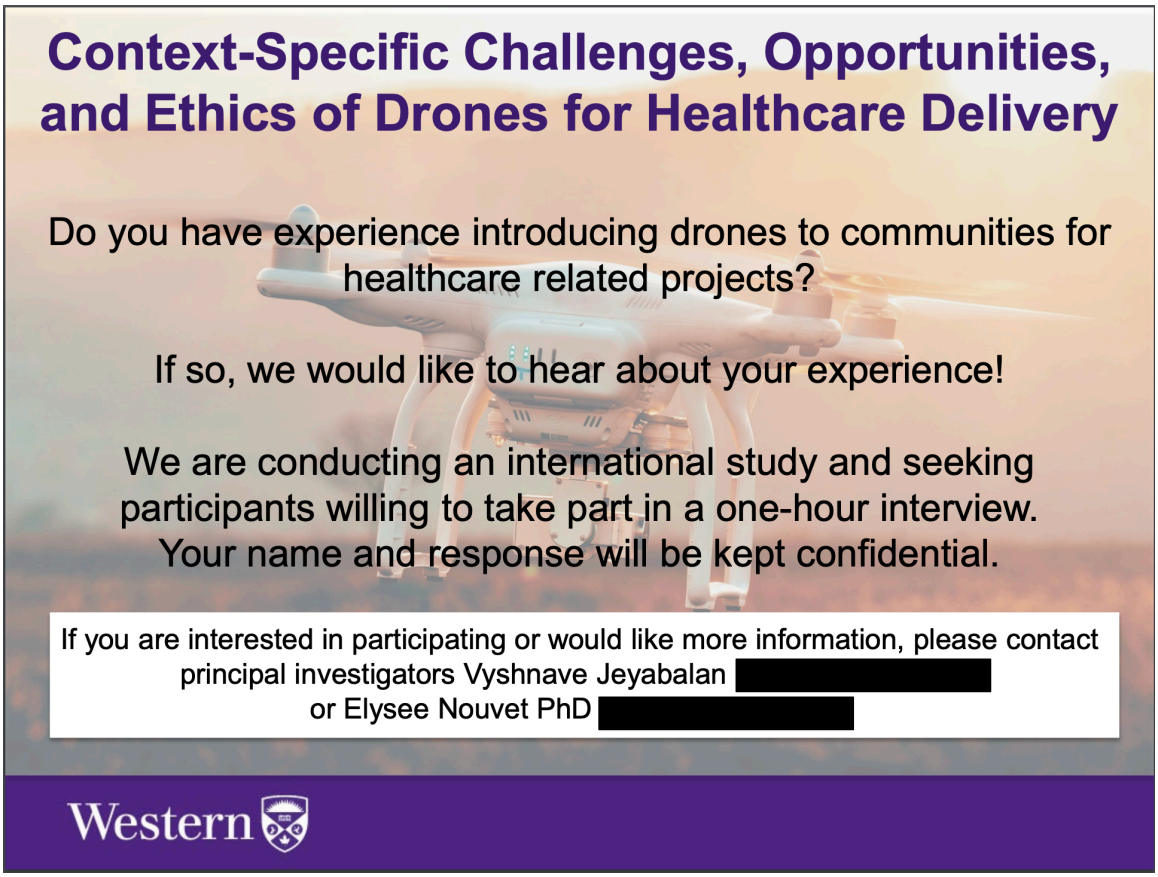
[redacted]

Name: Dr. Patrick Meier
Title: ED, WeRobotics

March 18, 2019

Date:

Appendix B: UPDWG Recruitment Poster



Appendix C: Letter of Information and Consent

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

LETTER OF INFORMATION AND CONSENT

For participants in the study:
"Context-Specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study"

Prof **Elysée Nouvet**
Principal Investigator
School of Health Studies
Western University
London, Ontario, Canada
[redacted]

Vyshnave Jeyabalan
Co-Principal Investigator
Health Information Science
Western University
London, Ontario, Canada
[redacted]

Funding: Western University Faculty Startup Fund

Conflicts of interest: The researchers declare that they have no conflicts of interest in relation to this study.

We are inviting you to participate in an interview-based research study. The study is led by Elysée Nouvet and Vyshnave Jeyabalan, from Western University Ontario, in Canada, in collaboration with Lorie Donelle (PhD, Western University), and Patrick Meier (PhD, WeRobotics).

WHY ARE WE CONDUCTING THIS RESEARCH?

We are conducting this study to advancing understanding of the work involved in introducing drones for health-related purposes in communities around the world. Our goal is to learn about context-specific considerations, strategies, and ethical and practical challenges of introducing drones to communities.

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

We are inviting you to participate in this study because of your experience working with a Flying Lab that has been involved in the use of drones for health-related deliveries in one or more community.

In order to decide whether or not to participate in this study, you need to understand what you will have to do if you decide to participate. You also need to understand the potential risks and benefits that your participation could entail. This form gives detailed information about the study.

You are completely free to accept or decline to participate in this study. If you choose to participate, you will always be free to change your mind. You can withdraw from the study at any time. If you do decide to withdraw from the study, you will not have to provide any explanations.

Please take your time to make your choice. You are free to talk it over with your colleagues, with the researchers, with your family, or with any other person.

If you choose to participate in the study, you will be asked to sign this form. You will receive a copy of this form that you can keep.

WHO WILL PARTICIPATE IN THIS STUDY?

We plan to interview individuals from various countries who have experience introducing drones to community for healthcare-related projects.

HOW LONG WILL THIS STUDY LAST?

If you decide to participate in the study, your engagement will last approximately one hour. You will participate in a single meeting involving a semi-structured interview.

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

In total, the study itself will last one year: data will be collected and analyzed in 2020.

WHAT WILL PARTICIPATING IN THIS STUDY ENTAIL?

If you decide to participate in this study, we will ask you to take part in a semi-structured interview via Skype, Viber, or WhatsApp (as you prefer).

- The interview will be conducted by a Health Information Science M.A. candidate. The principal investigator will also be there. She might also ask you some questions.
- Questions asked will be about your experience with drone projects that include the use of drones for health-related purposes. For example, we might ask you: "How did you introduce the drones to the community? ". Or: "How do you plan for a project like this?"
- The interview will last approximately one to two hours.
- The interview will happen in a place that suits you, at a time that suits you.
- The interview will be in English, Spanish, Nepali, or French. If necessary, an interpreter will work alongside the interviewer to translate your words.
- The interview will be recorded with an electronic audio recorder. After the interview, the NVivo software or a member of the research team will transcribe (write down) your words.

WHAT ARE THE POSSIBLE BENEFITS FOR ME AND/OR FOR SOCIETY?

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

We cannot promise any personal benefits to you from your participation in this study.

The information you share with us will help us better understand the ethical and practical challenges that frontline staff face when introducing drones into local communities for health-related purposes. We will better understand how to support frontline staff to ensure that drones are ethically and efficiently implemented. In the future, this will support the ethical conduct of drone use in healthcare by creating materials that stakeholders could consult to better understand, discuss, prepare for, and navigate the use of drones for healthcare.

WHERE WILL RESULTS BE PUBLICLY SHARED?

Key findings will be shared through a blog on the WeRobotics website and a webinar co-organized by Western University and WeRobotics in Spring or Summer 2020. Co-principal investigator Vyshnave Jeyabalan will be writing up findings for her Masters thesis, to be completed in August 2020. She and co-principal investigator Professor Nouvet will be applying to present preliminary findings from this study at upcoming academic conferences. Finally, in mid to late 2020, an academic article (for a journal such as Global Public Health) will be prepared with the plan of submitting this for peer review and publication. We will be happy to keep you informed of public dissemination activities related to this study, if you are interested, and regardless of whether you participate in an interview or not.

WHAT ARE THE POSSIBLE RISKS AND INCONVENIENCES?

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

We understand that your schedule is very busy, and that granting us approximately one hour for this interview may be difficult. There are no risks associated with participation in this study.

WHAT INFORMATION WILL STAY CONFIDENTIAL?

We will do our best to protect your confidentiality during and after the study.

Before starting the interviews, we will ask you for your name. We will ask you to sign a consent form. Only the principal investigators and co-investigators will see these documents. After the interview, the paper documents will be kept in a locked filing cabinet in a locked room. Electronic documents will be kept on a password-protected file on a password-protected computer. The *Western University Research Ethics Board* may require access to these identifying documents and files in order to monitor the conduct of this study.

We will transcribe the interview word for word. Audio files will be transcribed using artificial intelligence, NVivo (Microsoft Software) and any personal information and community-identifying information will be shared through this process. Once transcripts are recieved, we will remove your personal information and community-identifying information: your name, and the names of any persons you mention, the names of specific communities in which you have worked that may be discussed. These details will be replaced by a number. A list linking these numbers with your name will be kept in a safe place. Only the research team will have access to this information. Audio files will be deleted from NVivo as soon as the transcripts are received and verified.

Interview transcripts of interviews with these details already removed will be kept safe. If they are on paper, we will keep them in a locked office. If they are on electronic

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

document, we will keep them in a password protected file on a password protected computer.

We will publish and present the results of this study. Your name will not be used in our reports, publications, or presentations. No information revealing your identity, that of colleagues or community members that might be mentioned in the interview, or names of specific communities, will be released to the public or published.

We will keep these documents for some time after the study ends. Audio files will be destroyed after 7 years. Electronic documents with identifying information will be destroyed after 7 years. Paper documents will be destroyed after 7 years.

IF I DON'T WANT TO PARTICIPATE IN THIS STUDY, ARE THERE OTHER OPTIONS?

Yes. You do not have to participate in this study. You can choose to not participate.

CAN MY PARTICIPATION IN THIS STUDY END EARLY?

Yes. If you decide to participate in this study, you have the right to withdraw from the study. You can cancel or stop the interview.

If you change your mind after the interview is over, you can ask the researchers not to use data from your interview. To do this, contact the primary investigator and ask her to delete the recordings and transcripts from your interview. You will have the right to do this until results from the study are published.

If you choose to take part in this study, you will be informed of any new information that

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

may affect your desire to continue to participate.

DO I NEED TO ANSWER ALL THE QUESTIONS IN THE INTERVIEW?

No. You can participate in the study without answering all the questions in the interview. You do not have to do anything you do not want to do in the course of your participation in this study. If there is a question or questions you do not wish to answer, you can inform the interview you would rather not answer that question or cannot answer that question, and that is fine.

WILL I BE COMPENSATED FOR MY PARTICIPATION IN THIS STUDY?

No. You will not receive any money or compensation for participation in this study.

WILL I NEED TO PAY IN ORDER TO PARTICIPATE IN THIS STUDY?

No. You will not need to pay to participate in this study.

WHAT ARE MY RIGHTS AS A PARTICIPANT?

By signing this form, you are not giving up any of your legal rights.

Even if you sign this form:

- you do not waive any of your legal rights.

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

- you do not absolve the researchers of any of their legal and professional responsibilities.
- you do not absolve the research institutions of any of their legal and professional responsibilities.

WILL YOU CONTACT ME AFTER THE INTERVIEW ENDS?

We do not need to contact you after the interview. If you are interested, we would be happy to contact you after the interview ends to notify you of a webinar sharing key findings (anticipated for Spring/Summer 2020), as well as to notify you of any other publications that might be forthcoming from this study. For example, we do anticipate sharing some insights from this study through a WeRobotics blog at some point in 2020.

If you want, we can send you an invitation to this event. We can also send you updates about the study.

WHAT HAPPENS IF I HAVE QUESTIONS?

If you have any questions about the study, please contact:

Vyshnave Jeyabalan
Co-Principal Investigator
University of Western Ontario, London, Ontario, Canada
[redacted]

OR
Professor **Elysée Nouvet**
Principal Investigator
University of Western Ontario, London, Ontario, Canada
[redacted]

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

If you have any questions about your rights as a research participant, or if you think that these rights were not respected, please contact a representative of **The Office of Human Research Ethics** [redacted] email: [redacted].

This office oversees the ethical conduct of research studies and is not part of the study team. Everything that you discuss will be kept confidential.

This letter is yours to keep for future reference.

CONSENT STATEMENT

Participant:
I have read or had this consent form read to me in its entirety. I understand the information above. I have had the chance to ask questions about the study. The researchers answered all of my questions to my satisfaction. I agree to participate in this study. I know that I have a right to interrupt my participation at any time. I understand that I will receive a copy of this form.

☐ I agree to have my audio file uploaded to NVivo for transcription purposes and acknowledge that my information will be shared with the software. My personal information will be de-identified after the transcripts are produced.

Participant's name	Signature	Date

Witness (if the participant cannot read and sign him/herself):

☐ The consent form was read out to the participant. I affirm that the study, as described in this form, was fully explained to the participant, and that all his/her questions have been answered.

Name	Signature	Date

Relationship to the participant

Vyshnave Jeyabalan, M. A. Candidate in Health Information Science
Faculty of Information and Media Studies, University of Western Ontario
[redacted]

Interpreter (if the form was sight-translated into a different language for the participant):

☐ The consent form was sight translated and read out to the participant. I affirm that the study, as described in this form, was fully explained to the participant, and that all his/her questions have been answered.

Name	Signature	Date

Person obtaining consent:

I have discussed this study in detail with the participant. I believe that the participant understands what is involved and understands that he/she is free to withdraw from the study at any time. I am committed to honor what has been agreed upon in this consent form, and to give a signed copy of this consent form to the participant

Name	Signature	Date

Role in the study

Appendix D: Semi-structured Interview Guide

Semi-structured Interview Guide

Project Title: Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study

WREM #: 113823

For participants: Individuals working in communities on the front lines of drones for health programs

Total participant time required: approximately 60 minutes
Break: As many as necessary

Pre-interview briefing
The goal of this interview is to learn more about your experiences introducing and working with communities using drones for health-related purposes in (country). This study is being done for my Master's thesis in collaboration with WeRobotics. I am particularly interested in what you, as someone on the front lines of drone program in (country), have learnt to be important factors that need to be taken into account in order to do this work well. I will be asking you about your experience in general, but also about any challenges you might have encountered and strategies you have used to work with communities. The study will be comparing the experiences of staff from various countries.

The interview consists of semi-structured questions. During the interview I may ask you additional questions to further clarify or elaborate your answer. With all the questions, it is always your choice whether or not you answer the question: you may choose not to answer a question. You can take as many breaks as you would like – don't hesitate to tell me if you need a break please. You can also end the interview at any time.

Your responses, identifying information, names of communities mentioned, and any other names mentioned will be kept confidential in any presentation or publication of results. Your name will not be used in any analysis or publications. A report of study results will be ready by autumn 2020 and can be shared with you form if you are interested.

(The consent form will be emailed and signed in advance)
Please feel free to look over the consent form again and ask any questions that you may have about the process. (RA will read the consent form to the participant if necessary).

I will record this interview for data analysis and to ensure that the responses are captured and transcribed accurately. Audio files will be transcribed using the Nvivo software or a transcriptionist who has signed a confidentiality agreement . In addition to

those in this room and the transcriptionist, no one will have access to these recordings and they will be stored in a password protected file on a password protected computer in a locked office and the destroyed 10-years after our report is written.

Authorization to record the interview: participant's initials:

Do you have any question for me before we begin?

Main research questions (approximately 60 minutes; *Probes in Italics*)

PART I: GENERAL CONTEXT

1. Tell me a little bit about yourself: what is your professional background?

2. What is your role and what are your responsibilities in relation to the use of drones in (country name)?
    a. *How did you get involved in this?*

3. What are all the ways drones are being used by the Flying Lab in (country)?

4. Focus is on drones for healthcare related purposes. Challenges, strategies, and experiences of introducing drones for health in countries around the world. Tell me a bit about the first project on which you worked in (country) that involved using drones for some healthcare related purpose.
    a. When did you start that work?
    b. Were you involved with the project from the very start?
    -If not, what was your involvement
    If yes, is the project ongoing or has it ended? When did it end?

5. Was/is this a project that involves many communities in (country)?
    a. Why was a decision made to introduce drones in this/these specific community / region? Any particular reason to launch the health program with drones in those communities?

6. *How new was this approach of using drones to that first community: had community members seen drones prior to this?*

7. Did you or those with whom you were working have any concerns about introducing drones in this community (security, safety, viability, economics, sustainability)?
    a. *What were the concerns? Why did you have these concerns? Was there anything you could do to reduce those concerns or risks? Are these concerns/risks that you have felt when working in the other communities also?*

PART II: WORKING WITH THE COMMUNITY

1. How do you plan for a project like this?

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Do you have any question for me before we begin?

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7. Did you or those with whom you were working have any concerns about introducing drones in this community (security, safety, viability, economics, sustainability)?
    a. *What were the concerns? Why did you have these concerns? Was there anything you could do to reduce those concerns or risks? Are these concerns/risks that you have felt when working in the other communities also?*

PART II: WORKING WITH THE COMMUNITY

1. How do you plan for a project like this?

2. Can you describe to me what was involved in introducing this drone-mediated healthcare program to the community?
    a. *What sort of preparation was involved before actually showing up in the communities with drones?*
    b. *What was the initial contact like? Who did you contact and meet with? (ie community leaders, community members – probe to find out about the process, if included phone calls, required field visit to some leaders before visiting the entire community, and their understanding of why that process happened the way it did). Who was present in those first meetings with community members?*
    c. *How did you decide on that approach?*
3. *Set the scene for me: you arrive in village. You are expected? To whom do you speak? What do you say?*
    a. *It might not be easy to explain a drone project to a community that has never been exposed to them before. How did you explain your purpose?*
    b. *What kind of resources did you use to introduce drones? (scripts, news articles, videos, drone prototype, brochures)*
    Did you have to adopt any of these resources (wording/examples) to facilitate the understanding of the local community members? If yes, how did you do that?
    Did you have to do this in all the other communities you were in? If yes, were the modifications different between communities?

4. *Do you feel like the initial contact was enough for the community members to understand the nature of this project?*
    If yes, did anything in particular help you feel confident that community members understood the project?

5. In that first project, did you encounter any challenges?
    a. What happened? Did that result in any adjustment to your approach?

6. Was anything (else) difficult in your recollection?
    a. What happened? Did that result in any adjustment to your approach?

7. With that health project, did you have any concerns?

8. With that health project, did any of the community members seem concerned/unhappy/ uncomfortable about drones being introduced to their community?
    a. *If yes, what were their concerns? How did you manage those concerns?*
    Did you hear or face the same or different concerns in the other communities? What were these concerns?
    -has that been your experience in other communities and projects since?

b. *If no concerns, why do you think no concerns?*
-has that been your experience in other communities and projects since?

PART III: COMMUNITY ENGAGEMENT

9. According to the Humanitarian UAV/Drone Missions: Towards Best Practices, "it is particularly important to engage local communities and involve them in your mission."
   a. *Do you agree with this statement?*
   If yes, why is it important and how do you involve local communities?
   If no, why not?

10. *What does community engagement mean to you?*
    Were you able to enact all these elements in this location?
    If yes, did you adapt any part of you work in this community to better reflect the needs and/ conditions of this community?

11. *Is easy or difficult to involve local community members in a drone-mediated health program?*

12. *In the program we have been discussing, did you have any problems working with local community members? Engaging them?*

13. In what ways, if any, were community members invited to participate in the design of the program?

14. In what ways, if any, were community members invited to participate in the management of the program?

15. Are community members involved in evaluating the program?

16. Are/were any of the local community members getting trained to use drones?
    a. *If yes, who got trained? How many people got trained? Men and women?*
    b. *How did you select who got trained? Did they have to have any particular background (education level, ability to read, respected)? Did you get advice from anyone in the community to determine who should get training? Tell me more about that (who, why/why not).*
    c. *What were these individuals being trained to do?*
    d. *What did the training exactly involve? (How many days? What kind of activities?)*
    e. *Were there any challenges in this process? (ie finding people interested in being trained, the training process)*
    If yes, how did you manage them? Are those challenges you have seen in other communities?
    f. *Did you have to limit training to a certain a number of people? If yes, was it easy or difficult to limit training to a certain number of people? Tell me more.*

   g. *In your view, is it important to train locals? What would you say is gained by doing this training (might be for them or for the community)?*

17. For this program, did you work with any local associations, NGOs, community organizations?
    a. *If yes, why did you choose these specific local groups? Rephrase: How did you decide to approach these groups?*
    b. *Do you think it was a good idea to involve those particular groups? Why?*
    c. *Did you face any challenges during this process? (If yes) Tell me more about those. Were those challenges resolved? How?*
    d. *In retrospect, do you think that there were any other local partners or groups that maybe could have or should have been engaged earlier on?*

18. *So, How do you know when you do community engagement work that you are engaging the right people or the right number of people? (How do you know who represents the community?*

PART III: ADDITIONAL ETHICAL AND PRACTICAL CHALLENGES

19. So what are your thoughts on the use of drones for this particular purpose in (country)? Do you have any concerns or worries?
    a. *Do you think people outside of these communities where drones are not being used have any concerns?*
    b. If you were a residing in this community, would you want to see anything being done differently?

20. Would you say this drone project meet the needs of the local community? How/why (why not)?
    a. *If not, why do you think that? Are there any strategies that could be implemented so that future projects can meet the needs of the local community? (Are there any suggestions you would give future teams working on drone projects so that they can better meet the needs of the local community?)*

21. Are the drones flying over private properties and/or taking aerial images?
    a. *If yes, did you tell community members about this and how did you tell them?*
    b. *Has anyone in the community raised any concerns about this?*
       If yes, what were these?
       If yes, how did you or your team manage those concerns?
       Are you satisfied about that approach? Were the concerns similar/different in the other communities you worked in?

Appendix E: Non-Medical Research Ethics Board Approval

Western Research

Date: 13 May 2019

To: Professor Elysee Nouvet

Project ID: 113823

Study Title: Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study

Short Title: Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: June 7 2019

Date Approval Issued: 13/May/2019

REB Approval Expiry Date: 13/May/2020

Dear Professor Elysee Nouvet

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
Confidentiality_Agreement_Nouvet	Interview Guide	07/May/2019	v.1
WeRobotics Western Email Script First contact	Recruitment Materials	07/May/2019	1
WeRobotics Western Email Script May 7	Recruitment Materials	07/May/2019	2
Western WeRobotics Interview guide	Interview Guide	08/Apr/2019	
Western WeRobotics Letter of Information and Consent May 07 2019	Written Consent/Assent	07/May/2019	2

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix F: Continuing Non-Medical Research Ethics Board Approval

Western Research

Date: 20 April 2020

To: Professor Elysee Nouvet

Project ID: 113823

Study Title: Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study

Application Type: Continuing Ethics Review (CER) Form

Review Type: Delegated

Meeting Date: 01/May/2020

Date Approval Issued: 20/Apr/2020

REB Approval Expiry Date: 13/May/2021

Dear Professor Elysee Nouvet,

The Western University Non-Medical Research Ethics Board has reviewed this application. This study, including all currently approved documents, has been re-approved until the expiry date noted above.

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Daniel Wyzynski, Research Ethics Coordinator, on behalf of Prof. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix G: Certificate of acceptance for the manuscript (drones-875554) titled: Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study

drones

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Indexed in: Scopus

CERTIFICATE OF ACCEPTANCE

Certificate of acceptance for the manuscript (**drones-875554**) titled:

Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study

Authored by:

Vyshnave Jeyabalan; Elysee Nouvet; Patrick Meier; Lorie Donelle

has been accepted in *Drones* (ISSN 2504-446X) on 13 August 2020

MDPI Academic Open Access Publishing since 1996

Basel, August 2020

Curriculum Vitae

Name: Vyshnave Jeyabalan

Post-secondary Education and Degrees:
The University of Western Ontario
London, Ontario, Canada
2014-2018 BSc.

The University of Western Ontario
London, Ontario, Canada
2018-2020 M.A.

Honours and Awards:
Western Graduate Scholarship
2018-2019

Related Work Experience
Teaching Assistant
The University of Western Ontario
2020-2020

Research Assistant
The University of Western Ontario
2018-2020

Publications:

2020 Jeyabalan, V., Nouvet, E., Meier, P., & Donelle, L. Context-specific challenges, opportunities, and ethics of drones for healthcare delivery in the eyes of program managers and field staff: a multi-site qualitative study. *Drone*s, *4*, 1-20.

2020 Hiebert, B., Nouvet, E., Jeyabalan, V., Donelle, L. The application of drones in healthcare and health-related services in North America: A scoping review. *Drones, 4*, 1-17.

Conference Participation:

2019 Jeyabalan V. Context-specific challenges, opportunities and ethics of drones for healthcare delivery: A multi-site qualitative study. Talk presented at the Western University Health and Research Conference. London, Ontario, November 21.

2019 Jeyabalan V, Nouvet E, Donelle L, Meier, P. Context-specific challenges, opportunities and ethics of drones for healthcare delivery: A multi-site qualitative

study. Poster presented at the Power & Global Health Day. London, Ontario, November 14.

2019 Jeyabalan V. Context-specific challenges, opportunities and ethics of drones for healthcare delivery: A multi-site qualitative study. Talk presented at the Canadian Conference on Global Health. Ottawa, Ontario, October 17-19.

2019 Jeyabalan V. Context-specific challenges, opportunities and ethics of drones for healthcare delivery. Talk presented at the Innovation in Motion. London, Ontario, June 3.

2018 Jeyabalan V, Nouvet E, Mahboob O, Martínez-Pérez G, Knoblauch A, Grandjean Lapierre S, Schwartz L, Donelle L. A systematic review of the literature on the ethical and social complexities of providing incentives or remuneration to research participants in sub-Saharan Africa. Poster presented at the Power & Global Health Day. London, Ontario, November 14.

2018 Jeyabalan V, Nouvet E, Mahboob O, Martínez-Pérez G, Knoblauch A, Grandjean Lapierre S, Schwartz L, Donelle L. A systematic review of the literature on the ethical and social complexities of providing incentives or remuneration to research participants in sub-Saharan Africa. Poster presented at the Africa-Western Collaborations Day. London, Ontario, November 15.

2018 Jeyabalan V, Nouvet E, Mahboob O, Martínez-Pérez G, Knoblauch A, Grandjean Lapierre S, Schwartz L, Donelle L. A systematic review of the literature on the ethical and social complexities of providing incentives or remuneration to research participants in sub-Saharan Africa. Poster presented at the Global Health Students and Young Professionals Summit. Toronto, Ontario, November 18.