Gabrielle Park

QSS 30.18: Final Research Paper

Professor Elsa Voytas

Influence of Conflict on the Spread of COVID-19

Research Question

How does conflict influence the spread of infectious disease, and can this be mitigated by strong public health infrastructure?

Introduction

History has shown that war and disease often go hand in hand. The Influenza Epidemic of 1918 is just one example of this. It unfolded against the backdrop of World War I, ultimately taking more lives around the globe than casualties from the war itself (Byerly, 2001). Killing 20 to 40 million people, the Influenza Epidemic became the third worst plague in recorded history. World War I, and other conflicts, precipitate various factors that can heighten disease prevalence, including the movement of populations, poor sanitation, and the collapse of public health infrastructure (Gayer et al., 2007). Just as it held true in the 1910s, the same applies to conflicts and to health challenges today. Peace is fundamental for stable public health infrastructure, for disease control, and fundamentally for a population's health (Vahedi et al., 2023). Therefore, without peace, the question is raised about how public health is affected.

The emergence and transmission of infectious diseases alone are major challenges to public health; they put societies under stress and quickly expose weaknesses in health infrastructure. The factors and dynamics that intensify emerging diseases are wide ranging, from ecologic to social to biologic changes (Gayer, 2007). While there are multiple factors that can play a role in the spread of a new pathogen, this paper specifically studies how infectious diseases are affected by the presence of conflict, a social determinant of health (SDH). SDHs, according to the World Health Organization, are "the non-medical factors that influence health outcomes," such as income, education, food insecurity, and housing, that can contribute to health inequalities (World Health Organization, n.d.). These factors are essential to understanding the conditions that cause a disease to spread to certain populations over others. When conflict exists within a community, people's ability to attain good health is restricted in ways that are outside of their control. Therefore, by considering conflict as a SDH, I examine it as a predictor of health.

We do not have to reflect long to find a modern equivalent for the Influenza Epidemic of 1918, as we are still on the heels of the Coronavirus disease-2019 (Covid-19) pandemic. Caused by the novel pathogen SARS CoV-2 (Severe Acute Respiratory Syndrome Coronavirus-2), Covid-19 is a respiratory illness that spread across the globe and led to unprecedented levels of social and economic upheaval starting in December 2019 (Cox and Yah, 2020). Approximately four years after the outbreak, Covid-19 has become a valuable case study in the field of infectious disease. There exists a wealth of open-access Covid-19 data, from case counts to vaccination levels, which can help us understand an outbreak's characteristics. This project will use this case study to consider factors that could influence the spread of disease, namely conflict during the Covid-19 pandemic. I argue that the presence of conflict during the Covid-19 pandemic exacerbated factors that heightened disease prevalence, leading to higher transmission rates in areas of higher conflict.

Covid-19 and other infectious diseases that unexpectedly emerge and spread rapidly are especially dangerous due to their ability to weaken public health. These diseases put stress on health infrastructure, disease control programs, and infection treatment, rendering certain populations vulnerable to disease, especially across economic statuses (Gayer, 2007). Therefore, it is important to consider the individual economic conditions of a region in relation to the prevalence of disease. Economic status is another SDH that can indicate an individual or a society's capacity to achieve better health through financial means. This idea can be described within the theory of welfare economics (Raghupathi and Raghupathi, 2020). A country's overarching health expenditure can indicate how well social and economic resources are allocated to a population. When diseases like COVID-19 put infrastructure under unprecedented stress, sufficient funding provides stability in emergency health responses and allows for better provision of healthcare. Using this theory, I argue that stable, well-funded health infrastructure can mitigate the compounded instability of conflict and infectious disease.

This project narrows its geographic focus within the context of Covid-19 to the Middle East and North Africa (MENA) region. The MENA region is an interesting region due to the wide variation among these countries with respect to demographic, economic, and political trends (Katoue et al., 2022). More than half of these countries contribute significantly to the global energy production, yet despite the wealth of resources, there has been moderate progress in poverty reduction across the board. With low-income countries, like Yemen and Djibouti, and high-income countries with large oil industries, like the United Arab Emirates, the MENA region contains both ends of the spectrum. Politically, uprisings and armed conflicts have affected several countries in the region, and some large-scale conflicts still exist in countries such as Syria and in Gaza and Israel (Katoue et al., 2022). These factors pose major development challenges to the governments of some countries and therefore weaken the foundation for health infrastructure. Through a focus on the MENA region, this project will use this dynamic geographic context to analyze the relationship conflict, health expenditures, and the spread of COVID-19.

While previous literature has similarly examined the relationship between conflict and disease, including some in the context of Covid-19, they tend to focus on a reverse causality where the Covid-19 pandemic is a predictor for conflict and economic stress. In an early research paper from 2020, Mehrl and Thurner argue that Covid-19 may trigger armed conflict due to negative economic consequences and opposition parties being weakened. They examine the causal short-term effects of the pandemic on armed conflict through measures such as the first case of Covid-19 and governmental stay-at-home orders. At that time, Mehrl and Thurner found little evidence that Covid-19 affected global armed conflict but identified heterogeneous effects across regions, noting increased conflict in the Middle East (Mehrl and Thurner, 2020). In my research, I extend the window of study, looking at data from February 2020 to March 2022 (see the Methods section for more information). My results suggest that a longer-term analysis of the relationship between Covid-19 and conflict is more significant.

Additionally, I analyze a reverse causal relationship from Mehrl and Thurner's hypothesis because of the historical evidence that conflict is a "disease amplifier" (Price-Smith, 2020). While the causal relationship between conflict and infectious disease is complex and is shaped by various characteristics and non-linear factors, I posit that conflict introduces factors that directly increase the proliferation of disease, from increased population movement and exposure to lack of access to necessary health services. Especially within the MENA region where certain countries have endured conflicts since before Covid-19, such as Yemen's civil war that began in

2014, I argue that conflict harms healthcare systems and public health stability, promoting a higher spread of Covid-19 (Goniewicz et al., 2021).

This project looks at the MENA region during the Covid-19 pandemic as a case study for the influence of wartime conditions on the proliferation of infectious diseases and how robust health infrastructure can mitigate such shocks. While this case study may not necessarily generalize to other diseases with a different pathophysiology or other geographic and socio-economic contexts, I use this context as evidence that a causal relationship does exist. I find that greater levels of conflict have a positive relationship with increased Covid-19 cases. In addition, my results from Hypothesis 2 reveal that an increase in health expenditure can mitigate the increase in case counts that appears due to the presence of conflict.

As I examine both simple linear regressions, fixed effects models, and models with interaction terms, my findings require further investigation to demonstrate a predictive relationship for other regions and diseases, each with their own nuance. Overall, my results demonstrate the importance of enhanced surveillance methodology and health infrastructure that can endure conflict in order to protect public health and strengthen infectious disease response in politically unstable regions.

Hypotheses

Hypothesis 1a (H1a): Areas with heightened level of conflicts had a higher spread of infectious disease.

- Conflict exacerbates various issues that can heighten disease prevalence, such as the movement of populations, poor sanitation, and the collapse of public health infrastructure. These factors can increase the spread of infectious disease.

Hypothesis 1b (H1b): Areas with heightened level of conflicts had a higher mortality count due to infectious disease.

- High levels of conflict prevent the administration of an effective disease response and treatment, leading to a higher spread of Covid-19 and higher death rates from disease.

- *Potential implication*: Due to asymptomatic cases of Covid-19 and potential decreased testing during times of conflict, death count is a more reliable gauge of the spread of infectious disease. Deaths are more reliably reported than case numbers, so death counts are a better epidemiological measure of the prevalence of infectious disease (Cox and Yah, 2020).

Hypothesis 2 (H2): Areas with greater health expenditures diminished the heightened spread of COVID-19, despite the influence of conflict.

- A country's health expenditure can function as a measure of available health care resources and the stability of its infrastructure. It can result in better provision of health opportunities and human capital (Raghupathi and Raghupathi, 2020). If this value is high enough, indicating well-established health infrastructure, a country will be better able to mitigate the sudden disruption of infectious disease and conflict.

Empirical Strategy

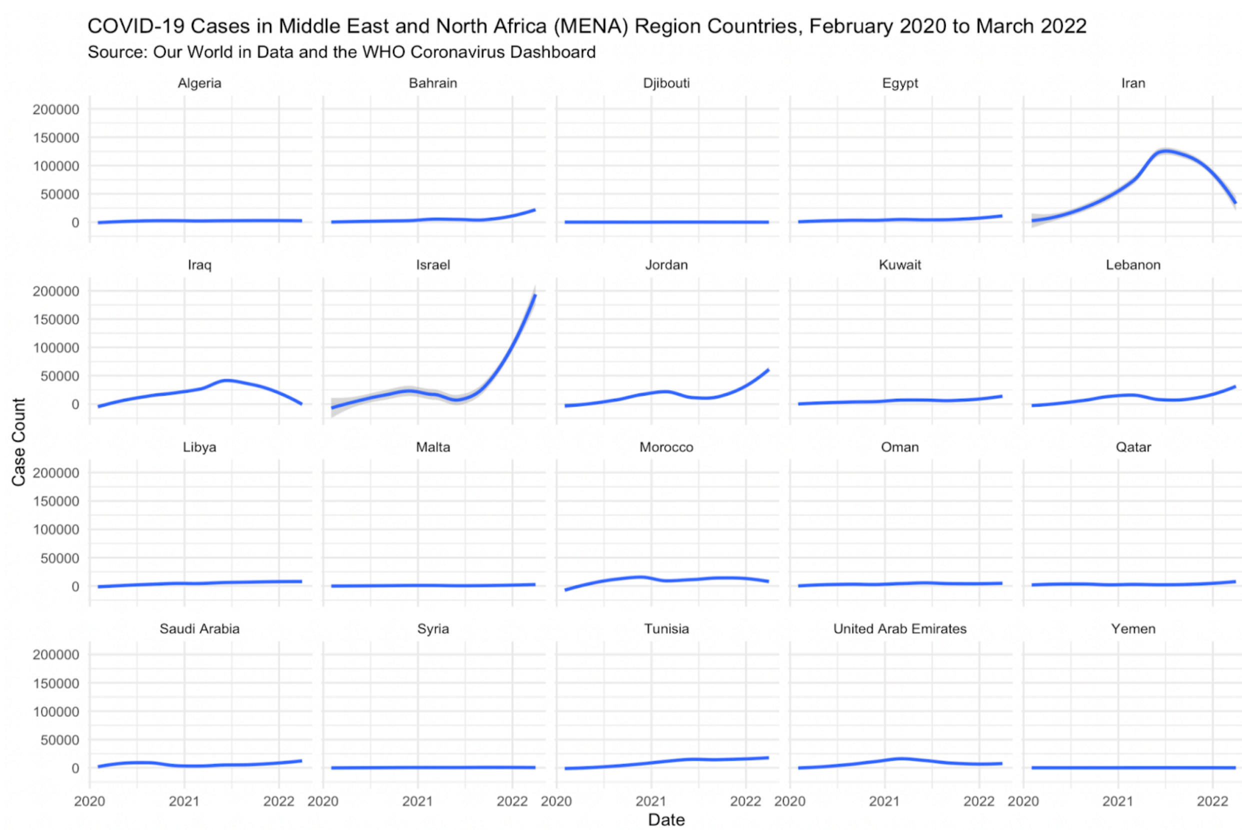
To study the relationship between conflict and Covid-19 in the MENA region and the effects of health expenditure, I gathered data from multiple open-access datasets—my results are replicable using the methods described below.

In my research, I define the Middle East and North Africa (MENA) region to include 20 countries: Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen.

COVID-19 has large amounts of open-access data on the prevalence, death totals, and vaccination rates of the disease available to the public. For this project, I rely on COVID-19 data from Our World in Data (OWID), available on GitHub, which was collected from the World Health Organization (WHO)'s Coronavirus Dashboard. This dataset was chosen instead of other COVID-19 related sources because of its open-accessibility and frequent updates by the OWID team and the WHO. I specifically use the weekly level data, which includes Case and Death counts. This dataset specifically covers new confirmed cases of and deaths from COVID-19 and can include probable cases, where reported. This data was cleaned to specifically look at just the

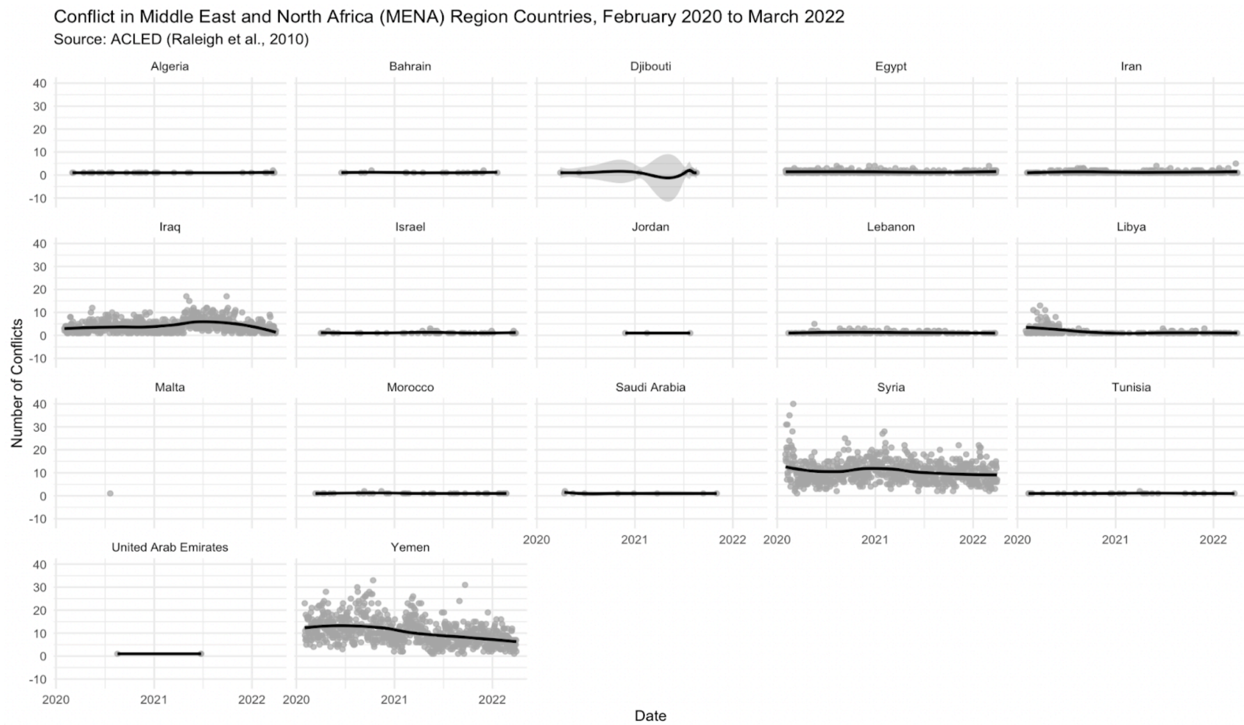
MENA region. My window of analysis is confined to February 1, 2020 to March 31, 2022. The starting date was chosen because the first cases of Covid-19 appeared in the MENA region in February 2020. The ending date was picked in 2022 to best capture the main time period of the Covid-19 pandemic. As the pandemic continued, Covid-19 vaccination rates increased and case surveillance became less stringent. Therefore, the end of March 2022 was selected to include the peak of Covid-19 and minimize confounding factors, like vaccination and decreased surveillance. Figure 1 is a descriptive plot of the Covid-19 cases during this time period, faceted by MENA countries. It indicates that there is country-specific variation in case counts over time.

Figure 1: COVID-19 Cases in Middle East and North Africa (MENA) Region Countries, February 2020 to March 2022



Notes: Covid-19 case counts were smoothed over the observation period of February 2020 to March 2022. Data is faceted by country in the MENA region. Y-axis represents Covid-19 case counts. Data is from Our World in Data and the World Health Organization (WHO) Coronavirus Dashboard.

Figure 2: Conflict in Middle East and North Africa (MENA) Region Countries, February 2020 to March 2022



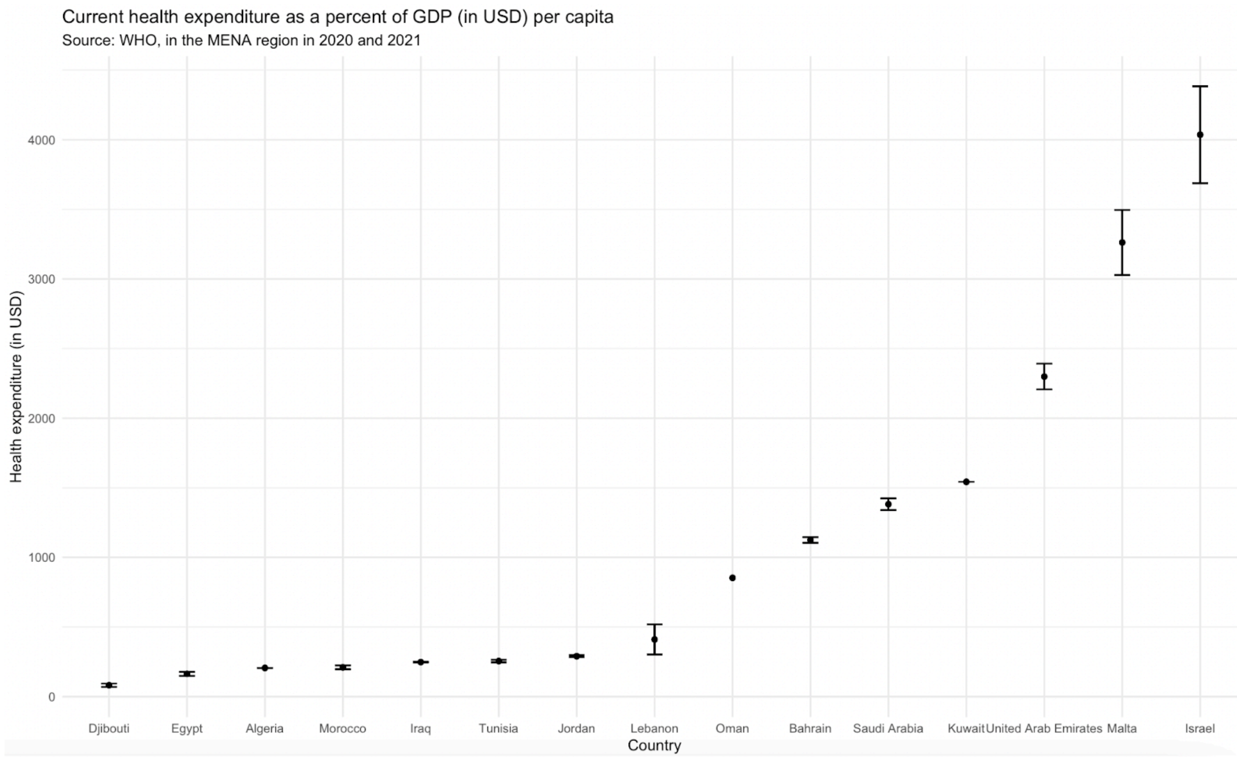
Notes: Gray points represent the total number of conflicts per day. The black line is the number of conflicts smoothed over the observation period of February 2020 to March 2022. Data is faceted by country in the MENA region. Data is from ACLED (Raleigh et al., 2010).

To measure levels of conflict, I use the Armed Conflict Location & Event Data (ACLED), a non-profit "disaggregated data collection, analysis, and crisis mapping project" (Raleigh et al., 2010). I chose this dataset because its data is updated weekly, which better matches the frequently updated COVID-19 data. This source is helpful because it has a wide inclusion catchment, meaning it collects data on a wide range of violence and conflicts (Raleigh et al., 2023). Since ACLED captures a range of violent and non-violent actions in every country, I narrowed my query to better align with my research hypothesis. I filtered the data to only include data from the MENA region countries and within the window of February 1, 2020 to March 31, 2022. ACLED includes a range of event, sub-event, and disorder types. For the purpose of this research scope, I define "conflict" as political violence, so I filtered the ACLED data to only include data categorized as Battles, Explosions/Remote Violence, or Violence against civilians. The data was cleaned to show the number of conflict events per day for each country. Figure 2 is a descriptive plot of the conflict counts during this time period. It is separated by MENA countries, revealing that there is variation in the frequency and intensity of conflict within each country. Countries, like Syria, Yemen, and Iraq have distinctly high levels of conflict counts. Kuwait, Oman, and Qatar have been omitted because they did not have conflict that fits my chosen categories during this time period. As a result, they are excluded from later analyses.

As a measure of public health infrastructure, I examine the health expenditure of a country. This data comes from the World Health Organization's Global Health Observatory database, which compiles a range of global development data. I specifically utilize the current health expenditure (CHE) as a percent of GDP (in USD) per capita for each country in the MENA region. While there are a variety of variables that could represent the stability of public health infrastructure, like the number of trained medical professionals or hospital beds, health expenditure is a value that can be easily compared, as it is standardized as a percent of GDP per capita. Future research should be done to explore the relationship between conflict and infectious diseases and these other measures of public health infrastructure.

This data source only included health expenditure values for 2020 and 2021, which is helpful for comparing health expenditures during the COVID-19 pandemic within my research window. Figure 3 shows that health expenditure values vary greatly within the MENA region. It is important to note that four MENA countries are missing data points for these years: Iran, Libya, Syria, and Yemen. These are countries with high levels of conflict and political instability, so it is plausible that the data would be missing. Since I was unable to find another measure of public health infrastructure with data as consistent and complete, the metric for comparing welfare economics was kept. These four countries will be disregarded in my analysis of health expenditure.

Figure 3: Current health expenditure as a percent of GDP (in USD) per capita, 2020-2021



Notes: Points represent the mean health expenditure in 2020 and 2021 by country and the error bar represents the standard deviation. Data is from the World Health Organization.

To test my first hypothesis, which studies the relationship between number of conflicts and Covid-19 prevalence, I use Covid-19 as my dependent variable. I study two related questions. First for H1a, how does conflict influence Covid-19 case counts? Second for H1b, how does conflict influence Covid-19 mortality? If case counts act as a predictor of death counts, is there a heterogeneous relationship between places with high or low levels of conflict? By analyzing the relationship between conflict and Covid-19 from different angles and with different measures of infectious disease, this analysis provides a more nuanced understanding.

My independent variable, or predictor, is the number of conflict events per day for each country. For H1a and H1b, I first run a simple linear regression to observe a more general relationship between conflict counts and case or death counts, respectively. Then I run my main model, which is a fixed effects model from the 'fixest' package in R that allows us to disregard unobserved individual effects as we model the relationship between conflict and Covid-19. The fixed effects in all of my models are time represented as date and location as country. Variables are clustered for standard errors at the country level. An example representation of this model would be:

$$y_{it} = X_{it}\beta_1 + \alpha_i + \epsilon_{it} \text{ for } t = 1,...T \text{ and } i = 1,...N$$

In this equation, y_{it} is the dependent variable observed for unit i at time t. X_{it} is the time-varying covariates. α_i is the unobserved time-invariant individual effect. ϵ_{it} is the individual- and time-level error term.

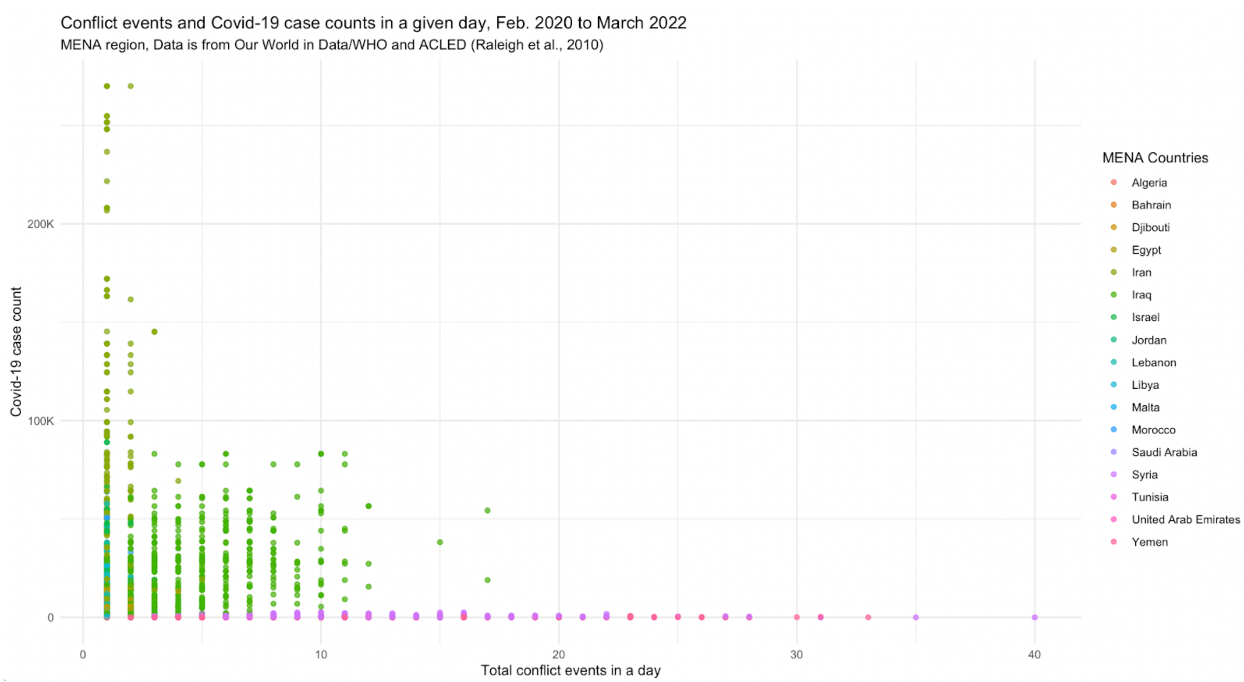
To test H1a, we fit the above regression with conflict count as the predictor variable, case counts as the outcome variable, date and country as the fixed effects, and cluster variables for standard errors at the country level. While I include a simple linear regression, the fixed effects model is better fit for examining diverse countries and different times, so we can account for unobserved effects.

To test H1b which considers the relationship between conflict and death rates, I hypothesize that higher levels of conflict lead to higher death counts from Covid-19. I analyze this relationship by first running a simple linear regression and then running a fixed effects model where conflict count is a predictor for death counts, similar to in H1a. Then, I hypothesize that there is a heterogeneous relationship between places with high and low levels of conflict, looking at case counts as a predictor for death. In other words, the relationship between case counts and death counts will be different depending on levels of conflict. This test could reveal that high conflict prevents effective disease response and proper treatment for Covid-19, leading to greater mortality. A heterogeneous relationship between high and low conflict could also indicate that death count is a more reliable, precise measure of Covid-19. This result could imply that case counts are not as accurately tracked in areas of high conflict that may not be politically stable enough to prioritize surveillance (Cox and Yah, 2020).

With Hypothesis 2, I introduce a country's health expenditure as a predictor variable for the spread of Covid-19 alongside conflict count. I argue that greater health expenditure can act as a measure of health infrastructure capacity and stability. Therefore, greater health expenditures can diminish the heightened spread of COVID-19, despite the disruption of conflict. To test this, I adjust the previously used fixed effects model to include the health expenditure value as another predictor. Instead of adding it as an independent predictor, I hypothesize that health expenditure and conflict count interact and add an interaction term between health expenditure and conflict count. I anticipate that there will be a negative coefficient for this interaction term, indicating that the correlation between Covid-19 cases and the predictor conflict count is affected by the predictor health expenditure. This would suggest that the effect of conflict on Covid-19 decreases as health expenditure increases. Following this methodology, I present my results and analyze whether or not my hypotheses prove to be accurate.

Results

Figure 4: Conflict events and Covid-19 case counts in a given day, Feb. 2020 to March 2022



Notes: X-axis represents the total number of conflicts in a day within a specific country. Y-axis represents the Covid-19 case count in that country on the same day. Colors represent individual countries. Data is from Our World in Data/World Health Organization and Acled (Raleigh et al., 2010). The graph appears to have a negative slope, supporting the results from the simple linear regression. When each point is subset by country, country specific trends are visible.

Hypothesis 1a (H1a)

After running a simple linear regression with number of conflicts within a day as a predictor for Covid-19 cases, I find that conflict has a negative coefficient and low p-value (β = -1247.3, p =

<2e-16) suggesting that the presence of conflict decreases case counts. This result is statistically significant and goes against H1a. At the same time, when I use a fixed effects model which accounts for variation in date and in country, conflict count has a positive coefficient (β = 410.47, p =0.03). Since this project studies this relationship within a geographically and politically diverse region and within a wide time period, using a fixed effects model is more beneficial. It allows us to control for all variables that are consistent within each specific time and location. Therefore, this fixed effect result suggests that high conflict levels increase Covid-19 case counts, controlling other unobserved variables.

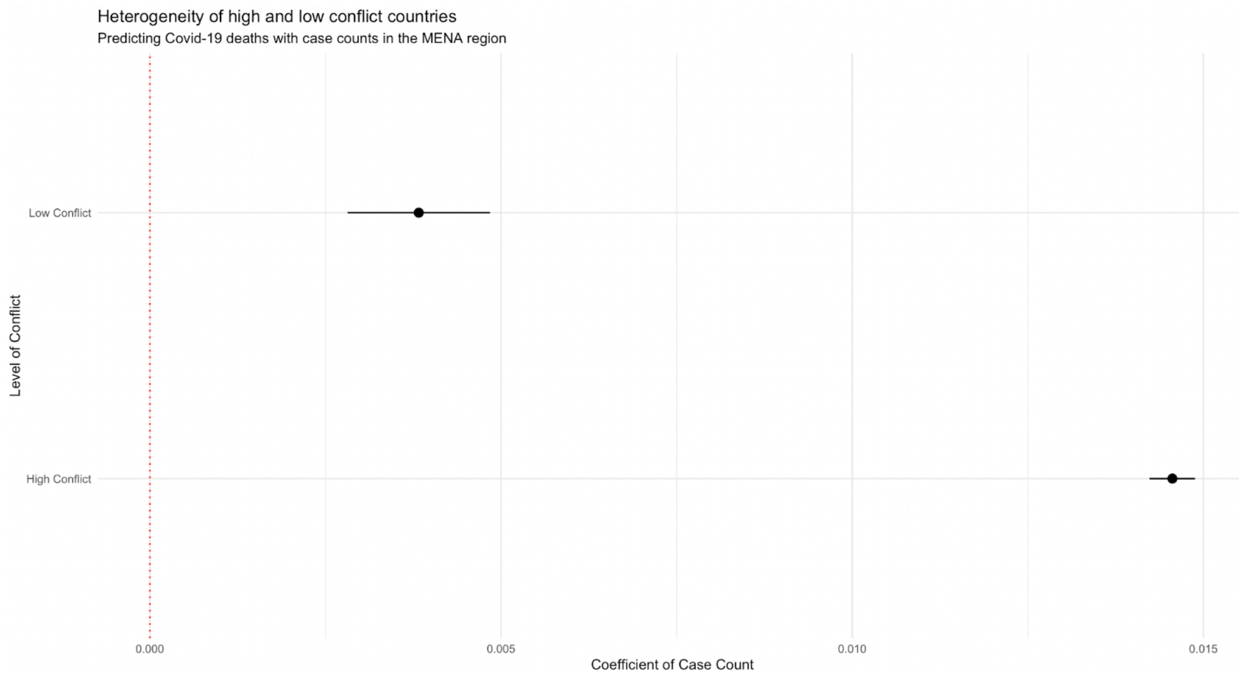
Hypothesis 1b

When studying the linear relationship between the predictor conflict count and the outcome death counts, conflict has a negative coefficient with a low p-value (β = -23.00, p = <2e-16), so we reject the null hypothesis and conclude that it is statistically significant. This result suggests that the presence of conflict decreases death counts, similar to the result from the linear regression in H1a. Despite the statistically significant result, this model does not control for potential confounding variables, such as time and place specific factors.

When I utilize a fixed effects model with the same predictor and outcome variables but use fixed effects for date and country, the coefficient for conflict is positive which could indicate that conflict causes death counts to increase. Despite this result, the p-value is greater than 0.05 (β = 1.91, p = 0.21). Therefore, we fail to reject the null hypothesis.

To analyze H1b from a different angle, I categorized countries with a binary variable for if they have high or low levels of conflict, which I define as under 100 conflicts in this time period. Then I use case counts as a predictor for death counts and examine potential heterogeneity between places with high or low conflict.

Figure 5: Heterogeneity of high and low conflict countries



Notes: When predicting Covid-19 deaths with case counts in the MENA region, there is heterogeneity between countries with high and low levels of conflict. Areas with lower conflict have smaller, positive coefficients. Areas with higher conflict have slightly larger, positive coefficients. Data is from Our World in Data/World Health Organization and Acled (Raleigh et al., 2010).

Figure 5 reveals that areas with high and low levels of conflict have a heterogenous relationship. They both have positive coefficients, but areas with low levels of conflict have slightly smaller coefficients. This suggests for every Covid-19 case in areas with lower levels of conflict, death counts increase at a slightly smaller rate than areas with higher levels of conflict. The difference between the two coefficient ranges are marginal.

Based on the results from Hypothesis 1, I find that the simple linear regression has more statistically significant results which go against the hypothesis, but the fixed effects models are better at controlling for unobserved variables. There appears to be a positive relationship between increased conflict counts and the increase in Covid-19 case counts. In addition, areas with high and low levels of conflict have a heterogeneous relationship when using case counts to predict death counts. Despite this, we cannot conclude that conflict increases mortality counts or that mortality is a more reliable measure of Covid-19 prevalence than case counts.

Hypothesis 2

The results from my Hypothesis 2 analysis examine a fixed effects model where an interaction term between conflict counts and health expenditure is used to predict Covid-19 prevalence. This interaction term is used to suggest that the effect of one predictor variable is dependent on another predictor variable. In this case, I hypothesize that the effect of conflict count on the spread of Covid-19 is dependent on a country's health expenditure variable.

I first study the effect of interaction term *conflict count : health expenditure* on case counts. I find that conflict counts (p = 6.7226e-11) and the interaction term (p = 6.0641e-06)are statistically significant while the health expenditure value alone (p = 3.3730e-01) is not. Conflict count has a positive coefficient (β = 3735.38), indicating that conflict increases case counts, as I observed in H1A. Yet, the interaction term between conflict count and health expenditure has a negative coefficient (β = -3.69). This result suggests that the effect of conflict on case counts decreases by approximately 3 units when health expenditure increases by 1 unit, supporting my hypothesis that health expenditure mitigates the effects of conflict on Covid-19.

When I examine the effect of the interaction term *conflict count : health expenditure* on death counts, conflict counts has a positive coefficient and a lower p-value (β = 14.55, p = 0.01), so its effect on death counts is statistically significant. Health expenditure value and the interaction term both have negative coefficients (β = -0.16 and β = -0.009, respectively) but both have statistically insignificant p-values, so I fail to reject the null hypothesis.

Discussion and Conclusion

In response to my research question—how does conflict influence the spread of infectious disease?—I find that higher conflict has a positive correlation with increased Covid-19 case counts. This result supports my hypothesis that conflict exacerbates factors that increase the spread and prevalence of disease. It is important to note that this result appeared using a fixed effects model that could control for unobserved factors across time and geographic locations. This same result did not hold true when I used a simple linear regression model, which produced the inverse result with high statistical significance. While I argue that the fixed effect model is a better measure of this relationship as it controls for confounding variables, more research is needed to demonstrate the robustness of my chosen model.

Despite this positive result, my findings were unable to generalize to increased death counts and could not prove that death counts have a closer relationship with increased conflict. I had hypothesized that death counts would be a better disease surveillance measure during times of conflict, as it is more accurately recorded than case counts. Especially during conflict, asymptomatic and non-fatal cases of Covid-19 would likely have gaps in surveillance, unlike deaths. Although I did not find support for this hypothesis, the issue of surveillance is a general limitation on my research. Lacking healthcare systems tend to lack inadequate surveillance and health information systems, even before the stress of conflict and a pandemic (Katoue et al., 2022). Mehrl and Thurner have also put forth a theory that the pandemic shifted attention away from armed conflict, leading to inaccurate reports of conflict (2020). This may be the case for the MENA region during the Covid-19 pandemic. My findings examine data, assuming that the conflict and Covid-19 datasets are complete, but my results are limited by their completeness. This gap calls for further research to understand the limitations in our data, a seemingly counterintuitive proposition. Nevertheless, by having a better understanding of what we know and what we do not know, we will be better equipped to address gaps in surveillance and respond to future public health emergencies.

Also, I note that the *weekly* data set from Our World in Data and WHO was recorded inconsistently, recording one value for multiple days in a row. There were inconsistencies in the duration of the “week” period and the starting days. This incongruity made it difficult to align well with the ACLED conflict dataset and could potentially be a limitation of my results.

I continue to address my research question by exploring how conflict and disease can be mitigated by strong public health infrastructure. I find that while death counts did not have statistically significant results as an outcome for health expenditure, the results for case counts suggest that health expenditure can mitigate an increase in case counts due to conflict. In this study, I use health expenditure as my measure of stable health infrastructure, due to sparsity of other datasets—even with the health expenditure data itself as it was missing data on four countries. I would suggest that future research should find other ways to measure the stability of public health infrastructure, from the number of hospital beds to the training of medical professionals. This can give a better understanding of the socio-economic context of health responses, especially in times of conflict.

Some confounding variables that could be future areas of research include government health department involvement and isolation/lockdown protocols, ACLED and other datasets' definition of conflict, specific parties that are involved in conflict that move across borders, and a better understanding of a potential reverse causality relationship between infectious disease and conflict.

Ultimately, I find that a range of variables can play into a population's health, especially in the dire context of conflict and a global pandemic. Through this analysis, I try to weigh the most impactful factors to conflict, the spread of disease, and the stability of public health infrastructure. Although this analysis may not necessarily discover a predictive relationship for other regions and other diseases, I discover that there is a lack of surveillance and data across the board in public health. While data collection is not always the top priority in unprecedented emergency situations, data informs our understanding of need and causal relationships. Therefore, better surveillance systems and stable health infrastructure should be invested in so they can respond to unexpected situations. Ultimately, I argue that these solutions are not complete and are unable to best mitigate public health disasters without the presence of peace.

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