



Journal of Epidemiology and Global Health

ISSN (Online): 2210-6014

ISSN (Print): 2210-6006

Journal Home Page: <https://www.atlantispress.com/journals/jegh>

Conflict and diarrheal and related diseases: A global analysis

Bradley T. Kerridge, Maria R. Khan, Jürgen Rehm, Amir Sapkota

To cite this article: Bradley T. Kerridge, Maria R. Khan, Jürgen Rehm, Amir Sapkota (2013) Conflict and diarrheal and related diseases: A global analysis, Journal of Epidemiology and Global Health 3:4, 269–277, DOI:

<https://doi.org/10.1016/j.jegh.2013.05.002>

To link to this article: <https://doi.org/10.1016/j.jegh.2013.05.002>

Published online: 23 April 2019



Conflict and diarrheal and related diseases: A global analysis

Bradley T. Kerridge ^{a,*}, Maria R. Khan ^b, Jürgen Rehm ^c, Amir Sapkota ^d

^a Department of Epidemiology and Biostatistics, School of Public Health, University of Maryland, College Park, College Park, MD 20742, United States

^b Department of Epidemiology, College of Public Health and Health Professions, School of Medicine, University of Florida Health Sciences Center, University of Florida, Gainesville, FL 32610, United States

^c Centre for Addiction and Mental Health, 33 Russell Street, Toronto, Ontario M5S 2S1, Canada

^d Maryland Institute for Applied Environmental Health, Department of Epidemiology and Biostatistics, School of Public Health, University of Maryland, College Park, College Park, MD 20742, United States

Received 15 February 2013; received in revised form 22 May 2013; accepted 24 May 2013
Available online 5 July 2013

KEYWORDS

Terrorism;
Civil war;
One-sided violence;
Global burden of disease;
Diarrheal disease

Abstract The purpose of this study was to determine the association between deaths owing to terrorism, civil war and one-sided violence from 1994–2000 and disability-adjusted life years (DALYs) attributable to diarrheal and related diseases, schistosomiasis, trachoma and the nematode infections (DSTN diseases) in 2002 among World Health Organization Member States. Deaths resulting from terrorism, civil war and one-sided violence were significantly related to DSTN DALYs across the majority of sex–age subgroups of the populace, after controlling for baseline levels of improved water/sanitation and a variety of economic measures: overall, a 1.0% increase in deaths owing to terrorism and related violence was associated with an increase of 0.16% in DALYs lost to DSTN diseases. Associations were greatest among 0-to-4-year olds. The results of the present study suggest that DSTN disease control efforts should target conflict-affected populations with particular attention to young children who suffer disproportionately from DSTN diseases in these settings. In view of the evidence that terrorism and related violence may influence DSTN DALYs in the longer term, control strategies should move beyond immediate responses to decrease the incidence and severity of DSTN diseases to seek solutions through bolstering health systems infrastructure development among conflict-affected populations.

© 2013 Published by Elsevier Ltd. on behalf of Ministry of Health, Saudi Arabia. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

* Corresponding author. Tel.: +1 301 345 0994.
E-mail address: bkerridg@umd.edu (B.T. Kerridge).

1. Introduction

Among those infectious diarrheal diseases most highly associated with unsafe water and inadequate sanitation are diarrheal diseases (including cholera, salmonellosis, shigellosis, amoebiasis, and other bacterial, protozoal and viral intestinal diseases), schistosomiasis, trachoma and the nematode infections (ascariasis, trichuriasis and hookworm disease). Taken together, these diseases account for approximately 5.0% of the global burden of disease, with diarrheal diseases (4.1%) disproportionately contributing to this toll of death and disability [1]. Diarrheal diseases are the second leading cause of death among children under 5 years old, killing more than 1.5 million children annually [1]. More than 200 million people worldwide are infected with schistosomiasis, and 700 million are at risk for this infection as a result of exposure to unsafe water and inadequate sanitation [2]. Trachoma is responsible for approximately 3.0% of the world's blindness and visual impairments among approximately 5 million people worldwide [3]. There are 2 billion intestinal nematode infections affecting one third of the world's population, with the largest percentage attributable to ascariasis. Globally, ascariasis causes about 60,000 deaths each year, predominantly among children [4].

In recent years a growing body of research has recognized the importance of the longer-term impact of armed conflict and related violence in the development of infectious and parasitic diseases [5–7]. This literature differentiates between the direct or immediate effects of armed conflict and related violence (e.g. battle deaths) from their indirect or longer-term effects on public health. Civil war and related violence influences the transmission of infectious and parasitic diseases in the long-term largely through deterioration of health-related infrastructures, including damage to water supplies, electricity, and sewage disposal systems necessary for health care services to operate [8]. Other indirect effects of conflict and related violence on morbidity and mortality from infectious diseases include reduced public and private investment in health, economic recession, increased poverty, famine, departure or death of health care workers, lack of shelter and overcrowding, and the displacement and forced resettlement of large numbers of persons resulting in reduced access to health care resources, food, safe water and adequate sanitation [9,10].

Despite the increasing recognition of the longer-term consequences of conflict and related violence

on infectious and parasitic diseases, only two studies to date have quantitatively addressed the relationship [11,12]. Both of these studies examined the relationship between civil war deaths from 1991–1997 and global burden of disease, as measured by disability-adjusted life years (DALYs), attributable to specific communicable diseases in 1999. The DALY is a measure that combines information on morbidity and mortality for specific causes and is derived as the sum of years of life lost to premature mortality plus the years of life lost to disability in a population [13]. Controlling for an array of economic and related factors (e.g., health care expenditures, and urban growth), civil war deaths were not found to be associated with diarrheal diseases, schistosomiasis, trachoma, or the nematode infections.

The work by Ghobarah et al. [11,12] has significantly increased the knowledge of the relationship between civil war and longer-term morbidity and mortality attributable to infectious diseases. However, this research did not directly control for major determinants of infectious disease morbidity and mortality, that is, the percentage of population with improved water resources and sanitation facilities, number of refugees in host countries and the number of persons affected by natural disasters. The absence of associations between civil war deaths and DALYs owing to diarrheal and related diseases, schistosomiasis, trachoma and the nematode infections (DSTN) diseases may have been, in part, the result of neglecting to transform DALY outcome measures that are skewed as required to satisfy the linearity assumption of the regression models. Foremost, these authors did not assess the impact of terrorist actions and one-sided violence on longer-term morbidity and mortality. One-sided violence is defined as the use of armed force by the government or by a formally organized group against civilians and includes genocide and summary execution of prisoners [13]. Between 1989 and 2004, the vast majority of fatalities from one-sided violence have taken place in countries experiencing armed conflict and terrorism [13–16] strongly suggesting that these three forms of intimately related violence be combined to better reflect the nature and intensity that has increasingly characterized civil conflict.

The present study builds upon prior work on the relationship between civil war deaths and longer-term morbidity and mortality attributable to infectious diseases. It is hypothesized that increasing numbers of deaths due to terrorism, civil war and one-sided violence from 1994–2000 will be associated with increasing levels of morbidity and

mortality (as measured by DALYs) in 2002 attributable to DSTN diseases among WHO Member States. This study will control for the effects of disease-specific vulnerability factors (i.e., percent of the population using improved water resources/percent of the population using improved sanitation facilities) and a number of economic factors (e.g., health expenditures, urban growth) generally measured at baseline in 1994. It is further predicted that terrorism, civil war and related violence on these infectious and parasitic diseases in the longer-term will inversely impact the majority of age–sex subgroups of the populace, and that this impact will be greatest among children under 5 years of age.

2. Method

2.1. Outcome: diarrheal and related disease DALYs

The outcome variables were the number of DALYs (in thousands) owing to DSTN diseases for 2002 among 183 of the 192 WHO Member States for the total sample and among sex and age subgroups of the populace [17]. DALYs are calculated as the sum of the years of life lost as a result of premature mortality and healthy years of life lost as a result of disability [13]. The 2002 DALYs used in the present study were discounted. Discounting reflects a social preference of healthy years now, rather than in the future [18]. Discounting is accomplished by decreasing annually the value of a year of life by a fixed percentage, in the case of 2002 DALYs, by 3% [19]. The DALY data were the most recently available that were disaggregated by age and sex.

2.2. Exposure: deaths from terrorism, civil war and one-sided violence

Since the severity and scope of civil war has changed over the last three decades to increasingly include fatalities arising from terrorist actions and one-sided violence, the major exposure variable in this study was the sum of these three types of intimately related violence [14–16].

Data on the number of deaths among victims and perpetrators resulting from terrorist actions from 1994–2000 were derived from the 2010 update of the National Consortium for the Study of Terrorism and Responses to Terrorism, Global Terrorism Database (GTD) [20]. Terrorist incidents include those that are intentional, achieve some level of violence or threat of violence, and are perpetrated by sub-national, non-State actors.

Data for civil war deaths occurring between 1994–2000 were derived from the battle deaths database [16,21]. Civil war is defined as armed conflict occurring between the government of a State and one or more internal opposition groups with or without intervention from other States. Civil war conflict is a contested incompatibility that concerns governments and/or territory where the use of armed force between two parties, of which at least one is the government of the State, results in at least 25 battle deaths. Battle deaths are defined as deaths resulting directly from violence inflicted through the use of armed force by a party to armed conflict.

Deaths resulting from one-sided violence for the years 1994–2000 were available from the one-sided violence database [13]. One-sided violence is defined as the use of armed force by the government of the State or by a formally-organized group against civilians which results in at least 25 deaths and includes genocide and summary execution of prisoners. Only one-sided violence deaths perpetrated by government actors were included since those perpetrated by formally-organized groups overlapped with those included in the GTD.

2.3. Pre-existing vulnerability control variables

The WHO defines two indicators to measure access to safe drinking water and basic sanitation: (1) the percentage of the population using improved drinking water sources; and (2) the percentage of the population using improved sanitation facilities [22]. For the purposes of this research, the percentages of the population using improved water sources and improved sanitation facilities were summed for the year 1994.

2.4. Economic and related control variables

Civil wars related to violence displace large populations either internally (i.e., internally displaced persons) or as refugees, including asylum seekers, or people owing to a well-founded fear of persecution for reasons of race, religion, nationality or membership of a particular social group or political opinion, outside their country of origin [23]. Refugees/asylum seekers/displaced persons are at an increased risk of disease and premature mortality from a variety of communicable and non-communicable diseases and malnutrition [23].

The number of refugees/asylum seekers/displaced persons (in thousands) residing in each host country at the end of the year 1994 served as an important control measure. These data were avail-

able from the United Nations High Commissioner for Refugee's Statistical Yearbook [24]. Similar to all control variables used in the present analyses, except the number of deaths/homeless/affected by natural disasters from 1994–2000, the number of refugees/asylum seekers/displaced persons was measured at the baseline, that is, as close to the year 1994 as the available data would allow.

The immediate health impact of natural disasters includes illness, disability and death typically associated with the spread of infectious diseases [25]. The natural disaster variable combined the number of deaths (persons confirmed as dead or missing), number of homeless (persons needing immediate shelter), and number affected (i.e., people requiring immediate assistance with regard to basic survival needs such as food, water and sanitation), in thousands, occurring at the country level for the years 1994–2000. Data were available from the emergency events database maintained by the WHO Collaborating Center for Research on Epidemiology and Disasters [26].

Numerous characteristics of the physical urban environment, including density of development, provisions for safe water and adequate sanitation infrastructure, and maintenance of public spaces are all predicted to adversely influence health outcomes [27]. This would be particularly true during the period of observation in the present study (i.e., between 1990–1995), when urban growth was occurring chaotically in less developed regions, but has essentially stabilized among most developed countries [28]. Urbanization was measured as the average percentage change in the urban population between 1990 and 1995, data collected routinely by the UN Department of Economic and Social Affairs and available on the UN Millennium Goals Database [29]. It is a longstanding and generally accepted principle that morbidity and mortality are reduced through public investments in health, sanitation and nutrition. Health economists have continually observed that 'wealthier is healthier' [30]. General government health expenditures as a percentage of total government expenditure (GGHE as a percentage of TGE) were also included as a critical control measure of health financing systems. Data on GGHE as a percentage of TGE for 1994 were available from the WHO Global Health Observatory Database [22].

Differences within a country in ethnic, linguistic and/or religious composition can be a major source of political contention and conflict. In turn, this produces discrimination and unequal access to political power that translates into inequality in access to care [11]. Dominant groups defined by ethnicity, language and/or religion often deflect

public health expenditures away from minorities, just as the wealthy shift resources away from the disadvantaged into government programs that would provide greater benefits to them. The measure of ethnic heterogeneity in this study is derived from Vanhanen [31] that combines racial, linguistic and religious division, each measured as the percentage of the largest group of a country's population for the years 1994–1996. These three percentages are summed and its inverse measures the degree of ethnic heterogeneity.

Tropical climate is a critical determinant for the development of infectious and parasitic diseases, and tropical country status is included in models in which communicable disease DALYs serve as outcome variables in this study [32]. Tropical country status was operationalized as a dichotomous variable (1 = at least one-half of the land mass in the tropics, and 0 = less than one-half of the land mass in the tropics). Data on tropical country status are collected by the International Union for the Conservation of Nature [33].

2.5. Statistical analyses

Using deaths from terrorism, civil war and one-sided violence in the years 1994–2000 produces a two-year lag to DSTN DALYs in 2002. The two-year lag between exposure to terrorism and related violence and DALYs attributable to the infectious and parasitic diseases examined in this study seems reasonable in terms of both the morbidity and mortality associated with these diseases. DALYs in 2002 reflect years of life lost owing to deaths from DSTN diseases during 2002 plus the disability incurred by people experiencing these same conditions in 2002. Thus, these are not deaths or disabilities experienced in earlier years during which the terrorism and related violence was active.

Prior to multivariable analyses, descriptive statistics will be presented for all study variables, including totals by age and sex and means, as appropriate. Multivariable linear regression analyses will also be conducted to examine the relationships between deaths from terrorism, war and one-sided violence from 1994 to 2000 and DSTN DALYs in 2002, controlling for pre-existing vulnerability and economic factors at baseline. Analyses were also conducted for the total sample and separately for age and sex (0–4, 5–14, 15–44, 45–59 and 60+ years) subgroups. Nine of the 192 WHO Member States had missing data on control variables and were excluded from the analyses, leaving 184 States. The majority ($n = 8$) of these countries were small islands or microstates. Rwanda was additionally eliminated from the analyses because the

country experienced 500,000 deaths as a result of genocide, rendering it an extreme outlier (leaving information on a total of 183 WHO Member States subject to analyses). The DALY outcome measures, the war and related violence exposure measure, and two control measures (number of deaths/homeless/affected by natural disasters and number of refugees/asylum seekers/displaced persons) were log transformed as the result of skew in order to satisfy the linearity assumption of the linear regression models.

3. Results

In 2002, there were approximately 69.8 million DALYs attributable to DSTN diseases among WHO Member States. DSTN DALYs were somewhat greater among males (35.4 million) compared with females (33.5 million) and among 0-to-4-year olds ($n = 56.6$ million) relative to all other age groups combined (12.2 million). Between 1994–2000 there were approximately 43,269 deaths from terrorist actions; 632,851 civil war deaths; and 27,895 deaths from one-sided violence (excluding 500,000 deaths from genocide in Rwanda), respectively, among the WHO Member States.

The mean percentage of the population with improved water resources/sanitation facilities was 147.7% (range: 27.0–200.0%). With regard to economic and related control variables, there were 24.4 million refugees/asylum seekers/displaced persons in 1994 and 1.1 billion dead/homeless/affected by natural disasters between 1994 and 2000. Mean percentage change in urban population between 1990 and 1995 was 0.9% (SD = 1.01; range = -2.41–4.35%) and GGH as a percentage of TGE in 1994 was 10.1% (SD = 4.5; range = 0.00–27.56%). The mean ethnic heterogeneity score was 43.9% (SD = 35.19; range = 0.00–147.00%). Average life expectancy among WHO Member

States in 1994 was 64.8 years (SD = 9.94; range = 38.4–79.5 years).

Table 1 shows the results from the multivariable linear regression analyses examining the relationships between deaths as a result of terrorism, war and one-sided violence from 1994–2000 and DALYs attributable to DSTN diseases in 2002 by sex. Regardless of sex, deaths as a result of terrorism, war and one-sided violence were significantly related to DSTN DALYs. On average, the beta coefficients associated with these relationships was 0.16, indicating that a 1.0% increase in deaths owing to terrorism, war and one-sided violence was associated with a 0.16% increase in DSTN DALYs.

Tables 2 and 3 shows the relationships between deaths owing to terrorism, war and one-sided violence from 1994–2000 and DSTN DALYs in 2002 by age among males and females, respectively. The results were generally consistent with the overall results. Terrorism, war and one-sided violence deaths were significantly related to DSTN DALYs among males and females in all age groups. However, this association was much greater among 0-to-4-year olds: a 1.0% increase in deaths owing to terrorism, war and one-sided violence was associated with, on average, an increase of 0.16% in DALYs lost to DSTN diseases. On average, a 1.0% increase in deaths owing to terrorism, war and one-sided violence in 1994–2000 was associated with increases of between 0.04% to 0.08% in DSTN DALYs lost in 2002 among the older age groups (5 years or older).

4. Discussion

Deaths from terrorist actions, civil war and one-sided violence from 1994–2000 were positively related to DSTN DALYs occurring in 2002, even after controlling for baseline percentages of the population using improved water resources/sanitation

Table 1 Multivariable linear regression analyses between terrorism, war and one-sided violence deaths from 1994–2000 and DALYs attributable to diarrheal and related diseases in 2002 by sex.

Variables	Male B (t)	Female B (t)	Total B (t)
Terrorism, war and one-sided violence deaths, 1994-2000	0.15 (4.91)	0.15 (4.82)	0.16 (4.83)
Percent improved water/sanitation, 1994	-0.01 (-6.40)	-0.02 (-6.27)	-0.02 (-6.31)
Number of refugees/asylum seekers/displaced, 1994	0.09 (2.10)	0.10 (2.20)	0.10 (2.09)
Number affected by natural disasters, 1994–2000	0.28 (9.28)	0.27 (9.09)	0.30 (9.45)
Urban growth, 1990–1995	0.11 (2.34)	0.21 (2.36)	0.22 (2.36)
Health expenditures, 1994	-0.05 (-2.52)	-0.05 (-2.57)	-0.05 (-2.64)
Ethnic heterogeneity, 1994–1996	<0.01 (1.43)	<0.01 (1.28)	<0.01 (1.06)
Tropical country status	0.22 (1.19)	0.24 (1.23)	0.22 (1.06)
Adjusted R ²	0.78	0.78	0.78

Note: $N = 183$; boldfaced beta coefficients significant at $p < 0.05$; figures in parentheses are t -values.

Table 2 Multivariable linear regression analyses between terrorism, civil war, and one-sided violence deaths from 1994–2000 and DALYs attributable to diarrheal and related diseases in 2002 by age among males.

Variables	Age (years)				
	0–4 B (t)	5–14 B (t)	15–44 B (t)	45–59 B (t)	60+ B (t)
Terrorism, war and one-sided violence deaths, 1994–2000	0.16 (5.16)	0.08 (3.72)	0.08 (3.31)	0.05 (2.53)	0.04 (2.46)
Percent improved water/sanitation, 1994	–0.02 (–8.01)	–0.01 (–2.90)	<–0.01 (–1.20)	<–0.01 (–0.85)	<–0.01 (–1.56)
Number of refugees/asylum seekers/displaced, 1994	0.08 (1.85)	0.06 (1.84)	0.09 (2.66)	0.07 (2.72)	0.08 (2.97)
Number affected by natural disasters, 1994–2000	0.25 (8.45)	0.17 (7.87)	0.18 (7.96)	0.12 (6.25)	0.11 (6.17)
Urban growth, 1990–1995	0.19 (2.21)	0.17 (2.55)	0.13 (1.96)	0.11 (2.02)	0.11 (2.17)
Health expenditures, 1994	–0.04 (–2.31)	–0.02 (–1.44)	–0.03 (–1.95)	–0.02 (–1.49)	–0.01 (–1.28)
Ethnic heterogeneity, 1994–1996	< 0.01 (1.69)	< 0.01 (1.73)	<0.01 (1.29)	<0.01 (1.61)	< 0.01 (1.75)
Tropical country status	0.19 (0.98)	0.50 (3.50)	0.24 (1.61)	0.21 (1.71)	0.16 (1.42)
Adjusted R ²	0.79	0.69	0.62	0.54	0.56

Note: $N = 183$ countries; boldfaced beta coefficients significant at $p < 0.05$; figures in parentheses are t -values.

Table 3 Multivariable linear regression analyses between terrorism, civil war, and one-sided violence deaths from 1994–2000 and DALYs attributable to diarrheal and related diseases in 2002 by age among females.

Variables	Age (years)				
	0–4 B (t)	5–14 B (t)	15–44 B (t)	45–59 B (t)	60+ B (t)
Terrorism, war and one-sided violence deaths, 1994–2000	0.15 (5.09)	0.08 (3.77)	0.07 (2.86)	0.04 (1.76)	0.04 (1.69)
Percent improved water/sanitation, 1994	–0.02 (–7.97)	–0.01 (–2.85)	<–0.01 (–0.85)	<–0.01 (–1.31)	<–0.01 (–2.01)
Number of refugees/asylum seekers/displaced, 1994	0.08 (1.91)	0.06 (1.87)	0.10 (2.83)	0.10 (3.12)	0.11 (3.44)
Number affected by natural disasters, 1994–2000	0.24 (8.17)	0.17 (7.87)	0.18 (7.67)	0.13 (5.90)	0.12 (5.80)
Urban growth, 1990–1995	0.20 (2.24)	0.16 (2.56)	0.13 (1.87)	0.12 (1.88)	0.13 (2.07)
Health expenditures, 1994	–0.05 (–2.41)	–0.02 (–1.29)	–0.03 (–1.72)	–0.02 (–1.33)	<–0.02 (–1.24)
Ethnic heterogeneity, 1994–1996	<0.01 (1.50)	< 0.01 (1.80)	<0.01 (1.29)	< 0.01 (1.93)	0.01 (1.89)
Tropical country status	0.19 (1.00)	0.50 (3.58)	0.26 (1.74)	0.23 (1.70)	0.19 (1.40)
Adjusted R ²	0.79	0.69	0.60	0.53	0.55

Note: $N = 183$; boldfaced coefficients significant at $p < 0.05$; figures in parentheses are t -values.

facilities and a variety of economic measures empirically shown to affect public health. In contrast to prior studies [11,12], the adverse impact of terrorism, civil war and one-sided violence on DSTN DALYs was found across a majority of sex–age subgroups of the populace. This discrepancy may, in part, be a result of broadening the major exposure variable, civil war deaths, to include deaths owing to terrorist actions and one-sided vio-

lence and applying appropriate transformations to the DALY outcome measures to render the data suitable for linear regression analysis.

Associations between terrorism, war and one-sided violence and DSTN DALYs were also strongest among the very young (0-to-4-year olds), highlighting DSTN diseases as leading causes of child morbidity and mortality with their exacerbation often occurring in conflict-affected populations. Children

are vulnerable to DSTN diseases since they have a greater risk of life-threatening dehydration than adults because water constitutes a great proportion of a child's bodyweight [2]. Vulnerability to DSTN diseases is even further increased among children with poor nutritional status and those exposed to poor environmental conditions characteristic of conflict [6,34]. Childhood malnutrition causes about 35% of all deaths among children and it is estimated that 50% of malnutrition is caused by repeated diarrhea or intestinal nematode infections as the result of unsafe water and inadequate sanitation [34,35].

The prior literature on the public health consequences of terrorism, war and one-sided violence has not generally considered other contributing factors that may increase the risk of specific diseases such as pre-existing vulnerability factors [36,37]. Although not the focus of this study, the percentage of the population with improved water resources/sanitation facilities was included as the pre-existing control measure, consistent with the Global Burden of Disease (GBD) Study perspective that DSTN diseases can be largely prevented by improving water supply, sanitation and water resource management [4]. That the percentage of the population with improved water resources/sanitation facilities at baseline in 1994 was associated with DSTN DALYs in 2002 among 0-to-14-year olds in the present study highlights the importance of inclusion of disease-specific vulnerability control variables in future research examining the impact of terrorism and related violence on DSTN morbidity and mortality.

DSTN diseases classified as tropical include schistosomiasis, ascariasis and trachoma. These tropical diseases contribute disproportionately to morbidity and mortality among school-aged children, many of whom will suffer chronic, irreversible diseases in later life, including cancer of the bladder, kidney failure and liver fibrosis [4,34]. Schistosomiasis, ascariasis and trachoma have also been identified by the WHO as neglected tropical diseases that, by definition, largely affect politically marginalized people and minorities [4]. Access to healthcare is a political process from which marginalized minorities are often excluded, a result consistent with the association found in this study between ethnic heterogeneity and DSTN DALYs [11]. Dominant groups defined by ethnicity, language and/or religion shift resources away from minorities and the disadvantaged into government programs that would be of greater benefit to them [12], a situation that appears to apply equally to countries experiencing peace as well as conflict-affected populations.

This study combined deaths from terrorism, along with deaths due to civil war and one-sided violence to more fully characterize the nature of violence occurring during armed conflict, thereby highlighting all three forms of conflict as substantial public health problems. The present study also benefited from consideration and inclusion of pre-existing vulnerability factors into the statistical models and the use of data transformations necessary to ensure the suitability of the data for linear regression analyses. Limitations, however, are noted. There always exists a potential for omitting an important control variable from the models presented herein, but the associated R^2 s were very high, indicating a reasonably complete specification of the relevant influences. Although the results of the ecological comparative design used in this study cannot fully capture within-country variability, they can play an essential role in defining the impact of major public health problems such as terrorism, war and one-sided violence that operate at a population level to influence morbidity and mortality. The measures used in the present analyses were also associated with various levels of reliability across WHO Member States. However, since the mid-1990s, efforts to increase the reliability of study variables has been unprecedented, including implementation of stringent inter-rater reliability standards for coding and quantifying conflict data [38,39], increased reliability and coverage of control variables and advances in consistency, completeness and reliability of morbidity and mortality data [40–42]. These measures are the most reliable that have ever been available [40], thereby permitting plausible, but tempered, systematic inferences of the longer-term influence of terrorism, civil war and one-sided violence on DSTN morbidity and mortality.

5. Conclusions

Terrorism, civil war and one-sided violence appear to influence DSTN infectious and parasitic diseases in the longer-term, independent of pre-existing vulnerability and economic factors whose relationship with DSTN diseases have been well established in the literature. The results of this study suggest that international governmental organizations (IGOs) and nongovernmental organizations (NGOs) should prioritize high risk populations for DSTN disease control to include conflict-affected populations with particular attention to young children who are most vulnerable to these diseases in these settings. In view of the indirect or longer-term impact of terrorism and related violence on DSTN

diseases observed in this study, control strategies should move beyond short-term provisions for safe water and adequate sanitation facilities, hygiene education, drug therapy, case management and vector control [43,44] to seek longer-term solutions through health systems infrastructure development. Private–public partnerships concerned with the mass distribution of medicines can also play an important role in strengthening health care systems through the development of rapid, integrated control measures targeted at several related DSTN diseases in conflict-affected populations [45]. Such interventions should be pro-poor, safe and cost-effective, similar to current efforts to mass distribute Mectizan, Albendazole, and Praziquantel for simultaneous treatment of ascariasis, trichuriasis, hookworm disease and schistosomiasis [46,47], diseases that are often comorbid and co-endemic in many countries [48,49]. Beyond intervention, the results of this study help underscore one of the hidden costs of terrorism and related violence providing an additional rationale for promoting peace.

Role of funding source

The NIH played no role in the study design, data collection, analysis and interpretation of the data, in writing of the report, and in the decision to submit the article for publication.

Conflicts of interest

None declared.

Acknowledgments

The support and guidance of Dr. Deborah Young, Dr. George Quester and Dr. Hongjie Liu are gratefully acknowledged.

References

- [1] World Health Organization. Diarrhea: why children are still dying and what can be done. Geneva: World Health Organization; 2009.
- [2] Steinmann P, Keiser J, Bos R, Tanner M, Utzinger J. Schistosomiasis and water resources in development: systematic review, meta-analysis, and estimates of people at risk. *Lancet Infect Dis* 2006;6(7):411–25.
- [3] Resnikoff S, Pascolini D, Mariotti S, Pkharal GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2002. *Bull World Health Organ* 2008;86(1):63–70.
- [4] World Health Organization. Working to overcome the global impact of neglected tropical diseases: first report on neglected tropical diseases. Switzerland: World Health Organization; 2010.
- [5] Bieberson P. Epidemics in the wake of conflict. In: Jean F, editor. *Populations in danger*. London: John Libby and Company; 1999.
- [6] Gayer M, Legros D, Formente P, Connolly MA. Conflict and emerging infectious diseases. *Emerg Infect Dis* 2007;13(11):1625–31.
- [7] Murray CJL, King AD, Tomijima N, Krug EG. Armed conflict as a public health problem. *Br Med J* 2002;324:346–9.
- [8] World Health Organization. *World report on violence and health*. Switzerland: World Health Organization; 2002.
- [9] Asgary R, Segar N. Barriers to health care access among refugee asylum seekers. *J Health Care Poor Underserved* 2011;22(2):506–22.
- [10] World Health Organization. *Violence – a global public health problem*. Geneva: World Health Organization; 2006.
- [11] Ghobarah HA, Huth P, Russett B. Civil wars kill and maim people long after the shooting stops. *Am Pol Sci Rev* 2003;9(2):189–202.
- [12] Ghobarah HA, Huth P, Russett B. The post-war public health effects of civil conflict. *Soc Sci Med* 2004;59(4):869–84.
- [13] Kreutz J, Eck K. *One-sided violence codebook: version 1.3*. Uppsala: Uppsala Conflict Data Program and Department of Peace and Conflict Research.
- [14] Eck K, Hultman L. One-sided violence against civilians in war: insights from new fatality data. *J Peace Res* 2007;44(2):145–66.
- [15] Ericksson M, Wallenstein P, Sollenberg M. Armed conflict 1989–2002. *J Peace Res* 2003;40(5):593–607.
- [16] Lacina B, Gleditsch NP. Monitoring trends in global combat: a new dataset of battle deaths. *Eur J Pop* 2005;21(3):145–66.
- [17] World Health Organization. *Disability-adjusted life years by country, sex and age*. Switzerland: World Health Organization; 2004.
- [18] Anand S, Hanson K. Disability-adjusted life years: a critical review. *J Health Econ* 1997;16(2):685–702.
- [19] Murray CJL, Acharya AK. Understanding DALYs. *J Health Econ* 1997;16(4):703–30.
- [20] National Consortium for the Study of Terrorism and Response to Terrorism. *Global terrorism database codebook, 1970–2010*. Maryland: National Consortium for the Study of Terrorism and Response to Terrorism.
- [21] Lacina B. *Battle deaths dataset 1946–2008. Codebook for version 3.0*. Oslo, Norway: Center for the study of civil war, International peace research; 2010.
- [22] World Health Organization. *Global health observatory database*. Switzerland: World Health Organization; 2011.
- [23] United Nations High Commissioner for Refugees. *The State of the World's Refugees: 50 Years of Humanitarian Action*. Geneva, Switzerland; 1995.
- [24] United Nations High Commissioner for Refugees. *Populations of concern to UNHCR. A statistical overview*. Switzerland: United Nations High Commissioner for Refugees.
- [25] Fogarty International. *Natural disasters: coping with the health impact*. DC, Disease Control Priorities Project: Washington; 2007.
- [26] Guha-Sapir D, Hargitt D, Hoyois P. *Thirty years of natural disasters, 1974–2000. The numbers*. Belgium: UCL Press; 2004.
- [27] Mohan V, Deepa R. Urban rural differences in prevalence of self-reported diabetes in India. The WHO–ICMR Indian NCD risk factor surveillance. *Diabetes Res Clin Prac* 2002;80(2):159–68.
- [28] Alirol E, Getaz L, Chappuis F, Loutan L. Urbanization and infectious diseases in a globalized world. *Lancet Infect Dis* 2010;10(2):131–41.

- [29] United Nations. United Nations millennium goals database. New York: United Nations; 2011.
- [30] Nixon J, Ulmann P. The relationship between health care expenditure and health outcomes: evidence and caveats for a causal link. *Eur J Health Econ* 2006;7(5):7–18.
- [31] Vanhanen T. Domestic ethnic conflict and ethnic nepotism: a comparative analysis. *J Peace Res* 1999;36(1):55–73.
- [32] Remme J, Blas F, Chitsulo L, Desjeux P, Engers H, Kanyok TP. Strategic emphases for tropical diseases and research: a TDR perspective. *Trends Parasitol* 2002;18(1):421–6.
- [33] International Union for the Conservation of Nature (IUCN). Climate and conservation. Switzerland: IUCN; 2000.
- [34] World Health Organization. Preventing diseases through healthy environments: toward an estimate of the environmental burden of disease. Geneva: World Health Organization; 2006.
- [35] World Health Organization. Safe water, better health. Switzerland: World Health Organization; 2008.
- [36] Levy BS, Sidel VW. Terrorism and public health. New York: New York; 2003.
- [37] Levy BS. War and public health. New York: Oxford University Press; 2007.
- [38] Kreutz K, Eck K. One-sided violence deaths database. Oslo, Norway: Department of Peace and Conflict Research; 2002–2012.
- [39] Lacina B. UCDP battle-related deaths version histories 4.1–5. Oslo, Norway: Center for the Study of Civil War, International Peace Research; 2012.
- [40] Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJL. Global burden of disease and risk factors. Washington, DC: World Bank; 2006.
- [41] Mathers CD, Bernard C, Iburg KM, Inoue M, Fat DM, Shubuya K, et al. Global burden of disease in 2002: data sources, methods and results. Geneva: World Health Organization; 2002.
- [42] Mathers CD, Ma F, Inoue M, Rao C, Lopez AD. Counting the dead and what they died from: an assessment of the global status of cause of death data. *Bull World Health Organ* 2005;83(3):171–7.
- [43] Esrey SA, Potash JB, Roberts L, Shiff C. Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. *Bull World Health Organ* 1991;69(5):609–21.
- [44] Fewtrell L, Kaufman RB, Kay D, Enanoria W, Haller L, Colford JM. Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *Lancet Infect Dis* 2005;5(1):42–52.
- [45] Amizago U, Brieger WR, Katarawa M, Akogoun O, Ntep M, Boetin B, et al. The challenges of community directed treatment with ivermectin (CDMI) within the African Programme for Onchocerciasis Control (APOC). *Ann Trop Med Parasitol* 2002;96(Suppl. 1):41–58.
- [46] Loukas A, Hotez PJ. Chemotherapy for helminth infections. In: Bunton LL, Lazo L, Parker KP, editors. Goodman and Gillman's the pharmacological basis of therapeutics. New York: McGraw-Hill; 2006. p. 1073–93.
- [47] Raso G, Luginbuhl A, Adjoua CA, Tian-Bi NT, Silue KD, Mathys B, et al. Multiple parasite infections and their relationship to self-reported morbidity in a community of rural Cote d'Ivoire. *Int J Epidemiol* 2004;33(5):1092–102.
- [48] Molyneux DH. Control of human parasitic diseases: context and overview. *Adv Parasitol* 2006;61:1–45.
- [49] Molyneux DH, Hotez PJ, Fenwick A. Rapid interventions; how policy of integrated control for Africa's neglected tropical diseases could benefit the poor. *PLoS Med* 2005;2:e336.

Available online at www.sciencedirect.com

ScienceDirect