THE EPIDEMIOLOGY OF CIVIL WAR

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Acknowledgements

Setting out in graduate school I knew that I wanted to study armed conflict and trace out that violence across space using maps. I have always felt that maps tell the best stories and wanted to explore armed conflict in a way that let me leverage mapping tools in a substantively meaninful way. I did not know in advance that I would eventually study infectious disease diffusion, nor did I anticipate that world events would eventually underscore the importance of this topic. A study of infectious disease and armed conflict is inherently interdisciplinary and I am certain it is a topic I would not have been able to study absent the right people in place to let me pursue it. Over the years these right people have helped to greatly improve this dissertation.

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Abstract

This dissertation explores the causal connection between violence occurring in armed conflicts and the emergence of infectious disease within or in close proximity to active conflict zones. While we have known for quite some time that war leads to disease, our understanding of what types of violence contribute to higher (or lower) incidence of specific types of infectious disease remains limited. Establishing the connection between disease and patterns of violence in armed conflict is important since that knowledge can help to inform where humanitarian aid should go and, crucially, what form that aid should take to best support the health needs of civilians suffering the effects of violence.

I propose a new theory explaining the disease-conflict connection through a mechanism of civilian population movements in response to changing patterns of observable violence occurring across varying conflict contexts. Variation in conflict intensity as well as the spatial location of that violence – conflict geography – helps to explain downstream variation in the spread of infectious disease. This theory relies upon a mechanism of rational civilians making decisions to maximize their safety in response to violence. As security conditions deteriorate, civilians attempt to improve their situation by pursuing a strategy to remove themselves from areas which present the greatest risk to their personal integrity. In order to decide how to respond to the violence they observe, civilians *jointly* examine the intensity and geographic location of violence and decide whether to *shelter* in place, *shuffle* into nearby areas to find safety, or *flee* longer distances into neighboring regions or countries.

My dissertation demonstrates that conflict context shapes how civilians respond to changing levels of violence. The varied strategies civilians pursue in response to this violence influences the spread of infectious disease by shaping which disease-causing pathogens civilians are more or less likely to encounter. Some patterns of violence facilitate *contagious* disease transmission while others create ideal conditions for *noncontagious* disease infections. By explaining the connection between conflict and war through civilian displacement mechanisms, the theory presented and tested in this dissertation allows us to better understand why disease emerges in some conflicts but not others, but also where and what types of disease will emerge across different conflict contexts.

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Chapter 1

Introduction

Disease often spreads in war. Multiple outbreaks of Ebola within insurgent controlled regions of Democratic Republic of Congo over the past two decades, widespread cholera infection during Yemen's civil war, and high rates of polio transmission during the height of the Iraqi civil war each have caused extensive suffering and mortality. Indeed, even millennia ago near the start of the Peloponnesian War, plague erupted in Athens as a result of the conflict.[1] This pattern has not changed with the passage of time and clearly persists now - disease and violence closely follow one another in war zones. But different wars often lead to the spread of very different diseases. Why? Consider two of the longest-running recent civil wars, in Colombia and Syria, respectively. In 2002, following an escalation in patterns of violence compared to trends just a few years prior, the US Centers for Disease Control declared an outbreak of measles in Colombia (US Centers for Disease Control and Prevention 2002). A decade later in Syria, Aleppo suffered a major outbreak of leishmaniasis (Rehman et al. 2018). Measles and leishmaniasis have very different causes: measles is caused by a virus

[1] The outbreak of disease in this case followed a large influx of civilians from surrounding regions escaping violence carried out by invading Spartan military forces. Contemplating the cause of this plague, Thucydides remarked that the situation was "aggravated by the crowding of country folk into the city... they had no houses... their mortality was out of control" (Thucydides 1993, p. 49).

transmitted between individuals and leishmaniasis is caused by parasites spread by sand flies. Left untreated each of these diseases is highly lethal. The World Health Organization reports that measles may cause mortality in 3-5% of cases but may reach as high as 30% and leishmaniasis causes fatality in over 95% of untreated cases (World Health Organization 2022a). Given the stark challenges of providing medical care in conflict zones, understanding which diseases are likely to emerge in which conflicts has the potential to arm health care providers with critical information.

This dissertation aims to fill the gap in our understanding of which diseases emerge in which conflicts and why. I argue that patterns of civilian displacement triggered by distinct patterns of violence in armed conflict create different risks of pathogen exposure among escaping civilians leading to unique downstream disease outcomes. Armed conflicts represent an ideal setting for the emergence of new disease. Measles, hemorrhagic fevers, and some forms of plague all spread more easily among densely-concentrated groups of people who cluster together while running away from the serious consequences of violence on a battlefield. While escaping conflicts, civilians also have an increased chance of coming into contact with wildlife creating new opportunities for novel zoonoses - new animal-to-human infections - to spill over into a human population. When these events occur, a virus that may produce no observable indicators of illness in an undomesticated, infected animal population can begin to rapidly spread through a human population that lacks any background exposure to mount an effective immune system response against the new disease (Wise 2017). Such events have devastating consequences on public health.[2] Civilians fleeing from belligerents by running into forested areas have much higher odds of exposure to these types of viruses likely to spread with close proximity to wildlife. Armed con-

[2]For example, COVID-19 may have originated due to a spillover event between wildlife and humans, although despite US Intelligence agencies and international public health organizations attempting to identify the source of the disease its true origins remain debated and may never be definitively confirmed (Harrison and Sachs 2022).

flicts therefore represent perfect laboratories for nature to experiment and prepare the next infectious pathogen with global pandemic potential.

This dissertation proposes a new theory based on civilians strategically responding to violence in order to explain the conflict-disease connection. Violent armed conflict produces conditions favorable to the emergence of disease. On its own, this observation is hardly new. We have long understood the consequences of extensive fighting, infrastructure damage, and widespread personal injury as catalysts that facilitate the emergence and spread of infections among individuals and across entire populations suffering from armed conflict (Connolly and Heymann 2002). However, what has remained unexplored concerns the role that conflict dynamics have to drive unique infectious disease outcomes. Do some diseases have a greater potential to spread through some conflicts than others? Does widespread disease infection occurring in conflict spaces increase the chances of community outbreaks of disease and do the chances of these outbreaks occurring vary across different types of armed conflict? In this dissertation I answer these and related questions by arguing that the unique patterns of violence which vary across and within conflicts over time drive the emergence of different infectious diseases in a conflict due to the civilian population movements these patterns of violence encourage. Rather than a general claim that war causes disease, here I argue and demonstrate that certain patterns of violence in a conflict - specifically the intensity and geography of violence - explain the incidence of specific infectious diseases across countries with ongoing wars. By explaining why some infectious diseases have a higher or lower chance of emerging across different conflict types, this dissertation provides a new theory and evidence that allow us to better understand and prepare for the future disease outbreaks by responding to the spread of disease in conflict zones with greater precision.

1.1 Unequal progress

While not without setbacks, global health has made remarkable progress over the past century and in particular since the turn of the new millennium (Packard 2016; Lozano et al. 2011; Disease Control and Prevention 2011; Benatar, Gill, and Bakker 2009). Investments made by international and non-governmental organizations have helped to increase life expectancy worldwide while driving down rates of infant and maternal mortality. This coincides with a steady rise in public sector health investment indicating a clear rising emphasis on population health care. Figure 1.1 reveals these trends demonstrating clear progress among these most important indicators of public health.[3] Gains to overall life expectancy in Africa stand out most clearly with that region experiencing an average 17% increase average lifespans over the last 20 years. Improvements to public infrastructure that support healthy populations such as development of freshwater and sewage systems, road construction, construction of new health care facilities, and major expansion to the number of medical professional workers across the region have all generated significant dividends in terms of the quality of life for many residents there.

These gains in general health extend to the domain of infectious disease as well which has also shown considerable declines over the past century and decades. Building on the successful eradication of smallpox, public health institutions such as the World Health Organization have made major gains to coordinate private and public actors who contributed to making significant reductions in the overall prevalence of major diseases such as measles, polio, and tetanus - diseases which historically have taken many millions of lives but which are now managed and relatively controlled, particularly in areas where just a few decades ago these disease represented a major

[3]This figure is based on mortality and life expectancy data collected from World Bank (World Bank Group 2022) and government healthcare spending from the Global Burden of Disease project (GBD 2021).

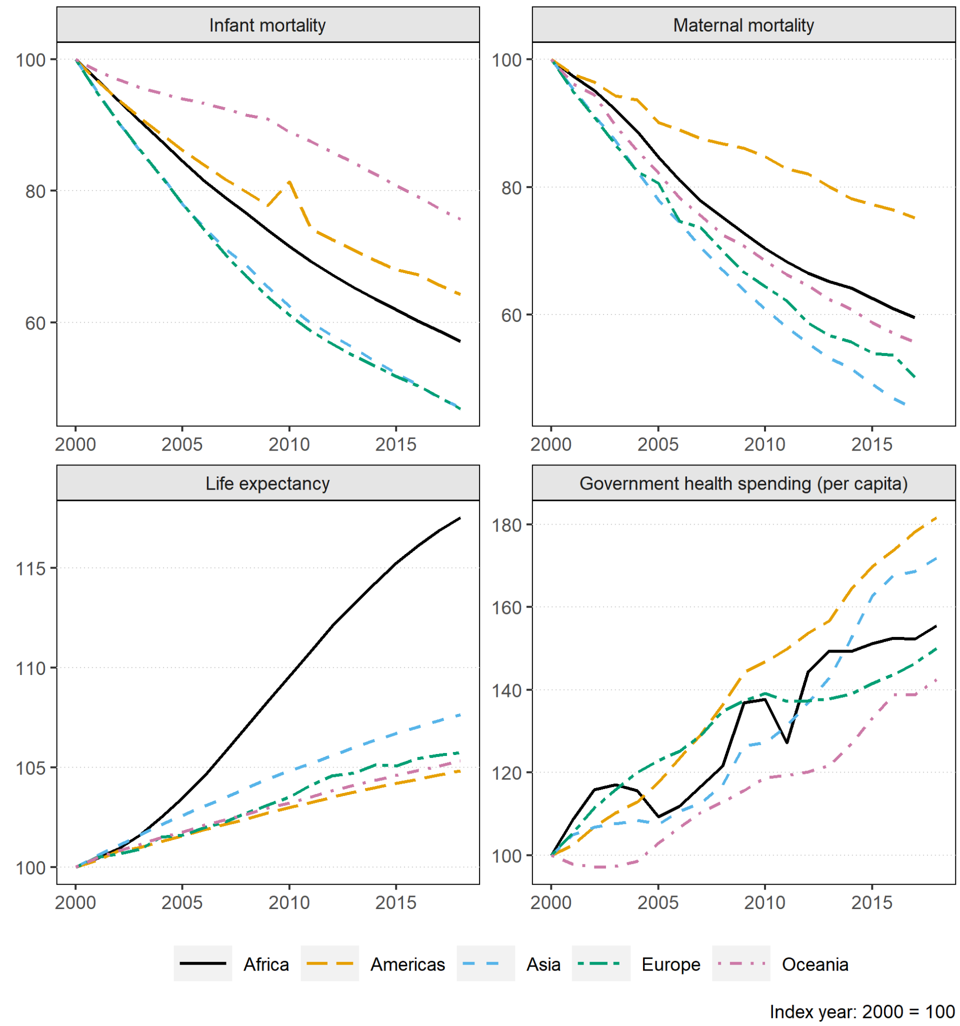

Figure 1.1: Health trends

cause of death among young children. Robust worldwide vaccine distribution efforts which have mitigated the spread of these diseases deserve credit for saving the lives of millions of children around the globe today (Disease Control and Prevention 2011). Figure 1.2 clearly shows the progress made to control and minimize infection with two common types of disease which typically infect millions worldwide: lower respiratory infections - LRI (such as tuberculosis) and malaria - an infection spread by mosquitoes in regions of the world where the disease is still endemic.[4] Investments

[4]Figure based on data from the Global Burden of Disease project (GBD 2021). Malaria was once endemic to significant portions of the United States as well, but aggressive mosquito eradication programs and disease containment efforts have since eliminated the disease from that country.

by nonprofit organizations such as the Bill & Melinda Gates Foundation to provide precision healthcare to areas most in need of health support have greatly contributed to these global declines in the prevalence of once endemic diseases. Both LRI and malaria incidence have significantly declined worldwide over the past two decades with reported case decreases of approximately 76 and 50 percent respectively.

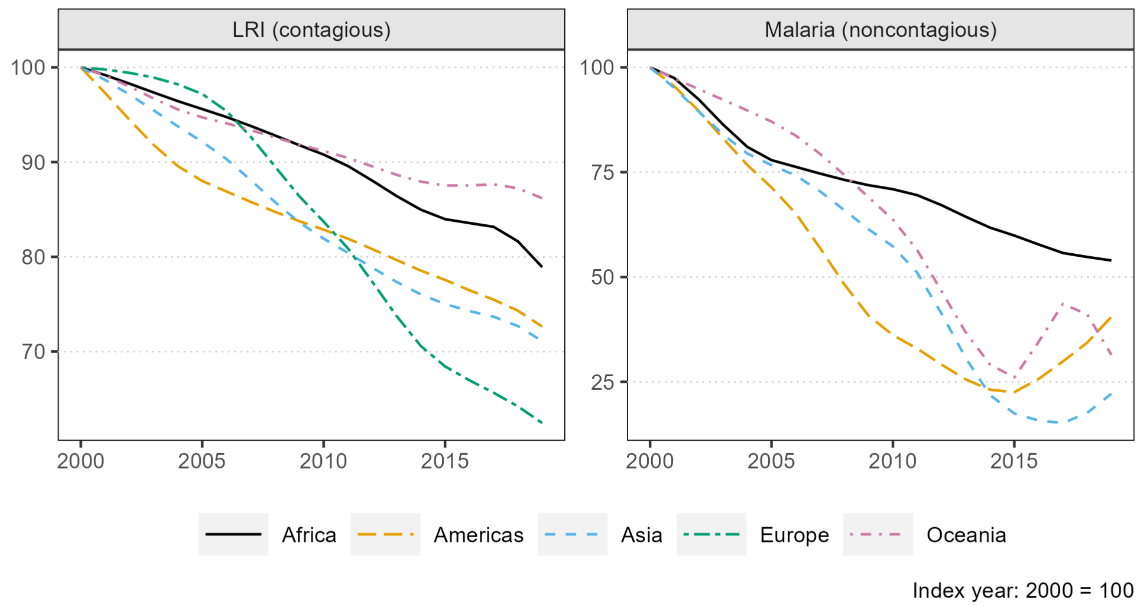

Figure 1.2: Infectious disease trends

However, these global trends and successes mask the unequal nature of progress in the domain of disease control. While many areas worldwide have enjoyed significant progress, many other regions where tens of millions still live have fallen behind - sometimes to a significant degree. Consider the previously referenced LRI and malaria global success stories. When examined at cross-national levels the data overwhelmingly show clear downward trends suggesting major progress in disease containment. But peel back the country-level masks and peer at incidence of disease at the local level and disparities in this story of progress reveal themselves more clearly indicating that many have not enjoyed this progress and live in regions where the spread of infectious disease has grown more serious with time.

Figure 1.3 shows the progress made in controlling the incidence of LRI and malaria across Africa between 2000-2017.[5] These data show clear reductions (blue color) in disease incidence with some regions completely eradicating the prevalence of malaria and many regions significantly curtailing the spread of LRI among the population. Indeed, some areas have lowered reported LRI cases by as much as 84% over the previous two decades and in many areas where malaria once spread without control that disease no longer presents any threat. But, these data also reveal another story. Many areas (red color) have suffered significant setbacks in the spread of disease. Not only do infections spread with greater severity in these locations, but this spread has increased to a remarkable degree with some areas reporting approximately 2.6 times the spread of LRI and malaria reported twenty years ago. Part of this change may have resulted from the dramatic increase in population in these areas which has nearly doubled over the past two decades (United Nations 2022). But armed conflict across this region and many others has also exacerbated the challenge of disease containment.

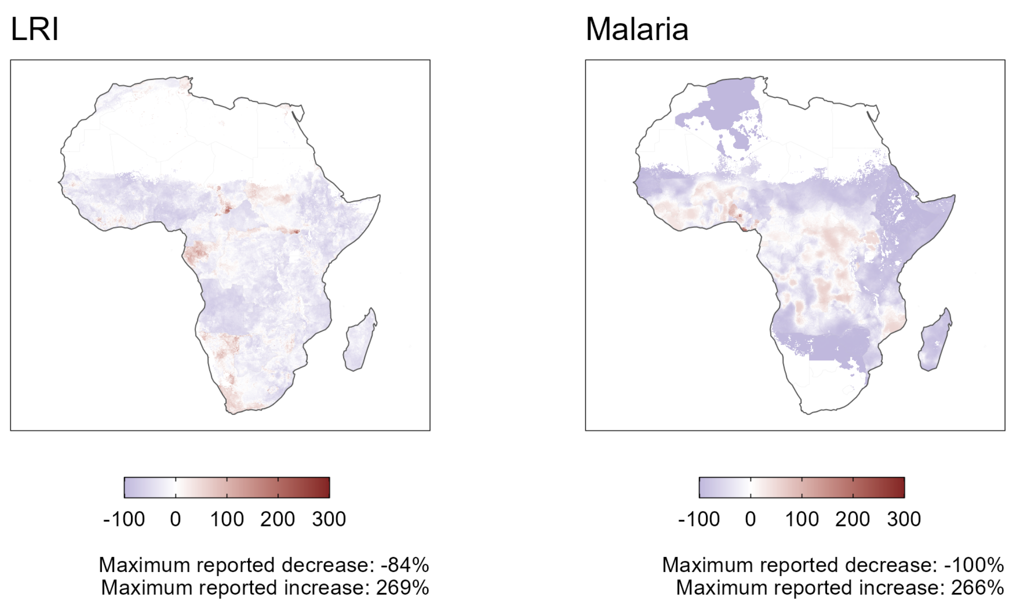

Figure 1.3: Change in subnational disease incidence in Africa: 2000-2017

[5] The data used to produce these maps is explored in great detail in Chapter 4. LRI estimates come from Reiner et al. (2019) and malaria estimates come from Weiss et al. (2019).

A puzzling aspect of the changes implied by these data on subnational disease across Africa over this time period concerns the clear disparity between regions which have enjoyed significant gains in controlling the spread of LRI but which have also struggled to control malaria, or vice versa. For example, consider the southern region of Mandoul in Chad, clearly visible as a bright red spot in the center of the LRI map, and the northeast District of Kotido in Uganda, visible on the right of the red cloud in the center of the malaria map. Between 2000 and 2016 these two regions experienced opposite disease trajectories. Consider Table 1.1 which summarizes these changes in infectious disease across these two regions.

Table 1.1: Illustrative disease trajectories

	LRI	Malaria
Mandoul, Chad	+35%	-11%
Kotido, Uganda	-13%	+46%

Estimates reflect regional averages.

What could account for these divergent trajectories for the spread of infectious disease within these regions? Treatments for these conditions are relatively similar - widely available pharmaceuticals which would be distributed by identical medical personnel staffed at the same clinics. Therefore, disparities in health care investments do not sufficiently explain these differences. Similarly investments in public health by international actors tend to approach health investment by targeting multiple aspects of health simultaneously to maximize the effectiveness of deployed resources while minimizing costs (Benatar, Gill, and Bakker 2009). Conflict however, may account for these disparities.

The ways that conflict unfolds and evolves over time creates the conditions necessary for some types of infectious disease to spread across some conflicts but not others. Returning to the example of Chad and Uganda, during the years between 2000 and 2016 these two regions experienced different conflict dynamics. In Chad a significant amount of violence erupted in and near the country's capital, N'Djamena, in the center-west as well as near a major-city, Abeche, in the center-east. This violence led to large numbers of displaced civilians shuffling south into comparably safer regions of the country near the Mandoul region to escape the consequences of the armed conflict. Moving away from regions with the most intense violence into comparably safer areas helped these civilians to both improve their security but also reduce their exposure to infrastructure damage attributable to the conflict. However, this came at the cost of many people moving into an area with fixed housing and thus needing to share space such as by moving into makeshift shelters or living in displacement camps (see Chapter 3) which lead to closer contact between people and better opportunity for the transmission of contagious pathogens that contribute to infection of diseases which cause LRIs.

Meanwhile in Uganda people had comparably fewer opportunities to escape from the consequences of violence. During this period residents in the region faced extensive amounts of violence both in their home regions but also in neighboring countries such as due to the ongoing civil war in Sudan. This extensive violence coupled with the relatively few nearby options for safety suggest that people sheltered avoid violence. Responding to violence in this way reduces their contact with others while increasing exposure to the environment which is exacerbated by damage attributable to fighting. This civilian response would explain the rising rates of malaria that occurred in this reigion of Uganda over this time period. This dissertation explains why these unique infectious disease outcomes occur as a direct consequence of armed conflict.

1.2 The theory - in brief

Violence that occurs in armed conflicts progresses and exhibits change along two key dimensions relevant to explain the spread of infectious disease - intensity and geography. As belligerents in a war engage in battles for control of territory, populations, or resources over time the location and destruction of these battles will shift and change to reflect changing priorities and power asymmetries among combatants. For example, periphery regions of a country might first experience the worst of violence in a conflict as an insurgent group establishes a foothold of support in the area and, over time, expands its efforts to nearby major population centers only after recruiting a sufficient number of soldiers and security material resources necessary to wage war in more distant locations. Civilians observe and experience the consequences of these changing conflict dynamics firsthand and often are the main victims of violence.

Rather than passively accept their circumstances and suffer from the worst consequences of the violence unfolding around them, civilians instead act and pursue different strategies to maximize their personal safety and to avoid encountering belligerents engaged in combat or who might directly target them. Civilians respond to violence by pursuing distinct security-improving strategies: *sheltering* in safe locations such as their home, *shuffling* short distances away from violence such as neighborhoods on the opposite side of a city or into a neighboring village, or by *fleeing* longer distances such as to a capital city or further into another country to escape the effects of violence. Each of these strategies has risks and potential benefits and civilians chose which strategy to pursue based on their understanding of violence taking place around them and nearby.

Escalating intensity of violence catalyzes civilians to reappraise their security situation and take actions to improve their safety when they feel threatened. If they feel the violence represents a one-off situation they might resist the costly choice of abandoning their homes and instead will shelter and minimize outdoor travel and public spaces to ensure they do not find themselves caught in the crossfire of a skirmish between belligerent forces. But, if violence indicates a general trend of declining security - such as when belligerents clearly contest an area with multiple skirmishes fought over a confined region - these same civilians might determine staying and sheltering no longer represents a viable option and will instead choose to abandon their homes and travel elsewhere. If the violence is relatively moderate and nearby areas appear to offer safety they may avoid the risks and costs of traveling long distances and choose to shuffle nearby. But, in some conflicts violence expands over a wide geographic area as belligerents field many personnel and resources to contest a wide space across a country. In these circumstances even short distance travel away from violence at home will not necessarily guarantee safety and will instead incentivize civilians to accept and endure the costs of longer distance travel, possibly even out of their home county as a refugee.

Critically, the strategies that civilians pursue in response to changing patterns in the intensity and geography of violence in armed conflict shape the disease-causing pathogens that they will encounter. Pursuing one strategy may increase the chances that civilians must take up temporary residence in congested temporary shelters with others who have also attempted to escape the consequences of violence leading to an increased likelihood of them contracting a *contagious* disease like a lower respiratory infection which spreads easily from one person to another, particularly when sharing enclosed and confined spaces. Or civilians might instead chose to remain at home and self-isolate by sheltering to minimize the chances they experience violence. This would reduce their contact with others but can lead to situations where they face greater exposure to environmental pathogens. This exposure can result from infrastructure damage or significant resource limitations due to supply disruptions and damage caused by the conflict that lead to shortages of fresh food and water. Environmental exposure can result in contact with a *noncontagious* disease causing pathogen such by consuming untreated water and ingesting the bacteria responsible for cholera.

How civilians respond to violence in armed conflict directly shapes the pathogens they encounter. These pathogens, in turn, cause infectious disease. Some conflicts lead to civilians pursuing strategies that expose them to situations conducive to the spread of *contagious* infectious diseases while other conflicts create situations where civilians pursue strategies leading to infection with *noncontagious* disease causing pathogens. By explaining why different diseases spread in armed conflict as a result of the choices that civilians make in war zones, this dissertation connects conflict dynamics to battlefield epidemiology.

1.3 Plan of the dissertation

In the following chapters of this dissertation I set out to explain why we observe distinct infectious disease outcomes across areas with armed conflict by taking a levels of analysis approach to demonstrating the causal connection between war zone violence and the spread of disease. I examine this relationship at the level of the individual, subnationally across regions, and cross-nationally. The three main empirical chapters containing these analyses are self-contained with each presenting a tailored version of the theory relevant to the examined outcomes in the chapter. Exploring the conflict-disease connection across these three levels allows me to trace out the connections with greater clarity while demonstrating the consequences of violence and the aggregate consequences of civilian decision making on disease.

In Chapter 2 I present a complete version of the theory of conflict induced civilian displacement and infectious disease. Here I elaborate on the scope of the theory as it pertains specifically to infectious diseases - or those spread by infectious pathogens capable of spreading from one living organism to another. I also elaborate on the main conflict variables in this chapter: intensity and geography of violence as well as the concept of the "battlefield" as it relates to conflict geography from the perspective of civilians living in conflict spaces. Following this I provide detailed descriptions of the three civilian strategic response to violence that drive downstream variation in infectious disease: *sheltering*, *shuffling*, and *fleeing.* Finally, I present expectations for the relationship between violence and infectious disease outcomes as a function of these strategic civilian responses.

In Chapter 3 I illustrate the microfoundations of the theory by providing a detailed literature review on civilian displacement patterns in armed conflict and reporting on the results of a number of semi-structured interviews I conducted with refugees who escaped armed conflicts. Using the narratives and responses from these interviews I qualitatively examine how research participants responded to violence and remained aware of the geographic scope of violence nearby and in other regions. I investigate how they responded to the violence they observed - the strategies they employed. Finally, I investigate their experiences with health while navigating conflict spaces including their access to health care and observations with infectious disease. I devote specific attention here to identifying themes in participant narratives which suggest how violence creates contact-points between displaced civilians and infectious disease causing pathogens. As a plausibility probe the evidence presented in this chapter illustrates the mechanisms proposed in the theory while also demonstrating the consequences of strategic civilian responses to violence and exposure to infectious disease.

In Chapter 4 I build upon evidence in the microfoundations chapter by analyzing the subnational spread of infectious disease across Sub-Saharan Africa over a 20 year period by constructing a novel dataset of armed conflicts and two measures of infectious disease: contagious lower respiratory infections and noncontagious malaria. The empirical models I use to test the relationship between conflict and disease directly incorporate my theoretical implications and microfoundations evidence: that civilians consider both intensity of violence and its geographic scope *jointly* when formulating strategic responses to violence and that these responses produce ripple effects across space as civilians disperse and share news of violence through word of mouth. These theoretical implications suggest interactive spatial models which provide strong support for the theory and indicate that the regional spread of infectious disease does indeed vary in substantively meaningful ways across conflict contexts that, in turn, vary according to the intensity and geography of violence.

In Chapter 5 I consider how the conflict induced spread of infectious disease across regions suggested by Chapter 4 might have carry over effects on the emergence of disease outbreaks - or situations with widespread community infection of a disease above normal levels. Leaning into my theory in this chapter I derive four types of violent armed conflict which vary according to their overall intensity of violence and geographic extent and test how each of these conflicts contribute to the outbreak of contagious or noncontagoius infectious disease. The results of this analysis bring the dissertation full circle and demonstrate the global consequence of armed conflict on infectious disease outbreak and, ultimately, global health security.

Chapter 6 provides a conclusion to the analysis presented here. Beyond revisiting the theoretical contribution of this dissertation and its main findings I provide additional discussion on important paths forward for research into the connections between infectious disease and war suggested by this project. Both the theory and the evidence presented in the empirical chapters suggest that the consequences of civilian targeting by belligerents in armed conflict has important implications for the spread of disease. As well, this study did not consider civilian demographic characteristics most relevant to health such as gender or age which deserve attention as each of these factors relate both to disease outcomes but also civilian strategic response preferences in response to violence. Finally, beyond simply explaining why disease emerges in some conflicts but not others, disease prediction represents a valuable goal. By predicting the spread of disease tomorrow as a function of conflict conditions observable today and likely to persist in the future aid workers and health organizations may have more opportunity to stage resources and respond to disease before transmission and infection spreads. In line with this goal predicting conflict dynamics is emphasized in the conclusion as a necessary for achieving future health goals.

Political scientists have started to seriously grapple with the consequences of politics on public health outcomes. Some of this work has argued for deeper analysis to explore the causal relationships between armed conflict and disease (Fazal and Stundal 2019). This dissertation answers this call. Other political scientists have examined the relationship between politics and health from other perspectives, for example, considering the role of partisanship to explain variation in vaccine uptake or mask wearing. Precision analysis (Desmond-Hellmann 2016) should motivate these and future studies by emphasizing causal mechanisms underpinning the connections between politics and disease or health more broadly conceived. This precision should also prioritize using data that matches the causal process examined, for example, examining the regional disease spread at subnational levels or country disease outbreaks at country levels as done in this dissertation.

As the preceding analysis of general and detailed infectious disease trends suggests, significant public health disparities hide behind aggregate success stories but only reveal themselves when examining problems at the appropriate level of analysis. Effectively addressing infectious disease by precisely targeting health responses in locations most likely to create conditions favorable for contact between people and infectious pathogens can help to alleviate some of these disparities. This dissertation seeks to increase the precision of these responses by presenting and testing a theory that explains why and where these disparities are most likely to emerge in armed conflicts.

Chapter 2

Theory

2.1 Introduction

While we have made great advances in understanding how civilians influence the outcomes of civil wars (Berman, Felter, and J. Shapiro 2018), the downstream consequences of civilian decision making in conflict zones on non-conflict outcomes such as public health and infectious disease is less understood. This chapter proposes a theory explaining why distinct categories of infectious disease spread in some conflicts but not others. Here I argue that civilians observe the conflict unfolding around them noting changing intensity of violence and its geographic scope and, acting upon that information, chose different strategies to evade violence. These strategies change where civilians locate and, in the process, expose them to different disease causing pathogens which contribute to distinct downstream disease outcomes across armed conflicts.

Understanding how conflict can produce these varied disease outcomes can prove invaluable to public health experts and policy makers seeking to craft tailored humanitarian responses to the downstream consequences of warfare on public health outcomes generally and disease containment specifically. The transmission properties that drive the spread of a disease demand tailored infection control strategies. Different diseases require different mitigation responses, pharmaceutical treatments, and resources. Cross-national public health logistics - deploying medical personnel and medicine over long distances and across international borders - take time to establish and implement, something which those in need of aid critically lack. Therefore, relying on earlier observable characteristics of conflict to make advanced predictions about later disease burdens within conflict impacted regions would greatly aid in humanitarian preparedness and response. Advanced prediction could support more efficient use of limited health resources as well as facilitating resource staging in advance of broader humanitarian crises. In order to achieve efficiency gains of this nature, however, we first require a theory that can connect conflict observables to specific disease outcomes. This chapter provides this connection by offering a nuanced explanation of the conflict-disease relationship by arguing for a causal link between conflict dynamics and specific disease outcomes through a mechanism of conflict-induced civilian displacement.

In brief, the theory proposed here argues that conflict causally precedes disease through a mechanism of civilian strategic choice in response to observed patterns of violence. Civilians in and near active battlefields in a conflict take actions to optimize their and their families' safety by minimizing their exposure to violent events and maximizing their safety and personal security. Civilians will hide and shelter in place when the conditions favor sheltering or will flee when the conditions of the conflict leave civilians with few other options. Change in the dynamics of conflict alter how civilians perceive the viability of some strategies to avoid violence relative to other strategies. Two pieces of information that characterize violence in armed conflicts help civilians to evaluate their personal security situation and implement best-response strategies to evade or minimize their exposure to violence: the *intensity* and *geography* of violence. Based on their perception of these conflict characteristics, even imperfect perceptions clouded by the confusion and uncertainty associated with ongoing warfare, civilians pursue alternative security-improving strategies by choosing either to: *shelter* in their homes, *shuffle* into nearby regions, or *flee* over greater distances such as across an international border into a neighboring country. Depending on the choices that civilians make they will encounter different infectious disease causing pathogens as they transverse battlefields or take refuge in a safe location. The different pathogens civilians encounter while implementing their violence-avoidance strategy creates different possibilities for exposure to *contagious* or *noncontagious* infectious disease. How civilians respond to the violence they observe leads to distinct downstream disease outcomes realized at individual, subnational, and cross-national levels.

To develop a more complete theoretical roadmap explaining the relationship between war and disease this chapter discusses these relationships at these three levels of analysis: the individual, subnationally, and cross-nationally By disentangling the outcomes in this way the causal mechanisms - the varied strategies civilians pursue - and their connections to disease outcomes will emerge more clearly. Starting at the individual level I explore how civilians interpret conflict conditions and how their understanding of violence motivates them to undertake potentially costly strategies to improve their security. I evaluate these individual-level decisions and themes in Chapter 3 which lays out the foundations of this dissertation. Following this, I explore how these individual choices in response to armed conflict result in different rates of infectious disease among populations across subnational regions. In Chapter 4 I test these implications using subnational panel data and spatial models. Finally, building on these implications of individual decision-making and subnational disease rate variation, I consider how distinct types of armed conflict that vary in their intensity and geography produce different risks for infectious disease outbreaks. I explore these patterns of disease outbreak in Chapter 5 using a crossnational panel dataset.

The remainder of this chapter proceeds as follows: in Section 2.2, I discuss the main theoretical concepts underpinning the proposed relationship: disease outcomes and conflict dynamics - intensity and geography of violence. Following this, in Section 2.3 I elaborate on the proposed causal mechanisms underpinning the theory - the strategies that civilians implement in response to observable conflict dynamics. After discussing the main variables and causal mechanisms of this theory, in Section 2.4 I explore these relationships and expectations at each of the previously-proposed levels of analysis discussed in Chapter 1 and explain how distinct patterns of conflict lead to varied infectious disease outcomes. I conclude this chapter in Section 2.5 by explaining how I test this theory in the remaining chapters of this dissertation.

2.2 Theoretical Concepts: Disease & Armed Conflict

2.2.1 Disease

While the definition of “disease” has changed over time (Scully 2004), the World Health Organization’s International Classification of Disease, an internationally used and recognized resource for the classification and reporting of disease, considers a disease broadly as “a set of dysfunctions in any body system”(World Health Organization 2022b). Typical conditions such as cancer, heart disease, and the common cold all qualify as disease. However, the theory of conflict-induced civilian displacement and disease proposed in this dissertation specifically pertains to the sub-category of diseases which are *infectious*. Infectious disease refers to “illnesses resulting from an infection caused by the presence or growth of a biological organism, often termed a pathogen, for its disease-causing behavior"(Kanki and Grimes 2013, p. 1). Critically to the theory, these infectious pathogens are capable of transmission from one living organism to another. Infectious disease therefore refers to a class of negative health outcomes caused by pathogens or disease-causing organism such as bacteria, viruses, parasites, or other disease-causing pathogens such a proteins (prions) which spread through a variety of transmission pathways. Common types of infectious diseases include the common cold and influenza - both caused by viruses, malaria - caused by parasites, or Creutzfeldt-Jakob Disease - caused by misshaped proteins (prions). These infectious diseases differ from noninfectious diseases - or diseases *not* caused by pathogens - such as cancer, heart disease, or genetic conditions the population incidence of which this theory does not attempt to explain.

The pathogens (bacteria, viruses, etc.) responsible for these infectious diseases spread in a variety of ways such as through direct contact, respiratory droplets, airborne transmission, transmission vehicles such as food or water, or through a disease-carrying vector such as mosquitoes in a process that results in the pathogen leaving one organism and entering another in a cycle referred to as a "chain of infection" (Centers for Disease Control and Prevention 2012; Hofman 2016). Direct contact transmission occurs through direct skin contact, such as when an individual might contract tetanus after contact between the bacteria responsible for the disease (which are common in many environments including soil or dust) and broken skin like a cut. Diseases spread by respiratory droplets occur when an individual inhales pathogens located in aerosols expelled when another infected individual coughs or sneezes such as when a person has COVID-19 or influenza. These droplets typically travel a few feet before falling to the ground and losing their infectious potential and therefore contrast with pathogens that spread by airborne transmission that can remain suspended in the air or remain on surfaces for long periods of time. Measles, a disease caused by a virus which produce droplets when an infected individual coughs or sneezes, can remain airborne and infectious for long periods of time even after the original infected individual has left an area. Some infectious pathogens reside in transmission vehicles such as in food or water that cause disease once ingested by an individual. For example, cholera, a disease caused by a bacteria, is typically found in unsanitary or untreated water. Finally, some diseases require vectors - primarily bloodsucking insects such as mosquitoes, ticks, or sand flies - to facilitate transmission from one person to another. These insects bite an infected individual and in the process ingest the disease-causing pathogen which the insect then spreads to another individual at a later time. Malaria is an infectious disease caused by parasites which spread from one person to another through mosquitoes which bite the infected individual and then later transmit the parasites to another uninfected individual.

Critically for the theory, only some of these transmission mechanisms result in infectious diseases which are *contagious* in nature - that is, "capable of being transmitted from one person to another by contact or close proximity" (Centers for Disease Control and Prevention 2012, p. 494). For example, COVID-19 and measles are both highly contagious infectious diseases causes by viral pathogens that spread through respiratory droplets. When people share confined (especially enclosed) spaces these diseases have a higher potential to spread from one person to another. This transmission mechanism underpins the emphasis placed on mask-wearing during the COVID-19 pandemic to curtail the spread of that disease. In contrast, other infectious diseases, no matter the proximity between one individual and another, cannot transfer from one infected individual to another uninfected individual as these diseases are noncontagious.

These *noncontagious* infectious diseases instead spread through alternative transmission modes among at-risk populations. Returning to the malaria example, this disease only spreads in the presence of Anopheles mosquitoes which are susceptible to the underlying parasite pathogen responsible for that disease. Similarly, tetanus requires broken skin contact with the causal bacterial pathogen. In the case of both malaria and tetanus as well as many other noncontagious infectious diseases close personal contact will not result in an uninfected individual contracting a disease. A person sharing a room with malaria patients would not need to feel concerned about ventilation or mask-wearing, but if conditions changed and the person found themselves isolated from others in an environment prevalent with noninfectious disease-causing pathogens - such as outdoor locations with large mosquito populations - then the potential for infection with these diseases would significantly increase.

To summarize, in this dissertation I argue that armed conflict produces patterns of civilian population displacement that explain patterns of *contagious* and *noncontagious infectious disease*. Infectious disease refers to diseases which spread from one organism to another and *(non)contagious* indicates whether these infectious diseases can spread directly from one person to another person or, instead if they require direct contact with the underlying pathogen or contact with a vehicle such as through ingesting contaminated food or water or through contact with a disease causing vector such as an insect. To be clear: any contagious disease is, by definition an infectious disease; but not all infectious diseases are contagious. Figure 2.1 provides a disease schematic summarizing these categories as well as highlights the dimension relevant to this theory.

Conflict dynamics create incentives for civilians to pursue different security improving strategies leading to different patterns of displacement that, on average, contribute to different rates of exposure to these underlying infectious disease causing pathogens thereby resulting in distinct downstream differences in contagious and noncontagious infectious disease attributable to conflict. Before explicitly connecting civilian strategies to these disease outcomes, I will first turn to describing the two observable fea-

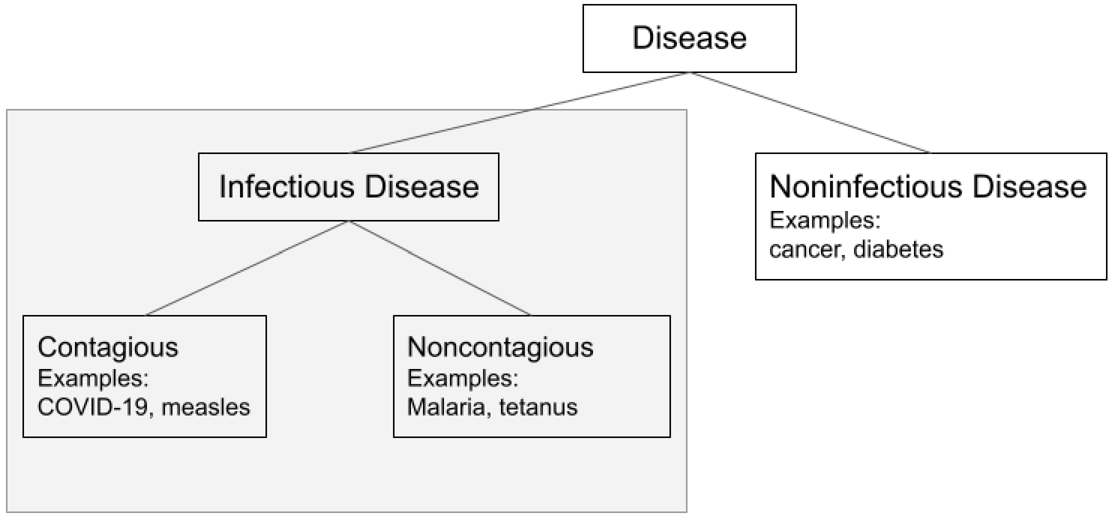

Figure 2.1: Disease Schematic

tures of an armed conflict which inform how civilians strategically respond to violence: the *intensity* and *geography* of a conflict.

2.2.2 Conflict

Two observable characteristics of violence in an armed conflict signal to civilians their current security situation: ***Intensity*** and ***Geography*** of violence. More detailed descriptions appear below, but by geography I mean the geographic distribution of violence across space within a country or how widespread a conflict is such as whether it encompasses a large amount of territory or is relatively confined to a specific area. Fighting intensity refers to the overall level of violence in a conflict which can vary from low, simmering conflicts with intermittent spells of violent skirmishes to high, which corresponds to conflicts characterized by consistent and extreme levels of violence which generate extensive casualties and damage. Both the geography and intensity of violence causally precede downstream population movements that result during a war and create situations or interactions conducive to the spread of contagious or noncontagious infectious disease. Population displacement occurring during a conflict may result in internal displacements of civilians within a country to other regions with greater levels of security and a lower presence of belligerents fighting or it may include outbound refugee flows of displaced civilians fleeing a country entirely. Some civilians will not travel in response to violence and will instead remain stationary and shelter from violence.

Civilians make decisions in response to conflict as a consequence of the geography and intensity of fighting they observe. How they chose to respond to this fighting determines whether they face a higher probability of exposure to other people or to damaged infrastructure or the outdoor environment which then influences which infectious disease causing pathogens they encounter on a battlefield and, therefore, which diseases emerge and where. Civilian choices proceed directly from the geography and intensity of violence in a conflict since civilians use these factors as inputs into their decision-making calculus as they evaluate how best to respond to their changing or deteriorating security situation. If certain categories of civil war better align with particular degrees of geographic concentration and conflict intensity then, all else equal, we should observe increased *rates* of particular infectious diseases spreading among some conflicts relative to others due to the way these conflicts shape civilian decision-making. The dynamics of violence that emerge in particular conflicts and higher rates of some types of infectious disease then create the conditions necessary for the onset of corresponding infectious disease *outbreaks*. The following provides more detailed descriptions of these conflict variables:

2.2.2.1 Intensity -

The intensity of conflict describes the overall level of violence in a location as revealed by its destructive capacity in terms of casualties produced and infrastructure destroyed. Some conflicts generate relatively subdued fighting that produce little in the way of lives lost or buildings destroyed and may simmer in this state for long periods of time. Other armed conflicts however exhibit extensive violence that produce many thousands of casualties with extensive damage to entire cities. The intensity of observable violence - witnessing or hearing of casualties and bombed out neighborhoods - compels civilians to reconsider their own personal security and to take advanced action to minimize the chances they experience violence themselves. Increasing conflict intensity characterized by higher levels of violence in an armed conflict catalyzes civilians to take action and pursue strategies to improve their immediate security situation. Where they go depends on their understanding of the broader conflict landscape and the geographic scope of violence.

2.2.2.2 Geography -

The geography of a conflict describes which areas of a country experience the direct and observable consequences of armed violence. Geographic concentration alone does not imply that impacted regions in a conflict zone will experience increased incidence of disease. Rather, geography indicates features of conflict in an armed conflict that informs civilians of the options available to them to escape locations with violence. It also indicates to these civilians their own relative position within a conflict space such as whether they are well outside an area with violence or directly in an active battlefield characterized by frequent fighting between belligerents. Specifically, geography suggests to observant civilians both how and where they should move based on the presence or absence of nearby fighting in their local neighborhoods and across their country as a whole. Observing an increasing intensity of violence and reflecting on the geography of that violence - locations with and without the presence of fighting belligerents - civilians settle on a strategy to minimize their likelihood of experiencing violence themselves.

2.2.2.2.1 Battlefields - At local levels civilians can observe the geographic incidence of violence and, based on those observations, determine whether the space of their home area and surrounding region qualify as a battlefield - or a space actively contested between belligerent forces characterized by frequent skirmishes between the forces of those groups. Battlefield spaces signal to civilians that their area may experience higher and more frequent violent events that could produce casualties and destroy buildings and infrastructure within the area. Battlefields represent areas with the greatest insecurity in conflict spaces. Therefore, recognition of whether the geography of a conflict encompasses their home area indicating an active battlefield serves as one indicator for local civilian responses to violence.

These strategies that civilians can choose to pursue, which I discuss next, influence where civilians reside and which infectious disease pathogens they have a higher chance to encounter. As civilians evaluate their own immediate insecurity, they weigh their odds of finding safety elsewhere based upon their knowledge of the geography of a conflict, whether fighting covers a diffuse or concentrated region of their home country. The *geographic* extent of a conflict and overall fighting *intensity* therefore *jointly* inform civilian decision making and produce variation in downstream population movements that contribute in distinct ways to the spread of infectious disease. The ***geography*** of the conflict informs civilians where they can go if they chose to leave a conflict-zone while the ***intensity*** of violence shapes what actions civilians within the proximity of a conflict will take in response to insecurity and catalyzes civilians to take action. The resulting conflict landscape defined by the intensity and geography of violence determines how civilians respond when their security is compromised, where they go when they face this threat, and the infectious disease risks they face while navigating in or through conflict zones.

In this theory civilians serve as the primary agents whose decisions in response to violence of varying intensity and geographic extent helps to determine how disease spreads as a consequence of violence that occurs in armed conflicts. Civilians strategically respond to events based on the fighting dynamics they observe between belligerents. These civilians then act to maximize their security while minimizing the risks they face to their welfare. Different conflict dynamics will compel civilians to pursue different strategies they believe will best maximize their security. The geography and intensity of fighting within a country determines where civilians move, if they do, as well as the disease-causing pathogens they are likely to encounter if they leave or remain stationary. The strategies the civilians employ when facing violence helps to explain why (non)contagious infectious disease spreads during some armed conflicts but not others as well as what type of disease (contagious or noncontagious) are more or less likely to emerge. I turn now to discussing these civilian response strategies.

2.3 Causal Mechanisms: The strategies civilians pursue

After observing the state of ongoing violence civilians update their beliefs regarding their personal security situation and respond appropriately to minimize the chances they will suffer from violence. When faced with the prospect of imminent violence civilians strategically respond to maximize their personal safety and minimize the risk they will suffer from either intentional violence perpetrated by belligerents or collateral violence related to ongoing skirmishes. Proximate local circumstances and knowledge of the broader conflict landscape help to shape civilian decision-making processes resulting in three possible strategic responses that civilians can employ to minimize the risks they face: ***sheltering***, ***shuffling***, and ***fleeing***. Different dynamics operating in an armed conflict shape which of these strategies civilians will feel most inclined to pursue and whichever strategy that civilian pursue shapes which disease causing pathogens they are more or less likely to encounter.

2.3.0.1 Sheltering –

Some conflict environments do not sufficiently compromise civilian security to warrant them assuming the risks of traveling across an active battlefield in pursuit of safety elsewhere. At other times, due to the strategies that belligerents employ or personal situations (familial or financial), civilians do not have the option to escape at all. In these circumstances, rather than travel into safer areas of their home country or escape into neighboring countries, civilians instead choose to shelter in place and hope that local fighting between belligerents subsides and their personal security situation improves. Civilians will choose to shelter when the opportunity to escape is low or when the risk of remaining in place outweighs the perceived cost of leaving. Sheltering civilians remain in active conflict spaces and largely stay indoors such as in their own homes or in the homes of a neighbor or family friend. In order to avoid the possibility of encountering belligerents or suffering violence such as due to a crossfire, civilians in these circumstances avoid public spaces or large gatherings and instead favor isolation and the improved safety it affords them.

2.3.0.2 Shuffling –

When exposed to fighting that compromises their security and increases their perceptions of physical vulnerability civilians will prefer to escape the deteriorated security situation by leaving the local battlefield and shuffling into a safer locations nearby. Nearby areas offer a number of incentives relative to more distant destinations including familiarity as well as improved opportunity to quickly return home should the security situation begin to improve. Traveling longer distances across their country and possibly across international borders increases the risks they will encounter belligerents or checkpoints on roadways where they could suffer violence or harm. This as well as uncertainty of what awaits them in more distant locations or a new country will compel civilians to first pursue opportunities for safety in proximate regions by traveling to nearby destinations slightly removed from the most observable violence. Under this logic, by shuffling around pockets of violence, civilians mix with their neighbors in nearby regions often moving in with family, friends, or into internal displacement camps nearby to live in confined and shared spaces that have greater security than did their original homes.

2.3.0.3 Fleeing –

If conflicts do not provide opportunities for civilians to shelter in their homes or shuffle around their home country civilians will instead feel compelled to assume the additional burden of risk that accompanies fleeing longer distances, in some cases across international borders. Long distance travel increases civilian exposure to the environment often compelling civilians to travel across undeveloped regions to avoid violence. Resource limitations and exposure to the elements further increase risks. Spending more time traveling greater distances also increases the odds that civilians will suffer an injury or encounter a hostile belligerent such as at a checkpoint. However, the anticipated security they expect at their destination and the insecurity they felt at their homes compensates for these risks. Fleeing situations arise when the cost of travelling to more distant regions is lower than local travel or when alternative local options seem extra risky given the local circumstances of violence. Civilians who chose to flee believe the risks of longer distance travel outweigh the costs of sheltering within a conflict-zone and shuffling into other nearby regions in an armed conflict.

Any decision civilians make in response to violence represents a potentially costly choice either in terms of further compromised security that results from moving across a battlefield and in the process abandoning property and personal belongings or due to remaining stationary and accepting the risk that local fighting intensifies. Based on their best, often imperfect[1], understanding of the conflict, civilians weigh their options for navigating a conflict space by evaluating where they could go if they chose to leave their homes. Therefore, variation in the geographic scope and intensity of a civil war *jointly* shape rational civilian interpretations of violence and inform the incentive structures that these civilians evaluate when choosing a response strategy that results in them moving across a battlefield or remaining in place.

This intermediate civilian displacement factor nested between conflict dynamics and disease outcomes is ultimately caused by the geographic extent and intensity of a conflict and therefore helps to explain why disease spreads due to conflict. By nesting *civilian population movement* as an intermediary factor between conflict dynamics and infectious disease, a clearer theoretical map emerges that offers causal explanation that connects the spread of disease to the dynamics of an armed conflict without conflating observable downstream symptoms as the ultimate cause.[2] Civilian population movement emerges as a direct response to violence and is therefore not the ultimate causal factor that explains for the spread of infectious disease in conflict zones. Table 2.1 sketches out the causal pathway[3] of the argument thus far:

[1]Frequently the fog-of-war limits how well civilians understand the violence unfolding around them. For additional details see Pearlman (2018) or Chapter 3 in this dissertation.

[2]This is a common mistake in epidemiological studies of disease which frequently do not seriously consider conflict dynamics. See Chapter 4 for additional details.

[3]Some studies suggest an alternative possible connection: that disease influences the dynamics of civil war such as by impacting government troop strength within areas of endemic disease where insurgents have greater natural immunity to disease giving them an advantage over government forces (Bagozzi 2016). Such endogenous connections are considered in the conclusion to this dissertation.

Table 2.1: Conflict-disease pathway

Conflict dynamics		**Civilian response**		**Disease outcomes**
Intensity × Geography	→	Shelter Shuffle Flee	→	Contagious or Noncontagious

2.4 Making the connection: disease and war - predictions

The theory is tested by exploring the relationship between disease and war at multiple levels of analysis beginning with an individual analysis of responses to violence and observations with health and disease that serves as the foundations of the theory. I test disease outcomes at two levels: first exploring local *rates* of infectious disease across subnational regions in Chapter 4, and second exploring *outbreaks* of disease across countries in Chapter 5.[4] At local levels civilians interpret the status of their home area as a battlefield or not and then respond to violence which affects the spread (rates) of disease across subnational regions. Higher or lower rates of subnational infectious disease alters the probability that disease spread will exceed normal expectations leading to the potential for an outbreak of disease to occur - or a situation with widespread disease infection. Therefore, here I first establish my expectations of the relationship between conflict intensity and battlefields on the rate of local disease transmission. Following this I explain how conflict intensity and the geography of a conflict across an entire country affect the potential for disease outbreaks.

[4]More precise explanations of disease rates and disease outbreak can be located in Chapter 4 and 5 respectively.

2.4.1 Disease spread: conflict intensity and battlefields

When will civilians decide to shelter, shuffle, or flee and how will this choice affect the spread of infectious disease? The intensity of a violent event first encourages civilians to evaluate their security. Violence shocks a civilian's interpretation of their understanding of personal security causing them to reevaluate their previous perceptions of the security of their home.[5] When the violence occurs in isolation, such as in a single skirmish between insurgent groups who unexpectedly encountered one another in a civilian's hometown, civilians will not consider their home as residing within the geography of the conflict space; that is, they will not consider their home as an active *battlefield*. Abandoning one's home represents an incredibly costly choice accompanied by uncertainty and for this reason most civilians will resist the temptation to leave when confronted with isolated violent events and will instead *shelter* to avoid the possibility of encountering belligerents engaged in these infrequent skirmishes. Sheltering generally will result in isolation from other individuals who are not family or close friends thereby reducing the chances for civilians to encounter pathogens which spread when people are in close proximity to one another. However, even infrequent skirmishes between belligerent forces can be highly disruptive. Infrequent skirmishes might disrupt commerce as merchants exercise caution against economic losses they might incur from shipping good to the area leading to shortages of food. These infrequent battles can also disrupt sensitive public infrastructure such as freshwater systems that have distributed pumping stations. Finally, they could also result in increased exposure to insects (vectors) responsible for spreading disease due to damage to buildings or interruption of pest control operations maintained by local governments. Therefore, when civilians shelter in response to increasing conflict intensity in non-battlefields, their exposure to contagious disease causing pathogens decrease but

[5]See Chapter 3 for a more detailed synthesis of past work on civilian responses to violence including psychological aspects.

their exposure to noncontagious pathogens increase leading to the following sheltering hypothesis:

> ***Shelter*** - In non-battlefields civilians will *shelter* in response to escalating violence. Sheltering strategies will lead to increased [decreased] incidence of noncontagious [contagious] infectious disease.

As the frequency of violent events occurring in an area increase civilians will begin to reclassify their home as an active battlefield space. This realization that their home area represents a space with a consistent belligerent presence characterized by ongoing fighting for control of the territory causes civilians to explore alternative options for identifying safety elsewhere to the extent they possess the means and opportunity to leave. Civilians will perceive sheltering in an active battlefield as unnecessarily risky since the frequency of violence will increase the likelihood they suffer from violence or become a casualty due to collateral damage that occurs in a battle. The cost of long distance travel will still encourage civilians to relocate close to home if they can so they will search out destinations nearby such as on the opposite side of their home city more removed from bouts of violence or in a neighboring region. Shuffling results in civilians needing to find living accommodations in new spaces which, due to others also shuffling to evade violence, results in shortages of available housing necessitating the need for sharing of limited space. By removing themselves from areas with the greatest insecurity civilians also minimize their risk of encountering pathogens that contributed to noncontagious disease - these safer regions should have better access to resources and much less infrastructure damage. However, since they now must share confined spaces with others their likelihood of exposure to pathogens which cause contagious infectious disease will increase leading to the following shuffling hypothesis:

> ***Shuffle*** - In battlefields civilians will *shuffle* in response to rising violence.

> Shuffling in this context will lead to increased [decreased] incidence of contagious [non-contagious] infectious disease.

Some civilians have a low threshold for violence and will immediately leave an area regardless of the frequency of violent events and battlefield status. These individuals may possess greater financial resources to secure transportation out of regions with greater insecurity or may feel the cost of remaining in a region is too high such as if they have children or low connections to an area such as individuals who might have temporary employment in a location. Individuals who flee in advance of further deteriorating security situations can spread word of imminent violence to nearby areas through word-of-mouth, explaining why they fled and what they observed that led them to undertake this costly action. This will amplify the consequences of civilians already sheltering and shuffling on the spread of disease. Arriving in a new area, news of violence shared by these sheltering civilians will encourage some hesitant civilians to preemptively change their behaviors to avoid possible contact with belligerents in public spaces by sheltering themselves. Others with a similar disposition to those who initially fled the region with active fighting will take the initiative to shuffle into neighboring regions early and removed themselves from even the slightest possibility of encountering violence before it arrives. These word of mouth amplifying effects lead to the following flee hypothesis:

> ***Flee*** - A portion of the civilian population will respond to violence in any context by *fleeing* to neighboring regions. This will lead to diffusion whereby the effects of violence on disease implied by sheltering and shuffling is further amplified by indirect changes to disease in neighboring regions.

2.4.2 Disease outbreaks: conflict intensity and geography

As a conflict unfolds it pushes and pulls civilians around a country. Some conflicts located in isolated regions might incentivize a large amount of shuffling nearby while other conflicts may cover such a wide area of the country that they obviate any incentive civilians might have to relocate to other areas and, if the violence is relatively low over this large area, could encourage widespread sheltering. These aggregate strategies across a country shift the spread of disease across regions and can lead to situations where infection with certain pathogens becomes more widespread leading to outbreaks - or disease infection above and beyond normal levels where health care systems can adequately manage the sick and those in need of medical attention. Building on the expectations presented in the preceding section regarding the relationship between conflict intensity and battlefield status at local levels, here I consider how conflict types characterized by varying degrees of conflict intensity and overall geography shape the potential for widespread disease transmission and disease outbreak.

Conflicts may fall into four categories based on the high (low) levels of intensity and diffuse (concentrated) geography of violence: high intensity, diffuse conflicts - expansive; high intensity, concentrated conflicts (hotspots); low intensity, diffuse (simmering); and low intensity, concentrated (localized). These conflicts each afford civilians differing degrees of agency to navigate around a country to escape violence resulting in different potential for onset of widespread disease transmission and disease outbreak.

High Intensity, Diffuse - (Expansive conflicts) - High intensity and diffuse, or Expansive conflicts cover wide regions of a country and exhibit extensive amounts of fighting across that area with high levels of violence destroying both lives and infrastructure. Civilians in these settings will chose to move to evade violence with some shuffling into neighboring regions and settling as internal displaced to escape violence and others fleeing even greater distances by navigating out of country. In these situations some number of civilians will no doubt contract noncontagious diseases as they move around, but these small number will prove insufficient to generate a widespread outbreak of noncontagious disease. In contrast, the widespread movement of people who will live in confined spaces in close proximity to others in these conflicts will create ideal conditions for the onset of a contagious disease outbreak. This leads to the expansive conflict hypothesis:

> ***Expansive*** - In geographically diffuse conflicts, high intensity fighting will increase the probability of contagious disease outbreaks.

High Intensity, Concentrated - (Hotspot conflicts) - Unlike expansive conflicts that encompass a wide geographic region within a country, more concentrated or Hotspot conflicts suggest that civilians will find themselves forced to shelter in response to violence. When conflicts concentrate in one small area of a country that suggests a strength asymmetry between belligerent forces.[6] When belligerents in a conflict exhibit a relative strength parity violence tends to cover a wider geographic extent. The asymmetry between belligerents affords the stronger party in the conflict (typically state military forces) with the option to surround the weaker force to curtail the flow of supplies into the contested space. These operations typically leave civilians trapped in the conflict space without the opportunity to escape elsewhere. Facing these conditions they are forced to shelter in their homes or in the homes of close friends or family. These conflicts therefore create situations where civilians experience greater contact with noncontagious disease causing pathogens which is especially pronounced due to the high intensity violence damaging buildings and infrastructure in the concentrated space. Sheltering reduces contact between unfamiliar groups thereby reducing the chances of contagious pathogen transmission. This combination of factors suggest

[6] Of course, secessionist civil wars represent an exception to this where insurgent groups concentrate their forces in a confined area for strategic purposes related to their political goals.

the following hotspot hypothesis:

> ***Hotspot*** - In geographically concentrated conflicts, high intensity fighting will increase the probability of noncontagious disease outbreaks.

Low Intensity, Diffuse - (Simmering conflicts) - Conflicts that encompass a wide geographic space but which exhibit a relatively low intensity of violence across that area indicate a lull in fighting or simmering tensions between belligerents of relatively comparable strength unwilling to escalate the conflict further. In conflicts that fit this pattern, civilians will feel less pressure to abandon the relative safety of their homes and will instead chose to shelter in order to minimize exposure to the low intensity violence that does permeate the conflict landscape. Owing to the comparable strength between belligerents, these conflicts will generate infrastructure damage due to ongoing and past fighting. Since civilians will chose to shelter in these conflicts due to the relatively lower risk of violence in low intensity conflicts as well as the lack of comparably safer regions elsewhere in a conflict that covers a diffuse area, exposure to noncontagious disease causing pathogens will increase. The widespread fighting in these conflicts strains state resources leading to repair deficits for damage buildings and damage to resource systems that exacerbate this exposure suggesting the following simmering conflict hypothesis:

> ***Simmering*** - In geographically diffuse conflicts, low intensity fighting will increase the probability of noncontagious disease outbreaks.

Low Intensity, Concentrated - (Localized conflicts) - Localized conflicts tend to generate relatively lower intensity violence while remaining concentrated to a limited area within a country. Similar to hotspot conflicts, these situations also reflect an asymmetry between belligerent forces. But unlike hotspot conflicts these localized conflicts suggest the weaker belligerent (typically non-state, especially when concentrated in one area of a country) is severely outmatched and unable to escalate violence to a serious degree. The lower overall level of violence does not warrant the stronger (state military) party bearing the expense and effort to completely encircle and cut off the impacted area. Instead, counter-insurgency tactics can provide comparable military results to degrade the weaker insurgent force at a fraction of the cost. These operations still generate skirmishes and violence and may even result in terrorist attacks committed by the weaker party. Since they still possess the ability to leave an area in these situations, civilians will choose to shuffle to nearby spaces rather than remain in an area with active counter-insurgent operations taking place. The relatively low intensity violence in the impacted conflict space will not sufficiently damage infrastructure enough to generate any outbreak of noncontagious disease in that area. But, civilians who chose to shuffle into other regions face greater exposure to contagious pathogens due to their increased contact with other people. This combination of factors suggest the following localized conflict hypothesis:

> ***Localized*** - In geographically concentrated conflicts, low intensity fighting will increase the probability of contagious disease outbreaks.

Figure 2.2 summarizes these conflict types as well as expectations regarding the possibility of disease outbreak occurring in those settings.

These anticipated expectations regarding the outbreak of disease rest upon the preceding expectations regarding the spread of infectious disease at local (subnational) levels when civilians observe violence and consider whether their home area falls within an active battlefield. Therefore, expectations about the relationship between violence and the *spread* or *outbreak* of disease suggested by this theory both rest on a series of assumptions about patterns of civilian behaviors in response to violence. These foundations of civilian decision-making in response to violence assume that civilians act rationally when exposed to violence by seeking to minimize their exposure to harm and maximize their individual or family's security. Rational civilian

		Conflict Geography	
		Diffuse	Concentrated
Conflict Intensity	High	<u>Expansive</u> Contagious - (+) Noncontagious - No effect Mechanism: Shuffle	<u>Hotspot</u> Contagious - No effect Noncontagious - (+) Mechanism: Shelter
	Low	<u>Simmering</u> Contagious - No effect Noncontagious - (+) Mechanism: Shelter	<u>Localized</u> Contagious - (+) Noncontagious - No effect Mechanism: Shuffle

Figure 2.2: Conflict typology and Disease outbreak expectations

strategic responses to violence therefore represents the last component of this theory.

In order to explain why contagious and noncontagious infectious diseases spread in different ways across conflict context I make the following assumptions regarding the civilian actors observing violence, considering their options (geography), and making strategic choices which cascade into downstream disease outcomes:

- The intensity of observable violence catalyzes civilians to change their behaviors
- Understanding where violence takes place relative to them is important information they will seek out
- While many information sources might provide news about conflict geography, circulation of information via word of mouth regarding the status of conflict elsewhere will serve as the primary means by which civilians remain informed of locations with ongoing fighting
- Civilians will seek to avoid abandoning their homes by sheltering and will only shuffle into nearby regions or flee greater distances when they feel they have no other choice such as when a sharp rise in violence pushes them beyond the threshold at which they will tolerate insecurity and they recognize their home

region as an actively contested battlefield

- Civilian strategic responses to violence will map on to health outcomes that reflect exposure to contagious and noncontagious disease suggested in the preceding section

Synthesizing the full theoretical pathway, I argue that civilians observe violence and respond in ways that trigger different rates of exposure to infectious disease causing pathogens. These generalizable strategic responses aggregate to population levels and produce subnational variation in the spread of infectious disease across a country. As a consequence of these changing rates of disease across subnational regions, certain types of conflict which vary according to the intensity and geographic dispersion of violence that a country experiences will have a higher or lower chance of contributing to the outbreak of disease. Having discussed the primary components of this theory as well as expectations at subnational and crossnational levels as well as assumptions made about individual behavior of civilians in conflict zones, I now turn to briefly revising how this theory is tested in the remaining chapters of this dissertation.

2.5 Theory review

The theory presented in this chapter traces a causal pathway that plausibly maps variation in patterns of violence in armed conflict onto distinct infectious disease outcomes through a mechanism of strategic civilian responses to violence in conflict spaces. When civilians respond to violence by sheltering, shuffling, or fleeing they alter their likelihood of encountering pathogens responsible for causing *contagious* or *noncontagious* infectious disease. The individual choices that civilians make aggregate to cause variation in the spread of disease across regions and this spread alters the likelihood that an outbreak of particular disease types will occur. The remainder of this chapter provides a road map describing how this theory is tested across three levels of analysis: the individual, subnationally, and crossnationally.

Individual analysis - In Chapter 3 - Civilian Voices, I set out to establish the plausibility of the assumptions I make regarding civilian decision-making in conflict spaces. Here I devote particular attention to demonstrating that civilians consider both the intensity of violence *and* the geography of that violence when making decisions. I further set out to establish that the patterns of armed conflict characterized by changing intensity and geography of violence contribute to civilians pursuing distinct strategic responses: sheltering, shuffling, or fleeing. Finally, this chapter seeks to establish that these strategic responses contribute in different ways to the pathogens civilians encounter while navigating conflict spaces leading to unique contagious or noncontagious infectious disease outcomes. In order to provide this evidence, I qualitatively examine the narratives and themes in the responses provided by conflict refugees recruited for interviews to explore firsthand accounts of the relationship between war and disease.

Subnational analysis - In order to demonstrate that the individual foundations established in Chapter 3 translate into real changes in disease outcomes, in Chapter 4 I examine how variation in the intensity of violence across (non)battlefields shifts the spread of disease over subnational regions embroiled in armed conflict. I examine these patterns using a novel subnational dataset that spans multiple countries over multiple years and test the theory in a manner that accounts for the *joint* way in which civilians interpret intensity and geography of violence when formulating a response to conflict conditions. Additionally, here I account for "word-of-mouth" effects that would amplify the effects of civilians sheltering or shuffling through a subset of civilians fleeing violence and, along the way, sharing news of what they had witnessed to passersby leading to downstream effects of violence on disease in other regions.

Crossnational analysis - Finally, based on the results of the Civilian Voices and

Subnational Analysis chapters I turn in Chapter 5 to testing the aggregate consequences of armed conflict on disease at country levels by exploring how types of conflict change the probability that an outbreak of contagious or noncontagious infectious disease will occur. To test the theory at this level I construct a crossnational dataset and derive a conflict typology based on the intensity and geographic extent of violence across conflicts. Whereas the subnational chapter demonstrates how individual choices in response to violence impact national health outcomes, this chapter makes clear the global health implications of armed conflict.

This chapter has proposed a theory of infectious disease and war grounded in rational civilian decision-making in response to observable changes in the intensity and geography of violence in armed conflicts. I have traced out the pathway leading from violence to disease across three levels: the individual, the region, and the country. The following chapter begins the process of evaluating this theory by establishing the individual foundations of civilian response to violence as well as by demonstrating the plausibility of these responses producing unique infectious disease outcomes.

Chapter 3

Civilian Voices[1]

> "They don't inform you before attacking, so you just wake up at night and see your village is being bombarded and start running from dusk to dawn."
>
> — Interview respondent sharing their experience fleeing home
>
> "To be honest, how I survived that place I don't even know. None of my family members got sick, but a lot of people got sick."
>
> — Interview respondent referring to their time living in a displacement camp

3.1 Introduction

As of 2020, the most recent year with complete data, the global population of civilians forcibly displaced from their homes had grown to approximately 80 million. This figure consisted of 30 million refugees who have sought asylum in foreign countries and

[1]This study was approved by the University of Minnesota Institutional Review Board, study ID: STUDY00014332.

nearly 50 million who experienced internal displacement within their home countries (UNHCR 2021). While some of this displacement occurred as a consequence of natural disasters[2], most of these people experienced displacement due to armed conflict and political violence, such as those escaping deteriorating security conditions in countries like Syria, Afghanistan, South Sudan, and Venezuela which together have contributed most to the total number of displaced with over 15 million people escaping violence in these countries alone. Meanwhile, a similar pattern emerges for internally displaced - those who have abandoned their homes but remain within their country of origin and have not crossed an international border. Among these 50 million individuals armed conflict has contributed the most to displacement; for example, dislodging over 8 million Colombians and 2.7 million residents of the Tigray region in Ethiopia. These displaced civilians travel to nearby cities in search of food, shelter, and medical aid and often take up residence in cramped aid camps which, in time, grow into permanent settlements for many. The global population of refugees and internally displaced represent some of the most vulnerable people in the world today. They face ongoing threats of violence due to the factors that initially led them to flee but also for reasons related to their physical situation, particularly compromised health conditions such as infectious disease.

These civilians, those forced to abandon their homes due to violence in civil war becoming internally displaced or refugees and those who remain behind and continue to live in areas with active conflict, suffer long term psychological and physical harm (Schon 2019; Ghobarah, Huth, and Russett 2003; Neumayer 2005) in addition to the many who lose their lives. One way in which these harms most acutely manifest for civilians is through illness and disease brought about by conditions in active war zones that limit access to sanitary living environments or quality health care to treat

[2]For example, such as due to climate change. See this chapter's conclusion for additional discussion on the relationship between climate change induced migration, disease, and armed conflict.

illness early. As conflict conditions vary, so too does the exposure these civilians face to both their personal security and their health situation which determines, in part, their exposure to pathogens responsible for infectious disease. War zones represent particularly ideal environments for the spread of disease: destroyed infrastructure increases exposure to wildlife and insects as well as degrades water purification systems that may increase the likelihood someone contracts a non-contagious infectious disease while the patterns and locations of violence can create situations which incentivize people to group together for safety in confined living spaces that may lead to the rapid transmission of contagious infectious disease. In armed conflicts health and security share a close connection (Connolly and Heymann 2002) and the conditions that civilians face either as a direct consequence of armed conflict or in response to violence impact the risks that a person will contract disease. Therefore, the various responses civilians pursue as conflict conditions change around them has profound implications for both individual and aggregate infectious disease outcomes in conflict zones.

In order to probe the causal pathway connecting armed conflict to the spread of infectious disease through a mechanism of civilian strategic responses to violence, this chapter investigates civilian decision making in conflict zones at the individual level[3] by examining how civilians navigate complex conflict spaces. Leveraging interviews conducted with conflict refugees who escaped violence from countries with ongoing armed conflict or political violence, I investigate the sources of information about violence that these refugees used to make informed (rational) decisions about their personal security situations. How did they remain aware of where violence took place and the patterns of violence occurring around them and how did they respond to this information? That is, what strategies did these refugees pursue in response to

[3]Chapters 4 and 5 consider aggregate infectious disease outcomes by examining subnational infectious disease rates and cross-national infectious disease outbreaks respectively.

violence to improve their personal safety? These interviews also devote particular attention to unpacking the health consequences of conflict with specific attention devoted to opportunities or conditions favorable to the spread of disease as well as illness which refugees directly experienced or observed while living in areas with high levels of violence, while escaping conflict spaces, and after arriving in locations with higher levels of safety such as temporary refugee camps.

Refugee narratives that emerge from these interviews provide individual-level evidence that illustrate the causal mechanism that I argue connects armed conflict to the spread of disease: strategic civilian responses to the intensity and geographic distribution of violence. The refugee experiences presented in this chapter illustrate the complex and varied pathways that connect conflict conditions to the spread of disease across different conflict contexts. Only individuals who experienced conflict firsthand can explain in their own words what factors informed their personal decisions on how best to respond to that violence. The narratives communicated by these refugees also illustrate how armed violence created situations and contexts favorable to the spread of infectious disease – what I refer to as *disease contact-points* – where contact with a disease causing-pathogen was made more likely due to the conflict and civilian responses to violence occurring in that conflict. These refugee narratives illustrate the health challenges faced by those living within and navigating through the complex environments that emerge in active conflict zones.

The motivations, patterns of behavior, and themes that interviewed refugees revealed underpin the foundations for the theory presented in this dissertation which argues that the conflict context (its intensity and geographic scope) explain the relationship between war and the spread of two categories of infectious disease: contagious disease which spreads easily between people and non-infectious disease which spreads from contact with the environment. The remainder of this chapter proceeds as follows. Section 3.2 provides a discussion of previous research on civilian displacement in response to violence and armed conflict. This background serves to present accumulated evidence of both why civilians experience violence and how (where) they respond when facing this violence. This past work directly informs the structure of the refugee interviews. Section 3.3 provides a brief discussion on the strategy used to recruit conflict refugees for interviews as well as discusses using interviews as a world building technique that can reveal themes relevant to a social process. Section 3.4 presents the results of these interviews and explores themes and patterns of behavior that emerged from these interviews. This section also discusses how the choices and experiences shared by these refugees can help us to understand how conflict conditions created contact-points where refugees faced heightened risk of encountering infectious disease-causing pathogens. Finally, Section 3.5 concludes by discussing the implications of the analysis presented here on the subsequent quantitative chapters as well as discusses possible future avenues of research that build upon the initial work presented in this chapter.

3.2 Civilian responses to violence

How civilians respond to patterns of violence and where those responses encourage civilians to travel - such as by taking shelter with others in a more secure part of their hometown or by traveling greater distance to other locations - connect conflict to disease. Civilians respond to deteriorating security situations in conflict zones in complex ways and do not always follow a predetermined path such as by leaving an area in response to violence. This section explains how we presently understand civilian behavior in armed conflicts and motivates the organization of the interview questions asked to recruited refugees.

Research on civilian displacement generally considers civilian responses to armed conflict through the lens of a utility maximization framework that evaluates factors which "push" and "pull" civilians around conflict zones (Davenport, Moore, and Poe 2003; Petersen 1958). Civilians respond to armed conflict as rational actors attempting to minimize their exposure to harm and maximize their personal security. Abandoning one's home is one of the most costly decisions a person can make and so civilians in war zones resist doing so unless they feel as though their situation leaves them with no other choice. Many factors can encourage a person to stay at their home despite deteriorating local security conditions. For example, familiarity and sentimental attachment to a place, network connections (through neighbors or family), and personal assets such as the home itself or a personal business all act as anchors which encourage a person to stay. Uncertainty about conditions elsewhere can reinforce a person's desire to remain in a place where conflict is occurring. They might feel they lack awareness about conflict conditions elsewhere and may, justifiably, fear the possibility of encountering conflict in new location where they do not possess the same situational awareness that they do in their hometown. The uncertainty of securing work, food, and shelter at a new location may further discourage them from leaving. Furthermore, arriving unscathed at a more secure location is also not guaranteed. Travel across a conflict space is risky and the fear of encountering fighting belligerents or needing to pass a security checkpoint maintained by hostile insurgents can also deter civilians from abandoning the perceived safety of their homes. Yet, in many cases, civilians do eventually leave and violence represents one of the best predictors for that strategic choice.

How civilians respond to violence - Extensive research has investigated the determinants of civilian displacement as a result of armed conflict and found that exposure to violence is one of the most significant predictors of civilian population movements (Adhikari 2012; Adhikari 2013; Braithwaite, Cox, and Ghosn 2021; Balcells and Steele 2016; Schon 2019; Ceriani and Verme 2018; Kaplan 2017; Masullo 2021; Schon 2021;

Balcells 2010; J. A. Stanton 2016; Steele 2017; Steele 2011; Steele 2019; Balcells 2018; Neumayer 2005; Davenport, Moore, and Poe 2003; Iqbal 2007; Melander, Öberg, and Hall 2009; Turkoglu 2022). Investigations of cross-national displacement reveal that threats to an individual's personal integrity have the largest effect on encouraging an individual to abandon their home. This may occur due to direct civilian targeting in civil war (Davenport, Moore, and Poe 2003), but also may result from economic destruction and loss of future growth potential (Neumayer 2005)[4], state-based targeting such as through violence committed during a genocide/politicide (Moore and Shellman 2006), and as a consequence of violence occurring during periods of regime change (Davenport, Moore, and Poe 2003; Melander, Öberg, and Hall 2009). Some civilians choose to stay, despite violence occurring around them, and may elect to work with armed groups (Kaplan 2017), protest the conflict or oppression (Masullo 2021), or simply hide and hope their situation improves over time (Schon 2021). For most, however, violence strongly encourages civilians to take remedial actions to improve their personal security and intentional civilian targeting by belligerents may exacerbate these pressures.

Fine-grained subnational and survey data have helped to reveal the complexity of civilian decision making in response to violence. Based on survey results from victims of violence in Nepal, Adhikari (2013) found that while the mere threat of physical violence, such as violence occurring within one's home village is sufficient to increase the likelihood that someone will flee with those who have directly experienced violence being four times more likely to leave. Civilians balanced their desire to run away by considering both opportunities to flee as well as potential economic costs. Civilians in regions where industrial and employment opportunities had not suffered as a conse-

[4] In Syria, for example, World Bank (2017) estimates suggest that infrastructure destruction from the civil war exceed ten times the country's pre-war GDP and the effects of capital infrastructure destruction may contribute to out-migration there for the next twenty years. This byproduct of violence has led many Syrians to flee the country.

quences of the violence indicated a significantly lower desire to abandon their homes, even in the presence of violence. The destruction of their homes or sources of income such as due to the destruction of farmland or a business, flip this desire to remain and increases the probability that a civilian will flee.[5] Opportunity also shapes this decision, as the presence of a paved road or major route out of a village increased the probability that someone would leave as well since navigating natural terrain can sometimes prove more dangerous than remaining in place (Adhikari 2013).[6] Civilian displacement research has increasingly highlighted how individual- and conflict-level factors interact to influence civilian decision-making.

In contrast to earlier studies of violence on civilian decisions to flee or stay, more recent work has highlighted threshold (conditional) effects of violence on civilian decision-making. In a subnational analysis using household level data Bohra-Mishra and Massey (2011) found evidence of a nonlinear relationship between violence and migration patterns. Low levels of violence deter migration up to a threshold after which the deteriorating security situation incentivize civilians to flee. Civilians resisted leaving their homes and instead implemented other strategies to avoid violence such as by avoiding public spaces and reducing travel outside the home. Recent evidence from Syrian war refugees suggests that civilians who directly observed violence attempted to leave conflict space *later* than those who did not witness violence firsthand (Schon 2019).[7] This was attributed to the onset of post-traumatic stress

[5]These individual survey results are borne out in country-wide subnational displacement data (Adhikari 2012). While physical threat persisted as a dominant explanatory factor to account for variation in displacement, perceived economic opportunity (or loss) also helps to shape why people choose to leave in aggregate population flow data. As the opportunity cost of remaining in place increase, people were more prone to flee as they perceived decreasing opportunities for future economic prosperity due to damaged infrastructure, the flight of neighbors, and the long-lasting impression of instability decreasing future investment in a region.

[6]Although interview results presented here suggest the civilians may pursue the opposite strategy depending on conflict context; that is, flee through natural areas rather than roads. When civilians are concerned about insurgent patrols on roadways they may be more likely to flee through backcountry regions rather than on paved routes. See the analysis section in this chapter for additional details on this point.

[7]Schon (2019) also found that those with more opportunity, or “wasta” - social means such as wealth

associated with experiencing violence firsthand which Schon found to have created a delay response in the decisions of civilians to flee a conflict space. Broken community support structures - common to neighborhoods beset by armed conflict - can further compound these psychological aspects. Lack of community support leaves individuals to address narrative ruptures - breaks in their understanding of their personal security situation - by themselves which leads to uncertainty and indecision regarding whether to flee from violence or not (Rosen 2017). This underscores that civilian desires to flee from violence operate on a motivation-opportunity continuum where individuals may possess the motivation to flee, but lack the opportunity; or they may have the opportunity to flee but lack the motivation to do so such as if they fear checkpoint violence as was often the case for Syrian refugees (Schon 2016) which lead to "involuntary immobility" (Lubkemann 2008) and individuals choosing to shelter in areas with violence rather than to endure the perceived risk of fleeing elsewhere.

Where civilians go - While civilians respond to violence in a variety of ways depending on both their own personal attributes and the characteristics of the conflict, civilians also seek out safety in various locations - some resettle nearby such as elsewhere within the proximity of their home city and others much more distant such in other cities within their home country or further such as across an international border into neighboring countries or beyond (Davenport, Moore, and Poe 2003; Neumayer 2005; Iqbal 2007; Balcells and Steele 2016; Balcells 2018; Roberts 2017; Pearlman 2018; Bohra-Mishra and Massey 2011; Moore and Shellman 2007; Steele 2019; Turkoglu 2022). Where civilians go significantly impacts their health as it influences the disease-causing pathogens they are likely to encounter as they settle in one location or travel to another influencing whether they have access to safe and sanitary living conditions or live in makeshift congested spaces with other people. Features of the conflict as well as personal characteristics of the civilians themselves influence

or network connections - pursued opportunities to escape violence before anyone else.

the choice of destination and how far a person is willing to travel for safety when responding to violence in an armed conflict.

Much like exposure to violence most decisively compels civilians to change their behavior and implement a security improving strategy, distance or geographic proximity of potential destinations most decisively influences where civilians travel when they decide to leave a place and resettle elsewhere (Neumayer 2005; Iqbal 2007). When civilians choose to flee a country and become refugees, the distance between two countries is the strongest determinant of conflict induced refugee flows (Iqbal 2007). Larger travel distances reduce the flow of refugees suggesting that, even in the presence of violence, civilians are sensitive to the costs of traveling long distances from home and prefer to remain closer if possible. Travel distance between two countries therefore mediates the effects of violence on displacement - refugees attempt to flee countries with ongoing armed conflict to destinations with no armed conflict, however, the magnitude of these conflict-induced refugee flows decrease as the distance between two contiguous countries increase. Indeed, as the data on global displacement referenced in the introduction to this chapter suggest, the vast majority of those who respond to violence by leaving their home choose destinations elsewhere within their home country.

Past research on population displacement patterns in conflict zones partly explain this trend suggesting that civilians rely upon social networks and word of mouth to inform their choice of destination (Davenport, Moore, and Poe 2003; Neumayer 2005). By relying upon trusted family and neighbors when choosing a location to flee, civilians try to minimize the chances they will encounter additional violence while traveling, such as by encountering hostile belligerents at checkpoints established in conflict zones across a country (Schon 2016). Beyond direct personal connections, civilians may also seek out destinations that appear friendly to settlement based on ethnicity. Examining internal displacement that occurred during the Spanish civil war, Balcells (2018) demonstrated that civilians fleeing from violence attempted to minimize the distance traveled and tended to resettle in locations with similar political or ethnic compositions to their home municipality. While familiarity based on ethnic or political identity may afford civilians an increased sense of security in their choice of destination, such resettlement patterns may also correspond to increased cohabitation which leads to the spread of contagious infectious diseases, particularly for individuals with compromised health resulting from their travel and escape from violence (Roberts 2017).

Beyond an intolerance for traveling longer distances and established migration routes implied by social networks and ethnicity ties shaping conflict-induced displacement preferences, the overall intensity of violence and geographic dispersion of the conflict itself shape the flow of displaced civilians throughout a country and into neighboring countries. Considering first the effects of violence on displacement, Bohra-Mishra and Massey (2011) examined displacement in the Nepalese civil war and demonstrated that in districts with lower levels of violence, civilians exhibited a tendency to remain in their home district, at moderate levels civilians moved into nearby districts, and at the highest levels of violence civilians attempted to escape the violence by seeking refuge in neighboring countries. Refugee characteristics further shaped these choices. The elderly were far less likely to migrate anywhere regardless of violence, perhaps owing to the difficulties and uncertainties associated with travel over long distances. Gender and marriage status also informed migration choices with married women exhibiting a stronger tendency than unmarried men to remain local and migrate to nearby destinations rather than internationally. Women were also significantly less likely than men to flee abroad regardless of marriage status, perhaps owing to different evaluations of the risks associated with long distance travel. Finally, larger sized households, such as those with children or the elderly, further deterred civilians from fleeing active conflict spaces. This suggest that civilians factor the overall intensity of violence in their choice of possible destinations but that their personal characteristics moderate these choices; for example, those with elderly or children in their care may lack the capacity to travel greater distances.[8]

The geographic concentration of a conflict also directly shapes displacement patterns (Balcells and Steele 2016; Turkoglu 2022; Steele 2019; Moore and Shellman 2006) which may operate through belligerent targeting; that is, the geographic distribution of conflict can in some cases provide belligerents with the ability to expel populations from certain regions or it may limit civilian choice of possible destinations.[9] Balcells and Steele's (2016) study of irregular and conventional civil wars revealed how diffuse conflict vs. concentrated conflict around frontlines created different opportunities for civilian targeting that resulted in distinct displacement patterns. For example, in the Colombian civil war - an irregular conflict with fragmented points of contestation and rapidly changing frontlines - civilians were displaced from contested spaces to uncontested spaces; this was especially the case if civilians were identified as sup-

[8]The connections between the overall intensity of violence, individual and household civilian characteristics (especially age and gender), and general health and disease outcomes warrants additional research.

[9]Civilians are often intentionally targeted by belligerents during armed conflicts. Civilians fill a critical role as a third actor between two belligerents in an armed conflict (Bueno de Mesquita 2013) through their ability to provide valuable resources to insurgent forces (Weinstein 2006) or critical intelligence information to state security agents (Berman, Felter, and J. Shapiro 2018; J. N. Shapiro and Weidmann 2015). Although, civilians are not entirely passive actors and sometimes resist violence by fighting back and forming civilian self-protection groups that respond to insurgent or state security force violence (Jose and Medie 2016). In many conflicts, belligerent forces specifically target civilians to achieve strategic goals by using violence as a tool to control a population friendly to an adversary, to displace a geographically concentrated population from a specific region, to coerce concessions from an opponent sensitive to civilian casualties (J. A. Stanton 2016), or to undermine political support for opposition groups (Balcells 2010). States may target civilians as part of a strategy to dislodge disloyal elements from within their borders, especially in conventional conflicts where clear front lines have emerged between belligerents with equivalent strength. For example, in Colombia state forces engaged in collective targeting of entire neighborhoods and paramilitary forces successfully expelled civilians living in neighborhoods that voting records indicated provided higher levels of support for a political party favored by an insurgent group operating in that country (Steele 2017; Steele 2011). By displacing these civilians and shoring up support in regions firmly in their geographic control, government forces were able to better concentrate and coordinate their military forces against insurgents elsewhere in the country.

porters of the attacking belligerent's adversary in the conflict. However, in a more conventional civil war such as in Spain where clear frontlines and contestation points emerged, civilian displacement followed the changing battle lines leading to patterns of displacement that concentrated around the battle space and only during periods when the frontline in the conflict shifted.[10]

While civil wars tend to produce higher internal displacement and state-based violence higher refugees (Moore and Shellman 2006), this may result from civilians facing limited strategic options attributable to the geographic distribution of violence (Turkoglu 2022) and intentional state targeting. Steele (2019) provided a theoretical scaffolding to explain civilian response to violence across various strategic contexts by deriving the types of civilian displacement likely to emerge from the interaction of targeting types and perpetrators. Specifically, who perpetrates the violence and the purpose of that violence shapes where civilians will go when attacked. For example, when attempting to escape violence carried out by armed groups, a civilian may attempt travel to other locations within their home country. However, if governments are seeking to cleanse a particular ethnic group from a region, then these civilians are predicted to both flee across an international border - where the state has less capacity to reach them - and to flee as a group where they will have greater safety in numbers.

In addition to geography providing opportunities for belligerent civilian targeting,

[10]Balcells and Steele (2016) provide an excellent subnational analysis of displacement in two civil war types and identify "rival" civilians using pre-conflict vote shares coded from archived records. However, they likely significantly understate the magnitude of civilian displacement implied by their models since they do not account for the highly significant and large magnitude spatial effects which they incorrectly interpret as a constant. These effects imply that civilians fleeing targeted violence in one region has a downstream effect leading to civilians in neighboring regions also fleeing. The interviews I conduct in this chapter suggest this is likely due to a "word-of-mouth" mechanism whereby news of belligerent-targeting from displaced civilians leads civilians in neighboring regions to predict they too will be targeted and to therefore take preemptive actions to flee in advance of that outcome. The subnational spatial models presented in Chapter 4 of this dissertation account for these spatial effects by decomposing disease incident rate changes resulting from civilian displacement as a result of violence into "direct" and "indirect" (neighbor) effects in addition to the "total" effect which accounts for both.

the geographic profile of a conflict may operate on displacement patterns by limiting civilian choice resulting in internal displacement in some conflicts or refugee flight in others. For example, Turkoglu recently (2022) explored how the perpetrator of violence and the geographic dispersion of that violence created conditions that either incentivized civilians to travel into other regions of their home country as internally displaced or to travel abroad as refugees. Specifically, government actors - owing to their general ability to perpetuate acts of violence anywhere within their borders - were found to increase refugee displacements while having no discernible effect on internal displacements. When targeted by their own governments, civilians flee abroad rather than risk the real possibility of experiencing violence by government forces elsewhere in their home country. When violence is perpetuated by rebel groups, however, internal displacement appears to represent a more viable option when violence occurs in a concentrated geographic space. Concentrated rebel violence presents civilians with the opportunity to travel elsewhere within their home country for safety without needing to cross an international border. As the areas with insurgent violence within a country expand, opportunities for civilians to travel into nearby spaces for safety decrease and they then instead favor traveling abroad in response to rising levels of insurgent violence. Despite the limitations in Turkoglu's study[11], it's

[11] While a significant step forward in decomposing the different factors that drive refugee flows versus internal displacement, Turkoglu's (2022) analysis suffers from a number of limitations. First, similar to my argument on the relationship between disease and conflict, Turkoglu's theory of civilian displacement in response to violence suggests an interactive relationship between violence and geography. However, Turkoglu only tests the relationships between violence and geography on displacement separately (i.e., as linear additive terms) which amount to testing the effect of violence on displacement independent of geography (and vice versa). A linear-additive model suggests, contrary to past work, theory, and intuition, that civilians consider only the intensity of violence or only the geography of violence in their decision to leave, but not the situation implied by both. The synthesis of past work presented in the review section of this chapter suggests that this is not the case and that civilians consider both overall conflict intensity and the geographic distribution of that violence *jointly* when formulating their strategic response to violence. My analysis of conflict on disease does consider the interactive, context conditional effect of conflict intensity and geography. Additionally, the measure of geography used in Turkoglu's analysis (areas within 10 or 20km radius from a violent event) does not represent the best measure for the geographic location of violence such as those used in more recent conflict studies (Kikuta 2022) or in this dissertation. A simple radius drawn around a violent event location treats all areas with a reported event as equal - whether an area suffers one event or one hundred events. This simple

findings underscore the importance of the geographic dispersion of violence to act as a constraining factor on civilian destination choices in conflict zones. This finding, along with research on the role of conflict intensity on civilian displacement, reveals the complex processes that connect conflict conditions to civilian strategic responses when exposed to deteriorating security conditions in conflict spaces.

3.2.1 Synthesizing the connection between civilian displacement and health

This past work on civilian displacement in conflict spaces reveals how both the overall intensity and geographic distribution of violence *jointly* operate to inform how civilians respond to violence and where they might go if they choose to leave a conflict space. The choices that civilians make will change their immediate personal circumstances leaving them more or less exposed to various contagious disease causing pathogens. By sheltering, shuffling, or fleeing to evade violence civilians will encounter a variety of *contact-points* - or sites and situations ideal for the transmission and infection by these pathogens. The preceding literature review indicates that conflict may increase opportunity for civilians encountering disease contact-points in a variety of ways.

Violence overwhelmingly explains civilian displacement out of conflict spaces. However, due to a combination of either personal characteristics (such as gender, wealth, or the presence of children in the home), the onset of post traumatic stress disorders, or a desire to wait and see if conditions improve or deteriorate, civilians appear to exhibit a tendency to *shelter* and remain in areas with ongoing clashes between bel-

radius technique also cannot account for areas with no reported events or areas outside the radius of nearby events but which are surrounded by nearby violence on all sides, such as if belligerents are contesting space on the surrounding outskirts of a strategically vital city. The conflict geography measures used in the quantitative analyses presented in Chapter 4 and 5 overcome all of these limitations.

ligerents. Locations with ongoing conflict tend to suffer from lower levels of public sanitation, infrastructure damage, and a breakdown in social services which could, for example, lead to a rise in the populations of many disease-bearing vectors such as mosquitoes with spread Malaria or Sand Flies which transmit Leishmaniasis - both of which are noncontagious infectious diseases caused by parasites spread by insects. When civilians resist the temptation to flee and instead shelter in areas with ongoing violence, the opportunity for contact-points between the civilian and these disease causing vectors increase.

When violence begins to deteriorate further from an initial baseline estimate, civilians then determine that leaving the immediate area represents their best strategic response. When civilians decide to leave a space, past research on civilian displacement overwhelmingly indicates that distance significantly moderates the effect of violence and that civilians therefore prefer to relocate close to home if possible. Relocating to areas near their homes - or *shuffling* into nearby spaces grants civilians an immediate security improvement as they will have distanced themselves from the most apparent sources of violence. This strategic response cuts the costs (financial and to personal security) of traveling greater distances while also providing civilians with confidence that they can quickly return home should the security situation improve. However, a fixed housing stock in nearby regions must absorb this influx of internally displaced people attempting to escape violence. When civilians shuffle they likely will temporarily live with friends or family and share spaces. This choice, while necessary to improve their security, increases the opportunity for contact-points between civilians and contagious infectious diseases which are especially likely to spread between people forced to share confined spaces.

Finally, when a conflict reaches very high levels of violence or covers a very wide geographic region civilians will decide to *flee* from conflict spaces entirely and attempt to relocate to more secure locations at greater distances, possibly across an international border into a neighboring country if such an opportunity presents itself. Longer distance travel that results as civilians flee conflict spaces will undermine health and increase the probability of contact-points between civilians and both contagious and non-contagious infectious disease causing pathogens. Traveling long distances, especially with family or other displaced civilians, leads to civilians sharing spaces within one another for long periods of time and often when their immune systems are compromised due to the stress of their situation. Additionally, traveling long distances across areas with active conflict exposes these civilians to many environmental disease-causing pathogens.

In order to establish these civilian strategic response mechanisms as the pathway connecting observable conflict conditions to disease health outcomes, this chapter investigates civilian responses to violence and civilian health experiences and observations in conflict zones by interviewing refugees who navigated through and successfully escaped from political violence in armed conflict spaces. The following section provides an overview of using interviews as a plausibility probe for evaluating these connections as well as briefly discusses refugee recruitment for interview participation as well as a data interpretation strategy based on thematic analysis of the narrative content resulting from these interviews.

3.3 Methods

In order to investigate the conflict-disease connection through a mechanism of civilian strategic response to observable conflict conditions, I conducted semi-structured interviews with conflict refugees who had resettled in the United States. Often missing from from quantitative analyses on the causes and consequences of civilian responses to violence are the narratives of civilians themselves.[12] By relying upon interviews, this chapter avoids this omission and through the refugee narratives that emerge during these interviews I identify common processes, themes, and motivations that underpin how conflict refugees navigated conflict spaces as they fled their countries of origin and how these intersect with disease contact points and shaped infectious disease outcomes. In contrast to the observational quantitative analytic approaches presented in subsequent chapters, the interview-based qualitative approach presented in this chapter provides opportunities to probe what people think.[13] Interviews can prove especially useful in research involving concepts such as personal motivations underpinning an individual's decision to flee violence or a person's observations and memories concerning health and disease which they directly experienced or observed while navigating a conflict space.

3.3.1 Interview Recruitment

Interview participants were recruited from among the population of conflict refugees who have resettled in the United States. In recent years, the United States has admitted approximately 30,000 refugees per year[14] from various regions around the

[12]Previous research on civilian displacement and the consequences of violence on civilian health has successfully leveraged interviews as an inferential technique (Evans 2007; Nidzvetska et al. 2017; Schon 2019; Pearlman 2018). Schon (2019) explained the timing of civilian decisions to leave by using interviews to illustrate how civilian observance of violence as well as financial means intersected to influence the motivation and opportunity for civilians to flee their homes. Nidzvetska et al. (2017) considered the health consequences faced by mothers and their children displaced by conflict in Eastern Ukraine (2014) who had subsequently resettled as internally displaced civilians in western regions of the country. Evans (2007) used interviews to demonstrate how existing migration networks and social connections helped to inform the choice of destination for civilians fleeing violence in sub-Saharan Africa. Finally, Pearlman (2018) offers a narrative recounting of the Syrian civil war in its various stages as told by refugees who had lived through that conflict and subsequently fled.

[13]Interviews represent a class of methodological approaches well suited to identify "life histories" (H. Rubin and I. Rubin 2005) that allow an interview participant to describe their experiences in, for example, a conflict as well as their understanding of both the conflict in general and their place within it.

[14]The number of admissions vary per year from recent highs during the early 2000s of approximately 50000 per year to a more recent low of 11,840 admitted in 2020 which coincided with both policy changes enacted by the Trump administration that lowered the refugee admission ceiling as well

globe who have fled their home countries as a consequence of armed violence or due to fear of persecution (Baugh 2022). Since 2011, the largest refugee flows resettling in the United States have originated from countries with high levels of armed conflict and political violence including: Burma, Iraq, the Democratic Republic of Congo, Somalia, and Syria. The United States therefore represents an ideal location to recruit refugees who have since resettled from countries with conflicts of varying levels of intensity and geographic extent. Recruitment of interview participants from among refugees who have successfully settled in the United States also has ethical benefits. Interviewing victims of violence in locations proximate to conflict zones increases the risk of retraumatization, especially when the research involves asking participants to relive painful events in their recent past. The research strategy employed here has recruited refugee participants more secure in their life situation and more removed from the source of trauma thereby reducing the stress and anxiety participants may feel during the research process.[15]

Potential interview participants were recruited using a *Facebook* advertisement campaign.[16] An advertisement indicating a research opportunity was deployed on the platform and appeared to specifically targeted users. Facebook's advertisement manager offers a robust array of demographic characteristics to use for targeted advertisement delivery. For the purposes of this project, users who now reside within the United States who are over 18 years of age were selected. In order to specifically target the subset of users who might plausibly qualify as refugees, users who met the following additional conditions were targeted: those whose behavior suggested that they lived abroad or who had family who lived abroad *and* those who lived apart from their family or away from their hometown.[17] Upon clicking the advertisement users

as limitations resulting from travel restrictions due to the onset of the COVID-19 pandemic.

[15]The appendix to this chapter provides additional discussion on research involving trauma victims.

[16]The appendix to this chapter provides more detailed discussion concerning the use of Facebook as a recruitment platform for social science research as well as references recent studies that have successfully used the platform for survey recruitment.

[17]While Facebook's demographic profile data allows for even more precise targeting of users, for

were directed to an interview sign-up survey which asked participants to indicate their country of origin and when they fled to determine whether their home country met conventional criteria for armed violence in civil war research (N. P. Gleditsch et al. 2002). Additionally, the recruitment survey asked participants to indicate whether they had experienced or observed violence directly in order to select refugees with a varying exposure to armed violence. The advertisement campaign was fielded on the Facebook platform between March 2, 2022 and March 13, 2022. The campaign reached 6382 users of which 126 clicked on the recruitment link and 50 of these completed the recruitment survey. From among the 50 who completed the recruitment survey, I selected 15 individuals to participate in semi-structured interviews.[18] The selected individuals provided variation across countries with varying levels of violence and within countries at different points in time.

3.3.2 Analysis Strategy

In contrast to interview samples constructed for parameter estimation (e.g., surveying conflict refugees to identify a proportion who pursued some strategy or another) which leverage sample metrics such as overall size, representativeness relative to a larger population, and randomness in selection, interviews may instead serve alternative purposes such as "world building" - or employing interviews to gauge an understanding of people, place, and process that underpin the microfoundations of a social process (Woldense, Sumner, and Ozcan 2021; Biernacki and Waldorf 1981). Rather that focusing on the unbiased estimation of a population parameter for some variable of interest, interviews conducted for the purpose of world building instead emphasize

example, such as those originating from any specific region in the world down to a specified radius within a precise latitude and longitude coordinate, this more general recruitment strategy was employed to recruit participants from conflicts across a variety of regions rather than any one specific area.

[18] While 15 may appear small it is a typical number for those who have conducted remote interviews on the health consequences of civilian displacement in conflict spaces. For example, Nidzvetska et al. (2017) conducted remote interviews with 9 mothers displaced from conflict in Easter Ukraine in 2014.

a process whereby the researcher conducts interviews to identify key themes and problems identified by interview participants as well as factors used in decision-making while navigating the process under study (Biernacki and Waldorf 1981).

Information gleaned from interviews conducted and presented in this chapter is not meant to demonstrate some strict causal pattern of behavior representative of the population of conflict-displaced civilians. That task would be impossible given the limited sample presented here. Rather, these interviews are intended to illuminate themes of the process that connects conflict observables to disease outcomes as described by individuals who lived through the violence and witnessed firsthand the impacts to health; that is, civilians with lived experiences who navigated through complex conflict spaces and experienced or witnessed violence, compromised health conditions, and disease. These interviews are therefore intended to probe the plausibility of the theoretical mechanisms briefly discussed in the preceding section and in more detail in Chapter 2 by demonstrating that these mechanisms emerge in the narratives of the conflict refugees that participated in this research.

When exploring individual motivations and memories, answers cannot be easily summarized into single values but rather require explanation or detailed description of experiences and themes that emerge from interview participant narratives.[19] Thematic analysis therefore represents an ideal analytic approach for dissecting the narratives and stories recounted by conflict refugees during the interview process by first operationalizing themes and then categorizing collected data along those dimensions (Mills, Durepos, and Wiebe 2012). Interview narratives will be categorized to explore each participant's exposure to violence and awareness of the geographic extent of violence in other locations and how they remained aware of locations with ongoing

[19]Furthermore, qualitative interviews provide unique opportunities for the researcher to identify moments during the interview for participants to reconstruct critical events in their narrative or describe situations that the researcher did not anticipate in advance. For example, the finding on mental health presented at the end of the analysis section of this chapter.

conflict. Respondent violence avoidance strategies (sheltering, shuffling, and fleeing) will also be categorized based on descriptions of how respondents avoided violence while within their home country. Finally, I identify themes that illustrate whether the participant's situation implied a higher risk of encountering a disease contact-point where exposure to infectious disease-causing pathogens was more likely.

3.4 Analysis

Interviews were conducted remotely over *Google Meet* during March 2022 and lasted between 25 and 60 minutes.[20] These interviews employed both open- and close-ended questions to explore: participant exposure to violence, awareness of conflict geography, the individual's decision to flee, their experiences while fleeing and destination choice, and their experiences and observations concerning health and disease.[21] Those who participated primarily came from urban environments in Sub-Saharan African countries which had experienced political violence or armed conflict, especially conflicts occurring during the 2010s. Table 3.1 provides a breakdown of relevant participant demographics.

Before considering each in greater detail, in general the conflict and health outcomes which emerged from these interviews indicate that those who participated in this research had a variety of experiences with violence in armed conflict: some suffered direct violence and others only experienced the downstream effects of violence indirectly through seeing neighbors or family members harmed. These participants also expressed differing levels of confidence in their understanding of violence in other regions and their belief in opportunities to find safety elsewhere. They primarily

[20] Other conflict researchers have successfully employed remote communication to conduct remote interviews with conflict refugees (Lund 2016; Nidzvetska et al. 2017). *Google Meet*, in contrast to alternative services, provided easy access to interview participants without the need for account creation.

[21] See the appendix to this chapter for the interview guide used during these interviews.

Table 3.1: Summary of interviewee characteristics

Variable	Categories	Count
Origin	Rural	5
	Urban	10
Gender	Male	11
	Female	4
Home country region	East Asia and Pacific	1
	Central Asia	1
	Middle East and North Africa	4
	Sub-Saharan Africa	9
Year fled	Before 2000	1
	2000-2005	1
	2006-2010	1
	2011-2015	6
	After 2015	6

remained informed of ongoing violence through radio broadcasts, although word of mouth was also a common method that respondents indicated they used to remain up to date on other locations with active violence. Before ultimately fleeing their home countries as refugees, these participants also responded to violence in a variety of ways with some sheltering in their homes before taking direct paths out of their country and others first making interim stops as displaced persons who shuffled into other areas of their home country to escape violence.

These participants also expressed varying degrees of difficulty securing health care and encountering disease; as well their narratives indicated varying levels of interaction with disease contact-points. While some expressed a great deal of concern about their ability to access health care services, most of those who participated here described situations and experiences where their likelihood of contracting disease was increased (disease contact-points) as well as described direct experiences with disease either before leaving their homes, while fleeing, or afterwards. Those who did not express health access concerns or who did not indicate they encountered a disease contact point or who indicated that they had personally observed disease were primarily urban and fled conflict spaces early at the first signs of escalating violence by traveling out of their home countries via international air travel. In contrast to these individuals, those who remained behind after the onset of escalating levels of violence - either because they felt personal attachment to a location or due to the financial costs of fleeing – had more experiences both with encountering disease contact points and through direct personal observations of infectious disease. Table 3.2 summarizes respondent breakdowns across the main categories related to violence, strategic responses, and health.

Table 3.2: Summary of interview outcomes

Variable	Outcome	Count
Violence Exposure	Direct	11
	Indirect	4
Conflict Geography Awareness	Limited	10
	Aware	5
Conflict information sources	News source (radio, newspaper)	4
	Word of mouth (family, neighbors)	11
Strategic response to violence†	Shelter	5
	Shuffle	10
Interim destination	Local (relative or neighbor)	3
	Internal displacement camp	4
	Refugee camp	3
	Other	5
Health	Access limitations	12
	Disease contact points	12
	Disease observed	10

† These values reflect initial strategic responses to violence.

3.4.1 Respondent experiences with violence

The interview participants expressed varying degrees of exposure to violence during their time in conflict spaces. Some had directly seen family members attacked by military forces while others had only observed violence indirectly such as by hearing explosions in their neighborhood or having seen armed groups patrolling the streets. The majority of participants explained situations where they had directly suffered as a consequence of violence in the conflict, often due to losing a family member. For example, one participant remarked "I saw many things I never want to remember, people died, people I knew, relatives" [R1]. Others described situations where they were hiding in their homes to avoid insurgent groups since they could see the consequences faced by civilians walking the streets. One participant remarked they had "witnessed people getting killed with my own eyes and that really stressed me out and I just wanted to get out... and live in a peaceful place" [R6]. Those who explained direct connections often articulated high levels of stress associated with the conflict and difficult longer-term consequences to their mental health, a topic revisited later.

Even those who did not suffer from violence directly described situations which increased their anxiety about their own personal security while residing at home. One way this manifested was through observing the consequences of violence on others who had fled from neighboring regions, for example, one respondent remarking that "the war was really really hard on us, we experienced a lot of killing, a lot of deaths, a lot of internally displaced persons whose homes had been destroyed, children were killed and kidnapped, women enslaved and raped. It was very difficult" [R12]. Seeing the effects of violence on those who had already fled contributed to increased anxiety and a general desire to travel elsewhere to locations with no conflict. Most, but not all, interview participants had a plan in advance of where they would travel if forced to abandon their homes, but how participants acquired information about the safety of these other locations varied.

3.4.2 Respondent understanding of conflict geography

The interview participants all indicated they had an intense desire to remain informed of where the conflict was occurring relative to their homes and the majority (11) kept up to date on the locations with violence through word of mouth or by "hearing a lot of rumors of violence" [R8] from individuals passing through their towns. Respondents also indicated that they preferred firsthand accounts of violence since they either did not trust media sources or because infrastructure damage in their locations had rendered Internet or radio inaccessible. For instance, one respondent indicated that "the news [about the conflict] was coming to us directly from words of mouth because we don't get access to Internet at this point because the whole place has been bombarded... even our soldier friends would tell us how the war has been going and how close it is to us" [R12]. Those who relied upon media such as the radio also indicated that proximity to nearby violence represented their biggest concern - "I could tune into radio and it was also in the news that said certain areas have violence and people shouldn't go there..." [R6]. Thus interviewees attempted to remain aware of the geographic extent and location of violence occurring across their home country and nearby.

The locations and patterns of movement for insurgent groups especially concerned participants since this factor more than any other served as their indicator for a possible attack - "what we were actually interested in is where they [insurgents] were operating from - where they were destroying people... we get our information and begin to position ourselves to know how close they were to us" [R12]. Many interview participants indicated they felt insurgent or military forces could attack them with little warning so they felt a need to develop an understanding of conflict geography and the proximity of belligerent forces in order to develop a sense of the probability that an attack might occur in their town or village.

3.4.3 Catalysts to leave - threshold effects

Extreme violence occurring in close proximity to a village or sudden instance of violence such as a night attack were commonly cited by interview participants as the catalyst that motivated them to eventually flee from their homes thereby tipping them past their personal thresholds of acceptable violence. Some of the respondents cited violence occurring on their doorstep as the factor that finally compelled them to leave, one remarking that "there was a crisis the night I left that a lot of people were being killed" [R12] and another indicating that "we heard gunshots, they [insurgents] displaced us, they burned down our house and I lost my dad through that violence. We had no option that night, we just had to run away from our home. We ran towards the border" [R8]. Those displaced by such sudden attacks generally expressed a lower degree of confidence in their understanding of where violence was taking place thereby partly explaining how the unanticipated nature of the attacks that ultimately displaced these individuals. Sudden violent events led the interviewed participants to flee into surrounding regions with less of a well formulated plan concerning their destination as discussed in the next section.

Violence in neighboring regions and the implied threat of violence also led some interview participants to flee. One interview participant remarked on violence occurring on the outskirts of their home city - "they [insurgents] were beheading innocent people... and one of my close friends got killed" [R3] - citing the event as the primary reason for reevaluating their personal security situation and leaving their home. The combination of the extremely violent act as well as the event's proximity to their home made this respondent feel sufficiently insecure that they decided to leave. Beyond direct confrontations with violence, the implied or indirect threat of violence also incentivized a few of the participants to flee, particularly when the threat originated from state military forces. One individual recalled how they were "confronted by a group of Syrian army soldiers... At that moment I didn't have any plan, I figured out a plan later" [R7].

Interview participants broadly confirm that both violence and the geographic distribution of violence shaped how they perceived their personal security and the threat they felt to their well being. Both factors contributed to their understanding of their position within a conflict and helped to inform where they traveled after making the decision to abandon their homes.

3.4.4 Strategic Responses - Where interviewees traveled

Given that data collection focused on interviewing refugees who resettled in the United States, all participants eventually opted to flee their home country; however, those interviewed approached this process differently with 5 describing how they sheltered in their homes before immediately leaving and 10 indicating they traveled within their home country before ultimately traveling abroad as refugees. Fear drove the respondents to change their daily routines, one remarking that "we were all looking over our shoulder... we changed how we moved about and how we interacted with each other" [R11]. This worry about what could happen if traveling through a populated place where belligerents engaged in combat led a number to hide indoors, for example, "I was usually an outgoing person... but when the war started I remained indoors because I wanted to be safe and we were not allowed to go outside because anything could happen" [R6]. While remaining indoors improved their safety to a degree, this did not isolate them from the consequences of combat on the destruction of infrastructure and interruptions to supply lines. One respondent lamented how violence in public common areas impacted their access to resources - "these insurgents were destroying or bombing public places... so we couldn't get access to food or proper water or good facilities... schools had been bombarded, structures had been destroyed, so we were suffering from a lack of basic necessities such as food and water" [R12]. The daily challenges of living in areas with ongoing conflict led the majority of respondents to first attempt relocating elsewhere within their home country.

Multiple interviewees indicated they did not want to leave their homes and in particular were seeking to avoid having to travel abroad - "I didn't mean to go out of the country… but I wanted to go to areas not covered by the war" [R1]; therefore perceived opportunities for improved safety nearby largely shaped where they would travel if they decided to remain in their home country. Roadways were largely perceived as unsafe for travel - "we didn't take roads because it is very dangerous. Once you hear any movement of cars you just have to take cover because whoever is driving those roads is nothing but [insurgent group] because there is no presence of army there, no one to protect you, no one to render help… " [R9]. Therefore, to avoid the increased threat of violence they might face by traveling on roadways, many instead indicated they traveled to nearby villages by trekking across undeveloped backcountry regions. Even while traveling some indicated that their understanding of the geographic scope of the conflict remained a concern; when asked why they did not travel to a more secure state capitol, one respondent living in the periphery of their country remarked that "you would have to cross [multiple states]… so it is very dangerous because [insurgent group] is operating in those areas too" [R8] indicating they had considered the alternative, but determined that the potential risk of encountering insurgents was too costly. Civilians therefore preferred nearby locations and often traveled to those destinations on foot - "we got there on foot, and it took us some days… my mom is old and she couldn't run much. There were nights we had to rest in caves because we could not rest in fields because the vegetation there is very sparse" [R8]. These respondents all experienced increased exposure to disease-causing vectors such as mosquitoes that lead to noninfectious contagious disease.

Others referenced familiarity and family ties in their choice of destination. Fleeing from the city where they lived after it was attacked by an insurgent group, one respondent remarked upon returning to their nearby home village that they had "discovered that a lot of places had been used as IDP [internally displaced persons] centers and these were the only available place for me to stay" [R12]. This reflected a pattern indicated by other interviewees who recognized that coordinated insurgent violence targeting weaker villages preceded large influxes of IDPs into one or two nearby villages perceived as safe spots. For example, one respondent noted that insurgents "would operate from one village to another village, they rarely come to towns. Then whenever they attack any village you see a lot of refugees in town, some abandon their homes, so they started living in the town because everybody was afraid" [R7]. Another respondent identified sectarian targeting on the basis of religious identity and spoken language as the factor that drove their family to fear the risk of traveling even a short distance and risking an encounter with unfriendly insurgent forces - "we left our home and we lived in our neighbor's house for a month" [R1]. There they pretended to live as part of one family whenever insurgents would patrol the area searching for the members of the targeted religious group. Often these interviewees indicated that crowded conditions in the IDP camp or in the homes of their neighbors increased their anxiety about perceived health risks. Congested living spaces increase the risks that civilians face for contracting and transmitting a contagious infectious disease. However, the security of the camp or neighbor's homes greatly outweighed any health concerns.

Finally, others who had sheltered for a time eventually would escape violence by fleeing their country altogether rather than attempting to find safety in other nearby regions, but they were only able to do this after they could acquire the financial means to afford escape. The high financial cost of travel in conflict spaces inhibited some interviewees from escaping, for example, one respondent indicated that "I sold my inheritance to travel outside my country at the time" [R10]. Others remarked that travel logistics prevented them from escaping sooner than they would have preferred since few or no transportation options existed - "there was no car or no bus" [R12] - to provide transportation across spaces where there was an active insurgent presence. This largely related to situations where insurgents controlled the roads leaving civilians trapped with no other choice but to remain sheltered in their homes far longer than they would have otherwise preferred. Some overcame these travel restrictions by resorting to smugglers. One respondent indicated that, after fearing for his life following an encounter with state soldiers, he and his family fled on foot in the night traveling approximately 5km to a meeting spot on the outskirts of their city to meet a smuggler who would transport them across the border to a refugee camp. The respondent's family along with three other families also fleeing the violence shared space in the transport vehicle for an overnight ride to the camp. This congested ride again underscores the health risks that respondents accepted in exchange for the possibility of relocating to safer regions outside the active conflict space.

The various strategies that the interviewees indicated they took in response to violence or due to their feeling trapped and unable to escape elsewhere led to a variety of health outcomes at three distinct locations: while they sheltered in their homes, while traveling to nearby destinations (often on foot) in search of safety, and after arriving at these destinations - whether interim locations within their home country or more permanent living spaces outside their home country. The following section explores these health consequences in greater detail.

3.4.5 Health outcomes

The interviewees reported varied observations regarding health access and disease as well as described situations implying their proximity to a disease contact-point while they navigated through four distinct locations in conflict spaces: their homes while sheltering from violence, the backcountry or roadways while shuffling away from violence to nearby safer areas, at interim destinations such as IDP camps or in neighbor's homes, and finally at more permanent destinations such as refugee camps in the border regions of neighboring counties.

3.4.5.1 Health Access

Restricted civilian access to health care or medical facilities serves as a major catalyst for the spread of disease in conflict zones. Restricted health care access creates conditions where individuals infected with disease lack the means to acquire treatment and have a greater likelihood of transmitting contagious infections to others or, in the case of noncontagious infectious disease, limited medical intervention leaves the source of the disease uncontrolled. While sheltering from violence a number of respondents shared the hesitation they felt with visiting clinics as these locations represented areas where insurgent forces would target civilians, one respondent remarking that "we didn't have access to medical care. At care centers we had been shot and we avoided them" [R15]. The physical threat of violence therefore deterred these civilians from accessing health care, but the perceived threat of violence also negatively impacted access. Some respondents indicated that hospitals and clinics were on the opposite side of their city and that insurgent groups had a strong presence in the neighborhoods in between cutting off their access to health care. They expressed concern about the risks of violence they feared they might have experienced if they had risked traveling through those neighborhoods if they got sick and went to the hospitals for treatment.

Those who had fled from their homes toward nearby destinations living in IDP camps or those who had fled the country and taken up temporary residence in the refugee camps located in border regions indicated varying levels of access to health care. Commenting on medical care while at an IDP camp, one respondent indicated that "we were attended to by a lot of medical teams"[R12]. Characterizations of treatment at these facilities emphasized trauma treatment for victims of violence as well as prescription of drugs to treat infections, particularly malaria contracted while traveling from regions with violence to the camp. Additionally, some indicated the clear focus in camps on isolating individuals who were sick upon entering the camp. However, resource limitations did concern respondents, for example one individual living in a refugee camp across the border from their home country indicated that "a lot of people were in the camp and with the limited resources we just had to share everything. People were getting sick every day. One doctor and two nurses attended to like 100 people. It was very disturbing… If you fall sick, there was a chance you might die" [R4]. This individual indicated they would routinely attempt to self-isolate while living in the camp for fear of contracting any illness.

3.4.5.2 Direct disease observations

Respondents appear to have been most likely to directly encounter disease either directly or in someone nearby while traveling or residing in an interim destination - such as an IDP camp or neighbor's home - or while in a more permanent living situation such as in a refugee camp. As previously indicated, due to security concerns with insurgent presence on roadways or security checkpoints, those who fled their homes on foot preferred to move across undeveloped backcountry areas where their odds of encountering hostile belligerents were lower. However, these rugged regions increased civilian exposure to disease causing pathogens, particularly those spread by vectors such as mosquitoes that spread malaria parasites, although illness attributable to poor quality drinking water also prevailed among those traveling through these areas. While fleeing across a prairie region to avoid insurgent patrols on roads, one respondent noted that "there was this little guy – 11 or 12 then – he was sick from trauma because his father got wounded… so, I had to put him on my back and try to help him on our journey because he couldn't walk." The child had contracted malaria while they were outside traveling to another town for safety and the respondent noted that the child "had a very serious body temperature. So, I had to help him on my back" [R8]. Also common were water-borne illnesses during the shuffling stage as civilians fled. Unlike food which can be more easily transported, water adds a great deal of weight as well as requires storage containers that a number of interviewees indicated they did not have since they had fled their homes in such haste. Thus, when they would encounter water sources they would drink beyond their fill due to the uncertainty of when they would find another source - one interviewee remarking that upon arriving at a water source "we filled ourselves because we did not have any container to fill with water and then we had to get moving because we could not stay there it was not safe" [R7]. Frequently this led to individuals contracting water-borne diseases such as typhoid fever (a bacterial disease) which could be subsequently transmitted to others nearby owing to the lack of sanitation while traveling.

One respondent who had lived for some time in an IDP camp noted that many new arrivals "had typhoid fever because their intake of dirty water they had been drinking before arriving at the camp"[R12]. Observations of disease in camps emerged as a major concern for the interviewees with another remarking that "the prevalence of sickness there [refugee camp] was malaria and meningitis... There were a few cases of Cholera, but they controlled that one very well" [R8]. As noted previously, malaria was attributed to infections which occurred while traveling from homes to the interim camps, but meningitis - a contagious infectious disease spread by either a bacteria or virus and spread through close proximity or coughing - largely infected people while at the camp in this instance. Most housing for displaced civilians in conflict zones utilize quickly deployable, prefabricated shelters tightly arranged due to space limitations. This creates environments ripe for the spread of disease between individuals inhabiting the same space.

Similar to the the situation where meningitis spread through the refugee camp, during interviews participant narratives indicated other situations and experiences which, while not indicating direct or firsthand experience with disease, suggest conditions where the spread of disease was more likely due to civilian responses to violence. These conditions, what I refer to as disease contact points - or locations or settings which increase the probability for the spread of disease due to factors attributable to armed conflict, underscore the various ways that armed conflict intersects with individual health to produce varied disease outcomes. I identify four themes in interviewee narratives suggesting contexts where conflict conditions pushed civilians into situations where interaction with disease contact points increased and with it the likelihood an individual would contract an infectious disease.

3.4.5.3 Disease contact-points -

Beyond health access limitations and directly observable experiences with disease, interviewee narratives revealed four thematic areas that indicated overlapping disease contact points civilians commonly encountered while navigating across conflict zones: congested living spaces, hygiene and sanitation limitations, freshwater and food scarcity, and conditions related to travel while evading violence.

Congested living spaces - Among all situations reported by interviewees, congested living spaces was perhaps the most commonly reported situation that would directly contribute to infectious disease spread. Civilian displacement patterns in conflict zones lead individuals to shuffle to common areas perceived as having a higher level of security. The fixed housing stock in these destination regions must absorb these influxes, for example, one respondent discussing how they took in displaced families noted how they modified space to accommodate them - “our town was surrounded by five or six other villages... while the violence was going on they had to abandon villages and take shelter in town... We had to pack out all our stores and our garage and make it comfortable for them [the IDPs]... We took in two families of four, one family stayed in our garage and another in our store" [R8]. Another respondent revealed their neighbors had offered shelter family members who had fled from violence in their hometown - "my neighbors took in their relatives so they could provide safety to them because the places where their relatives came from had been hit so they had to take them in and protect them... They were really crowded. It was really a small house and it had about 15 people... single rooms with a lot of people" [R6]. Another respondent shared similar concerns about neighbors who, upon taking in friends and family who had fled from elsewhere in the country, were crowded into small apartments; "they managed with limited space" [R2]. These congested living conditions create ideal contact points for the spread of contagious infectious disease which spread easily from person to person, especially when living in close proximity to one another.

Shared living spaces created disease contact points by forcing displaced civilians to utilize available facilities beyond capacity limits or by incentivizing individuals to share limited resources with one another such as through shared meals. Remarking about living conditions in their apartment complex following an attack in a nearby town by insurgent forces and a subsequent influx of displaced persons, one respondent remarked that intestinal infections were "a major thing during the war because poor sanitation... we had pit latrines and people were overcrowded" [R6]. The existing building management personnel could not maintain facilities given the large number of inhabitants sharing space in housing within the receiving city where displaced persons had shuffled. Another who had fled to their home to hide in their neighbor's attic recalled how their neighbor had tuberculosis at the time - a highly contagious disease spread primarily by respiratory droplets dispelled by coughing or sneezing - "we were staying in congested places, so I was very scared about TB. My neighbor had it and we were in the same house with no ventilation" [R1]. Thus, while the conditions of the conflict had dislodged this individual from their home forcing them to into their neighbor's, the security situation had left them with no additional options for escape thereby making the health risks of congested space at the neighbor's preferable to the risks of travel greater distances.

Beyond overwhelmed facilities, conflicts also created severe resource limitations - for example, insurgent groups displacing farmers to sell crops to merchants in a neighboring country. Discussing chronic food shortages due to insurgent attacks and confiscation, one respondent indicated how residents of their village and IDPs displaced from surrounding villages had to manage with fewer meals shared among larger groups, "you might not even cook three times a day, once you cook in the morning you have to starve yourself maybe until the afternoon... or wait until night when you do general cooking when everybody can share the food in one big plate" [R8]. A hand-to-mouth transmission route represents a common mode for the introduction of contagious infectious pathogens, especially those which cause intestinal disease which are more prevalent in conflict zones due to limited hygiene and sanitation access.

Hygiene and sanitation limitations - Civilians sheltering from violence in areas beset by active combat faced the most challenging hygiene and sanitation limitations owing particularly to freshwater access. In these environments the fear civilians felt for their own safety led them to change their daily routines in notable ways. One interviewee recalled during their time sheltering from violence that "you could not go outside unless you had a neighbor with you. We had buckets to help ourselves, and no taking showers... At this time there was no focus on hygiene, if was just taking care of yourself to not get killed." Limited freshwater access resulted in resource rationing and additional compromises that increased downstream opportunities for disease contact, such as when civilians refrained from washing dishes to conserve drinking water - "you don't have time to wash your dishes, sometimes we would wait two or three days... people got very sick, if they didn't die from violence, they died from cholera" [R1]. Accessing and securing a stable supply of freshwater- and food - that they could store and readily access at home represented a challenge for a number of interviewees that both created a great deal of anxiety concerning how they would collect these resources without experiencing violence, but also created new points of contact for the spread of disease.

Freshwater and food scarcity - Conflict induced resource scarcity that resulted in limited civilian access to food and freshwater created situations where respondents reported utilizing substandard resources for lack of superior alternatives as well as reported resource distribution methods favorable to the spread of contagious diseases. Due to freshwater systems covering a large area with critical nodes (such as pumping stations) creating many failure points, water systems commonly suffer damage in conflict zones forcing civilians to secure water elsewhere - "they bombed our water supply... the only means we had to get water was from nearby rivers, we didn't have running water" [R11]. Civilians can and often do attempt to treat water; for example, those interviewed indicated they attempted to boil water taken from nearby streams as well as treat with chlorine which was in limited supply. However, water contamination in areas with heavy combat can undermine these efforts by introducing particularly resistant bacteria or viruses into the water supply that require more aggressive decontamination efforts. For example, one respondent remarked that "I remember seeing them [insurgents]... they were just dumping bodies into the river" [R13].

Securing compromised water resources also often required civilians to travel far greater distances than they otherwise would prefer given local security conditions increasing the likelihood an individual would encounter a noncontagious disease causing vector. Due to violence, civilians would frequently travel in groups. For example, one interviewee noted they would "track to a nearby stream, maybe 5 or 10km, to get drinking water that would last 2 or 3 days... It was flowing water so we would bathe in it, wash our clothes in it, take some home for cooking, and drink it. So, one river serves all purposes" [R8]. Group travel and aggregation creates opportune circumstances for the spread of contagious disease while degraded water resources often contain bacteria and viruses that lead to infections of cholera or typhoid fever. These diseases can easily be transmitted to others when civilians are forced to share congested living spaces, especially if they have shuffled to other areas hosting many displaced persons who fled to escape violence

Civilian satisficing quality water resources due to the conflict also extended to food which interviewees often reported was in short supply, particularly in conflicts where insurgent forces had interrupted harvest cycles or displaced farmer populations from their land. Malnourishment can weaken an individuals immune system leaving them unable to effectively fight off infectious disease. Faced with such scarcity some interviewees reported securing food from alternative sources - "the problem we were having was getting the foodstuff to cook because nobody went to farm, nobody went to work, it was not easy to survive. We were eating what we had available, what we get from our garden near our house because we could not go too far to farms because we would be attacked" [R12]. In some conflicts, however, some interviewees reported that aid organizations attempted to intervene and fill the supply gap created by the conflict. However, the reported distribution modes indicate these situations too may have contributed to the spread of disease among civilians who had shuffled into nearby regions in close proximity to armed conflict. Since commerce stopped during the conflict, aid organizations provided food to internally displaced, "a whole village or city lin[ed] up for food" from NGOs. The distributed food was often fought over due to limited distribution supply, so "the food you have been given, by the time you get it you don't know if it's clean because people have grabbed it, it's fallen down" [R1]. Limited access to hygiene and lining-up to receive food places civilians into close proximity with one another creating an opportunity for contact with infectious disease. Desperation for food resources led many to accept substandard resources for lack of any available alternatives leading to situations where contact with disease causing pathogens increased. Food scarcity also occurred while civilians traveled to evade violence by shuffling into nearby regions - a period during which other opportunities for contact with disease also increased.

Travel risks - Civilians faced increased encounters with disease contact points while traveling such as by consuming sub-standard food as well as by sharing confined spaces with others while escaping a conflict space. Limited access to food emerged as a source of significant stress for interviewees who indicated they had fled from conflict, especially those who had done so on foot - "if I tell you we starved that is an understatement, we didn't get anything to eat [while fleeing]. So whatever foods we saw on the road we ate. You don't even care if it is ripe or not or safe to eat or not" [R8]. This increased exposure to potential disease caused by food-borne illness, but starvation can increase stress further reducing an individual's ability to manage infection - a point addressed in further detail below.

While fleeing from their homes civilians often secured travel on transportation that was highly congested with other civilians. Remarking why they had fled the city they were living in one respondent indicated they had fled due to the "consistent violence and the consistent fighting to seek shelter in my village… It is about a 6 to 7 hour journey." They had secured transportation for this 6 hour trip on a large flatbed transport truck with several other civilians also fleeing violence. Conditions traveling from the city to the village were highly conducive to the spread of contagious disease, "[i]t was a fresh attack… a lot of people were wounded and sick… and everybody was just piled on the truck" [R12]. Other interviewees also reported long travel conditions and some discussed days long trips, for example, one indicated that "leaving... was difficult because it was a long journey, I took a bus... it took us 2 to 3 days" [R9]. During these extended duration travels to intermediate destinations, civilians shared tightly enclosed spaces in close proximity to others with compromised health due to the conflict conditions they had fled, some had suffered injuries or other illnesses. The combination of these factors directly contribute to the spread of contagious disease among those shuffling into other spaces while fleeing violence creating more challenging health conditions in recipient areas.

Analysis of refugee narratives that emerged from interviews revealed four themes suggesting contact points where violence created conditions that greatly facilitated the spread of disease: congested housing and living conditions among the displaced who had shuffled to other regions, restricted access to facilities for hygiene and sanitation particularly for those trapped and sheltering in active conflict spaces, food and freshwater insecurity for both those who sheltered and shuffled around battlefields, and congested modes of transportation for those who shuffled out of a conflict space or fled their home country by utilizing public transportation such as buses or more private transportation such as smugglers. Each of these emergent themes suggest that how civilians respond to violence places them into varying contexts where disease risks change, for example, congested living spaces in regions where civilians shuffle increasing the likelihood of contagious disease while limited access to hygiene and sanitation among sheltering civilians increasing the likelihood of noncontagious infectious disease. Beyond these four themes, one additional factor emerged from interviews concerning interviewee mental health and stress which may plausibly lead to greater likelihood of contracting disease in general.

3.4.5.4 Stress and Mental Health -

In response to a final interview question inviting participants to share their thoughts on any topic not yet covered during the interview, a number responded by remarking on compromised mental health which they attributed to their exposure to violence and time spent in active conflict spaces.[22] These responses generally highlighted remorse due to personal losses suffered during their time escaping their home country (such as losing family members or friends) or emphasized challenges they faced due to fear of violence and the stress that placed upon them during that time which they felt they could still vividly recall, even some time after escaping the conflict space. This compromised mental health that interviewees attributed to violence suggests two additional possible pathways for a disease-conflict connection that implies short- and long-term effects. In the short-term the stress that compromises mental health may also sufficiently compromise an individual's immune system that those more stressed by the consequences of violence will be most susceptible to suffering an additional risk of contracting disease. In the long-term the stress of armed violence may produce downstream health consequences leading to a greater burden of disease faced by refugees emerging from the most violent armed conflicts, but also for those populations who remain behind living in post-conflict countries.

Stress increases the risk that an individual will contract an infectious disease (Hamer et al. 2019; Roth et al. 2019; Avitsur et al. 2015). Traumatic life events and psychological distress contribute to higher rates of infectious disease among the general population (Hamer et al. 2019). Negative experiences that generate high levels of stress in children (under-5) may also increase the likelihood of a child contracting an infectious disease (Roth et al. 2019) and this vulnerability may contribute to increased

[22] For the exact phrasing of this question see the interview guide included in the appendix to this chapter. Other common replies included the participant expressing thanks for the opportunity to share their memories and feelings concerning their experiences with armed conflict or the respondent indicating they had no further thoughts to share.

risk of infection later in life (Avitsur et al. 2015). Therefore, clinical work suggests a clear relationship between stress and the onset of infectious disease as well as indicates both short- and long-term consequences of stressful or traumatic events on downstream physical health. All of the interviewees who participated in this research suffered some form of trauma attributable to their experiences in conflict zones, but some more than others suffered the mental distress of first-hand experiences with violence and loss. The short- and long-term effects of stress on health and individual susceptibility to infectious disease suggest two observable implications for the relationship between conflict and disease as well as where those effects may be most likely to emerge.

In the short term violence greatly increases stress on the body leading to a compromised immune system and higher chance of an individual suffering infection. Multiple respondents here suggested that they often went without sufficient food or sleep during their time escaping from violence. For example, reflecting on their time in an IDP camp after having spent some time sheltering from violence one respondent remarked that "it was so peaceful there [the IDP camp] because those two months [while sheltering] we never slept. We cannot sleep because you do not know when they are coming... It was terrible" [R1]. Sleep deprivation, as suggested here attributable to uncertainty and fear of imminent attack, and malnutrition, as suggested in the previous section where respondents indicated they had "starved" while escaping regions with violence, increase the body's susceptibility to infectious pathogens making an individual more likely to contract an infectious disease (Irwin 2019; Walson and Berkley 2018). Those with the most exposure to violence and trauma who have suffered distress which would lead to sleep deprivation or who have suffered from a lack of access to necessary resources may therefore be most likely to suffer from an infectious disease. Subsequently higher rates of disease among these individuals seem most likely to occur while they shelter in their homes in regions experiencing violence or in the immediate aftermath of escaping those locations, such as when they travel while shuffling into nearby regions.

In the long-term we know that physical injuries and disabilities acquired during an armed conflict lead to increased suffering among populations in countries that suffered civil war in the years after the fighting has stopped (Ghobarah, Huth, and Russett 2003), but there is no reason to assume injuries that contribute to negative downstream health outcomes should be restricted to physical health and exclude mental health. As evidenced by the interviewee narratives analyzed here, the toll of a conflict on an individual's mental health also contributes to suffering in post-conflict years. One respondent, reflecting on their time in a conflict space when they were a child, remarked "mental health was very crucial at this point because you are thinking too much, and one thing is that you are a kid still and you have seen people die and the only people you have seen die is people you know and getting that from your head is very hard…" [R14]. As the clinical research suggests (Avitsur et al. 2015), childhood trauma may lead to greater risk from infectious disease later in life. This suggest a greater burden of disease both among refugees who directly experienced violence while fleeing from an armed conflict as well as within post-conflict countries through a mechanism of compromised immune system responses attributable to past trauma induced stress.[23]

3.5 Conclusion

Armed violence creates ideal conditions for the spread of disease and operates through a mechanism of civilian population movements in response to observable patterns of violence as well as understanding of conflict geography, or the spatial extent and lo-

[23] This in addition to other factors that contribute to greater burdens of disease in post-conflict countries including loss of professional medical staff, destruction of health care infrastructure, and reduced post-conflict investments in health due to other reconstruction costs. These and other factors are considered alongside conflict conditions in Chapters 4 and 5.

cation of warfare. This chapter set out to provide a plausibility probe to examine the relationship between conflict and disease by interviewing refugees who navigated conflict spaces. It achieved this by first providing a detailed analysis of past work on civilian displacement patterns in conflict zones with particular attention devoted to analysis of the effects of violence and the geography of violence on these displacement patterns. This review directly informed the interview guide used to explore the patterns and themes describing the relationship between conflict and infectious disease. The semi-structured interviews conducted here investigated the participant's understanding of conflict conditions, their strategic responses to violence, as well as key health outcomes. These health outcomes include access to health care, firsthand experience with disease and, most importantly, this chapter analyzed themes which emerged from interviewee narratives suggesting contact points where a civilian responding to violence has a greater susceptibility to contract an infectious disease due to the conditions brought about by conflict.

Both the extended literature review on civilian displacement and the qualitative interview evidence presented here suggest that civilians consider both the intensity of armed violence around them as well as the overall geographic extent of that violence in their strategic response and choice of destinations to evade violence. Aligning with previous research on conflict-inducted displacement, the interviewees here indicated a reluctance to abandon their homes and in many cases preferred to first attempt sheltering from violence prior to shuffling into nearby regions before ultimately fleeing their home countries as refugees. Frequently interviewees cited crisis events as the factor that exceeded their personal thresholds for violence that they would tolerate while sheltering and which ultimately incentivized them to travel away from violence. But factors such as uncertainty about conditions on roadways or the financial burden of securing transport often served as initial deterrents that led some interviewed here to shelter for longer than they otherwise would have preferred. When they did choose to leave, most indicated they first preferred to travel shorter distances to nearby (often familiar) locations in search of increased personal security. These choices in response to armed violence contributed to a variety of important health outcomes reported by interviewees.

By analyzing themes that emerged from interviewee narratives four disease contact points - locations and situations attributable to armed conflict which increase the odds an individual may encounter the pathogens responsible for an infectious disease - were identified: congested living spaces, hygiene and sanitation access constraints, food and freshwater resource limitations, and conditions related to travel away from conflict spaces. These disease contact points plausibly increase the risk of both infectious and noninfectious disease in ways which map on to civilian population movements in response to violence. Therefore, the evidence presented in this chapter underpins the foundations that support the hypotheses tested in the subsequent quantitative chapters on the relationship between conflicts with varying intensities of violence and geographic extent and the incidence rates of infectious disease and the probability of infectious disease outbreak outbreak.

While this chapter has demonstrated the plausibility of a connection between conflict and unique infectious disease outcomes through a mechanism of strategic civilian population movements in response to variation in observable conflict conditions future work could improve the evidence presented here in a number of ways. The interviews conducted here constitute a pre-testing (Kapiszewski, MaClean, and Read 2015) plausibility probe to explore the mechanisms underpinning the proposed theory connecting conflict to disease and are therefore not intended to make any direct claims of causality. That said, one source of potential bias for the conclusions presented here concerns the sample composition consisting entirely of conflict refugees who successfully resettled in the United States. This sampling frame may inadvertently privilege individuals who possessed more education, financial means, or broader social connections that afforded them opportunities to resettle as refugees not shared by those who remained behind and who ultimately resettled in their home countries after violence subsided. These characteristics may covary with the narratives and perspectives shared by the interviewees here leading to one set of perspectives that diverge from the population of conflict victims who returned home. In future work this could be rectified by conducting interviews with displaced populations in locations more proximate to armed conflict such as on-site in refugee camps in border regions to countries suffering from armed conflict.[24] However, despite these limitations which are beyond the sampling scope of this chapter, the insights from refugees who did succeed in escaping violence still provide useful information here by illuminating patterns and mechanisms underpinning the relationships between conflict-induced population movements and particular disease outcomes.

In addition to considering the voices of those remain behind, this research treated civilian demographics neutrally without delving deeper into connections between the burden of infectious disease and, for example, age or gender among other personal characteristics. Conflict creates significant gendered health outcomes with women suffering high levels of morbidity and mortality due to direct violence in armed conflict but also due to indirect consequences of violence relating to infectious disease but also sexual and reproductive health (Bendavid et al. 2021). One way this may intersect with infectious disease is through delayed migration timing (Schon 2019) and a tendency of women to relocate closer to home than men when shuffling away from areas with armed conflict (Bohra-Mishra and Massey 2011). This chapter did not attempt to explore these gender dynamics which manifest in conflict zones and

[24]Interviewing victimized populations in IDP or refugee camps poses its own set of risks to interview participants who may feel compelled to participate research believing incorrectly that doing so may lead to improvements in their personal situation. See the appendix to this chapter for additional discussion regarding ethical and security considerations for conducing field research with victimized populations.

contribute to distinct disease outcomes for women relative to men (only 4 of the 15 interview participants here identified as women). Future work could address this by interviewing a larger sample of women who escaped conflict spaces as well as by more directly investigating how conflict violence, gender, and infectious disease intersect.

One final connection emerging from this study concerns the relationship between infectious disease, conflict, and climate change. Recent research has revealed how variation in local weather patterns attributable to climate change increase the number of violent events, for example episodes of both drought and extreme rainfall increase violence within a region (Hendrix and Salehyan 2012). Some interviewee narratives suggest that climate change may shape how violence effects the incidence of infectious disease in conflict zones, particularly when refugees shuffle back and forth within a region to evade insurgent attacks. For example, one respondent's narrative suggested that insurgent violence occurring during wet seasons in their home country was particularly challenging due to a scarcity of dry wood to use as fuel for preparing meals and sterilizing water. In contrast, during dry seasons an abundance of firewood to use as a fuel source eased the difficulties faced by the displaced as they fled from violence since they could more effectively sterilize water and prepare easily transportable foodstuff that requires boiling (e.g., rice). This suggests complex pathways connecting changing climatic conditions brought about by climate change to infectious disease in conflict zones that warrants additional future research.

The foundations of civilian strategic responses to violence, patterns of displacement, and health outcomes presented in this chapter suggest that infectious disease outcomes vary across different conflict contexts. Building upon the qualitative insights presented in this chapter, the following chapters quantitatively explore these relationships using subnational (Chapter 4) and cross-national (Chapter 5) data.

Chapter 4

Subnational Analysis

4.1 Introduction

Conflicts create conditions ripe for the spread of disease by exposing both civilians and military personnel to various pathogens on a battlefield. However, we still know little about the mechanisms connecting the unique characteristics of conflict to particular disease outcomes. Over the past decade, higher rates of disease near ongoing armed conflicts has drawn significant attention, for example: Ebola in the Democratic Republic of Congo (Vinck et al. 2019), Leishmaniasis in Syria's civil war (Rehman et al. 2018), or acute respiratory infections among children fleeing with their families from the violence of Boko Haram in the rural regions of northeast Nigeria (Roberts 2017). What stands out about these cases and many others like them is not just the higher rates of disease but variation in the types of disease most common within the spaces impacted by active fighting. Not all regions with ongoing conflict exhibit similarity in the incidence of various diseases. Understanding why this variation exists and how it connects back to the conflict context can provide a productive path forward to explaining the disease-conflict connection and possibly predicting levels of disease tomorrow (and areas in need of health resources) on the basis of observable patterns of conflict today. Whether violence occurs in a contested space - active battlefields - shapes how civilians respond to changing levels of violence that they can observe. The population movement patterns that result from these different responses influence which disease-causing pathogens civilian encounter as they navigate conflict spaces thereby contributing to variation in the incidence of different disease types.

Leveraging insights from research on civil wars and epidemiology, this chapter builds upon our understanding of disease transmission mechanisms to explain how conflict drives downstream variation in disease outcomes. Conflict context shapes how civilians perceive their personal security and therefore influences how they respond to violence in order to improve their safety. Where civilians choose to go, if they decide to leave an area with rising violence, results in their exposure to different disease-causing pathogens. Differences in pathogenic-exposure accelerates or stunts the incidence of different disease categories. Seeking to minimize their vulnerability to violence, civilians may *shelter* in their homes, *shuffle* into nearby safer areas in their home region, or *flee* to neighboring regions. Civilians choose which strategy to pursue in response to escalating levels of violence by reflecting on the context in which that violence occurs - whether the violence is indicative of a broader conflict process occurring in an active and contested battlefield. When civilians choose to shuffle into nearby safer areas of their home region or flee to neighbors, they increase their contact with others also moving through conflict zones which increases the risk of contagious diseases spreading from person-to-person. However, if the conditions of the conflict make fleeing or shuffling impractical, such as when violence is more expansive across the space of a conflict zone, civilians may instead choose to shelter in place and hope their local security situation improves. While this reduces civilian contact with others decreasing the risk of contagious disease spread, this strategy increases exposure to environmental pathogens owing to the unsanitary nature of active conflict zones which have degraded infrastructure and housing. Thus, where civilians opt to shelter they face increased risk of contracting non-contagious infectious diseases originating from environmental pathogens.

This chapter proposes a theory connecting the observable variation in conflict contexts to variation in disease through a mechanism of civilians pursuing alternative security-improving strategies in response to changing levels of violence. The remainder of the chapter proceeds as follows: Section 4.2 explores current research on conflict conditionality and connects these insights to research on civilian decision-making in combat zones as well as research on the public health challenges endured by civilians living in or navigating through conflict spaces. Building upon these insights, Section 4.3 offers a theory of conflict and disease by deriving a unique conflict typology based upon observable conflict conditions to explain variation in two categories of infectious disease: contagious and non-contagious. Section 4.6 presents a novel subnational data set used to test hypotheses derived from this theory as well as presents the spatial dynamic models used to evaluate these relationships in a way that directly accounts for disease diffusion. Section 4.7 evaluates the results of this analysis with particular attention devoted to exploring how rising levels of violence contribute to different disease outcomes in varying conflict contexts. Finally, Section 4.8 concludes and explores both the policy ramifications of the findings with particular regards to disease forecasting for the deployment of public health resources in active and post-conflict zones.

4.2 Background

The relationship between disease and war has received limited attention in political science research with only a few articles directly exploring the possible connections. Due to data limitations, this past research has favored emphasizing the broader general consequences of conflict on disaggregated health measures, such as more years lived with disability in post-conflict countries (Ghobarah, Huth, and Russett 2003) or smaller budgetary allocations to public health in countries recovering from conflict (Iqbal 2010). While others have argued that disease prevalence within a society may cause war (Letendre, Fincher, and Thornhill 2010) such findings are contested (Hendrix and K. S. Gleditsch 2012) and the more likely yet under-explored possibility is that war causes disease.[1] More recent research has begun to address the deeper connections between disease and conflict. For instance Iqbal and Zorn (2010) found that instances of international war help to account for higher rates of HIV among Sub-Saharan African countries through a troop-movement mechanism, but that civil wars did not produce a comparable effect underscoring the context conditional nature of the relationship between disease and war.[2] More recently, during the COVID-19 pandemic, initial evidence suggests that disease led to a reduction in armed conflict (Bloem and Salemi 2021), but this relationship was not universal. For example, conflict in Afghanistan exacerbated the spread of COVID-19 in that country as attacks on civilians and healthcare workers led to internal displacement and subsequently higher rates of community disease transmission (Lucero-Prisno et al. 2020).[3] Missing from this research is a theory connecting specific patterns of violence - or conflict context - to specific disease outcomes. Two main features that characterize conflict context are the overall *Intensity* of fighting and the spatial extent and location of that violence - or whether an area falls within active *Battlefields*.

[1] Bagozzi (2016) demonstrates that while disease does not cause war, it can lengthen conflicts by providing an additional layer of protection for insurgents embedded in disease-endemic regions.

[2] One limitation of Iqbal and Zorn's study is its use of cross-national data which may mask important variation in patterns of conflict and disease more likely to manifest at finer spatial resolutions. This study overcomes that limitation

[3] Elsewhere recent work (Koehnlein and Koren 2022) suggests that pro-government paramilitary forces increased their attacks in response to rising COVID-19 cases suggesting an endogenous relationship between disease and war.

4.2.1 Conflict Intensity

The role of dynamics in the conflict process has received significant attention in the conflict literature.[4] Civil wars exhibit wide variation in the overall intensity of fighting as measured using combat-related fatalities (Lacina 2006) and exhibit patterns of escalation and deescalation (Chaudoin, Peskowitz, and C. Stanton 2017). The important conclusions from these papers on our understanding of conflict intensity is that it varies significantly between conflicts, but also within conflicts over time. This dynamic variation in conflict intensity produces a number of consequences for areas suffering from ongoing or past wars including infrastructure damage (World Bank Group 2017), reduced state health budgetary capacity (Iqbal 2010; Kang and Meernik 2005), and internal population displacement (Davenport, Moore, and Poe 2003). Among these consequences[5], extensive research has indicated that conflict intensity shapes the choices that civilians make regarding their own personal security.

Scholars have leveraged subnational data to gain deeper insights into the motives of civilians fleeing when exposed to violence. In an analysis of internal displacement patterns during civil war, Balcells (2018) found that a major factor shaping where civilians go when they decide to leave are ethnic or kinship ties implying that those fleeing will exhibit a tendency to remain within a close proximity to their homes, yet move sufficiently far away in order to gain the added benefit of improved personal security.[6] Iqbal (2007) found a similar pattern in a cross-national level analysis -

[4]For example, see Berman, Felter, and J. Shapiro (2018) for an extensive analysis of the theoretical progress made using fine-grained conflict event data.

[5]It would be worth considering these as alternative pathways through which conflict can cause disease rate variation. However, for now, data limitations prevent testing theories in this regard. Although, as subsequently discussed, infrastructure damage fits with the proposed theory as civilians will discount the future-value of remaining in places with extensive damage opting to become internally displaced or flee rather than remain.

[6]Balcells also found that refugees preferred relocating to regions at higher elevations perhaps due to the additional security afforded to individuals residing in areas with rugged terrain (Shaver, Carter, and Shawa 2019). The finding that individuals will favor relocating based on kinship ties reinforces findings in epidemiology (Roberts 2017) that have implications for the spread of contagious disease as well. This will be discussed further in the Theory section.

while conflict pushes civilians to flee elsewhere, this effect is negatively moderated by distance. That is, civilians prefer to relocate near their homes if they perceive that as a viable option.[7]

These findings on an individual decision to escape violence in armed conflicts make clear that civilians rely on information gained from observing changes in the local intensity of fighting that they directly observe in their immediate vicinity. Observing changes to the intensity of fighting among belligerents therefore catalyzes for civilians whether they should take actions to minimize their risk to harm. Yet the level of observable violence alone is insufficient for a civilian to make an *informed* decision. In order to make a rational and informed response to changing level of violence, they also must consider the broader conflict landscape - whether the violence they observe indicates their home region is located in a space contested by two or more competing forces (an active battlefield). Absent this additional contextual information, civilians would not possess all the facts necessary to decide whether remaining in place or attempting to find safety in nearby or more distant locations would better contribute to improving their security. The geography or spatial extent of fighting provides civilians with this contextual information allowing them to make informed decisions in response to observable changes in violence.

4.2.2 Conflict Geography

Scholars have long recognized the role of a conflict's spatial extent to compel or constrain the movement of non-combatants within and around battlefields (Posen 1993; Weidmann 2009; Schutte and Weidmann 2011). For example, Posen (1993) applied the security dilemma model to explain heightened ethno-nationalist conflict in the aftermath of the Cold War, arguing that features of space such as proximity

[7] Also see Schon (2019) for a detailed qualitative analysis on the motivations and incentives behind Syrian decisions to flee violence during civil war or Pearlman (2018) for a narrative recounting of the motivations Syrian refugees provided in their decision to flee rising violence.

or encirclement of one ethnic group by another helped to account for the sharp rise of ethnic conflict that came to characterize conflict in the 1990s. In more recent work on conflict geography, scholars have made great progress employing subnational research designs to explore variation in the spatial extent of fighting within civil wars (J. N. Shapiro and Weidmann 2015; Schutte and Donnay 2014; Schutte and Weidmann 2011). Thus, complementing research on variation in conflict intensity, these studies reveal that the regions impacted by active fighting change over time and exhibit significant variation both within and across active conflicts.

This work on the spatial dynamics of conflict indicate that violence exhibits a propensity to cluster in particular regions of a country such as near ethnic groups residing in close proximity to one another (Weidmann 2009) and that these spatial areas tend to shift over the course of a conflict (Schutte and Donnay 2014; Schutte and Weidmann 2011). Schutte and Weidmann (2011) explored the diffusion patterns inherent in a conflict process finding that features of particular conflict types help to explain tendencies in fighting to relocate or escalate across space and time as the tactical choices made by belligerents drive conflict expansion or contractions. Most civil wars are characterized by varying intensities of asymmetric violence between one belligerent and a stronger foe producing a jumping pattern - “escalation diffusion” - whereby conflict battlefields are characterized by growing and shrinking islands of violence that change location over time as belligerents relocate within a country fighting in new spatial theaters of war.[8] Schutte (2017a) extend these findings further by exploring determinants of the evolving spatial location of conflict and found distance to power centers helped to account for variation in the intensity of violence along battlefield peripheries. As belligerents deployed forces further from their power-centers, rising command and information costs contributed to more indiscriminate violence in a bat-

[8]These findings are consistent with my estimates of conflict battlefields employed in the analysis of this chapter. The geographic clustering of conflict within countries jumps from year-to-year as episodes of violence shift within countries.

tlefield as belligerents struggled to identify enemy forces apart from local inhabitants residing in these areas.

These findings underscore an important feature of conflict context: that the geographic locations of warfare - the battlefields where fighting takes place - exhibit significant variation both across conflicts, but also within conflicts over time. This implies that national level measures of disease and conflict miss important subnational variation apparent at finer spatial resolutions that reveal areas of a country more heavily impacted by these shifting conflict contexts.

Civilians do not remain ignorant to these changes in where fighting takes place or the intensity of that fighting; instead they are intimately aware of this flow of conflict and its potential to draw their homes into active battlefields.[9] The key implication here is that the overall intensity or geography of violence alone is insufficient to characterize the full context of a conflict landscape. Instead, conflict intensity and geography jointly identify where and in what contexts a civilian faces the greatest threat to their personal security. Using both pieces of information together, civilians can make informed and rational strategic responses to deteriorating security situations.

4.2.3 Rational Civilian Responses to Conflict

Civilians take cues from the observable conflict conditions they observe to minimize their risk of experiencing violence and maximize their personal security. A "push-pull" migration model has proven effective at explaining displacement dynamics in humanitarian crises and conflict (Adhikari 2012; Petersen 1958). The model argues that individuals respond to violence by comparing their current circumstances against their best understanding of the conditions in potential destinations. Given this evaluation, and their expected costs of reaching their preferred destination unscathed,

[9]For a more detailed analysis of civilian awareness of their personal security situations in conflict settings, see Chapter 3 - Microfoundations

civilians decide whether to leave (and if so how far to go) or to remain. In civil wars the costs that civilians face can be extreme given the risks of crossing territory controlled by potentially hostile belligerent forces. Compounding these complications, the fog of war that characterizes armed conflicts means civilians must contend with profound information asymmetries as they make their decisions - that is, the average civilian lacks a full understanding of their circumstances within the conflict so their notion of "best" suffers from error and limited resolution.[10] Civilians satisfice by accepting the limited information they have to respond to the violence they perceive locally and leverage group ties to make decisions about the broader conflict context (Danchev and Porter 2018; Wissink and Mazzucato 2018). These group ties help to inform both when civilians chose to leave and their destination.

The geographic extent of fighting along with the intensity of violence that civilians observe helps to define their options to evade violence. Exploring fine-grained migration data from Nepal, Bohra-Mishra and Massey (2011) found that while violence catalyzed civilians to become internally displaced or refugees, the extensiveness of fighting they observed informed whether they would choose local, regional, or international migration-based destinations as a preferred solution to the deteriorating conditions brought about by more intense instances of local violence. Civilians considered the risks associated with reaching viable destinations (to the extent they determined one existed) and factored these risks into their decision on whether to leave or remain in a place more removed but still in the same region as fighting in a war zone. When

[10]For civilians seeking to evade rising levels of violence, the fog of war impedes how well they understand the broader conditions on a conflict battlefield. Accounts of individuals fleeing violence (Pearlman 2018) indicate that those residing in or navigating through battlefields use a more coarse measure of fighting to characterize their understanding of the conflict landscape: "not bad over there, but worse in that direction. . . ". This reflects the limited resolution of available knowledge of conflict elsewhere. In choosing a response to violence, civilians therefore characterize areas as active battlefields or not, but they lack finer knowledge regarding the overall intensity of fighting in non-proximate locations due to the fog of war and conflicting (and often unreliable) information in conflict zones. Interviews conducted with conflict refugees for Chapter3 underscore these findings; see that chapter for additional detail.

surrounded by active fighting, civilians exhibited a greater resistance to abandoning the relative safety of their homes for the uncertain costs associated with traveling through territory controlled by competing rebel or state military forces. However, when the conditions in their home region sufficiently deteriorated, these perceived costs of insecurity no longer appeared to disincentivize civilians from fleeing an active combat zone. Bohra-Mishra and Massey's (2011) findings underscore the role that local conflict intensity and the broader spatial context of battlefield location at home and in neighboring regions help to inform a civilian's decision-making calculus in response to violence.

Extending work on internally-displaced and refugees within conflicts, Steele (2019) proposed a typology of civilian resettlement patterns conditional on the patterns of violence and the perpetrators of violence that civilians observed. Conditional on variation in conflict types, civilians exhibit a tendency to either cluster or independently settle and they do this either within their home country or abroad.[11] When civilians experience particular forms of violence, for example targeting on the basis of ethnicity, they exhibit a tendency to cluster (for safety) and, depending on the perpetrator of that ethnic targeting, may choose to shelter within their home state or flee to a neighboring country. For example, if a rebel group perpetuates the violence they will cluster within their home country hoping the state fulfills its obligation to provide their security, but if the state commits the violence, civilians will flee. In contrast, when civilians face belligerent violence motivated for strategic rather than ethnic-based factors[12], this tends to dispel larger groups into individual fragments who opt to relocate to their home country's economic hubs or greater distances across a border

[11]Steele refers to the four combinations as: expulsion, segregation, integration, and dispersion which refer to the circumstance of a civilian relative to their home state.

[12]For example, belligerents make strategic targeting decisions against civilians in order to deter defectors who would aid the belligerent's enemy. Armed groups balance these applications of violence by seeking to minimize members of their group from taking actions that might encourage resentment among civilians who are a valuable source of both supplies and information in civil wars (Berman, Felter, and J. Shapiro 2018; Weinstein 2006; Kalyvas 2006).

depending on the extent of violence they observe. Each of these outcomes - clustering or individual fragmentation - and the choice of destination - home or neighboring regions - have profound implications on the spread of disease.

Civilians therefore use two core pieces of information when deciding how to respond to escalating violence: changes to violence they can observe (conflict intensity) and the context of that intensity such as whether it represents an escalating trend or a one-off violent event (i.e., whether they would recognize their home region as being in a battlefield or not). How the average civilian uses this information to respond to rising levels of local violence determines the security-improving strategy they will pursue and, therefore, the disease-causing pathogens they are more- or less-likely to encounter on a battlefield.

4.3 Theory: How conflict context explains disease outcomes

4.3.1 Disease types

The strategies that civilians pursue in response to observable conflict conditions will, on average, expose people to different categories of disease-causing pathogens. These pathogens contribute to different rates of contagious and non-contagious infectious disease.[13] Contagious infectious diseases spread from person-to-person through close proximity whereas non-contagious infectious disease spread through contact with environmental vectors. Infectious disease in general refers to the category of illness caused by contact with and growth of foreign biological organisms in the body con-

[13] Contagious, infectious, and communicable are often used interchangeably, but differ in substantively important ways. All contagious diseases are infectious, however, not all infectious disease is contagious. Communicable diseases are those which can be transmitted between organisms; genetic disease are non-communicable. The theory presented here speaks to contagious and non-contagious infectious disease.

tracted through contact with a causal pathogen such as a virus, protozoa or bacteria, or parasite (Kanki and Grimes 2013). Not all of these pathogens spread among vulnerable populations through the same route or with the same ease, but rather vary significantly based on transmission mechanisms.

For example, measles, one of the most transmissible contagious diseases, spreads through the inhalation of respiratory droplets exhaled by one infected person and inhaled by another (Hofman 2016). This contrasts with infectious diseases that do not spread through close human proximity directly but rather spread through exposure to disease causing pathogens from the environment. Tetanus, caused by the bacterium *Clostridium tetani* commonly found in the soil (Mallick and Winslet 2004), spreads through direct contact such as a cut in the skin as would be common for someone fleeing in a combat zone. However, tetanus cannot spread from one infected person to another due either to close proximity or personal contact. Each of these two categories of disease: contagious infectious disease and non-contagious infectious disease[14] will vary with changes in conflict context that push or pull civilians into pursuing distinct strategies that facilitate or impair the transmission mechanisms most common to how diseases in these categories spread.

4.4 Civilian Strategies

Two primary features of conflict shape how an individual responds to deteriorating security conditions: conflict ***Intensity*** and ***Battlefield*** status. Together, these features of a conflict jointly inform how civilians perceive their opportunity to escape from the violence they observe. Based on their imperfect survey of the battlefield[15],

[14]This contrasts with non-contagious disease more generally which encompasses a broad category of non-infectious diseases caused by genetics or behaviors such as heart disease, Alzheimer's, and diabetes.

[15]Civilians are rational actors who will make best decisions they can given the information they have which, due to the fog of war, is inherently imperfect.

civilians make choices to improve their personal security. Increasing hostility characterized by an observable increase in the intensity of fighting between belligerents compels civilians to make decisions on how best to avoid the violence they observe.

In response to violence civilians pursue alternative security-improving strategies to reduce their risk from violence: they may ***shelter*** and remain in their original location, they may ***shuffle*** into nearby areas within their original home region, or they may ***flee*** to a neighboring region such as into another territory in their own country as an internally displaced person or further across an international border into another country as a refugee.[16] By optimizing their behavior to avoid violence, civilians encounter different disease-causing pathogens, on average, that then drive downstream variation in observable disease within a place impacted by rising levels of violence.

Whether civilians choose to evade fighting by shuffling into nearby areas, remain stationary by sheltering in place, or fleeing into neighboring regions when facing a compromised security situation helps to explain varied disease responses. Infectious diseases spreads through different causal pathways dependent on the primary transmission source, that is the origin-point for a disease, and the potential for secondary transmission between infected and non-infected individuals (World Health Organization 2018).

Contagious infectious diseases [CiD hereafter] primarily spread through major transmission modes facilitated through close inter-personal contact such as coughing, skin contact, or any exchange of bodily fluids. Conditions that bring people into close contact with one another or leave them in confined spaces - such as ***shuffling*** around neighborhoods in a city besieged by conflict to live in nearby shelters or with close friends or family - increases the odds that one individual will spread an infection to

[16] These strategies represent ideal-types which I propose civilians follow on average. Particular individual characteristics, such as familial ties, background knowledge, or network effects may compel some individuals to deviate from these strategies. However, I anticipate that in the aggregate civilians will respond similarly to increasing violence across varying conflict contexts.

others within the concentrated confines of the vulnerable population. Measles, hemorrhagic fevers, and certain forms of plague all spread more easily among densely-concentrated populations.

In contrast, non-contagious infectious disease [NCiD hereafter] originating from pathogens originating from the environment spread more easily in high exposure situations such as when people reside in areas with infrastructure damage to buildings or interruptions to general sanitation efforts such as with a pause to rodent and pest control that results from skeleton civil-service provision in armed conflicts. Damaged potable water resources increase the rate of exposure to harmful bacteria and structures with damaged walls which expose inhabitants to outside pests create opportunities for ticks, mice, fleas, and mosquitoes to enter and infect civilians with diseases such as Malaria (a parasitical infection spread by mosquitoes) or Lassa fever (spread by rats). When civilians ***shelter*** in areas experiencing active conflict between belligerents, the deteriorated environmental conditions due to fighting-induced damage increase the likelihood of a NCiD infecting members of the vulnerable civilian population. Since sheltering civilians will prefer to hide in isolated spaces while avoiding combat, their exposure to others decreases along with the odds of CiD transmission. During periods of fighting, civilians will avoid gathering in larger groups in order to avoid the risks of encountering combat. However, their decision to remain stationary increases the odds they will come into contact with an environmentally sourced disease-causing pathogen.

4.5 Hypotheses

Conflict context shapes the best strategies that civilians will pursue in response to observed patterns of violence in armed conflict. These strategies influence which disease-causing pathogens that civilians encounter which affects observable trends in disease. Depending on the spatial extent of fighting civilians will choose one strategy or another in response to changing levels of violence and these different strategic responses will affect the spread of disease. Since CiD and NCiD spread through different transmission mechanisms, the strategic choices that civilians make in different conflict contexts should translate into distinct disease responses. This implies context conditional hypotheses for the relationship between disease and war with different theoretically implied effects for conflict intensity depending on conflict context and disease type.

When violence occurs outside of battlefields where most violent events are located, civilians will resist the costs of abandoning their homes for what they perceive to be one-off events not indicative of the broader conflict landscape where the majority of violence occurs elsewhere. In these contexts - violent events occurring beyond areas beset by the majority of violence - civilians will prefer to *shelter* in response to rising violence. This strategy minimizes their contact with other people while increasing their exposure to possible environmental disease causing pathogens. Therefore,when violence occurs in non-battlefield settings, the resulting sheltering strategy that civilians pursue should result in a decrease in CiD and and increase in NCiD. The following hypotheses summarizes the context conditional response to rising conflict intensity in non-battlefield regions:

> **H1 - Shelter** In non-battlefields civilians will *shelter* in response to escalating violence. Sheltering strategies will lead to increased [decreased] incidence of non-contagious [contagious] infectious disease.

In contrast, violence occurring within a battlefield sends a different signal to civilians. When an area has experienced a sufficient amount of violence to qualify as a space actively contested by the belligerents in a conflict, civilians will instead consider an alternative violence-avoidance strategy as their personal security situation continues to deteriorate. In battlefield contexts civilians will prefer to *shuffle* and move away from the contested space in response to rising levels of observable violence. Due to the costs and risks associated with traveling long distances to escape a conflict space, civilians will instead opt for shorter travel moving to safety with friends and relatives nearby.[17] Movement over shorter distances also allows civilians to return to their homes if violence begins to subside. However, in the interim, large groups of people shuffling within a region to avoid the local areas with the greatest intensity of fighting will result in increased interpersonal contact between people such as when individuals group up to share a single-apartment or temporarily move-in to a congested shelter.[18] This close proximity will lead to an increase in the spread of CiD since these population movements will increase close person-to-person contact creating opportunities for diseases of that category to spread more easily. Moving away from areas with the highest intensity of violence into nearby more secure spaces will reduce civilian exposure to environmental pathogens spread due to infrastructure damage within a battlefield leading to a decrease in NCiD in these contexts. This implies the following hypothesis on the relationship between disease and violence in battlefields:

> **H2 - Shuffle** In battlefields people will *shuffle* in response to rising violence. Shuffling in this context will lead to increased [decreased] incidence of contagious [non-contagious] infectious disease.

Finally, regardless of context or local conditions, some civilians will always *flee* in response to violence. These individuals may have lower attachment to an area or have other concerns such as the safety of children or other family members lowering their tolerance to wait and see whether local security conditions improve. Civilians fleeing into neighboring regions implies that the previously mentioned relationships between violence and disease do not remain local, but instead produce spillover effects across

[17] See Chapter 3 - Microfoundations for evidence supporting civilians pursuing strategies in this regard.

[18] Based on interviews with conflict refugees, maintaining personal space and health represented a challenge for those who pursued this strategy. However, given the alternative of violence, the risk of illness was an acceptable alternative.

space. These spillovers that result from civilians who flee in response to violence will amplify the direct effects of violence on disease within one region by creating indirect downstream effects on disease in neighboring regions. This leads to the final hypothesis:

> **H3 - Flee** A portion of the civilian population will respond to violence in any context by *fleeing* to neighboring regions. This will lead to diffusion whereby the effects of violence on disease implied by H1 and H2 is further amplified by indirect changes to disease in neighboring regions.

Table 4.1 summarizes the context conditional expectations implied by these hypotheses on the relationship between rising violence in battlefield and non-battlefield settings on contagious and non-contagious infectious disease. Changes to conflict intensity that civilians can observe and the spatial context within which that violence occurs jointly influence civilian decisions to *shelter* in place, *shuffle* into other areas of a home region, or *flee* to a neighboring region. These strategies contribute to different disease responses due to the mechanisms of transmission underpinning the disease and variation in pathogen-exposure implied by these strategies.

Table 4.1: Predicted disease response to increased violence

		Disease Type	
	Civilian strategy	Contagious	Non-Contagious
H1	Shelter	(-)	(+)
H2	Shuffle	(+)	(-)
H3	Flee	(+) **Spatial Dependence**	(+) **Spatial Dependence**

4.6 Data and Methods

This chapter employs a novel data set comprising a sequential cross-section of 590 subnational administrative-1 units[19] from 43 Sub-Saharan African countries over a

[19] I make use of the Database of Global Administrative Areas (v. 4.0.4) Global Administrative Areas (2022)

span of 17 years from 2000 to 2016 for a cumulative total 10026 observations. Data availability for dependent variables determine the spatial and temporal extent of cases included in the panel.[20]

4.6.1 Disease

Limited access to quality subnational health data has significantly undermined global efforts to strategically respond to the diverse health needs of local areas most in need of health support (Dowell, Blazes, and Desmond-Hellmann 2016; Desmond-Hellmann 2016). Responding to these limitations, public health scholars, epidemiologists, and biostatisticians have worked to build more complete profiles of disease using the best data sources available today. These projects have expanded our understanding of subnational public health trends revealing disease hotspots that remain hidden in national data measures that smooth over important local variation. By providing a detailed subnational look at disease, these data efforts allow us to take seriously claims that analysis of health trends at aggregate national-levels overlook variation in the health outcomes that vary widely within and between countries. This chapter makes use of two recently developed data sources from these efforts: lower-respiratory infections (Reiner et al. 2019) and malaria (Weiss et al. 2019) to evaluate conflict effects on CiD and NCiD respectively.[21]

4.6.1.1 Contagious Infectious Disease, CiD -

The first of these two measures is Lower Respiratory Infection (LRI) in children. Using a comprehensive collection of geolocated survey data, Reiner et al. (2019) constructed fine-grained disaggregated estimates of the local burden of respiratory

[20] Following Chaudoin et al.'s (2017) work on the determinants of conflict intensity dynamics, I include all subnational divisions and years in the analysis regardless of conflict presence or absence within a particular place / year in order to explore the relationship between conflict and disease by incorporating non-conflict cases and their disease rates into the model.

[21] Both of these measures are available as high-resolution (1km grid-cell) disaggregated raster data cubes.

infections across Africa from 2000 to 2017. I spatially aggregate these estimates to subnational administrative divisions for analysis. Theoretically, LRI measures provide an excellent indicator of CiD. Reiner et al. prioritized surveys that identified a persistent cough among young children and which met the standard clinical definition for LRI: specifically pneumonia or bronchiolitis diagnosed by a medical professional.[22] Both pneumonia and bronchiolitis are infectious diseases transmitted by respiratory droplets exhaled by a person through breathing or coughing and therefore meet the theoretical criteria employed in this study for CiD.

4.6.1.2 Non-contagious Infectious Disease, NCiD -

Data on incidence of malaria (Weiss et al. 2019) in children provide an equivalent measure of non-contagious infectious disease. Malaria is an infectious disease endemic to significant portions of Africa[23] spread by Anopheles mosquitoes which serve as the delivery vector for the parasite *plasmodium* which causes the underlying disease (Hofman 2016). Unlike lower respiratory infections such as pneumonia or bronchiolitis used in the LRI measure, malaria cannot spread from person-to-person absent the presence of the transmission vector: the mosquito. Therefore, conditions where people must reside in close-proximity to one another will not increase the spread of this disease. However, in situations where vector control is compromised, such as when mosquito netting is unavailable, housing stock has been damaged with openings to the outdoors, or local insecticide efforts have stopped, the disease will more easily spread due to increased contact between people and the mosquito that spreads the parasite causing the underlying disease.

[22] Reiner et al. (2019), p. 2317. Additionally, the authors weighted estimates by prioritizing medical surveys reporting clinician-diagnosed cases of these diseases providing an additional degree of confidence in the validity of the measure. Predicted disease incidence rates estimated at the subnational Administrative-1 level (the same spatial level used in this study) were subject to out-of-sample five-fold cross-validation assessments and found to accurately capture reported survey results from original data sources (Reiner et al. 2019, p. 2311.).

[23] Approximately 90% of the sub-Saharan Africa population reside in malaria endemic regions (Weiss et al. 2019, p. 329)

LRI (CiD) and malaria (NCiD) are operationalized using disease incidence rates as the dependent variables presented in results section. Incidence rates, sometimes referred to as an "attack rate", report the number of new cases of a disease among the at-risk population (here children under-5) within a specified calendar period.[24] Incidence measures new cases of disease within the specified time period and therefore represents an ideal measure to test for conflict effects. Both CiD and NCiD measures are converted to rates per 1000 population to ensure comparability between estimates across various models.[25]

Table 4.2 provides descriptive statistics on LRI and Malaria disease incidence rate measures. Overall these data suggest there is a great deal of variation in the incidence of disease over the study time period and across the sampled regions. Malaria rates are significantly higher on average as individuals in endemic regions are likely to suffer from repeated infections of the disease over the course of a calendar year (Weiss et al. 2019).

Table 4.2: Descriptive statistics: Disease

	Mean	Min	Max	SD	N
LRI - Incidence rate	143.060	31.092	427.042	50.203	10026
Malaria - Incidence rate	669.724	0.000	2148.497	496.485	10026

To give a sense of the spatial structure of these data, Figure 4.1 maps LRI and Malaria incidence rates by reporting the maximum reported rate of respective disease transmission over the study period. These values are categorized based on quartiles and coded from very low to very high. In particular, these maps highlight areas which have suffered from endemic disease conditions. Additionally, despite the presence of

[24]Specifically,

$$Under\text{-}5\ Incidence\ Rate\ per\ 1000 = \frac{New\ under\text{-}5\ cases\ within\ year}{At\ risk\ under\text{-}5\ population} * 1,000$$

[25]The appendix to this chapter contains extended discussion on the benefits and applicability of incidence rates vs other comparable epidemiological disease reporting measures.

Malaria in all of these regions, difference hotspots emerge relative to LRI with Malaria largely clustered in central Africa and along the coastal NW while LRI appears more apparent in the NE.

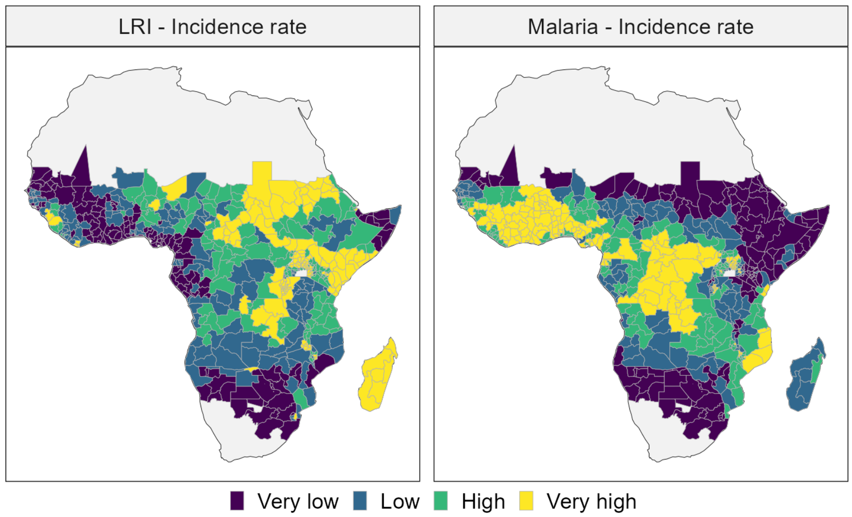

Figure 4.1: Disease Incidence Rates

4.6.2 Conflict

Conflict data come from ACLED's geographically indexed event data (Raleigh et al. 2010). ACLED treat recorded conflict events as the base unit of analysis recording attribute information who, what, where, and when with high levels of precision. These data provide spatially explicit location information (latitude and longitude) on reported violent events that include indicators on actors perpetuating the violence, dyadic information on the conflict associated with the event, date identifiers, and civilian casualty estimates.

4.6.2.1 Battlefields -

A number of approaches have been applied to identify conflict space. The simplest approach assumes any locations containing a violent event qualify as active conflict spaces, for example using raster grids (such as the PRIO-Grid) and coding all grid-cells with events as having conflict and the rest as not (Fjelde and Hultman 2014) or using other areal units (such as administrative boundaries) and similarly coding any containing an event as a conflict space (Ritter and Conrad 2016). All-or-nothing approaches to mapping violence rely on heavy assumptions about the units of analysis in a study (rasters, areal units, or others) but also discount theoretically important differences in the location and intensity of violence by treating those elements of a conflict as identical. More recent advances in conflict space identification have employed point process models (Schutte 2017b) and machine learning classifiers (Kikuta 2022). This chapter takes a middle ground approach that first identifies conflict spaces independently of the units of analysis using a kernel density estimation approach and then, leveraging the spatially explicit predictions from this method, classifies the first-order administrative units in analysis as lying within or beyond contested battlefield spaces.

A battlefield - or conflict space - represents areas within a country (or subnational region) most likely to give rise to violent skirmishes between belligerent forces in a conflict. Violent events may occur outside these areas - as the theory in this chapter suggests - but these battlefield areas reflect the space with the highest probability of producing violent events. These spaces are compact in the sense that they capture areas where fighting actually transpires rather than include vast tracts of empty land that lie between distant battle sites.

Using ACLED data I subset for violence against civilians occurring within countries which have experienced the conventional 1000 battle death threshold during a year.[26] Additionally, since rebel forces regularly move across international borders while committing violence (Martínez 2017; Salehyan 2008), I include events occurring within 100km of a country border to capture movement of belligerent forces that would in-

[26] Results are robust to including all events, not just one-sided violence against civilians. However, research on civilian displacement in conflict zones and the theory suggest that civilian violence is the most important factor to explain conflict-induced disease responses.

form civilian decision-making. Using these latitude-longitude indexed events, kernel density estimates are computed to identify areas where points cluster - that is, the primary location of violence. KDE estimates are then classified as “battlefield” or “non-battlefield” and finally these classifications are aggregated to the subnational administrative boundaries that serve as the units of analysis. Administrative areas are then assigned a binary coding as battlefield (1) or not-battlefield (0).

Figure 4.2 provides an illustration of this process using conflict in DRC during 2009 as an example.[27] Sub-figure (1) represents all violent events occurring within DRC in 2009 mapped over the target administrative units to eventually classify as battlefields, sub-figure (2) presents the initial KDE results estimated using the observed conflict points as inputs, sub-figure (3) classifies the KDE estimates as “battlefield” or “non-battlefield”, and finally sub-figure (4) demonstrates the result of these KDE classifications aggregated to administrative boundaries.

4.6.2.2 Intensity -

To measure conflict intensity, I spatially aggregate (sum) the reported estimate of civilian casualties associated with all ACLED events occurring within each subnational administrative-1 unit in the panel over each calendar year. In order to account for variation in population across units which would shape how civilians perceive violence relative to the number of people living in a place, I normalize this measure as the log of the reported casualty estimate.

Table 4.3: Descriptive statistics: Conflict

	Mean	Min	Max	SD	N
Battlefield class	0.144	0	1.000	0.351	10026
Battle deaths	11.882	0	4903.000	104.732	10026
Battle deaths (logged)	0.400	0	8.498	1.182	10026

[27] For extended discussion on employing KDE to identify conflict spaces, see Appendix section A.2.3.

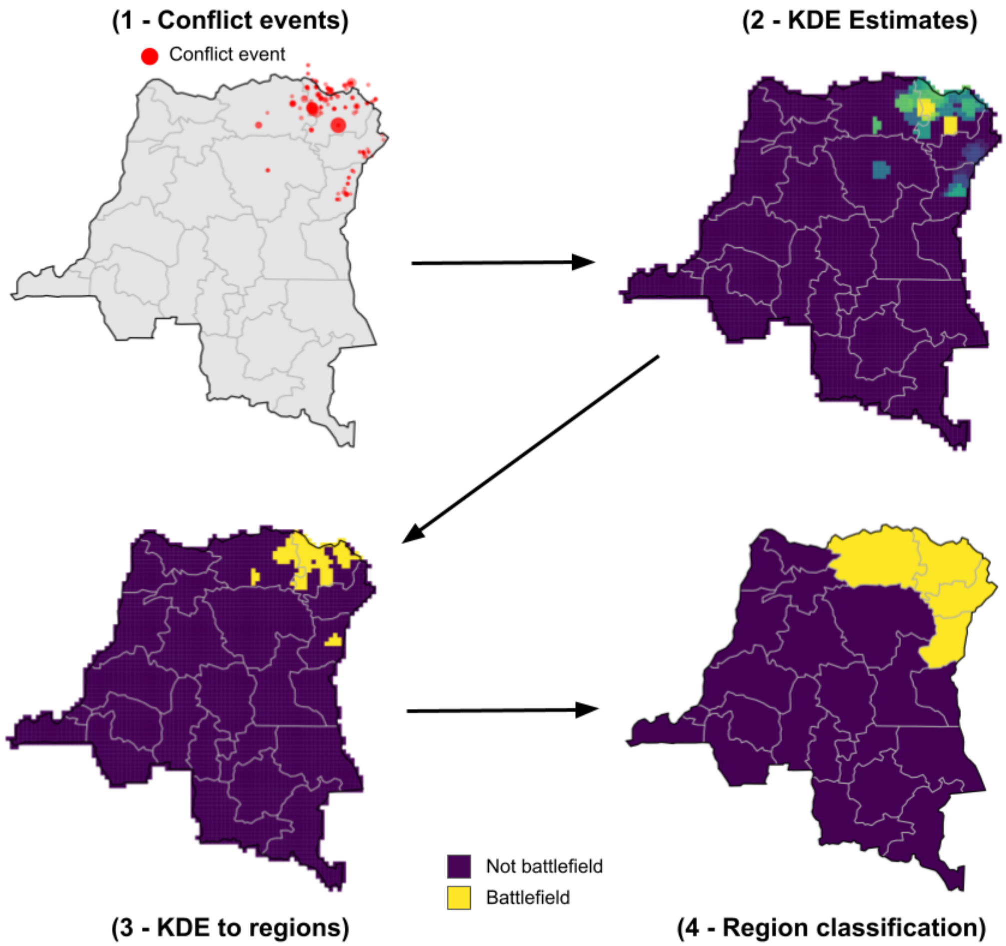

Figure 4.2: Battelfield identification illustration

Table 4.3 provides descriptive statistics on the conflict measures used in the analysis including logged and unlogged values of reported battle deaths. Overall, approximately 14% of the administrative units in this analysis met the conditions to qualify as an active battlefield at some point during the study period. To illustrate where conflict took place over and the context of that violence, Figure 4.3 provides a bivariate map of the relationship between battle deaths and battlefield status. Looking to the map legend, colors in the left column (labeled "No BF") correspond to rising levels of violence in areas not coded as battlefields. These are regions that primarily neighbor active battlefield spots and experienced periodic episodes of violence, but overall were located outside regions where most fighting in a conflict took place. Colors in the right column in the legend (labeled "BF") correspond to rising violence occurring in locations coded as active battlefields. Together, these variables illustrate both where violence occurred both also where violence was primarily concentrated in space over the study period.

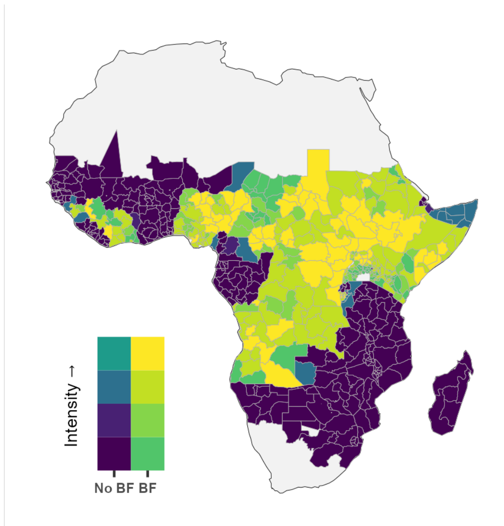

Figure 4.3: Conflict space

4.6.2.3 Control variables -

The primary models used to evaluate the disease-conflict relationship include a robust array of controls to help account for factors that covary with infectious disease transmission (Hammer, Brainard, and Hunter 2018; Connolly, Gayer, et al. 2004). All models include controls accounting for variation in administrative-1 unit development conditions (education (Local Burden of Disease Educational Attainment Collaborators 2020) and population (Linard et al. 2012)), health conditions (childhood malnutrition (LBD Double Burden of Malnutrition Collaborators et al. 2020) and measles vaccination coverage (Local Burden of Disease Vaccine Coverage Collaborators 2021)), and climate conditions (temperature, rainfall, and the interaction of these variables (McNally et al. 2017)).[28] Models also include measures on area accessibility including terrain roughness which is a measure the average deviation (in meters) of elevation in a region relative to surrounding regions (Shaver, Carter, and Shawa 2019), and area size (square kilometers) and distance from the country capital (km) - both computed locally via GIS.[29]

4.6.3 Methods

I begin by fitting a series of panel regression models with robust standard errors clustered on administrative-1 units along with country and year fixed effects to account for unmodeled heterogeneity. The empirical implication of the theorized connection between conflict and disease indicates that an interaction best captures the relationship between conflict battlefields, conflict intensity, and disease incidence rates due to civilians pursuing alternative strategies depending on the context in which violence takes place. Therefore, an interaction between conflict intensity and conflict battlefield classification is used to test Hypothesis 1 (Shelter) and Hypothesis 2 (Shuffle).

Hypothesis 3 (Flee) suggests that spatial dependence attributable to civilian flight will amplify effects of H1 and H2. This indicates that spatial autoregressive (SAR) lag models (Anselin 2009) are most appropriate to model the relationship between

[28] climatic conditions help to account for variation in the presence or absence of NCiD disease-causing vectors like the mosquito (these include rainfall, temperature, a rainfall-temperature interaction). Wet and warm climates are especially likely to have large mosquito population capable of infecting exposed people to malaria.

[29] Descriptive statistics for control variables are provided in the appendix to this chapter.

conflict and disease.[30] The spatial form of the model is as follows:

$$y = \rho \mathbf{W} y + \beta_1 * Intensity + \beta_2 * Battlefield + \beta_3 * Intensity * Battlefield + \gamma + \epsilon \quad (4.1)$$

where the spatial dependence parameter, ρ, captures dependence in disease rates across the units in the data and, most importantly here, amplifies the effects of changes in conflict on disease. A spatial weights matrix, $\mathbf{W}$, defines spatial relationships between units in the data. Here I employ a row-standardized spatial weights matrix based on a queen's neighbor definition.[31] Shifts in disease in a region which result from changes in the conflict processes in their neighbor can only result from the movement of people around conflict spaces. Therefore, the significance of ρ serves as a test for H3.[32] Since battlefields are coded using a binary operationalization (1 = battlefield, 0 = non-battlefield), this interaction implies, as the theory suggest, that the effect of violence on disease will vary depending on whether that violence occurs in a contested battlefield space or not as civilians will pursue different violence avoidance strategies in battlefields and non-battlefields when exposed to violence. In battlefields, this model suggests that the effect of rising violence on disease is captured as $\beta_1 + \beta_3$, while in non-battlefields the effect of rising violence on disease is simply β_1.

[30] Previous studies of disease incidence across areal units have similarly employed spatial autoregressive models to account for disease dynamics including tuberculosis incidence in Beijing districts (Mahara et al. (2018)), Japanese Encephalitis incidence across regions in Nepal (Impoinvil et al. (2011)), and more recently incidence rates of COVID-19 across US counties (Mollalo, Vahedi, and Rivera (2020)). Additional details including discussion on spatial weights selection for SAR models is located in this chapter's appendix.

[31] A queen neighbor definition classifies all units which share a border or point as neighbors. This contrasts with the more conservative rook definition which only considers neighbors which share a border. Row standardization reparameterizes binary [0/1] values for neighbor relations in the spatial weights matrix by weighting based on the total number of neighbors. For example, for a unit with four neighbors each value in W would equal $\frac{[0,1]}{4} = [0, 0.25]$. This reparamterization yields a more interpretable ρ in Equation (4.1) which then describes the proportion of variation in y attributable to $y's$ neighbors. Of course, the simultaneity implied by Equation (4.1) still complicates interpretation of marginal effects as discussed in the results section.

[32] The remaining terms in Equation (4.1) correspond to controls, an intercept term, and country and year fixed-effects (γ), and an error term (ϵ), which after modeling spatial dependence and controlling unit and temporal heterogeneity with fixed effects is assumed i.i.d. normal.

Briefly, returning to the theory, it is expected that increased violence in non-battlefields will encourage civilians to shelter which, according to H1, indicates that β_1 should be negative in the CiD model and positive in the NCiD model. In battlefields rising violence will lead to civilian shuffling which, according to H2, indicates that $\beta_1 + \beta_3$ should be positive in the CiD model and negative in the NCiD model.

Specification testing, such as Lagrange Multiplier diagnostics performed on non-spatial models can be used to identify the presence or absence of remaining spatial dependence. I will begin by discussing the results of these diagnostics tests to motivate SAR models as the appropriate modeling choice for these data and theory.

4.7 Results

Models with country-year fixed effects provide initial estimates to test for spatial lag processes. Lagrange Multiplier diagnostics strongly indicate the presence of a spatial lag process present in the static models.[33] This provides initial evidence in support of H3 (Flee) process whereby disease patterns in these data exhibit diffusion processes. In order to properly test for this form of endogeneity, a series of Spatial Autoregressive (SAR) models were fit. These models are presented in Table 4.4. Columns 1 and 2 present parameter estimates for Lower Respiratory Infections (LRI) to model the relationship between conflict and Contagious Infectious Disease (CID) and columns 3 and 4 present equivalent estimates for Malaria to model the conflict and non-contagious infectious disease (NCiD) relationship.

Table 4.4: Spatial Lag Models

	LRI		Malaria	
	(1)	(2)	(3)	(4)
Battlefield	1.30	1.61	-8.70	-3.05
	(1.02)	(1.01)	(7.87)	(7.66)
Battle deaths°	-0.97^{*}	-1.51^{***}	15.35^{***}	9.10^{**}
	(0.40)	(0.39)	(3.05)	(2.99)
Battlefield x Deaths	1.97^{***}	2.18^{***}	-22.14^{***}	-18.59^{***}
	(0.49)	(0.48)	(3.77)	(3.67)
Wasting (%)		-0.89^{***}		-7.17^{***}
		(0.12)		(0.91)
Educ. (F, yrs)		-1.15^{***}		-12.83^{***}
		(0.23)		(1.77)
Terain Rough.°		-1.46^{***}		6.48^{*}
		(0.36)		(2.73)
MCV Coverage (%)		-0.04		0.27
		(0.02)		(0.17)
Rainfall (mm)°		33.99^{*}		-919.17^{***}
		(14.33)		(108.64)
Temperature (c)°		101.48^{**}		-1778.03^{***}
		(30.99)		(234.75)
Rain x Temp.		-9.49^{*}		301.79^{***}
		(4.42)		(33.53)
Population density°		1.71^{***}		5.48
		(0.38)		(2.86)
Area (Sq.km.)°		3.62^{***}		10.59^{***}
		(0.37)		(2.80)
Capital distance (km)°		-0.50		12.51^{***}
		(0.32)		(2.40)
Intercept	24.30^{***}	-342.20^{***}	75.68^{***}	5299.52^{***}
	(2.30)	(100.00)	(16.69)	(758.01)
ρ	0.74^{***}	0.72^{***}	0.77^{***}	0.73^{***}
	(0.01)	(0.01)	(0.01)	(0.01)
Fixed effects - country	Yes	Yes	Yes	Yes
Fixed effects - year	Yes	Yes	Yes	Yes
LogLik	-46233.43	-45992.38	-66721.66	-66331.40
AIC	92594.87	92132.77	133571.32	132810.80
N	10026	10026	10026	10026

○ denotes logged values. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

4.7.1 Spatial Lag Models

Results confirm the presence of strong spatial dependence in the data as evidenced by the highly significant and substantively large spatial lag parameter (ρ) providing support for H3 (Flee). Turning to the conflict parameters, conflict intensity and the interaction between conflict intensity and the battlefield classification are significant in all models with and without control variables. Directly interpreting these coefficients is complicated both by the presence of ρ capturing spatial dependence and the context conditionality implied by the interaction term $Battlefield \times Deaths$. The effect of conflict on disease can be decomposed into distinct spatial effects: the direct effect (which occurs within the unit experiencing violence), the indirect effect (which occurs in neighboring units and is attributable to people fleeing according to H3), and the total effect which is the cumulative change in disease attributable to direct and indirect responses due to violence (Anselin 2009).

Before turning to these spatially explicit and context conditional effects of violence on disease, a cursory look at control variables indicates general alignment with expectations. Areas with higher levels of education experience lower rates of disease, more challenging terrain has higher rates of malaria and lower rates of LRI, and population density significantly explains LRI. The climate interaction ($rainfall \times temperature$) significantly and substantively explain variation in malaria incidence suggesting that warmer and wetter climates have much higher rates in line with expectations.

Figure 4.4 presents the estimated marginal effects of rising levels of disease in battlefield and non-battlefield setting for LRI and Malaria after accounting for the spatial dependence implied by these models.[34]

[33] These fixed-effects models with no spatial lag and diagnostic tests are presented in the appendix to save space.

[34] These estimated marginal effects use estimates from models (2) and (4) in Table 4.4 which include control variables. Confidence intervals were computed via parametric simulation with 1000 simulated parameter draws. To avoid solving the determinant of the spatial multiplier ($(I - \rho W)^{-1}$ which contains $n^2 \sim 100$ million elements) for each iteration of the simulation, I make use of Ord's

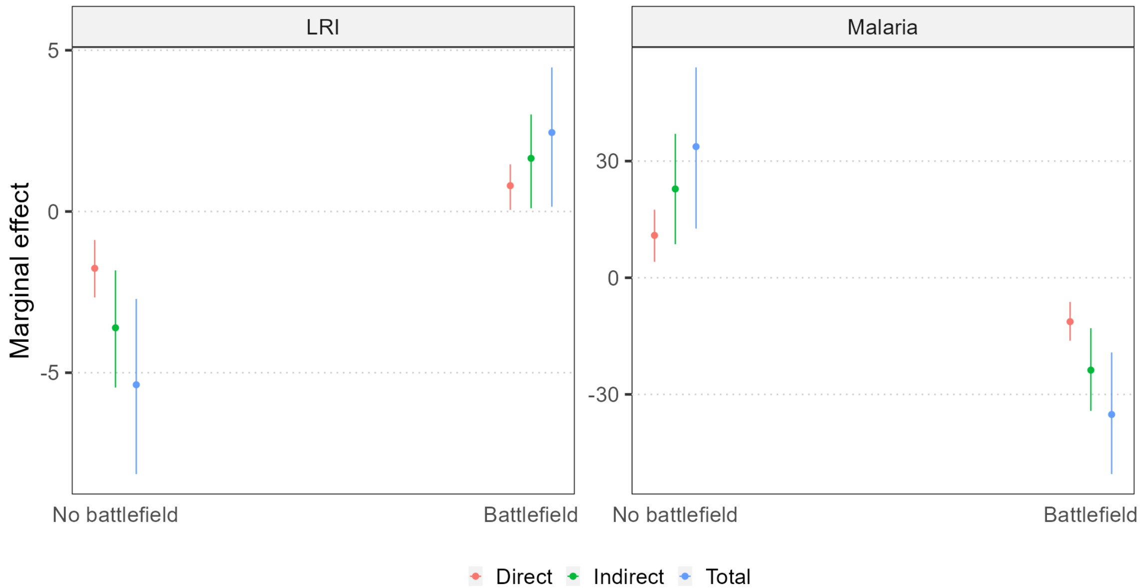

Figure 4.4: Spatial (marginal) effects of rising violence on disease incidence rates

These results provide strong support for H1 (Shelter) as evidenced by the clear negative LRI incidence rate response to escalating violence in non-battlefields and opposite increasing response in Malaria incidence rates in non-battlefields. Estimates for disease responses in battlefield spaces also find support here. In line with theorized expectations, malaria rates decline as violence increases in battlefield spaces attributable to civilians shuffling to other nearby regions in search of safety thereby removing themselves from areas with the most damage and exposure to environmental pathogens. In contrast, although significant and in the hypothesized direction, the confidence intervals for LRI disease response in battlefields are close to 0 suggesting moderate support for H2 with respect to CiD. The estimated effect of rising violence in battlefields suggest a moderate rise in LRI providing support for a shuffling response leading to civilians enduring more congested living spaces after shuffling into other areas and living in more space-limited housing.

To evaluate whether these estimated effects explain meaningful substantive variation

(1975) eigenvalue technique. Numerical values corresponding to this figure are reported in table format in the appendix.

in disease incidence rates, Figure 4.5 presents predicted disease incidence rate responses to representative changes in conflict Intensity measured as an increase from 4 to 63 battle deaths which corresponds to a shift from the 1st to 3rd quartile of observed values for regions which reported any casualties during the study period.[35]

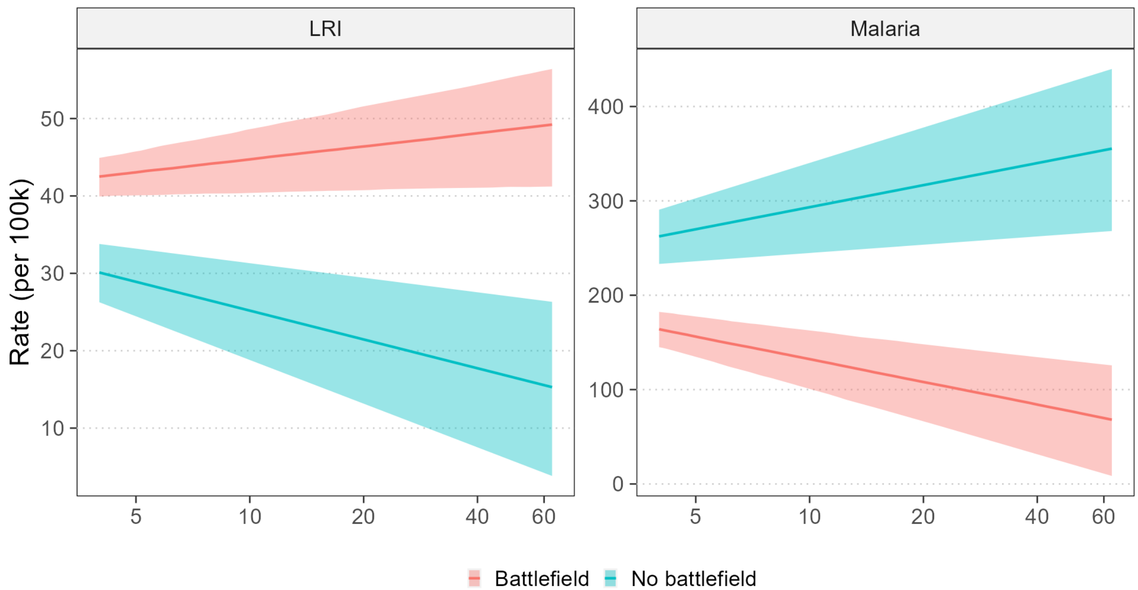

Figure 4.5: Spatial Effect: Incidence Rates

Looking first to the estimated disease responses in non-battlefield contexts, both LRI and Malaria rates shift in substantively meaningful ways over this representative conflict shock. LRI decreases by 14.8 cases per 1000 [95% ci: 7.5, 22.5]. An equivalent increase in non-battlefield violence leads to an increase in Malaria incidence rates of 93 cases per 1000 [95% ci: 34.9, 149.1]. For a region with a median population of children under 5 these disease incidence shifts correspond to 1908 fewer cases of LRI or an additional 11993 predicted cases of Malaria. In battlefield settings the direction of these shifts change in line with the theory and different civilian strategic responses to violence. Predicted LRI incidence increases by a modest 6.7 [95% ci: 1.3, 11.5] cases per 1000 and predicted Malaria incidence decrease by 95.9 [95% ci: 56.7, 136.5].

[35] Control variables are held at their median values to calculate predicted disease response to the specified shift in conflict intensity. Predicted values report the total spatial response to a shift in violence which incorporates both direct (within unit) and indirect (neighbor unit) responses.

For a region with a median population of children under 5 these shifts correspond to 864 additional cases of LRI and 12367 fewer predicted cases of Malaria.

Given the limited medical capacities and resources available for clinics and hospitals to provide healthcare to civilians in need, especially in areas that lie within or near close proximity to contested battlefield spaces, these estimated disease responses attributable to context-specific changes in observable patterns of violence represent meaningful shifts. Advanced knowledge of where these patterns of disease are likely to emerge in conflict zones due to ongoing patterns of violence would facilitate staging of limited medical resources in advance to treat illness and disease as it arises in these settings. I turn to these implications now in the conclusion to this chapter.

4.8 Conclusion

This chapter proposed a novel theory connecting rising levels of violence across varying conflict contexts to distinct disease response trajectories. The theory was tested using a novel subnational dataset of precise conflict and disease measures tested with dynamic spatial models to explore the dependence between disease and war. The findings presented here provide support for a context conditional relationship between violence and disease: whether that violence occurs in the context of a battlefield space significantly shapes disease incidence responses. Conflict context and rising violence intensity produce different disease response for two categories of infectious disease with distinct transmission mechanisms. The proposed theory suggests that these differences emerge due to the alternative security-improving strategies that civilians pursue in response to the rising levels of violence they observe. These unique response strategies - sheltering, shuffling, or fleeing - place civilians in situations where they are more or less likely to encounter disease causing pathogens. These difference in pathogen exposure account for distinct disease incidence outcomes in response to rising levels of violence in different conflict contexts.

As a first step at unpacking mechanisms that connect specific types of conflict to observable disease responses, the findings presented in this chapter have a number of policy implications. First, advances in conflict forecasting (see Hegre et al. (2017) for a recent summary) introduces new opportunities to predict changing conflict conditions at precise levels. Predicting where and when violence is more likely to take place may provide advanced warning for looming health crises. Second, advanced warning resulting from conflict prediction may facilitate the staging of limited health resources in close proximity to conflict zones, especially to aid refugees fleeing violence. Understanding how conflict shapes specific health outcomes may aid in precise health aid targeting. Finally, the results presented in this chapter underscore the spillover effects of conflict on health. Local violence produces regional disease responses with incidence rates in neighboring regions responding to changes in violent conflict elsewhere. These findings underscore the need for policymakers to take seriously the implications of conflict on their periphery for public health outcomes in their local jurisdictions.

These findings reveal a number of potential paths forward to explore the connection between conflict and disease. First, the findings presented here restrict analysis to a specific region of one continent - Sub-Saharan Africa - for two diseases - lower respiratory infections and Malaria. Extending this work to other domains could occur along two trajectories: alternative regional analysis or more fine-grained subnational analysis of specific disease-conflict responses. In the first category, new insights could be gained by testing the disease conflict connection in South East Asia or Latin American contexts where different disease burdens impact civilians (for example, Zika virus). Fine-grained analysis is also possible. Epidemiological surveillance data, such as those collected by the World Health Organization during the conflict in Syria[36]

[36]For example, Early Warning Alert and Response System (EWARS) epidemiological reporting.

offer opportunities to test new mechanisms connecting disease and conflict such as by examining connections between observable damage to housing stock in a conflict and the spread of environmental infectious disease such as Leishmaniasis. Analysis at this level would also facilitate exploring the speed of the conflict-disease response relationship - whether disease incidence changes rapidly or more slowly to changing conflict conditions. Such tests were not possible in this chapter with data aggregated at the yearly level, but is feasible using weekly epidemiological reports and temporally precise conflict measures. Finally, while this chapter has focused on disease rates among children in conflict zones, past research has demonstrated the gendered implications of conflict particularly on women's and maternal health.

The violence perpetuated in civil wars has a profound effect on local populations proximate to that violence, but the consequences of this violence has global reach. The continuing COVID-19 pandemic has clearly demonstrated the global reach of local disease outbreaks. As populations continue to grow more interconnected with technology and expanding trade and travel connections, it will become increasingly critical to develop theoretically informed models that explain how conflict contributes to the spread of disease across international borders. The next chapter of this dissertation turns now to this topic of the relationship between civil war and cross-national disease outbreak.

Chapter 5

Cross-National Analysis

5.1 Introduction

The previous chapter explored the consequences of conflict on disease at local levels demonstrating how violence shapes civilian decision making in conflict zones to produced unique disease outcomes. In regions with representative populations, modest shifts in observed violence produce substantively meaningful shifts in the incidence of disease. In ordinary circumstances, rising disease case counts can place a strain on available healthcare resources, but in countries experiencing armed conflict where health systems have suffered damage due to fighting and personnel loss, equivalent rising disease case counts may strain healthcare capacity beyond its limits. Situations like these create opportunities for disease to spread unrestrained throughout a community leading to outbreaks - or case surges beyond what is otherwise typical. Disease outbreaks have profound and negative consequences on the capacities of states to respond to the health needs of their citizens and to limit disease spread. Outbreaks also have greater potential to spread across international borders undermining global health in the process.

While we understand the broad contours of the relationship between conflict and health - that residents in countries with ongoing or recently concluded civil war experience a significantly lower quality of life (such as higher infant mortality rates or shorter lifespans) - we currently do not understand how civil war intersects with the critically outbreak element of public health and disease management. The disease-war connection has conventionally been understood in general terms as war creating conditions ripe for the emergence and spread of infectious disease (Packard 2016). However, a causal theory connecting the particular characteristics conflict to disease outbreak remains absent. Why certain diseases emerge in the context of some wars, but not others or why some conflicts produce no disease outbreaks at all is not yet understood. For example, why do we observe the emergence of intense pockets of polio-myelitis in Somalia, Hepatitis E in Chad which neighbors conflict-ridden Sudan, or Ebola in the Democratic Republic of Congo? Why has one of the world's worst Cholera outbreaks occurred in Yemen, but not in Syria?

This chapter argues that the patterns of conflict-induced variation in sub-national disease incidence demonstrated in the previous chapter has downstream consequences on the potential for disease outbreak at the national level. While battlefield status and intensity of observed conflict shape civilian responses to violence at local levels and thereby influences disease incidence, the overall geography of a conflict at a national level shapes the potential for a disease outbreaks to occur. Local conflict dynamics produce national population movements that can create conditions ripe for the unrestricted spread of disease within communities which can quickly overwhelm available regional medical capacities leading to disease outbreak. These conflict dynamics may be especially prone to creating conditions ideal for the emergence of some disease types relative to others.

Variation in the intensity of violence catalyzes civilians to make choices to improves their security while knowledge of the geography of the war across a country informs their available options for removing themselves from the areas where they feel they face the greatest risk. Together these factors of civil war: the *Geographic* extent and *Intensity* of fighting send signals to civilians that help them to make informed decisions regarding their broader security environment. How civilians chose to respond to this information in order to best evade violence during a civil war informs both where as well as what types of disease outbreaks emerge and thereby connects battlefield dynamics to conflict epidemiology. Building on insights from the analysis in the previous chapter, I argue here that the spatial extent and level of fighting across a country - a civil war's geography and intensity respectively - meaningfully influence the likelihood that a country will experience a disease outbreak due to widespread population movements in areas with significant infrastructure damage and limited local health capacity.

This chapter proceeds as follows: Section 5.2 surveys the literature on conflict, public health, and disease outbreaks and epidemics. Section 5.3 presents a theory connecting categories of civil war dynamics to national level disease outbreak through a mechanism of civilian strategies that aggregate local health variation to national level health outcomes. Section 5.4 describes the data and methods used to test this theory with a cross-national sample of countries which have suffered high levels of violence between 1999 and 2012. Section 5.5 presents results and Section 5.6 concludes with discussion of the implications of these findings on global health as well as discussion on ways to extend this analysis.

5.2 Background

Civil war undermines public health. Combat between belligerents destroys critical health infrastructure, produces casualties who must live with injuries, and creates a shortage of available healthcare personnel as these professionals tend to possess the financial means to escape dangerous environments.[1] After a war, common indicators of health in countries with legacies of conflict lag behind others without similar histories (Gates et al. 2012). The destruction of non-health infrastructure during fighting generates multiplier effects that further compromise health systems across a country and stretch already limited state capacities in post-conflict areas. For example, destroyed roads hinder hospital reconstruction and limit rapid access options for those in need of swift medical care. Similarly, damaged water treatment facilities restrict access to freshwater and industrial damage within a country severely compromise public sanitation capacities.

Why disease outbreaks emerge from some civil wars and not others is not yet clear. Given the global potential for disease to rapidly spread[2] beyond the borders of countries suffering from ongoing or recently concluded civil wars, it is surprising that few articles have looked at this relationship in detail (Bagozzi 2016; Hendrix and K. S. Gleditsch 2012; Letendre, Fincher, and Thornhill 2010; Iqbal and Zorn 2010). This past work has significantly advanced our understanding of the conflict-disease connection for example, by employing disease as an explanatory factor to account for variation in conflict conditions. These studies have also illustrated the consequences of armed conflict across a variety of critical public health measures including infant mortality, government health expenditures, and overall life expectancies in post-conflict countries. Despite these considerable gains, more room remains to engage with the epidemiology of disease and mechanisms of disease proliferation. Engagement of this nature could illuminate mechanisms and processes that build upon our understanding

[1]For example, the medical brain drain which occurred in the context of the Iraq war peaked in 2006 just as violence was reaching a peak prior to the 2007 US troop surge (Al-Khalisi 2013).

[2]Studies on the spread of disease have revealed the complex pathways by which an outbreak of an infectious pathogen can globally diffuse, particularly through air-travel (Brockmann and Helbing 2013). The rapid spread of COVID-19 in the spring of 2020 underscores the significance of these findings.

of conflict dynamics and help us to develop a better causal model of conflict-disease connections.

Some scholars have attempted to identify such causal connections and in the process have identified the complex pathways that connect conflict and disease dynamics. For example, Letendre, Fincher, and Thornhill (2010) argued that factors such as ethnic tension and poverty typically identified in political science work as contributing to the onset of civil war have a prior causal connection to the prevalence of disease within a society. While they found that disease prevalence significantly accounts for conflict onset, Hendrix and Gleditsch (2012) argued those results emerged due to endogeneity: civil war *likely* produces more disease.[3] This endogeneity debate between Hendrix and Gleditsch (2012) and Letendre, Fincher, and Thornhill (2010) highlights the complex pathways that likely connect conflict to disease in locations with ongoing and active conflicts. While previous chapters in this dissertation have unpacked this connection through a mechanism of civilian displacement, no work has yet investigated how conflict can lead to widespread disease transmission in conflict or post-conflict environments leading to disease outbreaks.

In contrast to Letendre, Fincher, and Thornhill (2010) who examined conflict onset, Bagozzi (2016) explored how the presence of disease could contribute to armed conflicts which lasted for longer periods of time. He found robust support for a model suggesting that areas with endemic presence of malaria tended to suffer from armed conflicts which persisted for longer periods of time relative to other regions which did not have similar rates of malaria. Bagozzi argued that an insurgent troop immunity mechanism underpinned his findings. Specifically, he argued that insurgent groups

[3] The endogenous relationship between disease and war has been highlighted elsewhere in this dissertation and implied, but not yet explored in recent research. For example, two recent papers examining the relationship between violence and COVID-19 in Afghanistan arrived at complementary conclusions that violence led to the spread of disease (Lucero-Prisno et al. 2020) and the spread of disease led to a rise in armed violence (Koehnlein and Koren 2022). This endogeneity represents an important dimension for future research revisited in this dissertation's conclusion.

who remained largely stationary within one region during a conflict developed an immunity to malaria not shared by government forces who rotated around regions of a country. Malaria thereby compromised government force capacity leading to longer civil wars.

Letendre, Fincher, and Thornhill (2010), Hendrix and Gleditsch (2012), and Bagozzi (2016) advanced how we conceptualize the direction of causality between conflict and disease while also illustrating the complexity of this relationship. This complexity also suggest new avenues to approach unpacking causal directions. Important questions remain concerning whether certain features of the armed conflicts examined in the sample of cases included in these articles contribute differently to the spread of epidemic disease. For example, building off the endogeneity debate between Letendre et al. and Hendrix and Gleditsch, it remains unclear which types of fighting in armed conflict might contribute to epidemic malaria spread in areas of the world endemic with that disease.[4] These findings suggest vicious cycles between disease and war. For instance, while endemic malaria results in longer civil wars, longer civil wars further compromise disease containment efforts leading to more widespread malaria transmission. Unpacking which conflicts are most prone to facilitating the transmission of these diseases is therefore a necessary step towards advancing our understanding of the conflict-disease cycle.

Other scholars have explored the role of violence on epidemic disease spread by examining the relationship between conflict and specific disease. For example, Iqbal and Zorn (2010) analyzed the consequences of conflict on AIDS prevalence in Sub-Saharan Africa, finding that countries participating in international wars experience a significant increase in the rates of HIV transmission relative to civil wars due to

[4]Malaria results in approximately 430 thousand deaths every year. Given this toll on human welfare as well as the international investment to combat malaria in heavily impacted regions (which surpassed $2.5 billion in 2018), more research needs to explore the conflict-related factors that undermine of facilitate the containment of this disease.

greater geographic movement of military personnel over larger distances in the former category. While Iqbal and Zorn (2010) advance our understanding of the connection between disease and war the connection between the mechanisms of disease transmission and conflict dynamics are left under-theorized and instead broader trends are analyzed between conflict categories: inter- vs. intra-national conflict. While making important contributions, this past work highlights room for areas in need of deeper theorization that can explain why civil war contributes to the emergence of certain disease outbreaks in some conflicts but not others.

While these studies illustrate the complex pathways between conflict and disease, the consequences of armed violence on public health operate along complex dimensions and contribute to extensive human suffering in a myriad of ways. For instance other political science research in this domain has focused on the broader public health consequences of conflict such as on years of life lost (Ghobarah, Huth, and Russett 2004), health infrastructure damage (Iqbal 2010), and the prevalence of post conflict disabilities across different types of conflict (Hoddie and J. M. Smith 2009). While contributing to our understanding to the relationship between war and health, these general examinations of the dynamic relationships between conflict and broad measures of health leave room for more detailed work theorizing the possible causal pathways that connect the dynamics of civil wars to more detailed measures of disease outbreak.

Finally, scholars in public health and epidemiology have also made progress in exploring the connections between civil war and disease (Berry and Berrang-Ford 2016; Kerridge, Khan, Rehm, et al. 2013; Kerridge, Khan, and Sapkota 2012; Gayer et al. 2007). These studies demonstrate broad trends between conflict or terrorism and disease prevalence rates cross-nationally and within specific cases. While valuable in demonstrating the general patterns between conflict and disease and changes over time, an emphasis on the analysis of trends in disease and conflict comes at the expense of considering the causal role that specific features of conflict have as contributing factors to the onset of observable disease outbreaks and, critically, *why* this might be the case. More work remains to better understand how conflict dynamics cascade to produce differential disease outbreak outcomes.

Taken together past work in political science, public health, and epidemiology indicate that significant room exists to advance our knowledge of the connection between disease outbreaks and country-level patterns of violence that emerge across civil wars. This past research suggests that certain logics of armed conflict may help us to better understand why disease outbreaks emerge in some conflicts but not others. These logics of violence and their connection to the transmission mechanisms of infectious disease suggest new avenues for developing a theoretical model that connects the violence of civil war to disease. To fill this gap, the following section provides a theory connecting disease outbreaks back to the characteristics of civil wars themselves by exploring how *dynamics* of violence across distinct categories of civil war contribute to the onset of disease outbreaks.

5.3 Theory

Two factors connect civil war to disease outbreak: ***Geography*** and ***Intensity*** of fighting. At local levels these factors shape civilian decision making in response to violence and, through the decisions that civilians make, impact rates of disease. At country levels, however, the geography and intensity of a conflict aggregate individual civilian response decisions and shape the probability of unrestrained disease spread within a country.

At the national level, geography of a conflict refers to the *concentration* or *diffusion* of fighting across space within a country.[5] Fighting intensity refers to the overall level of violence in a conflict which can vary from low, simmering conflicts with intermittent spells of violent skirmishes to high, which corresponds to conflicts with consistent levels of violence characterized by more extensive casualties and damage. Both the geographic scope and intensity of fighting causally precede downstream conditions that emerge during a war to produce environments or interactions conducive to the onset of particular disease outbreak types.

Civilians respond to armed conflict with different strategies that depend on the geographic extent and overall intensity of violence they observe. The previous chapter demonstrated the consequences of conflict on local disease as civilians respond to violence by choosing to *flee* into to nearby regions, *shuffle* into safer areas in their home territory, or *shelter* in place and hope their local compromised security situation improves. Conflict induced increases in the burden of disease at local levels can lead to situations where national healthcare capacities are quickly overwhelmed.[6] Therefore, at aggregate levels, how conflict shapes population movement patterns helps to account for disease outbreaks. The act of staying or moving through a battlefield determines what categories of disease have greater opportunities to spread among vulnerable populations. The *Geography* and *intensity* of a civil war helps to determine the average civilian response to violence and therefore the potential for outbreak of disease. Analyzing the strategic motivations of civilians to avoid harm provides opportunities to predict both the emergence and location of disease outbreaks based on the rational strategies these key actors employ in their response to violence.

[5] This contrasts with the binary "Battlefield / No battlefield" conceptualization employed in the subnational chapter. At finer local levels binary classifications make more sense as civilians will conceptualize their local region as either a space with active and contested fighting or not. At the national level, however, disease outbreak is more likely a function of how *widespread* a conflict in space.

[6] For example, the 2014-15 West Africa Ebola outbreak may have reduced access to healthcare in that region by as much as half and contributed to thousands of additional deaths due to malaria, HIV/AIDs and tuberculosis (Parpia et al. 2016).

Geography [Diffuse / Concentrated] - Conflict geography describes the spatial extent of combat relative to the size of a country and provides critical information to civilians on what areas within a country provide improved security opportunities or which have the increased risk for harm. Significant variation exists across countries in the scope of their civil wars. Some occur in relatively concentrated areas of a country, such as in Tajikistan which, after gaining independence from the Soviet Union in 1991, experienced a contested fight for control of government that occurred primarily in the western regions of the country near the capital, Dushanbe. In contrast, other civil wars have spilled over to cover a much wider area with the conflict sprawling to most areas of a country. Following the breakup of Yugoslavia, modern-day Bosnia-Herzegovina and Croatia experienced combat between armed groups that occurred across the vast areas within these countries with few regions spared from fighting.

Intensity [Low / High] - Conflict intensity describes the overall destructive nature of a war which can range from simmering conflicts to more expansive wars which produce high fatality counts and destroy infrastructure. The intensity of fighting informs civilian decision making with country level implications. In some conflicts belligerent forces remain organized and active for long durations of time but carry out limited operations. For example, the Maoist forces in Nepal operated at lower-levels in predominantly rural areas of that country for most of the 1990s with limited combat operations. Thus, despite the backdrop of a widespread insurgency throughout the country, the few episodes of violence over this time period did not translate into extensive combat. However, by the early 2000s this latent capacity for violence transformed into widespread and extensive fighting between Maoist insurgents and government forces which resulted in a large number of casualties as well as damage to critical infrastructure within the country. Widespread violence which occurs in high intensity conflicts that produce a high number of fatalities should result in more population movement around a country as well as more infrastructure damage within towns and cities. High intensity combat helps to shape the incentives of civilians to shelter, or if safer spaces exist, to shuffle into nearby regions or flee greater distances.

When civilians evaluate their insecurity in response to violence they consider the diffuse or concentrated geography of fighting as they weigh their odds of finding safety elsewhere. Conflict geography shapes how civilians respond to violence which they observe. If they believe they have a high likelihood of finding improved security elsewhere they may flee, but if they believe this likelihood is low or the costs too high (such as needing to escape over a large geographic distance), they may instead opt to remain stationary and hope instead that their local condition improves. At national levels conflicts vary along their geographic extent and intensity which shapes how civilians in these wars respond to violence.[7] These response thereby shape the potential for disease outbreaks in some conflicts, but not others.

In this theory civilians serve as the primary agents whose decisions in response to violence of varying intensity and geographic scope helps to determine how disease outbreaks emerge due to civil war. Civilians act strategically, responding to events based on the dynamics they observe between belligerents. Civilians exercise their agency to act purposefully in order to maximize their security while minimizing the risks they face to their welfare. Different conflict dynamics will compel civilians to pursue various strategies to maximize their security which, due to the pathogens civilians will encounter as they navigate conflict spaces, create ideal conditions for widespread disease transmission.

5.3.1 Disease Outbreak Types

Infectious diseases spreads through different causal pathways dependent both on both the primary source vector, that is the origin-point for a disease, as well as the poten-

[7]Past research has examined the individual incentive structures that compel civilian flight in civil wars in greater detail (Bohra-Mishra and Massey 2011; Lischer 2007).

tial for secondary transmission between infected and non-infected individuals (World Health Organization 2018). Population movements in civil wars create different potential for the spread of **contagious** and **non-contagious** infectious disease.

Contagious diseases [CiD] primarily spread through major transmission modes facilitated by close inter-personal contact such as coughing, skin contact, or any exchange of bodily fluids. Conditions that bring people into close contact with one another or leave them in confined spaces - such as while ***fleeing*** in groups or ***shuffling*** out of a city besieged by conflict to live in refugee camps - can increase the odds that one individual will spread an infection to many others within the concentrated confines of the vulnerable population. Measles, hemorrhagic fevers, and certain forms of plague all spread more easily among densely-concentrated populations. Additionally, while running away from fighting, civilians also have an increased likelihood of coming into contact with wildlife. This creates the opportunity for novel zoonoses, new animal-to-human infections, to spillover into the human population. When these events occur, a virus that may produce no observable indicators in an undomesticated, infected animal population will spread rapidly through a human population with limited background exposure to mount an effective immune system response (Wise and Barry 2017). Civilians fleeing from violence by escaping into forested areas have much higher odds of exposure to these types of viruses due to the closer proximity they share with wildlife.

In contrast to contagious disease, infrastructure damage due to bombed buildings or interruptions to general sanitation efforts (such as rodent control) which results from fighting can facilitate the emergence of non-contagious infectious [NCiD] disease vectors or disease sources. Damaged potable water resources can increase the rate of exposure to harmful bacteria, structures with damaged walls exposing inhabitants to the outside can present opportunities for ticks, mice, fleas, and mosquitoes to enter and infect civilians with diseases such as Malaria or Lassa fever. When civilians are ***sheltering*** in regions with active conflict, the deteriorated environmental conditions due to fighting-induced damage will increase the likelihood of a non-contagious disease outbreaks occurring within a country. Since sheltering civilians will prefer to hide in isolated spaces when taking shelter from combat, their exposure to other people decreases along with the odds of CiD disease transmission. During bouts of fighting in localized conflicts, civilians will avoid gathering in larger groups in order to avoid the risks of encountering combat. However, their decision to remain stationary increases the odds they will come into contact with an NCiD disease vector.

The dynamics of conflict constrain or create opportunities for civilians to respond to violence through alternative means (fleeing, shuffling, or sheltering) which produce different potential for the spread of CiD or NCiD disease within countries.

5.3.2 Hypotheses

Civil war dynamics vary according to overall conflict intensity and geographic scope of fighting. This variation produces four types of civil war that each correspond to different predictions for the onset of a disease outbreak. The geographic extent and intensity of fighting within a conflict jointly inform civilians on how to best improve their personal security. Civil wars vary across their geographic extent and overall fighting intensity creating different categories of conflict. Different conflict types produce different incentives for civilians to pursue alternative security-improving strategies. The typical response that civilians pursue across these conflicts will shape the potential for different disease outbreaks to emerge across varying conflict categories which comprise four classes: low and high intensity wars fought in concentrated or diffuse conflict spaces.

High Intensity, Diffuse - (Expansive conflicts) - High intensity and diffuse, or Expansive conflicts exhibit the most extensive violence over the widest geographic area within a country. These wars typically contain two or several belligerents with strength parity or loose coalitions that produce parity. Due to the relative balance of strength between the main warring factions, high levels of violence permeate the battlefield which, due to the diffuse geography of the fighting, encompasses extensive portions of a country relative to its size.

Civilians, observing these conditions, will decide to *shuffle* into neighboring areas or *flee* greater distances to escape violence since local conditions afford them limited possibility for safety. By traveling great distances over a wide geographic space to find safety outside of a conflict space, civilians are, on average, likely to contract a disease due to the deteriorated health conditions they experience due to exposure to long term fighting (malnourished, stress, limited access to fresh water and sanitation). As a consequence of these conditions, traveling over distance will result in some number of individuals contracting disease from exposure to wildlife or contaminated environmental resources. Since civilians fleeing from a battlefield and not remaining stationary, it is unlikely that a non-contagious disease that exclusively infects people through environmental exposure will reach outbreak potential. Instead, diseases which flourish through secondary person-to-person transmission will spread in the dense clusters of civilians fleeing violence towards similar points of safety. Arriving at their destination and residing in the close confines of a refugee camp, the contagious disease will be more likely to spread. Given these conditions, I anticipate the following:

> **H1 - Expansive** - In geographically diffuse conflicts, high intensity fighting will increase the probability of CiD disease outbreak.

One illustrative example of high-intensity conflicts waged over a diffuse geographic area producing contagious disease outbreaks is the conflict in Sudan in 2004. After experiencing violence perpetuated by belligerents in the Sudanese civil war, civilians fled to find safety. The civil war in Sudan encompassed an extensive geographic area covering the greater part of the country excluding largely uninhabited areas to the north covered in desert. Facing these conditions, civilians fled to nearby Chad for safety. While there an outbreak of Hepatitis E spread through the refugee camps contributing to hundreds of deaths. The unsanitary conditions of the journey coupled with the confined housing conditions in the refugee camp facilitated the spread of the Hepatitis E virus among individuals traveling to and residing in the refugee camps within Chad.[8]

High Intensity, Concentrated - (Hotspot conflicts) - In contrast to civil wars which cover a large geographic space, concentrated or Hotspot conflicts imply a sheltering response. Geographically concentrated fighting indicates a strength asymmetry between belligerents. If the main factions involved in a conflict shared strength parity, violence would cover a wider geographic area. Thus, in geographically concentrated conflicts, the asymmetrically weaker party sacrifices the extent of their political ambitions and opt for more modest war claims that assume the form of demands for autonomous control a specific geographic territory (Buhaug 2006).

Due to this strength asymmetry, the stronger party in the conflict (generally the state) possesses the resources and military capacity to surround and encircle the weaker party limiting the free-flow of individuals into and out of the combat-zone. This denial of territory resulting from encirclement tactics benefits the stronger force

[8]Civilian refugees returning home after the end of fighting could experience disease outbreaks for similar reasons. Due to the limited financial support refugee aid organizations receive, civilians returning home after the end of a conflict will likely need to travel through similarly unsanitary conditions to arrive at a destination damaged by the war. As an example, the Orientale Province of DRC has experienced noticeable spikes in Pneumonic plague that coincide with years of high intensity armed conflict between numerous armed groups competing for control of the state. Areas hardest hit by this fighting include the Orientale Province where significant outbreaks of Pneumonic Plague have occurred as well as the North and South Kivu provinces on the country's eastern border which has suffered from repeat Ebola outbreaks exacerbated by violence perpetuated by insurgent forces.

by allowing them to concentrate their fighting capacity in one central location. However, this strategy of encircling the weaker party, trapping them in one location, has consequences for civilians weighing their options to escape violence. Encirclement eliminates the option for civilians to shuffle into nearby areas or flee longer distances. As a consequence, civilians instead *shelter*. By remaining stationary and minimizing their exposure to others, sheltering civilians face lower probability of contracting contagious diseases spread person-to-person. However, when encircled by a stronger belligerent force laying siege to a concentrated territory, deteriorating environmental conditions will increase the likelihood of non-contagious infectious disease outbreaks occurring. This leads to the following hypothesis:

> **H2 - Hotspot** - In geographically concentrated conflicts, high intensity fighting will increase the probability of NCiD disease outbreak.

The Syrian civil war provides an illustrative example of this process during the Siege of Aleppo in 2015 by the Assad regime. In 2015 the Assad regime encircled Aleppo and pursued an extensive and indiscriminate bombing campaign under the guise of rooting out insurgent forces. This tactical choice by the regime trapped civilians who lacked an alternative means to escape and, as a consequence chose to shelter. The regime's bombing campaign produced extensive human suffering as well as resulted in a tremendous level of damage to local infrastructure. In addition to damaging many of the buildings in the city, the siege halted local sanitation efforts - such as garbage collection. As a result, the local sandfly population erupted due to the abundance of available breeding sites within the bombed out city. These insects are the primary transmission vector for Leishmaniasis, a disease causing skin lesions and death if left untreated, a common outcome in conflict zones. The prevalence of sand flies and the encirclement of civilians in Aleppo by government forces resulted in a significant outbreak of this disease which, by 2018 had produced in excess of 80,000 reported cases in the Aleppo region (Muhjazi et al. 2019; Burki 2017; Al-Salem et al. 2016).

Low Intensity, Diffuse - (Simmering conflicts) - When conflict stretches over a wide extent of a country, but occurs at a low level of intensity, such as during a lull in combat between warring factions, civilians face a lower incentive to abandon the relative safety of their homes and will instead chose to shelter in place. These simmering conflicts indicate greater parity between belligerents. Conflicts of this type are more likely to exhibit greater infrastructure damage due to ongoing and past fighting. The relative improvement in security that civilians observe due to lower intensity fighting combined with the diffuse nature of the conflict zone disincentivizes civilians from leaving their homes since they will perceive alternative destinations as likely having the same exposure to violence. Remaining in place surrounded by areas damaged in combat, these civilians face a higher likelihood of contracting non-contagious infectious disease due to increased exposure attributable to infrastructure deterioration as well as degraded sanitation efforts. The stationary nature of civilians who voluntarily chose to shelter while waiting for a wide-spread, but low-intensity conflict to end suggests:

> **H3 - Simmering** - In geographically diffuse conflicts, low intensity fighting will increase the probability of NCiD disease outbreak.

During the mid-1990s after securing independence from the Soviet Union, Tajikistan suffered from a short civil war during which it experienced a sharp increase in the number of reported malaria cases which reached epidemic proportions. The conflict peaked during its first year with lower level hostilities dominating the remainder of the conflict. Over the course of the lower-intensity fighting that persisted between 1993-1996, many civilians remained in the country and, during this time, levels of malaria skyrocketed from pre-conflict low of approximately 600 cases in 1992 to nearly 30,000 reported cases by 1997 when the conflict officially ended (Matthys et al. 2008).

The civil war contributed to the spread of this disease in a number of ways. Variation in the overall intensity of fighting compelled civilians to initially flee and then return as fighting subsided.[9] Upon returning home they found extensive damage to infrastructure which resulted from the first year of fighting as well as a complete disruption of state provision of public health management, particularly in the infectious disease vector control (i.e., mosquito extermination) which was sorely needed in urban areas where the population of disease-carrying insects had grown significantly (World Health Organization 2005). The sense of security due to the lower intensity of fighting following the first stage of the conflict as well as the costs of remaining outside of their home country encouraged civilians who had initially fled to return and shelter in place for the remaining duration of the Tajikistan civil war. These returning civilians found themselves exposed and vulnerable to malaria leading to the subsequent outbreak of that disease.

Low Intensity, Concentrated - (Localized conflicts) - Finally, low intensity concentrated conflicts will increase the probability of contagious infectious disease outbreaks. Like concentrated high-intensity (hotspot) conflicts, these represent cases of clearer asymmetry between one party and the other in the conflict. However, unlike the case of higher-intensity conflicts, the lower overall intensity of violence in this Localized conflict-type does not warrant the stronger party (frequently the state) incurring the costly expense of deploying a large military force to fully contain and isolate the contested territory. Rather, lower-cost counter-insurgency efforts will suffice in these situations. Key to the spread of disease, these tactical decisions have implications on the strategy that civilians will employ to improve their security. Since the conflict takes place in a relatively contained area, civilians will identify nearby safe areas as viable destinations where they can escape from violence. These conflicts lead civilians to *shuffle* into nearby areas which implies:

[9] This pattern of fleeing and returning home was a violence-avoidance strategy also shared by interviewed conflict refugees. See the microfoundation chapter for additional details.

> **H4 - Localized** - In geographically concentrated conflicts, low intensity fighting will increase the probability of CiD disease outbreak.

The ongoing insurgencies that characterize violence in India's northeast provide an illustrative a case of low-intensity, concentrated conflict leading to this type of disease outbreak scenario. During late 1997 and into the following year ethnic insurgency in the Churachandpur District of Manipur, a state in NE India, resulted in a sufficient number of clashes that over 10,000 civilians fled the immediate area of hostilities into nearby regions within the state - particularly the district capital. These civilians resided in makeshift shelters in the surrounding region as well as occupied local governmental structures such as schools or police stations. Their close proximity resulted in an outbreak of tuberculosis among those living in these encampments (Rodger et al. 2002). This disease, spread by coughing that passes the disease-causing bacteria throughout a susceptible population, proved challenging for local authorities to contain. The internally displaced population moved through the region toward the capital in search of safety and it was this movement of people through the conflict space that exacerbated treatment as it prevented medical personnel from delivering a full dose of antibiotics to individuals before they would leave.[10]

The combination of low-intensity and concentrated violence in the Manipur case led civilians to flee, but remain local in the hopes that the security situation would improve. This brought large groups of people into close proximity with one another in a nearby region to the fighting in their home country. The nearby region, having not experienced the consequences of the concentrated fighting, did not suffer from the sort of infrastructure damage which would facilitate the emergence or spread of environmental disease vectors. However, the close proximity of individuals who fled their homes did lead to the outbreak of a person-to-person disease in this case.

[10]This also contributes to the spread of antibiotic resistant strains of particular disease emerging in conflict zones as infected individuals fleeing conflict routinely will start, but often fail to finish treatment regimens and, in the process, contribute to the growth and development of antibiotic

		Conflict Geography	
		Diffuse	**Concentrated**
Conflict Intensity	**High**	<u>H1 - Expansive</u> CiD - (+) NCiD - No effect Mechanism: Shuffle Example [Sudan, 2004]	<u>H2 - Hotspot</u> CiD - No effect NCiD - (+) Mechanism: Shelter Example [Syria - Aleppo, 2015]
	Low	<u>H3 - Simmering</u> CiD - No effect NCiD - (+) Mechanism: Shelter Example [Tajikistan, 1997]	<u>H4 - Localized</u> CiD - (+) NCiD - No effect Mechanism: Shuffle Example [India - Manipur, 1997]

Figure 5.1: Conflict typology and hypothesized relationships

Table 5.1 summarizes these hypothesized relationships between different conflict classes and disease outbreaks across two disease classes. Having laid out a plausible theoretical pathway connecting the classes of civil war to the outbreak of specific categories of disease as well as specifying a number of testable implications of this theory, the following section will provide an overview of the data and methods used to test the theoretical implications of this theory using a cross-national sample of countries with recent or ongoing civil wars.

5.4 Data and Methods

Building upon the subnational analysis of contagious and non-contagious infectious disease conducted in the preceding chapter, this chapter examines a broader set of contagious and non-contagious disease outbreaks reported cross-nationally between 1999 and 2012 and explores their relationship to four categories of armed conflict.

resistant strains of bacteria, especially tuberculosis (Relman, Choffne, and Mack 2010).

This section details the operationalization of these disease outbreak measures, conflict classification, control variables, and the modeling strategy employed to test the hypothesized relationships detailed in the previous section.

5.4.1 Dependent Variable - Disease Outbreaks

Data reporting disease outbreak incidence were collected from the Global Infectious Diseases and Epidemiology Network (GIDEON) by Smith et al. (2014).[11] Over the 14 year time period analyzed here, 6268 outbreaks of 110 distinct diseases were reported with some of the most common being cholera, dengue fever - diseases contracted from environmental exposure - and meningococcal disease, and measles - disease spread from person-to-person.

The epidemiological characteristics of infectious disease varies considerably with transmission and infection achieved through differing mechanisms. Non-contagious diseases primarily originate from individual exposure to food or water contaminated by a bacteria (such as Cholera), protozoa (such as Leishmaniasis), or exposure to a virtues spread by nuisance vectors (such as mosquitoes spreading dengue fever, West Nile virus, or malaria). In contrast to diseases of this type are those spread through contact with or proximity to other people, that is, contagious diseases. Diseases in this category do not depend on environmental exposure to infect a large number of people, but instead spread through respiration or air droplets projected via sneezing or coughing, through skin-to-skin contact, or exchange of bodily fluids. Ebola is one example of disease in this category as it spreads easily through contact with

[11] GIDEON serves as a repository for the collection and dissemination of disease incidence data reported in peer-reviewed published studies or official government publications or reports. This contextual information on the emergence of a new disease outbreak is stored in the GIDEON database as a text-based record containing information on when and were a disease emerged, the extent of the outbreak in terms of reported infected, as well as the source of the disease whether bacterial, viral, or some other causal agent. Smith et al. (2014) developed an automated text-analysis pipeline to extract these relevant contextual indicators on disease outbreak incidence in order to analyze the changing dynamics of global disease outbreak emergence over a 33-year time period spanning from 1980-2013.

the perspiration of another infected individual. Similarly, measles - one of the most infectious diseases - spreads rapidly through close proximity with other infected individuals who are coughing or sneezing or who simply share similar spaces as the virus can survive on surfaces after an infected individual has left an area.

In order to code the 110 diseases that comprise the 6268 outbreaks in these data as *contagious* or *non-contagious* infectious disease (CiD and NCiD respectively) according to their primary transmission mechanisms, I consult a number of valid epidemiological manuals (Hofman 2016; Kanki and Grimes 2013) as well as the US Centers for Disease Control (CDC 2022b; CDC 2022a) on the primary mechanisms of pathogen transmission[12]. Diseases where person-to-person transmission potential was impossible were unambiguously coded as non-contagious disease. As an example of disease in this category Tick Bite Fever or Malaria spread by specific insect vectors (ticks or mosquitoes) and cannot be spread from one person to another, even through close or direct personal contact. In contrast, diseases such as Measles reach outbreak potential through their capacity to spread rapidly from person-to-person through respiration, coughing, or direct skin contact. Diseases of that spread in this manner were coded as contagious disease.[13]

Using this coded disease data, two binary indicator measures are constructed to record whether a country reported a contagious (CiD) or non-contagious (NCiD) infectious disease outbreak during a year. Table 5.1 presents descriptive statistics on the outbreaks reported in these data between 1999 and 2012.[14] Overall, approximately 61% of the country-years in this analysis reported at least one disease outbreak during

[12]Some diseases, such as bacterial infections due to food-borne illnesses, have an ambiguous coding due to their potential to infect an individual through environmental exposure or through close-contact with another infected person. Since these cases represent a small percent of outbreak observations, they are dropped from the analysis.

[13]A detailed coding list of all diseases in these data and their contagious / non-contagious classification constructed for this analysis is located in the appendix to this chapter.

[14]These data consist of 170 countries with 14 years of data (1999 and 2012 inclusive). The panel is not balanced as some countries entered the international system during the study period (e.g., Serbia) while others suffer from limited missing observations on a few control variables.

the time period. Non-contagious disease outbreaks appear to be more common than contagious outbreaks with 3874 reported non-contagious outbreaks comprising 61.8% of all reported outbreaks (there were 2394 reported contagious disease outbreaks).

Table 5.1: Descriptive statistics: Disease Outbreaks

	Mean	Min	Max	SD	N
Outbreak - Total	0.609	0	1	0.488	2350
Outbreak - CiD	0.402	0	1	0.490	2350
Outbreak - NCiD	0.472	0	1	0.499	2350

Figure 5.2 presents a cross-sectional overview of these disease data mapping the number of reported disease outbreaks within each country in the sample over the study period. As this overview of the data demonstrates, significant variation exists across countries in regards to which regions and countries are more prone to experiencing a disease outbreak. These data suggest that wealthy countries appear to report significantly more outbreaks than do lower-income countries. This stems, in part, from the reporting mechanisms underpinning the source material from GIDEON which relies upon peer review publications and government reports to identify instances of widespread disease transmission within a country. In order to account for this, the analysis conducted in this chapter controls for democracy and telecommunications connectivity which is discussed in greater detail below.

The onset of disease outbreaks also exhibit considerable variation over the time during the years included in this study. Figure 5.3 indicates a clear upward trend in the total number of outbreaks among both categories of disease since 1999. Given the potential for rapid spread of disease, especially through transportation networks, this trend is unsurprising (Brockmann and Helbing 2013).

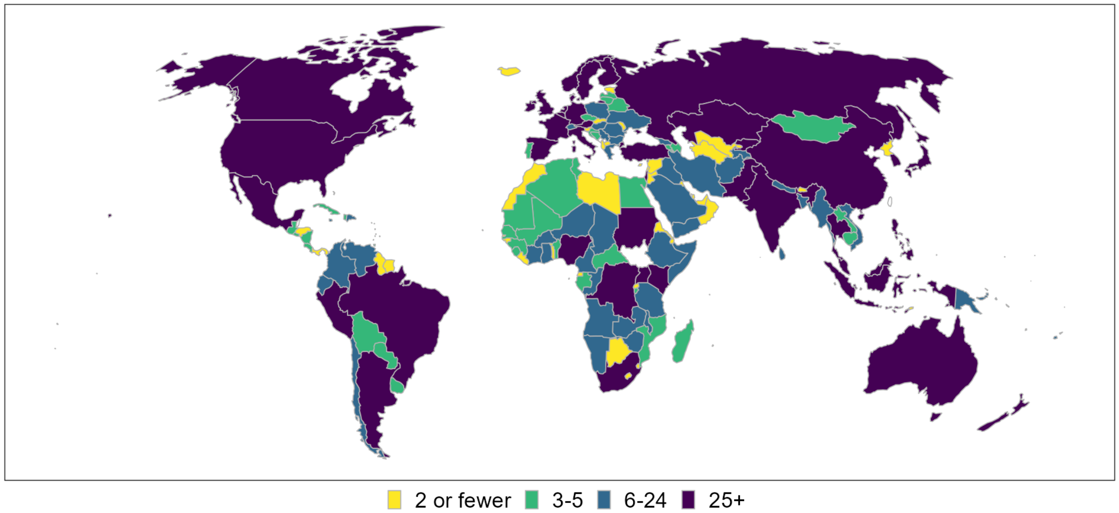

Figure 5.2: Total reported disease outbreaks

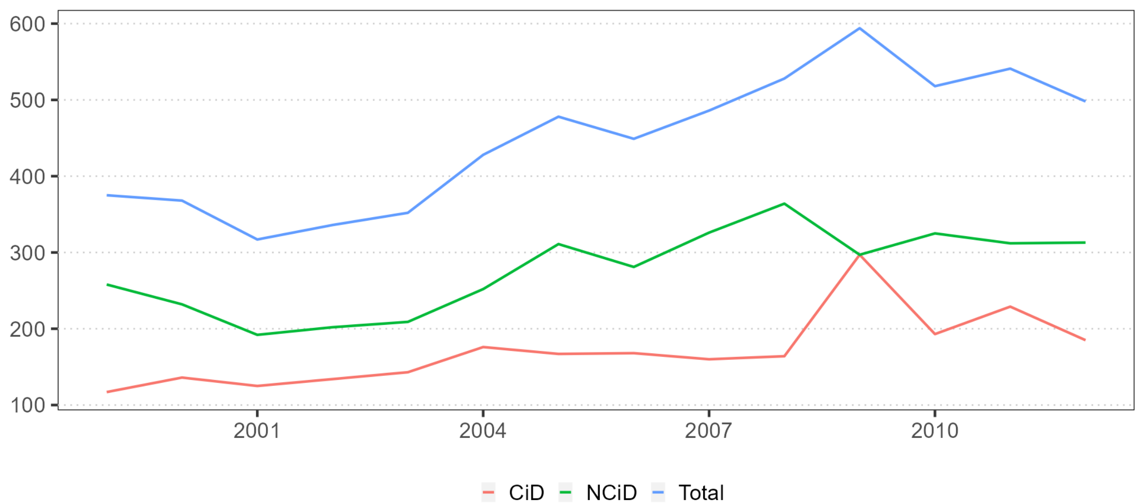

Figure 5.3: Annual reported disease outbreaks: 1999-2013

5.4.2 Independent Variables - Conflict

This chapter uses the UCDP Georeferenced Event Dataset (GED) (v. 21.1) (Pettersson, Högbladh, and Öberg 2019; Sundberg and Melander 2013) to identify both the spatial extent of conflict across countries as well as to record the overall intensity of fighting within these conflicts. The subnational chapter made use of ACLED (Raleigh et al. 2010) to identify similar patterns of violence across Sub-Saharan Africa and while ACLED does provide data for other regions of the globe, temporal coverage varies considerably across locations. In contrast, GED provides cross-national coverage over the full range of years considered in this chapter ensuring a more consistent measure of conflict across countries. Similar to ACLED, GED records violent events reporting precise latitude and longitude coordinates, the date, perpetrators, and number of fatalities associated with the event. These data are subset to retain events reporting instances of violence which occurred in the context of ongoing civil wars identified as countries that recorded at least 1000 battle related deaths within a country year.

Conflict Geography - The subnational chapter explored the consequences of conflict on disease by examining how local battlefield status shaped the potential for disease to spread in response to violence due to civilian population movements. At local levels this binary classification approach is appropriate as civilians in smaller subnational areas have more capacity to directly observe and to identify for themselves whether their home area falls into a contested conflict space or not. However, at a country-level a binary classification would prove too coarse of a measure as it collapses any reported conflict within a country to a "Battlefield" classification without preserving a measure of a conflict's overall spatial distribution across a country which is necessary to classify conflict types implied by the theory. Rather than battlefield classification status explaining disease incidence rates, here it is the overall extent of fighting across a country that should explain disease outbreak occurrence. Therefore, this chapter first measures the overall spatial extent of fighting within a country before using that information to classify conflicts into *diffuse* or *concentrated* conflict types.

Figure 5.4 illustrates the process of operationalizing conflict space at a country level. This example provides a snapshot of violence in Colombia in 2002, a period characterized by rising levels of violence between FARC insurgents and government forces which occurred over a wide geographic area within the country. Rather than considering conflict space along a binary battlefield / no battlefield dimension, here the conflict space is first measured in continuous terms as the area of a country identified as having the highest density of violent conflict events. Similar to the subnational chapter, this is achieved through kernel density estimation (KDE) to identify areas where most violence occurred.[15]

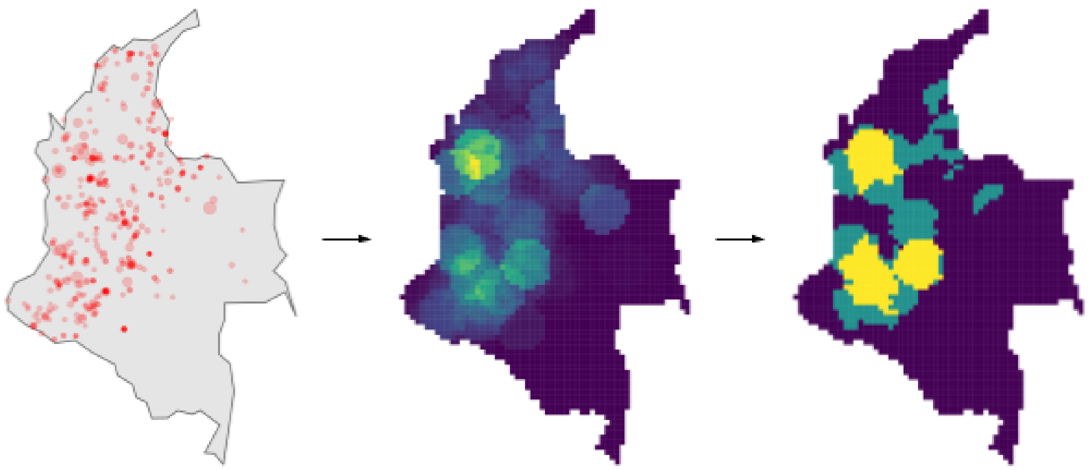

Figure 5.4: Operationalizing conflict geography at country levels

In Figure 5.4 separate violent events occurring within a country-year (left) serve as inputs for KDE estimation (middle) the results of which are used to classify conflict space (right). In contrast to the subnational chapter, here these spaces are summarized as the overall area within a country actively contested by belligerent forces. Since the size of countries with armed conflicts vary considerably, estimates are normalized as the percentage of a country experiencing armed conflict during a year to ensure equivalent comparison of conflict geography across small and large countries alike as well as to accurately classify conflict classes. In this example, 27% of Colombia in 2002 contained areas plausibly contested by government and insurgent

[15]For an extended discussion on employing spatial KDE techniques to identify conflict spaces see Appendix section A.2.3, especially related to the method used to aggregate country-level conflict measures.

forces.

Conflict Intensity - Here conflict intensity is measured as the total fatalities reported within a conflict year in a country. Similar to the geography measure, these values are also normalized to account for variation in the scale of conflicts relative to the population size within a country. This is achieved by measuring the total conflict fatalities per 100 thousand population within the country. Scaling the intensity of reported violence in this manner facilitates classifying the overall intensity of conflicts occurring in countries with both large and small overall populations. These normalized conflict intensity estimates range from lower levels of violence such as Nigeria in 2004 to more serious conflicts such as Nepal that same year.

Table 5.2: Descriptive statistics: Conflict classifications

	Mean	Min	Max	SD	N
Low intensity - Concentrated	0.016	0	1.000	0.125	2350
Low intensity - Diffuse	0.013	0	1.000	0.112	2350
High intensity - Concentrated	0.016	0	1.000	0.125	2350
High intensity - Diffuse	0.013	0	1.000	0.112	2350
No conflict	0.943	0	1.000	0.232	2350

Conflict Classes - The percent of land area within a country experiencing conflict (conflict geography) and the reported combat fatalities per 100k (conflict intensity) are used to identify four distinct categories of conflict: Low and High Intensity wars fought over Concentrated or Diffuse geographic areas. These two variables yield four combinations of conflict corresponding to the conditions presented previously in Figure 5.1. Since the geography and intensity measures have been normalized to account for differences in the spatial extent of conflict across countries of with different areas and populations, median values of the calculated geography and intensity measures serve as ideal cut points to distinguish between low and high intensity conflict and between concentrated and diffuse geography. Using these cutoffs four conflict classes are identified: low intensity-concentrated, low intensity-diffuse, high intensity-concentrated, and high intensity-diffuse. For example, with over one-quarter of the country in regions experiencing armed conflict and reported fatalities of approximately 7 per 100k placing it at the 68th percentile of observed combat fatalities in these data, the 2002 Colombia case was classified as a high-intensity and diffuse conflict.[16] Table 5.2 provides a breakdown on these four conflict categories while Figure 5.5 presents the conflict classification for countries with armed conflict reported in these data based on the median reported conflict geography and intensity over the years included in the analysis.

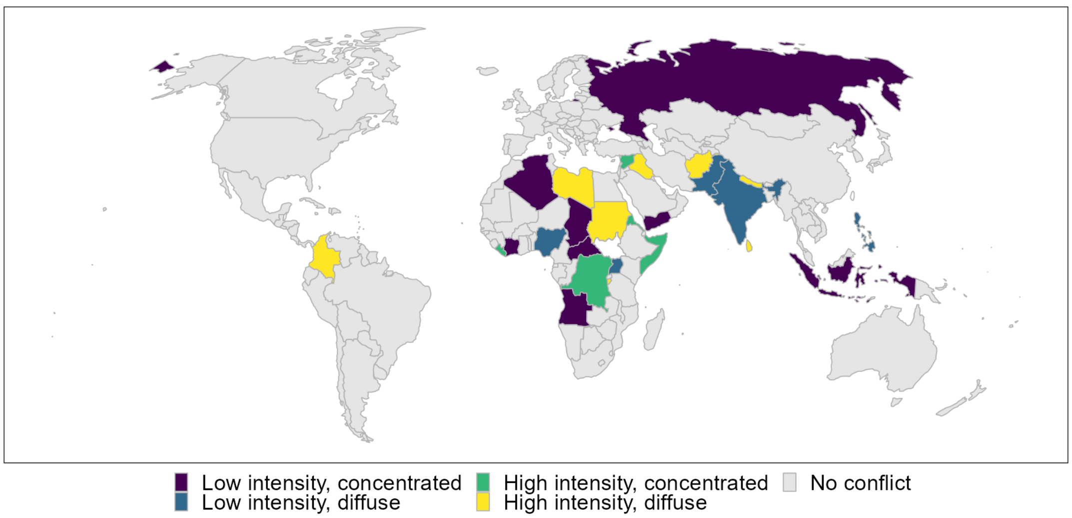

Figure 5.5: Conflict classes

Control variables - The analysis controls for a number of potential confounding factors including population density, phone access, and wealth (United Nations 2022), average life expectancy in years (World Bank Group 2022), government health care spending per capita (GBD 2021), and democracy (Coppedge et al. 2021).[17] Wealthier countries with better communications infrastructure and capacity have a higher probability of reporting disease outbreaks. While this may partly relate to increased

[16]This remained the case there from 2000 through to 2005 with the exception of a lull in fighting occurring in 2003 resulting in a "Low intensity-Diffuse" classification. In 2003 violence momentarily subsided as a result of counterinsurgency efforts undertaken by the new Colombian president, Alvaro Uribe. FARC subsequently regrouped and renewed fighting persisted until 2007.

[17]The appendix to this chapter provides descriptive statistics for all control variables.

trade and travel within these countries leading to a higher likelihood of outbreak, this is primarily an artifact of how GIDEON reports outbreaks - through medical or government reporting, and peer reviewed academic publications. Countries with limited telecommunications infrastructure may have limited capacity to report outbreaks and countries with more closed systems of government may suppress news of disease spread (Worsnop 2019). In order to account for this, the models control for democracy, gross domestic product per capita, and the interaction of democracy and wealth. Additionally, the models include a measure of per capita phone access to account for variation in telecommunications access which may account for variation in disease outbreak reporting potential.[18]

5.4.3 Method

In order to test the hypothesized relationship between disease outbreak and conflict class I fit a series of probit regression models with and without controls for CiD and NCiD outbreaks. All models include both time and region fixed effects (Beck, Katz, and Tucker 1998) to account for the increasing baseline probability of a disease outbreak occurring as indicated by Figure 5.3. Finally, all models employ panel corrected standard errors (Beck and Katz 1995).

5.5 Results

The results presented here provide evidence that the outbreak of contagious and non-contagious infectious disease vary significantly with conflict class. Table 5.3 presents the main results of models testing these relationships with models 1 and 2 evaluating predictors of CiD disease outbreak and models 3 and 4 evaluating predictors of NCiD disease outbreak. The conflict classification variables included in these models

[18] Smith et al. (2014) controlled for internet connectivity, but internet access was not as widespread globally in the early 2000s, so I instead opt for phone access here.

indicate that both H1 (Expansive) and H2 (Hotspot) conflicts find clear support here while H3 (Simmering) and H4 (Localized) find mixed support.

High intensity conflicts differ in how they contribute to the onset of CiD and NCiD based on the geographic extent of fighting: whether concentrated or diffuse. **High intensity-diffuse**, or expansive civil wars create a high number of fatalities over a wide area which H1 suggests will increase the probability of CiD disease outbreak since, in these contexts, civilians will favor escaping violence by shuffling around a country or fleeing greater distances. The estimated coefficient for this class of conflict is both positive and significant with (Model 1) and without (Model 2) controls indicating that these civil wars have a higher relative probability of experiencing a CiD disease outbreak. However, as anticipated, high intensity-diffuse conflicts do not appear to predict the onset of NCiD disease outbreaks which are more likely when people shelter in one location such as would be the case in a high intensity-concentrated conflict. This provides support for H1.

In **high intensity-concentrated** conflicts, or hotspot civil wars the asymmetrically superior force can surround and cutoff their adversary which H2 suggests would force inhabitants of the impacted conflict space to shelter and remain largely stationary thereby increasing their odds of exposure to pathogens that contribute to the onset of non-contagious infectious disease. Models 3 and 4 provide support for H2 indicating that these hotspot conflicts characterized by high intensity fighting within a concentrated geographic space have a higher overall probability of NCiD outbreaks; the coefficient is significant with and without controls and the sign is in the anticipated direction. When civilians shelter in these conflicts they decrease their exposure to other individuals thereby lowering their chances of contracting a contagious infectious disease. This is supported by the results as this class of conflict does not appear to explain the onset of CiD outbreaks. Taken together, these findings provide support for H2.

Table 5.3: Probit Models

	CiD		NCiD	
	(1)	(2)	(3)	(4)
Low intensity-concentrated	1.010***	1.063***	1.045***	1.129***
	(0.247)	(0.253)	(0.316)	(0.327)
Low intensity-diffuse	1.291***	1.326***	0.875***	0.930***
	(0.377)	(0.387)	(0.263)	(0.282)
High intensity-concentrated	−0.004	−0.027	0.815***	0.791***
	(0.212)	(0.213)	(0.214)	(0.231)
High intensity-diffuse	0.539*	0.619*	0.281	0.294
	(0.255)	(0.266)	(0.278)	(0.302)
Democracy		−0.029**		−0.027***
		(0.010)		(0.006)
GDP (log)		0.086		−0.127**
		(0.051)		(0.049)
Democracy x GDP		0.004***		0.004***
		(0.001)		(0.001)
Pop density (log)		−0.042*		−0.038*
		(0.019)		(0.016)
Phone access (log)		0.117**		0.274***
		(0.040)		(0.076)
Life expectancy (yrs)		0.005		−0.008
		(0.009)		(0.007)
Govt. health (PC, log)		−0.159***		−0.059*
		(0.035)		(0.028)
Intercept	4.956***	3.349***	5.109***	5.785***
	(0.030)	(0.792)	(0.022)	(0.581)
Fixed Effects - Region	Yes	Yes	Yes	Yes
Fixed Effects - Year	Yes	Yes	Yes	Yes
N	2350	2350	2350	2350
LogLik	−1366.323	−1303.380	−1489.557	−1449.144
AIC	2780.647	2668.760	3027.114	2960.289

Panel corrected standard errors in parantheses. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Turning to low-intensity conflicts, the results indicate that both CiD and NCiD outbreaks have a higher probability regardless of conflict geography. This provides mixed support for H3 and H4. Hypothesis 3 anticipated a higher probability of NCiD in diffuse conflicts where the widespread by relatively low intensity of fighting would encourage people to shelter while H4 expected an increased probability of CiD outbreaks in localized civil wars where localized, yet lower intensity violence would encourage civilians to shuffle into other regions of the country in search of safety thereby increasing their exposure to others and, in turn, the probability of a CiD disease outbreak.

These results indicate that conflict class substantively explains variation in the onset of a disease outbreak. Figure 5.6 presents the average marginal effect across the various conflict classes on the probability of CiD and NCiD outbreak.[19] In high intensity-diffuse conflicts, the probability of a CiD outbreak increases by 20.7% [3.1, 38.2] while in high intensity-concentrated conflicts, the probability of NCiD outbreaks increase by 26.9% [13.3, 40.6]. Low intensity conflicts all have a higher probability of disease outbreak with no discernible difference between conflict geography or between CiD and NCiD disease types. These represent substantively meaningful shifts in the probability of a disease outbreak occurring. For comparison, these models indicate that a shift from the 3rd to the 1st quartile of government per capita health spending (a shift from spending approximately $470 down to $16 per person) would increase CiD disease outbreak by 16.8%[9.4, 24.3] and the probability of NCiD disease outbreak by 7.02%[0.482, 13.6]. This indicates that, while government investment in public health represents a meaningful strategy for disease containment, so too does conflict prevention efforts.

The identical CiD and NCiD disease outbreak response in low intensity conflicts, regardless of conflict geography, may result from these lower intensity wars providing more flexibility for the average strategic responses that civilians pursue in response to violence (Adhikari 2012). At lower levels of violence civilians might be more likely to pursue multiple strategies with some remaining behind while others flee depending on personal circumstance and risk tolerance. Greater flexibility of civilian strategic response would then lead to increased probability of both disease types regardless of

[19]The appendix to this chapter presents these values in table format.

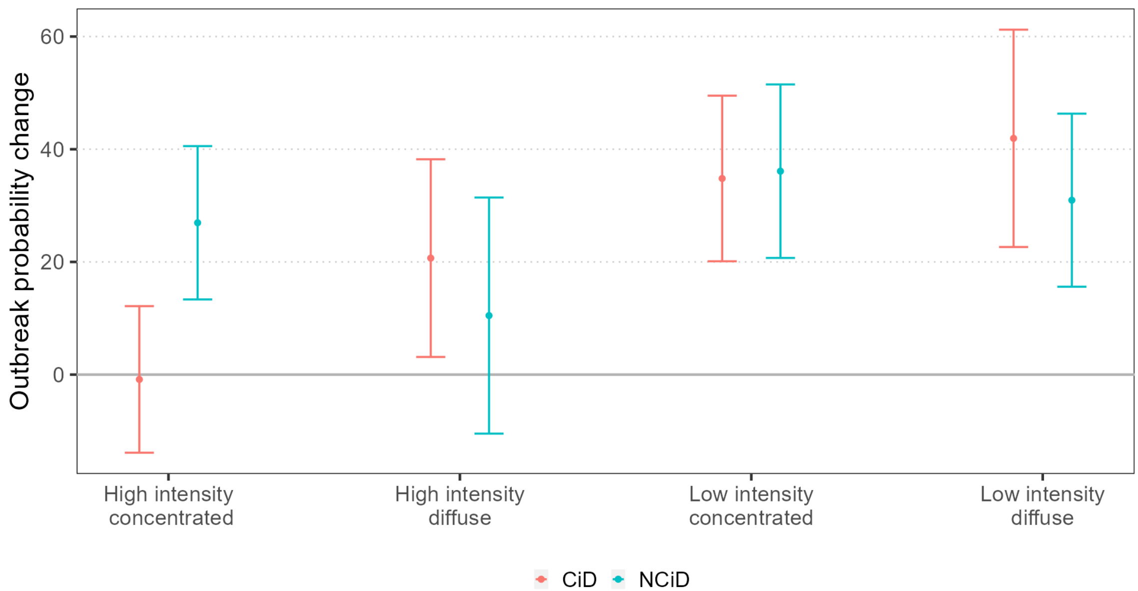

Figure 5.6: Average marginal effects of conflict class on disease outbreak

conflict geography.

Disease outbreaks analyzed in these data inflicted extensive human suffering on people in almost every country around the world. This human suffering is compounded for those residing in countries with an ongoing armed conflict who must deal with the additional burden of disease attributable to the conditions these wars create. Understanding these connections represents a valuable first step towards addressing the disease burden that civilians face in war zones.

5.6 Conclusion

This chapter has demonstrated that different classes of internal armed conflict have varied probabilities for the onset of two broad categories of infectious disease: contagious and non-contagious. These conflict classes vary according to the intensity of observed fighting as well as the overall geographic extent of that fighting resulting in four categories of violence: expansive (high intensity-diffuse), hotspot (high intensity-concentrated), simmering (low intensity-diffuse), and localized (low intensity-concentrated) conflicts. The patterns of violence which emerge across these conflicts create different incentive structures for civilians pursuing strategies to avoid violence as well as create differing degrees of infrastructure damage within a country. These intermediary, conflict-induced factors generate different possibilities for the spread of disease and for outbreaks to occur. Empirical results using a cross-national panel of countries demonstrated the heterogeneous effect of conflict classes on different disease outcome probabilities as well as indicated that these effects are substantively meaningful when compared to factors such as healthcare spending which also helps to account for disease outbreak onset.

Conflict has profound implications for global health. The COVID-19 pandemic has demonstrated the potential for novel disease to bypass national borders and, even when politically motivated trade and travel barriers are imposed (Worsnop 2017), containment represents a formidable challenge. Early identification of disease transmission through epidemiological intelligence collection represents a path forward to contain the spread of disease and limit its impact before the onset of an outbreak. As this chapter has demonstrated, disease reporting data too often suffer from underreporting bias that suggest wealthy, more open (democratic) societies suffer from a higher probability of disease while more closed (autocratic) and lower income nations appear comparably less prone to this risk. The evidence from this chapter clearly demonstrate that countries suffering breakdowns such as a result of armed conflict do have a higher risk of disease outbreak. Therefore, early identification and reporting of disease transmission within these locations represents a viable path forward to improve global health outcomes.

Investment in global health has traditionally suffered not from a lack of resources, but from resource coordination. Too often funds intended to address critical global health challenges such as freshwater access or disease treatment in war zones fail to reach those in need leaving the most vulnerable populations to deal with the indirect consequences of conflict alone (Wise 2017). Investment in local community-based health infrastructure (Garrett 2007) may help to bolster identification and treatment of infectious disease before widespread transmission events occur that lead to outbreaks, but theoretical and conceptual models provide a first step towards predicting where outbreaks of specific types of disease are more or less likely to emerge as a result of conflict.

Several findings presented in this chapter indicate possible paths for future research that could improve our understanding of the relationship between disease outbreak and classes of armed conflict. Space, conflict, and disease share an important and complex relationship. While this chapter has investigated how the diffusion of conflict contributes to the onset of disease outbreaks, it has left unexplored how the disease outbreaks in a country experiencing armed conflict might contribute to the onset of disease outbreaks in neighboring countries, especially when these neighbors represent likely destinations for refugees fleeing across international borders. Recent advancements in computation and empirical modeling have provided tools necessary to test these complex interdependent relationships for the types of data structures used in this chapter (Franzese, Hays, and Cook 2016). Therefore theorizing how civilian responses to violence aggregate to change the probability of disease outbreaks in neighboring or nearby countries represent a viable future research path.

Additionally, an important element of the disease-conflict relationship left unexplored here concerns the timing of these disease outbreaks relative to changing conflict conditions across the various conflict classes. The findings presented in this chapter indicate that the potential for different categories of disease to spread varies across conflict class, but the timing of these outbreaks may also significantly differ across these conflicts. Understanding when these conflicts may contribute to widespread disease transmission that leads to outbreaks could provide critical information for resource staging and targeted humanitarian response that seek to contain and control the spread of disease in area inflicted or proximate to ongoing armed conflicts.

This chapter explored the complex relationship between the onset of a disease outbreak and armed conflict and demonstrated how this relationship varies between diseases based on transmission mechanisms and along dimensions of conflict related to geography and intensity of fighting. Significant work remains to improve our understanding of the relationship between the spread of disease and war. The most recent (i.e., not final) pandemic underscores the potential for local to global disease diffusion emphasizing the need for us to improve our understanding of the spread of disease from multiple perspectives, including its relationship to armed violence and conflict.

Chapter 6

Conclusion

The COVID-19 pandemic clearly illustrated the risks of novel infectious disease and its potential for rapid global transmission. The pandemic also demonstrated the quick local to global trajectory that novel infectious pathogens can take over a relatively short period of time. This potential and trajectory underscores the need to both identify environments conducive to the emergence of novel infectious pathogens and to control their spread. This dissertation thus offers a timely intervention in the space of infectious disease research by explaining why different types of infectious disease spreads in different types of wars. In the preceding chapters I have demonstrated the consequences of violence in armed conflict on unique infectious disease outcomes - individual infection, subnational spread, and cross-national outbreaks. But I have also elaborated on precisely *why* we should anticipate observing these effects - conflict induced civilian displacement. The theoretical scaffolding provided by this research maps armed conflict to infectious disease and refines our capacity to anticipate and predict the spread of infection as we observe conflicts begin and unfold. The findings presented in this dissertation reveal the clear consequences of war on the spread of infectious disease as well as provide a foundation for a number of important new research projects that can both expand the primary findings presented here but also extend into related domains such as the intersection of gender, disease, and war, climate change, and conflict prediction.

6.1 Review

The primary theoretical contribution of this dissertation is an explanation for the emergence of *contagious* or *noncontagious* infectious diseases in war zones. Infectious diseases refer to the class of human ailments which involve an individual contracting a disease-causing pathogen (bacteria, virus, etc. . .) from another organism (directly through water, or from a carrier such as an animal or insect) or person. The patterns of violence in armed conflicts weigh on civilians who worry about their safety and the safety of their family and neighbors. The concerns civilians feel and fear of harm due to active fighting in a war zone compel them to respond to the violence they see by pursuing strategies to improve their safety - sheltering, shuffling, or fleeing. The choices that civilians make depend on the *intensity* of violence that they observe and the geography of that violence - how violent events (such as battles or small skirmishes) are distributed across a local region or country. By *jointly* observing the intensity and geography of violence civilians can make informed and rational choices to minimize the chances they will experience harm by pursuing one of these aforementioned strategies. Beyond impacting their security, this choice determines which types of pathogens civilians are more or less likely to encounter as they navigate war zones - pathogens responsible for contagious disease or those more likely to result in noncontagious infections. Conflict induces strategic civilian displacement that results in predictable infectious disease outcomes.

I tested this theory by employing a levels of analysis approach that examined the consequences of violence at individual, subnational, and cross-national levels. This nested analysis approach both clarified the causal pathway from conflict characteristics to individual strategic choices to disease outcomes and facilitated the analysis of three distinct outcomes: individual exposure to disease causing pathogens, subnational disease spread, and cross-national onset of disease outbreaks. The microfoundations established through interviews with conflict refugees strongly suggested how individuals responding to violence considered both the intensity and geographic distribution of violence jointly when formulating strategic responses. These responses exposed them to different types of infectious disease causing pathogens as evidence by the diseases interviewees observed and described. At subnational levels this individual exposure was shown to aggregate and contribute to the spread of infectious diseases across regions as evidenced by different incidence rates of contagious and noncontagious infectious disease in conflict zones. Finally, at the cross-national level I demonstrated how different types of armed conflict that vary in their intensity and geographic scope of violence have different probabilities of contagious or noncontagious disease outbreaks occurring. These results underscore conventional knowledge that conflict leads to disease while adding a new perspective that explains why the violence in armed conflict leads to distinct infectious disease outcomes. This new perspective also suggests a number of new research paths to both expand the main findings presented in this dissertation as well as extend them into related domains.

6.2 Future research: Three inter-connected bins

This dissertation suggests a number of trajectories for new research which I group into three categories. The first category consists of avenues to expand the primary findings such as by exploring relationships between civilians demographic characteristics, violence-avoidance strategies, and infectious disease risk. The additional two categories consist of avenues to build upon the research here by extending into new contexts related to climate change and armed conflict prediction. I consider each of these three categories below first discussing avenues to expand this research, and then extending this research into the domains of climate change and conflict prediction.

6.2.1 Expanding this research

Interviews conducted for Chapter 3 suggested a number of important new research avenues. When responding to open-ended questions, interviewees highlighted new elements to the conflict-disease relationship that deserve a more critical exploration including: the role of rumors on battlefields, gender, and provision of health care by aid organizations. Most refugees interviewed suggested they stayed informed of violence elsewhere primarily through word of mouth and news shared by local neighbors, but also from new faces such as displaced civilians from elsewhere. These stories motivated civilian action encouraging some to preemptively flee from their home as they predicted imminent violence. However, distrust also underpinned these exchanges. Frequently, interviewees indicated they did not know who to trust while in areas with armed conflict, especially when incidence of violence involved insurgents who targeted civilians. For example, when discussing the provision of aid to displaced civilians from nearby villages one interviewee remarked that "we had been hearing stories of [insurgent] spies. But we couldn't verify anything so we just rendered help... but I think those guys had spies in the towns or villages" [R8]. Social distrust can have a number of implications relevant to the spread of disease; for example, consider how distrust of experts exacerbated vaccine update during the COVID-19 pandemic. Misgivings about the veracity of information shared by displaced civilians may alter the strategies that some civilians pursue in response to news of violence. It may also reduce the willingness of some communities to provide medical support to civilians displaced by violence for fear of supporting insurgent forces.[1] Interviews with victims of violence

[1] Distrust attributable to rumors of insurgent spies could also create conditions where civilians in need of medical aid do not seek out assistance from medical workers whom they do not know.

in armed conflicts that focus on the role of trust and solicitation of health support would help to further unpack these relationships.

Civilian demographic characteristics such as gender or age also warrant deeper attention in the future. Past research has demonstrated that women, parents, and those caring for elderly all approach travel out of conflict spaces in distinct ways and often prefer shorter distance travel (Bohra-Mishra and Massey 2011). However, distance itself likely serves as a proxy for lived experiences and perspectives such as individual perceptions for safety and risks associated with traveling further distances or into areas where an individual feels less familiarity with a place. For example, systemic wartime sexual violence (Cohen, Hoover Green, and Wood 2013) likely creates gender-based shifts to the choices of preferred destination and mode of travel when escaping violence. Past work has already demonstrated that troop movement patterns in international wars help to explain changes in the prevalence of HIV in international armed conflicts (Iqbal and Zorn 2010). For example, in Ukraine a surge in demand for emergency contraceptives in the country's east has left many humanitarian organizations scrambling to deliver medical supplies to those areas in the midst of armed combat (Strzyżyńska and Koshiw 2022). These patterns of wartime sexual violence and related spread of sexual infectious disease in war zones certainly extends to internal armed conflict as well but has not yet been examined with data at subnational local levels where observable implications of these relationships likely emerge with greater clarity. Exploring how patterns of violence in armed conflict explain incidence of sexually transmitted infections could offer new ways to stage resource in advance of conflict regions most susceptible to wartime sexual violence. For example,

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If these civilians required treatment of an infectious disease, medical avoidance would exacerbate the spread of infections in war zones where mistrust permeates conflict spaces due to insurgent targeting of civilians. In another working paper I have explored how legacies of violence stemming from civilian targeting in West African civil wars exacerbated the spread of Ebola in that region during 2014-2016. I attributed this response to distrust between civilians and outside authorities like health care workers that stemmed from civilian targeting and victimization during conflicts years prior.

past research indicates that insurgent groups with weaker commander control over troops that lead to higher prevalence of wartime rape (Hoover Green 2016). The presence of insurgent groups that demonstrate these characteristics could also serve as a leading indicator of armed conflicts with higher prevalence of wartime sexual infections, but such relationships have not yet been examined. Humanitarian staging and preparation for aid delivery also warrants more work; as the previous Ukraine example suggests aid organizations often struggle to predict areas likely to suffer from violence which results in suboptimal staging of health resources that can undermine efforts to treat infections in conflict zones.

In the ongoing Ukraine conflict, humanitarian aid organizations did not account for Russia's invasion into Ukraine from the north and thus opted instead to focus on staging medical supplies in Ukraine's eastern regions. According to leaders with aid organizations operating in that conflict, this choice largely left residents of the Kyiv area without a stable supply of medical resources as they dealt with advancing Russian troops (Morris and Diamond 2022). This dissertation did not address how health aid workers intervene in conflict zones and work to contain the spread of infectious disease. This represents an important dimension to the relationship - certain features of violence contribute to infections spreading, but different health intervention policies may produce better or worse disease containment outcomes in these spaces. Interviewing stakeholders and policy administrators at organizations that both monitor and provide health care in conflict zones, such as at the World Health Organization (WHO) or other non-governmental organizations can therefore help to build on the initial findings present in this dissertation and to begin investigating health interventions in conflict zones that emphasize disease containment.

Humanitarian aid workers in conflict spaces often also experience targeted violence by belligerent forces (Narang and J. A. Stanton 2017) and this frequently extends to health workers attempting to treat infectious diseases. For example, during the 2019 Ebola outbreak in Democratic Republic of Congo, health workers were regularly targeted while trying to treat patients infected with that disease and contain its spread (AP News 2019; AFP News 2019). Unfortunately, this led some organizations such as the WHO to withdraw their personnel from that area which no doubt undermined efforts to contain that disease and lead to more infections (Branswell 2019). Conflicts which exhibit violence against aid workers in general, but especially against health workers most likely will suffer from more widespread transmission of infectious disease owing to civilians in these conflicts lacking access to medical care. Indeed, most of the conflict refugees interviewed in Chapter 3 indicated they had difficulty accessing health care due to the violence they saw and experienced. Data collected on health worker attacks (Raleigh et al. 2010) alongside precise local data on clinically reported infectious disease admissions such as from WHO's Early Warning, Alert and Response System offers new opportunities to explore how targeted health aid worker violence may help to explain local patterns of disease transmission among communities in conflict zones.

As suggested a few times in the preceding chapters, infectious disease and violence in armed conflict may exhibit an endogenous relationship (Koehnlein and Koren 2022; Lucero-Prisno et al. 2020; Bagozzi 2016). For example, in two recent papers discussing COVID-19 and violence, one study suggested that escalating patterns of violence in armed conflicts exacerbated the spread of COVID-19 due to conflict induced displacement (Lucero-Prisno et al. 2020) while another study found that the spread of COVID-19 corresponded to higher levels of pro-government nonstate actors filling security voids left by states responding to the pandemic (Koehnlein and Koren 2022). These recent findings complement existing work that suggests disease leads to more protracted conflicts (Bagozzi 2016). These results suggest a vicious cycle in the relationship between violence and infection in war zones that has neither been sufficiently theorized nor explored.

These ideas represent ways to expand the initial research presented in this dissertation. In addition to these additional opportunities exist to explore connections between infectious disease, climate change, and conflict as well as to investigate conflict prediction as a tool for advanced disease forecasting in conflict zones.

6.2.2 Extending this research

Beyond expanding this research by investigating the disease-conflict relationship in more detail as suggested in the preceding section, this dissertation also suggests two additional research avenues to extend the main findings by exploring climate change and conflict prediction.

6.2.2.1 Climate, conflict, and disease spread

We know that extreme weather events such as droughts or flooding that will grow more common in the decades ahead can lead to resource stress that invites local conflict (Hendrix and Salehyan 2012). Initial estimates suggest that by 2050 a significant portion of all internal and cross-border migration will result from unfavorable climatic conditions (Kaczan and Orgill-Meyer 2020). This suggests two possible research trajectories: first the role of climatic stressors to act in a manner similar to conflict to compel civilian population displacement; and second conflict induced displacement within the context of a changing climate.

A recent review of evidence on climate induced displacement suggest that migration tendencies cut across socio-economic divisions with poor and wealthy households alike relocating in response to changing local climate conditions (Kaczan and Orgill-Meyer 2020). Furthermore, unlike displaced responding to conflict, these refugees tend to favor more distant locations in their choice of destination and often relocate to cities. This pattern of resettlement creates greater separation between the refugee and the source of the climate disturbance while also minimizing potential economic costs such as unemployment. These strategic migration responses to changing climate conditions also appear to follow slowly degrading patterns of change such as due to consistent seasonal drought. The scale of predicted migration as well as the strategic nature of relocation strongly suggest the potential for infectious disease to follow these patterns of civilian population movement. Contagious disease potential will likely increase significantly as city population densities increase after absorbing these refugee inflows and the potential for noncontagious infectious pathogenic exposure will also change as wildlife and insect populations also respond to changing climate conditions. Unpacking these responses within the context of proposed policy solutions - such as the creation of safe migration routes as proposed in United Nations development goals - can help us to better understand the potential trajectory of global infectious disease spread going forward. The first climate refugees have already resettled in a global trend that will continue.

In addition to these direct effects, climate change can also influence the spread of infectious disease directly within conflict spaces. Changing climates and the seasons when violence most commonly occurs determine the conditions that civilians face while fleeing from violence. For example, insurgent attacks that occur during wet or dry seasons - which continue to shift and grow more pronounced in their precipitation patterns - determine the resources and conditions available to displaced populations. For example, variability in precipitation patterns determine the availability of dry wood that civilians may use as a fuel source to prepare meals and sterilize water after escaping violence during an attack. However, as places like Nigeria grow wetter over the next century this will place a greater burden on fleeing refugees navigating damp climates which offer few resources. In fact, these environments may contribute to increased infectious disease prevalence by providing new habitats for disease-causing vectors such as mosquitoes to inhabit. Predicting which areas will experience these changes as well as which areas will most likely continue to suffer the consequences of violence may help to explain patterns of infectious disease attributable to climate change in conflict zones.

6.2.2.2 Conflict prediction and forecasting

Conflict prediction presents a number of opportunities to refine our understanding of conflict processes and, building on the insights of this dissertation, also begin to anticipate future infectious disease responses in conflict zones. While a great deal of conflict research focuses on explaining the causal determinants of armed conflict, far fewer projects emphasize conflict prediction that can explain when and where violence will most likely take place. In fact, of the many possible explanations for armed conflict identified in the literature, only a small handful of the variables identified as causal contributors to the onset of conflict have any capacity to explain the actual occurrence of armed conflict in the future (Ward, Greenhill, and Bakke 2010). This finding stems from an over emphasis in research on the identification of statistical significance at the expense of identifying where and when violence might occur. This underscores the importance of including prediction in our theoretical explanations (Schrodt 2014). The findings presented in this dissertation also suffer from this limitation and could benefit from an extension which, for example, evaluates the validity of in-sample disease incidence predictions across subnational Africa estimated using observed conflict intensity and geography. Prediction can provide a more concrete and valuable guide for policy.

Lack of emphasis on conflict prediction represents an unfortunate research omission, particularly with increasingly precise data available from machine-coded news resources which can identify the location and timing of violent events with comparable accuracy to more limited human coders (Stundal et al. 2021). Scholars have increasingly paid attention to the role of fighting seasons on incidence of violence in their research (e.,g Lyall (2019)). This seasonal variability in conflict suggest new opportunities to interface new "big-data" conflict resources to predict future local incidence of violence into the near future with moderate degrees of precision. Evaluating locally precise conflict predictions over shorter time horizons can aid in our understanding of conflict dynamics, but such efforts could also help to improve analysis of the relationship between infectious disease and conflict.

This dissertation made use of subnational measures of intensity and geography of violence in armed conflicts to explain infectious disease. By predicting local variation of violence in the future we may be able to better anticipate civilian displacement results and associated infectious disease risks. An enterprise of this nature would have immediately apparent policy applications, especially for humanitarian aid practitioners interested in identifying locations most likely to experience violence in order to properly deploy resources to locations in need. Too often a major limitation of humanitarian assistance concerns a mismatch in the location of aid and the location of individuals in need. For example, as suggested in the preceding section, the geographic incidence of violence in the Ukraine conflict left some aid organizations unprepared to deliver aid to locations with the highest concentrations of individuals negatively impacted by armed violence. Building on the theoretical insights of this dissertation, it should be possible to utilize the information about conflict available today to predict the future burden of disease with a higher level of precision.

By forecasting disease spread by using new big data resources that automate coding of ongoing armed conflict from international newswire reports, we may be able to more effectively predict the types of infectious disease likely to emerge across across conflict locations. Such efforts may also facilitate the advanced staging of medical resources in locations with predicted violence onset to treat civilians in need.

6.3 Broader implications - The national security of infectious disease

Infectious disease represents a concern and threat in international relations as demonstrated by this dissertation, but also as indicated by the funding priorities of the US military. The Department of Defense (DoD) prioritizes infectious disease containment by allocating strategic resources and making financial contributions from its operating budget to achieving that task. In fact, based on data from USAID, over 75% of US DoD funded health-related projects support efforts to reduce the spread of either HIV or other novel diseases such as anti-bacterial resistant tuberculosis or malaria in endemic regions of the world with a US military presence (Foreign Assistance Data and Reporting Team (FA-DART) 2022). This financial and material support underscores the awareness that US military leaders have regarding the security implications of regional or global disease spread and that US leadership recognizes the spread of infectious disease as a key US national security strategic priority.

Beyond its capacity to undermine military tactical effectiveness - especially in situations where troops deploy to regions with disease causing pathogens against which they lack immunity - infectious disease diffusion also generates significant negative downstream political consequences for society. For example, the spread of disease can destabilize social systems and upend public health budgets compromising the ability of governments to devote resources to other problems, such as those of concern to the US government like counter-terrorism programs. These negative effects of disease diffusion weaken key allies by inhibiting their ability to respond effectively in other policy areas and thereby impair US foreign policy interests.

As argued and demonstrated in this dissertation, armed conflict serves as a reservoir for infectious disease by encouraging predictable patterns of civilian displacement in response to violence. Understanding the conflict-disease connection represents a first step towards more effective disease containment in war zones. Ultimately, since the spread of disease does not obey international borders, conflict induced disease transmission represents an issue with international implications worthy of concern. The local transmission of infectious pathogens anywhere represents a threat to global security everywhere.

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Appendix A

Appendix

A.1 Appendix to Chapter 3

A.1.1 Interview guide

A.1.1.1 Conflict background:

- Can you describe when you first became aware of fighting between [CONFLICT PARTY A] and [CONFLICT PARTY B]?
- How did you stay informed about this conflict? What sources of information did you rely upon?
- Before you left your home did you observe any fighting first-hand?
  - (If no) - Were you aware of any fighting nearby or did you see any signs of the war in [HOMETOWN].
  - (If yes) - Can you describe your the fighting that you witnessed? How did this made you feel about your safety in [HOMETOWN]?
- What elements of the conflict most concerned you with respect to your [or your family's] personal safety?

A.1.1.2 Decision to leave hometown

- Can you describe your experiences in [HOMETOWN] between the time when you first became aware of the conflict up until the point just before you left? What did a typical day look like for you? During this time what changes did you observe in [HOMETOWN]?
- Thinking back to the days prior to your decision to leave, what factors stand out as being particularly influential to your decision to leave? Were there any specific events, people, or conversations you had which contributed to your choice to leave [HOMETOWN]?
- When you set out, did you have a specific destination in mind and, if so, why did you choose this destination? Were there features of this place that drew

you there?

A.1.1.3 Experience traveling away from hometown

- Can you please describe your trip from [HOMETOWN] to [DESTINATION]?
  - How long did that journey take you?
  - How did you travel?
  - Did you travel alone or with others?
  - Did you observe any armed conflict on this trip?
  - Did any events in particular cause you concern or make the trip more difficult than you feel it otherwise might have been?
- If DESTINATION was within interview participant's home country:
  - Can you describe living conditions in [DESTINATION 1]? Where did you stay? Relative to your home, how did your living situation in [DESTINATION 1] compare in terms of living facilities?
  - Eventually you decided to leave [DESTINATION 1] as well. Thinking back to the days leading up to your decision to leave, what factors stand out as most strongly influencing your choice to leave [DESTINATION 1]?
  - Did you travel to any other locations within your home country before fleeing to another country?
- Relative to other locations within your home country, what factors contributed to your decision to flee to [DESTINATION]?
- Can you describe the support you received once you did cross into [DESTINATION]? For example, did you receive any assistance from humanitarian organizations or the [DESTINATION] government when you arrived? Where did you stay? How did the living conditions compare to your home?
- During your time abroad as a refugee but before immigrating to the United States, were there any particular difficulties in terms of living conditions that you faced which you feel made daily life more difficult?

A.1.1.4 Interviewee observations regarding health

- Returning to your time in [HOMETOWN], how would you describe your access to medical care?
- *Sheltering* - Did you observe anyone experiencing health-related difficulties during the period of time after you became aware of the conflict, but before you left [HOMETOWN]?
  - Can you describe these challenges, for example, what types of illnesses did these individuals have?

- *Shuffling* - Thinking about your time traveling to [DESTINATION], how did your health experiences change? Did you observe different health-related issues which were not present in [HOMETOWN]?

- *Fleeing* - How did your experiences with health change as you settled away from your hometown? How did these conditions change after you arrived in [DESTINATION]?
- *Disease* - During the various stages of your travels from [HOMETOWN] to [DESTINATION] do you recall disease posing a problem for you or for the people living or traveling with you? Can you describe these challenges and the nature of the disease that you can remember?

A.1.1.5 Open ended response

- Are there any other stories or experiences you would like to share about your time escaping the conflict in [COUNTRY] which you feel are important, but you have not yet had an opportunity to share?

A.1.2 Discussion on Facebook recruitment strategy

For the year ending 2021 Facebook reported 2.91 billion Monthly Active Users - the number of unique users who engage with the platform at least once per month; approximately 190 million of these users live or reside within the United States (Meta Platforms, Inc 2021). This degree of engagement has increasingly led scholars to employ the platform a research tool, particularly for sample recruitment purposes (Neundorf and Öztürk 2021). For example, Grow et al. (2020) explored using targeted advertisement campaigns on Facebook to gather information during public health emergencies in order to acquire information to inform policy responses. The large user base coupled with the sizable number of daily users make the platform an ideal choice to rapidly recruit individual into a research project. The following section provides additional details on the methods employed to recruit conflict refugees from Facebook to participate in interviews for Chapter 3.

A.1.2.1 Facebook recruitment advertisement

The following advertisement appeared for targeted users meeting demographic selection criteria who logged into the platform between March 2, 2022 and March 13, 2022. The choice of this advertisement was intended to strike a neutral response from users without conveying any sense of conflict through the image in order to mitigate any risks for retraumatization for users with backgrounds that include extensive exposure to violence.

Table A.1 provides a breakdown of engagement with this advertisement. In the 11 days it was fielded it reached over 6000 unique users and was viewed over 10000 time resulting in 126 clicks. Given the small target demographic - approximately 10000 refugees admitted into the the United States per year in recent years - this recruitment

Figure A.1: Ch 3 - Facebook advertisement

method facilitated ideal access to potential research participants from an otherwise hard to reach population (Baugh 2022).

Table A.1: Ch 3 - Facebook recruitment - Advertisement interaction

Impressions	Reach	Link Clicks	Interview enrollment	Final participants
10,353	6,382	126	50	15

Upon clicking the link, users were directed to an external *Qualtrics* recruitment survey which briefly explained the research project to interested users and asked them a series of questions to ensure their qualifications for the research project as well as to guarantee final recruitment of refugees from a variety of backgrounds.

A.1.3 Risks of interviewing refugees in locations proximate to conflict zones

Interviewing conflict displaced persons at humanitarian camps as is the typical research strategy poses a unique set of risks owing to the convergence of multiple professional groups (journalists, academics, aid workers, intelligence agents) operating at these sites (Parkinson 2022). Overlapping groups asking refugees similar questions in these settings can undermine the consent processes (such as by giving refugees the impression that their continued residence in those safe locations depends on their responding to questions). Additionally, interviews conducted in these settings can impair the validity of the research process due to refugee fatigue leading to response regurgitation where interviewees repeat answers that they believe interviewers want to hear, which will end the interview sooner, or which requires the least mental fatigue on interviewees who have responded to identical questions on multiple occasions. Therefore, interviewing refugees after they settle into a more permanent living situation affords prospective research participants greater autonomy to consent or decline to participate in research as well as improves research validity by interviewing refugees about conflict processes outside of contexts where they might have experienced similar repeated questions. Interviewing settled refugees in the United States as done in Chapter 3 achieves this. Furthermore, academic researchers often lack the training necessary to ensure their own safety or the safety of their interview participants in these settings (Lake and Parkinson 2017). Thus interviewing conflict displaced persons in settings removed from violence is a research strategy that prioritizes participant safety and personal integrity.

A.2 Appendix to Chapter 4

A.2.1 Incidence rates to measure the spread of disease

Epidemiology studies of disease employ a number of complimentary measures to operationalize aspects of the burden of disease in a population[1]. Three of the most commonly used measures of disease burden report the prevalence, incidence, and mortality rates of a disease. The disease *incidence rate* is the most empirically appropriate operationalization of disease burden for the theory proposed here. While conflict almost certainly increases the mortality of disease, the theory speaks to conflict's effect on the *spread* and not lethality of disease. This leaves either incidence or prevalence.

Incidence and prevalence capture similar underlying elements of disease burden, yet differ in important ways. The incidence rate reports the number of new disease cases among an at-risk population *in a given time window.* In contrast, prevalence reports *all* cases of disease - both new infections and preexisting cases alike. Fundamentally, this amounts to the prevalence rate reporting the number of individuals who *have* an underlying condition at a point in time compared with the incidence rate reporting the number of individuals who *develop* an underlying condition in a specified time window. Since the theory proposes that changes in conflict characteristics should produce changes in the underlying spread of disease, the incidence rate reflects the most appropriate epidemiological measure to study this relationship[2].

Disease prevalence, in contrast, measures the *treatment-capacity* of an area in addition to disease *spread* within an area. With greater capacity to treat those with a condition, a region's prevalence of disease will decrease. While conflict effects the prevalence of disease across locations by damaging health care infrastructure (Iqbal 2010), the proposed theory speaks to disease spread through population movements and not due to impaired treatment capacity.

[1]This discussion pulls from Centers for Disease Control and Prevention (2012)

[2]The prevalence rate is also more commonly employed to measure the burden of chronic disease in a region since disease of this type often have ambiguous onset dates for patients (e.g., heart disease) (Centers for Disease Control and Prevention 2012, p. 3-17).

A.2.2 Control variables - descriptive statistics

Table A.2: Ch 4 - Descriptive statistics: Controls

	Mean	Min	Max	SD	N
Wasting (%)	9.116	1.265	38.767	5.580	10026
Educ. (F, yrs)	4.659	0.059	12.902	2.614	10026
Terain Rough.·	3.470	-0.921	5.732	1.018	10026
MCV Coverage (%)	70.651	4.992	99.930	20.124	10026
Rainfall (mm)·	6.802	0.000	8.187	0.740	10026
Temperature (c)·	3.184	2.617	3.416	0.130	10026
Population density·	3.802	-1.414	9.671	1.687	10026
Area (Sq.km.)·	9.490	2.513	12.689	1.683	10026
Capital distance (km)·	5.433	-0.010	7.448	1.103	10026

· denotes logged variable

A.2.3 KDE Extended discussion

Spatial kernel density estimation (KDE) provides a non-parametric solution to identify the probability density of a spatially indexed random variable assumed to follow an unobserved latent density across space. Reported episodes of violence reported by international news agencies and catalogued in data repositories such as UCDP or ACLED therefore represent realizations of unobserved latent conflict processes to be estimated.

In spatial statistics this random variable (here reported violent events) is assumed to cluster across space and is appropriately indexed; for example, each observed value of the variable indexed by latitude and longitude. Density estimates vary based on the concentration or dispersion of these spatially explicit observed values. Areas with higher concentrations of points yield higher density estimates while areas with lower concentrations of observed points yield lower density estimates. These resulting density values therefore provide the means to identify hotspot locations where the random variable clusters across space. Stated differently, density estimates provide an ideal solution to identify areas with both reported and unreported violence within a region or country where violence has clustered and is present.

Computed density estimates may be weighted by attributes associated with each observed input observation. Weighting allows some events to exert more influence than other events on estimated density values. Here I leverage theory and weigh conflict event inputs by reported casualties for each event. The logic here is simple - from a civilian's perspective one violent event which generates several reported deaths matters much more for how they evaluate their personal security than would many reported events which produced no casualties. For example, several skirmishes between belligerents where gunfire was exchanged but no casualties produced should matter less to a civilian than a single battle which produced dozens of fatalities. By weighing observations according to reported event casualties, the resulting estimated areas of fighting across regions correspond to locations with the most violent armed conflict that would occur within a conflict space – or a conflict battlefield.

Latitude-longitude indexed violent event points are continuously distributed across space within a region or country. To translate these reported instances of violence into estimates of the spatial concentration of violence over a discrete area, density estimates are computed for grid-cells constructed within each country area. First, a raster grid-cell is constructed over a country using an input shapefile. Each input country is divided into grid-cells of 25km. The spatial precision of input data on violent event points reported by ACLED informed this choice of grid-cell dimension. ACLED identifies all reported events within a subnational area and most remaining events are connected to a specific town, location, or nearby geographic feature. No events reported in the ACLED data correspond to country-level units [ACLED Codebook v. 1.1, p. 29]. Therefore, the 25km grid-cell size accounts for the spatial resolution of the input point data without significantly compromising computation by using too fine a grid-cell resolution.[3]

Density estimates yield the highest values at the location of an observed data point but decay before reaching 0 at a pre-specified distance defined as the search bandwidth. Here in consideration of grid-cell sizes and the 100km border established around each input country shapefile to account for transnational insurgent group movements, I set the search bandwidth radius around each grid-cell at 50km. Since theory suggests little regarding the nature of decay associated with the influence of one violent event across space, I employ a uniform kernel to define the rate of influence decay. A uniform kernel imposes constant influence for each point on the resulting density estimates up to a defined distance cutoff bandwidth (again, 50km here) is reached after which the influence of a point on density estimation drops to 0. Since density estimates are computed for each grid-cell, distance here refers to the distance between each observed point and the centroid (x,y) of each grid-cell used in the estimation procedure. Observed violent events greater than the 50km bandwidth from a grid-cell centroid do not influence density estimates for that cell; all remaining points less than the cutoff bandwidth uniformly influence the density estimates but matter more or less based on input weights (reported event fatalities). Density estimates are then computed for each grid-cell centroid $\left[density_{(x,y)}\right]$ by evaluating all conflict event points as follows:

For all conflict events i where $[distance_i < (bandwidth = 50km)]$

$$Density_{(x,y)} = \frac{1}{50km^2} \sum_{i=1}^{n} \left[\frac{3}{\pi} * Deaths_i * \left(1 - \left(\frac{distance_i}{50km^2} \right)^2 \right) \right] \tag{A.1}$$

These grid-cell indexed density estimates are subsequently multiplied by the sum of the estimation weights – here reported event fatalities. This results in the value of the uniform spatial density integral employed in this analysis exceeding 1. Therefore, to classify a grid-cell as battlefield or non-battlefield (Chapter 4) or as various conflict types (Chapter 5), a discrete transformation is applied to these continuous density estimate values that identifies conflict spaces as those grid-cells with estimated density values 2 inter-quartile range units above the estimated median density value for all estimated grid-cells. After classifying grid-cells based on discrete conflict labels, resulting values are then applied regionally (Chapter 4) or at the country-level (Chapter 5).

A.2.4 Subnational classification:

Following the discrete classification of estimated continuous KDE values, spatial geometries are reconciled by spatially joining subnational identifier attributes to grid-

[3]Raster data scales by an exponential factor of 2. For example, doubling the resolution of a single 1km grid-cell - that is increasing the resolution from 1km to 0.5km - increases the number of cells from 1 to 4 (2^2). Therefore, at country-scales moving to grid-cell resolutions below 25km would create significant computational bottlenecks with little efficiency gains.

cells. The following decision-rule is then applied: if any grid-cell for a subnational region is discretely classified as conflict space, that subnational region is classified as a conflict space. Otherwise, the region is classified as a non-conflict space.

A.2.5 Country classification:

Conflict geography is computed as the percentage of a country classified as a conflict space at the grid-cell level. To compute this value, I estimate the percentage of grid-cells classified as a conflict space (per the preceding paragraphs) relative to all grid-cells within a country.

A.2.6 Fixed effects (non-spatial) models - without controls

Table A.3: Ch 4 - Fixed Effects Models - no controls

	Incidence Rate	
	LRI	Malaria
Battlefield	4.85^{**}	-34.07^{*}
	(1.82)	(15.43)
Battle deaths°	-1.96	30.93^{**}
	(1.16)	(10.88)
Battlefield x Deaths	3.67^{**}	-39.21^{***}
	(1.26)	(10.76)
Intercept	111.14^{***}	465.23^{***}
	(1.83)	(32.00)
Fixed effects - country	Yes	Yes
Fixed effects - year	Yes	Yes
LogLik	-48742.00	-70087.63
Adj. R2	0.61	0.72
N	10026	10026

∘ denotes logged values. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

A.2.7 Fixed effects (non-spatial) models - with controls

Table A.4: Ch 4 - Fixed Effects Models - with controls

	Incidence Rate	
	LRI	Malaria
Battlefield	5.31^{**}	-25.29
	(1.73)	(13.80)
Battle deaths°	-3.02^{*}	18.50^{*}
	(1.21)	(8.35)
Battlefield x Deaths	4.16^{***}	-29.23^{***}
	(1.24)	(8.56)
Wasting (%)	-1.41^{***}	-16.54^{***}
	(0.39)	(3.64)
Educ. (F, yrs)	-3.66^{***}	-15.52
	(0.87)	(8.05)
Terain Rough.°	-3.56	1.56
	(1.88)	(12.14)
MCV Coverage (%)	-0.09	0.25
	(0.08)	(0.59)
Rainfall (mm)°	169.02^{**}	-1223.61^{**}
	(52.61)	(392.65)
Temperature (c)°	412.72^{***}	-2029.59^{*}
	(112.36)	(838.71)
Rain x Temp.	-50.32^{**}	418.33^{***}
	(16.01)	(124.11)
Population density°	1.54	12.01
	(1.37)	(11.69)
Area (Sq.km.)°	3.06^{*}	2.98
	(1.38)	(11.26)
Capital distance (km)°	-1.43	37.50^{**}
	(1.30)	(11.60)
Intercept	-1259.08^{***}	5966.60^{*}
	(367.39)	(2619.43)
Fixed effects - country	Yes	Yes
Fixed effects - year	Yes	Yes
LogLik	-48283.97	-69281.17
Adj. R2	0.64	0.76
N	10026	10026

∘ denotes logged values. $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

A.2.8 Lagrange multiplier tests for spatial dependence

Table A.5: Ch 4 - Lagrange multiplier spatial diagnostics - Fixed effects models

	LRI		Malaria	
	M(1)	M(2)	M(3)	M(4)
LM Error	5023.71***	4317.15***	6440.70***	5872.76***
LM Lag	5261.36***	4716.86***	6413.90***	5696.45***
Robust LM Error Robust	100.22***	63.17***	585.05***	663.50***
Robust LM Lag	337.87***	462.88***	558.25***	487.19***

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

A.2.9 Spatial marginal effect tables

Table A.6: Ch 4 - Spatial Effects: Incidence Rate - LRI

	Direct	Indirect	Total
No battlefield	-0.32^*	-0.66^*	-0.98^*
	$[-0.49; -0.16]$	$[-1.00; -0.33]$	$[-1.48; -0.49]$
Battlefield	0.15^*	0.30^*	0.45^*
	$[0.01; 0.27]$	$[0.02; 0.55]$	$[0.03; 0.81]$

* Null hypothesis value outside the confidence interval.

Table A.7: Ch 4 - Spatial Effects: Incidence Rate - Malaria

	Direct	Indirect	Total
No battlefield	1.99^*	4.16^*	6.15^*
	$[0.75; 3.19]$	$[1.57; 6.75]$	$[2.31; 9.86]$
Battlefield	-2.06^*	-4.33^*	-6.41^*
	$[-2.95; -1.14]$	$[-6.24; -2.37]$	$[-9.20; -3.50]$

* Null hypothesis value outside the confidence interval.

A.2.10 Spatial lag model motivation

Since disease incidence spreads through a natural diffusion process (owing to internal dynamics of disease transmission (Rock et al. 2014) independent of exogenous factors, including conflict) I focus primarily on estimates from Spatial Autoregressive Lag (SAR) models[4]. These models include nonlinear parameters (rho, ρ) on the spatial lag of the dependent variable allowing for identification of dynamic diffusion properties that characterize the spread of disease through space[5].

A.2.11 Spatial Lag model derivation

A.2.11.1 SAR Model Extended Discussion

Equation (A.2) presents the structural form of the SAR fixed effects panel regression model.

Structural form:

$$\begin{aligned} y = \rho \boldsymbol{W} y + \beta_1 * Intensity \ + \ \beta_2 * Battlefield + \\ (\beta_4 * Intensity * Battlefield) + \\ \boldsymbol{Z} + \gamma + u \end{aligned} \tag{A.2}$$

where:

- y is the LRI or Malaria disease incidence rate
- $\rho\boldsymbol{W}$ is the spatial dependence structure on spatial lag y.
  - $\boldsymbol{W}$ is an $n \times t$ row-standardized bloc-diagonal spatial weights matrix constructed using a queen definition of discrete neighbor relationships.
  - Due to $\boldsymbol{W}$ being row-standardized, ρ is an estimate of the proportion of variation in y for some $unit_i$ attributable to variation in y in $unit_i$'s neighbors
- $\boldsymbol{Z}$ is a covariate vector and associated parameters
- γ is a vector of country and year fixed-effects
- u is an i.i.d normal error term

The interaction implies the following *pre-spatial* marginal effect of a unit-change in conflict intensity on disease:

$$\beta_{Intensity} = \ \beta_1 + \beta_4 * Battlefield \tag{A.3}$$

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[4]I fit these models using a novel non-linear least-squares estimation method that overcomes the significant computational hurdles of identifying spatial autocorrelation in a model with a spatial weights matrix, $\boldsymbol{W}$, containing 10026^2 spatial relations (approximately 100 million values).

[5]Despite estimating a spatial lag model on HIV/AIDs prevalence, it does not appear that Iqbal and Zorn (2010) accounted for the spatial multiplier effect implied by this model which influences the unit-changes in conflict on disease. Therefore, it is likely their results *understate* the effect of conflict on disease. Although, their study also employed prevalence rates which, as discussed elsewhere in this appendix, likely reflects an incorrect operationalization of disease in conflict models given the underlying epidemiological concepts.

Substantively, this interaction indicates that local conflict intensity (violence) and the geographic location of that violence - whether it takes place in a battlefield or not - *jointly* condition the marginal effect of changing levels of violence on disease incidence rates. Translating back to the theory and evidence from Chapter 3 interviews with conflict refugees, civilians consider both the intensity and geographic location of violence when choosing a strategy to pursue to evade violence.

Notice, however, that due to the spatially dynamic lag process in y that Equation (A.2) has the dependent variable on both sides of the equality. Collecting all explanatory variables (primary IVs and covariates) and fixed effects into a matrix $\boldsymbol{X}$ and solving the reduced form of Equation (A.2) for y yields:

Reduced form:

$$y = (I - \rho \boldsymbol{W})^{-1}(\boldsymbol{X}\beta \ + \ u) \tag{A.4}$$

Equation (A.4) implies that the context conditional marginal effect indicated by equation (A.3) is further multiplied through the spatial dynamics inherent to disease processes. This spatial multiplier effect can be decomposed into an average direct (own-unit response), average indirect (neighbor response), and average total (all-unit response) effect which is the sum of the direct and indirect effects (LeSage and Pace 2021). Using the results from equations (A.3) & (A.4) above, the total spatial (marginal) effect of a unit-change in conflict intensity on disease which accounts for both space and context conditionality of conflict geography (battlefield or not) is:

$$\frac{\partial Disease}{\partial Intensity} = \ (I - \rho \boldsymbol{W})^{-1}(\beta_1 + \beta_4 * Battlefield) \tag{A.5}$$

A.3 Appendix to Chapter 5

A.3.1 Disease classifications

Table A.8: Ch 5 - Infectious diseases - outbreak classification

Disease	Classification
Acute Haemorrhagic Fever Syndrome	Contagious
Acute Jaundice Syndrome	Non contagious
Acute Neurological Syndrome	Contagious
Acute Respiratory Syndrome	Contagious
Aflatoxicosis	Non contagious
Anthrax	Non contagious
Ari	Contagious
Avion Influenza H5n1	Non contagious
Chikungunya	Non contagious
Cholera	Non contagious
Crimean congo Haemorrhagic Fever	Contagious
Cryptosporidiosis	Non contagious
Cutaneous Leishmaniasis	Non contagious
Dengue And Hemorrhagic Fever Outbreaks	Non contagious
Dengue Fever	Non contagious
Diarrhoea	Non contagious
Diarroheic Diseases	Non contagious
Diphteria	Contagious
Dysentery	Non contagious
Ebola Haemorrhagic Fever	Contagious
Enteric Diseases	Non contagious
Gastroenteritis	Non contagious
Haemorrhagic Fever	Contagious
Haemorrhagic Fever With Renal Syndrome	Contagious
Hepatitis A	Contagious
Hepatitis E	Non contagious
Hand foot and mouth disease	Contagious
Influenza	Contagious
Influenza A	Contagious
Infuenza (H5n1)	Non contagious
Japanese Encephalitis	Non contagious
Lassa Fever	Non contagious
Legionellosis	Non contagious
Leishmaniasis	Non contagious
Leptospirosis	Non contagious
Marburd Virus	Contagious

Disease	Classification
Measles	Contagious
Meningitis	Contagious
Meningococcal Disease	Contagious
MERS-CoV	Contagious
Monkeypox	Contagious
Nipah Viral Disease	Contagious
Pertusis	Contagious
Plague	Non contagious
Pneumonia	Contagious
Pneumonic Plague	Contagious
Polio	Contagious
Poliomyelitis	Contagious
Poliovirus (Wpv1)	Contagious
Rift Valley Fever	Non contagious
Septicaemia	Non contagious
Shigellosis	Non contagious
Tetanus	Non contagious
Tularemia	Non contagious
Typhoid Fever	Non contagious
Vibrio Cholerae	Non contagious
Viral Meningitis	Non contagious
Visceral Leishmaniasis (Kala_azar)	Non contagious
West Nile Fever	Non contagious
Wild Poliovirus Type 1	Contagious
Yellow Fever	Non contagious

A.3.2 Control variables - descriptive statistics

Table A.9: Ch 5 - Descriptive statistics: Controls

	Mean	Min	Max	SD	N
Democracy	41.905	3.140	85.720	24.805	2350
GDP (per capita, log)	8.305	4.651	11.640	1.503	2350
Pop density (per sq. km. log)	4.276	0.387	12.059	1.596	2350
Phone access (per 100, log)	2.291	0.000	4.328	1.266	2350
Life expectancy (yrs)	68.056	38.634	83.096	9.869	2350
Govt. health spending (per capita, log)	4.565	0.000	8.824	2.099	2350

A.3.3 Country-level intensity and geography used in conflict classification

Table A.10: Ch 5 - Descriptive statistics: Conflict

	Mean	Min	Max	SD	N
Battlefield (Percent country area)	1.153	0	97.362	6.858	2350
Battle deaths (per 100k)	0.486	0	199.938	5.178	2350
Battle deaths (per 100k, logged)	0.486	0	199.938	5.178	2350

A.3.4 Average marginal effects table

Table A.11: Ch 5 - Probit Average Marginal Effects

	CiD	NCiD
High intensity - concentrated	-0.85	26.95*
	$[-13.86; 12.15]$	$[13.34; 40.55]$
High intensity - diffuse	20.68*	10.48
	$[3.13; 38.22]$	$[-10.47; 31.43]$
Low intensity - concentrated	34.81*	36.10*
	$[20.11; 49.50]$	$[20.70; 51.50]$
Low intensity - diffuse	41.93*	30.96*
	$[22.65; 61.22]$	$[15.60; 46.31]$

* Null hypothesis value outside the confidence interval.