ETHICAL CONSIDERATIONS OF USING GEOSPATIAL TECHNOLOGIES IN COMMUNITY HEALTH RESEARCH

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(Bioethics and Health Law)

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Declaration

I, Pascal. O. Bessong, declare that this Research Report is my own, unaided work. It is being submitted for the Degree of Master of Science in Medicine (Bioethics and Health Law) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

This 13th day of August 2025, in Louis Trichardt.

Dedication

To Margaret Ekamba Takang and Philip Bessong Bessong

Presentation arising from the study

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Abstract

Geospatial technologies (GST), such as remote sensing (RS), geographical information systems (GIS), global positioning system (GPS), and internet mapping technologies (IMT) are innovative data collection tools increasingly deployed in community health research (CHR). However, application of these stools in CHR does not always respect ethical norms, principles, and frameworks for ethical research. In this report, I present evidence from the literature that GST are intrusive data collection instruments; and defend the thesis that CHR in which GST is applied ought to comply with ethical guidelines. I defend the thesis from three premises. I use notions of principlism, the research guidelines of the National Health Research Ethics Council (NHREC), the National Health Act (NHA), international research ethics guidelines, principles grounded in virtue ethics and Kantian moral theory to defend the premise that autonomy, privacy, and confidentiality are violated when GST is used in community health research without prior informed consent from individuals and communities. On the second premise, I demonstrate that the constitution of South Africa, the National Health Act, Protection of Personal Information Act, and case law make it unlawful to collect, share or distribute personal identifiable information without approval from individuals or communities concerned. Thirdly, I use the principle of maximizing the good grounded in utilitarianism and the social value of research to defend the premise that the application of GST in CHR ought to have social value. In my arguments, I examine and provide rebuttals to potential objections and conclude that the use of GST in CHR ought to comply with ethical norms and guidelines throughout the life of a research project. Finally, to strengthen the ethics of community health research in which GST are used, I propose some recommendations for research ethics committees, researchers, and journal editors.

Keywords: Geospatial technologies; Community Health Research; Principlism; Virtue Ethics, Kantianism; Utilitarianism; Legislation.

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CHAPTER 1: INTRODUCTION AND OVERVIEW

1.1 Introduction

1.1.1 Background

Why would a community demand that data collected by geospatial technologies (GST) in the course of a research project in their community be destroyed? Or why would a community refuse to participate in research that uses GST? Or why would a community undertake 'countermapping' as an attempt to address perceived injustices done to their communities through the application of GST without their initial approval and inclusion in the activities? Or how would you react to an air-borne instrument hovering over your home or neighbourhood?

Geospatial technologies such as remote sensing (RS), geographical information systems (GIS), global positioning systems (GPS), and internet mapping technologies (IMT) are increasingly used in research, including community health research (CHR). These tools are innovative; and combined with artificial intelligence and deep learning (Bill et al., 2022), allow health researchers to gather large amounts of data in ways that were not possible before. Moreover, these technologies are capable of gathering data associated with individuals and their communities even without direct physical contact (Onsrud, 1995; Dobbs and Louis, 2015; Cinnamon, 2020; Hirt, 2022). If the information gathered is not ethically and responsibly managed, it could put the community and its residents at risk of discrimination, stigma, socio-economic and cultural loss; resource pillage, and dehumanization (Parcak, 2009; Berman et al., 2018; Cinnamon, 2020; Cohen et al., 2020; Gupta et al., 2020; Davis and Sanger, 2021). Existing national and international research ethics frameworks focus mostly on data collected through direct contact with study communities and their residents to assess safeguards for informed consent, privacy, confidentiality, safety, and social value. However, considering that the application of GST in CHR may not require direct contact with a community or its residents,

research ethics guidelines and frameworks, in their current form, are not adequate in addressing the ethical challenges posed by GST in CHR.

In view of the potential harm to communities and its residents from the application of GST, important questions arise: how ethical is the application of GST in CHR? Why would some researchers ignore or dismiss ethical considerations in the application of GST in CHR? In this report, I examine the ethical intricacies of GST in CHR. I argue that despite the huge benefits of GST, researchers must apply them ethically and responsibly at all stages in the lifecycle of a research project.

1.1.2 Brief historical background on ethical conduct of research

The need for ethical and responsible conduct of human health research has evolved over the years. Generally, attention to ethics in research involving humans has mostly been prompted and informed by highly regrettable events against human dignity (Miller and Wertheimer 2007; Resnik, 2019). The Nuremberg Code of 1947, which was the first international guide comprising ten standards to attempt at regulating research on humans, stemmed from medical experiments carried out during World War II, particularly by the Nazi regime in Germany. These experiments were heinous and paid no regard to the dignity and freedom of individuals (Leaning, 1996; Vollmann and Winau, 1996). According to the Nuremberg code, it is absolutely essential to obtain inform consent from humans for research purposes. It emphasized that benefits must outweigh the risks in research involving humans (Shuster, 1997). A year later, in 1948, the United Nations General Assembly proclaimed the "Universal Declaration of Human Rights" (Resolution 217A), "*which included protection of the rights of research participants*" (Dhai, 2019, p44). The "World Medical Association" developed the Declaration of Helsinki, in 1964. It is "*a statement of ethical principles for medical research involving human subjects,*

including research on identifiable human material and data." "*The declaration set the standard for ethical human experimentation conducted by researchers."* (WMA, 2024). Following "The Declaration of Helsinki", other guidelines comprising "Good Clinical Practice Guidelines by the International Conference on Harmonisation", "Guidelines for Biomedical Research by the Council for International Organizations of Medical Sciences" (CIOMS), and the "United Nations Educational, Scientific and Cultural Organization (UNESCO) Declaration on Bioethics and Human Rights" were developed.

There have been other abuses of humans in the course of research. The violations in the Tuskegee Syphilis Study in the United States led to the development of the Belmont Report in 1978 by the "US National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research." In the Tuskegee study,

> "*The ethical violations were multiple: Subjects did not provide informed consent (indeed, they were deliberately deceived); they were denied the best known treatment; and the study was continued even after highly effective treatment became available."* (Angell, 1997, p848).

The Belmont Report specified moral principles and guidelines to protect humans in clinical trials. It also called for diversity, as a requirement, in research projects (Department of Health, Education, and Welfare, United States, 2014). Subsequently, the Singapore Statement was adopted at the "Second World Conference on Research Integrity" in 2010. According to Resnik and Shamoo (2011, p72), the Singapore Statement

> *"Includes four principles - honesty, accountability, professionalism, and stewardship - and fourteen responsibilities for the ethical conduct of research. The responsibilities address such topics as data integrity, data sharing, record keeping, authorship, publication, peer review, conflict of interest, reporting misconduct and irresponsible*

research, communicating with the public, complying with regulations, education, and social responsibilities."

Grave ethical violations have also been observed in South Africa. For example, "Project Coast," a biological and chemical weapons programme conducted medical experiments, during the apartheid government. These experiments are generally seen as genocidal acts against the black population (Singh, 2008; Jackson, 2015). Also, an efficacy trial of high dose chemotherapy on South African women with high-risk and metastatic breast cancer was judged to have not received regulatory approval, and that the patients did not provide informed consent (Crown, 2000; Weiss et al, 2000). Elsewhere, without the approval of regulatory authorities and informed consent, an interventional study using new drugs and anaesthetics was conducted by Dr Richard McGown in Zimbabwe which unfortunately resulted in the death of six people (The Herald, 1994; British Medical Journal, 1995). Also, Pfizer conducted a clinical trial of an experimental antibiotic, Trovan, during an outbreak of bacterial meningitis in northern Nigeria in 1996, in which eleven children died, and many others suffered debilitating effects from the trial. Pfizer did not apply, nor receive approval for the study from an ethics committee; and Pfizer investigators did not seek informed consent from the study participants (Ahmad, 2001; Stephens, 2006; Okonta, 2014; Archibong and Annan, 2021).

An examination of the Pfizer case, and the others indicated herein, underlines how the safety and dignity of individuals could be compromised, with regrettable outcomes, if the review and regulation of research protocols, before and during the research, are not adhered to. In the application of GST outside of regulatory frameworks, physical harm may not be obvious, however, without the provision of informed consent and acceptable safeguards for privacy and confidentiality, individuals and community leadership may suffer from mental and psychological harm due to stigma and discrimination, in addition to injury to dignity and

insecurity which could be as debilitating as physical injury (Bryan, 2010; Chennells and Steenkamp, 2018; Fischer et al., 2019; Saeed et al., 2020; Kang and Hwang, 2023; York et al., 2023).

National and international guidelines on health research ethics are aimed at protecting the dignity and respect for research participants, of which obtaining informed consent and the scientific and social value of the research are important considerations. Taken together, there is significant awareness of the responsibilities of researchers, institutions, sponsors, and regulatory bodies to protect study participants . However, this does not appear to be always the case, when GST is applied in research (Kim et al., 2022; Jeyabalan et al., 2023).

1.1.3 Brief overview on research ethics and communities

Discussions on prior informed approval from communities for research in their spaces are beginning to receive tangible attention. For example, concerns and discussions gave rise to the "San Code of Research Ethics" in South Africa. According to Schroeder et al. (2019, p73)

> "*In 2017, the South African San finally published the San Code of Research Ethics, which requires all researchers intending to engage with San communities to commit to four central values, namely fairness, respect, care and honesty, as well as to comply with a simple process of community approval."*

In Mexico, the "Union of Organizations of the Sierra Juarez of Oaxaca" (UNOSJO) in 2019 raised a dispute in a letter that criticized the first Bowman expedition (Dobson, 2012; Wainwright, 2013), with the "San Miguel Tiltepec" community of Oaxaca. In the letter, UNOSJO demanded the destruction of all data collected in the project. Researchers sponsored by the American Geographical Society, in consultation with the San Miguel Tiltepec community, had collected a series of geospatial data to map the community. It was then alleged that there was no disclosure that the Foreign Military Service Office (FMSO) of the United

States of America and Radiance Technologies, an arms development and military intelligence company, also funded the project (Mychalejko and Ryan, 2009). The project was also presented in English, a language that the community did not master. The points of contention included informed consent, collection of geospatial data, the involvement of the military, and vulnerability of the community.

In addition, UNOSJO rejected, as unacceptable, the engagement of only the San Miguel Tiltepec community. UNOSJO believed all the communities of Sierra Juarez of Oaxaca are inter-related, and the expedition ought to have engaged them as a collective. Moreover, they expressed the view that the purpose of the expedition, with funds from FMSO, was for counter-insurgency purposes, and accordingly all the communities in Sierra Juarez of Oaxaca ought to have been informed, with full disclosure in an acceptable communication process. As a result, the Union contended that informed consent was not obtained from the Sierra Juarez of Oaxaca, and therefore the expedition should be discontinued (Grassroots International, 2009; Bryan, 2010). It should be noted that the leaders of the Bowman expedition in Mexico contested the allegations of UNOSJO (Dobson, 2009; Herlihy, 2010). However, the general consensus is that relations with the study community were not well handled prior and during the research (Finn et al., 2014). Young and Gilmore (2014), commenting on this matter, posit that the ethical use of GST required a deeper discussion. Young and Gilmore also noted that increased publicity in the conceptualization of participation GIS makes the approach susceptible to exploitation by government agencies and other groups outside of the community with an interest in the data.

There are a few implications from the ethical fall out of the Bowman expedition in Sierra Juarez of Oaxaca. First, the stance of UNOSJO that informed consent was not obtained, in a manner acceptable to them, dampened the trust of the community to engage and collaborate with

researchers. Second, with the knowledge that Mexican government officials were aware of the project, the community felt betrayed. Third, they fear the GIS maps generated were shared with undisclosed third parties who have the power to appropriate their communal land or use the information against them in the future (Grassroots International, 2009).

1.1.4 Geospatial technologies and health research

There is a rapid uptake in the use of GST in community health research (Rambaldi et al., 2006; Nelson et al., 2022). Health research, with immense value for communities, has been defined as

> "*the process for systematic collection, description, analysis, and interpretation of data that can be used to improve health*" (Oravec et al., 2022, p4).

Health research provides useful information about the spread of diseases and risk factors, treatment outcomes, and cost and socio-economic gains of healthcare (Institute of Medicine, 2009).

According to the American Association for the Advancement of Science, GST refers to approaches that provide datasets for which the exact locations of the data can be determined on the surface of the earth (AAAS, 2024). Key examples of these technologies include Remote Sensing (RS), which is the use of unmanned aerial vehicles to collect images and data from space or airborne cameras; Geographic Information Systems (GIS), which is a suite of software that maps, analyses and assigns a specific location on the earth's surface; Global Positioning System (GPS), which transmits, through satellites, the geographical coordinates of an object; and Internet Mapping Technologies (IMT), which provide an interface between a user and an object or person of interest (AAAS, 2024). These technologies have great value in enhancing health care delivery through (1) the enhancement of holistic approaches for health solutions,

(2) improvement in health outcomes through resource allocation and targeted interventions in communities, for example during the COVID-19 outbreak; (3) the ability to address disparities and equity in health care delivery, for example when minorities have reduced access to health care; and (4) providing evidence for community advocacy for improved health and wellbeing, such as identifying the reasons for disparities in cancer treatment outcomes (Gregory and Cooper, 2013; Ahasan and Hossain, 2021; Fadiel et al., 2024).

However, the use of GST in CHR raises ethical issues. For example (1) there is the risk of violating the right to privacy and confidentiality;(2) associating communities with a negative geospatial outcome, for example with labels such as high risk for a disease or natural phenomenon, could lead to stigmatization, discrimination, loss of income and other inequalities; (3) there is a possibility of false conclusions leading to wrong interventions and negative consequences; (4) geolocation of individuals to control population-wide diseases could have legal and policy consequences; and (5) the cultural and religious heritage, and natural resources of a people could be exposed to others against the wish of a community (Blackemore and Longhorn, 2004; Young and Gilmore, 2014; Finn and Wright, 2016; Apte et al., 2019; Garett and Young, 2021; Brand et al., 2023). Consequently, researchers using GST in CHR must be cognizant of potential harm to communities from the deployment of GST in CHR.

1.2 Research Question

The question this report aims to answer is: Is it ethical to use geospatial technologies in community health research without safeguarding the principles of autonomy of persons, beneficence, non-maleficence, justice, and community rights? I herein address these questions by providing an overview of what community health research is; secondly, I describe the principal types of geospatial technologies and their capabilities in data and information

generation; and thirdly, drawing from norms and principles guiding community health research and moral theories I provide arguments on why GST should be used ethically in community health research.

1.3 Rationale of the study

There is evidence from reported empirical studies, in which GST is used, that ethical principles, such as obtaining informed consent, that normally apply for other types of health research involving humans are not always followed in studies using GST that do not require contact with humans, whether in the global south or in the global north (Bryan, 2010, Wagenaar et al., 2018; Baker et al., 2019; Makungo et al., 2020; Boulos et al., 2022; Kim et al., 2022). In addition, there is the need for all research ethics committees to take cognizance of the ethical implications of new technologies such as GST, and when big data is involved (Ferritti et al, 2021; Gomez et al., 2022, Oluoch, 2024). Data collection using GST may sometimes not require direct active participation of communities or residents of a community. However, residents and communities are concerned about their privacy and about the collection of data without their approval (Mann et al., 2003; Cann and Price, 2022; Zhang and McKenzie, 2022; Jayabalan et al., 2023; Solymosi et al., 2023). Without approval and protection, the potential for violations of individual and communal sovereignty, privacy, fear of oppression and exploitation by powerful outsiders should not be ignored (Young and Gilmore, 2014; Berman et al., 2018; Resnik and Elliot, 2019; Elliott, 2019; Swanlund and Schuurman, 2019).

Obtaining informed consent, in line with respect of persons, is a fundamental requirement in health research involving humans. However, a cursory examination of the literature reveals varying positions on the need to obtain informed consent in the application of GST in CHR. For example, in the identification of environmental factors associated with malaria in Dar es Salaam, Tanzania, Système Pour l'Observation de la Terre (SPOT) (a high resolution satellite

imagery system) and ArcGIS (a geographical information system analytic and mapping package) were applied without informed consent of community members (Kabaria et al., 2016). The authors also indicated that ethical approval was not required for the study.

Systeme Pour l'Observation de la Terre satellite imagery provides a partial resolution of 20-2.5m and a location accuracy of up to 10m, which is adequate to identify buildings and the location of individuals. Similarly, in estimating the number of children to plan for polio vaccination in Borno State, Nigeria, researchers use high resolution (31–50 cm) imagery from DigitalGlobe without consent from the communities (Higgins et al., 2019). On the other hand, some researchers do seek informed consent. For example, in applying geospatial analysis, Dominguez et al (2019) obtained informed consent from hospital identified-patients to describe hot spots of gastric cancer in communities in Honduras, Central America. Also, in exploring the acceptance of drones in response to public health emergencies, Shapira and Cauchard (2022) obtained consent from Israeli adults in the Negev, Southern Isael. In other instances, authors indicated ethical approval as obtained from ethics committees but did not indicate whether or not informed consent was obtained from the study community. For example, in the study by Garcia et al (2019) in which satellite imagery, remote sensing and household enumeration methods to support measures for interventions to control malaria in Bioko, Equatorial Guinea.

There are also grey areas worthy of noting. There are reports in which researchers do not obtain informed consent before the collection of geospatial data but seek informed consent when the collected geospatial data are to be applied in subsequent research activities in which direct human involvement is required. For example, in a collaborative study on the surveillance of typhoid fever in South Africa, Senegal and Sudan, researchers applied Google Earth Pro

satellite imagery to identify households before seeking permission for questionnaire administration by members of the identified households (Baker et al., 2019). In a study in Mozambique, households in a community were first geolocated before informed consent was sought from the households for a subsequent community health survey (Wagenaar et al., 2018). In another case, researchers applied GPS to identify and describe spatial distribution of households with typhoid fever during an outbreak in Sekhukhune district in South Africa in 2017 (Makungo et al., 2020). Although ethical approval was obtained for the study, there was no indication of informed consent having been obtained from the households that were geolocated. Furthermore, there are situations in healthcare delivery projects in which new data were collected by GST but for which consent was not sought (Jeyabalan et al., 2023). Jeyabalan and colleagues, further described ambiguities in the responses of individuals responsible for '*drone for health projects*' on whether their work involved research or not. They reported that in addition to the fact that ethical approval was not sought for these projects, some project leaders described their work as having components of experimental research in which identifiable data were collected with GST without informed consent from individuals in the community.

Other cases in which ethical norms were ignored abound. Kim et al (2022), in a review on the use of qualitative geographical information systems, described published studies conducted in some countries of the global north (Australia, Canada, Germany, Ireland, Netherlands, Sweden, United Kingdom, United States of America), and in the global south (India, Liberia, and Malawi) in which ethical approvals of the study protocols are not even mentioned. In fact, 15 of the 38 studies reviewed '*lacked a description of ethical approval.*' (Kim et al., 2022, p5). It is plausible that researchers in these studies did not consider that ethical guidelines ought to be followed in data collection employing GST. In another vein, some researchers argue that it is

impossible to consent everyone if the research area is large (Hall and Wahab, 2021), implying that consent or approval could be traded off for a supposedly higher value.

Ethical sense also need to be made in the use of GST in spaces that could be seen as public, in which case privacy and confidentiality may not be necessarily important. For example: (1) where a supposedly public space becomes private and vice-versa (e.g. a picnic corner in a public park or a party in someone's house); (2) when there is no clear distinction between private or communal space or property (for example a chief's compound that is also used as the community meeting place); (3) when a confidential activity is carried out in a public space (such as when one has "*the right to be let alone by others"* (van der Sloot, 2021, p1)), or (4) when the relevance and social value of research in a community needs to be established (Emmanuel et al., 2008; Hall and Wahab, 2021).

To provide a clearer synthesis of the empirical basis for the claim that GST is frequently deployed in CHR without prior engagement or consent, Table 1 summarises selected studies, their methodologies, and whether informed consent or community engagement was sought.

Table 1. Selected examples of the use of GST in CHR with and without informed consent or community engagement

	Study (year)	Country (Region)	GST employed	CHR focus	Consent / community engagement	Ethical approval	Ethical implication
1	Eisen et al. (2010)	Uganda	GPS, to locate homes in northwestern Uganda.	Risk of human exposure to *Yersinia pestis* (cause of plague).	No mentioned of informed consent or community consultation.	Ethics approval stated.	Risk of autonomy, confidentiality and privacy violations.
2	Tenu et al (2014)	Ghana	GPS to locate participants, GIS for mapping	Control of Buruli ulcer	Prior informed consent was obtained; the community was consulted and community approval obtained.	Ethics approval stated.	Protection of individual and community interests. Example of best practice in the use of GST in community health research.
3	vonHedemann et al. (2015)	USA	Light Detection and Ranging (LiDAR) for mapping.	Community mapping for mosquito control.	Focused groups engaged after geospatial mapping of communities.	Ethics approval not indicated.	Risk for autonomy and privacy violations.
4	Kabaria et al. (2016)	Tanzania	High resolution SPOT satellite imagery to identify environmental factors associated malaria.	Malaria prevalence.	No direct community engagement: consent not obtained prior to mapping of community.	Stated as 'not applicable.'	Data collection without prior consent raises autonomy concerns; mapping preceded community engagement
5	Hardy et al. (2017)	Zanzibar	Drones	Study to assess the use	No community engagement.	Ethical approval and consent to	Risk for privacy violations.

				of drones to map environmental factors for malaria control.		participate stated as 'not applicable.'	
6	Wagenaar et al. (2018)	Tanzania	GPS tracking of field workers.	HIV prevention outreach.	Informed consent obtained before GPS tracking commenced. Communities were engaged.	Ethics approval stated.	Illustrates ethical best practice; community was informed and permission obtained.
7	Baker et al. (2019)	Senegal, South Africa, Sudan	Satellite imagery and GPS for locating health cases.	Geographical position accuracy for typhoid surveillance.	Consent sought post-mapping; no prior community engagement.	Ethics approval stated.	Potential privacy infringement; highlights ethical risks in retrospective engagement.
8	Higgins et al. (2019)	Nigeria	High resolution DigitalGlobe to assess habitation in villages.	Mapping villages for polio eradication	Informed consent not sought; no engagement with communities prior to mapping.	Ethical approval and consent to participate stated as 'not applicable.'	Potential for privacy violations; and communal
9	Garcia et al. (2019)	Equatorial Guinea	Remote Sensing imagery, GPS, GIS to map and enumerate households for malaria control.	Community-based control of malaria	Informed consent not sought; no engagement with communities prior to mapping.	Ethics approval stated.	Potential risk for autonomy and privacy violation.
10	Makungo et al. (2020)	South Africa	ArcGIS and GPS for location of typhoid fever	Investigation on typhoid	No information on informed consent process on	Ethics approval stated.	Risk for violation of autonomy and privacy.

			cases and suspected cases, and water sources.	fever outbreak	geolocating typhoid case-location. Community engaged in health promotion campaign.		
11	Gbonhinbor et al. (2024)	Nigeria	GPS and GIS to geolocate participants and community	Spatial distribution of intestinal parasitic infection.	Informed consent obtained. Community engaged and community approval obtained.	Ethical approval stated.	Protection of individual and community interests highlighted. Example of best practice in the use of GST in community health research.
12	Piwpong et al. (2025)	Thailand	GPS and GIS to map mobility of elderly in communities.	Health centre coverage and disparities among the elderly.	No information on the informed consent process for geolocation of study participants and health care service centres. No direct community engagement.	Ethical approval not stated.	Risk for violation of autonomy and privacy.

As Table 1 demonstrates, the absence of community engagement or informed consent in the initial application of GST in CHR is documented in multiple peer-reviewed studies across diverse contexts. In several cases, consent was obtained only after geolocation or mapping had already occurred, undermining respect for autonomy and privacy. The recurrence of such practices in both the global north and south supports the contention that non-consensual deployment of GST in CHR is a frequent and ethically significant phenomenon. Including examples of best practice illustrates that ethical compliance is both possible and practicable in GST-based research.

By inference or by direct expression, there is a school of thought that upholds ethical principles in the use of GST in CHR (Apte et al., 2019; Ribeiro et al., 2022; Bennett et al., 2024). And there is another school of thought that holds that it could be permissible to apply GST in community health research without considering ethical principles, particularly when there is no direct contact with humans (Vacek, 2017; Sella-Villa, 2021). All in all, there is sufficient evidence that some researchers do not think that the application of GST in CHR, particularly in the absence of human participation, has ethical implications. Therefore, the use of GST presents ethical dilemmas regarding privacy, confidentiality, freedom, exploitation, stigma, discrimination, and safety. The question that arises is whether matters related to informed consent, privacy, confidentiality, community consultation, and social value ought to be dealt with according to established guidelines before the deployment of GST in community health research. In the face of conflicting positions, it is important to determine the morality of GST in CHR without prior appraisal of ethical considerations. Ethical clarity will potentially strengthen research ethics guidelines and the composition of ethics committees for the protection of communities and their residents (Chennells and Steenkamp, 2018).

1.4 Thesis Statement

I argue that it is not ethical to use geospatial technologies for community health research without observing the principles that guide research in communities. This is because doing so violates respect for persons, community integrity, and the use of community for ends that may not be of value to the community. In Chapter three, I use ethical norms and guidelines for health research involving humans and communities, and principles from Kantian, Virtue ethics and utilitarianism to defend three premises for my claim.

1.5 Research Aim

The aim of this study is to defend the thesis that it is not ethical to use geospatial technologies in community health research without observing the ethical norms and principles that guide research in communities.

1.6 Research objectives

1. To provide an overview of community health research.

2. To describe the range of geospatial technologies (GST) used in community health research.

3. To make the argument that health researchers who use GST in community health research ought to adhere to norms and standards, principles, and guidelines for ethical and responsible conduct of research in communities.

4. To refute counterarguments for non-observance of ethical principles in the use of GST in community health research.

1.7 Research design

The focus of this study is on the ethics of GST in community health research. I will use a philosophical inquiry approach to answer the question whether it is ethical to use GST in community health research without adhering to guidelines that safeguard autonomy of persons,

privacy, confidentiality, community integrity, and social value. A philosophical inquiry is appropriate to provide answers to what ought to be done (Steve Biko Centre for Bioethics – "Guidelines for Developing and Submitting a Research Proposal").

1.8 Research Methods

This report is based on desktop research. I discussed the literature on the topic. For this, I used journal articles; websites of professional and academic societies; ethical guidelines and frameworks on community health research; the constitution, legislations, and case law. I provided a critical analysis of the ethical issues using philosophical concepts and moral theories.

In this chapter, I called the attention of the reader to the underlying ethical issues on the use of GST in CHR. Using evidence from literature, I demonstrated that some researchers, whether from the global south or the global north, do not appreciate the need for prior informed consent in the application of GST in CHR. This situation is more pronounced when there is no direct contact between a form of GST and a community or its residents, for example when remote sensing approaches are applied. When researchers do not consider prior informed consent on the premise that there is no direct contact with the target community, issues of privacy, confidentiality, and safety also arise. The situation where there is no direct contact also appears to amplify the lack of deeper consideration of ethical principles and of the social value of GST in CHR. Against this background, I contend that it is not morally permissible to use GST in CHR without ethical considerations. To further demonstrate the ethical dimensions of the use of GST in CHR, a description of CHR and the different main types of GST used in CHR is provided in Chapter 2.

CHAPTER 2: COMMUNITY HEALTH RESEARCH AND GEOSPATIAL TECHNOLOGIES

2.1 Community health research (CHR)

Here, I briefly described what a community is, what health research is, and by deduction what community health research is. I also answered the anticipated question, 'who is a research participant?' From these bases, the relationships and interactions between research participants, communities, and GST are made evident, thereby laying the foundation on which to enhance our understanding of the ethical issues that arise in the application of GST in CHR - the focus of this research report.

Several views have been expressed as to what constitutes a community. Some authors have argued that a community is a group of people in a particular geographical area (Campbell and Jovchelovitch, 2000; MacQueen et al., 2001; Lavery et al., 2010). Examples of this type of community would be a village, a town, a city, or an area comprising several human settlements. In these cases, physical proximity is a key descriptor of what a community is (Cobigo et al., 2016), and the geographic identity binds and distinguishes members of the community. On the other hand, a community could also be described as a group of people with a shared social, political, cultural, economic or health identity (MacQueen et al., 2001; Goodman et al., 2014), without necessarily situated within the confines of a territorial boundary. However, since health, culture, political, social and economic ties may change, and also since individuals do not always adhere to these characteristics, it is plausible that these types of communities may not be in a particular location; and may not be static. Examples of this type of a community would be a collective of researchers, alumni, immigrants, drivers, healthcare workers, internet users, cancer patients, or bioethicists. Following an analysis of the concept of community, based on a literature search (1 January 2003 to 31 December 2013), in addition to a focus group

discussion on the concept of community, for the purpose of policy decisions, Cobigo et al (2016; p95) defined a community as

> "*a group of people that interact and support each other, and are bounded by shared experiences or characteristics, a sense of belonging, and often by their physical proximity*."

The World Health Organization (WHO, 2024)) also defines a community as:

> "*A specific group of people, often living in a defined geographical area, who share a common culture, values and norms, are arranged in a social structure according to relationships which the community has developed over a period of time. Members of a community gain their personal and social identity by sharing common beliefs, values and norms which have been developed by the community in the past and may be modified in the future."*

Geospatial technologies are fundamentally applied geographically; and it is therefore evident that a community that is not defined by physical proximity or geographical coordinates would not be amenable for GST application. Consequently, for the purposes of the current report, a community will be considered as a group of people inhabiting a defined geographical area, sharing a common culture, interests, and linked by socio-economic determinants.

Research is needed to advance human health and healthcare delivery. Health research encompasses a broad range of enquiries, and may include biomedical (Kapoor, 2016), clinical (Clarke et al., 2010; Kandi and Vadakedath, 2023), health systems and services (Decoster et al., 2012), social (Umberson and Montez, 2010; Cho et al., 2020), cultural (Woodland et al., 2021; Rice and Liamputtong, 2023), environmental (Manisalidis et al., 2020), and population health studies (Kindig and Stoddard, 2003; Alder et al., 2013). Health research has immense value for communities, as it provides useful information about the spread of diseases, risk

factors for diseases, treatment outcomes, and cost and socio-economic gains of healthcare (Institute of Medicine, 2009).

Community health research, distinguishable from other forms of public health research, may then be described as the collection of approaches and tools applied in the identification of risk factors for diseases, development of interventions, implementation of developed interventions and the dissemination of interventions in a defined geographic area or for a defined group of people (Lavery et al., 2010; Goodman et al., 2014; Hoon-Chuah et al., 2018). This usually involves the participation of members of the community and other stakeholders (Brear et al., 2018; Kretchy et al., 2022). Although benefits may accrue from the participation of community members, there is evidence that community-based participatory approaches significantly enhance social and health outcomes (Hoon-Chuah et al., 2018; Karras et al., 2024). However, factors such as culture, gender, social and economic status; and power relations should be considered for optimal participation and better service delivery (Lavery et al., 2010). Community-based participatory research implies that the researcher engages the community. This could be in the form of community consultation to obtain permission to conduct the research, or involvement of the community members to identify the research questions, or to recruit community members on whom research will be conducted or a combination of all of these (Weijer et al., 1999; Goodman et al., 2014; Lazo-Porras et al., 2020; Luisi and Hamel, 2021; Mthembu and Chimbari, 2023).

2.2 Research participant

After having described what a community is, and what community health research is, I will now delve into the concept of a research participant. The term ‘research participant’ is fundamental in the discourse of applied ethics in which moral norms and principles are used to

gauge whether or not research activities are conducted in an ethically acceptable manner. I am aware of the discussion of whether 'research participant' or 'research subject' is more appropriate to describe those who voluntarily give consent to participate in a research project (Corrigan and Tutton, 2006; Corpuz, 2023). I am also aware of the nuanced descriptors 'research-centred participant' and 'researcher-participant' (Feeney et al., 2018; Oyinloye, 2022). However, for the aim of this report, I will restrict myself to the 'research participant' descriptor since it is the recommended descriptor by the South African National Health Research Ethics Council. Two questions arise: 'who is a research participant?' Does 'research participant' refer only to an autonomous individual (a person) or can it also refer to a community? It is important that I deal with this anticipated question, so that my subsequent arguments on the ethics of community health research are properly situated.

Community health research evokes a community as the target of the intended research. In this case, the objective of community health research, which is to generate generalizable knowledge, could only be achieved by conducing the research in a target community. This means the community is the "*key unit of identity*" of the research (Collins et al., 2018, p4). I hold the position that it suffices for this key unit to be the participatory entity of the research, even if individuals who constitute the community are not necessarily participating in the research. So, if the application of GST, such as RS and GIS, in a community is to generate knowledge useful for that community, one could rationally say the community is participating in the research. So, whether or not there is active or passive participation, protection with the highest possible standards is demanded for the '*key unit of identity'* of the research – that is the community.

2.3 Geospatial technologies used in community health research

In section 2.1, I described the concept of community and underlined that for the current report, community refers to a group of people in a specific geographic area. I also indicated that health

research refers to all processes aimed at improving the health of peoples. Consequently, community health research would then refer to all processes aimed at improving the health of people in a specific geographic setting.

Innovative technologies are used increasingly in CHR, and one set of these technologies is geospatial technologies (GST). In Chapter 1, I mentioned four GST (RS, GIS, GPS, and IMT) commonly used in CHR. Often, these technologies are used in combination (Beck et al., 2000; Dobbs and Louis, 2015; Paris and Rienow, 2023). I now provide a brief description of these four technologies, and their integration with artificial intelligence through deep learning, with the goal of demonstrating their potential impact on ethical principles and norms, namely autonomy, non-maleficence, benevolence, privacy, confidentiality, justice, and social value.

2.3.1 Remote Sensing (RS): The United States Geological Survey (United States Geological Survey, 2024) described RS as

> "*the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth.*"

In RS, data about an object are collected without direct physical contact with the object. Sensors, mounted on an appropriate platform, collect the required data. The platforms used are either earthbound, such as on tripods; airborne, such as on planes, drones, and the space station; or on satellites (SpatialPost, 2020; Jafarbiglu and Pourreza, 2022). Drones, also referred to as unmanned aerial systems (UAS) are a frequently common airborne platform in CHR , because of their relatively low cost and capacity to capture data on a relatively large area, and in not easily accessible areas (Sharma and Sharma, 2024). Sensors for RS are either passive or active. Passive sensors rely on the natural reflected light or emission from the object to obtain

information, while active sensors produce their own energy or light and then determine distances by measuring the time it takes for the energy to get to the object and back to the sensor (Javaid et al., 2021; GIS Geography, 2024). The camera in the sensors produces digital or analogue images of the object or area sensed (Paul and Pati, 2021; Mehmood et al., 2022).

The quality of remotely sensed images depends on the radiometric, spatial, spectral, and temporal resolution of the sensor. Radiometric resolution refers to the ability of a sensor to differentiate among objects using the differences in the amount of energy emitted. Spatial resolution is a measure of how objects can be shown to be distinct from others, even from the smallest objects. Spectral resolution measures colour wavelength by recording spectra bands; while temporal resolution is the frequency or number of times that an object is sensed over a given span of time (Verde et al., 2018; Hu et al., 2024). A combination of radiometric, spatial, spectral, and temporal resolutions is employed, in varying degrees, to obtain the quality of images desired.

The launch of the Landsat-1 satellite in 1972 increased the pace of the application of remote sensing to map features on the earth's surface (Beck et al., 2000; Cohen and Goward, 2004; Wulder et al., 2012). Subsequently, several remote sensing tools applied to sense data on human health and other applications: The Landsat's Multispectral Scanner (MSS) combines radiometric, spatial, spectral and temporal resolutions. Thus, it can provide images in which water, colour, vegetation, and lands masses can be differentiated (Schowengerdt, 2007). It has a spatial resolution of 79m (European Space Agency, 2024). The Landsat's Thematic Mapper (TM) is an "*advanced, multispectral scanning, earth resources sensor designed to achieve higher image resolution, sharper spectral separation, improved geometric fidelity and greater radiometric accuracy and resolution than the MSS sensor*." (National Aeronautic Space

Administration, 2025). It has a spatial resolution of about 30 metres. The Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA) is used to investigate temperatures of radiating surfaces and sea surface temperature and vegetation coverage, land-water boundaries, cloud distributions during the day and night, sea surface temperature and vegetation (Yin et al., 2012; National Oceanographic and Atmospheric Administration, 2024). Therefore, the applications of AVHRR include environmental, meteorological, climatological (Prasannakumar et al., 2020); monitoring of food crops, deforestation and forest fires (Al-Kindi et al., 2017); animal habitats and animal migration patterns (Wegmann et al., 2014); and insect infestations (Zang et al., 2019; Prasannakumar et al., 2020). AVHRR has spatial resolution of about 1km (Dech et al., 2021). The relatively low spatial resolution of AVHRR is compensated by the relatively high temporal resolution of several times per day. The relatively high temporal resolution makes AVHRR useful in the monitoring of continuous events, for example floods, fires, and volcanoes (GIS Geography, 2024).

A commonly used RS technology is the Système Pour l'Observation de la Terre (SPOT). In-service SPOT platforms, such as SPOT-7, has sensors with a very high spatial resolution of about 1.5m, coupled with a temporal resolution of several times per day (Hubert-Moy et al., 2020). The extremely high spatial and temporal resolution capacities of SPOT-7 means that the technology can be used to 'see' and produce astonishing high quality images of a community, including its natural resources, agricultural activities, cultural and religious landmarks without the knowledge of the community (Hubert-Moy et al., 2020; Apostolopoulos and Nikolakopoulos, 2022; defenceWeb, 2024) .

With the possibility to map human settlements and structures, earth formations, water bodies, and vegetation, RS can also be used to describe the dynamics of contact between disease vectors and humans, such as for malaria, dengue fever, yellow fever, schistosomiasis, and other environmentally influenced disease transmission infections (Beck et al., 2000). From a 10-year bibliographic analysis, Viana and colleagues (2017, p1) argued that

> *"for some infectious diseases and other highly pathogenic or emerging infectious diseases, remote sensing has become a very powerful instrument,"*

to study the spread, transmission, and risks factors for diseases. Despite the desirable capabilities of RS, geolocation presents a potential for privacy violation and disrespect for a community, and through RS technology community residents are associated with a particular location, disease or risk factors for a disease. This knowledge could lead to undesirable situations in which the community members are exposed to stigma, discrimination and even violence, particularly if it pertains to a minority population, or when the data collection design was biased (Berman et al., 2018; Gomez et al., 2022; Tiwari et al., 2023).

2.3.2 Geographic Information Systems (GIS): Geographical information systems integrate spatial and non-spatial data. They comprise a suite of software that maps, analyses and assigns a specific location on the earth's surface (Wright et al., 1997; Wang, 2020). Thus, GIS comes at a later stage in the workflow for geolocation. To map and analyse a specific location by GIS, hardware (even a personal computer), data points, and trained personnel are required (Maguire 1991; Wang 2020). The GIS process of data collection, analysis, and mapping is applied in health to describe the source and geographical spread of disease-causing agents, and to identify areas at various times and spaces where people may be exposed to disease-causing agents (Cromley 2003; Richardson et al., 2013; Khashoggi and Murad, 2020). Geographic information systems are also used to predict patterns in health outcomes, healthcare planning,

and healthcare delivery (Bojago et al., 2023; Faizal and Basri, 2024). Datasets in GIS, such as personal information, may be made available, even unintentionally to unauthorized parties, and data manipulation could be used for nefarious purposes (Onsrud, 1995; Cinnamon, 2020; Gomez et al., 2022). Risks related to privacy, confidentiality, stigma, discrimination, safety, and economic loss are matters worthy of thorough ethical consideration in GIS research. Therefore, the development, analysis, storage, and sharing of health related data of individuals must be done ethically. Otherwise, as with RS, communities may suffer from stigmatization and discrimination (Fischer et al., 2019; Ransing et al, 2020; Kuper, 2021; Yuan et al., 2022); insecurity and socio-economic loss (Dako-Gyeke et al., 2017).

2.3.3 Global Positioning System (GPS): Global positioning system is

> *"a network of satellites and receiving devices used to determine the location of something on Earth. Some GPS receivers are so accurate they can establish their location within 1 centimeter,"* (National Geographic, 2024).

Because of the use of multiple satellites emitting radio waves which have a constant speed, GPS data are generally highly accurate (Kumar and Dutt, 2020; National Aeronautic Space Administration, 2024). Besides providing an objective location, GPS receivers also provide velocity, accurate time, and latitude and longitude data (Doong et al., 2011; Ocal et al., 2021; Souza and Guerra, 2024). Notwithstanding, a lack of clear radio signal from the satellites may diminish the accuracy of GPS data. This could happen from gravity pulling the GPS satellites out of orbit, and distortion of radio signals by the earth's atmosphere, trees or other structures. To counteract loss of signals and accuracy of GPS receivers, control and monitoring stations around the world track and constantly monitor the signals, making corrections which are relayed to GPS receivers (Enge, 1994; Duncan et al., 2013; Kumar and Dutt, 2020).

Global position system is used to objectively track the movement of airplanes, ships, automobiles, trains, individuals (Fillekes et al., 2019), animals (Jin et al., 2022), and even mobility of access points to food (Cetateanu and Jones 2016). Its use in health research has grown exponentially, for example, in objective data collection from study participants, geolocating households, and detecting environmental risk factors (Kerr et al., 2011). The application of GPS involves selecting the appropriate device, collecting data from participants or associated objects, processing the data, and integrating the data into GIS. It provides more accurate data compared to self-reporting or other estimated measures of exposure to a risk (Kerr et al., 2011). The capability of GPS to identify the location of individuals and associated features (homes, farms, and mobile trajectory) also raises privacy and security concerns (Apte et al., 2019; Garett and Young, 2021; Mathenjwa et al., 2023).

2.3.4 Internet Mapping Technologies (IMT): Forms of IMT include Internet GIS, distributed GIS, and Web GIS (Kemp, 2008; Veenendaal et al., 2017). Internet mapping implies using the internet as a mapping tool, and according to Kemp (2008, p511) it represents

> *"the implementation of GIS functionality through a World Wide Web browser or other client program, thus allowing a broader usage and analysis of a particular geographic database* ."

Applications of IMT in research projects come in three formats: (1) data sharing, for example through online data warehousing and data clearing houses such as Geodata.gov and SANDAG GIS; (2) information sharing in the form of web-based map display and navigation services such as Google Maps and Google Earth; and (3) knowledge sharing, comprising online GIS models and web-based spatial analysis tools such as ArcGIS server mapping services (Lefer et al., 2008; Smith, 2016; Alexander et al., 2021; Phuangsuwan et al., 2024). As a result, an

interface between a user and an object or person of interest is provided (Rzeszewski and Kotus, 2019; Bello et al., 2021; American Association for the Advancement of Science, 2024).

All in all, GST generate large amounts of geographical information (GI) that is amenable to a variety of uses. As Blakemore and Longhorn (2004; p10) noted,

> *"… spatial data itself is seldom either 'ethical' or 'unethical', rather its use, abuse and misuse, either with or without spatial analysis technologies, lead to the true ethical questions. Given the generally promoted view that GI is 'ubiquitous' in information space and underpins so much of our society, economy, and government, we also argue that all ethical issues impinge on the GI community. Indeed, if GI is really that important to society, then the GI community should have the strongest ethical statements and practices of any sector in the information society, globally."*

The rapid advances and success of GST and the associated expansion and uptake of GIS in almost all disciplines of research are accompanied by complexities in the ethical considerations of their use (Nelson et al., 2022). As noted earlier, GST can collect confidential information intentionally or unintentionally and identify personal or communal characteristics. These include data on the location of individuals or private structures, the behaviour and activities of individuals or a collective, and how individuals or a collective use space (Carrasco-Escobar et al., 2022). Geospatial technologies can also indirectly collect information on the composition and characteristics of families, use of natural resources, and income (Finn and Wright, 2016). Whether this information is collected intentionally or unintentionally, the use of GST introduces ethical issues related to respect for persons and communities, privacy, confidentiality, and safety.

2.3.5 Geospatial technologies and artificial intelligence

The capabilities of GST have improved tremendously over the years, leading to the acquisition of huge data sets and outputs with high resolution. Worthy of note is the convergence of the developments in GST with rapid developments in artificial intelligence (AI), with added capabilities that are revolutionizing GST data analytics, management, and decision-making (VhoPham et al., 2018; Sahana et al., 2022; Choudhury and Um, 2023). The combination of GST and AI brings with it new possibilities for enhanced data mining for trends and predictive modelling (VhoPham et al., 2018; Boulos et al., 2019). Ethical challenges accompany these benefits; for example, through incorrect predictive models with the potential to perpetuate injustice in resource allocation, thereby violating the right to human wellbeing and dignity. Another key concern is privacy. Most of the time, geospatial AI relies on delicate spatial data, such as human and mobile patterns of animals, household geolocation, land use and other geo-tagged images, through which identifiable personal information could be exposed if not managed appropriately (Gao et al., 2019; McKenzie et al., 2023; He et al, 2024). According to Mai et al (2025, p12),

> "*The integration of AI with geospatial data heightens the risk of inadvertent privacy breaches, particularly when datasets are combined, re-identified, or released for public use."*

After examining the nature and capabilities of GST, I have shown that GST represent a set of powerful tools for data collection in CHR. I have also shown that GST brings huge benefits to health research, and at the same time GST presents risk of harm to individuals and communities. It is therefore clear that a tension exists on how to reap the benefits of these technologies and at the same time avoid the harm that they could impute to communities and their residents. The potential harm due to GST should not be traded off for the benefits;

therefore, it is important to flesh out what is morally permissible in the application of GST for CHR. In sum, GST collects data linked to individuals or communities; or objects or resources associated with individuals or communities. Therefore, GST constitute a set of intrusive data collection instruments. Consequently, the decision to use GST in CHR ought to involve the persons or communities who could experience the intrusiveness of the use of GST. Arguments on why the use of GST in CHR must be guided by the norms, standards, and principles of ethical research are presented in Chapter 3.

CHAPTER 3: ARGUMENTS FOR THE ETHICAL USE OF GST IN COMMUNITY HEALTH RESEARCH

The focus of this study is on the ethical use of GST in community health research. I chose a philosophical inquiry approach to answer the question of whether it is ethical to use GST in community health research, particularly when there is no human contact, without adhering to ethical norms and guidelines that safeguard autonomy of persons, privacy, confidentiality, community integrity, and social value of research. I discussed literature on the topic, and I used journal articles, normative ethics, guidelines, and frameworks for ethical research. I then provided a critical analysis of the ethical issues using philosophical concepts of moral theories.

3.1 Thesis statement

While some researchers hold that it is permissible to dispense with ethical norms and principles in the application of GST in community health research, I argue that it is not ethically permissible to use GST in community health research without engaging the community and its residents on matters of autonomy, privacy, confidentiality, and the social value of the research. To justify my argument, I defend the following premises:

3.2 Ethical arguments

3.2.1 Premise 1: Autonomy, privacy, and confidentiality are violated when GST is used in community health research without informed consent from individuals or informed communal approval.

Researchers must make full disclosure of a study protocol to prospective participants and communities in order for prior informed consent to be possible. Consent depends on the methodology to be applied; data collection instruments envisaged; the nature of involvement of study participants; and how data associated with individuals, and the community will be

collected, processed and shared. The application of GST without consideration of these principles, even in the absence of active participation of the community or its residents, is a violation of autonomy and privacy.

3.2.1.1 Argument grounded on principlism, research ethics guidelines and frameworks

One of the key components in the ethical evaluation of research protocols is the assessment of the study design, methodology and instruments proposed for data collection, the procedures for data storage, processing, information sharing, and the associated risks and benefits (Eccles et al., 2011, Li et al., 2016; Page and Nyeboer, 2017; Davies, 2020; NHREC, 2024). As earlier indicated, GST are approaches and instruments for data collection. Therefore, if GST are proposed for data collection in community health research, any health ethics review committee ought to be interested and understand the nature of their deployment and assess how this could potentially affect the community and its residents.

Four normative principles, namely respect for persons (autonomy), non-maleficence, beneficence, and distributive justice generally guide ethics in health related research; and every health research ethics committee examines how the proposed research activities stand up to ethical principles, norms and standards as a measure to reasonably protect and safeguard individuals or communities (Emanuel et al., 2008; Beauchamp and Childress, 2012; Keeling and Bellefleur, 2016; Dhai, 2019). Respect for persons entails that the right to dignity and freedom of well-informed study participants or an engaged community to voluntarily give consent to participate in a study is respected, privacy is not violated, and information provided by residents and the community is safeguarded (CIOMS, 2016; NHREC, 2024). Carrying out research in a way that allows for the least minimum harm (non-maleficence) and a favourable risk/benefit ratio (beneficence) caters for the wellbeing and best interest for the community and its residents (Bernabe et al., 2012; CIOMS, 2016; Wikler, 2017; van Rijssel et al., 2024). In

addition, the burden borne by participants must be fairly and equitably distributed (Wood, 2017; Hadler and Rosa, 2018; Andersson, 2022; Bhasker, 2023).

In Chapter 2, I provided evidence from the literature that GST has the capability to capture, store, and process high resolution spatial data, whether matrix or imagery, of individuals, private property and spaces, communal property, and resources. In addition, the accuracy of the data is enhanced by high temporal resolution capabilities of some systems. More importantly, the data generated are actionable. When GST is applied in CHR, the data collected rightfully belongs to the community residents or the community as 'the key unit of identity.' For the right to data ownership to be exercised, the owner ought to have had the opportunity to provide informed consent on how the data will be collected, stored, processed, and shared. For consent to be informed, researchers must make full disclosure on why the research is being conducted, the role of study participants (active or passive), the benefits and risks to the community and its residents, and the value of the study to the community (United Nations, 2008). Through the letter and spirit of research ethics frameworks and guidelines, I will now show that prior informed consent is required for the use of GST in CHR because of the potential for the violation of autonomy, privacy and confidentiality (respect for persons), and exposure of communities and residents to potential discrimination, stigma, and socio-cultural and economic loss (beneficence, non-maleficence and justice).

The research ethics guidelines of the South African National Health Research Ethics Council (NHREC) stipulates the minimum norms and standards for conducting health research in South Africa. The Guidelines stipulate that:

> *"Protocols to conduct research involving humans undergo independent ethics review before research activities start. Proposed health or health-related research broadly*

addresses human health and wellbeing and is in the domain of curiosity-driven basic sciences or applied and immediately relevant research. Protocols to conduct health research stand up to scientific and ethical scrutiny appropriate to the context and disciplines concerned. Harm to research participants is prevented or mitigated and balanced against the likelihood of benefit to the individual and/or society." (NHREC, 2024, pii).

The NHREC guidelines draw from research ethics guidelines globally. Worthy of note is that the NHREC guidelines are legally binding with authority from Section 72 of the South African National Health Act of 2003. The Act requires NHREC to develop minimum norms and standards for research involving humans, animals, and clinical trials.

In weighing the risk of harm against likelihood of benefit, the analysis ought to be concerned not only with current participants or research animals themselves but also with societal interests and future hypothetical beneficiaries. On stakeholder engagement, section 2.3.3 of the NHREC guidelines states

"Researchers should involve and collaborate with ***stakeholders*** *(*my emphasis*) at an early stage and in a sustained manner, for the duration of the study, to enhance the scientific and ethical quality of a study. For example, co-researchers, academics and non-academics such as* ***community representatives*** *(*my emphasis*), governmental departments. ... Engagement involves implementing actions to meet the needs and expectations of the different stakeholders and aims to achieve accepted outcomes for all parties, with levels of collaboration dependent on the prevailing circumstances. Engagement efforts may comprise of various activities, including awareness-raising*

initiatives for stakeholders, including ***participating communities*** (my emphasis)*."* (NHREC, 2024, p9).

Notwithstanding the fact that NHREC guidelines do not specifically mention the use of GST in research, they require the observance of autonomy in the collection of data from individuals or a collective. This means, irrespective of the instruments applied, in so far as the data are associated with individuals or is collectively owned, autonomy must be respected. Therefore, if GST obtain data on the location of people's houses, movement of people, location and movement of livestock, or data on resources belonging to a community, respect for the inherent right and freedom to provide informed consent prior to the collection of such data must be sought. As I indicated in the rationale section of this report, there have been instances in South Africa (Baker et al., 2019; Makungo et al., 2020), and in other countries in the global south and global north (Kabaria et al., 2016; Wagenaar et al., 2018; Higgins et al., 2019; Kim et al., 2022) in which geolocation of households in communities or the application of GIS was carried out without prior consent from members of the households. However, according to the norms of health research ethics, consent from the community members ought to have been obtained prior to geolocating the households or resources of the communities. These requirements on data collection, are also encapsulated in the research ethics guidelines of the South African Medical Research Council, and the Health Professions Council of South Africa. International health research ethics frameworks such as the Committee of International Organization of Medical Societies (CIOMS, 2016), the Singapore Statement on Research Integrity (2010), and the World Medical Association Declaration of Helsinki (2024) also underline the observance of these norms.

To emphasize the need for ethical research in communities, the NHREC Guidelines make ample reference to the San Code of Research Ethics, giving recognition to the aspirations of indigenous communities defined by geography, culture, religion, and language, on how they

want to be appreciated and engaged with on health research. The code was developed by the San Council of South Africa, with support from the TRUST Project of the European Union (Chennells and Steenkamp, 2018; TRUST, 2025).

The San are known to be the oldest inhabitants of Africa (Mitchell, 2013; Hitchcock et al., 2016), with carbon dating and Bayesian modelling suggesting that the San could have been in South Africa from about 44,000 years ago (d'Errico et al., 2012). According to South African History Online (2018), the San are the first inhabitants and true indigenes of Southern Africa; with San communities in Angola, Botswana, Namibia, South Africa, Zambia, and Zimbabwe (Hitchcock et al., 2016). They constitute minorities in Southern Africa and suffer unequal access to health and social services (Phiri et al., 2020).

The San Code was borne out of dissatisfaction and frustration of the San people of South Africa with the insensitive, exploitative and manipulative tendencies of certain 'outsiders' with respect to their community (Callaway, 2017; Chennells and Steenkamp, 2018; Schroeder et al., 2019). As pointed out by Chennells and Steenkamp (2018, p16)

> *"One of the most important roles of the San councils of Namibia, Botswana and South Africa is to protect their people from unwanted, inappropriate or exploitative research."*

Briefly, the San Code of Research Ethic stipulates Respect, Honesty, Justice and Fairness, and Care as important norms to be observed in carrying out research in their communities (The San Code of Research Ethics, 2017). It puts forward the San Research Protocol which all researchers must adhere to. The Code cites lack of respect for their norms and culture in several ways. For example,

> " *In Genomics research, our leaders were avoided, and respect was not shown to them. Researchers took photographs of individuals in their homes, of breastfeeding mothers,*

or of underage children, whilst ignoring our social customs and norms. Bribes or other advantages were offered."

The Code specifically calls for respect for the Community and their privacy as a collective. It reiterates that

"Prior informed consent can only be based on honesty in the communications, which needs to be carefully documented. Honesty also means absolute transparency in all aspects of the engagement, including the funding situation, the purpose of the research, and any changes that might occur during the process."

This means individual consent does not override collective community consent, obtained through recognized community structures and leadership. According to the Code, respect for the community also entails disclosure of any potential harm or problems that may rise for the community and its members from the research. In short, the Code demands respect for community sovereignty.

While acknowledging the benefits of GST for a community, there is also potential harm from their application, and this could vary. I now hereby briefly describe a few. One of the key outcomes of satellite imagery, aerial photography and GIS is the production of high-resolution imagery in the form of pictures and maps. Satellite imagery, as a RS technology, does not require direct physical presence in an area. As a result, the need for a direct relationship with individuals of the area under investigation could be avoided, in addition to the fact that the data could be freely available to different audiences (Fisher et al., 2021). From the pictures and maps, the land area, religious and cultural landmarks, and natural resources (which provide sustenance to a community), in addition to sites of potential archaeological interest, could be clearly identified. A specific community, in the context of a country, is weak compared to powerful external political and economic forces. The irresponsible sharing of imagery on the

cadastral features of a community could lead to illegal archaeological prospecting (Parcak, 2009; Frank et al., 2015; Parcak, 2017), land grab (Nalepa and Bauer, 2012; Sidiq, 2021; Paris and Rienow, 2023), and even illegal mining (Hausermann et al., 2018; Oskarsson et al., 2019), with disastrous consequences for the environment, and dehumanization of the said community (Slonecker et al., 1998; Myers, 2010).

The San code also calls for co-ownership of research, fairness in sharing of benefits from research, and the inclusion of community members, for example as field workers. In taking care of the community, the Code speaks on the need of research to be aligned to their needs, to be of high quality for optimal impact, considering those involved, their families, and the social and physical environment. The elements of the San Code are similar to those stipulated for research among the indigenous people of Canada, for whom community is the overarching identity (Canadian Institute of Health Research, 2014; Morisano et al., 2024), and the "Global Code of Conduct for Equitable Research Partnerships" (TRUST, 2018). Of interest is the adoption of the TRUST Code by the American Geophysical Union (AGU) as a

> *"framework to guide global research collaborations;"* and to "*foster greater equity and transparency in global research collaborations."* (Xenopoulos et al., 2024, p1).

The adoption of the TRUST code takes effect in the research policy statements across the twenty-four scholarly journals of AGU.

The experience of the San people, other Indigenous communities, and communities of low socio-economic status brings to the fore salient inherent attributes of these communities: (1) For these communities, individuality is secondary to the identity of the collective (Chennells and Steenkamp, 2018). (2) The collective is the "*key unit if identity*" as argued by Collins et al (2018, p4) for any form of engagement, including research. (3) The principles of respect for persons, benevolence, non-maleficence, and justice go far beyond the individual, into the

community, which is a group of inter-related and interconnected individuals forming a social fabric (Dobbs and Louis, 2015; Chennells and Steenkamp, 2018; Hirt, 2022). Article 1 of the United Nations Declaration on the Rights of Indigenous Peoples also strongly emphasizes the collective unity in indigenous communities:

> *"Indigenous peoples have the right to the full enjoyment, as a collective or as individuals, of all human rights and fundamental freedoms as recognized in the Charter of the United Nations, the Universal Declaration of Human Rights and international human rights law*." (UNDRIP, 2007; p7).

The implication for researchers, including those using GST, is that the approach of obtaining informed consent for community research must begin with the leadership of the community before individual consenting.

Emanuel et al (2008) expanded on the normative principles of autonomy, benevolence, non-maleficence, and justice, and proposed additional precepts for ethical community-based research and research in populations of low socio-economic status, and in environments of weak regulatory oversight. Weak regulatory oversight is evident from some reported studies which have used RS technologies to geolocate households in communities without obtaining approval of the study protocol from an ethics review committee or without obtaining informed consent from the households (Kabaria et al., 2016; Higgins et al., 2019; Makungo et al., 2020). According to Emanuel et al (2008), and relevant to the current discussion on CHR, the following requirements are essential for researchers: (1) collaboration with the study community, (2) social value from the research, (3) scientific validity of the research, (4) informed consent from the study participants, (5) respect for research participants at all times of the research process, and (6) review of the research protocol by a research ethics committee before the enrolment of research participants.

Each of these precepts must have a positive evaluation for the research to be considered ethical and responsible. Collaboration requires that the researcher engages the community on how the research will be conducted, what role the community is expected to play, and potential benefits and harm to the community. Social value begs the question: What remains for the community after the research project closes out? This value can only be determined and appreciated through engagement with the community, as this cannot come about in a vacuum (Lairumbi, 2008; Lutge et al., 2017; Filho et al., 2022). Scientific validity speaks to the appropriateness of the study methodology to the research questions (Resnik and Kennedy, 2010; Otieno-Odawa and Kaseje, 2014; Patino and Ferreira, 2018; Douglas, 2023); informed consent and respect demands that, with full knowledge of the nature of the proposed research, the community gives approval with the right to make reservations as they deem fit.

Since some GST approaches, such as RS and GIS, may not require direct contact with a community or its residents, a researcher may use these approaches without considering the required collaborative nature of community-based research, the scientific validity, and social value of the research, and not even see the need to seek approval of the study protocol from an ethics committee (Kabaria et al., 2016; Jayabalan et al., 2023). The need for an independent review board is relevant in all circumstances of CHR. It is even more relevant when marginalize and vulnerable communities are the intended participants in the proposed activities (Emanuel et al., 2004; Schopper et al., 2015; Nkosi et al., 2022; World Medical Association, 2024).

3.2.1.2. Counter-arguments against subjecting GST application in community health research for ethical review.

In the preceding section, I provided evidence from the elements of principlism, scientific literature, research ethics guidelines and research ethics frameworks to support my position that the use of GST in CHR must be subjected to ethical considerations. However, I acknowledge that there could be dissenting positions to my thesis. This is even expected due to the fact that the use of GST could have nuances because of the lack, at times, of direct or intimate contact with individuals and communities. I now consider potential objections to my claim that researchers who use GST in community health research ought to observe ethical norms of informed consent, privacy, and confidentiality; and that their research protocol ought to be submitted to a research ethics committee.

1) One may say, granted that prior informed consent ought to be obtained to use GST in community health research, however, it is not practical to obtain prior informed consent if a large region, encompassing several communities, is the subject of a research study, especially when resources for research are lean. I concede that there is a persisting reduction in available funding for biomedical research (Mandel and Vesell, 2004; Alberts et al., 2014; Ralaidovy et al., 2020). However, this should not be traded for meeting the minimum standards of ethical research, such as obtaining the required consent. The expected outcome of research is for human benefit; therefore, it would be morally unacceptable to tread afoot the autonomy of humans and the dignity of communities in order to provide a benefit. In another perspective, I contend that a practical dilemma (when something could not be done) must be understood differently from an ethical dilemma (when something ought to be done or not). Even so, there are alternative ways to engage consultatively and get valid permission prior to the research when the resources are lean or when the study area is extensive. For example, recognized representatives of the different communities of the targeted research area could be consulted

collectively instead of individually. This approach is used in other developmental endeavours, such as in environmental impact assessment for a proposed public infrastructure or industrial complex.

Even when satellites are used on a planetary scale and obtaining informed consent appears difficult (Davis et al., 2021), it is still possible to obtain consent. The United Nations resolution on the "Principles Relating to Remote Sensing of the Earth from Outer Space" calls on member states to share and discuss data generation, processing, and sharing (United Nations, 2009). Principle V of the Resolutions states that:

> *"States carrying out remote sensing activities shall promote international cooperation in these activities. To this end, they shall make available to other States opportunities for participation therein. Such participation shall be based in each case on equitable and mutually acceptable terms."*

Therefore, a researcher, with adequate planning, could obtain prior informed consent even when resources are lean, and when the study area is extensive.

2) One may also say if there is no direct human involvement and researchers follow guidelines to safeguard privacy and confidentiality of the data obtained through GST, then consent should not be required. At face value this may sound acceptable, however, it is important to note that what should be considered acceptable safeguards for privacy and confidentiality is principally for individuals and communities to make. The role of researchers is to guarantee these safeguards to the highest possible standards. Furthermore, study participants derive benefits from discussing matters of autonomy, privacy and confidentiality. Absence of discussions on these matters could lead to emotional and psychological distress among community residents and its leadership, and provoke distrust for science (Chennells and Steenkamp, 2018; Kang and Hwang, 2023). Therefore, researchers are obligated to prevent these forms of harm, by

engaging communities, even if there would be no direct contact in the course of conducting the research activities.

A nuance linked to the disregard for obtaining consent, on the grounds that there is no direct contact with humans, is that there should be no concern if the data are anonymised. To this, I would say it is possible to anonymise geospatial data by geocoding, cropping and masking for purposes of geoprivacy (Zandbergen, 2014; Ahmad et al., 2023; Tiwari et al., 2023). However, there is evidence that approaches to anonymise data have risks, and through reverse geocoding and reverse masking reidentification is possible (Brownstein et al., 2006; Kounadi et al., 2013; Zandbergen, 2014; Boulos et al., 2022). Moreover, through fine-graining of Big Data, it has become easier to re-identify an individual or a community through reverse engineering, or by aligning the data with other data sets that have personal identifiers. This means, even anonymised data carry the risk of re-identification (Kondor et al, 2017; Lubarsky, 2017; Foomkin, 2019). Therefore, even if researchers intend to apply decoding and geomasking techniques, it is important to have a discussion with those who will be potentially affected, so that the nature of the risks involved is understood, weighed, and voluntary prior informed consent is provided or otherwise.

The objection also covertly raises the question of what human involvement in research means if there is no direct contact with humans. In response, it is worthwhile to note that human involvement in research would refer to any activity or set of activities carried out with or about people, in so far as data associated which humans or their communities are used to produce generalizable knowledge (Fletcher, 2015; Newson and Lipworth, 2015). Therefore, activities that involve only the observance of people or conducting surveys would mean human involvement. In as much as data of individuals or a group of individuals are being collected, active or passive participation of the individuals is immaterial. What is important is that data

associated and identifiable to them are being collected and processed, for which prior informed consent must be obtained to permit the individuals or the community to opt in or out in accordance with their autonomy and freedom to choose, and to be respected for doing so without prejudice.

3) Related to the second objection is the position that identifiable data pertaining to individuals, or the community may not always be collected in the application of GST in community health research and therefore the research is of low risk and must be exempted from ethics review and its implications. For example, when RS and GIS are employed to map vegetation, water bodies, and topography related to diseases vectors, houses or personal information may not be necessarily collected. I acknowledge that there are studies of this nature and that they could be deemed as low risk. However, the absence of data on individuals does not mean there is no risk to them. This is because individuals or a community can be discriminated against and stigmatized by a simple association of a disease risk with the community (Fischer et al., 2019; Saeed et al., 2020). Moreover, researchers are not arbiters of the ethical implications of their own research. This rests with research ethics committees.

Other scenarios should also be considered. For example, data associated with a community could include forests and water bodies which a community holds sacred (Cocks et al., 2012; Mokashi and Diemont, 2021; Sinthumule, 2024). Revealing these through imagery or other means to 'outsiders' may be seen as disrespectful to their culture and religion and an injury to the dignity of the community (York et al., 2023). Communities may also hold and protect resources such as flora, fauna, and water bodies from 'outsiders' for their livelihood and sustenance (Natural Justice and Namati, 2015). Ethical issues can also arise if community members are criminalized without due process if anti conservation activities are revealed

through GST (Parris-Pipper et al., 2023); or deprived of their natural resources by powerful political forces (Natural Justice and Namati, 2015). Therefore, researchers must know and be sensitive to these aspects, and a discussion to get the approval of the community on how these types of data will be processed and shared is important in preventing harm to people.

4) Another objection could be that if researchers have considered the principle of proportionality (the application of a technology in proportion to the benefits of its use) and the principle of necessity (that is, there is no other alternative to the technology and data required for the aim of the research), then GST could be used without approval from a community. The two principles are well established in the United Nations Universal Declaration of Human Rights of 1946. On the basis that everyone, irrespective, has inalienable rights, any restrictions to these rights must be seriously considered. The question that arises is: what expectations are there from the use of GST in CHR that would warrant a researcher to ignore human rights when dealing with a community? Moreover, when dealing with an indigenous community (UNDRIP, 2007). Even if the researcher expects a substantive good outcome, he or she is not in the position to assess the right balance between outcomes from the research methodology and the infringement on human rights. This would be the responsibility of an ethics committee, with strong legal support; and the researcher is expected to submit a protocol for review. The same rationalization applies to any attempt at using the principle of necessity in research to avoid engaging the community.

3.2.1.3 Argument grounded on Virtue ethics for ethical use of GST in CHR

Virtue ethics refers to the morality of an action based on what a virtuous person would do in the same circumstances (Obermeyer, 2009). It is a normative philosophical approach that exhorts individuals to a moral life by practising and cultivating virtuous (good) habits (The Ethics Centre, 2016). A virtuous life calls the individual into a life-long project to truly change

one's dispositions or character. It is a morality from the 'inside', different from principlism, deontology, and consequential systems of morality (Devettere, 2002; Swanton, 2003; Misselbrook, 2015; Gentry and Fleshman, 2020). Health researchers are professionals and leaders in their own right, and therefore they are required to show ethical leadership (Gentry and Fleshman, 2020; Nicolaides and Dludla, 2023). Apart from acting due to the call of duty or for an outcome, the researcher must have a disposition for right action. That is, the researcher is called to ethical professionalism.

I contend that submitting a research protocol for review by an ethics committee must be a good habit for any researcher. This is founded on the requirement and call for all research seeking empirical evidence to be ethically appraised even before the activities start. Hence, a virtuous researcher will therefore act in a way that is considered good by the community in which he or she conducts research, by peer researchers, employer, affiliations, funders, and the society at large. In essence, the researcher must be disposed and act according to the ethical requirements of his or her discipline. This involves, for example, adhering to codes of ethics for health research scientists. Borrowing from Nicolaides and Dludla (2023, p13), the researcher should ask herself questions such as:

> "*Does my behaviour comply with relevant laws and regulations, and does it align with the organisation's mission as expressed in the code of ethics and any other internal policies? Does my actual or intended behaviour truly reflect the organisation's core values or ethical guidelines? Do I maintain personal and interpersonal connections that are crucial for a 'good' life? Are my actions a good moral guide and do they have a positive influence on my coworkers? Do I possess the needed virtues of honesty, compassion, fairness, trust, transparency, openness, and courage that are important in the workplace?"*

In other words, the virtuous person acquires, over time (Lockwood et al., 2024), the *"ability to know when and how to apply moral perspectives.*" (Bhuyan, 2007, p45). The question then is what character traits are essential for a researcher in making moral decisions in the employment of GST in CHR? Honesty, fairness and justice, humility, courage, and benevolence would be some of the important character traits. An honest researcher leans towards making full disclosure to the target community and its residents of the intrusive nature of GST, and the capability of GST to gather swathes amount of diverse data engendering privacy issues, even if the community or its residents are passive participants. It is also important to the honest researcher to discuss expectations of the research outcomes and disclose the identities of other parties with interest in the research outcomes. From the character for fairness and justice, the researcher endeavours to ensure fair treatment for all, and that individuals and communities get what is due to them, with the view of strengthening the community through the research process. Through humility and courage, the researcher is open to suggestions, community perspectives and wisdom on the research process; and welcomes their participation, with the mind to share authority in making decisions (Schaffer, 2009; Groot and Abma, 2022). Overall, a researcher with the moral character of benevolence has the disposition and the will to understand the needs of the community; show empathy, realize and appreciate the connection and interdependence with the community; and see to it that the desires of the community are realized (Cohen and Morse, 2014; Mogodi et al., 2019; Konadu-Osei, et al., 2023; Maluleke, 2024). These desires include respect for the community, and its cultural, religious and socio-economic wellbeing. Therefore, a virtuous researcher employing GST in CHR sees reward in respecting the dignity and autonomy of research participants and espouses community values.

An objection to my position on virtuous scientists using GST in CHR could be that we ought not to depend on the good dispositions of individuals for ethical behaviour, and that to obey rules and carryout out our duties are more dependable drivers for ethical research. There is some strength in this objection. However, I hold the position that nurturing good dispositions enhances and facilitates obeying rules and carrying out duties, in this case to conduct research ethically. This is because there is self-motivation, character and choice, founded on a good disposition to follow rules set by rightful authorities or carry out duties demanded of the researcher (Pauw, 2021; Ethics Unwrapped, 2025).

Furthermore, not every situation is anticipated in ethical guidelines and frameworks, which are intended to provide the minimum standards for compliance. Hence, a person who sees virtue as a reward in itself, finds personal happiness in the virtue, and whoever is inspired by virtue will augment the minimum standards that ethics guidelines demand, in practical terms (Devettere, 2002; Duffy et al., 2018). If a researcher does not have the good disposition to submit research protocols for ethical review, he or she will flout the process at the slightest opportunity to do so. Therefore, a researcher with good dispositions and who, in addition, obeys rule and carries out duties will be more ethical in using GST in CHR. Thus, the researcher could readily be a role model to others. This is even more desirable when no one is 'looking' or when the researcher operates in a weak regulatory environment. As argued by Nguyen and Crossan (2022), misconduct is largely due to the absence of character, and the promotion of virtue transforms the individual and mitigates misconduct.

With this in mind, I submit that the researchers who conducted the clinical trial of Trovan in Northern Nigeria in 1996 (Ahmad, 2001; Stephens, 2006; Okonta, 2014; Archibong and Annan, 2021); those who carried out genomics study among the San people of South Africa in

2009 (Chennells and Steenkamp, 2018); and researchers of the Bowman expedition in which GST was used among the Oaxaca of Mexico in 2019 would have acted ethically if they had good dispositions and the character for accountability to the communities. The researchers in these instances did not have virtue. The Pfizer investigators on the Trovan open label clinical trial exploited a weak regulatory environment; the genomic researchers exploited the vulnerable San community for the purpose of scientific inquiry, devoid of social value, while the researchers of the Bowman expedition also exploited the vulnerability of the Oaxaca community. Finckenauer (2023), in his paper '*Why do people obey or not obey the law,*' says it takes principled people to foment a change to unjust laws. Conversely, I contend that it also takes principled people, people of good character, people of virtue, to ensure that guidelines for the ethical conduct of research, including research employing GST in communities, do not need enforcement; and misconduct is minimized. All things considered, a life of virtue will motivate a researcher to ensure that CHR in which GST is applied complies with his or her good dispositions and values; and consequently, respect the ethical norms and guidelines for research.

3.2.1.4 Argument from Kantian moral theory for ethical use GST in CHR

I will now draw on the Categorical Imperative in Kantian moral theory to show that it is not morally permissible to use GST in CHR without adhering to ethical guidelines.

Kantian ethics consists of a set of universal moral principles applicable to all humans, irrespective of the situation. According to this theory, a permissible action is judged based on *what ought to be done*, and not what should be done (Dimmock and Fisher, 2017). As a result, duties must be performed, and obligations must be honoured, notwithstanding the nature of the outcomes from carrying out those duties or obligations. Duties refer to those things that we know are required of us irrespective of our desires. For example, to submit (duty) a health research protocol for review by an ethics committee and to abide (obligation) by the

recommendations from the ethics review process. According to this norm, the feelings of the researcher, or the outcome of an act, are not to be used in judging whether an action is morally acceptable or not. Put differently, actions are intrinsically right or wrong, not the consequences or the outcomes of the actions (Tomassini, 2023; Notre Dame Philosophical Reviews, 2024; Ramsauer, 2024).

Kantian morality is based on duties, driven by *good will*, rather than the feelings of the individual or outcomes of the act. *Good will* refers to the appropriate reason for a morally acceptable action. In other words, an individual must *will* to do good. Dimmock and Fisher (2017), writes that Kant distinguishes *good will* as something that is *good irrespective of effects*:

> *"A good will is good not because of what it effects or accomplishes - because of its fitness for attaining some proposed end: it is good through its willing alone - that is, good in itself*." (Kant, 2013; 40). Also, the goodness should have no qualification:
>
> *"It is impossible to conceive anything at all in the world, or even out of it, which can be taken as good without qualification, except a good will."* **(**Kant, 2013, p30)

In the context of the current argument, the question for the researcher is: what does the researcher *will*? Does the researcher have a *good will* in the application of GST in community health research? What is the proper motive in applying GST in CHR? The researcher must examine the questions in all ramifications, from advancing science to the wellbeing of the target research community. Therefore, the *will* to do good compels the researcher to ensure that GST is deployed ethically and responsibly. The concept of fully doing what ought to be done or obeying rules of duty, not according to duty is also referred to as the Categorical Imperative; it

is at the heart of Kantian ethics, and it is driven by *good will*. Categorial Imperative presents in three categories (Foot, 1972; McCarty, 2009); which are relevant to the theme of this report.

The first form is the "principle of the law of nature". It is also known as "the law of universalizability", because it argues that if an action is morally right, it must apply consistently to everyone, without exception and contradiction (Geiger, 2010; Wolf, 2023). The researcher applying GST then ought to act in such a way that her or his actions will become a universal law of nature. In other words, if anyone else were to be in *similar* circumstance to that of the researcher, that person would be required to act in exactly the same manner. So, a researcher whose maxim is not to observe ethical guidelines in the use of GST in CHR *ought to will* that everyone else does not observe the guidelines in the circumstances. In other words, what she advocates ought to be accepted by others, without exception. Since the maxim of not keep to research ethics guidelines cannot be universalized, then it must be rejected. And the right act will be to adhere to research ethics guidelines.

The second form of the Categorical Imperative, called the "principle of ends", states that we should always treat humans, including ourselves, as if they are an end in and of themselves, and never only as a means to an end (Schultze, 2012; Misselbrook, 2013; Geiger, 2015). In other words, we should respect and see value in others and not simply use or manipulate people to accomplish our own ends. How should this be applied to the use of GST in CHR? I contend that if the application of GST is not for the good of the community and its residents in itself, then the community would have been used only as a means to an end – to satisfy an inquiry. Therefore, it would not be morally permissible to use GST in the circumstance. On the other hand, the only way to know whether a community sees value in the application of GST in their community would require a consultative process; and thereby understanding and incorporating

what they want into the proposed research. It is possible that the community would want to know how to use GST in seeking solutions to some of their problems that the researcher may not be aware of. For example, there is evidence that participatory RS and GIS enables communities to counter-map their territories and through advocacy safeguard their land and resources (Rambaldi et al., 2006; Dobbs and Louis, 2015; Hirt, 2022). This way, the community is not used only as a means to an end, but also for the end of the community.

The third form of the Categorical Imperative is the principle of autonomy, which says that an individual is not dependent upon other people to tell her or him what is right or what is wrong, but that the person has the freedom and the ability, by the use of reason, to find out this for herself (Campbell, 2017; Fasoro, 2019; Elsner and Rampton, 2022). For the Kantian ethicist, the responsibility to know and perform the morally right action is the charge of each person. We are to use our ability to reason to help us apply the categorical imperative to moral questions, and for individuals to make their own decisions on how to act, rather than relying on another individual. Therefore, for a research participant, informed consent is at the core of autonomy (respect of persons). According to the Categorial Imperative each person intrinsically possesses self-governing reason which provides an unmistakable foundation for seeing each person as possessing dignity, worth and deserving of respect as every other person (Premat, 2008; Renger et al., 2017; Fasoro, 2019).

The concepts of privacy and confidentiality are constituents of autonomy of persons (Cooke, 1999; Taylor, 2002; Zhang et al., 2021). Privacy is a fundamental right, and it refers to non-intrusion into the private spaces of an individual or of a community (Nissim and Wood, 2018; Allen, 2020; da Veiga, 2022; Phiri, 2023; Nxokweni, 2024). For example, accessing data belonging to someone, or accessing someone's property, through any means, without

permission would be a violation of privacy. To access communal data, resources, or a religious or cultural shrine without permission would also be a violation of privacy (Kaufman and Ramarao, 2005; Codio et al. 2012; Rath and Kumar, 2021). Furthermore, to disclose or share information about an individual or community without permission is a violation of confidentiality. In health research ethics, privacy and confidentiality must be upheld and safeguarded, including those obtained by GST, because of the serious potential harm that could result from unauthorized disclosures. In brief, the law of universalizability, the principle of ends, and the respect of autonomy in Kantian moral theory requires that the application of GST in CHR be ethical.

I set out to defend the premise that autonomy, privacy, and confidentiality are violated when GST is used in CHR without informed consent from individuals or without informed communal approval. I did show that GST present a set of tools for research data collection, processing, storage, and sharing. After examining elements of principlism, research ethics frameworks and guidelines of South Africa and international bodies, moral principles grounded in Virtue Ethics and Kantianism, I deduced that research tools used for data collection, storage, processing and storage are required to adhere to research ethics guidelines; and the study in which they are implemented must be overseen by a research ethics committee. Therefore, the use of GST in CHR must comply with the norms, standards, and guidelines for health research.

Notwithstanding, I considered potential objections to my position. This include the proposition that informed consent should be dispensed with for GST application in CHR that does not involve direct contact with the community, or if the data are anonymised, or if the study is of low risk since identifiable data to individuals or a community are not collected. In these situations, I argued that the absence of direct contact does not mean that identifiable data are not collected, and that minimal risk does not mean no risk, for example when the potential for

stigma, discrimination and psychological harm is present. I further argued that a life of virtue; not using people as a means to an end; and acting in a way that you would want it to be applicable to all, compel researchers to respect autonomy, privacy and confidentially in the application of GST in CHR.

3.2.2 *Premise 2: It is unlawful to collect, share or distribute personal identifiable information without approval from individuals or community concerned*.

With evidence that the application of GST collects, even inadvertently, personal and communal data, the question to answer is if this is not against privacy and human dignity if approval to access the personal or communal data were not provided. A secondary question is what are the provisions in law to protect against these violations? To answer these questions and defend the premise, I appeal to common and case law, the Constitution of South Africa of 1996 (The Constitution, 1996); the Protection of Personal Information Act of South Africa of 2013 (POPIA, 2013), and the National Health Act of 2003 (NHA, 2003). This will also provide a picture of the data protection framework in South Africa.

3.2.2.1 Argument grounded on the constitution, legislations, and common law

Data privacy law comprises the rules regulating the acquisition, storage, processing, mining, and sharing of data; and the law is to preserve the interests and rights of individuals (Bygrave, 2014). Privacy is also protected under common law. Privacy and its ramifications have been variously described. However, it is generally accepted that it is an infringement on the right of an individual to privacy, to gain access and process data belonging to the individual (Ross, 2007). For example, most people will object to be photographed, even when they are in a public space, without permission. Also, there will be an objection to a drone fitted with cameras flyer over one's home, or over an occupied public building. In these cases, the individual does not

expect, reasonably so, that his or her photograph would be taken while walking the street; and it is also not expected that an instrument such as a drone, piloted by an unknown or unauthorized person, would be collecting data on the features of one's home, or over the occupied public building, and perhaps tracking the movement of people. From the forgoing, Neethling defined privacy as:

> *"an individual condition of life characterised by seclusion from the public and publicity. This condition embraces all those personal facts which the person concerned has himself determined to be excluded from the knowledge of outsiders and in respect of which he has the will that they be kept private"* (Neethling et al., 2005, p32).

According to Naude and Papadopoulos (2016), Neethling's definition of privacy was confirmed in the case of National Media Ltd v Jooste (1996), in the appellate division of the Supreme Court of South Africa on 26 March 1996. In the judgement, delivered with unanimous concurrence, the appellants were found to have disclosed personal data of the respondent and associated individuals and also to have subsequently violated the terms of a consent agreement provided by the respondent for the publication of information pertaining to her and others. In the consent agreement, the respondent had reserved the right to approve the final version of a write up for publication in a newspaper and to also approve the date for the publication. The appellants did not adhere to these. The implication of this judgement is that an individual has the right to control his or her personal information free from unwanted intrusions (Naude and Papadopoulos, 2016).

Privacy is seen as equal to the right to dignity (Whitehead and Wheeler, 2008; Floridi, 2016); and common law has developed giving the right to privacy an independent recognition. In Grutter v Lombard, the presiding judge determined thus:

"*the interest that a person has in preserving his or her identity against unauthorised exploitation seems to me to be qualitatively indistinguishable and equally encompassed by that protectable variety of personal rights*" (Grütter v Lombard 2007 4 SA 89 (SCA 2)).

Accordingly, the right to privacy and the right to identity are now part of the South African common law pertaining to the law of personality (Visser, 2020; Mangope and Wim, 2022; Chachalia and Klaaren, 2024).

How a proposed research protocol could potentially impact the human dignity of individuals is an essential element in research ethics, and Chapter 2, Section 10 of the Bill of Rights of the Constitution makes provision for this:

"Everyone has inherent dignity and the right to have their dignity respected and protected."

This provision is 'entirely' protected with no limitation in law. Privacy is also recognized as a fundamental human right in the Bill of Rights, and it also protected in common law. Section 14 of the Bill of rights of the Constitution states that:

"Everyone has the right to privacy …"

According to Section 8(2) of the Constitution, the right to privacy is binding on natural and juridic persons. Therefore, the conduct of researchers using GST in CHR, with regards to privacy and human dignity, must comply with Founding Provision 2 of the Constitution:

"*This Constitution is the supreme law of the Republic; law or conduct inconsistent with it is invalid, and the obligations imposed by it must be fulfilled."*

The National Health Act (NHA) is the legislation that operationalises the provisions of the Constitution on privacy and dignity on health and health related research. Section 10 of the Constitution of states that

> *"Everyone has inherent dignity and the right to have their dignity respected and protected."*

And Section 14 of the Constitution states

> *"The right to privacy includes the right to protection from unlawful collection, retention, dissemination and use of personal information*."

Drawing from the Constitution, the NHA operationalizes the right to informed consent in research that is therapeutic and non-therapeutic. On the recruitment of individuals for research Section 71(1)(a-b) of the NHA states:

> "*Notwithstanding anything to the contrary in any other law, research or experimentation on a living person may only be conducted (a) in the prescribed manner and (b), with the written consent of the person after he or she has been informed of the objects of the research or experimentation and any possible positive or negative consequences on his or her health."*

Section 72 of the NHA directs the establishment of a National Health Research Ethic Council (NHREC), while section 73 directs the establishment of Research Ethics Committee (REC) in institutions or entities that conduct research involving humans. The implication is that recommendations made by HREC and REC on a research protocol are binding in law.

Another piece of legislation fulfilling the aspirations of the Constitution is the Protection of Personal Information Act, No. 4 of 2013 (POPIA, 2013). It governs the law of data protection and privacy in all spheres of human endeavour. It governs how personal information is

managed, from why it is obtained, how it is obtained, how it is used, to when and how it is destroyed. The Act deals with personal information in the broadest sense; that is, any information that can be traced backed to an individual or an organisation. POPIA, in its preamble, draws from Section 14 of the Constitution and underscores the point that

> *"The right to privacy includes the right to protection from unlawful collection, retention, dissemination and use of personal information*."

Condition 2 of POPIA deals with full disclosure and informed consent, justification for use of data, and objection from data subjects, while Condition 3 deals with retention and restriction of records obtained from data subjects. The amplitude and implications of POPIA in all sectors of life, including health research has been extensively discussed (Hertzog et al., 2021; Lockhat, 2021; Staunton et al., 2021; de Wall, 2022; Bronstein and Nyachowe, 2023; Thaldar, 2023; Thaldar et al., 2023). According to Swales (2022), the spirit of POPIA requires that consent obtained for research would have to be specific. Therefore, in the context of this discussion, consent should be given for the use of GST in CHR.

In an effort to synthesize POPIA for the research community, the Academy of Science of South Africa (ASSAf), which was established under the Academy of Science of South Africa Act 67 of 2001, developed a Research Code of Conduct (RCC) to guide researchers to comply with POPIA. Although the RCC is currently not binding in law, its serves as a framework document for researchers (ASSAf, 2024). The Research Code of Conduct covers all forms of personal data acquisition, including acquisition by the use of tracking devices. The tracking devices envisaged in RCC are not specifically enumerated. However, for all intents and purposes, it is rational to hold that GST would fall under the umbrella of tracking devices, and therefore their application in CHR would also be governed by POPIA.

3.2.2.2 Potential objection for prior approval to collect and share personal information

Despite the good intentions of the Constitution, legislations and codes of ethics to protect the privacy and dignity of persons, while furthering health research, there is bound to be some displeasure on the regulations. A potential objection is that a researcher my not require ethics approval or may not need to obtain informed consent if there is no intimate contact with people and if the data are remotely collected, for example by satellite or near-earth RS. This objection supposes that it is legally permissible to use personal data on condition that the data subject is unaware. It is important to note, that if the data can be traced to an individual, or collective, or an organization, the use of the data for whatever purpose, unless permitted by law, would be illegal. Notwithstanding my response to the objection, it could be impossible to get informed consent from the individuals or community for data *already* captured by remote sensing approaches. In this situation, would it be legal to proceed with data processing, usage, and dissemination without consent? To examine this situation, I make a corollary with a vague provision in POPIA. According to Malekela and Thaldar (2024, p57),

> *"Section 27(1)(d) of POPIA permits the processing of special personal information, including genomic data, if obtaining consent is impossible or would involve a disproportionate effort."*

The meaning of 'disproportionate efforts' requires clarity, and this is a matter for the Information Regulator to address. On the other hand, I believe that a REC would reasonably consider situations of this nature and make the necessary recommendations. Therefore, even if the researcher applying RS assesses that it is impossible to obtain consent, an independent regulatory entity must decide on whether to proceed with the research or not. Ultimately, a

balance between advancing science and protecting the rights of individuals, organisations and communities is required; and this is essential to build trust and credibility in science.

It is worthwhile to note that besides South Africa many other countries and jurisdictions have enacted data protection laws. For example, about 35 other African countries have data protection laws, with substantial similarities among the legislations (Data Protection Africa, 2025). There are also similar data protections laws in the European Union (European Commission, 2025), and in the United States of America (DLA Piper, 2025). All in all, it is clear from the 'sectorial legislations' on health research (Bronstein and Nyachowe, 2023; Thaldar, 2023), and other legislations on data protection, that researchers and REC have the obligation to comply with the set of regulations on prior informed consent (plus continuous consent as the case may be), data acquisition, storage, processing, dissemination; and feedback.

In conclusion, data collection and processing is regulated by the Constitution, the legislations that give effect to the provisions of the Constitution, and by common law. The application of GST in CHR seek to improve the wellbeing of people. Improving the wellbeing of people invariably requires data from individuals and communities. And since GST collects, processes, and shares swathes of data, it is imperative that researchers applying these technologies comply with the legislations that regulate data use, even if the data subject is not aware of the data collection.

3.2.3. Premise 3: Community health research in which GST is used must have relevance and social value for it to be ethical.

This premise is derived from the practice whereby a researcher does not consider the social value of research that uses GST, since technology may be applied without direct contact with

a community or its residents. To defend this premise, I firstly used the principle of maximizing the good, grounded in utilitarian moral theory, to show that it is not permissible not to consider the value of the research even if there is no direct contact with the community and its residents. Secondly, I reasoned through empirical evidence that co-production of knowledge, through the use of GST with communities, builds trust in science, fosters community acceptability of subsequent interventions, and empowers communities through skill acquisition.

3.2.3.1 Argument grounded on utilitarianism

The utilitarian moral theory promoted by Jeremy Bentham and John Stuart Mills in the Eighteenth and Nineteenth centuries (Heydt, 2006; Binmore, 2021), posits that a right action is one from which the outcome is favourable and maximised for all concerned. This means, the overriding utilitarian principle on the morality of an action is not the nature of the action, but the quantum of the overall outcome derived from the action (Fredericksen and Nielsen, 2013; Savulescu et al., 2020). Therefore, our actions should be chosen to obtain the greatest good in comparison to the harm emanating from the action (Chappell and Crisp, 1998; Hayry, 2021).

Considering that the goal of research is to generate knowledge that is beneficial to society, it is implied that the outcome of CHR ought to be beneficial to the community. In the application of GST in CHR, the maximum common good that ought to accrue or the least common harm that ought to be suffered from the application of GST is foundational. Extended to a community, the right action ought to be the one that maximises the total utility experienced by a community, giving equal weight to the welfare of each person of the community (Howarth, 2013). A question to answer is how does a researcher determine the good of a proposed study to a community? And how will this good be maximized? It goes without saying, that to determine what is good for the community, the researcher must engage the community. This is important,

because if the privacy of residents of a community is violated, or the social, cultural and religious norms of a community are disregarded through the application of GST without the permission of the data subjects, then grave harm is imputed to the residents or to the community, and the welfare of the community and its residents is degraded. This outcome is negative irrespective of what 'good' may have accrued for the researcher, since all parties are not sharing in the greatest overall good. And since utilitarianism does not permit intentional harm without first evaluating the good and the harm, to obtain an outcome tilted to an overall common good, a researcher is not permitted to knowingly ignore the right of a community to know and understand the utility of GST for their wellbeing, as a trade-off for an expected good as determined solely by the researcher. In essence, there is no social value to the community or its residents as the dignity, an intrinsically invaluable human attribute, has been disregarded, without the permission of the community or its residents. A utilitarian approach of this nature generates distrust between communities and researchers and makes the implementation of research-derived interventions in a community difficult, thereby cancelling the application and utility of the study findings. Having said this, I nevertheless concede that to uphold the utilitarian principle of 'the end justifies the means' it is also possible to deduce a morally permissible action without consultation, in this case, with the community.

One may argue that not every research endeavour is capable of delivering on social value, and to demand that the use of GST ought to always provide social value for it to be ethically acceptable is to kill research from which the application of the study outcome is not immediately envisaged. My response to this is nuanced. This is because, I am not simply advocating for material or financial outcomes from CHR as the yardstick to measure social value. It is understandable that not all research could immediately produce social value. However, my argument is that there is intrinsic social value if the researcher primarily honours

and defends the rights and dignity of a people. Looking at it from another perspective, people also value accorded honour and respect for their contributions to human endeavours. Therefore, respecting and defending the rights of people, constitute social value, even if there is no immediate material benefit to the people.

3.2.3.2 Argument grounded on co-production of knowledge and social value

I herein discuss why co-producing knowledge with communities through research that involves the use of GST maximizes social value. Many instruments used to collect data in CHR are nominally not versatile, with little or no use for communities. For example, questionnaires, voice recorders, medical devices, and others are useful only for what they are made for and have no community empowering capabilities. On the other hand, GST are innovatively versatile, and their capabilities could be harnessed to solve a range of community-identified challenges, even those which a researcher could not have thought of.

Communities usually lack evidence for advocacy or to support their request for resource allocation from government departments or other developmental agencies. Many times, communities may not have data on their demographics, cadastral attributes, and natural resources. These are domains in which RS, GIS, and GPS could provide empowerment through capacitating community leadership and governance – in essence engaging communities through GST (Rambaldi et al., 2006; Dobbs and Louis, 2015; Bill et al., 2022; Hirt, 2022; Faizal and Basri, 2024).

Let us examine a hypothetical scenario: A researcher applies RS/GIS to map the proximity of homes for risk factors of a vector-borne disease in a community. The data are collected, processed, and the information is shared with health authorities, the community, and published in a scholarly journal. The researcher moves on to other projects, perhaps elsewhere. Let us examine a modification of this scenario: In the implementation of the RS/GIS in mapping the

risk of the vector-borne disease, the researcher also discusses the potential of RS/GIS with the community leadership and how it could be used to address other challenges. For example, by mapping territorial boundaries; proximity to healthcare services, educational establishments, and sources of water; vegetation coverage and grazeland. Through this added engagement, the community has the opportunity to gain skills and produce evidence from GST with utility to advance causes of their priority, other than the one the researcher had prioritised. In so doing, the social value accrued by the community is more tangible and of a superior value than the initially solely intended risk mapping for a vector-borne disease. Through participatory GIS, communities have been empowered, for example through territorial counter-mapping to reclaim previously dispossessed land (Gilmore and Young, 2012; Counter Cartographies Collective et al., 2015; Dalton and Stallmann, 2017; de Vos, 2018; Pinfold et al., 2020; Paris and Rienow, 2023; Abushama, 2024); detect and raise awareness on deforestation (Gonzalez and Kroger, 2022; Mataruse et al., 2024), and advocate for more allocation of basic health services (Viana et al., 2017; Wang, 2020; Faizal and Basri, 2024).

In another vein, researchers collaborate among themselves to add value to study outcomes (Kedron et al. 2021). However, I contend that it is also important that researchers collaborate with the communities they intend to generate data from, and to which the obtained information will be implemented. Overall, participatory GIS "*allows communities to actively participate in decision-making processes, contribute local knowledge, and promote social and spatial justice.*" (Malakar and Roy, 2024; p1).

In conclusion, social value is an important ethical element of health research, and this also applies to research in which GST is at the centre of the research activities. The idea that social value should not be brought to the fore because GST may not directly involve contact with

individuals is worthy of examination. As a response, I have argued that social value does not only reside in the provision of immediate tangible goods or services when individuals actively participate in research project, but social value should also be considered as the respect of the dignity and freedom accorded to individuals and communities where GST is applied for health research purposes. I also argued, using the principle of maximising the good, grounded in utilitarianism, and evidence from participatory GST, that the GST researcher would not be acting ethically if he or she does not engage the community to explore the use of GST to respond to other needs of the community.

CHAPTER 4: CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

I set out in this report to defend the thesis that it is not morally permissible to carryout CHR with GST without adhering to ethical principles and guidelines, before, during, and after the research closeout. My thesis was premised on three propositions: (1) that to collect data by GST without permission, even when there will be no direct contact with humans, is a violation of autonomy and privacy of persons and disrespect for the community involved. (2) That, it is unlawful to collect, processed and disseminate data obtain by GST from the community and its residents without their permission. (3) That CHR with GST must have social value for it to be ethically acceptable.

With evidence from the literature that GST present a set of intrusive approaches into personal and communal livelihoods, I used norms, research ethics guidelines and research ethics frameworks to defend the first premise. A key objection is that individuals or communities may not actively participate in research using GST and therefore seeking ethics review is not warranted. I refuted this objection by stating that participation in research does not have to be direct, and that the collection of data associated with individuals or a community, even if they are not aware of the data collection ought to adhere to mechanisms to protect the privacy and dignity of the individuals or the community concerned. I also drew from the development of good character in virtue ethics and showed that researchers who object to the ethical guidance of GST in CHR are not virtuous in that regard and are acting unethically. To refute the objection that we ought not to rely on the character of researchers to implement ethical regulations, I countered with the proposition that a researcher who sees virtue as a reward is less likely to flout ethics guidelines. In addition, I drew from the maxims of the Categorical Imperative in Kantian ethics to also show that it is a violation of autonomy of persons; using people only as

an end to achieve scientific enquiry; and it is against the law of universalizability to use GST in CHR without consent from the community and its residents; and without providing social value for the community concerned.

I reasoned from the constitution of South Africa, the National Health Act, the Protection of Personal Information Act, and case law to defend the premise that data collection by GST, even when there is no direct participation of a community and residents, ought to be disclosed or shared only with the approval of the community and its residents. Lastly, using evidence from the literature, principles of ethical health research, and the principle of maximising the good grounded in utilitarianism, I demonstrated that it is not ethical to employ GST in CHR without a social value benefit for the community. A key objection to this premise is the position that 'blue sky' research would be killed if all research must have social value. I countered this position by stating that GST are innovative tools and researchers have the capacity to demonstrate the versatility of these tools to the communities they work with. That through open engagement, communities could be trained on the capabilities of GST, and they will be in a position to deploy them in ways that seek solutions to other problems that they may have, beside that of the researcher.

In conclusion, I have shown that the principles of autonomy, privacy, confidentiality must be upheld in CHR that uses GST, even when there is no direct human contact; that the legislation provides for the protection of personal identifiable data; and that the use of GST in CHR ought to bring social value to the community. Considering potential objections to my position, my concessions and accompanying rebuttals, and all things considered, I conclude that it is not ethically permissible to use GST in CHR without adhering to ethical principles and guidelines.

4.2 Recommendations

Researchers, research ethics committees, and editors of scholarly journals are expected to promote and ensure adherence to ethics in research. This duty is even more pressing when novel approaches and technologies, such as GST, infused with AI, are introduced in health research. However, through my rationalisation of the literature, arguments and rebuttals, it is evident that a considerable proportion of researchers, research ethics committees (REC), and editors of scholarly journals are not vigilant to the ethical challenges posed by GST in CHR. In so doing, research protocols employing GST are being exempted from ethics review, and research is being conducted and published when participants did not, for example, provide consent for their homes to be geolocated or their community to be spatially mapped; and editors are publishing work in which GST is used even though authors specifically state that ethical review of the study protocol was not required, or do not mention ethical considerations. These shortcomings call for action with the goal to further good habits in researchers and strengthen the capabilities of research ethics committees and editors of scholarly journals. In this regard, I make a few recommendations in an attempt to strengthen ethical oversight and regulation of GST in community health research:

***For research ethics committees**:*

1) I recommend that RECs have members who are knowledgeable on the ethical and legal implications of GST. Ethics committees should be particularly vigilant in the application of GST that does not require direct contact with individuals or the community. This is because, it is in this scenario that the rights to dignity, autonomy, privacy, confidentiality could be obliviously violated, or where harm due to stigma and discrimination could be surreptitiously incurred. So, the granting of waivers for protocols in which GST are used should be carefully considered.

2) To ground and propagate vigilance on GST, RECs should include the ethical implications of GST in the training of their members and researchers. This training should go beyond generalities and include the capabilities of the different approaches of GST (RS, GIS, GPS, and IMT) to emphasize the nature and extent of their intrusiveness, and moreover when they are used in combination or infused with elements of artificial intelligence.

3) I also recommend that research ethics training does not only focus on the application of ethical norms, principles and regulations, but these trainings should also provide the foundational elements of the moral theories underpinning applied research ethics.

***For Researchers**:*

1) From the principle of best practice, researchers employing GST in research should submit their research protocol to an appropriate ethics committee for review and oversight.
2) Principal investigators should endeavour that researchers in their teams are knowledgeable in obtaining and handling data ethically, especially data obtained without the active participation of the individuals or communities.

***For editors of scholarly journals**:*

1) Editors should include a requirement for evidence of ethics approval for manuscripts on studies in which GST have been used.

2) Editors should request reviewers to comment, if they have the competence, on the ethics of manuscripts in which GST was used.

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