Geographic Injury Surveillance in Low-Resource Settings

by

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Abstract

Injury is a leading cause of morbidity and mortality in almost every country and in almost every age group. The global societal and economic burden of injury dwarfs many other health issues, yet attention to the problem is proportionally low. Effective injury prevention relies on injury surveillance – the collection, analysis, interpretation, and dissemination of data on injury and its social and environmental determinants. Injury surveillance has been widely implemented in many well-resourced settings, yet in most low- and middle-income countries and in low-resource settings within high-income countries, surveillance is poor or non-existent, meaning it is difficult to design effective prevention programs. Given the high-cost and complexity of many conventional surveillance activities, novel, easy-to-use, and affordable strategies must be developed to enable low-resource settings to engage in injury surveillance.

The objective of this dissertation was to develop theoretical and methodological knowledge that could enable community-groups, health facilities, and other organizations to engage in injury surveillance activities, especially in settings with limited resources. In particular, this dissertation explores the role of geospatial technologies in all phases of surveillance – from data collection through to dissemination. The dissertation addresses this objective through both hospital- and community-based surveillance activities in two study sites, Cape Town, South Africa, and Vancouver, Canada. In South Africa, GeoWeb technologies and citizen-generated data approaches were used to enable injury surveillance at a low-resource hospital. In Vancouver, a method was designed and demonstrated to understand the relationship between road-user behaviours and pedestrian injury. This method was developed for community-based surveillance and prevention organizations, and was utilized by a local pedestrian safety project to understand a pedestrian injury problem in an impoverished Vancouver neighbourhood. Together, these investigations comprise an integrated project informed by and contributing to global health perspectives on injury. While research at each study site provided empirical evidence pertaining to the local injury burden, the main findings of this dissertation was the broader evidence that could be used to inform geographic injury surveillance in other low-resource settings, whether in high-, medium-, or low-income countries.
Keywords: injury; surveillance; GIS; GeoWeb; global health; low-resource
Dedication

To my parents, Dale and Pamela,
following your path – to the mountains someday…
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1. Introduction

1.1. Overview

If global health is about health issues that transcend national borders, injury may be the quintessential global health issue. Unlike many health issues, injury truly knows no boundaries; it is a scourge in every part of the world and wilfully traverses all social classes, age groups, and health statuses. Injury is a leading cause of death in children and working-age adults in most countries (Mock et al., 2004; World Health Organization, 2010), a sobering fact that belies the conventional belief that injuries are the consequence of ‘accidents’, or events that cannot be predicted or controlled (Krug et al., 2000). Despite this massive burden of morbidity and mortality, injury has traditionally been overlooked as a public health issue (Mock et al., 2004), and insufficient attention has been allocated to this health issue by governments, health organizations, health funders, and by the public itself. This has been especially true in low-resource settings\(^1\), both in the developing and developed worlds.

Although injury does transcend socio-economic status, age, sex and other dimensions of difference, noticeable variations do exist. Indeed, analysis of injury data

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\(^1\) In this dissertation ‘low-resource’ is a general term to describe settings that are relatively disadvantaged with respect to access to resources (e.g. financial, material, human-resources). It has no absolute meaning. Although specific resources are sometimes limited in even wealthy organizations, this term is used to denote settings or organizations with chronic and severe shortages of these and other resources required for engaging in activities such as injury surveillance and prevention.
often highlights particular age groups, social classes, and geographic locations that are disproportionately burdened by injury. Once identified, evidence-based injury prevention efforts can be implemented that target the affected population group or geographic location. *Injury surveillance* – commonly referred to as the collection, analysis, interpretation, and dissemination of data on injury and its determinants and risk factors – is the foundation by which injuries are reduced and prevented in society. The availability of surveillance data is strongly linked to reductions in the societal burden of injury, yet many jurisdictions – especially those with more severe resource limitations – lack data on injury incidence and prevalence, and on its risk factors and determinants. Herein lies the main motivation for this dissertation, the lack of injury surveillance activities in low-resource settings (which often also have higher rates of injury), compared to settings with more resources available to design effective injury surveillance and prevention programs. Required are simple, streamlined, and accessible tools and approaches that allow settings with limited financial, technical, and personnel resources to engage in data collection, analysis, interpretation, and dissemination. Margaret Chan, the Director General of the World Health Organization (WHO) recently summed up the challenge: a global effort is required that focuses on “common standards for documenting and sharing of data, … the development of user-friendly analytic tools, and a sustained effort to strengthen countries’ own capacities to gather data” (2012, p. 2054).

### 1.2. Research Problem, Purpose and Objectives

This dissertation is focused on the particular problem sketched out above, the limited ability to engage in injury surveillance activities in low-resource settings. In settings that have limited access to financial, technical, and personnel resources, injury
surveillance activities are pitted against the more immediate concerns of patient care. Given this reality, surveillance is typically a low priority, especially in the many low-resource settings that already struggle to maintain patient care duties. This dissertation takes a pragmatic stance to this problem. As resources are scarce, and convincing decision-makers to focus on surveillance and prevention in the face of enormous injury burdens is difficult, the purpose of this exploratory project was to develop and demonstrate surveillance strategies that could be implemented in a variety of hospital and community settings with limited resources. A geographic and geospatial lens could provide a unique and powerful perspective for engaging in novel injury surveillance efforts in environments that lack the resources to engage in conventional surveillance activities.

This project sought out novel injury surveillance solutions for local settings, with an eye on their potential applicability to low-resource settings more broadly. Although there is a small existing literature in this area, this dissertation has sought to advance the agenda; in particular, this dissertation focused on exploring the potential role of geospatial technologies in these activities. Two overarching research questions have guided this project:

- What methods and approaches can be designed to enable low-resource settings to engage in injury surveillance activities?

- How can geospatial technologies contribute to injury surveillance? In particular, for what purposes can geospatial technologies contribute to injury surveillance (in addition to the spatial analysis and visualization of injury events)?
Guided by these research questions, the objective of the project was to develop theoretical and methodological knowledge that could enable community-groups, health facilities, and other organizations to engage in injury surveillance activities, especially in settings with limited resources. In addition to these broader scale objectives, the project also sought empirical knowledge of the burden of injury in the two locations that were the sites for this research project.

1.3. Study Sites

This project was carried out in two settings, Cape Town, South Africa, and Vancouver, Canada. Together, research conducted at these two locations comprised an integrated global health project designed to contribute to the collective understanding of injury surveillance in low-resource settings.

South Africa is a middle-income country with relatively high rates of injury, especially in the urban centres such as Cape Town. The population of Cape Town, located in Western Cape Province, is approximately 3.5 million, however, this is an estimate due to the challenges in enumerating the residents of the city’s vast and shifting landscape of informal settlements. My research at this location was conducted at and with the Trauma Centre of Groote Schuur Hospital (GSH), a large publicly funded facility in the centre of the city. Like many hospitals in LMIC, the GSH Trauma Centre operates under severe resources constraints, in part due to an extremely high load of often very severely injured patients, which dictates that the bulk of available resources go to patient care at the expense of injury surveillance. Thus, little is known about injury types, causes, and determinants, or its distribution in time and space in the Cape Town
context, which has restricted the ability to engage in evidence-based injury prevention. Working in conjunction with the staff and managers of the Trauma Centre, a major focus of my work at this location was to design and test novel injury surveillance protocols. The aim was to develop solutions that could be implemented within the abilities of the hospital, given their personnel and financial resource limitations. While the aspect of the project undertaken in Cape Town was designed to benefit GSH specifically, the bigger picture was also a main objective; to provide knowledge concerning locally appropriate, simple, and cost-effective solutions for injury data collection and analysis for low-resource hospitals more generally.

Vancouver, a city of approximately 2.3 million, is situated in the Province of British Columbia on the west coast of Canada, a high-income country. Overall, Vancouver has a relatively low injury burden compared to many other settings including Cape Town; yet like many cities, rates of injury are highly variable between parts of the city, often corresponding to social class and built-environment differences. While surveillance and prevention activities are generally very good in the Vancouver context, there is room for improvement, especially with respect to understanding more localized injury problems. The research from Vancouver reported on in this dissertation primarily centres on a low-resource, impoverished neighbourhood of Vancouver with a disproportionate burden of injury (indeed many health problems here mirror those of the developing world), yet which has been overlooked with respect to injury surveillance and prevention. I designed simple and streamlined strategies to understand pedestrian injury in community settings, and collaborated with a community-based injury surveillance and prevention group in the impoverished and marginalized downtown eastside (DTES) neighbourhood. This collaboration helped to shine the spotlight on the large burden of
pedestrian injury in the DTES, and was successful in advocating for injury prevention in this area. As in the portion of this project conducted in Cape Town, the objective was to benefit the local community, while also providing knowledge and protocols for community-based surveillance and prevention activities in low-resource settings more generally.

1.4. Conceptual Framework

This dissertation is informed by two different, yet in some ways closely aligned fields, *global health* and *critical GIS*. Each of the two arms of the theoretical framework is discussed in detail below, including the specific themes within each that helped to frame and guide the research. This is followed by a brief discussion of the overlaps and parallels between the two, which helps to underscore their appropriateness for this project.

1.4.1. Global Health

*From International to Global Health*

Surprisingly, *global health* is a relatively new field, however concern for health around the world is certainly not new. Prior to global health, the older term *international health* was the primary term used. International health has its roots in empire and colonization, focusing mainly on the infectious diseases and tropical medicine of Global South countries (Byass, 2013; Rowson *et al*., 2012). Although international health is sometimes still used, a progressive shift to global health has been identified (Brown *et al*., 2006), both for politically-correct reasons informed by post-colonial theory (Brown &
Bell, 2008; Koplan et al., 2009), and also, due to the influence of globalization (Byass, 2013), a phenomenon with massive consequences for health. Simms (2012, p. 333) cogently sums up the reason for the shift from international health to global health:

“This evolution [from international to global health] has meant that the reductionist and linear thinking which have typified relationships between rich and poor countries, donors and recipients, policy-makers and policy-takers, and, development aid and expected outcomes have faltered and given way to the realisation that health is global and that we are all part of a whole”.

Koplan et al. (2009) provide a more detailed comparison of global health and international health according to a number of categories. With respect to geography, global health focuses on issues either directly or indirectly affecting health that transcend national borders, while international health is typified by high-income countries (HIC) getting involved in the health issues of low- and middle-income countries (LMIC). In terms of level of cooperation, global health seeks global collaboration while international health efforts are usually binational collaborations between a HIC and a LMIC. Access to health according the global health perspective focuses on health equity among nations and for all people, while access in international health seeks to improve access to health for people of other (typically poorer) nations. With respect to the range of disciplines involved, global health is highly inter- and multi-disciplinary within the health sciences, while also heavily informed by the social and physical sciences – including economics, sociology, political science, anthropology, geography, climatology, and development studies. International health is much less multidisciplinary within the health sciences, and has little engagement with other disciplines.
Global Health: Definitions and Conceptualizations

Although the basic notion of global health is generally understood, especially in relation to international health, a common, discrete definition does not exist. It is generally agreed upon, however, that the field of global health stresses commonalities rather than differences, health equity amongst nations and people, global participation and cooperation, and health as an interconnected and complex global system. In the absence of a widely acknowledged definition Koplan et al. (2009, p. 1995) attempt to create a summary definition of global health:

“Global health is an area for study, research, and practice that places a priority on improving health and achieving equity in health for all people worldwide. Global health emphasises transnational health issues, determinants, and solutions; involves many disciplines within and beyond the health sciences and promotes interdisciplinary collaboration; and is a synthesis of population-based prevention with individual-level clinical care.”

Although the rubric ‘global health’ suggests a focus only on health issues that are worldwide or that transcend national borders, global health research and practice can be enacted locally. Emerging perspectives on global health seek to explore health at the local level, while framing the investigations in light of global processes, impacts, or understandings. In response to the definition of global health by Koplan et al. (2009) cited above, Bozorgmehr (2010, p. 1) suggests that the authors overlooked a crucial question in their attempt to define global health, that is: “What is the global in ‘global health’?”. The author provides an alternative conceptualization of global that differs from the two characterizations that are widely used to characterize global health: global as
worldwide’; and ‘global as transcending national boundaries’. Bozorgmehr describes ‘globality’ in the context of global health as entailing the spread of supraterritorial processes and connections that transcend territories, yet “whose impacts nevertheless always ‘touch down’ in territorial localities” (p. 4). This conceptualization of global enables global health to be both territorial and supraterritorial, meaning “‘local’ engagement in ‘global’ health can be possible” (p. 10). Bozorgmehr draws from the literature on globalization, especially the work of Scholte (2000, 2005). Scholte’s influential theorization described the increasing supraterritoriality associated with globalization, but with a paradoxical effect; as the author illustrates (2000):

“Territory still matters in the contemporary globalizing world. Indeed… globalization (as an increasing transcendence of territorial space) can also be linked to processes of reterritorialization such as localization and regionalization. In short, while the spread of supraterritoriality means that some aspects of social space are no longer reducible to territorial geography, it by no means follows that territoriality has become irrelevant” (pp. 42-43). … “[G]lobalization does not entail the end of territorial geography; territoriality and supraterritoriality coexist in complex interrelations” (p. 8).

This conceptualization has an analogue in relational notions of spatial scale from human geography as part of the wider ‘scale debates’ (see Cummins et al., 2007; Jonas, 2006; Marston et al., 2005; McCann & Ward, 2010; Sayre & Di Vittorio, 2009), and helps to illustrate how many contemporary health issues and their causes and consequences are the product of complex processes and relations constituted at various scales. As a simple example, Swinburn et al. (2011) describe how obesity is clearly a highly complex health problem influenced by the global food system (supraterritorial), yet local
environmental processes and factors (territorial) produce heterogeneous patterns of obesity. So for example, those involved in research on local 'food deserts' in a specific urban environment might frame their highly-localized project in the context of global health using this conceptualization, as both territorial and supraterritorial processes and interactions serve to influence access to healthy food and rates of obesity. This particular conceptualization of global health helps to frame the research carried out for this dissertation. In particular, the project sought to engage with ‘globality’ in two ways; by framing local solutions within global health contexts, and by seeking first to address a local-injury problem, but at the same time, trying to connect with and contribute to larger ‘global’ bodies of knowledge in health, geography, information and communication technologies, and beyond.

**Health Equity and the Social Determinants of Health**

Health *equity* – a fundamental principle of global health – is concerned with evening out health *inequalities* (e.g. disparities in health outcomes or access to services), based on the notion that these inequalities are unjust and that health, overall, is a global human right (Kawachi *et al.*, 2002). Thus, health equity is greatly concerned with issues of social justice, ethics, and access to power and resources (Brown & Moon, 2012; Dybul *et al.*, 2012), which are investigated as part of a core research theme in the field of global health, the *social determinants of health* (SDH) (World Health Organization, 2013). Broadly, SDH theory is concerned with conceptualizing health and disease as social phenomena, and investigating the structures of society that influence the health of individuals and populations (Wilkinson & Marmot, 2003). Research on SDH has highlighted a number of structural and social determinants that powerfully influence health. At the structural level, health, social, and economic policies and governance are
highly influential, which in part shape social influences such as socio-economic status, gender, education, and living and working conditions (Solar & Irwin, 2010). Health follows a social gradient – elevated levels of poverty, lower levels of education, and reduced access to material goods are associated with increasingly poorer health outcomes (World Health Organization, 2008a). A global health perspective recognizes that the complex patterns of social and material inequality in all countries are highly correlated with health outcomes. Addressing these inequities is a guiding principle of global health; as Marmot et al. (2008, p. 1661) state “[s]ocial injustice is killing people on a grand scale, and the reduction of health inequities, between and within countries, is an ethical imperative”. A 2008 WHO report set out a global agenda for health equity and the SDH (Commission on Social Determinants of Health, 2008). The three overarching recommendations of this report were: 1) improve daily living conditions; 2) tackle the inequitable distribution of power, money, and resources; and 3) measure and understand the problem and assess the impact of action. In addition to social and structural factors, geography and the physical environment play an important role in mediating health outcomes, the so-called *environmental determinants of health*. For instance, proximity to point source environmental pollution is linked with various respiratory diseases, distant geographic proximity to health services is associated with poorer relative health outcomes (the so-called ‘inverse-care law’), and poor urban design is increasingly recognized as a determinant of both obesity and injury.

**Interdisciplinarity and Partnerships**

Growing recognition of the diversity of social and environmental determinants of health has helped to shape the interdisciplinary nature of the field, as evidenced by the range of disciplines it draws from. The Millennium Development Goals (MDGs), while
ostensibly aimed at eradicating poverty, has been an influential platform for highlighting health inequities and the determinants of health at a global scale; out of eight total MDGs, three are directly global health related, four target health equity and the SDH, and one is aimed at promoting global partnerships for development. Although the 2015 MDG deadline is fast approaching with only partial success (United Nations, 2012), the attention this program has brought to the range of non-medical factors that influence health provides a strong platform for convincing decision-makers to address the determinants of health towards the goal of global health equity.

Partnerships between diverse stakeholders – the eighth MDG – are a major tenet of global health research and practice (Syed et al., 2012). A Canadian-based global health partnership – the Global Health Research Initiative (GHRI) – connects the Canadian Institutes for Health Research (CIHR), the Canadian International Development Agency (CIDA), the International Development Research Centre (IDRC), and Health Canada (Canadian Institutes of Health Research, 2008). The GHRI uses its interdisciplinary expertise to build capacity for global health research in Canada and around the world. International partnerships between multiple countries include for example: large scale collaborations such as the Grand Challenges in Global Health initiative led by the Bill and Melinda Gates Foundation, the US National Institutes of Health (NIH), CIHR, and the Wellcome Trust in the UK (Grand Challenges, 2013); a UK-led health partnership scheme that aims to improve health services through the bidirectional exchange of skills, knowledge and experience between the UK and various other countries (THET, 2013); and the many small-scale partnerships between global health researchers from diverse settings.
1.4.2. Critical GIS

The second arm of the conceptual framework guiding this research is *critical GIS*, a subfield of geographic information science (GIScience) concerned with the social implications of geographic information systems (GIS) and related geospatial technologies, and, with developing socially-responsible and democratic alternatives to hegemonic, exclusionary, or unethical GIS and mapping practices. GIS has been widely acknowledged as a practical tool for representation, analytics and decision-making for myriad social and scientific issues. Major international organizations have explicitly lauded the use of GIS for tackling social issues, including for global health (World Health Organization, 2011), food security (UN World Food Programme, 2009), housing (UN-HABITAT, 2003), and sustainable development (UN Food and Agriculture Organization, 2004). Despite general agreement regarding the value of GIS for society, numerous ongoing critiques and debates over the past two decades – now collected under the broad rubric of critical GIS – have cast a shadow over these merits. Critical emerged in the 1990s as the progeny of the earlier ‘GIS and Society’ debates (Schuurman, 2000). During the GIS and Society period of the early 1990s, a series of anti-GIS polemics rattled the discipline. Fanning the flames of this discontent was the unbridled enthusiasm for the technology from some of its more vocal advocates (e.g. Openshaw, 1991). Ethical concerns were highlighted by a number of commentators including Curry (1997) and Crampton (1995) who implicated GIS in the erosion of personal privacy with the rise of targeted marketing using geodemographic approaches, and Onsrud (1995) who explored the need for a code of conduct for the ethical use of GIS. A particularly excoriating ethical critique of GIS came from Neil Smith (1992) who brought to light its contribution to military planning in the first Gulf War. Some observers at this time
focused on the epistemological and ontological rigidity of GIS, and the resulting ethical issues and societal implications (Lake, 1993; Taylor, 1990), while others identified its tendency to marginalize weak voices and empower the status quo (Obermayer, 1998; Weiner et al., 1995). A broad range of criticisms emerged from these early debates, spearheaded by both external critics and introspective members of the GIS community who identified a host of social, political, methodological, ontological, and epistemological issues (e.g. Pickles, 1995; Sheppard, 1995).

Critical GIS mixes social, critical, and political theory with GIScience to better understand GIS and related geospatial technologies. It crosses sub-disciplinary boundaries and draws from various fields including philosophy, science and technology studies (STS), participatory action research (PAR), poststructuralism, and feminist studies (Chrisman, 2005; Elwood, 2010; Harvey, 2000; Leszczynski, 2009b; McLafferty, 2005; Schuurman, 2009). Critical GIS has had considerable success in theorizing the social implications of geospatial technologies, and has also spawned new GIS and mapping practices that aim to address the issues that the critiques brought to light. Broadly speaking, critical GIS is now a socially- and politically-informed project that has as its aim the creation of a more accessible, appropriate, equitable, and diverse GIS. Although the contributions of critical GIS have been many, there are two broad transcending themes that many of the critiques and responses centre on, democratization and diversification.

Democratization and Diversification

Much of the focus of critical GIS theory and practice has centred on democratization – on broad questions of power, access, inclusion and exclusion, and
public involvement in the context of GIS. Questions of what groups engage with GIS and for what purposes were central to the GIS and Society debates, and now represent a recurrent theme for investigations in the critical GIS literature. Directly emerging from these debates were attempts to create a “more people-centered GIS” (Schlossberg & Shuford, 2005, p. 15), through addressing societal issues such as the purported anti-democratic, technocratic, and exclusionary nature of GIS (Obermayer, 1998). Public participation GIS (PPGIS) evolved as a direct response to a central criticism of GIS from the early years, the reality that GIS – by virtue of its cost and complexity – includes some groups at the expense of others (Corbett & Keller, 2005). According to Elwood (2009b, p. 521), PPGIS is focused on “empowering marginalized communities and social groups by fostering greater access to GIS, spatial data, and the decision-making processes in which they are used”. By focusing on giving the data, tools, and the projects to the people, PPGIS has tempered some of the primary criticisms of GIS. PPGIS projects have enabled the inclusion and empowerment of the disenfranchised, public engagement in policymaking, and grassroots use of GIS by community groups, activists and non-governmental organizations (Elwood, 2009b; MacEachren, 2000; Sieber, 2006).

The Geospatial Web (GeoWeb) – the collection of Web-based mapping platforms, geospatial services, satellite imagery and data (Lake & Farley, 2007) – may have the potential to advance the democratic aims of critical GIS, through addressing some of the goals of PPGIS and ‘GIS-2’ efforts (Miller, 2006). This is because the GeoWeb represents a fundamental shift – from GIS as desktop-based, expensive, and difficult-to-use, to Web-based, free (or low-cost), and easy-to-use. These characteristics of the GeoWeb – largely alien to big-box traditional GIS – are closely associated with the democratization challenges of critical GIS. The GeoWeb is defined by user-friendly,
lightweight and accessible packages designed not for GIS professionals or geographers, but for the average Web user. These neogeographers (Turner, 2006) are using GeoWeb platforms to create maps of their personal or professional interests. Data created by neogeographers and other amateurs known as volunteered geographic information (VGI) (Goodchild, 2007a) is closely tied to the development and expansion of GeoWeb technologies. Together, the emergence of the GeoWeb, neogeography, and VGI are enabling citizens and community-groups to engage with geospatial technologies and data. The potential for these phenomena to advance the critical GIS agenda is underexplored, and thus represents a fertile area for research that this dissertation takes up.

If PPGIS and related approaches are about democratization through empowerment and inclusion of grassroots organizations and the disenfranchised in the use of GIS technology, knowledge creation, and decision-making, other critical GIS theorizations and practices are about **diversification** – about fundamentally changing the technology itself. The growing diversity in GIS practices and cartographic representation owes its origins to the ongoing and fundamental criticisms of GIS that targeted its purported ontological and epistemological poverty. With respect to epistemology, GIS was demonized for its supposed foundation in positivism (Leszczynski, 2009a), the epistemological perspective of objectivity, value-neutrality, and subject-object dualism (Lake, 1993), which is cultivated by empiricism and quantitative methods. Catalyzed by the critiques, defenders of the technology retaliated, suggesting that GIS – despite existing in a numerical and computational environment – is in fact far less positivist, quantitative, and empiricist than is commonly believed (e.g. Pavlovskaya, 2006; Sheppard, 2001; Sheppard, 2005).
GIS is becoming increasingly diverse. Innovative GIS practices are capable of reflecting epistemological and ontological diversity. For instance, *qualitative GIS* is now a recognized area of inquiry that actively positions GIS outside of the positivist and quantitative by nurturing diversity in data, method, and representation (Elwood & Cope, 2009). Similarly, *feminist GIS* (Elwood, 2008) seeks to diversify the technology to accommodate feminist ideals and address the gender-based critiques of GIS (McLafferty, 2005; Schuurman & Pratt, 2002). GIS was critiqued along the dimension of gender for its purported ‘masculinist’ nature, which enabled the technology to reinforce unequal power relations by promoting the status quo with respect to ethnicity, class and gender (Pavlovskaya, 2002). Also, from a feminist perspective, GIS was critiqued for its ontological limitations pertaining to its reinforcement of binary thinking and categorization, while resisting diversity and plurality, two important tenets of feminist theory (Pavlovskaya & St. Martin, 2007). This new era has witnessed the emergence of new areas for GIS application; for example, the use of GIS within the qualitative worldview can trace at least a part of its lineage to the feminist critiques of GIS. According to Knigge and Cope (2006) “[f]eminist engagements with GIS have been particularly apropos for qualitative researchers who are interested in GIS because of feminist concerns for subjectivity, positionality, difference, reflexivity, context, socially constructed or situated knowledge, power, everyday life, meaning, discourse, and the relationships between researchers and ‘subjects’” (p. 2023).

Critical cartography – a field of inquiry closely aligned with (and perhaps part of) critical GIS – has explored issues of ontology and representation in maps and
geovisualizations. In a paper that preceded (and strongly informed) early GIS and Society debates, Harley (1989) argued that maps should be understood as social constructions, as sites of power-knowledge – a theme that has been echoed by subsequent commentators (Kitchin & Dodge, 2007). According to Harley (p. 1), “…we still accept uncritically the broad consensus, with relatively few dissenting voices, of what cartographers tell us maps are supposed to be” [emphasis in original]. This notion is derived from the map communication model (MCM) in cartography, in which the cartographer was thought of as an objective bystander creating an accurate depiction of reality (Hallisey, 2005). Fundamentally then, critical cartography is concerned with the links between geographic knowledge and power (Crampton & Krygier, 2006). Maps must be understood not simply as devices for one-way communication, but as representations that are “…open to interpretation, contested, and mutable” (Del Casino & Hanna, 2006, p. 39). Maps not only communicate but construct knowledge (Crampton & Krygier, 2006; Kitchin & Dodge, 2007). Mapmakers facilitate knowledge construction through cartographic and representational choices, yet knowledge is also constructed by the map reader, since their interpretations are influenced by their own knowledge, biases and proclivities (Cidell, 2008; Del Casino & Hanna, 2006). Recognition of the social construction of maps and geovisualizations has influenced the development of alternative ontological possibilities with respect to geographic representation, including new approaches to mapping that undermine hegemonic political viewpoints propped up by traditional cartographic practices and mapping agencies. Research on ‘counter-mapping’ (e.g. Harris & Hazen, 2006; Peluso, 1995) – the attempts to re-present space in order to highlight the interests of the socially, culturally, or politically disenfranchised – is a product of these theoretical developments in cartography. In addition to its achievements with respect to democratization outlined above, PPGIS has also
encouraged diversification. Engaging with diverse stakeholders such as community
groups and marginalized individuals has fostered the inclusion of diverse knowledges
and representations in a GIS, and the use of qualitative and non-cartographic forms of
data (Elwood, 2009b).

The theory and practice of critical GIS provides a foundation for engaging
ethically and democratically with grassroots communities and the disempowered, and for
fostering diversity with respect to ontology, representation, and knowledge production.
This body of theory and practice, along with global health, has provided a conceptual
framework for engaging in the research described in this dissertation. In particular, this
dissertation is informed by the democratization and diversification aims of critical GIS,
and explores the role of the GeoWeb and its social phenomena in advancing these aims.

1.4.3. Linking Global Health and Critical GIS

A conceptual framework informed by global health and critical GIS provide a
means of linking the two overarching disciplines that this dissertation exists at the
interface of – health, and geography/GIScience. While the conceptual framework guiding
this study has come from two distinct sources, the theory and concepts developed in
these two areas of inquiry often overlap and speak to each other in important ways.
Figure 1-1 illustrates the two domains of knowledge that comprise the conceptual
framework, and their linkages. *Ethics* is a principal constituent of both global health and
critical GIS. Although the particular ethical considerations do not necessarily align
closely, there is some overlap; for example, moral obligations under global health are
evocative of efforts to create codes of conduct for the ethical use of GIS\textsuperscript{2}. In global health, *Health Equity* is closely linked with the overarching *Democratization* theme from critical GIS. For example, global health concepts of equity in health outcomes and access to services map closely to aspects of democratization such as access to GIS, data, and decision-making, and the inclusion of marginalized and disempowered citizens in the use of GIS. Under the *Social Determinants of Health*, a focus on social and material deprivation and asymmetrical access to power and resources aligns very closely with all of the foci of the *Democratization* theme of critical GIS. Finally, global health’s *Interdisciplinarity* within the health sciences and across the social and physical science disciplines is reminiscent of the *Diversification* theme of critical GIS.

\textsuperscript{2} At this point, it is necessary to note that ‘surveillance’ has very negative connotations within critical GIS, yet it has a very different, positive meaning in global health. This meaning is described in detail below.
1.5. **Literature Review**

1.5.1. **The Global Burden of Injury**

The global societal burden of injury is massive. The Global Burden of Disease (GBD) Study, a comprehensive, ongoing attempt to model global mortality and morbidity for all causes, estimated that injury was responsible for over 5 million annual global
deaths (9.6% of total mortality) in 2010, an increase from the 1990 baseline of 4.1 million (8.8% of total mortality) (Lozano et al., 2012). In 2010, mortality from injury was substantially higher than the approximately 3.8 million deaths caused by the three attention grabbing and heavily funded infectious diseases combined, HIV/AIDS, malaria, and tuberculosis (Lozano et al., 2012). Although the 2010 version of the GBD notes that age-standardized mortality rates for all injury types combined have dipped since 1990, some injury subtypes have risen dramatically in this time frame; most conspicuously, pedestrian injury rates rose 17.6%, and for motor-vehicle injury rates overall, a rise of 6.2% was noted (Lozano et al., 2012). Motor-vehicle injury is predicted to rise to become the 5th largest cause of death for all age groups by 2030, yet today it is already the leading cause of death worldwide for those aged 15-29 (World Health Organization, 2010). It is crucially important to note that injury mortality is just the tip of the iceberg; for each injury death, many more people are hospitalized, disabled, and forced to live with their injuries, the non-fatal consequences known as injury morbidity (World Health Organization, 2010). When combining injury mortality and morbidity, the GBD study estimated that in 2010 injury was responsible for 11% of disability-adjusted life years (DALYs) – a measure of years of healthy life lost (YLLs) and years lived with a disability (YLDs) – a slight increase (1%) since 1990 (Murray et al., 2012).

Cause of injury is broadly grouped into two categories, intentional and unintentional. Intentional injuries result from interpersonal violence, homicide, self-harm and suicide, while frequent causes of unintentional injuries are motor-vehicle collisions, falls, burns, poisoning, and near-drowning (World Health Organization, 2010). In general, most countries have higher rates of unintentional injury than intentional. A notable contradiction to this pattern is South Africa, one of the only countries with
equivalent or higher rates of intentional versus unintentional injury (Norman et al., 2007; Prinsloo, 2007). Despite the reduction in political conflict and violence in the post-apartheid era, interpersonal violence has continued to plague South Africa (Norman et al., 2007). Levels of violence in South Africa dwarf many other countries, irrespective of income status; for example, the United States – which many regard as a relatively violent society – has a murder rate of 10.6 per 100,000 people, while this same figure in South Africa is 56 per 100,000 (Brooks & Barker, 2003). South Africa also has some of the highest rates of serious injury/death stemming from motor-vehicle collisions in the world (van Schoor et al., 2001); the rate of casualties per kilometres driven is more than 10 times higher than in the USA (Forjuoh et al., 1998; Peltzer & Renner, 2004).

Although more than 90% of global injury mortality occurs in LMIC (Hofman et al., 2005a; Peden et al., 2002), this statistic belies the huge variations in injury rates and causes between different low-, middle-, and high-income countries, and within specific regions and countries themselves. In HIC, some populations and geographic regions possess rates of injury more in line with those of LMIC. These populations and geographic regions are typically less affluent and have reduced access to resources for tackling the problem. At the global scale, “evidence supports the position that regardless of whether a country is industrialized or less developed, vulnerable populations living in poor social conditions are at disproportionate risk of injury” (Auer & Andersson, 2001, p. 169). For example in Canada, rates of injury are often found to be much higher in Aboriginal populations compared with the general Canadian population. Harrop et al. (2007) found a significantly higher relative risk (RR) of mortality across the spectrum of intentional and unintentional injuries (RR of between 4 and 17 depending on type) in Aboriginal versus non-Aboriginal children in the Province of Alberta. Overall rates of
suicide and self-harm injuries in First Nations communities are twice as high as the Canadian average, and as high as 6-11 times higher among Inuit populations (Kirmayer et al., 2007). Similarly high rates of suicide and self-harm have been noted in Indigenous populations from other HIC, including the United States, Australia, and New Zealand (Hunter & Harvey, 2002). Particular geographic regions within HIC have much higher injury burdens than the national/regional averages. Impoverished inner-city areas within HIC often have much higher rates of interpersonal violence; for instance a study noted that the rate of hospitalization for violence-related injury in an inner-city area of New York City was approximately three times higher than the US average (Yadav et al., 2005). In Vancouver, Canada, Schuurman et al. (2009b) identified a vastly disproportionate burden of pedestrian injury in an impoverished inner-city neighbourhood, the downtown eastside (DTES).

Returning briefly to the 2010 GBD study, the overall findings for total global mortality and morbidity for all causes pointed to a progressive shift away from premature deaths, to an increase in years lived with a disability (Murray et al., 2012). In the case of injury specifically, such a shift might indicate the existence of improved trauma care for patients, with a consequent reduction in injury deaths. Although better trauma care will reduce injury mortality, the corollary of this is higher-levels of injury morbidity at the population level. In addition to the social burden this also augments the economic burden of injury, which is massive. Those most affected by injury are typically also the most economically productive, males aged 15-44; this means the families of injury victims are often impoverished by health care costs, lack of income, or both (Murray, 2006). Countries are also hit hard by the economic effects of injury; the costs to LMIC can exceed the total amount received in these countries for development assistance.
Injury also places a high economic burden on HIC such as the US, where funds devoted to this health issue are often a fraction of that devoted to more visible problems like chronic diseases (Cohen et al., 2003). In Canada, the annual economic cost of injury was estimated at $19.8 billion, including the direct costs ($10.7 billion) of patient care and rehabilitation on the national health system, and the indirect costs ($9.1 billion) to the economy through decreased productivity (SMARTRISK, 2009).

1.5.2. Global Injury Surveillance and Prevention

While improved trauma care can reduce injury mortality, upstream solutions via injury prevention efforts can address the full spectrum of the injury burden, both mortality and morbidity. In the past several decades, injury prevention initiatives have helped to reduce the burden of injury, although, these initiatives have largely been confined to well-resourced settings, mostly in HIC (World Health Organization, 2010). Sleet et al. (2012) traces the emergence and trajectory of injury prevention and control in the US, from its emergence in the mid-20th Century, and continued growth over the following decades coinciding with the growth of evidence-based public health. In many HIC over this period, the implementation of injury prevention and safety promotion initiatives has contributed to a considerable reduction in the burden of injury over this time frame (Mock et al., 2004). Using the example of motor-vehicle injury prevention, evidence-based interventions in the areas of education, enforcement, and engineering have had great success in saving lives or reducing injury severity; interventions include speed limits, safer roadway design, seatbelts, airbags, and mandatory helmets for motorcyclists (Peden et al., 2004). Injury prevention can also be a cost-savings measure. Bishai and Hyder (2006) conducted a study of the cost-effectiveness of injury interventions in LMIC.
The interventions tested were improved traffic enforcement, the introduction of speed bumps on roads, promoting helmet use for cyclists and motorcyclists, and storing kerosene in childproof containers. All of the interventions tested were cost effective, based upon a comparison of the cost of implementation versus the cost of productive life-years lost.

Surveillance represents the foundational building block in the public health approach to injury prevention and control, as shown in Figure 1-2. Surveillance via data collection, analysis and interpretation, as the first phase in the process, enables the identification of determinants specific to the particular injury problem in the second phase. In the third phase, evidence from phase one and two are used to design, implement, and evaluate prevention programs, and in the final phase, these programs can be scaled-up and evaluated for cost-effectiveness.
Injury surveillance is the foundation for evidence-based injury prevention and control. Surveillance is typically undertaken at the level of community or health facility to collect, analyze, interpret, and disseminate information on injury and its determinants. Surveillance enables the identification of causes and risk factors, and the design, implementation, and evaluation of interventions.

Injury prevention relies on injury surveillance programs that collect, analyze, interpret, and disseminate data on injury and its determinants. Data collected during surveillance activities include patient details and demographic information, injury event details including time and location, type of injury sustained, and injury cause (Holder et al., 2001). Surveillance efforts vary, from small-scale one-time ecological data collection and analysis studies, to large-scale prospective efforts focused on longitudinal data collection and analysis. Community-based surveillance is often of the former (though not...
always), whereby a localized effort is carried out to understand a specific injury burden, with the philosophy that the community represents both the target, and the catalyst for change (Nilsen & Yorkston, 2007). The trauma registry is a widely used model for injury surveillance in hospital and health facility settings. Patient data are collected at a facility, which can then be further aggregated upward to regional and national injury surveillance systems (Moore & Clark, 2008). Data collected using these systems are used for analysis of injury epidemiology in the facility’s catchment area, and for assessing the quality of trauma care provided, examining typical patient outcomes from injuries sustained, analysis of trauma system functioning, and for resource allocation purposes (Moore & Clark, 2008). In HIC, both the community-based and hospital-based systems are common, however, they are both rare in LMIC. Engaging in surveillance in LMIC is hindered by two broad barriers, the limited financial resources available to set up and maintain surveillance programs, and a lack of trained personnel to collect, analyze, interpret, and disseminate the information (Nwomeh et al., 2006). As a result, little is known about the causes and consequences of injury in many LMIC. This dearth of data severely restricts the possibility of designing effective injury prevention measures to lessen the huge burden of injury (Hofman et al., 2005b). In HIC, some settings that have large injury burdens often also have limited surveillance, which, like LMIC, means that injury prevention is difficult. Recent work on the development of community-based surveillance systems on Aboriginal reserves in Canada points to the unique challenges these low-resource settings face, and also to the need for unique solutions (Brussoni et al., In press). In low-resource settings in both LMIC and HIC, surveillance programs must be developed such that they can be operated with few resources and by existing personnel, be that clinical staff in hospitals, or the local residents in the case of community-based surveillance programs.
1.5.3. Geographies of Health and Injury

The subdiscipline of health geography is broadly focused on the socio-spatial and place-based dimensions of health and well-being. A recent review article (Andrews et al., 2012) overviewed the diversity and range of research themes within the subdiscipline. In terms of research foci, the authors cite examples of currently popular research topics including the geographic dimensions of aging, disability, health services, health inequalities, environmental health, and mental health. A range of methods are described by the authors, from quantitative approaches such as spatial analysis, GIS methods, and multi-level statistical modelling, to qualitative methods including, oral history, participatory methods, and narrative analysis. In terms of broader theoretical and conceptual engagements, the authors refer to recent work that has explored gender, the body, criticality and culture, wellness, narrative and metaphor, scale, and globalization and global issues. In Canada, health geography is presently thriving and diverse, as evidenced by the comparatively large number of health-related sessions at a recent Canadian Association of Geographers annual meeting compared with previous meetings and the broad range of research themes and methodologies described (Giesbrecht et al., forthcoming).

Global health and health geography share many similarities. As Brown and Moon (2012) suggest, the definition of global health put forward by Koplan et al. (2009) and discussed above “chimes well with much current health-related research by geographers” (p. 13). Like global health, health geography has a strong ethical commitment to health equity, and the social determinants of health are also a core topic of research. Moreover, the terms global health and health geography have followed parallel trajectories – both emerged within the past two decades to quickly overtake a
longer standing term in common usage. Health geography is a relatively new sub-disciplinary epithet; like global health, it can trace its lineage to an earlier, more bounded term – in this case, ‘medical geography’ (see Kearns & Moon, 2002; Kearns, 1993). The earlier medical geography was said to be driven by the biomedical model of health that focuses on death and disease, in comparison to the new health geography, which subscribes to a social model of health that places health within social, behavioural, and structural contexts (Moon et al., 2009), although some would challenge this bifurcation (e.g. Dorn et al., 2010). While the term medical geography is still used, its use has declined in favour of the more holistic, diverse, and inclusive term health geography – much like how the shift from ‘international health’ to ‘global health’ reflected an increasing commitment to the determinants of health, health equity, interdisciplinarity, and reciprocity. The sub-disciplinary shift from medical to health geography reflected an expansion of research foci, from a narrow focus on concerns with disease distributions and health service accessibility to a broader spectrum of interests that also included research on well-being and social aspects of health and health care (Kearns & Moon, 2002). Also, this linguistic change purportedly represented a shift from epistemological and methodological rigidity (positivism and quantitative methods respectively), to pluralism with respect to knowledge production and methodology (see Rosenberg, 1998).

Along with the growing interest in health themes from within geography, much geographical research on health has come from outside of the discipline (Kearns & Moon, 2002). This is perhaps no surprise, since health geography itself has been heavily influenced from outside of geography – from public health, sociology, and environmental science to name a few cognate disciplines. This in fact relates to a real strength of health...
geography – the tendency for research projects to include members from a wide variety of disciplines – as interdisciplinarity is required to tackle the diversity of health-related challenges (Luginaah, 2009). Interest in the geographical dimensions of health from various disciplines is part of a larger ‘spatial turn’ in the health, physical, and social sciences and humanities, in which geographic concepts, methods, and theories are increasingly being taken up by non-geographers in various fields (Soja, 2009; Warf & Arias, 2009b).

A recent article by Richardson et al. (2013) in the journal Science entitled ‘Spatial Turn in Health Research’, although brief and narrow in its disciplinary focus, suggests the arrival of GIS into the mainstream of health research. In the past decade especially, GIS and geospatial technologies have become widely used in health research, both in health geography and by non-geographers in public health and other disciplines as part of the wider spatial turn. Nykiforuk and Flaman (2011) conducted a literature search of the use of GIS for health, and identified four main application areas; disease surveillance, risk analysis, health access and planning, and community profiling. New GeoWeb technologies have been used to visualize health data. Platforms such as Google Earth have been employed in health research due to their usability and widespread accessibility, and in low-resource settings in particular, these technologies present a means of bypassing the barriers to engaging in cartographic visualization of health data due to their cost-effectiveness and ease-of-use (Lozano-Fuentes et al., 2008; Stensgaard et al., 2009).

Geospatial technologies have been widely used to analyze injury, especially in well-resourced settings. The use of GIS for injury has primarily focused on two main
areas: 1) approaches that guide the development, evaluation, and improvement of regional trauma systems; 2) epidemiological applications that identify the spatial distribution of injury and determinants of injury (Schuurman et al., 2008b). For trauma systems research, GIS analyses are useful for both their development and enhancement. For example, GIS has been used to calculate appropriate catchment areas for trauma centres (Schuurman et al., 2008a), to develop more precise deployment of emergency medical service (EMS) resources in order to provide better service to an area (Schuurman et al., 2009a; Warden et al., 2010), and to determine the most suitable locations for new trauma centres (Kivell & Mason, 1999). For epidemiological research, GIS has been used to link datasets on injury and risk factors, map injury distributions, and uncover the determinants of injury through analysis of its social and environmental correlates (e.g. Bell et al., 2012; Lai et al., 2009; Lightstone et al., 2001; Yiannakoulias et al., 2003). These types of studies have helped to highlight populations and geographic areas that possess a disproportionate injury burden. Less common, however, is the use of geographic and geospatially-informed approaches for the data collection aspect of surveillance. A key contribution of this dissertation is a demonstration of the utility of these approaches for all aspects of surveillance – for data collection, analysis, interpretation, and dissemination. Moreover, this dissertation also points to the strengths of geography and geospatial approaches for injury prevention activities. The section below outlines the injury surveillance and prevention activities carried out in each study.
1.6. Dissertation Outline and Structure

The four main chapters following this Introduction explore the purpose and objectives of this dissertation research project. These four chapters were originally written as standalone papers designed for academic publication. Chapters 2 and 4 are based on research at the Cape Town study site, and Chapters 6 and 8 are based on research from Vancouver. Together, the four chapters comprise an integrated global health research project concerned with enabling injury surveillance in low-resource settings. Between the main chapters, three ‘linking chapters’ – 3, 5, and 7 – are added to help illustrate the connections between the four main chapters. The final Conclusion chapter further ties together the dissertation, sums up individual and overall findings, discusses the contributions of the dissertation, and provides a personal reflection on the project.

Chapter 2 details an injury surveillance pilot study carried out in Groote Schuur Hospital in Cape Town, South Africa. This chapter documents the design and testing of a series of simple protocols for injury surveillance. A data collection system was developed for the hospital, in which existing surveillance data were identified from various sources and collated, and a data management and visualization system was set up using a Web-based database and GeoWeb technologies. The purpose of the pilot study was to assist the hospital in collecting injury surveillance data for epidemiological and hospital administrative purposes, and as a proof of concept to demonstrate the potential for low-cost and easy-to-use Web technologies to be used in settings with few resources available to set up and operate surveillance systems.
Chapter 4 also describes an injury surveillance pilot study conducted in Cape Town, but one that used a very different approach to the more conventional hospital-based strategy discussed in Chapter 2. This study used GeoWeb technologies and a citizen-generated data collection approach to collect opinions from emergency medical services (EMS) personnel regarding the sites of injury hotspots (high-incident locations) in Cape Town. The purpose of the study was to identify injury hotspot locations since it was not possible to collect these data in the pilot study described in Chapter 2. Also, the study had a bigger picture goal of demonstrate how citizen knowledge can be harnessed to create previously unrecorded datasets using GeoWeb technologies and a VGI-informed data collection approach.

Chapter 6 outlines the development and testing of a method for community-based surveillance of the behavioural determinants of pedestrian injury. The purpose of the study was to explore the relationship between road-rule violations by pedestrians and motorists and the existence of pedestrian injury hotspots in Vancouver, Canada, and, to develop a method that low-resource community groups could undertake in their local area to explore the behavioural contributions to pedestrian injury. This study was designed and conducted in conjunction with a local pedestrian safety group from a marginalized neighbourhood with a disproportionate burden of pedestrian injury in Vancouver, who used it in a community-based injury surveillance and prevention project.

Chapter 8 is a theoretical exploration of the collaboration with the community-based surveillance group in Vancouver. This chapter argues that the production of geographic knowledge is not restricted to universities and the academic realm, but is actively produced in extra-institutional domains, yet is rarely recognized as such by
academic geographers. This argument is developed by tracing the unfolding of the pedestrian safety collaboration, which produced ‘public geographies’ of injury surveillance and prevention in a marginalized neighbourhood of Vancouver.
2. Injury Surveillance in Low-Resource Settings Using Geospatial and Social Web Technologies

2.1. Abstract

Background: Extensive public health gains have benefited high-income countries in recent decades, however, citizens of low and middle-income countries (LMIC) have largely not enjoyed the same advancements. This is in part due to the fact that public health data - the foundation for public health advances – are rarely collected in many LMIC. Injury data are particularly scarce in many low-resource settings, despite the huge associated burden of morbidity and mortality. Advances in freely-accessible and easy-to-use information and communication (ICT) technology may provide the impetus for increased public health data collection in settings with limited financial and personnel resources.

Methods and Results: A pilot study was conducted at a hospital in Cape Town, South Africa to assess the utility and feasibility of using free (non-licensed), and easy-to-use Social Web and GeoWeb tools for injury surveillance in low-resource settings. Data entry, geocoding, data exploration, and data visualization were successfully conducted.

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Conclusion: This study examined the potential for Social Web and GeoWeb technologies to contribute to public health data collection and analysis in low-resource settings through an injury surveillance pilot study conducted in Cape Town, South Africa. The success of this study illustrates the great potential for these technologies to be leveraged for public health surveillance in resource-constrained environments, given their ease-of-use and low-cost, and the sharing and collaboration capabilities they afford. The possibilities and potential limitations of these technologies are discussed in relation to the study, and to the field of public health in general.

2.2. Introduction

2.2.1. Technology and Global Health

Massive gains in health and medicine over the past decades have brought great improvements to quality of life. This is most notable by soaring life expectancy rates and plummeting infant mortality rates; however, these gains have largely been confined to high-income countries (Laxminarayan et al., 2006). As such, new strategies are required to support health innovation to benefit the low and middle-income countries (LMIC) of the world in particular (Gardner et al., 2007). One of the current priorities for global health research is information and communication technologies (ICT) (Ijsselmuiden et al., 2008). In fact it is argued that advances in ICT will likely have the greatest impact on reaching the Millennium Development Goals (Juma & Yee-Cheong, 2005). In LMIC where resources for health are severely limited, policy-makers “often have to make
difficult decisions that pit investment in new technologies and capacity-building in science and technology against basic population-wide services such as healthcare and water supply and sanitation” (Acharya, 2007, p. 53). What is required then, are longer-term public health solutions which can be implemented without affecting more immediate necessities. The present study addresses this issue by assessing the possibility for Social Web technologies to support the development of public health surveillance systems for low-resource environments. Social Web technologies may be valuable tools for LMIC because they are designed to be easy to use, and many have no licensing fees. The promise of these technologies was demonstrated through an injury data collection and analysis pilot study conducted in Cape Town, South Africa.

2.2.2. The Burden of Injury in Low and Middle-Income Countries

The ‘invisible epidemic’ of injury is one of the leading causes of death in working-aged adults and children in almost every country in the world (Mock et al., 2004). Injury is a serious threat to public health and to future generations in all countries around the globe, whether high, middle or low-income (Sommers, 2006). In LMIC however, the problem is particularly acute because of a disproportionately high incidence of injury, a scarcity of resources and prevention efforts, and an extremely low level of funding devoted to this problem in comparison with the high-profile communicable diseases such as HIV/AIDS, tuberculosis, and malaria (Krug et al., 2000; Lett et al., 2002). Of the approximately 5 million deaths annually attributed to injury, 90% occur in LMIC (Hofman et al., 2005b; Peden et al., 2002). In South Africa, the burden of injury is massive; this huge contribution to overall mortality and morbidity is largely attributed to road-traffic crashes and interpersonal violence (Norman et al., 2007).
2.2.3. Injury Surveillance in Low and Middle-Income Countries

In LMIC, high rates of injury are coupled with poor injury surveillance. Public health surveillance involves “ongoing systematic collection, collation, analysis and interpretation of data and the dissemination of information to those who need to know in order that action may be taken” (World Health Organization, 2008b). Injury surveillance systems are relatively well-developed in resource-rich settings; however, they are frequently non-existent in LMIC. This lack of injury data has been highlighted as a major barrier to injury prevention in LMIC (Hofman et al., 2005b; Odero et al., 2007). It is imperative that data on injury are collected and analyzed so that public health officials can gain a better understanding of the magnitude and characteristics of the problem (Krug et al., 2000).

2.2.4. Geographic Information Systems

Geographic Information Systems (GIS) and spatial analysis can play a crucial role in understanding the burden of injury (Cusimano et al., 2007; Schuurman et al., 2008b). GIS has been used increasingly to help uncover the determinants of injury through analysis of its social and environmental correlates (e.g. Lai et al., 2009; Lightstone et al., 2001; Schuurman et al., 2009b; Yiannakoulas et al., 2003). In addition to its use for epidemiological analysis of injury, GIS and geospatial technologies are beginning to be used for various purposes within injury surveillance systems. For example, in Kenya, a recent study combined GIS with patient medical records to create an electronic injury surveillance system (Odero et al., 2007). This spatially-equipped system was used to ascertain the environmental attributes at the location of injury. GIS
technologies range from sophisticated licensed desktop software to free, lightweight, Web-based applications.

### 2.2.5. The Social Web and the Geospatial Web

The Social Web (alternatively known as Web 2.0, the read-write Web, etc.) refers to what has been described as the ‘second wave’ (Deshpande & Jadad, 2006) of the World Wide Web. It is generally agreed that the Social Web represents a paradigm shift from the capabilities of the first incarnation of the Web, despite the original intentions for the Web by its inventor (IBM, 2006). This shift is identified by a fundamental change in how the Web is used, and by advances in its technological capabilities (Murugesan, 2007; Rinner et al., 2008). ‘The participatory Web’ as opposed to ‘Web as information source’ is a distinguishing theme of the Social Web, of which user-created content, information-sharing, and collaboration are the hallmarks. User contribution and collaboration aspects of the Social Web have the potential to provide an open platform for political and societal debates, and could increase diversity of opinion, the free flow of information and freedom of expression (Organization for Economic Co-operation and Development, 2007). The second major theme of the Social Web - a shift in technology usage and capabilities - is characterized by the use of the Internet as a technology platform. Improvements in technology and changing patterns of technology consumption have contributed to the increasing use of no-cost Web-based applications in place of licensed proprietary software. Cheung et al. (2008) outline the technological innovations that define the Social Web; rich Internet applications, collaboration tools, user contributed content databases, and integrative technologies.
The uptake of rich Internet applications is beginning to take hold as the products offered become more robust. The ‘Web office’, or Office 2.0 (Gambadauro & Magos, 2008) is revolutionizing productivity software availability, with word processing, spreadsheet, and presentation software now available free and accessible anywhere through a Web browser. There is the potential for easier and more efficient collaboration amongst colleagues, as documents can be stored, edited, and shared online. For example, revisions of a common Web-based document can be undertaken by many distributed authors, while avoiding the problem of having several versions of the document (Gambadauro & Magos, 2008). Google Docs (Google, 2008a) and ThinkFree Office (ThinkFree Corporation, 2008) each offer a suite of office productivity tools including word processors, presentation designers, and spreadsheet editors designed to compete with traditional software such as Microsoft Office.

The geospatial Web (or GeoWeb) refers to the “global collection of general services and data that support the use of geographic data in a range of domain applications” (Lake & Farley, 2007, p. 15). These new technologies, described as “not quite-GIS” by Elwood (2009a) are bringing Social Web approaches to GIS, which suggests the potential to democratize this once exclusive domain (Boulos & Burden, 2007; Butler, 2006b; Goodchild, 2008; Sheppard & Cizek, 2009). Virtual globes such as Google Earth (Google, 2008b), NASA World Wind (NASA, 2008), and ArcGIS Explorer (ESRI, 2008) have fast become ubiquitous; much of the success of Google Earth and the other virtual globes stem from their simplicity. This is accomplished by “avoiding reference to the technical details of georeferencing, projections, and figures of the Earth, and presenting the planet as it would appear from a user-controlled viewpoint” (Goodchild, 2008, p. 34). Since GeoWeb platforms are freely accessible and easy to
operate, it is posited that the traditional barriers of domain training and financial resources could be reduced, thereby allowing many more people and organizations to leverage geospatial technology for their own purposes.

### 2.2.6. **Social Web Technology for Health**

This new generation Web is poised to initiate great change in the health and science realms (Boulos & Wheeler, 2007). The richer, more complete experience promised to the average Web user extends to researchers, patients, and practitioners in the health and science fields. Despite lagging behind in technology uptake and the use of Social Web applications and services (Boulos & Wheeler, 2007; Butler, 2007; Johnson, 2007), health and science stakeholders could gain from this revolution in technology, communication, and interaction. The fact that virtual globes are quick, popular and ubiquitous, render these tools particularly appropriate to use for data visualization (Wood et al., 2007). For example, an early demonstration of Google Earth for data visualization in the health domain was a simple interactive application highlighting the Health Authorities in England (Boulos, 2005). A Web site that hosted a Google Earth file was created, which users could download and open on their local machine. Clicking on the geocoded point opened a Web page from the National Health Service within the Google Earth interface with information on that specific health authority. The unique characteristics of the Social Web may be particularly well-suited to LMIC, where lack of finances and trained personnel have traditionally acted as barriers to information and technology uptake (al-Shobakky & Imsdahl, 2007).
These benefits are already coming to fruition, as Social Web technologies are beginning to appear in support of public health projects in LMIC. Lozano-Fuentes et al. (2008) describe the use of Google Earth to support the mapping of dengue disease data for visualization and analysis. A dengue decision support system was developed using Google Earth in conjunction with traditional GIS software. Spatial data files for two cities in Mexico were created by tracing satellite imagery using the drawing tools available within the Google Earth software. These tools allowed for the creation of block-level city maps to illustrate the distribution of city blocks with dengue cases. These data layers could then be exported into GIS software for use in a dengue information system. No previous experience with Google Earth was needed to create the spatial data files. Kamadjeu (2009) used Google Earth to monitor polio in the vicinity of the Congo River. Google Earth was used to create maps of areas of the river that were unavailable elsewhere. These maps improved public health planning and resource allocation in a region where the topography was previously not fully understood. These recent examples of Social Web software use for public health endeavours represent a major step towards increasing access to technology for LMIC. However, what remains is a true adaptation to the new paradigms of the Social Web, as computer programming and traditional GIS data are still employed in these and most recent examples.

The purpose of the present study was to demonstrate the capability of Social Web technologies to be used for public health projects in low-resource settings. As a test case for these technologies, an injury surveillance pilot project was undertaken in Cape Town, South Africa. All aspects of data input, analysis, and visualization were undertaken using Social Web and GeoWeb technologies. An advancement in this study over recent demonstrations was the use of tools that did not require programming or
advanced computer skills, GIS data, or licensed proprietary software. This pilot study points to the potential for these technologies to contribute to public health surveillance in low and middle-income countries, and low-resource settings more generally. The protocols described herein could likely be transferred to other settings and adapted to local capabilities for organizations that wish to engage in public health surveillance.

2.3. Methods

2.3.1. Needs Assessment

A pilot study was conducted in the trauma unit at Groote Schuur Hospital (GSH), a large publicly-funded tertiary hospital in Cape Town. The trauma unit at GSH processes approximately 900 patients monthly, often with serious traumatic injuries largely resulting from interpersonal violence and road-traffic collisions. An initial needs assessment highlighted a need for a streamlined data collection system which could be used for epidemiological analysis and hospital administrative purposes. At the time of the needs assessment, a trauma registry system that consisted of a data collection form and computerized database was in place in the trauma unit, however, it was not capturing the complete population of trauma patients. For the records that were collected in the database, many were incomplete, with vital data missing including the patient’s demographic details, the injury cause, the types of injuries sustained, and injury location information. During the needs assessment phase it was hypothesized that the sparsely-populated database was likely to be a result of the current system’s complexity, and not a lack of appropriate information available for each patient in the unit. As such, a pilot study was undertaken in order to ascertain the feasibility of developing a trauma registry
system which would be able to collate information for all patients seen in the unit. A main element of the pilot study was a 30 day data capture exercise designed to determine the nature of data that could be consistently collected as part of the normal routine of the trauma unit staff. A paper form was developed to collect data on various aspects of the patient, including traditional trauma registry information such as demographic details, injury type, and injury mechanism. In addition, spatial data were also collected, including details of the patient’s residence location, and the location where the injury was sustained. The paper form was modified according to the needs of the proposed data system, and according to the feasibility of field collection. The form was limited to one page in order to keep this duty as streamlined as possible for the busy clinical staff who would be charged with its completion.

The pre-existing data management system in place at the hospital was under-used as it was deemed to be too time-consuming and difficult to operate. In this pilot study, we developed and tested a streamlined and readily modifiable trauma data entry and management system using Google Docs (Google, 2008a). Using the Forms utility within Google Docs, it was possible to create an online data entry form to mimic the paper hardcopy form without the need for programming or advanced computer skills. This online form could be filled out by copying the data from the paper form into the online form. Submitting the form would then populate the spreadsheet with the data without the need to interact with the spreadsheet cells during the data entry phase.

The importance of user-friendly data analysis tools for in-house data exploration and visualization was highlighted during the needs assessment phase. An aspect of the pilot study was to demonstrate the feasibility of free and easy-to-use GeoWeb
applications for these purposes in place of complex and costly desktop GIS. Several GeoWeb applications were explored to test their suitability for this purpose, including BatchGeocode, Mapalist, and Google Earth. Ethics approval for this study was granted by Simon Fraser University and the University of Cape Town.

2.4. Results

2.4.1. Data Collection and Management

785 patients were recorded in the 30 day data capture feasibility study. Two researchers conducted the data capture; this required assembling the data from various sources and recording it on a one-page paper form, one for each patient. Halfway through the study, doctors and the clinical staff who would eventually be charged with form completion began to assist with completion of the forms as part of their routine patient documentation. These staff were provided training and assistance in order for them to become familiar with the data, where it could be abstracted from, and the purposes of its completion. The form underwent several revisions as the study progressed; the final version of the paper form is shown in Figure 2-1.
A one-page paper form was created in order to assemble the data to populate the trauma registry. The form went through several iterations over the course of the pilot study based on the feasibility of collecting the fields. The fields on this final iteration of the form were collectible as part of the regular documentation duties of the trauma unit’s clinical staff.
Between 20 and 50 patients were recorded daily during the data capture study. Each day, one researcher spent between one and three hours entering the data into the trauma database, depending on the number of patients recorded that day. Figure 2-2 shows the Google Docs Form that was created to allow for easy population of the database, housed online in a security-protected Google Spreadsheet. The online form was designed to allow for a sequential input of data in the same order as on the paper form, i.e. demographic information first, injury event details second, clinical procedures third, and injury details last. As the paper form went through several iterations during the period, the online Google Docs Form had to be redesigned as some fields were removed or had changed position on the paper form. Redesign of the online form was very simple; fields could be removed through a simple deletion, or their sequential position could be changed by dragging the field to its new position and dropping it in its new place.
Figure 2-2: Google Docs Form used for data entry.

A simple online form was created for entering the injury data into a Google Spreadsheet database. The Form creation utility allows for the design of a data entry system without the need for programming or advanced computer skills. Once completed, the form is submitted and the data automatically populates the spreadsheet.

2.4.2. Data Exploration and Visualization

A data processing, exploration, and visualization system was developed as a demonstration of the potential for free and simple Social Web and GeoWeb technology to be used for injury control in low-resource settings. Two free Web-based geocoding tools were tested, BatchGeocode (www.batchgeocode.com), and Mapalist (www.mapalist.com), both of which operate on the Google Maps platform.
BatchGeocode proved to be an easy to use data georeferencing system, with high accuracy at the neighbourhood level in Cape Town. The interface of this Web site allows users to paste a table of data into a form, which is then geocoded (see Figure 2-3). The updated table complete with geographic coordinates can then be downloaded, or exported in Keyhole Markup Language (KML) format, the file type native to Google Earth. In addition, the results can be saved to a Web page within the site which can be open to public viewing, or restricted. The data can be mapped individually, or it can be grouped into categories by any of the fields in the data table.
BatchGeocode allows the user to paste a table of data into a form, which is then geocoded. Results can be viewed and stored online at www.batchgeocode.com for public or private viewing. In this map, the user can click on a location of interest to see details on the injury event. The map can also be exported as a KML file for further exploration in Google Earth. Note that the displayed data point is fictitious and used for demonstration purposes only.

The Mapalist geocoding Web site is designed for the average Web user; its simple operation is organized as a set of 5 steps that the user proceeds through in order to complete the geocoding, visualization of the data, and saving the work. In Step 1, a
Google Spreadsheet (the only type that can be used in Mapalist) is loaded. In Step 2, geocoding parameters are chosen (i.e. the fields with address information are highlighted), and the fields to highlight in pin pop ups are chosen. In Step 3, the data are geocoded according to the address information assigned in the previous step. Step 4 allows the user to configure the resulting output of the data on the map. For example, the data can be mapped individually or grouped by any data value. A unique option available at this stage is the ability to create a simple density (hotspot) map, ideal for the purposes of visually highlighting areas with multiple data points, as shown in Figure 4. Additionally, in Step 4 the user can select more advanced options, including displaying only a selection of the data, for example, all patients between the ages of 16-24 who were injured. In Step 5, the user sets the save parameters for the map, including the name, and whether it can be viewed by the public on the Mapalist's Web site, or restricted to private viewing. Also, there is a noteworthy option that allows the mapmaker to set the map to automatically update if the Google Spreadsheet undergoes a modification, such as the addition of new data.
A simple hotspot map can be made using the Mapalist georeferencing system. Although the options for hotspot mapping are rudimentary, this is a valuable and distinctive feature of the Mapalist system, as GeoWeb applications generally do not have the capability of visualizing concentrations without API modification. Also of significant value is the option to set the map to update automatically if new data points are added to the linked Google Spreadsheet.

In addition to the visualization options available within the geocoding Web sites, the free version of Google Earth was used to develop a injury data spatial visualization tool. Two interactive visualizations were created; a map
of injury incidents by suburb (Figure 2-5), and a map of the location of facilities that transferred patients to GSH (Figure 2-6). In order to create these visualizations, data were aggregated in two new Google Spreadsheets; one for the number of incidents occurring in each suburb, and one for the number of patients transferred to GSH by health care facility. This was a simple process of sorting the data in the appropriate column in the original spreadsheet, summing the number of incidents by suburb and the number of patients transferred by facility, and copying this into the new spreadsheet. KML files for the two visualizations were then created using the online geocoding tools described above. These files could then be opened in Google Earth to allow for exploration and visualization of the spatial data at multiple scales. With these interactive visualizations, the user can easily explore the spatial distribution of injury in Cape Town, and the network of hospitals and health centres in which transferred patients originated from, prior to their arrival at GSH.
Figure 2-5: Google Earth visualization of injuries by suburb.

In this interactive visualization the map user can explore the spatial distribution of injury in Cape Town. Incidents were aggregated to the suburb (neighbourhood) level. This type of simple visualization may be useful for epidemiological and injury prevention purposes. The visualization was created by exporting the geocoded results from free Web-based geocoding tools as Google Earth (KML) files.
The map user can use this interactive visualization to observe the number of patients that arrived at GSH from the network of referral hospitals and clinics throughout the city. This visualization may be particularly useful for hospital administration uses, as this information could be used in trauma system planning for the city.

2.4.3. **User Evaluations**

Informal user-evaluations were conducted throughout the study with hospital staff as a preliminary assessment of the usability and utility of its various components. The participating staff members had no specific background or training in the use of information technologies. The purpose of these evaluations was to assess whether the data collection and analysis system would be useful for the trauma unit, and if the system could be operated and utilized without the need for outside expertise. User-
evaluations of the paper form were positive, with clinical staff suggesting that they were easy to complete and were less time-consuming than the pre-existing system’s longer two-page form. An informal user-test of the Google Docs Form and Spreadsheets with a non-clinical member of staff who held data entry duties was positive. In comparison with the previous database system, the data entry and management system developed in this study was deemed to be much simpler to use and the records could be entered into the database more rapidly. Once the data had been georeferenced and visualized, members of staff engaged in data exploration within Google Earth. Persons with experience using the platform were easily able to explore the data, and were able to recognize spatial patterns of injury in Cape Town. The users were particularly excited about the potential for the interactive patient transfer facility network visualization to inform future trauma system planning for GSH and the city of Cape Town in general.

2.5. Discussion

In this paper, an injury surveillance pilot study was conducted at a low-resource hospital in Cape Town using Social Web technologies. This pilot study represents the first stage in the development of a sustainable trauma registry that could be used for epidemiological analyses and administrative purposes. Free and easy-to-use data management and analysis tools available on the Web were demonstrated in order to highlight a simple and affordable alternative to traditional software that is expensive and requires comprehensive training in its operation. As a result of these benefits, there is great potential for organizations with limited resources to leverage Social Web and GeoWeb technologies for organizing and operationalizing public health surveillance, including for the increasingly recognized problem of injury.
2.5.1. Social Web Technologies

Technology may hold the key to improved public health in LMIC (Chandrasekhar & Ghosh, 2001), however, technology advocates must fully understand the barriers to technology uptake faced in these countries. In the case of injury surveillance in LMIC, the two chronic roadblocks to the implementation of sustainable data registries are a lack of finances and trained personnel (Nwomeh et al., 2006). This study focused on addressing this problem by designing simple, easy-to-use protocols for collecting, managing, and visualizing injury data.

Social Web technologies may be very attractive options for public health surveillance in settings where resources are limited, most notably as a result of their simplicity and affordability. The technologies demonstrated in this study exemplify simple and affordable data management and visualization solutions. The database developed using Google Spreadsheet was simple to set up and operate, including the data entry form and the spreadsheet. In addition, the Forms data entry system was designed to use dropdown menus and tick-boxes and did not require spreadsheet interaction; it is likely that this would result in few data entry errors as opposed to data entry through direct spreadsheet input. With regards to the GeoWeb tools, Mapalist proved to be a better system than BatchGeocode for the purposes of this study, as it is designed to work specifically with Google Spreadsheets which made the process more streamlined. Additionally, in comparison with the BatchGeocode tools, more visualization options and data query functionality were available.

Virtual globes are largely responsible for introducing geospatial technologies to the masses (Miller, 2006). Google Earth, the most well-known of the virtual globes is
widely used for educational and entertainment purposes, however, its use as a tool for endeavours in science and health is growing (Stensgaard et al., 2009). Recent studies have used Google Earth for scientific activities in low-resource settings (e.g. Chang et al., 2009; Conroy et al., 2008; Kamadjeu, 2009; Lozano-Fuentes et al., 2008; Stensgaard et al., 2009), however in most cases licensed proprietary software was also relied upon in addition to Google Earth, or computer programming was required. In this study, other applications were used to complement Google Earth as described above, however all tools were chosen explicitly because they had no licensing fees, were simple to use, and required no programming or sophisticated computer skills. This is a notable contribution as most organizations in LMIC are unlikely to have access to traditional licensed geospatial software, nor the expertise to operate it. In addition to the abovementioned benefits, there are other reasons that may lead organizations to choose Google Earth. For the average user, Google Earth may be more user-friendly and flexible than traditional GIS, given its more intuitive user-interface that allows the user to readily pan and zoom in for greater detail (Sheppard & Cizek, 2009), thereby allowing for exploration of spatial data at multiple scales. Furthermore, organizations may be attracted to Google products since it is developing initiatives to address humanitarian and global health issues through the use of its products, by way of Google Earth Outreach (Google, 2010a) and Google.org (Google, 2010c). Above all, the ubiquity and simplicity of the Google Earth system make it an ideal platform for data visualization for organizations with financial constraints or no expertise in traditional GIS platforms.
2.5.2. Information Sharing and User Collaboration

Although this paper is chiefly focused on the technological aspects of the Social Web, another strongly heralded characteristic of the new Web - which is also important to this study - is its enormous potential for sharing and collaboration (Boulos et al., 2006; Scotch et al., 2008). Through the Social Web’s superior sharing and collaboration abilities, and the potential it holds for increased engagement, these visualization and analysis tools could help to bridge the gap between researcher and stakeholder, including policy-makers and citizens (Guralnick et al., 2007). The Google Spreadsheet powered database was accessible and editable anytime, at any Web-enabled computer, providing the user was provided access. For example, as the database was populated by the data entry person, the trauma unit manager could access the most recent records of patients from another computer in real time for administrative purposes, or another data entry person could collaborate on editing the database. The georeferencing Web sites possessed similar sharing and collaboration characteristics. BatchGeocode allowed the user to store their newly created maps on their Web site. These can then be viewed by collaborators on their own computer by providing them with the unique URL that the map is stored on. Mapalist has a more advanced user-account system where users can view, edit, and update all of their maps in an easy-to-use interface. Maps can be privately or publicly viewable; if maps are restricted from public viewing, an email link can be sent to collaborators for viewing on a different computer. The Google Earth platform also enables user collaboration and data sharing as KML files of data in Google Earth can be shared instantly via email, which may be one of the most appealing aspects of virtual globes (Stensgaard et al., 2009). In fact, the potential for these systems to allow for swift collaboration and sharing may be one of the most promising
aspects of the Social Web for use in public health surveillance in any setting, irrespective of the level of resources at hand.

2.5.3. **Future Work**

A suitable next step in this study could be to conduct a more thorough user-test of the tools and protocols developed for this study, in order to assess the suitability of the system for local capabilities and to ensure the end result is sustainable. In subsequent phases of this project, attention will be focused on ensuring that the system can be expanded to include other hospitals and jurisdictions. This will require - along with other considerations - the use of international injury coding and database standards. A major direction for future work on this project involves an assessment of the utility of geospatial analysis for injury prevention in the local setting. As GeoWeb tools are not particularly suited to high-level geospatial analysis, it will be necessary to assess the utility of the technology’s analysis, visualization, and data exploration capabilities. Although the focus of the present study was on the potential applicability of Social Web tools in this setting, the ultimate goal is to identify environmental and social correlates of injury in Cape Town using the spatial data collected and the visualization tools. Once a sustainable data registry is functioning, a future study will identify high-incident injury locations, and will examine the social and environmental characteristics in order to identify injury risk factors at these locations. This will require obtaining higher-resolution spatial data, which could possibly be obtained by querying the patient or ambulance driver regarding site of injury, followed by a confirmation of the geographic coordinates using global positioning system (GPS) technology. A similar method has been successfully demonstrated in a study by Dwolatzky *et al.* (Dwolatzky *et al.*, 2006)
regarding location confirmation in informal settlements of Johannesburg. This is also a focus for future work.

2.5.4. Limitations and Possibilities

Although the protocols described in this study are likely to be feasible in many middle-income countries such as South Africa, limitations may exist regarding the potential use of Social Web technologies in truly low-income countries. al-Shobakky & Imsdahl (2007) outline several barriers to the uptake of these tools in LMIC, despite their lack of licensing fees and apparent simplicity. First, the computers that exist in some low-resource settings are likely old and may not be able to cope with some of the new Social Web applications. Second, a lack of education and proficiency in English (the language of the Web) will limit who can use them, as these applications are rarely available in local languages. Relying on Web access is an obvious potential limitation; as a result, ‘free’ technologies are not likely to be without some financial cost. Internet penetration in many of the low and middle-income countries is low. For example, in Africa in 2006, less than 5 out of every 100 people used the Internet, compared with an average of 1 out of every 2 residents of the G8 countries (International Telecommunications Union, 2007). Google Docs requires Internet access at all times, whereas traditional proprietary spreadsheet applications such as Microsoft Excel do not. This is also the case with the Web-based georeferencing tools. As a result, the sharing and communication benefits of the Web-based tools may be less alluring. Google Earth also requires an Internet connection at the outset of use. However, using Google Earth may less of a hurdle compared with other Social Web tools, as once the satellite images are stored in memory the platform can operate without an Internet connection. These
problems pose serious barriers to the uptake of these technologies in low income countries. However, there is some light on the horizon. The cost of Internet access is dropping as advances in wireless technology and hardware are reducing the cost of access (Cohen et al., 2008). Also, there is a call for new technologies to be developed specifically for low-resource environments, or modifications of existing technologies to allow for access through poor connections (Missen & Cook, 2007). Additionally, there is some evidence that the number of Internet users in developing nations is growing quickly (Brooks et al., 2005). Despite the constraints, the Social Web holds great promise in LMIC. There is much work to be done however, to ensure that this recent stage in the technological revolution can contribute to the improvement of public health in these settings.

Limitations not specific to LMIC must also be noted, such as the potential tendency to overemphasise what is visualized because of the perceived ‘reality’ of a virtual globe (Sheppard & Cizek, 2009). Proponents of these technologies must be cognisant of the ‘wow’ factor that these visualization tools can elicit in the viewer. A major issue with the GeoWeb’s so-called ‘democratization’ of GIS is the potential for erroneous mapping and visualization by users unfamiliar with geospatial or epidemiological concepts (Boulos et al., 2008), which could lead to inappropriate decision making. It must also be noted that restrictions may be placed on the use of these Web-based technologies. For example, Google has strict use criteria that determines how its maps and imagery can be used; however, the content can be used for academic purposes such as this study through the ‘fair use’ guidelines, on condition that attribution is given to Google and its suppliers, and content is identifiable as a Google product (Google, 2010b). When using Google products or other Web
technologies, the user must ensure they are complying with legal terms and conditions. Lastly, relying on these Web-based services for data manipulation and storage may be a point of concern, as potentially sensitive or valuable data could be subject to system instabilities or security breaches. As was done in this study, it is recommended that sensitive health data stored on the Web are anonymized and stored privately.

2.6. Conclusion

Despite considerable advancement in health and medicine in recent decades, the overall health and life-expectancy of citizens in low and middle-income countries remain poor. Public health data are fundamental to public health advances, however current and comprehensive public health data are rare in most LMIC. This is particularly true for the huge problem of injury, given the fact that it is largely overlooked as an immediate health problem, despite its huge toll of morbidity and mortality. As a result, little is known about the magnitude of the problem in many locations, nor its correlates or implications. As health resources are insufficient in LMIC, what is needed are novel solutions for data collection and analysis that will not impinge on already depleted financial and personnel resources. The enormous potential for simple and cost-effective Social Web technologies to be used for injury surveillance in low-resource settings was demonstrated in this study.

This exploratory study suggests that the ease-of-use, information sharing, and collaboration aspects of the Social Web may be particularly suited to public health surveillance in low-resource settings such as South Africa, and likely other low and middle-income countries. Although this study was successful in illustrating the potential
for new Web technologies, further assessments of the hospital’s needs and capabilities will be needed to ensure the system is useful, effective, and sustainable. The results of this study could be useful for organizations that wish to commence public health data collection and analysis in a resource-constrained environment. We encourage researchers and practitioners to continue to examine methods of engaging in data collection and analysis through the use of Social Web, GeoWeb, and related information and communication technologies.

2.7. Acknowledgements

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3. Linking Chapter: Access to Data as Global Health Equity

Speaking about the challenges of accurately documenting the global burden of disease and injury, Margaret Chan, the Director-General of the World Health Organization, summed up the prevailing problem: “we must not forget that the real need is to close the data gaps, especially in low-income and middle-income countries” (Chan, 2012, p. 2054). The preceding chapter and the following chapter both describe efforts that seek to address the inequity of access to data for decision-making that exist in many low-resource settings, but are particularly evident in LMIC. Seemingly paradoxical in the age of ‘Big Data’ in well-resourced settings, many settings in fact have limited access to data, be that specialized public health data, or even vital registration and census data. This ‘data-divide’ is separating the haves and the have-nots according to their ability to engage in evidence-based decision making. A global health equity perspective must also recognize access to data as a key determinant of health promotion and prevention. The following chapter addresses a specific shortcoming from the findings of the study described in the previous chapter – the poor resolution of injury location data collected. The previous effort was successful in collecting information on neighbourhoods where injuries occur, which may have some value for community-based injury prevention efforts, perhaps for violence-related injury in the Cape Town context. However, for motor-vehicle and pedestrian injury, precise roadway locations are much more valuable for facilitating the design of effective interventions. The study in the following chapter also uses GeoWeb technologies, but this time to collect the opinions of knowledgeable
participants concerning the locations of injury hotspots (high-incident locations) in Cape Town.
4. Confronting the Data-Divide in a Time of Spatial Turns and Volunteered Geographic Information

4.1. Abstract

Geography is enjoying a period of unparalleled visibility, driven by the growing use of geographic methods and concepts across the sciences and humanities—the so-called spatial turn—and the pervasive use of geospatial Web technologies and their concomitant influence on society, especially the phenomenon of volunteered geographic information (VGI). The field of public health is beginning to harness spatiality with gusto; however, the geospatial Web and its social phenomena are underexplored in this context even though they may be particularly useful for public health enquiry, especially in low-resource settings that lack traditional data collection mechanisms. A case study framed within these two current phenomena is presented to illustrate the influence of geography and its potential for addressing the data-divide—the disparity in availability of data for scientific inquiry and decision-making most felt in low-and middle income countries. A facilitated VGI data collection initiative collected public health-related injury data in Cape Town, South Africa, as a pragmatic alternative given the lack of data from traditional sources. Emergency medical services personnel interacted with a GeoWeb interface to volunteer their informed opinions of high-incident injury locations. Previously unrecorded injury location data were created, and combined with traditional injury data for use in an ongoing study examining the environmental determinants of injury in this region.
setting, which illustrates the possibility for hybrid authoritative/asserted data collection strategies. This study speaks to the growing influence of geography and one of its driving forces, the techno-social revolution in geospatial technology and data. Future work should continue to examine their potential to address the data-divide.

4.2. Introduction

The discipline of geography is undergoing a period of transformation. This is by no means geography’s first period of great change – previous eras of transformation such as the ‘quantitative revolution’ that began in the 1950s (Barnes, 2009), the emergence in earnest of GIS in the early 1980s (Goodchild, 2009a; Longley, 2000), and the ‘cultural turn’ in the later 1980s (Philo, 2009) all left distinct marks on the discipline. The current innovatory phase, however, is unique due to one important detail – its external significance. Sui (2011) describes two changes that have transformed geography since the beginning of the twenty-first century. First is the so-called ‘spatial turn’, the witnessed increase in geographic thinking across the sciences and humanities. The second major shift observed in this period is of a combined social and technological nature; specifically the use of Web-based geospatial interfaces (known as GeoWeb technologies) coupled with the consequent social developments of neogeography and volunteered geographic information (VGI).

The study described in this paper is framed within the context of these two current phenomena – the growing use of spatial methods and concepts in the sciences and humanities, and what might be referred to as geospatial technology’s techno-social
revolution. This paper illustrates these two phenomena through the account of an injury data collection pilot study conducted in Cape Town, South Africa, a city burdened by massive rates of injury due to violence and motor-vehicle collisions. This study focused on the collection of injury data using GeoWeb interfaces and VGI protocols, and was part of an overarching project that involved academics and professionals from diverse disciplines, yet the project was motivated by spatial questions. The present study was designed in response to an identified shortcoming from a previous study (Cinnamon & Schuurman, 2010), the limited ability to collect precise injury location data in this setting. Through a review and case study highlighting the two-abovementioned transformational changes for the discipline of geography, this paper illustrates one effort to address an important challenge faced in many low-resource settings, the limited availability of data with which to make informed decisions on diverse issues, such as the economy, civil society, the environment, and health.

4.2.1. The Spatial Turn: The Influence of Geography in the Sciences and Humanities

Non-geographers are increasingly taking advantage of geographic and spatial perspectives as organizing themes in their work. This spatial turn throughout the sciences and humanities is raising the profile of geography in a wide range of disciplines, from archaeology to zoology. The influence of human geography has grown as a consequence of the spatial turn, a phenomenon in which it played a role in creating (Thrift, 2002). In particular, critical human geographers such as David Harvey and many others must be acknowledged for their role in (re)introducing space across the social sciences and humanities (Arias, 2010). Harnessing spatiality as a dimension of analysis outside of geography is a not an entirely new trend; however, it is expanding rapidly and
holds the promise of considerable influence. As Soja (2009, p. 12) posits, greater expansion of the spatial perspective in academic disciplines “has the potential to be one of the most significant intellectual and political developments of the twenty-first century”. The defining issues of the recent period such as globalization and global environmental degradation – due to their inherent geographic dimensions – have helped to engrave the dimension of space and spatiality across the social sciences and humanities (Warf & Arias, 2009a). Also, the broader adoption of geographic terms and metaphors such as mapping, place, space, regions, and territory might at least in part be attributed to the pervasive use of global positioning systems (GPS), geographic information systems (GIS), and related geospatial technologies in academia and society (Soja, 2009). In some cases, use of the spatial perspective in other disciplines might be manifest simply in the use of these geographic terms and metaphors, however in other instances space has been much more influential and transformative. As Warf and Arias (2009a, p. 1) have described, sometimes “the spatial turn is much more substantive, involving a reworking of the very notion and significance of spatiality to offer a perspective in which space is every bit as important as time in the unfolding of human affairs, a view in which geography is not relegated to an afterthought of social relations, but is intimately involved in their construction.” Numerous domains of research and intellectual inquiry are embracing space as a theoretical and organizing concept, for instance in areas as diverse as planning (Lloyd & Peel, 2005), law (Philippopoulos-Mihalopoulos, 2010), theology (Bergmann, 2007), sociology (Green et al., 2010), and the history of science (Finnegan, 2008).
4.2.2. **Geospatial Technology’s Techno-social Revolution**

A revolution for geospatial technology began in the middle of the first post-millennial decade due to the emergence of the *geospatial Web* (or GeoWeb). The GeoWeb refers to the geospatial applications, services, and data that are operated or enabled through the World Wide Web (Lake & Farley, 2007). The GeoWeb is fostered and made possible by newly available technology and a ‘user-friendly’ development paradigm – the same defining hallmarks of the new-generation Web, or ‘Web 2.0’ (Murugesan, 2007; Rinner *et al.*, 2008). The Web 2.0 (O’Reilly, 2005) era has heralded a marked difference in how the Web is used, hallmarked especially by interactive, user-friendly, and collaborative Web experiences where the average user can engage in content creation through platforms such as wikis, blogs, social networking sites, and the ubiquitous user-rating systems on Web sites (Hendler & Golbeck, 2008). Paralleling this rise in *user-generated content* on the Web has been the explosion in the availability of Web-based geospatial technologies. Such has been the ascendancy of the GeoWeb, according to Rinner *et al.* (2008, p. 387), geographic applications can in fact be considered “cornerstones of Web 2.0”. The GeoWeb offers free or low-cost technologies and Web services, including virtual globes, satellite imagery, spatial data, and basic analysis and database querying in user-friendly, lightweight and accessible packages (see Batty *et al.*, 2010; Crampton, 2009; Haklay *et al.*, 2008). Although traditional desktop GIS platforms such as ESRI’s ArcGIS are still the standard for complex GIS procedures, new tools are being provided by geospatial upstarts such as Google (Google Maps and Earth) and the growing array of independent Web sites devoted to providing tools to automate or simplify tasks such as the georeferencing of spatial data. These new GeoWeb platforms and services are not likely to replace desktop GIS.
platforms due to their limited ability to perform spatial analysis, modelling, and visualization, however ESRI has now emulated the GeoWeb model with the ArcGIS Explorer virtual globe, and ArcGIS Online (www.arcgis.com), which boasts “Maps and Apps for Everyone” (ESRI, 2011). If the GeoWeb is a litmus test for a larger migration from the desktop to the Web, desktop computing may be in danger of extinction. As Crampton (2009, p. 94) has suggested, “the operating system of the future will not be Macintosh, Windows, or Linux, but the Internet itself – the Internet Operating System”.

The availability of free, easy-to-use platforms has created a new type of Web-user, the neogeographer (Turner, 2006). Neogeographers are average Web users that typically lack formal instruction in geography or the use of geospatial technologies, yet who harness the GeoWeb for the purposes of productivity or entertainment. There have been concerted efforts to open GIS to the masses over the past 15 years or so from within the geographic information science (GIScience) community and especially from ‘critical GIS’ observers who claimed it to be exclusionary due to its cost and complexity (see for example Chrisman, 2005; Elwood, 2006; O’ Sullivan, 2006; Schuurman, 2000). The ongoing efforts to democratize GIS has received a boost from unlikely sources – technology giants such as Google (especially with the watershed-moment release of Google Earth in 2005), and from individuals from outside of the GIScience community (Boulos et al., 2008; Butler, 2006b; Miller, 2006). This outside influence from the neogeography community is changing the face of geospatial technology, from a mostly restricted professional and academic endeavour to what has been referred to as ‘mapping for the masses’ (Hudson-Smith et al., 2009).
Volunteered geographic information – a term and concept popularized by Michael Goodchild (2007a, 2007b) broadly describes geographic data that are created by diverse users via novel protocols and technologies on a voluntary basis. The growth in interest in VGI has been aided by a more interactive and collaborative Web that facilitates the creation of user-generated content, and the explosion of geospatial technologies (especially the user friendly geospatial Web tools and interfaces) (Goodchild, 2007a). A recent review of the VGI phenomenon (Elwood et al., 2012) describes three of the different ways that VGI is created and shared: 1) by using geo-aware mobile devices to collect information and contribute it to user-generated datasets, 2) through adding and annotating geographic features using GeoWeb mapping interfaces, and 3) by bestowing location information to existing media such as photographs. There are several well known VGI projects that fit under the first category, most notable is OpenStreetMap (http://www.openstreetmap.org/), a user-generated open-source Web-based interactive world and street map, created in part from the uploaded GPS tracks of volunteers all over the world. A prominent project fitting into the second category is Wikimapia (http://wikimapia.org), a project that allows the public to tag places and provide attribute information on a map interface. An example of the third category is Web sites such as Flickr (http://www.flickr.com/), in which users can geotag (provide geographic coordinates) digital photographs and other media.

VGI initiatives vary with respect to their origins and level of organization. Gouveia and Fonseca (2008) describe how the level of formalization of VGI environmental monitoring initiatives range from queries initiated by individual citizens to structured data collection efforts organized by government agencies. In this, the authors point to the variability of the volunteer in VGI projects. For instance, in some cases volunteers both
create and use data, while in other cases the data are created by volunteers and used by other citizens, researchers, or official agencies (Girres & Touya, 2010). The term *produser* (Budhathoki et al., 2008) has been used to define the phenomenon of the dual role of an individual as both producer and user of information. Current research in VGI, and spatial data more broadly, is exploring the potential value in approaches that combine data from authoritative sources with information from volunteers (asserted information) such as neogeographers and other non-expert sources. As Goodchild (2009b) describes, integrating structured traditional data collection activities with neogeographic approaches such as VGI may be a promising strategy for the production of geographic data. Connors et al. (2012) illustrate the potential to collect environmental monitoring data with hybrid approaches that involve both experts and neogeographers. The authors describe a Web based tool that allows various users from average citizens to expert scientists to provide data for the ongoing monitoring of disease in Oak trees. *Mashup*, a term first used in music and more recently to describe the combination of data from different sources to create a new product or service (Batty et al., 2010; Butler, 2006a), has been reinterpreted by Elwood et al. (2012) as a broader term to denote synthesis in the context of VGI and the GeoWeb, and could provide a useful framing for hybrid approaches to geographic data production.

VGI is a nascent topic of inquiry (at least as a formal topic within GIScience and related fields), however there has been some early research into the motivations for volunteers to contribute geographic information. Coleman et al. (2009) describe eight potential motivations for volunteers to contribute geographic information, derived from research in related domains (motivations to contribute to Wikipedia and the open-source software community). The authors suggest the following reasons why individuals
contribute geographic information: altruism; professional or personal interest; intellectual stimulation; protection or enhancement of a personal investment; social reward; enhanced personal reputation; to provide an outlet for creative and independent self-expression; and pride of place. Many of the best-known VGI projects such as OpenStreetMap, WikiMapia, and the post-natural disaster mapping initiatives such as in Haiti (http://haiti.ushahidi.com/) appear to be fuelled by altruistic motivations (see Goodchild, 2007a) and operate on a distributed model in which the data user and data creator do not necessarily interact directly. Some VGI, however, is created through an assisted voluntary data collection model in which a participant group is asked to volunteer spatial information according to predefined questions or criteria, what Seeger (2008) has dubbed ‘facilitated VGI’. This type of VGI can be created via a distributed approach, or through face-to-face interaction with volunteer participants. In either case, the motivations for contributing may diverge from those used in such projects as WikiMapia, given that volunteers may be recruited. Although the literature on facilitated approaches to VGI is currently limited, we posit that motivations will vary greatly depending on the project, from altruism and professional or personal interest, to intellectual stimulation and pride of place. For example, Thompson et al. (2011) used a facilitated VGI approach to collect data in support of local landscape planning. Volunteers were recruited to participate in a facilitated face-to-face planning exercise designed to collect the opinions of residents regarding the preferred locations for social, economic, and environmental enhancements in the local area. Participants created VGI by interacting with paper maps, which was later used by landscape planners for mapping and spatial analysis. Although the reasons for volunteers to participate in this project are not stated, it may be that they were motivated by a local pride of place, a professional or personal interest, or protection of a personal investment. Also, Fritz et al. (2009)
describe www.geo-wiki.org, a Web site that allows distributed users to interact with Google Earth imagery to contribute to a global land classification project. These volunteers are asked to compare existing land cover maps with Google Earth imagery and their personal knowledge of local areas to evaluate the accuracy of land cover classification in the maps. Again, participant motivation was not explored, however, we posit that motivations to become involved in a distributed facilitated VGI project such as this may include altruism, an outlet for creative self-expression, intellectual stimulation, and pride of place. Despite the relatively small amount of literature that expressly identifies with the facilitated VGI approach, we argue that it could provide a useful framing for some current geographic data collection activities, especially hybrid approaches that focus on combining expert (authoritative) and non-expert (asserted) sources.

The VGI projects outlined above indicate value to society in these diverse approaches to geographic data production. More specifically however, the diversity of VGI might prove to be valuable for advancing scientific inquiry and decision-making. With VGI, there is the potential to gather enormous amounts of information about the earth and its inhabitants on a magnitude heretofore unobserved, and perhaps more importantly, as Elwood posits (2008) the possibility exists of developing digital databases of previously unrecorded digital data made up of human observations and experiences. This particular potential of VGI – the creation of previously unrecorded spatial data – may be the most exciting characteristic of this phenomenon.
4.2.3. **Public Health’s Spatial Turn**

Notably, the currency of geography is rising in the field of public health. There is growing appreciation that geography and health are closely linked, and in particular, the concept of ‘place’ has become an important framework for understanding public health (Dummer, 2008; Potvin & Hayes, 2007). Of the three oft-cited elements of inquiry in public health – person, place, and time – Rezaeian *et al.* (2007) describe how place has often been overlooked despite its importance as a determinant of health. Recently however – perhaps as a result of the wider spatial turn – geography is becoming better understood as an important determinant of health and well-being. Tom Koch (2009) – citing evidence from the 18th and 19th centuries – describes this burgeoning interest as not entirely new but in fact the re-instatement of geography to an important role in public health inquiry after a period of remission in the 20th century. The absence of geography over that period has taken its toll. Dunn *et al.* (2007) have suggested that inconsistent research findings from public health studies of inequality and health may be due to the failure to interrogate the geographic perspective. This notion echoes an earlier accusation by Gould *et al.* (1991, p. 82), who were “…astounded at the lack of geographic or spatial thinking” in the HIV/AIDS modelling approaches of the 1980s. Following inadequate attention to geography historically, the past decade in particular has witnessed an explosion of geographic influence on public health. Mirroring the spatial turn in public health is the growth and increasing influence of the sub-discipline of *health geography* in recent years. It seems there is some degree of synergistic influence between the spatial turn in the various health disciplines and the growth of health geography; for example, Carolan *et al.* (2006, p. 203) have suggested that the growth in
the use of spatial concepts in nursing research might be the corollary of an increasingly prominent and influential health geography.

In recent years there has been a marked increase in the use of GIS and related geospatial technologies in health research (McLafferty, 2003; Nykiforuk & Flaman, 2011; Sui, 2007). Increasing use of GIS in this domain is frequently attributed to advances in the technology and a surge in the availability of geographically referenced health data (Cromley & McLafferty, 2002; Higgs, 2009). In addition to these catalysts of GIS uptake, a distinguishing mechanism is contributing to its growth in the health domain – the potential for geospatial technologies to foster evidence-based decision-making (EBDM) (Baum et al., 2010; Boulos, 2004; Joyce, 2009), an emerging tenet of health policy (Dobrow et al., 2004). EBDM is defined as “the conscientious, explicit and astute use of the best-available evidence from relevant research fields to inform practice and policy decisions regarding health care, health systems, and population and public health programs” (Kiefer et al., 2005, pp. I-14). Demand for EBDM by health organizations and governments has encouraged an upsurge in interest in GIS approaches (Barnard & Hu, 2005; Joyce, 2009). Benigeri (2007) describes the development of a health atlas for Montréal, designed to provide a platform for bridging the gap between researchers and decision-makers. This map-based public health application was assessed to be a strategic and effective communication tool, which allowed for improved decision-making by administrators. Following the increasingly common use of GIS in public health in recent years, there is great potential for the advances of geospatial technology’s technosocial revolution – the GeoWeb, neogeography, and VGI – to also contribute to public health. This potential has been illustrated in recent reviews of the emerging use of Web maps and virtual globes for visualizing and sharing public health data (Stensgaard et al.,
2009), and the use of neogeographic and volunteered approaches for public health data creation (Boulos et al., 2011). The use of these geospatial technologies and approaches in public health may particularly benefit low and middle-income countries (LMIC) (Stensgaard et al., 2009), especially those settings that have limited access to data. The consequences of poor data access as experienced in LMIC are described below, followed by a case study that illustrates how the GeoWeb and VGI could facilitate access to public health data in LMIC and other settings that have limited access to data for decision-making.

4.2.4. The Data-Divide

Patterns of information and communication technology (ICTs) access and utilization vary greatly resulting in a phenomenon referred to as the digital-divide (Norris, 2001). The digital divide’s haves and have-nots are typically differentiated by social factors such as education and socio-economic status, meaning the harmful effects of the digital divide are most widely experienced in LMIC (Brooks et al., 2005; Ford, 2007), yet its necessary to mention that access to ICTs can also vary greatly within HIC. Similarly, patterns of access to current and appropriate data for scientific inquiry and decision-making vary greatly. This data-divide, while seemingly of less consequence than access to technology, is a key determinant of the strength of national health systems (Smith & Koehlmoos, 2011). A report by the World Health Organization describes health information as one of the six essential building blocks of an effective health system (World Health Organization, 2007). Access to health data is required in order to address inequities in health, however many countries lack current and appropriate data sources to plan interventions and promotion activities (Bambas Nolen et al., 2005). At a more
broad level, a country’s overall development status may be influenced by the availability of data. As Ashraf (2005) describes, some international development agencies are only disbursing funds to countries that can demonstrate with current and reliable data how money is spent and what effect it has. Further, Godlee et al. (2004) suggest that universal access to information is necessary for achieving the Millennium Development Goals (MDGs). The MDGs are a United Nations-led global effort to address the main development challenges (all of which are directly or indirectly health-related) in all parts of the world by 2015; these include the eradication of poverty and hunger, and the promotion of health, education, gender equality, and environmental sustainability (United Nations, 2011).

Timely and appropriate data are a foundation of public health’s new EBDM era, and indeed, access to data is one of the key concerns of global public health (AbouZahr & Boerma, 2005). Basing decisions on evidence is challenging in settings without data collection mechanisms in place, a reality in much of the global South. Even vital registration, including births and deaths are sparse; in sub-Saharan Africa, vital statistics are only collected for between 5 and 60% of the population, depending on the country (London et al., 2002). On top of that, some countries do not even provide national identification numbers for citizens (Odero et al., 2007). The free (or low cost) and easy to use nature of Web 2.0 and GeoWeb technologies may have the potential to benefit organizations with limited resources available for data collection and research. Using these technologies combined with neogeography and VGI approaches, there may be the potential to reduce the traditional financial and technological barriers to technology use and data collection, an especially exciting prospect for data-poor settings.
The following case study section describes an effort to address this important challenge of limited data available for scientific inquiry and decision-making faced in LMIC and other low-resource settings. This study was designed in response to the limited ability to collect spatial data using traditional public health surveillance protocols in a prior, larger interdisciplinary injury research project that used spatial questions as a guiding framework. In the present study, a facilitated VGI approach was used to fill the gap in the availability of injury location data in Cape Town, South Africa. Participants interacting with a map interface were successful in creating an injury hotspot (high-incident location) dataset that could be used for decision-making on injury prevention in this setting.

4.3. Case Study: A Facilitated VGI Approach to Injury Data Collection

4.3.1. Study Origin and Motivation

This study evolved out of a larger injury surveillance project undertaken at Groote Schuur Hospital (GSH), a large tertiary referral hospital in Cape Town. The purpose of the project was to undertake injury surveillance in order to better understand the social and environmental factors associated with injury in the city. GSH is a large, publicly funded hospital with a very high-volume trauma unit. The hospital has built up an excellent reputation worldwide as a leader in trauma patient care. Knowledge of best practices in patient care has accrued at this site due to the high volume of patients receiving care for severe injuries resulting primarily from motor-vehicle and violence-related injury mechanisms. Despite the noteworthy achievements in patient care, injury surveillance efforts at the trauma unit have been patchy and unsustainable. Surveillance
the ongoing and systematic collection, analysis and interpretation of public health data, and the dissemination of information and analysis (World Health Organization, 2008b) – is required in order to design and implement injury prevention strategies. Due to the unsustainable nature of previous surveillance efforts at GSH, this larger project has sought to design and demonstrate innovative and streamlined methods of injury data collection and analysis suitable for limited resource settings such as this. The intention is to overcome two of the main traditional barriers to injury surveillance – limited personnel and financial resources – which have constrained the success of surveillance efforts at this hospital and many other hospitals in LMIC.

The overall surveillance project is comprised of data collection and mapping components. Our earlier surveillance efforts achieved a certain degree of success (Cinnamon & Schuurman, 2010; Schuurman et al., 2011), however, the spatial information collected was of limited use. In data-rich settings, injury location data have proven extremely valuable for understanding the burden of injury at hotspot (high-incident) locations, its social and environmental correlates, and for targeting injury safety interventions (Cinnamon et al., 2011; Edelman, 2007; Warden et al., 2010). The resolution of data collected in our prior efforts was limited to the neighbourhood level due to the lack of GPS installed in ambulances, which typically record patient pick-up locations and are the source for injury location information in surveillance databases. Moreover, the numerous informal settlements in Cape Town present a further challenge to collecting location data, given the lack of street names and numbers in many of these areas. While useful for understanding the contextual factors contributing to violence related injury (e.g. socio-economic status of the neighbourhood in which the injury
occurred), neighbourhood-level data are less useful for motor-vehicle related injury, in which precise road location data are more useful for understand environmental context.

4.3.2. **Study Design and Findings**

To address the lack of suitable spatial data collected in the earlier studies, a facilitated VGI (Seeger, 2008) protocol was developed to collect location information from emergency medical service (EMS) personnel regarding injury hotspots in Cape Town. Informal interviews with EMS paramedics were conducted at GSH (see Figure 4-1), during downtime after patients were brought to the trauma unit. Using the Google Maps JavaScript API (Google, 2011), a GeoWeb map and data collection interface was developed to elicit injury hotspot information from this informed participant group. The interface consisted of a familiar interactive Google Map layout and four fields requiring data input.
Informal consultations with EMS paramedics were undertaken to collect volunteered opinions regarding high incident injury locations in Cape Town. Due to the nature of their work—retrieving injured patients from incident locations—it was assumed this would be a knowledgeable and informative participant group. Consultations took approximately 5 min, and were conducted in a trauma unit setting.
A tablet computer was presented to EMS personnel loaded with the Web interface (see Figure 4-2). EMS volunteers were then asked to interact with the interface to volunteer their opinions of injury hotspot locations, based on their experiences attending injury events. A hotspot could be identified by either tapping the location on the map using the touchscreen, or by typing the location into a form that would then geocode the text. After tagging the location, the volunteer could provide any additional details regarding the hotspot, including the type of injury hotspot (e.g. motor-vehicle, assault, etc.), the suspected intent (intentional, unintentional), the suspected cause (violence, undue care and attention, etc.). Also, there was a free text field available in which the user could provide any additional comments regarding the suggested location. Once the location and injury event fields were entered into the interface, the injury hotspot location was submitted and stored in a database. Although the intention of this study was not to examine the usability of the interface, it was observed that EMS personnel were able to interact with the interface, locate the hotspot on the map, and enter information with little difficulty.
A knowledgeable participant group—emergency medical services paramedics—was asked to volunteer opinions on locations of injury hotspots in Cape Town. In a facilitated VGI data collection exercise, the participants were asked to interact with a map interface running on a tablet computer. Volunteers tagged locations by pointing on the touchscreen or by typing the name of the street address or neighbourhood into a geocoding form. Once the location was identified, the participant was then prompted to fill in the following injury event fields: ‘injury type’, ‘intent’, ‘cause’, and ‘other comments’.

Interactions with 25 EMS personnel produced 108 entries in the database. Each entry was a volunteered opinion on the existence of an injury hotspot at a specific location, either a neighbourhood (area) or point location. Two types of hotspots were volunteered for two injury mechanisms, motor-vehicle collisions, and interpersonal violence. Violence hotspots accounted for 71 of 108 entries in the database, of which 69
were attributed to interpersonal violence and two were attributed to self-harm. Motor-vehicle hotspots accounted for 37 of 108 entries, of which 21 were considered pedestrian hotspots and 16 were vehicle-occupant hotspots. Qualitative information regarding the EMS personnel’s subjective opinion on the nature of hotspots was also recorded in the ‘other comments’ field on 16 of the entries.

4.3.3. **A Hybrid Approach: Combining Volunteered Data and Existing Data Sources for Injury Prevention**

As suggested in this study, a knowledgeable participant group may be able to provide proxy public health location data in the form of educated opinions, as an alternative when traditional sources are unavailable. In the case of injury, data are typically extracted from hospital-based trauma registries, systems designed to record patient injury information from first point of contact through to their discharge from a hospital. While the trauma registry model is common in high-income settings – collecting a wealth of information such as patient demographics, injury cause and mechanism, injury location, and care provided – they are rudimentary or non-existent in most LMIC (Nwomeh et al., 2006). As such, novel strategies such as the one outlined in this paper may be required in the many settings that lack formal data sources, such as trauma registries in the case of injury. Although the chief purpose of this pilot study was to develop and test a novel data collection protocol for settings with limited ability to undertake conventional data collection exercises, the identified hotspot locations will be used to inform a future analysis of the social and environmental determinants of injury in Cape Town. The data collected in the present study using the facilitated VGI method will complement the data collected in the more conventional injury surveillance efforts occurring at the hospital, thereby helping to fill a gap in the availability of data on injury
locations. In this, the combination of the traditional authoritative injury data with the asserted VGI injury location data speaks to the potential for hybrid approaches to data collection, whereby the strengths of each approach can be utilized.

Especially useful will be the information collected regarding motor-vehicle related injury hotspots, including injuries to pedestrians and vehicle occupants. Data collection methods in this setting have been unable to yield data on precise motor-vehicle related injury locations, and in general, this information was largely unknown in this setting. Figure 4-3 illustrates the locations that the participants suggested were motor-vehicle injury hotspots. In general, most of the vehicle occupant injury hotspots are located on major roads and highways, especially along the N2 motorway and adjacent roads. Of note, several participants suggested the intersection of Vanguard Drive and the N2 was a vehicle occupant injury hotspot (see location 2 on Figure 4-3). Pedestrian injury hotspots are more evenly distributed between highway/major roads and smaller urban streets; however, of interest is the density of pedestrian injury hotspots in close proximity to each other in the city centre of Cape Town (see location 1 on Figure 4-3). As part of the larger study, these locations will be surveyed to examine potential social and environmental factors that may be contributing to the presence of injury hotspots at these locations, a key step towards decision-making on injury prevention. Further, comments offered by the contributors in the ‘other comments’ field of the Web interface have uncovered some concerns that may have been unknown in this setting. In particular, there were some interesting contributions that might be useful for designing localized injury prevention strategies. For example, the two hotspots attributed to self-harm were located in relatively affluent areas of the city – anomalies in a city where intentional injuries are believed to occur in socio-economically deprived areas. Also,
frequent motor-vehicle collisions on a stretch of the N2 near an informal settlement were believed to have an intentional aetiology; in other words, participants believed the collisions at this location were deliberately caused by local residents in order to steal from collision victims (see location 3 on Figure 4-3). Although these responses are the subjective opinions of a particular group and require further corroboration, this type of information may be uniquely known by EMS personnel, and would likely not be collected using conventional hospital-based injury surveillance methods.
From 108 entries in the EMS participant-created database, 37 were suggested as motor-vehicle related injury hotspots (21 pedestrian, 16 vehicle occupant hotspots). Generally, the majority of vehicle occupant injury hotspots are located on major roads and highways, especially along the N2 motorway and adjacent roads. Pedestrian injury hotspots are more evenly distributed between major roads/highways and smaller urban streets. Three locations of potential interest are highlighted on the map: 1) the clustering of pedestrian injury hotspots in Cape Town city centre; 2) the intersection of the N2 and Vanguard Drive was suggested as a vehicle-occupant injury hotspot; 3) several participants suggested the presence of an ‘intentional’ vehicle-occupant injury hotspot along a stretch of the N2, adjacent to the KTC informal settlement.
Although this pilot study did help to address the data availability gap in the larger injury surveillance project, it should be noted that some limitations could exist for implementation of similar data collection efforts. Internet access was required (wireless Internet in the case of the present study), however many data-poor settings may also have poor access to the Web, a reality in many LMIC (International Telecommunications Union, 2007). This limitation could be overcome by having participants provide information by annotating paper maps. This solution may even reduce another potential limitation, the fact that a degree of digital literacy was required to operate the tablet computer and Web site. The participants had little apparent difficulty interacting with the technology, although the use of technologies such as these may create a barrier in less-developed settings or with certain participant groups. However, despite their novelty, there is some early indication that touchscreen technology may not be a serious barrier. A recent study found that novice users of touchscreen interfaces were able to perform tasks at a skilled level in a short time and with only minimal briefing (Landis Lewis et al., 2010), although specific research into touchscreen map-interface usability should be undertaken.

4.4. Discussion

This paper describes two important trends for the discipline of geography, the spatial turn in the sciences and humanities and the techno-social revolution in geospatial technologies. By harnessing these phenomena, the case study presented in this paper sought to address the gap caused by the data-divide. In this study, informal interviews
were conducted with EMS personnel, who were asked to volunteer their opinions regarding the locations of injury hotspots in Cape Town. Given the nature of their job – which includes attending injury event locations – this knowledgeable participant group may be able to provide information that has heretofore gone unrecorded in this setting. As described above, collection of previously unrecorded information may be one of the most exciting and valuable aspects of the VGI phenomenon (Elwood, 2008).

In contrast to earlier revolutionary periods in the discipline, geography’s current period of transition is curiously set apart by its external genesis and influence. Perhaps this should be no surprise in our postmodern age, given the fading of boundaries due to interdisciplinarity (Rhoten & Parker, 2004), the rise of the amateur-professional (Leadbetter & Miller, 2004), and with the enabling technologies of Web 2.0 (Boulos & Wheeler, 2007). This study arose out of shortcomings observed in a larger study, as a pragmatic alternative for collecting injury location data in a data-poor setting. Through collecting and analyzing injury data, a main end goal of the larger project that includes the present study was to contribute to the understanding of the social and environmental determinants of injury in Cape Town. Due to the inherently spatial nature of this goal, a geographical lens provided an organizing framework throughout the various aspects of the study, despite extensive participation in the study from academic and practitioner collaborators trained in the health and medical sciences. Perhaps this collaboration is reflecting not so much a turn to space as the appropriate re-emergence of spatiality and geographic approaches in this domain – because, as Koch (2009, p. 100) has articulated: “[t]he history of public health investigation is, at heart, as much cartographic and geographical as it is numerical and statistical.” In public health, as in other domains in the sciences and humanities, the contributions from geography are proving fruitful; this
is evident not just in the introduction of geographic perspectives and methods to other disciplines, but also in the broader education of geographers in external domain knowledge.

The techno-social revolution for geospatial technology, and VGI in particular, are emerging as preeminent topics of inquiry within geography and GIScience, and are major facilitators of the bidirectional exchange of techniques, knowledge, and perspectives between geography and other disciplines. Thus far, however, VGI has been predominantly heralded due to its use for the collection of geospatial framework data (e.g. roads, bridges, land-use, etc.) as in the standard-bearing OpenStreetMap project, and for gazetteer development (collections of place names and points of interest), typified by the WikiMapia project. It is likely that these categories of VGI will continue to gain traction as an alternative to institutionally-collected data given the decline of state-sponsored mapping (Goodchild, 2007b). While the prospect of amateur volunteers creating and updating framework and gazetteer data is exciting – and a phenomenon that the discipline of geography can claim a contribution due to its increasing attention to the VGI phenomenon – it is possible that another category of VGI might be responsible for its future accolades. There exists great room for research and practice concerning the use of VGI approaches for the creation of thematic data for the purposes of scientific inquiry and decision-making, especially in the absence of existing data sources. Thematic data have been collected under the auspices of VGI, typically through using an interactive Web map interface in which users can contribute information to the map (Elwood et al., 2012). Perhaps the best-known examples of thematic VGI projects are the efforts to create maps and geographic data quickly after a crisis event or natural disaster, in the absence of data from conventional sources. De
Longueville et al. (2010) describe the role of thematic VGI in post-natural disaster management activities such as earthquakes, floods, and hurricanes and in crisis events such as terrorist attacks, while Goodchild and Glennon (2010) described how VGI in the form of text, videos, and photographs informed forest fire management in California. Another related area of thematic VGI proliferation is for the purpose of ongoing monitoring and inventorying (Gouveia & Fonseca, 2008; Tulloch, 2008), as evidenced by the proliferation of ‘citizen science’ surveying initiatives such as annual bird surveys (Wiersma, 2010). Additionally, it is interesting to note that thematic VGI is also flourishing for recreation and entertainment purposes. For instance, Kessler (2011) describes thematic VGI initiatives within the cycling community. The author outlines the common practice of cyclists recording their routes using GPS enabled cycling computers, and then contributing this information via Web based maps and repositories for route planning purposes. While thematic VGI initiatives are increasingly used for natural disaster/crisis management, for monitoring and inventorying, and for recreation and entertainment, harnessing thematic VGI to create data specifically for scientific inquiry and decision-making has yet to truly emerge, however examples are appearing. As an example in the health domain, Chen and Sui (2010), Boulos et al. (2010), and Lampos and Cristianini (2010) describe VGI data collection approaches for the purposes of disease surveillance. These authors describe methods for examining Internet keyword searches and social media postings pertaining to influenza symptoms and the locations of these postings in order to uncover disease patterns. Although thematic VGI data collection for the purposes of scientific inquiry and decision-making do exist, there remains much room for expansion insofar as the data are shown to be useful and appropriate. If so, thematic VGI approaches may be especially impactful in data-poor settings that are unable to collect comprehensive data for decision-making using
traditional mechanisms, as seen in the present case study. As a methodological approach, facilitated VGI may have a role in enabling the collection of volunteered thematic data in data-poor settings, or it could contribute to hybrid solutions that include both expert and non-expert sources. The following section situates facilitated VGI and explores some of the key concerns, challenges, and opportunities presented by utilizing a facilitated approach to VGI creation.

4.4.1. **The Challenges and Opportunities of Facilitated VGI**

Facilitated VGI diverges from normative conceptions of VGI. For comparative purposes, we describe ‘gold-standard’ VGI as geographic information consciously and voluntarily created by individuals or groups, available to any person or group for any purposes, providing the creator is aware and agrees to its use. In practice, many examples of VGI diverge from this definition, including facilitated VGI efforts. In certain ways, facilitated VGI may be able to overcome some of the criticisms and challenges presented by citizen-volunteered data. At the same time, facilitated VGI introduces new concerns, and in some cases may reignite longstanding criticisms of geospatial technologies. For example, one of the foremost anxieties in the VGI literature focuses on the quality, reliability, and value of data created by citizens (Elwood, 2008; Flanagin & Metzger, 2008). Appropriately, there is concern that information contributed with minimal or no oversight and by non-experts may be inaccurate and have little value, as Haklay (2010) outlines in a paper comparing the authoritative Ordnance Survey and amateur OpenStreetMap datasets. Noting the variable quality of the French OpenStreetMap dataset, Girres and Touya (2010) concluded that a balance must be struck between contributor freedom and the need for contributors to comply with specifications, in order
to improve data quality. VGI projects that are facilitated typically utilize a knowledgeable participant group and are designed for a specific purpose (Seeger, 2008); thus, we posit that the quality of the data might be higher than geographic information volunteered using a more hands-off distributed model with potentially less-informed participants. OpenStreetMap data creation is frequently facilitated, through organized ‘mapping parties’ that bring participant groups together with the specific intention of creating geographic information for a local area (Haklay et al., 2008). In a move taken from OpenStreetMap’s playbook, Google MapMaker – a platform designed for users to contribute information to Google Maps – also facilitates contributions through their mapping parties, called MapUps (Google, 2012). Targeting and recruiting specific groups such as members of an online community may be an effective strategy to help create VGI for a scientific project (Connors et al., 2012). Other VGI efforts may benefit from incorporating the ‘mapping party’ data creation model or by using targeted recruitment to increase data quality and value, especially those that seek to use VGI for scientific inquiry or decision-making.

Some VGI is collected through a data mining approach, whereby geographic information is ‘harvested’, frequently without the knowledge of the individuals or groups responsible for creating it (see Fischer, 2012; Stefanidis et al., 2011). Geographic information is now pervasive on the Web, with much of it created by distributed users through interacting with social networking and Web 2.0 platforms. What this means is that there is a wealth of geographic information that can be collected and used for various purposes, without the data creator’s involvement or awareness. Stefanidis et al. (2011) refer to this type of geographic information collection exercise as ‘ambient geospatial information’. The approaches to VGI for disease surveillance described in the
previous section operate on this model, since the data are collected remotely and without the awareness of the contributor. Although many would regard this approach as a valid and potentially valuable VGI resource, Elwood et al. (2012) have suggested that geographic information must be contributed by individuals or groups in a conscious voluntary manner to qualify as VGI. This debate parallels earlier social theory-informed critiques that exposed the privacy infringement and surveillance potential of geospatial technologies (e.g. Armstrong & Ruggles, 2005; Curry, 1997; Dobson & Fisher, 2003; Klinkenberg, 2007), and which have recently been re-examined in light of the new technologies and social practices of the GeoWeb (Elwood & Leszczynski, 2011).

Connors et al. (2012) use the concept of intentionality to describe a VGI creator’s intent to provide information for a specific end use, whereby high intentionality would characterize data produced expressly for a specific project, and low intentionality might describe data that are harvested or used for purposes other than the creator’s intent (and likely without their knowledge). Facilitated approaches to VGI may be able to avoid these criticisms, due to the likelihood that they will have high intentionality. Further, as direct contact between the facilitator and the participant is likely – either face-to-face or through digital communication – data are likely to be consciously volunteered.

Although facilitated VGI initiatives might address some of the concerns surrounding this source of data, this approach may present its own unique set of limitations and concerns that could limit its appeal and suitability, especially with regards to restricted participation and access to data, and limited potential for empowerment. Increases in data quality and value may come at the expense of grassroots participation in VGI. While facilitated VGI data collection projects will include relevant participants, other groups may be excluded. Although this will not necessarily cause social detriment,
it does resemble a major longstanding criticism of geospatial technologies regarding power asymmetries and patterns of inclusion and exclusion created by differential access to GIS (Elwood, 2006; O’ Sullivan, 2006; Schuurman, 2000). In a related vein, the extent of a participant’s involvement may be limited. In the present study, participation by the EMS personnel was limited to the VGI creation phase. In an ideal scenario, participation might exist at all stages, from setting the purpose of the exercise, to the study design, data collection strategy, data analysis and interpretation, and decision-making stages. The limited participation positions this particular example of facilitated VGI in contrast to the ideals of public participation GIS (PPGIS), which focuses on involving participants from marginalized communities in GIS projects throughout their lifespan. Similarly, facilitated data acquisition projects may not produce datasets that are available to the general public, meaning that the VGI created is not necessarily available to anyone for any purpose, as it should be according to our gold-standard definition of VGI. This issue speaks to broader debates about (spatial) data accessibility and the resulting costs to society of unequal access to data (e.g. Klinkenberg, 2003). Facilitated VGI projects may create a situation where the data creator ultimately may not have access to something that they had a hand in creating. Ethically, this should be addressed by fully briefing the participants on the purpose of the data collection exercise, however it does run counter to the ‘open access’ ideal of VGI. Empowerment is a primary objective of many socially aware mapping and spatial data collection initiatives. Although the concept of empowerment is notoriously difficult to define and measure (see Corbett & Keller, 2005), facilitated approaches to VGI may have little ability to truly foster the empowerment of marginalized communities. In the case of the EMS volunteers, it could be argued that a small sense of empowerment was achieved due to knowing that their contributions will be valuable and useful for injury
prevention in their local area. However, the degree of empowerment that the participant group achieves would likely be less than if they were involved in a well-executed PPGIS project or if they engaged in VGI activities on their own accord. Although facilitated VGI approaches are likely valuable for contributing to scientific projects and decision-making, further research should explore these potential limitations.

4.4.2. Facilitated VGI and its Relatives

The above critique of facilitated VGI points to both parallels and diversions from other socially-aware approaches to working with maps, geospatial technologies, and spatial data. Citizen science broadly denotes efforts that include the general public in science. Although the phenomenon is not new, in recent years projects that involve citizen scientists are gaining interest; in particular due to the availability of tools for information dissemination and data gathering, the realization that the public represents a source of potentially free labour and skills, and because of mandates from funders that grant recipients undertake public outreach (Silvertown, 2009). In its common current form, citizen science projects typically coordinate networks of observers to prospectively monitor some object or phenomena, such as weather patterns or species distributions (Goodchild, 2007a). This description highlights the often ongoing and facilitated nature of citizen science projects. In addition to data collection objectives, citizen science projects frequently have public education ambitions, especially in the area of scientific literacy (Bonney et al., 2009). Although a facilitated VGI project could fit with this conceptualization of citizen science, we argue that facilitated VGI may be a more suitable description for projects that are temporally discrete (e.g. a one-time data collection exercise) and do not have public education as a primary objective. As hinted
to above, facilitated VGI also shares a kinship with participatory and collaborative approaches to using GIS. PPGIS has been conceptualized as an alternative, more socially conscious approach to using GIS that includes the disenfranchised and promotes the goals of community and non-governmental organizations (Sieber, 2006). On an operational level, PPGIS projects attempt to involve public participants in all aspects of a project’s lifespan, from its design through to data acquisition and management, the use of geospatial technologies, and the interpretation and dissemination of findings (Sieber, 2001). In addition to public involvement, a core objective of PPGIS is to foster the empowerment of marginalized communities (Corbett & Keller, 2005), which may or may not be sought in facilitated VGI projects that may have other goals, such as the creation of otherwise unattainable information for scientific inquiry (as in the described case study). Tulloch (2008) has interrogated the relationship between VGI and PPGIS and examined their position within the larger GIScience framework. Although the narrative is very much still evolving, the author suggests that perhaps VGI is about applications and information while PPGIS is about processes and outcomes. Participatory (or collaborative) spatial planning generally describes the process of involving participants in a planning problem that has a spatial dimension, and/or which uses maps and geospatial technologies as facilitation tools (McCall & Dunn, 2012). Participatory spatial planning is often undertaken to harness the local knowledge of citizens and groups, which is then used to inform decision- and policy-making processes. Education and empowerment of participants may also be an objective of these exercises. Clearly, participatory spatial planning allies closely with facilitated VGI, citizen science, and PPGIS. All approaches focus on harnessing the local knowledge of participants, however the overall objectives are likely to be different. Future research should continue to explore the relationship between the variants of VGI,
citizen science, PPGIS, and participatory spatial planning, including where they converge and diverge, and what each has to offer the other with respect to theory and practice. Due to the nascent and evolving nature of these areas of inquiry, their definitions are likely to further develop and perhaps converge; however, the intended objective(s) of the project – whether it is data collection, public education, monitoring, advocacy, empowerment, policy-making, or scientific inquiry – may be the ultimate deciding factor for classifying these allied and overlapping concepts. The larger concern of this paper – the issue of poor access to data in many settings – may benefit from further examinations into the particularities of these various approaches. Identifying the strengths and weaknesses of each approach, and the points of overlap may be a useful area for future research. Doing so could ultimately result in the development of guidelines for selecting a suitable approach, for those that wish to harness citizens’ local knowledge for a multitude of purposes, including scientific inquiry and decision-making.

4.5. Conclusion

Through a literature review and case study, this paper describes how geography’s stock is rising in diverse disciplines, especially public health. Two of the key changes occurring in geography – the spatial turn and geospatial technology’s technosocial revolution – have the potential to benefit society in diverse ways, including for beginning to address a fundamental problem in many settings – especially in the world’s low and middle-income countries – the limited availability of data for scientific and decision-making purposes. Poor access to data presents a barrier to improving a nation’s health and development status, as societal challenges require informed decision-making based on current and appropriate data sources. In the case study, a
facilitated VGI approach was used to create injury hotspot location data to complement the data collected in a conventional injury surveillance effort occurring at a hospital in Cape Town, South Africa, thereby helping to fill a gap in the availability of data on injury locations in this setting. Combining the traditional authoritative injury data with the asserted injury location data collected from the facilitated VGI initiative speaks to the potential for hybrid approaches to data collection, whereby the strengths of authoritative (organization, oversight) and asserted (local knowledge, financial savings) methods can be combined in order to take advantage of each approach. Further research should examine the opportunities of facilitated VGI, especially the potential for improving the quality of VGI data via this more structured approach. On the other hand, the limitations of this approach also demand further attention, especially the trade-off between potentially improved data quality and the requirement of facilitation and oversight, and how this approach might be compared with related socially-conscious and citizen-focused data collection and mapping efforts. The current influence of geography in the wider sciences and humanities presents an exciting opportunity for showcasing the strengths of this discipline for addressing pressing societal issues, including for reducing the gap in the availability of data caused by the data-divide.

4.6. Acknowledgments

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5. Linking Chapter: From Hospital- to Community-based Surveillance

Recalling the overall objective of this dissertation, the aim of project was to develop theoretical and methodological knowledge that could enable community-groups, health facilities, and other organizations to engage in injury surveillance activities, especially in settings with limited resources. Half of the project was conducted in Cape Town and the other half in Vancouver. Together, research from both locations provide evidence that speaks to the overall objective of the dissertation. The main preceding chapters – 2 and 4 – document the part of this dissertation project conducted in Cape Town, which focused on hospital-based surveillance. The following two main chapters – 6 and 8 – document community-based injury surveillance activities conducted in Vancouver.

In the following chapter, a method for investigating behavioural contributions to pedestrian injury was designed and tested in Vancouver. The purpose of this study was to demonstrate a quick and straightforward method that local community-based surveillance and prevention groups could undertake to document road-rule violations by pedestrians and motorists on streets in their local area. This surveillance study, like those conducted in South Africa, was designed to be conducted with few resources and by non-experts. The method described in this study was designed with input from a community-based surveillance group in a marginalized neighbourhood of Vancouver, and was used by the group to collect pedestrian injury surveillance data, which were
then used to inform evidence-based injury prevention interventions in the local area. The successful use of the method by the community group is described in detail in Chapter 8. In addition to the local empirical knowledge about injury in Vancouver highlighted in this work, the research – as in the work in Cape Town – also contributes to the larger bodies of knowledge concerning injury surveillance in low-resource settings, and the roles of geospatial technologies in these activities.
6. Pedestrian Injury and Human Behaviour: Observing Road-Rule Violations at High-Incident Intersections\(^5\)

6.1. Abstract

**Background:** Human behaviour is an obvious, yet under-studied factor in pedestrian injury. Behavioural interventions that address rule violations by pedestrians and motorists could potentially reduce the frequency of pedestrian injury. In this study, a method was developed to examine road-rule non-compliance by pedestrians and motorists. The purpose of the study was to examine the potential association between violations made by pedestrians and motorists at signalized intersections, and collisions between pedestrians and motor-vehicles. The underlying hypothesis is that high-incident pedestrian intersections are likely to vary with respect to their aetiology, and thus are likely to require individualized interventions – based on the type and rate of pedestrian and motorist violation.

**Methods:** High-incident pedestrian injury intersections in Vancouver, Canada were identified using geographic information systems. Road-rule violations by pedestrians and motorists were documented at each incident hotspot by a team of observers at several different time periods during the day.

Results: Approximately 9,000 pedestrians and 18,000 vehicles were observed in total. In total for all observed intersections, over 2000 (21%) pedestrians committed one of the observed pedestrian road-crossing violations, while approximately 1000 (5.9%) drivers committed one of the observed motorist violations. Great variability in road-rule violations was observed between intersections, and also within intersections at different observation periods.

Conclusions: Both motorists and pedestrians were frequently observed committing road-rule violations at signalized intersections, suggesting a potential human behavioural contribution to pedestrian injury at the study sites. These results suggest that each intersection may have unique mechanisms that contribute to pedestrian injury, and may require targeted behavioural interventions. The method described in this study provides the basis for understanding the relationship between violations and pedestrian injury risk at urban intersections. Findings could be applied to targeted prevention campaigns designed to reduce the number of pedestrian injuries at signalized intersections.

6.2. Introduction

Road-traffic collisions are responsible for 1.2 million deaths and as many as 50 million injuries annually according to estimates by the World Health Organization (World Health Organization, 2009). Although death and injury due to road-traffic collisions have decreased in recent years in many high-income countries, their burden remains a large contributor to overall mortality and morbidity. Furthermore, for the world as a whole, road-traffic collisions are projected to be the fourth leading cause of disability adjusted life-years (DALYs) lost by 2030, responsible for 4.2% of total DALYs (Mathers & Loncar, 2006). In the US in 2009, there were approximately 4,000 deaths and 60,000 injuries due to pedestrian-motor vehicle collisions (National Highway Traffic Safety
Pedestrian injury comprises a substantial proportion of total road-traffic injuries around the world. In fact, there is some evidence to suggest that pedestrian injury is increasing as a proportion of total road-traffic injuries. For instance, in Canada between 2003 and 2007, serious pedestrian injury increased each year as a proportion of total road-traffic injuries, from 9.8% to 12.2% over the 5 year span (Transport Canada, 2004, 2010). Debates as to the significance of this increase aside, enhancing pedestrian safety on roadways should be a prime concern in both the public health and roadway engineering realms. The fact that walking is increasingly promoted for environmental and personal health reasons only fortifies the argument for improving pedestrian safety.

Addressing the risk factors associated with pedestrian injury could help to reduce this persistent public health burden, however, greater understanding of these risk factors is required in order to develop effective pedestrian safety campaigns. Geographic information systems (GIS) are immensely helpful for these purposes, including for a large number of injury prevention tasks, such as; assembling injury and socio-demographic data, analyzing spatial patterns, and visualizing results (e.g. Cusimano et al., 2010; Schuurman et al., 2008b). In addition to these established applications of this technology, GIS can also be used to inform prevention activities, most notably through identifying specific locations to target prevention efforts. In this study, A GIS approach was used to identify high-incident pedestrian injury locations (hotspots) in Vancouver, Canada. Then, a method was developed to elucidate the potential contribution of violations committed by roadway-users on pedestrian injury at the hotspots, in order to provide evidence that could lead to interventions that target pedestrian or motorist behaviour.
6.2.1. **Human Behaviour and Pedestrian Injury**

The pedestrian injury event can result from a single factor, or the complex interplay of multiple contributing factors, both human and environmental. A number of studies have highlighted the environmental and social determinants of pedestrian injury (e.g. Clifton & Kreamer-Fults, 2007; LaScala et al., 2000; Schuurman et al., 2009b). Human behaviour is another extremely important factor in pedestrian injury (Papaioannou, 2007), however, less attention has been paid to this constituent of pedestrian-motor vehicle collisions. Typically there are actions or behaviours committed by motorists or pedestrians which set off the collision event (Kim et al., 2008a). Thus, fault in a collision can be attributed to pedestrians or motorists, however, there is conflicting evidence regarding the distribution of fault between the two groups. For the parties involved in a pedestrian-vehicle collision, fault can be assigned by examining violations of roadway legislation. Common violations committed by motorists that could contribute to a pedestrian collision include failure to yield to pedestrians, speeding, and disobeying traffic signs and signals; for pedestrians, failure to yield to vehicles, crossing against a pedestrian signal, or crossing outside of designated markings are frequent violations (Stutts et al., 1996; Ulfarsson et al., 2010). In addition to legal violations, non-legal considerations such as negligence or inattention can be used to ascribe fault to either party (Stutts et al., 1996). Results of a study by Kim et al. (2008a) provides useful information regarding the breakdown of fault between pedestrians and motorists, and detailed information on subgroups of pedestrians and motorists. Fault was determined by violations of legislation (jaywalking) and non-legal considerations (misjudgement and inattention), as recorded in a police crash dataset. Overall, motorists were over 12 times more likely to be at fault in pedestrian-motor vehicle collisions in Hawaii, with male
drivers comprising two-thirds of at-fault cases. For the cases in which pedestrians were at-fault, almost 70% were male. Furthermore, male jaywalkers under the influence of alcohol were over 10 times more likely to be at fault than other groups. The authors suggest that even though determining fault may be difficult, “identification of those at-fault can assist in the determination of where to focus efforts of enforcement or educational programs” (p.2048). On the other hand, a US study found that pedestrians were more likely to be at fault than drivers in both Washington, DC and Baltimore (Preusser et al., 2002). Police crash data were coded according to precipitating factors leading to the injury event, including legal violations by pedestrians (crossing against the light) and motorists (failure to stop for red lights or stop signs). Inattention and distraction by pedestrians and motorists also played a role in ascribing fault. However, a study in Saudi Arabia found that motorists and pedestrians bore equal responsibility for collisions (Al-Ghamdi, 2002). Using police records, fault was assigned if a pedestrian (crossing outside of designated markings) or motorist (speeding) violation occurred, or if inattention was a factor for either party. This conflicting evidence may suggest that culpability is highly variable, and may be influenced by the specific attributes of the city or country (culture of safety and enforcement for example), or indeed by the characteristics of the exact injury location (e.g. presence of pedestrian infrastructure, speed limit, local land-use, demographic composition, etc.).

Human behavioural factors such as failure to observe roadway regulations by both pedestrians and motorists clearly contributes to pedestrian-motor vehicle collisions (Hatfield et al., 2007). For motorists, driving behaviour and road-rule compliance have been identified as major contributors to pedestrian injury. Excessive speed, and failure to yield have been cited as common motorist-contributed factors (Stutts et al., 1996). For
example, Preusser et al. (2002) found that failure by drivers to yield to pedestrians when turning at intersections was a factor in many pedestrian injuries. In Canada from 2002 to 2004, 40% of pedestrian fatalities at intersections were caused by a driver failing to yield the right-of-way or disobeying a traffic sign or signal (Transport Canada, 2008a). Faster vehicle speeds are also implicated in pedestrian-motor vehicle collisions, in part because stopping distance increases in relation to vehicle speed (Anderson et al., 1997). Faster speed is associated with increased injury severity and fatality; one study found that the risk of pedestrian fatality was 5 times greater at speeds of 50 km/h versus 30 km/h (Rosén & Sander, 2009). It is possible that excessive speed and signal non-compliance at intersections may be attributed to the existence of a ‘dilemma zone’ – the area at the approach to an intersection in which a driver has to choose between increasing speed or braking suddenly in order to comply with traffic signal regulations (Papaioannou, 2007). Driver distraction is also a factor in motor-vehicle collisions. Distractions include technologies such as mobile phones, GPS navigation systems, and audio systems, and seemingly innocuous actions such as eating, smoking, and conversing with passengers (Young et al., 2003). Harbluk et al. (2002) examined the change in drivers’ cognitive abilities as tasks of varying complexity were communicated to them via a hands-free mobile phone. The drivers’ visual scanning movements were recorded; as the complexity of the task increased, drivers made significantly fewer eye movements, looked less at the sides of the street for hazards such as pedestrians, and spent less time inspecting instruments and their rear-view mirror. For pedestrians, unsafe road crossing behaviour and non-compliance with road-rules is also a major contributor to pedestrian injury. In some cases, pedestrians are struck by vehicles as a result of knowingly disobeying road crossing rules, however, there is also evidence to suggest that pedestrians may not have full knowledge of right-of-way rules and other road
crossing responsibilities (Hatfield et al., 2007). Failure to yield right-of-way, and alcohol impairment are common pedestrian-contributed factors (Stutts et al., 1996). Modern distractions such as mobile phones and personal music players may also be responsible for pedestrians not complying with road rules (Transport Canada, 2008b). A study set on a university campus (Nasar et al., 2008) examined the effects of talking on a mobile phone on pedestrian awareness and road crossing safety. Results found that those talking on the phone exhibited lower awareness of their surroundings, and crossed unsafely into traffic significantly more than pedestrians not using a phone. In addition, adverse weather conditions may play a role – a recent study has suggested that pedestrians are more to likely become impatient and engage in risky crossing behaviours as outdoor temperatures decrease (Li & Fernie, 2010).

6.2.2. Pedestrian Injury Prevention

Injury prevention countermeasures aimed at pedestrian safety are described as either active or passive. Active countermeasures include – for both drivers and pedestrians – education regarding the safe use of the road area and enforcement of road-rules, while passive countermeasures centre on engineering solutions, including, modification of the roadway and implementation of traffic-calming solutions in the interest of pedestrian safety (Nilsen, 2004; Stevenson, 2006). These three E’s of traffic safety – education, enforcement, and engineering – are the primary tools available for pedestrian injury prevention.

Pedestrian injury prevention programs vary greatly, from nationwide programs focused on educating pedestrians about personal safety (an active intervention), to upgrades of local injury hotspots designed to redress an engineering defect that was
deemed responsible for a high number of injuries at a specific location (a passive intervention). The scale and type of intervention employed for a prevention program depends on the underlying cause of the problem, in addition to other factors including, the availability of funds for prevention, and political will (Lyons et al., 2006).

Generalized, large scale injury interventions are likely to be useful prevention tools, however, they may be less effective in some situations, such as for addressing a high-risk injury location or high-risk group (Nilsen & Yorkston, 2007). In many cases, targeted, focused interventions are required to address these pressing issues. This notion has likely contributed to the increased focus in recent years on community-based injury surveillance and prevention. It has been observed that the effectiveness of community-based injury prevention programs vary temporally and spatially (Nilsen, 2004). In other words, what has worked in one location at a specific point in time will not necessarily prove effective in another location or at another point in time. What is required, then, are mechanisms that allow for identifying appropriate prevention alternatives for a certain location at a specific time. For pedestrian injury interventions specifically, Heinonen and Eck (2007) suggest that responses must be tailored to local circumstances and should be based on reliable analysis of local conditions.

Modifying pedestrian and motorist roadway behaviours is a common goal of large generalized prevention programs (e.g. through education campaigns), however, behavioural interventions aimed at specific groups or locations are less common, perhaps because of the perceived difficulty of obtaining evidence regarding local roadway users’ behaviours. This paper addresses the need for evidence of locally-specific factors that contribute to pedestrian injury. In response to the uncertain
effectiveness of generalized pedestrian injury prevention (e.g. Duperrex et al., 2002), a method was developed that could be used to inform the development of interventions that target road rule violations at pedestrian injury hotspot intersections. The method was designed with the goal of providing an easy to implement strategy for community-based injury prevention groups wishing to understand and address a localized pedestrian injury problem. A main hypothesis for this study is that the behavioural contributors to pedestrian injury are likely to vary between hotspots, suggesting the need for individualized responses.

6.3. Methods

In this study, a method was developed to observe violations of road rules by pedestrians and motorists at high incident pedestrian injury locations. The study demonstrates a simple method that could be applied by community-based injury prevention groups to understand the potential role of pedestrians and motorist violations, which could be useful for designing prevention programs in the local area. First, intersection-level pedestrian injury hotspots in the City of Vancouver were identified using GIS. Next, in-person team surveys of hotspots were conducted to examine violations by motorists and pedestrians and total volume of vehicle and pedestrian traffic, in an effort to elucidate the underlying behavioural mechanisms of pedestrian injury at each hotspot. Signalized intersections were the focus of this study because they have been identified as one of the most common sites of pedestrian-vehicle collisions within the road network (Guo et al., 2010), and they were the setting for a majority of the incidents recorded in the dataset examined for this study.
Six years (2000 to 2005 inclusive) of pedestrian injury data were extracted from the Insurance Corporation of British Columbia’s (ICBC) pedestrian injury dataset. The ICBC dataset consists of information regarding all incidents reported to the provincial automobile insurance corporation. To determine pedestrian injury hotspots, these data were mapped using ArcGIS 9.2 (ESRI, 2006). Incidents that occurred at midblock locations were removed, as the study was restricted to incidents occurring at intersection locations. A smoothed map was produced to facilitate visualization of high incident intersections using a kernel density smoothing function. A search distance of 100 metres was chosen as it best represented individual incident locations. These methods were first demonstrated in an earlier study that focused on the contribution of the built-environment to pedestrian injury at hotspots in Vancouver (Schuurman et al., 2009b).

For the purposes of this study, the eight intersection hotspots with the highest number of incidents over the study period were considered for analysis (number of incidents in parentheses): Hastings and Main (16), Broadway and Fraser (11), Georgia and Burrard (11), Hastings and Commercial (11) Hastings and Carrall (11), Broadway and Commercial (10), Hastings and Gore (10), and Howe and Davie (9). The set of eight intersections had similar grid layouts, standard two-directional pedestrian crosswalks (i.e. no pedestrian scramble crossings), and each was located on a ‘major arterial’ route. Five of eight locations had 12 approach lanes, two had 9 (Hastings and Carrall, Hastings and Gore), and one had 8 (Howe and Davie). One of the eight intersections (Howe and Davie) was situated on a one-way street (Howe) in one direction; the remainder were two-way streets in all directions. All eight intersections had fixed traffic signal cycles (i.e. each phase completes the full cycle at all times), with green, yellow, and red light phasing for vehicles, and walk, flashing hand, and steady hand phasing for pedestrians. The British Columbia Motor Vehicle Act (MVA) (Government of British Columbia, 1996)
outlines the regulations for traffic and pedestrian signalization at intersections in the province. Pedestrians must adhere to the pedestrian signal phasing regulations as set out in the MVA; *walk* (pedestrian has right of way to cross road within designated crosswalk area), *flashing hand* (pedestrian must not enter roadway or must complete crossing if already started), and *steady hand* (pedestrian must not enter roadway). Motorists must follow the regulations for traffic signal phasing; *green light* (motorist may enter the intersection), *yellow light* (motorist must stop before entering the intersection unless it is unsafe to do so), and *red light* (motorists must not enter the intersection).

Next, violations of the MVA that pertain to intersection signalization were observed (henceforth referred to simply as violations). Teams of five people surveyed eight intersections at three different time periods, morning rush-hour (07:00-09:00), off-peak (10:00-12:00), and evening rush-hour (16:00-18:00). Each site could be visited for any 20-minute window during each of the three time periods. Intersection observations took place on midweek days in November 2009. All intersections were observed on the same day for each time period (e.g. all morning rush hour observations were recorded on the same day for all intersections). Two people were responsible for counting pedestrian violations at intersections. The three violations recorded were; entering the roadway to cross the intersection during the flashing hand phase, entering the roadway during the steady hand phase, and crossing outside of a designated crossing area. One person recorded the motorist violations. Two violations were recorded; entering the intersection during the yellow light phase (note, this is not a violation of the MVA if it is unsafe safe for the driver to stop), and entering during the red light phase. In addition to observing violations, two persons counted the total volume of pedestrians and one person counted the total number of motorists in order to contextualize the number of
violations, which will allow for comparisons to other sites and with future observations. All persons involved in the intersection observation portion of the study received task-specific training materials and verbal instructions. A pilot test of the methods was conducted prior to the data collection to ensure the data could be collected by a team of five people with the abovementioned tasks. The methods used to observe pedestrians are similar to a study by King et al. (2009), which examined the risk associated with illegal road crossing by pedestrians, and a study of motorist and pedestrian behaviours at pedestrian crosswalks by Kim et al. (2008b).

For all observations, a small degree of latitude was afforded to both pedestrians and drivers for pragmatic reasons. For pedestrian violations, a flexibility of two seconds was allowed for pedestrians entering the roadway to cross the intersection after the walk phase had ended. No affordance was allowed for pedestrians entering the roadway on the steady-hand phase. Persons crossing more than 20 metres from the crossing area markings were not included, as they were considered to be crossing mid-block. Also, when counting pedestrians crossing within designated markings, one metre of leeway was allowed on either side of the designated crossing areas, and leaving the crossing area momentarily when entering or exiting the roadway was not considered a violation of road rules. Motorists entering the intersection two seconds or less after the initiation of the yellow light phase were not considered to be in violation of the MVA, because in some cases it may not be safe to stop suddenly at the immediate onset of the yellow phase. For the purposes of the data collection, motorists entering more than two seconds after the yellow light phase started were considered to be committing a violation. No affordance was allowed for motorists entering the intersection on a red light.
6.4. Results

Figure 6-1: Pedestrian injury hotspot intersections in the City of Vancouver.

The top eight pedestrian injury intersection hotspots were (number of incidents in parentheses): Hastings and Main (16), Broadway and Fraser (11), Georgia and Burrard (11), Hastings and Commercial (11), Hastings and Carrall (11), Broadway and Commercial (10), Hastings and Gore (10), and Howe and Davie (9).

Figure 6-1 illustrates the pedestrian injury hotspot intersections in the City of Vancouver for the 6 year study period. Eight Vancouver intersections were surveyed at three different times of day. However, one intersection – East Hastings St. and Carrall St. – was excluded from analysis as it was blocked in one direction for maintenance.
during the observation periods and could thus not be compared to the seven other normally functioning intersections. Figure 6-2 highlights the location and total pedestrian and motorist violations observed during this study at the seven intersections included in the analysis. Table 6-1 breaks down the results for all pedestrian and motorist violations observed, for all observation periods separately and for the total observations combined. Overall, 9,808 pedestrians and 17,874 vehicles were observed. For all pedestrians observed at all intersections, 8% crossed outside of the designated crossing area; this ranged from just 0.8% at Howe St. and Davie St. to 24.7% at East Hastings St. and Commercial Dr. Overall, 9.8% of pedestrians observed entered the crosswalk area during the flashing hand phase, this varied from 7.2% at Georgia St. and Burrard St. to 15.8% at Broadway and Commercial Dr. Just 3.2% of all observed pedestrians entered on the steady hand; this ranged from 0.5% at Georgia and Burrard, to 9.7% at East Hastings St. and Gore St. Overall, 2,069 (21%) pedestrians committed one of the observed road-crossing violations, ranging from just over 12% at Howe St. and Davie St., to 39% at the East Hastings St. and Commercial Dr. intersection. For motorists, 4.6% overall entered an intersection during the yellow signal phase; this varied between intersections, from 2.5% at East Hastings St. and Commercial Dr., to 6.6% at Howe St. and Davie St. Just 1.3% of motorists entered an intersection during the red signal phase for all intersections, this varied from 0.7% at East Hastings St. and Commercial Dr., to 2% at Broadway and Commercial Dr. Overall, 1,051 (5.9%) of motorists committed one of the observed violations, ranging from 3.2% at East Hastings St. and Commercial Dr., to 7.5% at Broadway and Commercial Dr.
Figure 6-2: Total pedestrian and motorist violations observed at intersection hotspots.

Pedestrian and motorist volume and road rule violations were recorded at the top seven high-incident intersections. This map highlights the total combined violations as a proportion of total volume, for pedestrians and motorists. Great variation was observed between hotspots, for example, at Hastings and Commercial almost 40% of pedestrians committed one of the observed road-crossing violations, while only 12% did at Howe and Davie. Meanwhile, just 3.2% of motorists committed a violation at Hastings and Commercial, but 7.4% of motorists did at Howe and Davie.
Table 6-1: Violations and volumes of pedestrians and motorists at pedestrian injury hotspots.

<table>
<thead>
<tr>
<th>Location</th>
<th>Observation Time</th>
<th>PEDESTRIANS</th>
<th>MOTOR-VEHICLES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total pedestrian volume</td>
<td>Cross outside markings</td>
</tr>
<tr>
<td>Hastings &amp; Main 1</td>
<td>AM peak</td>
<td>292</td>
<td>30 (10.3)</td>
</tr>
<tr>
<td>Hastings &amp; Main 2</td>
<td>AM off-peak</td>
<td>742</td>
<td>23 (3.1)</td>
</tr>
<tr>
<td>Hastings &amp; Main 3</td>
<td>PM peak</td>
<td>637</td>
<td>28 (4.4)</td>
</tr>
<tr>
<td>Hastings &amp; Main 2</td>
<td>Combined</td>
<td>1,671</td>
<td>81 (4.9)</td>
</tr>
<tr>
<td>Broadway &amp; Commercial 1</td>
<td>AM peak</td>
<td>575</td>
<td>142 (24.7)</td>
</tr>
<tr>
<td>Broadway &amp; Commercial 2</td>
<td>AM off-peak</td>
<td>619</td>
<td>125 (20.2)</td>
</tr>
<tr>
<td>Broadway &amp; Commercial 3</td>
<td>PM peak</td>
<td>1,104</td>
<td>55 (5.0)</td>
</tr>
<tr>
<td>Broadway &amp; Commercial 1</td>
<td>Combined</td>
<td>2,298</td>
<td>322 (14)</td>
</tr>
<tr>
<td>Broadway &amp; Fraser 1</td>
<td>AM peak</td>
<td>60</td>
<td>9 (15.0)</td>
</tr>
<tr>
<td>Broadway &amp; Fraser 2</td>
<td>AM off-peak</td>
<td>100</td>
<td>13 (13.0)</td>
</tr>
<tr>
<td>Broadway &amp; Fraser 3</td>
<td>PM peak</td>
<td>80</td>
<td>9 (11.3)</td>
</tr>
<tr>
<td>Broadway &amp; Fraser 1</td>
<td>Combined</td>
<td>240</td>
<td>31 (12.9)</td>
</tr>
<tr>
<td>Georgia &amp; Burrard 1</td>
<td>AM peak</td>
<td>1,205</td>
<td>32 (2.7)</td>
</tr>
<tr>
<td>Georgia &amp; Burrard 2</td>
<td>AM off-peak</td>
<td>902</td>
<td>26 (2.9)</td>
</tr>
<tr>
<td>Georgia &amp; Burrard 3</td>
<td>PM peak</td>
<td>1,401</td>
<td>49 (3.5)</td>
</tr>
<tr>
<td>Georgia &amp; Burrard 1</td>
<td>Combined</td>
<td>3,508</td>
<td>107 (3.1)</td>
</tr>
<tr>
<td>Hastings &amp; Commercial 2</td>
<td>AM peak</td>
<td>80</td>
<td>24 (30.0)</td>
</tr>
<tr>
<td>Hastings &amp; Commercial 3</td>
<td>AM off-peak</td>
<td>70</td>
<td>21 (30.0)</td>
</tr>
<tr>
<td>Hastings &amp; Commercial 3</td>
<td>PM peak</td>
<td>125</td>
<td>23 (18.4)</td>
</tr>
<tr>
<td>Hastings &amp; Commercial 2</td>
<td>Combined</td>
<td>275</td>
<td>68 (24.7)</td>
</tr>
<tr>
<td>Hastings &amp; Gore 1</td>
<td>AM peak</td>
<td>112</td>
<td>23 (20.5)</td>
</tr>
<tr>
<td>Hastings &amp; Gore 2</td>
<td>AM off-peak</td>
<td>506</td>
<td>115 (22.7)</td>
</tr>
<tr>
<td>Hastings &amp; Gore 3</td>
<td>PM peak</td>
<td>361</td>
<td>55 (15.2)</td>
</tr>
<tr>
<td>Hastings &amp; Gore 1</td>
<td>Combined</td>
<td>979</td>
<td>193 (19.7)</td>
</tr>
<tr>
<td>Howe &amp; Davie 1</td>
<td>AM peak</td>
<td>244</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Howe &amp; Davie 2</td>
<td>AM off-peak</td>
<td>273</td>
<td>5 (1.8)</td>
</tr>
<tr>
<td>Howe &amp; Davie 3</td>
<td>PM peak</td>
<td>320</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Howe &amp; Davie 1</td>
<td>Combined</td>
<td>837</td>
<td>7 (0.8)</td>
</tr>
<tr>
<td>Total (all observations)</td>
<td>Combined</td>
<td>9,808</td>
<td>809 (8)</td>
</tr>
</tbody>
</table>
In addition to the overall findings at each location, several individual findings are notable. For instance, at Hastings and Commercial, fully 39% of total observed pedestrian crossings resulted in a violation; however, even more striking are the results of the individual observations at this location. During the off peak observation, 30% crossed outside the markings, 17.1% crossed on the flashing hand phase, and 11.4% crossed on the steady hand phase; thus, almost 59% of crossings by pedestrians included one of the observed infractions. At Hastings and Gore, more pedestrians crossed on the steady hand phase than the flashing hand phase during the AM peak observation (22.3% crossed on the steady hand phase compared to 12.5% on the flashing hand phase), during the PM peak observation (8.6% steady hand, 5.8% flashing hand), and results were almost equal for both phases during the off peak observation (7.7% steady hand, 8.1% flashing hand).

In Figure 6-3, the proportional results of each surveyed violation combined for all observation times are standardized using a Z score transformation. This graph allows for the variables to be visually compared between intersections, based on the overall mean of each violation. Values higher that 0 are above, and values below 0 are less than the overall mean for that violation. All vehicle violations are above the mean at Hastings and Main, Broadway and Commercial, and Georgia and Burrard, and below the mean at Hastings and Commercial and Hastings and Gore. All pedestrian violations are above the mean at Broadway and Fraser, and below the mean at Georgia and Burrard and Howe and Davie.
Figure 6-3: Standardized scores for all violations at seven intersections.

Values above 0 are higher than the mean, below 0 are less than the mean. Using this graph, it is possible to visualize the potential contribution of pedestrian and motorist roadway violations. For example, at Georgia and Burrard, all pedestrian violations are less than the overall mean, while all motorist violations are higher than the mean. This may suggest that interventions at this site might be most effective if motorists are targeted.

6.5. Discussion

In this study, GIS methods were used to identify pedestrian injury hotspots. A GIS approach allows researchers to identify the spatial distribution of injury, and then to
examine the contextual factors associated with pedestrian injury; specifically, how location interacts with human, social, and environmental factors to influence injury risk. For decision-makers, maps and cartographic visualizations created in a GIS environment are powerful knowledge translation tools for understanding a problem and forcing action on important societal issues. The power of GIS for examining pedestrian injury has increasingly been demonstrated in recent years (e.g. Chakravarthy et al., 2007; Pulugurtha & Sambhara, 2011; Sciortino et al., 2005). Following the identification of hotspots at signalized intersections, violations of road rules by pedestrians and motorists were observed in order to elucidate their potential contribution to pedestrian injury in Vancouver, Canada. Based on the premise that certain high-incident intersections should be targeted individually with regard to safety countermeasures, a simple observational-based method was developed that could be used to determine what types of behaviour-modifying interventions may be most appropriate. The results of this study highlight great variability in violations observed between locations, which may suggest accordance with the hypothesis that hotspots are likely to be dissimilar with respect to their aetiology. In Figure 6-3, a clear pattern emerges for some of the hotspots in particular. For example, at Georgia and Burrard Sts. the relative values are low for the pedestrian violations and high for the motorist violations. This may indicate that motorists entering the intersection after the green light phase is contributing to pedestrian injury. Interventions that target violations by motorists may be most appropriate in this location. On the other hand – at Hastings and Commercial – pedestrians may be the more likely contributor, as this location boasts the highest proportion of pedestrians committing a violation (almost 40%) coupled with the lowest proportion of motorists committing a violation (3.2%). As such, countermeasures that target violations by pedestrians may be
most appropriate at this location. In other cases, it is less clear which group may be responsible; this may suggest that both motorists and pedestrians should be targeted.

Inconsistencies in violations observed between different locations in a city might indicate actual variability in the people frequenting each intersection, or it might point to the notion that road users may be influenced to commit violations due to characteristics of the surrounding area. For instance, certain types of land use might influence a pedestrian to cross against the signal. The presence of a pedestrian generator such as a public transit hub might influence a pedestrian to commit a violation in order to avoid missing a transit connection. Also, research linking commercial and residential areas, schools, and alcohol establishments to pedestrian injury (e.g. Clifton & Kreamer-Fults, 2007; LaScala et al., 2000; Schuurman et al., 2009b) might suggest these types of land use influence a road user to commit a violation. The seven locations observed in this study diverge with respect to characteristics of the surrounding area. Looking at the local characteristics of some of the more concerning findings from this study, it may be possible to posit alternative explanations. The land use at Hastings and Commercial is predominantly light industrial – which is not typically a significant pedestrian attractor, however several public buses stop at three of the four corners of this intersection. Pedestrians alighting from one bus and then rushing across the street to board another might provide an alternative explanation for the very high proportion of pedestrian violation crossings observed at this location. Hastings and Gore is situated in an area comprised of commercial and residential land uses, and multiple alcohol serving establishments. It is possible that these land uses are influencing pedestrians to commit a violation. For organizations wishing to determine why violations are occurring at certain locations, a logical next step might be to attempt to understand the variability between
locations and assess how local characteristics such as land use contribute to violations. Combining the methods described in this study with an on-site inspection of local characteristics and a survey of road users’ attitudes may help to shed further light on the specific contextual factors that influence violation of road rules by pedestrians and motorists.

The present study was not designed to identify local characteristics, however, it may be useful for identifying another potential contributor to pedestrian-vehicle collisions, the total volume of pedestrians and vehicles at certain locations. For example, if little non-compliance is noticed at hotspots, it is possible that hotspots may be associated simply with pedestrian or vehicle volumes based on the notion that greater volume of all road users will provide more opportunities for conflicts between vehicles and pedestrians (Retting et al., 2001). Research has confirmed this idea (e.g. Stevenson et al., 1995; Wier et al., 2009), however studies have also documented a tapering off of this relationship at the higher end. In a study of intersections in Florida, Lee and Abdel-Aty (Lee & Abdel-Aty, 2005) found that the likelihood of pedestrian-vehicle conflict is higher at intersections with greater traffic volume. However, the relationship attenuates as traffic volumes increase, suggesting that congestion (very high vehicle volume) reduces the likelihood of conflict. Evidence has also suggested pedestrian injury may be associated with higher volumes of pedestrians (e.g. Harwood et al., 2008; Pulugurtha & Sambhara, 2011). However, there is also evidence to suggest this relationship diminishes as pedestrian volumes increase (Leden, 2002). This may have to do with the so-called ‘safety in numbers’ effect, whereby motorists may be influenced to drive slower and with more caution in the presence of elevated pedestrian volumes (Jacobsen, 2003). In a study in Oakland, California, Geyer et al. (2005) concluded that the risk of
injury for pedestrians decreases as pedestrian volumes increase, and, increases as vehicle volumes increase. Some of the wisdom regarding volumes coming from previous research is echoed in the current study. For example, very low relative pedestrian volumes and high relative vehicle volumes at Hastings and Commercial and Broadway and Fraser could suggest an exposure-related etiology at these locations, following the findings from the Oakland study. This varying evidence of the effect of volumes on pedestrian injury suggests that the relationship may be non-linear, context-specific, and confounded by other variables. What is needed in particular is more research to understand the combined, interconnected effects of pedestrian and vehicle volumes at hotspots. By focusing on both pedestrian and vehicle volumes, the present study could provide a starting point for examining how different volumes of all road users coalesce to either increase or decrease pedestrian injury risk. For hotspots that appear to be affected by high vehicle or pedestrian volumes, suitable interventions may include engineering solutions to segregate vehicles and pedestrians, or simply, a reduction in the speed limit at these hotspots.

6.5.1. **Modifying Roadway-Users’ Behaviours**

Despite the fact that choices made by motorists and pedestrians while in the roadway have an obvious effect on pedestrian injury, behavioural-focused injury interventions are rare compared to engineering solutions (Winston & Jacobsohn, 2010). Because engineered solutions such as traffic calming are not always feasible or effective, behavioural interventions could be targeted directly at those road users who are committing violations in order to see results (Boyce & Geller, 2000). Interventions aimed at changing behaviours focus on reducing the risk of injury through promotion of
safe behaviour while operating a vehicle or walking in the roadway (Winston & Jacobsohn, 2010). For problem intersections, behavioural interventions can be designed that target pedestrians, motorists, or both groups to emphasise safe behaviours and knowledge of road regulations. With regard to pedestrians, an obvious target for intervention is choices made at the side of the road (Holland et al., 2009), including where and when to cross an intersection. Harré & Wrapson (2004) examined the effects of installation of visual media and provision of rewards for road-rule compliance on pedestrians road-crossing behaviour at five intersections in Auckland. These interventions were successful in reducing the proportion of pedestrians crossing during the red light phase by half. For motorists, proceeding through an intersection after the green light phase is a decision that increases the risk of colliding with a pedestrian. Speeding, carelessness, and distractions are all factors that influence drivers’ choices made at intersections, and are clear targets for behavioural intervention. Nasar (2003) examined the benefit of an intervention designed to encourage drivers to yield to pedestrians at crosswalks. Signs were held up by volunteers to thank the driver for stopping when compliance was observed, or, to ask the driver to stop next time in the case of non-compliance. This simple intervention was successful in increasing the proportion of drivers stopping for pedestrians at the study crossing, and was also associated with an increase at a nearby crossing that was not subject to the treatment.

These successful examples of intersection-level behavioural interventions underscore the notion that modifying the behaviour of roadway users with respect to safety at trouble spots could reduce the burden of injury. Winston and Jacobsohn’s (2010) step-by-step behavioural intervention tutorial could be a useful framework for implementing the required interventions. Results could allow for evidence-based
decision making by communities that wish to reduce their burden of pedestrian injury. Following an intervention, the method could be applied again in order to understand the potential effects of the program.

Previous research has focused on examining violations using observational techniques. For example, Cambon de Lavalette et al. (2009) examined the interplay between environmental factors and the decision-making processes of pedestrians. The aim of this study was to examine how the surrounding environment potentially mediates safe road crossing behaviours. One of the findings of this observational study suggested that violations increase with the absence of crossing signals. King et al. (2009) attempted to determine the risk of injury for pedestrians that violate crossing signals. The results of the study provided both evidence for the risk of crossing against the signal (approximately 8 times greater than crossing legally), and a method to undertake this type of study. Research has also focused on violations by motorists. For instance, in a study by Yang et al. (2007), violations at signalized intersections were examined using red-light photo enforcement camera data. Findings from this research suggested that younger drivers were more likely to disobey red lights than other age groups, and red light violations were lower during off-peak times of the day. Kim et al. (2008b) directly observed both pedestrian and motorists at pedestrian crosswalks after the implementation of new pedestrian right of way legislation. Similar to the results of the present study, this study found great variability between locations. Accordingly, the authors state (p. 902): “it may be necessary to develop localized enforcement, education, and engineering solutions. A one size fits all approach, evidently, will not be as effective as a more customized approach to addressing particular locations or at least types of locations.” The present study used simple observational techniques to examine
violations by motorists and pedestrians at signalized intersections. A relatively easy to implement strategy was developed and demonstrated that could allow pedestrian injury stakeholders to identify the specific types of behavioural interventions that may be most appropriate for targeting pedestrians or motorists in their community. A community-based pedestrian injury advocacy group in Vancouver, Canada has adapted and utilized the methods described in this study to examine violations on local neighbourhood streets (Russwurm & Buchanan, 2010). Using information gleaned from the observations, the group developed overall and site-specific recommendations for improving pedestrian safety in the neighbourhood, including education, engineering, and enforcement solutions.

6.5.2. Limitations

Several limitations are evident with this study. The method described in this paper is designed to provide greater understanding regarding violations of road rules by pedestrians and motorists, which may be useful for designing targeted interventions. Fault, however, is likely to be speculative. In this case, we enumerated both pedestrian and motorist violations but there may be underlying factors that enhance likelihood of such violations. Findings may be better understood when compared to other research findings; for example, studies of pedestrian unfriendly roadway design at intersections. Another limitation of this study relates to the choice of violations included for analysis and the length of time for hotspot observations. In addition, observing intersections at any 20-minute window within the two-hour time periods may be a limitation if volumes change over this time. These study design choices reflect the restrictions imposed by the funding period and availability of personnel, however, we believe this was adequate in
order to demonstrate a methodological framework for providing insight into this lesser known issue. Organizations that wish to undertake a study of human behaviour at intersections may wish to observe for longer periods, add more observation times during the day, or include a different set of violations, non legal considerations, or other aspects of human behaviour deemed appropriate at the specific location.

6.5.3. **Acknowledgements**

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7. Linking Chapter: From Community-Based Surveillance to Community-Based Production of Geographical Knowledge

The following chapter explores a community-based pedestrian safety project that was organized to respond to the findings of a paper published in 2009, which exposed a serious burden of pedestrian injury in the impoverished and marginalized downtown eastside (DTES) neighbourhood of Vancouver\(^1\). Given my involvement in the study, I was asked to become involved in the pedestrian safety project. In addition to sitting on the project's advisory board, the main contribution that I made to the project was the development of the surveillance methodology described in the previous chapter, which was also used in the pedestrian safety project to collect data on observed violations within the DTES neighbourhood. The project was successful in identifying some of the causes and solutions to the problem, and was ultimately responsible for changing pedestrian safety policy in the DTES. This project can be described via the injury prevention and control cycle, as illustrated in Figure 1.2 (reproduced below as Figure 7-1). This project began with Phase 1 (surveillance) and progressed to Phase 2 (identifying the causes and determinants of injury). The project successfully advocated for the implementation of safety interventions in the neighbourhood, further advancing pedestrian injury in the DTES to Phase 3 (intervention) of the cycle. If the pedestrian

safety measures implemented in the DTES are demonstrated to be effective, they could potentially be applied in other areas, thereby progressing to Phase 4 (broad scale implementation) of the injury prevention and control cycle. The injury prevention measures that resulted from this collaborative effort between local residents, City of Vancouver representatives, public health employees, and academics will likely reduce the burden of pedestrian injury in this area. The success of the collaboration underscores the value in recognizing knowledge production in community settings, and its value for informing public health and safety policy. The following chapter addresses this notion, by unpacking the collaboration, describing how it unfolded, and how it produced valuable geographical knowledge in the public sphere.
Figure 7-1: The public health approach to injury prevention and control
8. Geography in the Public Sphere: Acknowledging the Diverse Sites of Geographical Knowledge Production

8.1. Abstract

Geographical knowledge is widely produced in extra-institutional domains by non-academics, yet it is rarely utilized or even acknowledged by academic geographers. This imbalance in the division of geographical labour has served to entrench the divide between the academy and wider society. This paper argues that recognizing and uniting diverse geographical knowledges will strengthen academy-society ties while also opening the ‘black box’ of academic geography. Drawing on notions of the public sphere and the work of sociologist Michael Burawoy, this position was developed by dissecting a community-based pedestrian safety project that unfolded organically at the interface of professional and public geographies.

2 This chapter is currently undergoing a second revision for consideration in Progress in Human Geography.
8.2. Introduction

“...if the geographical Left is to move beyond academicism in the spirit of a renewed activism and engagement it needs not to reject professionalisation but to exploit the potential inherent within it further” (Castree, 2000, p. 963).

Although priorities and research areas come and go in geography, questioning the role of the discipline in wider society represents a common thread coursing through successive decades of disciplinary debate. The first significant wave emerged in the 1970s when influential geographers initiated broad interest in the relevancy of geographic research for informing public policy, by framing the debate in light of the environmental, economic, and social challenges of that time (e.g. Coppock, 1974; Harvey, 1974). On one side of this entrenched debate, commentators decried the limited influence of academic geographical knowledge on public policy (Dorling & Shaw, 2002; Johnsen, 2011; Martin, 2001; Massey, 2001). Counterpointing those advocating for stronger engagements with policy and society, a number of arguments disrupted the relevancy agenda by illuminating its challenges and paradoxes – for instance the potential loss of academic freedom (Demeritt, 2000; Heyman, 2006), the emergence of research output metrics and the favouring of abstract and theoretical knowledge over policy or ‘grey’ contributions (Eden, 2005; Gleeson, 2011; Peck, 1999), and narrow definitions of relevance that serve to support neoliberal imperatives and hegemonic power (Fuller & Kitchin, 2004a; Harvey, 1974; Ward, 2007a).

Advocates for a more societally-relevant human geography identify as a central argument the need to eliminate a series of dualisms – theory/practice, policy/activism, activist/academic (cf. Pain, 2006) – and in particular the overarching academy/society
divide. To this end, theoretical, epistemological, and methodological approaches have been designed that draw especially from critical and radical traditions in geography (see Fuller & Kitchin, 2004b). This includes participatory geographies (e.g. mrs kinpaisby, 2008; Pain et al., 2011), which have as an overarching priority the dissolution of the aforementioned academy-society divide, and more specifically “[t]o involve in a nonhierarchical way those being ‘researched’ in one or more of the different stages of the research process, from conception to evaluation” (Ward, 2007a, p. 698). Activist geographies, engage beyond the academy on issues of power and oppression, while at their core lies a mandate to challenge the activist/academic binary (e.g. Blomley, 1994; Maxey, 1999; Ward, 2007a). In recent years, new dimensions for framing the relevancy debate have taken shape. One emerging perspective draws from feminist notions of positionality, reflexivity, and situated knowledges (Maxey, 1999), and from early radical geography that, in addition to its critique of positivism, also advocated for the democratization of knowledge production (Heyman, 2007, 2009). The crux of this nascent discourse, I would argue, is the need to reconceptualize the academy-society relationship not as a binary that must necessarily be overcome, but rather, as a bidirectional, non-hierarchical, and mutually beneficial alliance. While this standpoint generally parallels the principles of activist and participatory geographies, the unique focus here is on recognizing and promoting the myriad legitimate sites of geographical knowledge production. This, for those advocating this reconceptualization, is the crucial point – that geographical knowledges are produced within and outside of the academy, and moreover, that these knowledges can be harnessed, combined, and shared for broad societal benefit.
Extra-institutional geographical knowledge is produced by individuals or groups, for personal or public consumption. These include the ‘small g’ geographies of everyday life and the more formalized geographical knowledge produced by, for example, research institutes, the media, and community organizations (Castree, 2006a; Castree et al., 2008). Acknowledging that “geography does not belong to geographers alone” (Bunge, 1974, p. 482) can itself improve academy-society relations in geography, however doing so should not discount academic knowledge production as a vital source of evidence for improving society. As Castree (2006a, p. 1189) describes, “…universities are merely one site where geographical knowledges are produced and from which they circulate into the wider society”; yet, as the author notes, we must also uphold universities as important sites where knowledge is created and democracy is defended. Indeed, social problems are better served by expanding access to the means of knowledge production, not by simply producing more knowledge (Heyman, 2007). This emerging standpoint on academy-society relations stresses the need for stronger links between the various nodes within the expansive epistemological landscape of geography.

Strongly informing this new reinterpretation of the relevancy debate in geography has been the work of sociologist Michael Burawoy whose ideas have influenced how academy-society relations are conceptualized. Indeed his call for ‘public sociologies’ (Burawoy, 2004, 2005a) set off a wave of interest in the ‘public’ side of many social science disciplines. For Burawoy, public sociology is about, simply, engaging publics in a dialogue about public issues studied by sociologists. As Burawoy describes – which is of particular significance to the democratization of knowledge production – “it is a triple dialogue – a dialogue among sociologists, between sociologists and publics, and most
importantly within publics themselves” [emphasis added] (Burawoy, 2005b, p. 71). Following Burawoy, interest in public geographies is growing (e.g. Castree, 2006b; Fuller, 2008; Fuller & Askins, 2007, 2010; Hawkins et al., 2011; Murphy, 2011; Sheppard, 2013; Smith, In press; Ward, 2006), yet attempts to characterize the field have not been thoroughly fleshed out (see Castree et al., 2008; mrs kinpaisby, 2008; Ward, 2006). I argue that public geographies are, at their root, focused on recognizing and encouraging geographical knowledge production in diverse sites within and outside of academia, and on enabling stronger linkages between professional (academic) geography and the wide world of geographical knowledge produced in the public sphere.

Against this backdrop of emerging viewpoints on relevancy, the democratization of knowledge production, and the ‘public turn’ (Fuller, 2008) in the social sciences, this paper reflects on a collaborative project that united public and professional geographical knowledges of pedestrian safety in a marginalized neighbourhood of Vancouver, Canada. Through recounting the unfolding of this project, this paper argues for increased awareness of the value of geographical knowledge produced in diverse sites, and the benefit of uniting these knowledges while also retaining their distinctions. This argument draws from emerging positions on the relevancy debate in geography as well as Burawoy’s division of disciplinary labour, and theories of the ‘public’ and the public sphere. The paper is outlined as follows: in the next section, I trace the emergence of public geographies via the recent work of Burawoy, and further back to the writings of Habermas and Dewey. Following this, the main section of the paper unpacks the pedestrian safety collaboration in light of the emerging interest in public scholarship and the place of geography in the public sphere. To conclude, the paper reflects on the
challenges and opportunities of identifying and recognizing diversity in knowledge production.

8.3. Public Geographies in the Public Sphere

Several years ago Ward observed that recent consideration of public policy and relevance within human geography has typically queried the policy while ignoring the public (2006). He argued that “…the bulk of the recent emphasis on public policy has taken place at the expense of proper consideration of what is meant, or might be meant, by the publics [emphasis in original]” (p. 496); this, despite significant attention to issues of public space in the discipline and to the public sphere more generally. Contemporary interest in the ‘public’ is informed by the writings of John Dewey, the influential American pragmatist philosopher who advocated the primacy of education and strong civil society for enabling democracy. According to Dewey, “the public, consists of all those who are affected by the indirect consequences of transactions to such an extent that it is deemed necessary to have those consequences systematically cared for” (1927, pp. 15-16). Dewey’s optimism about the potential for public involvement in democracy counterpointed his contemporaries who posed serious concerns about the capacity of the public to engage in rational political discourse. The writings of Jürgen Habermas have direct relevance here. Habermas popularized the notion of the public sphere – “the sphere of private people come together as a public” to mediate between the private and state spheres (1989, p. 27). In his interpretation, the public sphere emerged in the new urban social spaces and media (popular press, books, art) of bourgeois late 17th and early 18th Century Europe. At this time newly autonomous private individuals could now gather to discuss and debate issues that had previously gone unquestioned by church or
state – through conversations, discursive debate, and the subsequent formation of public opinion concerning the needs of society within the state (Johnson, 2006). Through face-to-face conversations and the press, new knowledges were propagated that challenged hegemonic positions (Hudson, 2004). The erosion of the public sphere, however, began in the 19th Century at which time public opinion increasingly reflected capitalist and consumerist ideals, enabled by a shift in the role of the press from one that “took ideological sides to one that was primarily a business” (Habermas, 1989, p. 184). This ‘eclipse of the public’ (Dewey, 1927) blurred the distinctions between state and society, and eroded the public sphere through the consequent decline of rational-critical discourse. Yet, the writings of Dewey, Habermas and others demonstrate that the revitalization of a vibrant public sphere is a real possibility, and one that we should relentlessly seek (Bernstein, 2012).

Despite its widespread influence, numerous commentators took issue with the Habermasian interpretation of the public sphere, and alternative models have emerged. While agreeing with the basic premise of the public sphere and its utility for theorizing the distinctions between the state, market, and democratic institutions, Nancy Fraser (1990) argued that Habermas’ conception was not a universal public sphere due to the exclusion of women and those of lower-socioeconomic means – if not overtly then through style, dress, and behaviour protocols that served to prohibit these groups. And, because “[t]he media that constitute the material support for the circulation of views are privately owned and operated for profit. Consequently, subordinated social groups usually lack equal access to the material means of equal participation” (Fraser, 1990, p. 65). Her argument, in a departure from Habermas, points to the necessary existence of multiple publics, and, what she refers to as subaltern counterpublics, “…parallel
discursive arenas where members of subordinated social groups invent and circulate counterdiscourse, which in turn permit them to formulate oppositional interpretations of their identities, interests, and needs” (Fraser, 1990, p. 67). Habermas, along with many of his contemporaries and critics, however, converge on the centrality of communication for enabling the public sphere and promoting democracy, through both literal and metaphorical forms of dialogic conversation (cf. Dahlberg, 2005). Yet, publics are only constituted if communication is discursive and multidirectional; individuals, simply consuming media, are not a public (Dahlgren, 2005).

Michael Burawoy’s 2004 presidential address to the American Sociological Association – a call to arms for ‘public sociologies’ – has been influential in that discipline and beyond. Burawoy describes the justification for a strong public-focused sociology:

“The growing interest in public sociologies marks an increasing gap between the ethos of sociologists and social, political, and economic tendencies in the wider society. Public sociology aims to enrich public debate about moral and political issues by infusing them with sociological theory and research. It has to be distinguished from policy, professional, and critical sociologies. Together these four interdependent sociologies enter into relations of domination and subordination, forming a disciplinary division of labor that varies among academic institutions as well as over time, both within and between nations” (Burawoy, 2004, p. 1603).

Although Burawoy traces a long history of the four sociologies that make up his division of sociological labour (Burawoy, 2005a) – professional, critical, policy, and public sociologies – his main thesis points to an ever-growing imbalance whereby the
academic forms take precedent over public sociologies, despite the distinctive relation of sociology to multiple and heterogeneous publics. Professional sociology is of the academic type taking place in university settings and is the foundation by which all other types exist, while critical sociology examines the foundations of professional sociology and acts as its conscience. Policy and public sociology are related and inter-dependent, yet the author delineates some key differences. Policy sociology is about working on specific problems that are typically pre-defined by clients in government, private sector, or non-governmental organizations. In contrast, public sociology “strikes up a dialogic relation between sociologist and public in which the agenda of each is brought to the table, in which each adjusts to the other” (Burawoy, 2005a, p. 9). Public sociology is about mutually beneficial and reciprocal engagements of academics and publics, while relationships in policy sociology are often forged by formal contract and the exchange of financial payment for sociological expertise (Burawoy, 2004). In the public sociology model, knowledge is produced through a model of multidirectional and equitable communication between publics and sociologists, while in policy sociologies knowledge production is forged by the academic. Each type is vital to the overall success of the discipline, yet “if we map out the division of sociological labor, we discover antagonistic interdependence among four types of knowledge... [i]n the best of all worlds the flourishing of each type of sociology is a condition for the flourishing of all, but they can just as easily assume pathological forms or become victims of exclusion and subordination” (Burawoy, 2005a, p. 4).

Recognizing that geographical knowledge is produced within and outside of the academy points also to the existence of a division of geographical labour in which professional geographers are but one source of geographical knowledge. Growing
interest in public geographies recognizes the need to illuminate knowledge production in the public sphere and forge stronger links between professional, public, critical, and policy geographies. Ward (2006) provided an early interpretation of public sociology for a human geography audience in his own call for public geographies, and identifies two aspects of Burawoy’s framework in particular that could be useful for thinking about the relevancy debate in human geography. One aspect of Burawoy’s framework that caught Ward’s attention was his distinction between policy and public sociologies. Following Burawoy, Ward (2006) contrasts policy and public geographies based on several criteria, including knowledge, politics, and accountability. As the author describes, knowledge created in policy geographies is instrumental or concrete, while public geographies create reflexive or communicative knowledge. Politically, policy geographies are concerned with interventions in policy discussions, while public geographies are about public dialogue on geographical issues of importance to society. Accountability in policy geographies is to clients and evaluators; in public geographies it is to pertinent stakeholders. A second aspect that Ward identified was Burawoy’s attention to the multiple and diverse publics that academics can engage with. Certainly, this includes engagements beyond the academy with community, governmental, and non-governmental publics, yet it also recognizes the existence of publics within sites of education, including students and pre-university geographers (Castree et al., 2008; Castree et al., 2007). It is vital to recognize and foster the four types of geographical knowledges, yet, as in sociology, knowledge production within professional, critical, (and to some extent) policy geographies is legitimized at the expense of geographical knowledge produced in the public realm. The focus on public geographies seeks to right this imbalance, to foster an awareness of the public sphere as a legitimate, active, and progressive site of knowledge production in the service of the public good. Public
geographies recognize the need to more readily share the knowledge produced in professional geographies with publics, and vice versa, to share public geographical knowledge with professional geographers, among others.

Although the scope of public geography and the forms that it can take are still emerging, Fuller and Askins (2010) delineated two main types, ‘traditional’ and ‘organic’, derived from the same variants of public sociology sketched out by Burawoy. *Traditional public geographies* are initiated when academics deliberately converse with publics beyond the academy through publishing their work in newspapers, books, and other broadly read venues. The role of the academic in this form of public geography is to foment public debate and awareness, with the goal of helping to form public opinion on important issues to society. An empirical exploration of the frequency of US newspaper op-ed articles (opinion pieces, commentaries) written by academics between 2004-2008 provides evidence of the relative contributions of geographers to public scholarship measured against their colleagues in allied physical and social science disciplines (Moseley & Teske, 2011). Geography ranked 6th out of 7 disciplines overall, and 4th out of 7 when standardized by the number of Ph.D. degrees granted as an estimate of discipline size. Sitting high above the rest of the ranked disciplines were political science and economics with 71% of all op-ed pieces, perhaps of little surprise given their longstanding attention to policy and publics. These disciplines will likely remain at the forefront of public scholarship, yet geographers also have much to say of import to the broader public. Another perspective was provided by Castree (2006b), who perceived recent books by well-known geographers of the Left – David Harvey, Michael Watts, and the late Neil Smith – as indicative of a new public intellectual movement in the discipline. These books, as the author points out, are written not for academic peers, but in a style
and tone suitable for and directed at a wider public audience, suggesting a conscious effort to reach out to the public. An upshot of geographers in the public sphere is the promotion of the discipline itself. Unfortunately, unlike perhaps political science and economics, geography has a distorted and outdated public image, so having public intellectuals to ‘sell’ the discipline becomes a key part of traditional public geographies (Ward, 2007b).

Organic public geographies, meanwhile, describe more fluid and linked engagements between different publics, in which the academic typically plays the role of catalyst. Fuller and Askins (2010, p. 654) describe organic public geographies as “often unplanned, serendipitous encounters that evolve organically into research/learning/teaching endeavours”. Differing from traditional versions as Burawoy describes vis-à-vis public sociology, “here publics are local rather than national, thick (bound by a dense set of relations) rather than thin, active rather than passive, often counter-publics rather than mainstream” (2005b, p. 72). Mills (2013) describes two ‘surprise’ forays into the public sphere during her Ph.D. research, both emerging from her own volunteer work with Scout organizations. While unfolding organically outside of the planned structure of her research project, this engagement helped to shape the formal research process, and in doing so, merged public and professional geographies. An organic public geography project ‘Making the Connection’ (Hawkins et al., 2011; Making the Connection, 2008) united a university geography department with local school-level geography teachers and pupils. This project allowed university students and school pupils to together explore the quotidian geographies of material culture, using a combination of academic writing, group work, creative writing, and a live performance that brought together university students and pupils on the same stage. Outcomes
included a co-designed geography school curriculum, pupils’ involvement with an academic geography conference, and co-written project documentation for both academic and public audiences.

While traditional public geographies bring the discipline to the public, it is the more organic engagements such as these that especially help to illuminate the heterogeneous spaces of knowledge production and the value in engaging with those shaping these knowledges. Although the public sphere is certainly not terra incognita for geographers, I argue that the overarching purpose of the public geographies movement is to advance the use of diverse geographical knowledges for societal benefit. The following section unpacks a collaboration that united professional and public geographical knowledges of pedestrian safety. Although the unexpected collaboration was catalyzed by professional geographical knowledge, pedestrian safety policymaking occurred due to its merger with geographical knowledge produced in the public sphere, and, importantly, due to the strong advocacy skills of public collaborators. The success of this collaboration speaks to the value in integrating the knowledges and competences of academics and publics for addressing societal challenges.

8.4. Border Crossings and Conversations: Uniting Professional and Public Geographical Knowledges

The argument put forth in this paper was inspired by an unplanned collaboration between diverse stakeholders in the downtown eastside (DTES), a severely marginalized neighbourhood of Vancouver, Canada. Initiated by the findings of a pedestrian injury mapping study in the city, this collaboration engaged community
organizations, academics, community activists, and civic employees in a triple dialogue that produced public and professional geographies of pedestrian injury surveillance and prevention. The DTES, one of the most impoverished urban neighbourhoods in Canada (Evans & Strathdee, 2006; Lazarus et al., 2011), has for several decades been known for homelessness, crime, poor health, illicit drug use, and the survival sex trade. The area’s decline has been tied to a progressive shift westwards of the city core over the 20th Century (Campbell et al., 2009), and more recently, by neoliberal policies of deinstitutionalization and cuts to social housing which have encouraged in-migration of the poor and mentally ill to the area’s relatively affordable accommodations (McCann, 2008). The DTES is now an area of mixed residential/commercial/industrial land use spanning several smaller neighbourhoods, with a diverse population of approximately 18,000 people although this number is likely higher due to under-representation of homeless and low-income residents of the area (City of Vancouver, 2012a). Although a gloomy picture is painted of intense societal challenges, looking deeper, as Asfour & Gardiner (2012, p. 7) describe, unearths “an historic community that epitomizes activism, ability, and creativity”. Roe (2009) outlines the history of community activism in the DTES, and how the strong culture of activism owes much of its existence to a campaign waged by local residents in the late 1960s and early 1970s against the building of freeways into the core of the city, which would have razed several east end neighbourhoods. The success of this community-led campaign helped to engender a culture of counterpublic activism in the DTES, which later expanded to the interconnected challenges of substandard housing, the lack of community and social services, and public health concerns.
Pedestrian injury is a serious issue in the DTES, yet this public health burden was underappreciated prior to the publication of an injury mapping study (Schuurman et al., 2009b) which highlighted the disproportionate burden of pedestrian injury on East Hastings Street in the DTES, a major arterial street that simultaneously bisects this neighbourhood as it connects Vancouver’s city centre with its eastern suburbs. This article was the stimulus for a community-based pedestrian safety collaboration that produced valuable geographical knowledge in the public sphere. Pedestrian safety and injury prevention relies on information collected from injury surveillance activities, commonly defined as the collection, analysis, interpretation, and dissemination of injury data. In addition to more formalized, authoritative approaches to injury surveillance, community-based surveillance and prevention strategies have become popular in recent years. This approach stresses community involvement and multidisciplinary collaboration as Nilsen (2004) notes, due to the assumption “that those most able to solve local injury problems are those people who live in that particular community” (p. 268). Using this approach, the collaboration was successful in influencing policy on pedestrian safety in the DTES neighbourhood (City of Vancouver, 2012b).

8.4.1. All of Us Crossing Borders...

Fuller described public geographies as “about academics, teachers, families, all of us crossing borders [emphasis added] to help create meaningful, contemporary, exciting geography that travels far beyond petty concerns about which river is longest, and where the hell Dubrovnik is . . .” (in Hawkins et al., 2011, p. 921). Although some have conflated traditional and organic forms by describing public geography as about unidirectional flows of geographical knowledge from professional geographer to wider
publics (Mrs Kinpaisby, 2008). I would argue, echoing Fuller, that public geographies (especially organic versions) are best typified by diverse groups actively involved in the production and sharing of geographical knowledge across divides. Yet, public geographies are but one category in the division of geographical labour. The role of each type of geographical knowledge and the borders themselves are retained and indeed valued; thus, borders are crossed, not dissolved. Engaging in border crossings can be a challenge for academics accustomed to operating within traditional academic research and publishing models. Alternatively, non-academic venues such as white papers, trade journals, reports and other ‘grey’ sources are a possibility for reaching wider audiences and decision-makers (Eden, 2005; Peck, 1999), however publishing in these venues alone is not a likely path to tenure or promotion. Still, some academics do engage in grey research and publishing despite the lack of respect it receives and the strong possibility that their teaching and administrative responsibilities will suffer (Burgess, 2005). If public geographies are not about dissolving but crossing borders and recognizing the intrinsic value of public and professional knowledges, then how exactly can this be operationalized in the increasingly restrictive world of academia? In the future perhaps grey research and publishing will elicit full academic recognition and thereby encourage more meaningful forays into the public sphere. In the meantime, open access (OA) publishing represents a third option, or a sort of ‘boundary object’ (Harvey & Chrisman, 1998; Wenger, 1998) that can unite academics and publics. OA can allow an academic to remain within the academic publishing model, yet also reach the eyes of wider publics beyond the academy.

Although the pedestrian safety collaboration evolved organically, it did have a recognized starting point – the publication of the abovementioned pedestrian injury
mapping study that uncovered a public health concern in an already troubled area of the city. The study used the conventional ‘publication as dissemination’ model for sharing the findings; however, it was published in an online OA journal in order to maximize the potential audience since it was believed the findings would be of interest to publics such as safety advocates, local DTES residents, police, and public health professionals. Due to the accessibility of the OA article, and the findings of the study which provided evidence of a hidden public health problem in a neighbourhood already coping with serious health concerns, the press took note and provided coverage just days after its publication (e.g. Pablo, 2009). Restricted access models of knowledge dissemination have been criticized for their limited ability to reach the eyes of politicians and other decision-makers, and, from a political economy angle, for adherence to dubious capitalist modes of production - as Berg (2012, p. 260) describes, traditional, restricted access academic publishers engage in ‘accumulation by dispossession’ strategies “whereby they extract surplus value from the (primarily) state-funded labour of academic researchers, editors, and peer reviewers in the production of scholarly publications”. Certainly, this argument could be deflected since authors and peer reviewers should not receive payment for their contributions in the interest of a rigorous scientific process, and so the academic publishing houses are simply upholding long held standards. Yet, it is in the control of access where this publishing model fails authors by circumscribing potential audiences, and society as a whole by restricting the flow of academic knowledge. Researchers and institutions in low- and middle-income countries that cannot afford purchasing fees for restricted access publications are being cut off from academic progress (Mehlum, 2012), yet in high income countries, non-academic publics can suffer the same fate. OA articles can reach a larger and more diverse audience, are typically cited more often and faster than restricted access articles, and can help to
accelerate scientific progress (Evans & Reimer, 2009; Eysenbach, 2006; Wagner, 2010). For these reasons OA is increasingly mandated by major research funders, national governments, and international organizations (see list of institutions and their policies at ROARMAP, 2012). Anecdotally, in the example of the pedestrian safety collaboration, rapid reporting of the injury mapping study findings by the media, and broad interest in the safety project by diverse stakeholder publics were unlikely to occur had the study been published in a restricted access journal.

While OA publishing can be a useful tool for crossing borders and enabling the flow of academic knowledge to the public sphere, it has yet to make a substantial impact on the dissemination of professional geographical knowledge, however it has rapidly become a subject of debate in the discipline. A key concern is the commonly employed reverse financial model known as ‘Gold Open Access’ in which article-processing fees are levied on the author rather than the reader (or their affiliate institution); this presents an obvious financial barrier for some, and for others, perhaps the impression of ‘buying’ a peer-reviewed publication. Publishing in the discipline’s prestigious (read restricted-access) journals remains a priority for academics seeking career advancement. Moreover, the quality and integrity of some OA journals has been called into question. Dubious practices include inadequate or non-existent peer review, spam email solicitations to publish or join an editorial board, dependency solely on fees to authors, and in the case of some journals, publishing plagiarized works (Beall, 2012). Certainly, these concerns are a serious barrier to the expansion of this publishing model in

3 Jeffrey Beall has an updated list of what he refers to as ‘predatory’ open access publishers and journals at: http://scholarlyoa.com/2012/12/06/bealls-list-of-predatory-publishers-2013/. The methodology is here: http://scholarlyoa.com/2012/11/30/criteria-for-determining-predatory-open-access-publishers-2nd-edition/
geography, yet many OA publishers are legitimate and scientifically rigorous. The use of institutional repositories to share articles, known as ‘Green Open Access’, is also gaining traction as a no-fee, fully open model. For those without institutional repositories, publications can be hosted at Green OA archives such as OpenDepot.org. Some universities it must be acknowledged – despite being portrayed as bastions of neoliberal economics – are actively pushing the both the Green and Gold OA agenda, including my own which will pay the article processing charges for authors (Simon Fraser University, 2011). Finally, perhaps the move by the editors of Geoforum to openly question their own publisher Elsevier’s restricted-access policy is a sign of growing interest in professional geographical knowledge dissemination practices (see Geoforum Editorial Board, 2011; Jackson, 2011).

After the publication of the injury mapping study and subsequent media attention, the City of Vancouver initiated the creation of the Downtown Eastside Pedestrian Safety Project (PSP)\(^4\), which was coordinated by an advocacy group with roots in harm reduction for injection drug users but with a vested interest in pedestrian safety given that their membership consists of potentially vulnerable road users. Project coordinators developed a border crossing strategy that would unite numerous stakeholders, including DTES residents, City of Vancouver employees, public health workers, and academic injury researchers (including myself) to form an advisory group to help steer the project to meet its goals of pedestrian injury surveillance and prevention. The collaborative effort grew organically to comprise multiple components that illuminated the geographies of pedestrian injury in the DTES. Through sharing expertise, professional and public

\(^4\) See: http://pedestriansafety.vandu.org/
geographies entwined, producing deliverables suited for both academic and public audiences. At the same time as the initiation of the PSP, I designed a follow-up academic study to look at pedestrian injury and human behaviour in Vancouver [the subject of the previous chapter], which recorded motorist and pedestrian road-rule violations at intersections in various areas of Vancouver. This surveillance methodology was shared with the PSP coordinators, who identified value in conducting an analysis of violations on East Hastings Street in the DTES compared with other locations around the city. By using this method, the PSP coordinators believed they could demonstrate that both motorists and pedestrians are violating road-rules in the DTES, and – by comparing their data collection to the city-wide academic study – that rates of pedestrian violations would be comparable between the DTES and locations in various parts of the city. Doing so, the coordinators believed, could help to dispel the general impression that the marginalized residents of the DTES – as pedestrians – are solely responsible for the high rate of pedestrian-motor vehicle collisions in this area. Data collected using this surveillance method provided evidence of both pedestrian and motorist violations on East Hastings Street in the DTES – which suggested that DTES residents are not solely to blame – as described in the final report of the PSP (Russwurm & Buchanan, 2010). This lay report, which also described the project’s educational and awareness activities, was submitted to the City of Vancouver at the end of the 9-month project. Central to the report was a thorough discussion of safety measures that should be implemented DTES-wide, and at individual midblock and intersection locations. The academic behavioural surveillance study, meanwhile, was conducted contemporaneously with data collection assistance from PSP volunteers, and was published in an OA journal the following year (Cinnamon et al., 2011). Based on our collaborations with the PSP and their successful use of the surveillance method, the academic paper was framed as a simple, easy-to-
implement method for observing behavioural contributions to pedestrian injury suitable for community-based injury surveillance and prevention advocates, such as the PSP. While the public report and academic publication were each written for and within their particular sphere, they were enabled by crossing borders to harness both professional and public geographical knowledge.

Based on the recommendations of the PSP final report, the City implemented a number of measures to improve safety including pedestrian crossing countdown timers and extended pedestrian clearance times at specific intersection locations, and area-wide, the implementation of a reduced vehicle speed zone (from 50 to 30km/h) along the suggested six-block stretch of East Hastings Street identified in the original injury mapping study (see Figures 8-1 and 8-2). This success in influencing pedestrian safety policy illustrates the tangible benefit of sharing professional geographical knowledge beyond the academy, engaging in public geographies, and harnessing the strengths of community collaborators to see research turned into action. The academic injury mapping study did uncover the pedestrian injury problem in the DTES, made traffic-calming recommendations, and initiated the collaboration, yet simply publishing the article would not have ushered in such swift action. Instead, it was in the subsequent collaboration, and in particular the activism and advocacy skills of members of the PSP that resulted in policy making aimed at improving pedestrian safety.
Figure 8-1: Location of pedestrian injury hotspots and reduced speed zone on East Hastings St in DTES, Vancouver, Canada.

This map shows the pedestrian injury hotspot locations identified in the injury mapping study, and the location of the reduced speed zone implemented on East Hastings St between Abbott and Jackson Sts. Note the correspondence between the locations of the highest density hotspots identified in the injury mapping study and the reduced speed zone. This injury prevention measure was directly informed by the findings of the study, yet was implemented due to the collaborative effort and advocacy work of the PSP.
Several recommendations from the final report of the PSP were implemented soon after its release. Most significantly, a reduced speed zone along a 6-block stretch of East Hastings St, an area of disproportionate pedestrian injury burden as identified in the injury mapping study.

8.4.2. *Conversations, Literal and Metaphorical*

“Communication can alone create a great community” (Dewey, 1927, p. 142).

“Cyberspace in all its diverse forms—chat rooms, blogs, and email, as well as neogeographic practices such as wiki-webs—arguably exemplifies
the Habermasian vision of diverse groups engaging in practical discourse more than any other realm today” (Warf, 2011, p. 19)

Murphy (2011, p. 367) identifies another important tenet of public geography – the notion that “geographers should engage in ‘conversations’ with publics to encourage progressive social change [emphasis added]”, a belief echoed by Fuller and Askins (2010, p. 654) who add that “…these conversations are both literal and metaphorical, encapsulating a wide range of possible approaches and styles of engagement...”. For Dewey (1927), communication was central to an engaged public, yet he argued that the technological advancements of his time such as radio, films, motor cars, and affordable reading matter that might have stimulated interest in public affairs have actually shifted conversations away from political- and community-focused topics. Paralleling Dewey’s account, the World Wide Web was touted as a technological advance that could unite the public, yet Habermasian interpretations of the 1990s era Web (read Web 1.0) downplayed its ability to enhance the public sphere. Forgoing its potential as an enabler of rational-critical discourse and public opinion, as Dahlberg described, “…cyber-interaction is dominated by commercial activity, private conversation, and individualized forms of politics” (2001). In both cases, the technological advances were marked by an increase in one-way communication, not true bidirectional conversation. Recently however, the emergence of ‘Web 2.0’ (O'Reilly, 2005) in the mid-2000s, and rapid development in information and communication technologies (ICT) more broadly are enabling conversations between academics and diverse publics, initiating dialogue and opportunities for engagement. Indeed, Fuller and Askins identify the communication and social media platforms of Web 2.0 as key “tools in the public geographies arsenal” –
both for enabling multidirectional conversations that can lead to organic public geographies, and, as a platform for making them visible (2010, p. 656). The second generation of the Web ushered in a transformative change in the fundamental purpose of the Web – what began largely as a platform for one-to-many information dissemination became a collection of tools for enabling many-to-many conversations between people and organizations with diverse roles in society, which is blurring the traditional producer/consumer binary and making possible the ‘triple dialogue’ touted by Burawoy. Social networking sites such as Facebook popularized this activity, but interaction, communication and participation tools are now standard features of much online activity. Take for example the social-rating systems on retail or social media Websites such as Amazon and YouTube in which a ‘thumbs-up’ or ‘5-star’ rating can strongly influence consumer decisions (Yang et al., 2009), and reader commenting capabilities in online news items in which contributed content can take on a life of its own, initiating new conversational directions and influencing public opinion (Wang et al., 2012)\(^5\). For the media stories covering the findings of our initial pedestrian injury mapping study, reader comments point to both the polemical nature of this issue in Vancouver, and the role of commenting functionality in influencing public opinion and enhancing the public sphere (see reader comments in Pablo, 2009). Indeed, some academic journals are replicating this model, whereby readers can engage in the conversation of science by posting comments or rating an article after publication, thereby creating a sort of crowdsourced peer-review and alternative to the controversial

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\(^5\) For an interesting example of this phenomenon, witness a comment thread in an article about a new restaurant opening in the DTES morph into a heated debate about gentrification: http://scoutmagazine.ca/2013/02/03/diner-a-look-inside-chef-makoto-onos-stylish-pidgin-on-the-downtown-eastside/#comments
Impact Factor (Crotty, 2009). The ‘live’ article – enhanced by Web 2.0 communication and interaction tools – has been proposed to allow the reader to, for example, interact with the study data, and contribute to the article’s discussion section (Ahlqvist et al., 2013).

Habermas and others have traced a connection between the decline of the public sphere and the growing ability of the press and mainstream media to shape public opinion according to their own ideals; yet the world of media is rapidly changing in the era of Web 2.0. Although the dust has yet to settle, traditional one-to-many models of communication are being challenged by social – i.e. consumer-generated – media, which is reducing the ability of mainstream media to control public opinion and the flow of information (Holtz, 2006). Social media have transformed how information is shared, the speed at which it becomes available, and crucially, the voices that are able to contribute and help shape public opinion. These advancements are enabling a more engaged citizenry – a ‘citizen 2.0’ – whereby the general public can be widely consulted with speed and ease, and in doing so can help to influence public opinion and decision-making on issues of public policy (Kloby & D’Agostino, 2012). With respect to political participation, social media can encourage engagement in politics by typically disengaged groups such as youth (Holt et al., 2013). Blogging and microblogging (e.g. Twitter) have become an important platform for fast and efficient communication and knowledge sharing. For academics, they are an increasingly common way to rapidly communicate

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6 The Society for Scholarly Publishing’s blog, “The Scholarly Kitchen: What's Hot and Cooking in Scholarly Publishing” (available at: http://scholarlykitchen.sspnet.org/) has a number of interesting posts providing insight into the academic publishing industry. Entries examine, for example, the (de)merits of the peer review process and the Impact Factor, and emerging trends in scholarly communication including open access publishing and alternative impact metrics.
research, reaching much wider publics than traditional dissemination in specialized journals and at conferences. By posting to a blog, an academic can instantly foster the triple dialogue through multidirectional conversations with readers, and between readers through their commenting functionality. For the general public, activists, and politicians, blogs and Twitter represent a simple way to get involved in public debates on issues of personal or professional interest. Organizers of the Pedestrian Safety Project, for example, actively used a blog and other social media to engage the public during the project and to disseminate the final report at its conclusion, as have other public geography initiatives (e.g. Engaging Geography, 2008; Making the Connection, 2008; Rescue Geography, 2009). While advancements in Web communication can enable conversations and the sharing of diverse geographical knowledges, access and utilization remain challenges. Although Warf (2011) describes the Web as potentially a very strong contributor to the public sphere, he also draws attention to Internet censorship in several countries and the digital divide in society as barriers to this possibility. A recent survey of academic geographers pointed also to a generational divide, in which younger and early-career geographers were more engaged with Web 2.0 tools such as blogs, Twitter, and social networking, compared with their older and more senior counterparts (Wilson & Starkweather, In press). These challenges illustrate the potential for these technologies to actually reinforce asymmetrical communication if some voices dominate at the expense of others. Web 2.0 also presents a challenge with respect to how these technologies are influencing processes of learning and knowledge production and the attendant effect on attention spans (Schuurman, 2012), which should be a concern for anyone wishing to use these technologies for collaboration and multidirectional conversations. It is certainly premature to pass judgment on Web 2.0 as
a true architect of the public sphere, yet the potential is there for enabling conversations and the sharing of geographical knowledges across borders.

8.4.3. Communication Geographies

Geographers specifically, I would argue, are well positioned to engage in conversations with publics, given the advantage of their attention to topical issues at local, regional, and global scales. The geographical nature of many issues of concern to the public – climate change, gentrification, disease outbreaks, and globalization to name a few – presents a distinct advantage for bringing together public and professional geographies. The communicative strengths of the discipline itself, however, might be an even greater advantage. Interest in communications and media studies is at a high point in geography, evidenced by the formation of the Communication Geography specialty group of the Association of American Geographers, the launch in 2007 of Aether: The Journal of Media Geography, and a number of new books and publications on the topic (Adams, 2009; Sui & Goodchild, 2011). Indeed, according to one observer writing in 2010, at least one article from the majority of recent issues of leading geography journals contain reference to communications/media (Adams, 2010). Likewise, corresponding attention to geography from within communications/media studies suggests much in common between the two disciplines, and perhaps the potential for a new, semi-autonomous field at their interface (Adams & Jansson, 2012). Geographers’ explorations in communications and media are both extensive and heterogeneous; more obvious engagements include research on the geographies of Internet and ICT (e.g. Batty, 1997; Kitchin, 1998; Warf, 2013; Zook & Graham, 2007) and geographic analyses of communications infrastructure (e.g. Grubesic & Murray, 2006; Torrens, 2008). Other
immersions explore the use of media such as film in geographic research (Garrett, 2010), the production of place and space by journalists and newsmedia (Buchanan, 2009), and explorations of media and communications through the lens of cultural geography (Aitken & Zonn, 1994; Lukinbeal, 2004). Perhaps, however, the deepest and longest running connection between communications/media studies and geography exists in the field of cartography and geographic visualization.

The strongly visual focus of humans is an advantage for geographers – given the strongly visual focus of geographic research and pedagogy (Rose, 2003; Thornes, 2004) – especially for those that use maps and other visualizations in their work. Given their pervasiveness in society, cartographic and other visualized representations represent a powerful platform for enabling conversations with publics. The initial injury mapping paper included a kernel density map (an earlier version of Figure 8-1) illustrating high-density locations of pedestrian injury in Vancouver. The visual image – which clearly identified the DTES as the epicentre of pedestrian injury in the city – became a valuable and influential communication device for the PSP. Once I became involved with the PSP, the map was shared with the project coordinators for reproduction in their educational and promotional materials including flyers, the Website and blog, and the final report; additionally, the map was used on the City of Vancouver’s own Website about the project\(^7\). While maps can certainly stimulate conversations with diverse publics, the established and still-influential ‘map communication model’ conceptualizes communication as a one-way process, from cartographer to map-reader (Hallisey, 2005). Poore and Chrisman (2006) suggest that two common yet outdated geographic

\(^7\) Can be viewed at http://vancouver.ca/people-programs/pedestrian-safety-in-the-dtes.aspx
information metaphors borrowed from cybernetics have hamstrung the progressive and socially responsible use of maps and GIS. This includes what the authors refer to as the\textit{invariance} metaphor, which conceptualizes information as something that is transported unidirectionally (e.g. by a cartographer) through a conduit (e.g. a map) without loss (e.g. being changed or employed by the end user differently than intended by the creator). The second, what the authors call the \textit{refinement} metaphor (aka the DIKW Pyramid) depicts information as the second stage in the unidirectional refinement of raw data into information, knowledge, and finally, to wisdom. Undoubtedly, in the context of map and GIS use for sharing professional and public geographical knowledge, a conversational metaphor is more fitting. As the authors argue, “it is possible that the notion of communication should be reframed as conversation – a two-way process [emphasis added]” (2006, p. 519), because “[i]nformation is actively transformed and reworked by its recipients. The originators of the information are no longer in control of meaning” (Poore & Chrisman, 2006, p. 520). This was certainly the case in the use of the injury density map by the PSP. The meaning of the map was actively reworked over the course of the project, from its academic origins as a spatial illustration of pedestrian injury in an urban setting, to its use by the media as a further example of health inequities in a marginalized neighbourhood, and finally to its use by the PSP as a rallying cry for pedestrian safety in the DTES.

GIS technology is highly touted for its ability to bring disparate stakeholders together (Benigeri, 2007), including researchers, administrators, policy makers, and advocacy groups. The ability of GIS to communicate and share knowledge has led some observers to call for GIS technology itself to be reframed as media – i.e. a platform for communication – rather than simply a problem-solving tool (Sui & Goodchild, 2001,
Yet, as has been widely discussed since the late 1980s, maps and GIS are not neutral and value-free, rather they construct as well as communicate knowledge (Crampton & Krygier, 2006; Harvey & Chrisman, 1998; Kitchin & Dodge, 2007). In an early paper that strongly informed the emerging ‘GIS and Society’ movement in the 1990s – an area of inquiry that explores the social implications of GIS (Pickles, 1995; Sheppard, 1995) – Harley (1989) argued that maps should be understood as social constructions, as sites of power-knowledge – a theme that has been echoed by subsequent commentators (Kitchin & Dodge, 2007). To the naïve map-reader, cartographic outputs can read as objective reality, not subjective (and possibly biased) representations that are in fact “…open to interpretation, contested, and mutable” (Del Casino & Hanna, 2006, p. 39). The mutual engagement of professional and public geographies hinges on the elimination of hierarchical relationships between academics and publics; thus, it is imperative that cartographic outputs are carefully produced to resist bias and asymmetrical power relations. Certainly, the take away message is the need for caution when engaging in conversations with publics using maps and geographic visualizations given their powers of persuasion and potential subjectivities. Advice and approaches for promoting the socially responsible use of GIS and maps have been developed over the past two decades, as part of the critical GIS (Schuurman, 1999) movement. Critical GIS draws from myriad subjects of inquiry, including philosophy, critical theory, science and technology studies (STS), participatory action research (PAR), and feminist studies to critique the social implications of geospatial technologies (Chrisman, 2005; Elwood, 2010; Leszczynski, 2009b; McLafferty, 2005; Schuurman, 2009). In addition to theoretical interventions, critical GIS has spawned methodological and epistemological approaches that seek to address these concerns. For instance, research and practice in participatory GIS (PGIS), public participation GIS
(PPGIS), and community mapping have actively sought to eliminate power-laden hierarchies between academics/GIS practitioners and participants, not in the least by placing GIS technology in the hands of under-represented communities (see Corbett & Keller, 2005; Dunn, 2007; Elwood, 2006; Harris & Weiner, 1998; Sieber, 2006). Feminist and qualitative GIS, as sub fields of critical GIS, seek to rewrite the technology to reflect diversity in knowledge production and representation (Cope & Elwood, 2009; Kwan, 2002; Kwan & Knigge, 2006; Pavlovskaya & St. Martin, 2007). For GIS scholars and practitioners interested in sharing professional geographical knowledge with publics, the critiques and interventions of critical GIS might provide the foundation for successful, equitable collaborations and public geographies.

Having said all that, GIS, as we know it, is dead\(^8\). Advancements in Web-based geospatial technologies, collectively referred to as the Geospatial Web (GeoWeb), are rapidly revolutionizing this domain. GeoWeb tools such as virtual globes (e.g. Google Earth), interactive Web-maps (e.g. Bing Maps, OpenStreetMap), reworkable application programming interfaces (e.g. Google Maps API), and map mashups (e.g. www.housingmaps.com, a combination of Google Maps and Craigslist accommodation ads) have flourished in the public realm. Sui and Goodchild (2011), in an update of their earlier ‘GIS as media’ argument, frame this revolution in geospatial technology as the unification of GIS and social media, due to their user-friendly interfaces, their low (or no) usage fees, and their Web 2.0-inspired interaction and communication capabilities. Members of the public that use these technologies – aka ‘neogeographers’ (Turner, 2006) – actively produce geographic information for the public good; for instance,

\(^8\) This of course is hyperbole, but there does appear to be a transition away from the hegemony of trained GIS experts operating expensive and complex desktop GIS.
citizens are now vital sources of location data in the aftermath of catastrophic events such as oil spills and natural disasters (Goodchild & Glennon, 2010; Liu & Palen, 2010). It is becoming apparent that using GeoWeb technologies to produce geographic information “has become a language for citizens to voice their opinions on world events that are of interest to them. They are not only talking to themselves but also broadcasting about their findings to the world, or at least to those who have access to the Internet (Sui & Goodchild, 2011, p. 1738). Undoubtedly, this phenomenon is enabling conversations and border crossings, and perhaps, represents “one of the best examples of public geographies” (Raven-Ellison in Haklay, 2009). In this case, however, citizens are crossing borders to engage in mapping activities that in the past were mostly confined to academic and government realms. In doing so, citizens are creating their own public geographies (with or without academic collaboration), and in doing so are helping to promote the discipline. Yet, it is but a narrow slice of the discipline. The public’s rapid and widespread production of ‘spatial’ geographical knowledge via the GeoWeb is perhaps a double-edged sword. While this interest by a sometimes geographically-averse public is encouraging, there is a danger of pigeonholing a broad and diverse discipline of ‘contested identities’ (Turner, 2002), and further engendering geography’s distorted public image (Carter & Steinbrink, 1974; Walker & Unwin, 1989). True diversity in geographical knowledge production will require also bringing to light the many other (non-)representational geographies. How and in what ways this can be

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9 This type of ‘citizen science’ activity does have a much longer history, however, the GeoWeb and Web 2.0 have drastically increased the scale and frequency of these activities.
accomplished is perhaps a future research objective for those interested in sharing professional geographies with wider publics.

8.5. Conclusion

In a past-president’s address to the Association of American Geographers, Murphy (2006) implored that geography as a discipline must seek to fuel public debate and generally be more influential in the public sphere. The author sets out a prescriptive agenda for promoting the use of geographical knowledge and approaches for societal issues. As have many other commentators however, his argument focused on one half of the equation – the need to unidirectionally transfer geographical knowledge from universities to the wider world. As I hope to have made apparent in this paper, perhaps a better way to promote the discipline and to foster stronger academy-society relations is to reframe the debate by promoting the existence and value of diverse geographical knowledges and the myriad sites of knowledge production, rather than reigniting the longstanding polemic of research relevance. In doing so, cooperation and mutual appreciation can define the academy-society relationship rather than apathy and disconnection. While some may see this as a threat to the academy, public knowledge can instead be viewed vis-à-vis its potential to complement professional varieties, and the novel potential this might unlock for societal advancement. In addition to drawing on notions of the public sphere by Habermas and his critics, Burawoy’s division of academic labour, and the emerging public geographies movement, this argument was also developed by unpacking a collaborative pedestrian safety project that unfolded organically at the interface of public and professional geographies. Although the project was initiated by transferring professional geographical knowledge to the public sphere,
developing a triple dialogue – between academics, between academics and publics, and between publics themselves – ultimately led to the project’s success in influencing safety policy. While the paper identified border crossings through open access publishing and engaging in conversations with publics via Web 2.0 technologies, citizen-generated (social) media, geographic communications, and GeoWeb technologies as key enablers, certainly this is a situated and partial list. Hopefully it will encourage a much deeper exploration of the factors that help to unite professional geographers of all stripes with their publics.

The division of geographical labour is (and perhaps should remain) skewed such that academic (professional and critical) geographies are dominant. However, acknowledging the multitude of knowledges produced outside the walls of the Ivory Tower will benefit both the academy and society. For society, this will serve to enhance the public sphere, helping it to fulfill its important democratic role as a mediator between the private sphere and the structural forces of the state and market. An active public sphere fuelled by a strong academy-society connection will also encourage the formation of informed public opinion on important societal issues, many of which are inherently geographical. At the same time, the growth of extra-institutional geographical knowledges will stimulate geography as an academic discipline, yet it will be necessary for academics to embrace these knowledges. Fuller and Askins’ (2010) progress report outlined numerous examples of public geographical knowledge production, and concluded by posing a question for further thought: “given that many non-academics appear to be doing some amazing and inspiring projects and activities, thoughtful, critical and (arguably) examples of organic public geographies, what then is academia’s role?” (2010, p. 654). As I have contended, professional geographers can play the role of
catalyst of public geographies, while also providing leadership and expertise on challenges requiring more specialized geographical knowledge. The multitude of geographies produced in the public sphere should not be perceived as a threat but rather an opportunity to engage publics and to open the ‘black box’ of academic geography. To paraphrase Burawoy, public geographies “should not be left out in the cold, but brought into the framework of [the] discipline” to make them a visible and legitimate enterprise, which will also help to revitalize professional geographies (2005a, p. 4).

Not all professional geographers will have the opportunity to engage in these oft-unplanned collaborations with publics; for those that do get the chance, their personal agency, political beliefs, and positionality will determine whether opportunities that present themselves are followed up (Fuller & Askins, 2010). In the end, however, the ability for professional geographers to engage with wider society is primarily a function of the level of support within the system, and unfortunately, current academic structures act to obstruct these engagements. While academics are superficially encouraged to reach beyond the university, efforts to do so are rarely or inadequately recognized, in research assessment exercises or for tenure and promotion. Yet, there appears to be some progress in the fight to adequately recognize these activities. In the UK for instance, the upcoming Research Excellence Framework (REF) has been restructured to recognize the economic and social ‘impact’ of research, although this has not been without its critics. Pain et al. (2011) cautiously support impact accounting in the REF, yet – paralleling the argument drawn out in the present paper – also stress that impact is a bidirectional force between academics and publics and so impact metrics must recognize and encourage co-produced knowledge. As the authors state, “relevance and
accountability might be better produced were the metric of impact explicitly attentive to instances in which academics listen, not only talk, to the rest of society” (p. 186). Thus it will be necessary for academics to continue to push for greater recognition of public engagements, much as it will be necessary for geographers themselves to recognize and engage with the diverse geographical knowledges produced in the academy and society.

8.6. Acknowledgements

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9. Conclusion

Injury is one of the leading causes of death and disability in all countries of the world. Local scale policies and governance pertaining to safety clearly have an influence on local rates of injury; yet at the same time, global processes such as industrialization, globalization, and motorization also influence injury at various scales but with local consequences. Given the multi-scalar nature of the causes, consequences, and effects of injury, using a global health lens such as the one outlined by Bozorgmehr (2010) may be useful for understanding local injury experiences by situating them in global contexts.

This dissertation has attempted to understand and address local injury surveillance challenges in two diverse settings, through viewing them as parts of an integrated global health project informed by global considerations. In addition to the empirical knowledge obtained about injury in Cape Town and Vancouver, the overall findings of the project contributed theoretical and methodological knowledge to an emerging literature on injury surveillance in low-resource settings, and in particular, advanced the discussion concerning the role of geospatial technologies in these activities. The following section summarizes and discusses the contributions of each chapter and the dissertation project as a whole, and ponders some future research questions and directions that the project could give rise to. Following this, I personally reflect on the project and how it evolved, and the contributions it has made to the two fields the comprise the conceptual framework. Lastly, I discuss the challenges and limitations of this research.
9.1. Project Summary, Research Contributions, and Future Research Directions

In Chapter 2, a pilot study demonstrated the feasibility of a series of simple data collection, management, and visualization protocols to enable hospital-based surveillance in a low-resource setting, the Trauma Unit of Groote Schuur Hospital in Cape Town, South Africa. Locally, the main contribution of this study was the successful collection of a minimal injury dataset that could be used for epidemiological and administrative purposes. Another contribution was demonstrating the potential utility of Web-based data management and visualization technologies for surveillance. This aspect of the study was designed to inform other surveillance projects in resource-constrained environments, and the findings have contributed to a small but growing literature regarding the use of GeoWeb and Web-based technologies for scientific and public health inquiry. The success of this initial pilot study initiated a longer-term (12-month) surveillance project at the hospital. Although not reported on in this dissertation, the second study built on the knowledge gained from the study described in Chapter 2. I was involved in the design and startup of the longer-term surveillance project, however the data collection protocol was designed such that existing clinical staff in the hospital were responsible for its collection. Currently the data are being analyzed, which will provide a wealth of information on injury morbidity and mortality in Cape Town. Future plans to develop and refine the surveillance protocols for this hospital are in development. The next major phase of the ongoing surveillance project is focused on the development of a digital interface to collect injury data in the hospital setting. This system will allow for clinical staff to enter data at the point of care, which would remove the data entry step. Currently the system is in development and pre-testing, and will
eventually undergo a comprehensive multi site user test in health facility settings. If successful, this approach could enable low-resource settings to leapfrog paper based data collection to full electronic data entry and management, a status that more well-resourced settings are yet to fully take up. The knowledge acquired from the findings of Chapter 2 provided the foundation for the subsequent longer-term surveillance project, which itself prompted the current phase.

In Chapter 4, an alternative strategy to conventional data collection was developed to investigate the spatial context of injury in Cape Town, due to a lack of data available from existing sources. Using GeoWeb technologies and a novel citizen-generated data approach, injury hotspot location data were collected based on the opinions of an informed participant group. In addition to contributing knowledge regarding the local spatial context of injury in Cape Town, this chapter also contributes to the bodies of literature on the GeoWeb, VGI, and citizen engagement, especially with regards to their role in scientific inquiry. Further, the chapter expands the conversation on health equity to the issue of unequal access to data – the ‘data-divide’ – an overlooked yet significant global asymmetry with serious consequences. Knowledge of the location of injury hotspots in Cape Town will allow for research to be conducted on the social, behavioural, and environmental determinants of injury at the newly identified locations. Future research is planned to empirically assess the built and social environments at these hotspots using an approach similar to the one developed in Schuurman et al. (2009b), and the behavioural determinants of injury using the approach developed and tested in Vancouver and described in Chapter 6.
Chapter 6 describes a method that was developed for exploring behavioural contributions to pedestrian injury, an important, but not well-understood determinant. This method for community-based surveillance was used to collect violations data from seven hotspot intersections across Vancouver. Findings were highly variable between locations, perhaps suggesting that each individual hotspot is unique in terms of aetiology. This finding speaks to the highly localized nature of injury, and in general, how targeted prevention rather than large-scale generalized programs may be more effective. In terms of research contributions locally, this study uncovered the top intersection-level pedestrian injury hotspots in Vancouver, and elucidated some of the potential behavioural contributions at each location. More broadly, this study contributed to a nascent methodological literature on community-based injury surveillance. The method was designed for community groups and other organizations with limited resources that wish to understand an injury problem in their local area. Indeed, the method was designed with input from members of a local community-based pedestrian safety project, and was used by the group for surveillance at locations within the impoverished DTES neighbourhood. Future research in this area should focus on combining this behavioural surveillance method with techniques to assess the impact of other social and environmental determinants of pedestrian injury. A mixed-methods approach that combines for example quantitative spatial analysis of the built-environment and roadway design with interviews with various road-users could provide a much bigger picture of the role of these factors in mediating pedestrian injury in urban settings. As noted above, future research will transfer and adapt these methods for examining motor-vehicle and pedestrian injury in Cape Town.
In Chapter 8, the collaboration that led to the development of pedestrian safety policy-making in the DTES was explored, and situated within theories of knowledge production and public engagement. The chapter investigates emerging ideas for framing the academy-society relationship, and argues for the importance of recognizing the wealth of geographic knowledge produced in the public sphere. This chapter demonstrates with a specific example – the production of geographic knowledge by a DTES community-based surveillance and prevention project – the value of publicly created knowledge. By recounting how this collaboration between diverse stakeholders unfolded and its success in influencing safety policy and (most likely) injury prevention, the chapter suggests that the academy-society relationship should be understood as a bidirectional and mutually beneficial association. While the collaboration itself was locally-based, this chapter targets an audience in geography and academia more broadly. Its main argument, that valuable knowledge is produced in myriad domains, might be a useful contribution to ongoing debates on research relevancy and academy-society relations. My future research plans involve exploring the links between this idea of public knowledge production/public geographies, and the emerging interest by the public in GeoWeb technologies and citizen-based spatial data production. My intention is to bring together these two areas of inquiry, to see how their concepts and understandings can inform each other.

While each individual chapter is unique and distinct, the overall project is quite narrow in focus and its purpose can be summarized simply: to explore local, feasible solutions to injury surveillance, but also to design these solutions with the ‘global’ in mind. The focus on global-local relations and processes as they relate to injury
surveillance was a major contribution of this dissertation. ‘Globality’ was enacted in two ways:

1. By framing local solutions within global health contexts.

2. By seeking first to address a local-injury problem, but at the same time, trying to connect with and contribute to larger ‘global’ bodies of knowledge in health, geography, information and communication technologies, and beyond.

Advancing the conversation regarding approaches for engaging in injury surveillance in low-resource settings is a defining contribution of this dissertation. This was achieved through demonstrating the feasibility and utility of streamlined, locally-appropriate, low-cost, and easy-to-undertake solutions for both community- and hospital-based surveillance. Through theoretical and methodological developments, this project has contributed to a small but increasingly important body of literature concerning injury surveillance in low-resource settings – both in high-income countries (e.g. Auer et al., 2011; Auer & Andersson, 2001; Brussoni et al., In press) and in low- and middle-income countries (e.g. John et al., 2008; Kobusingye & Lett, 2000; Liu, 2009; Matzopoulos et al., 1999; Schultz et al., 2007; Schuurman et al., 2011). It is hoped that this dissertation will stimulate an expanded interest in the development of enabling solutions for injury surveillance, and public health surveillance more broadly.

A significant contribution of the overall project was its focus on demonstrating the value of geospatial technologies for all stages of injury surveillance – data collection, analysis, interpretation, and dissemination. Although the role of geospatial technologies in the analysis and interpretation stages have been well documented, very little has been written about the use or value of these technologies for the other stages of surveillance. The use of geospatial technologies for data collection was demonstrated most evidently
in Chapter 4, whereby a GeoWeb mapping interface enabled the collection of citizen-generated data on injury hotspots. Mapping and visual analysis of injury surveillance data was conducted in Chapters 2, 4 and 6, as was the interpretation of the findings. Dissemination, the final stage of surveillance, was an important aspect of the pedestrian safety collaboration discussed in Chapter 8. This holistic approach to geographic injury surveillance is a defining contribution of this dissertation. Moreover, Chapter 8 also speaks to the value of mapping and geospatial technologies for injury prevention, the ultimate goal of all injury surveillance activities. This chapter identifies the 'power of the map' in communicating the disproportionate burden of injury in the DTES, which laid the foundation for subsequent injury prevention policy-making. With respect to the use of geospatial technologies and a geographic lens in injury surveillance, future research should seek to move beyond their use solely for data analysis and visualization. These technologies hold great potential for data collection and management, and also dissemination and decision-making in this domain. This dissertation has only scratched the surface of this potential.


Reflecting back to the early days of my doctoral studies, I had always planned to situate my dissertation project within global health. At the time, although I was not entirely sure of the specific research studies I would undertake, I envisaged the entirety of my project to be undertaken in Cape Town. Concurrently to the first few years of my doctoral studies, I was also involved in locally based injury surveillance activities,
including those documented in Chapters 6 and 8. As the years progressed, I increasingly observed parallels between my projects in the two locations. At a fundamental level, the research objectives were the same, and the settings ended up being similar. At one point I realized, I was ‘doing’ global health research in both locations. Reading deeper into contemporary conceptualizations of global health suggested the suitability of combining the research from the two locations into an integrated global health project.

I believe this project not only takes from global health, it contributes new knowledge to it. For instance, the research described in Chapters 2 and 4 is heavily informed by the focus on international partnerships to advance health, yet the findings provide little new knowledge to advance global health in this regard. On the other hand, Chapters 2 and 4 are also heavily informed by concepts of health equity, yet it advances the conversation to consider access to data as a fundamental issue of global health equity. In Chapter 6, the determinants of health concept is advanced by focusing on behavioural contributions. Actions and behaviours on the part of individuals are clearly associated with health outcomes, yet surveillance of behavioural determinants is under-explored. This is perhaps due to the challenges in empirically measuring behaviours, however, the study in Chapter 6 is a starting point for future, perhaps more rigorous inquiry into these determinants of health. While Chapters 2 and 4 take from global health concepts of partnerships to advance health without adding much new knowledge, Chapter 8 advances knowledge in this area. The argument and conceptualization of collaboration and knowledge sharing between diverse domains has much to offer the global health body of knowledge concerning partnerships.
If I had the chance to start over, I would do a few things differently. Primarily, I would have attempted to conduct the same studies in both settings. This would have allowed for more directly comparative research, thereby potentially increasing the overall impact of the findings. Secondly, I would have actively tried to engage in more overtly bidirectional knowledge exchange between my research settings. Admittedly, the directional flow of the overall project is primarily North – South, yet many innovations originating in the Global South could add value for research and health system administration in the Global North. The concept of ‘reverse innovation’ – originally described in business settings – has recently shown up in the global health literature. The idea is to take health and medical innovations developed in LMIC and implement them in HIC, for the purposes of cost-containment and streamlining of health systems and public health research (Bottles, 2012). The ongoing Global To Local (G2L) reverse innovation project is being carried out in an impoverished area of Washington State with large health disparities. A partnership between several stakeholder organizations, “G2L builds on the expertise of Washington State’s global health institutions, bringing home strategies that have proved effective in addressing health disparities in developing countries. G2L is piloting approaches to improve individual and community health outcomes, lower health care costs, and empower economic development” (Global To Local, 2012). Reverse innovation perhaps is the best indicator of truly globally-focused health. In terms of reverse innovation at a smaller-scale, my dissertation may have been enhanced by, for example, borrowing simple data documentation strategies from Groote Schuur Hospital and applying them to my community-based work in Vancouver.

As with global health, this dissertation not only takes from critical GIS, it contributes new knowledge to it. While this project was informed by the theory and
practice of critical GIS – especially in the areas of public engagement and access to GIS, data, and decision-making – it also adds to these literatures. In particular, this dissertation advances the conversation about the potential of the GeoWeb and its social phenomena to fulfill the potential laid out by critical GIS via PPGIS and other GIS-2 efforts. Although the evidence is circumstantial, demonstrating the usability, accessibility, and grassroots potential of these technologies and data production approaches suggests their potential to overcome some of the persistent criticisms of geospatial technologies. Also, while Chapter 8 in particular is indebted to the large body of theory and practice devoted to participatory and community-based GIS, I believe it adds new dimensions for thinking about relationships between experts and amateurs, the democratization of knowledge production, and turning knowledge into action – all core concerns of critical GIS.

9.3. Challenges and Limitations

The individual studies and the overall dissertation have several limitations. While the limitations of each study have already been discussed within each corresponding chapter, it is worth reiterating some of the main drawbacks that might limit their impact. A main goal of the Cape Town research was to investigate how the GeoWeb and its social phenomena might contribute to injury surveillance. While valuable as a proof of concept, a number of limitations are evident. First off, the digital-divide, which manifests itself in low-resource settings in particular, will restrict the actual implementation of the described protocols in many places, despite rapidly increasing access to the Internet and information and communication technologies. Also, as briefly discussed in Chapter 2, the actual value of the basic GeoWeb platforms for mapping and analysis was not assessed.
Are they actually useful for the analysis stage of surveillance? Also, are they usable? An informal user-test suggested their usability in this setting as described in Chapter 2, however more extensive testing is needed. Finally, with reference to the Web-based technologies, privacy and security regulations are a severe limitation to using these platforms for the storage and visualization of health data. Indeed, Chapters 2 and 4 only demonstrated these technologies; longer-term storage of the data on the Web was not possible due to restrictions in place by the ethics boards, despite the anonymity of the records.

While the method for surveillance of behaviours in Vancouver was developed to serve a particular context and user-group, by itself it is unlikely to provide a clear picture of behavioural contributions, only the potential need for interventions targeting this determinant. The dataset collected using this method, by itself does not provide much more than anecdotal evidence of the contributions of behaviours at the particular locations surveyed. This is not strictly a limitation as the primary goal was to develop and test the method; however, a more in-depth, multi-dimensional analysis of the determinants of pedestrian injury would be required to provide definitive evidence. With regards to Chapter 8, it is worth mentioning that collaboration and public engagement go largely unrecognized by many academic institutions, meaning opportunities to exchange knowledge with the public are infrequent. This is not a limitation of the chapter, but a limitation of academia itself.

Overall, for the dissertation as a whole, a main limitation is the lack of transferability of the findings. All of the studies were unique and discrete, and any findings cannot be confirmed equivocally. Ideally, the findings would provide robust
evidence that would allow other researchers and injury surveillance advocates to utilize the technologies, protocols, and methods from this dissertation to conduct similar projects in other settings. Certainly, this work provides a foundation for other surveillance projects, however the findings are more exploratory than confirmatory. This dissertation was always envisaged as an exploratory study given the lack of existing knowledge in this area; however, future research may wish to seek transferability in order to advance geographic injury surveillance in low-resource settings.
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Appendices
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