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Documenting the Effects of Armed Conflict on Population Health

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Abstract

War and other forms of armed conflict have profound adverse effects on population health. It is important to document these effects to inform the general public and policy makers about the consequences of armed conflict, provide services to meet the needs of affected populations, protect human rights and document violations of international humanitarian law, and help to prevent future armed conflict. Documentation can be accomplished with surveillance, epidemiological surveys, and rapid assessment. Challenges include inadequate or absent data systems, social breakdown, forced migration, reporting biases, and the fog of war. The adverse effects of the Iraq War on population health demonstrate how the effects of armed conflict on population health can be documented. We recommend the establishment of an independent mechanism, operated by the United Nations or a multilateral organization, to investigate and document the effects of armed conflict on population health.

In war, truth is the first casualty.
–Aeschylus

INTRODUCTION

War and other forms of armed conflict cause extensive morbidity and mortality among military personnel and noncombatant civilians. Morbidity includes a wide range of disorders, from disabling injuries to adverse effects on mental health, some of which continue for long periods and even impair future generations. Populations suffer much morbidity during, and in the aftermath of, armed conflict because of damage to the health-supporting infrastructure of society, including systems to provide safe food and water, medical care and public health services, sanitation and hygiene, transportation, communication, and electrical power. Armed conflict uproots individuals, families, and entire communities, accounting for large numbers of internally displaced persons and refugees. Armed conflict violates human rights and humanitarian law. Armed conflict diverts human and financial resources away from nonmilitary purposes. And finally, armed conflict leads to further violence (18).

In recent decades, the nature of war and other forms of armed conflict have evolved in several ways that make it increasingly difficult to document associated effects on population health:

1. Civil wars. Today, armed conflict between countries is infrequent. Most armed conflict occurs in the form of civil wars and insurgencies within countries. Because access to countries engaged in armed conflict is difficult, it may not be possible for independent investigators to accurately document adverse effects on population health.
2. Targeting of noncombatant civilians. During armed conflict, noncombatant civilians are frequently targeted. Attacks aimed at civilians are likely to be considered war crimes, which perpetrators do not want documented. In addition, when journalists or other independent individuals attempt to investigate these attacks on civilians, they may place themselves at increased risk of injury or death.
3. Roles of nonstate actors in armed conflict. Since the end of the Cold War in 1991 between the Soviet Union and the United States, nonstate actors have played increasingly prominent roles in armed conflict. The nature of both the attacks by nonstate actors and retaliatory attacks sometimes makes it difficult to assess the adverse effects of these attacks on population health.

RATIONALE AND METHODOLOGIES FOR DOCUMENTING THE EFFECTS OF ARMED CONFLICT ON POPULATION HEALTH

It is important to recognize and document adverse effects of armed conflict on population health, for a variety of reasons including

- Informing the public and policy makers about the consequences of armed conflict;
- Identifying immediate needs of affected populations so that appropriate services can be provided;
- Reducing the likelihood of future armed conflict;
- Identifying violations of international humanitarian law;
- Protecting human rights;
- Preventing the use of indiscriminate weapons (including antipersonnel land mines and chemical, biological, and nuclear weapons); and
- Preventing genocide.

Many types of entities attempt to document the effects of armed conflict on population health. These entities include United Nations agencies, governments and their military forces, academic institutions, news-media organizations, humanitarian aid organizations, and nongovernmental organizations that seek to prevent armed conflict and to promote peace. Documentation of adverse effects can be achieved by surveillance, epidemiological studies, and rapid assessment methodologies. Each of these approaches is described below.

Although this article focuses on public health methodologies, we must recognize that the personal stories of individuals directly affected by armed conflict, as well as written and photographic documentation of the health effects of armed conflict by journalists, are important ways of documenting the adverse effects of armed conflict on population health. In fact, these approaches may be more effective than statistical reports or epidemiological studies in informing the general public and policy makers about the adverse effects of armed conflict and in motivating people to take action to minimize these consequences and to prevent armed conflict. In addition, the increasing use of social media, including the taking and electronic sharing of photographs and videos with mobile phones, provides opportunities for many people who are not professional journalists to document and to communicate with others about the adverse effects of armed conflict on population health.

CHALLENGES

Accurately documenting the adverse effects of armed conflict on population health is often difficult or impossible for numerous reasons, including the following:

1. Inadequate or absent data systems. Wars and other forms of armed conflict often damage existing systems that monitor morbidity and mortality. In addition, armed conflict often occurs in countries where these systems are already inadequate or absent.
2. Social breakdown. Because of the inadequate security that generally accompanies armed conflict, it is often difficult or impossible for independent investigators to gather information on population health during armed conflict or its immediate aftermath. For example, when fighting is ongoing, it may be impossible for independent journalists or investigators to enter war zones to document the effects of armed conflict on population health.
3. Forced migration. Because many people are uprooted from their homes during armed conflict, it is difficult to gather information on how armed conflict adversely affects individuals or to accurately determine the baseline health status of a population in the period before armed conflict began. Although refugees, who have escaped to other countries, can provide eyewitness accounts of the consequences of armed conflict, their reports may be perceived as biased or exaggerated. In addition, they may not be representative of the entire affected population.
4. Underreporting and overreporting biases. Data obtained may not accurately represent the consequences of armed conflict. For example, when all the people in a community are killed and/or forced to flee, it is virtually impossible to document the nature, severity, and magnitude of the adverse health effects of armed conflict on that population. In addition, those involved in armed conflict, such as governmental military personnel and nonstate actors, may have vested interest in underreporting morbidity and mortality among their own forces and overreporting morbidity and mortality among opposing forces. Furthermore, language and cultural barriers may impede ascertainment, analysis, and accurate dissemination of data to the general public and policy makers.
5. Difficulties in distinguishing between noncombatant civilians and combatants. It is often difficult, especially during civil wars, to distinguish combatants from noncombatant civilians

who may be serving in supporting roles for combatants. And, to complicate this process further, combatant nonstate actors are known to disguise themselves as noncombatant civilians.

6. Inadequate attention to civilian mortality and morbidity. Whereas surveillance and epidemiological studies focus on military personnel, the adverse health effects of armed conflict on noncombatant civilians are usually documented far less completely.
7. The fog of war. Chaos and confusion, present during war and other forms of armed conflict, often make it difficult to obtain accurate information on the resulting population health consequences.
8. Lack of focus on the health of "enemy" civilians. During armed conflict, the engaged entities rarely focus on the health status of noncombatant civilians on the opposing side. To do so may undermine public support for the military campaign.
9. Effects of remotely controlled weapon systems. The use of unmanned armed drones, which the United States has employed in Afghanistan and Pakistan, has inadvertently caused the deaths of many noncombatant civilians. It is difficult to accurately measure the impact of drone strikes on noncombatant civilians, due in part to the challenge of distinguishing these individuals from combatants.
10. Dependence on aerial bombing. The dependence on aerial bombing before (or without) the mobilization of ground troops, such as by the United States and Russia in Syria, complicates the ability to determine the numbers of noncombatant civilians who have been injured or killed.

WAYS OF ASSESSING THE IMPACT OF ARMED CONFLICT

The effects of armed conflict on population health can be documented in three major ways: public health surveillance, epidemiological studies, and rapid assessment. Each of these is described in general terms below. However, it is beyond the scope of this review to describe these methodologies in detail.

Public Health Surveillance

Public health surveillance is the ongoing systematic collection, analysis, and dissemination of data, which is performed for various purposes, including the prevention of morbidity and mortality. Because it is ongoing, it has the potential to provide valuable, timely information on the effects of armed conflict on population health. Surveillance before, during, and after armed conflict can provide information on direct and indirect morbidity and mortality due to armed conflict, as well as information on hazardous exposures and other factors that may place people at increased risk of illness, injury, or death. Identification of population-based risk factors present before an outbreak of armed conflict could be used to trigger interventions that might prevent armed conflict from occurring.

Surveillance can be passive, relying on existing data systems to provide information, or active, such that those operating the surveillance systems initiate and maintain new methods to gather information. Active surveillance can include sentinel surveillance, by which specific health care providers or other entities, such as hospital emergency departments, who are serving the needs of the affected populations, provide relevant, timely data.

Surveillance can help to identify trends, not only in morbidity and mortality, but also in the prevalence of risk factors. Although surveillance data are generally incomplete, they nevertheless provide useful information for government agencies, humanitarian organizations, and other

entities to provide services that meet the basic needs of affected populations. In addition, surveillance is often useful in identifying issues and hypotheses for further investigation with epidemiological studies.

Epidemiological Studies

Epidemiological studies can provide valuable information on the nature, severity, and magnitude of morbidity and mortality related to armed conflict as well as helpful information on associated risk factors. Epidemiological studies, in ways similar to how they are applied to other public health problems, determine incidence rates of injury, illness, and death and measures of prevalence, such as the presence of malnutrition or other disorders that may not be adequately treated in the midst of armed conflict.

Epidemiological studies often arise out of analyses and reports of surveillance data. However, epidemiological studies generally provide much more detailed information than surveillance does and can collect data on a wider range of health outcomes and associated risk factors. However, surveillance systems usually provide relevant information more promptly than epidemiological studies can.

Epidemiological studies of armed conflict are generally cross-sectional in design; although they may provide valuable information on health outcomes and risk factors, they generally cannot provide strong evidence for cause-and-effect relationships. To calculate incidence and prevalence rates, epidemiological studies need to collect data not only on numerators (such as the number of people affected with a specific disease), but also on denominators (at-risk populations).

Given the nature of armed conflict, it is exceedingly difficult to conduct prospective epidemiological studies on the health of affected populations. In addition, because epidemiological studies during armed conflict are generally performed at one point in time or over a short period of time, they are generally not helpful in discerning trends in morbidity and mortality or trends in the prevalence of risk factors, as surveillance can.

Epidemiological studies cannot gather information on entire populations that may be affected by armed conflict; therefore, they rely on methods to sample subsets of populations, from which they obtain information with standardized questionnaires, interviews of affected individuals or family members, and basic measurement techniques, such as determining height and weight to assess nutritional status. Results from subsets of populations that have been sampled are then extrapolated to the entire population. Important issues include determining sample size, ensuring the representativeness of surveyed populations, reducing sampling error, and minimizing bias. Epidemiological studies should be designed and field-tested with input from members of the affected populations. Questionnaires should be administered by trained interviewers recruited from the affected populations to minimize language and cultural barriers.

Rapid Assessment

Rapid assessment, often intensely performed during a short period of time, can accomplish the following:

- Obtain preliminary information on the nature, severity, and magnitude of a disastrous event or situation related to an armed conflict;
- Help to predict the future course of those affected;
- Estimate the likelihood of future health and related problems;
- Determine the need for immediate services; and
- Help to set priorities for assuring that basic human needs are met.

Rapid assessment often lays the groundwork for new or improved surveillance systems and specific epidemiological studies. In contrast to surveillance systems and epidemiological studies, which collect quantitative data, rapid assessment collects qualitative or semiquantitative data from a convenience sample of individuals, health care facilities, and other sources. Like surveillance, rapid assessment focuses on collecting data on both numerators and denominators.

Rapid assessment often includes visits to key areas; interviews with leaders in medical care, public health, and humanitarian aid; discussions with government officials and community leaders; small-scale studies; and assessments of existing data in vital records, public health surveillance systems, and medical care registers.

In the context of armed conflict, rapid assessment is generally employed when there has been a disastrous event or situation that seriously affects large numbers of people. It is designed to evaluate needs quickly and to help determine and prioritize intervention measures. In contrast with surveillance and epidemiological studies, rapid assessment is performed quickly and generally with little advance notice and is oriented toward saving the lives of and stabilizing the health of those affected by a disastrous event or situation. Examples of these situations in armed conflict include intensive bombing campaigns, large-scale terrorist attacks, major migrations of refugees and internally displaced persons, and intense acute damage to health- and life-supporting infrastructure. Challenges in performing rapid assessments include obtaining and appropriately analyzing representative data, gaining access to populations that are most seriously affected, coordinating with other agencies and organizations, and ensuring that findings are disseminated to those individuals and organizations that can use them promptly and effectively.

APPLICATION OF PUBLIC HEALTH METHODOLOGIES IN DOCUMENTING THE EFFECTS OF THE IRAQ WAR ON POPULATION HEALTH

The health impacts of many wars and other armed conflicts have been studied, as exemplified by publications on the Vietnam War (20) and the civil war in the Democratic Republic of Congo (31). We believe, however, that, among the health impacts of all armed conflicts, the health impact of the Iraq War has been most extensively studied, especially regarding mortality among noncombatant civilians and both morbidity and mortality of US and allied military personnel.

Studies of the adverse health consequences of the Iraq War illustrate approaches for collecting relevant information to document the adverse impact of armed conflict on population health as well as the challenges in collecting accurate information (19). The following section describes the methodologies and results of four studies of mortality among Iraqi civilians, followed by our comments on the limitations of these studies. There remain huge gaps in our knowledge about the health impact of the Iraq War, especially among Iraqi civilians, including nonfatal injuries and resultant disabilities, chronic disease morbidity, impact of childhood malnutrition, mental health problems, and the impact of hazardous environmental exposures.

War-Related Mortality Among Iraqi Noncombatants

Investigators have used several different approaches to estimate the number of deaths among Iraqi noncombatant civilians during the Iraq War. However, we are aware of only four epidemiological studies that have estimated mortality among Iraqi noncombatants during the war that were population-based, were reported in peer-reviewed journals, and estimated both the excess number of deaths attributable to all causes since the start of the war as well as the number of deaths caused by violence. These four studies are described below.

Roberts et al. In September 2004, Roberts and colleagues (30) performed a cluster sample survey in which members of 30 households in each of 33 household clusters in Iraq were interviewed about household composition as well as births and deaths since January 2002. In households where deaths were reported, interviewers administered a questionnaire that covered the dates, causes, and circumstances of violent deaths.

The researchers estimated the relative risk of death associated with the 2003 invasion and occupation by comparing deaths in the 17.8 months after the invasion with those in the 14.6 months that preceded it. They used population estimates from January 2003, but did not adjust population numbers for recent displacement or immigration. To reduce researchers' travel, they clumped clusters, which probably reduced the precision of their total mortality estimate. Within clusters, researchers attempted to confirm at least two reported noninfant deaths by asking to see the death certificates. To explore the possibility that families with many deaths were unlikely to be found and interviewed, thereby creating a survivor bias, members of one or two households in each cluster were asked if, in the area of the cluster, there were any entire families in which all family members had died or in which most family members had died and survivors were then living elsewhere.

The researchers estimated the death toll associated with the war by subtracting the preinvasion monthly mortality rate from the postinvasion monthly mortality rate and then multiplying that rate difference by the estimated population of Iraq and by 17.8 months (the average period between the invasion and the survey). Even though they made conservative assumptions, the researchers estimated that 98,000 more deaths than expected occurred after the invasion (not including the outlying Fallujah cluster, in which two-thirds of all violent deaths were reported).

They also found that the risk of death from violence in the period after the invasion was 58 times higher than in the period before the war. They found that violent deaths were widespread and were attributed mainly to Coalition forces. Violence accounted for most of the excess deaths. Air strikes from Coalition forces accounted for most violent deaths. Most people who had been reportedly killed by Coalition forces were women and children.

Burnham et al. Burnham and colleagues (3), between May 2006 and July 2006, performed a cross-sectional cluster sample survey of mortality in Iraq. There were several stages of sampling: In the first stage, researchers systematically selected 50 clusters from Governorates with a population-proportional-to-size approach; in the second, the Governorate's administrative units were listed by population and investigators chose locations randomly in proportion to population size; and, in the third, researchers randomly selected a main street within the administrative unit and then a residential street was randomly selected from a list of residential streets crossing the main street. Then, a start household was randomly selected on the residential street, and the team surveyed adjacent residences until 40 households were surveyed. Ultimately, data from 12,801 individuals in 1,849 households in 47 clusters were obtained.

Among the 629 reported deaths, 547 (87%) were in the postinvasion period and 82 (13%) in the preinvasion period. Among postinvasion deaths, the male-to-female ratio was 9.8 for violent deaths and 3.4 for all deaths. Among the conflict-related violent deaths, all but two were in the postinvasion period. Of these violent deaths, 91% were in men, and deaths were concentrated between the ages of 15 and 44. Gunshots accounted for most (56%) of the violent deaths; the remainder were equally divided among air strikes, car bombs, and other explosions/ordnance. Through 2005, death rates from nonviolent causes were the same as those prior to the invasion. The male-to-female ratio of nonviolent deaths was 1.8. Cardiovascular disorders were the primary cause of nonviolent death, accounting for 37% of these deaths during the entire extended period. The researchers compared the annual mortality rate in the 40 months postinvasion (13.3 per 1,000

people) with the preinvasion annual mortality rate (5.5 per 1,000 people). They estimated that, as of July 2006, there were 654,965 excess postinvasion deaths, 601,027 of which were due to violence.

Iraq Family Health Survey. Researchers performed a nationally representative survey of 9,345 households in which information on deaths was collected since June 2001 (13). A two-stage, stratified survey was performed, with an initial target sample of 10,080 households. The researchers used various methods to estimate the magnitude of underreporting. They compared reported death rates with those from other sources. Interviewers visited 89.4% of 1,086 household clusters; the household response rate was 96.2%.

Between January 2002 and June 2006, 1,325 deaths were reported. The percentage of injury-related deaths increased from 10.5% prior to the invasion to 23.2% after the invasion, most dramatically among males between the ages of 15 and 59, for whom the proportion of deaths from injuries rose from 31.2% prior to the invasion to 63.5% postinvasion, becoming the most prevalent cause of death in this age range. The percentage of deaths related to communicable and reproductive diseases decreased from 28.5% prior to the invasion to 21.3% after the invasion.

After they had adjusted for missing clusters, the researchers determined that the overall mortality rate per 1,000 person-years was 5.31 and that the rate of violence-related deaths was 1.09 per 1,000 person-years. After adjusting for underreporting, this rate was estimated to be 1.67 per 1,000 person-years. On the basis of study data, they estimated that 151,000 violent deaths had occurred from March 2003 through June 2006.

Hagopian et al. In mid-2011, Hagopian and colleagues (7) estimated mortality during the Iraq War by performing a national cluster sample cross-sectional survey of 2,000 randomly selected households throughout Iraq. Interviewers obtained information on causes of death; for war-related deaths, they asked for specific causes, such as explosions and gunshots, and also asked about perceived responsible parties. The researchers trained interviewers to probe for sensitive information about disappeared or missing persons. To adjust for migration, the researchers reviewed several secondary data sources to estimate the number of Iraqis who migrated out of the country during the war.

To ensure that their sample was nationally representative, they utilized a two-stage cluster sampling method in 100 clusters. They asked each head of household about births and deaths since 2001 and asked all adults in the household about mortality among their siblings during this period. In the first stage of selecting clusters, they randomly selected 100 areas, each 1 km in size. They then superimposed a smaller grid, 10 m^2 in size, onto each of the selected areas and randomly selected one grid cell in each of the 100 clusters. They then chose, in each small grid cell, the residential rooftop that most fully fit in the square to serve as the start household and then chose 19 adjacent dwellings using a previously established protocol. The response rate was 98.6%.

The researchers found that, between March 2003 and June 2011, the crude death rate in Iraq was 4.55 per 1,000 person-years, more than 50% higher than the death rate during the 20-month period before the war. They estimated that ~405,000 excess deaths attributable to the war occurred during this 8-year period. Investigators used secondary sources to estimate death rates among emigrants; data from these sources suggested that households would have reported an additional 55,000 deaths had these individuals remained in Iraq. The researchers acknowledged that their survey was limited by their reliance on outdated census data and the long recall period required of participants. Although they found that most increases in mortality could be directly

attributable to violence, about one-third were attributable to indirect causes, such as failures of health, sanitation, transportation, communication, and other systems.

Commentary. Each of the four studies described above utilized population-based methodology to reduce bias that could be introduced by the researchers, such as by random sampling. Researchers of each of the four studies acknowledged sampling imprecision by reporting the results with confidence intervals. Researchers in the Roberts, Burnham, and Hagopian studies requested death certificates to confirm the causes of death and acquired death certificates in a substantial majority of reported deaths. Although the Roberts and Burnham studies faced some criticism in the news media and elsewhere, part of which may have been politically motivated, these studies have been widely viewed among peers as the most rigorous investigations of Iraq War–related mortality among Iraqi civilians (34); we agree with this assessment and believe that the Hagopian study is also scientifically rigorous. Although the methodology and results in the four studies cited here have varied somewhat, it is clear that the Iraq War caused, directly and indirectly, a very large number of deaths among Iraqi civilians—which, in fact, may have been underestimated by these scientifically conservative studies. A paper by Tapp and colleagues (34) and a recent report by three country affiliates of the International Physicians for the Prevention of Nuclear War (12) have extensively reviewed these four epidemiological studies as well as other studies that attempted to assess the impact of the Iraq War on morbidity and mortality.

War-Related Mortality Among US Military Personnel

The US Department of Defense documents deaths of US military personnel. As of December 2015, the Department reported that 4,411 US military personnel had died in Iraq and nearby areas between March 2003 and December 2015. Of these deaths, 930 were attributed to nonhostile causes, such as self-inflicted wounds and diseases (41). The US military's prospective documentation and investigation of each of these deaths stands in stark contrast to the retrospective studies that estimated mortality among Iraqi noncombatant civilians.

War-Related Morbidity Among Iraqi Civilians

The approximate numbers of war-related illnesses and nonfatal war-related injuries among Iraqi noncombatant civilians have not been established; they have not even been estimated with any precision. Many illnesses and injuries are thought to have occurred because of damage to the health-supporting societal infrastructure, including public health services and medical care, systems to provide safe food and water, and facilities for sewage treatment and sanitation. Medical care facilities lacked basic equipment. Public health facilities were damaged and their records were destroyed. Basic public health services were disrupted, and many health workers were displaced within Iraq or fled to other countries. Among the few attempts to systematically gather information was a 2009 survey, which determined that many injuries occurred among Iraqi civilians as a result of the breakdown of societal infrastructure, including injuries from unintentional explosions, unintentional gunshot wounds, falls, and injuries from electric shock; only 8.4% of injuries were found to be intentional. Fatal injuries represented only 1.7% of the total injury burden (5).

War-Related Morbidity Among US Military Personnel and Their Families

In contrast with the paucity of data on morbidity among Iraqi noncombatant civilians, there has been extensive surveillance and many epidemiological studies performed on the health status of US military personnel and their family members. The US Department of Defense has reported

that 31,951 US military personnel were wounded in action in the Iraq War (42). On the basis of Department of Defense data, a study found that explosions caused a larger percentage of injuries from the war than in other large-scale conflicts (6). The injuries most frequently associated with explosions were mild traumatic brain injury (TBI), open leg wounds, and open face wounds. Body parts most often injured were arms, legs, head, and neck (6).

Most epidemiological studies of US military personnel have focused on mental health disorders. For example, data obtained from postdeployment health assessments during the first year of the war found that 19% of returning soldiers and Marines met the risk criteria for a mental health concern. Even more of them (31%) accessed mental health services in the year after returning home (8). Another study found that 151 (17%) of 882 US Army personnel and 127 (16%) of 813 US Marines met preliminary criteria for posttraumatic stress disorder (PTSD), major depression, or generalized anxiety (9). Multiple epidemiological studies found that risk factors for PTSD after combat included exposures during combat, especially the threat of death, serious injury, and witnessing of injury or death (27); killing or being responsible for killing (22); previous assault (33); low mental or physical health status before combat (17); and adverse childhood experiences, such as physical neglect (4, 16).

Mild TBI, characterized by loss of consciousness or altered mental status, was found to have occurred frequently among military personnel returning from the Iraq War. For example, an epidemiological study of 327,388 veterans demonstrated that 6.7% of them were diagnosed with TBI and that 89% of those with TBI had a diagnosed mental disorder during the year of the study, most commonly PTSD (35).

Epidemiological studies also documented that mental health disorders and related problems occurred often among spouses and partners of Iraq War military personnel. For example, among 250,626 wives of active-duty US Army soldiers who received outpatient care between 2003 and 2006, those whose husbands had been deployed (for less than 1 year) received more diagnoses of depressive disorders, sleep disorders, anxiety, and acute stress reaction and adjustment disorders than did wives of nondeployed military personnel (23).

Epidemiological studies have also documented mental health disorders and related problems among children of military personnel deployed in the Iraq War. A review of nine studies of the effect on children of parental deployment found an increase in emotional and behavioral problems in these children (32).

Population Health Status

In documenting the adverse health effects of war on population health, investigators must recognize and understand the impact of previous warfare on a population. For example, in the 23 years before the start of the Iraq War, the health of Iraqi civilians was adversely affected by the Iran–Iraq War (1980–1988), the Persian Gulf War (1990–1991), and economic sanctions (1990–2003). In addition, as a result of the Persian Gulf War and economic sanctions, between 1991 and 1998 an estimated 400,000 to 500,000 excess deaths occurred among children in Iraq (1).

Parameters of childhood malnutrition represent another way to monitor population health status during war and its aftermath. For example, a 2004 study performed by the Iraq Ministry of Planning and Development Cooperation together with the United Nations Development Program demonstrated that among Iraqi children between 6 months and 5 years of age, 23% had chronic malnutrition (low height-for-age), 12% had general malnutrition (low weight-for-age), and 8% had acute malnutrition (low weight-for-height) (14).

Related information on food security can supplement information on malnutrition. For example, a 2007 study estimated that 933,000 people in Iraq were food insecure, compared with

4 million people 2 years before (40). Another study found similar improvement in food security: Between 2005 and 2007, the proportion of people dependent on a monthly food ration decreased from 31.8% to 9.4% (40).

Environmental Health

During the course of war and its aftermath, it is often difficult to obtain accurate data on the direct and indirect impacts of war on air, water, and soil contamination and resultant impacts on human health. During the Iraq War, there were no systematic analyses of environmental health problems, and available data were scarce. Millions of tons of raw sewage had been dumped into rivers in Iraq at the start of the war, but the impact of this dumping on population health was never determined (15).

However, some data on sanitation and access to safe drinking water were available. For example, between 1991 and 2010, studies found that the proportion of the population with access to "improved sanitation facilities" (those that hygienically separate human excreta from human contact) increased from 67% to 73%, and, during the same period of time, the proportion of the rural population that had access to an adequate amount of water from improved water sources increased from 44% to 56% (44).

During the course of the war, several "environmental hot spots" were identified by the Iraq Ministry of Environment, such as a demolished metal plating facility with hazardous wastes, a pesticides warehouse that had been looted, a petrochemicals warehouse that had been looted and partially burned down, a large sulfur mining complex that had been damaged by fire, and a military scrap yard site (37). However, the impact on population health by these environmental hot spots was not determined.

Similarly, at and around US military bases, contamination had occurred as a result of depleted uranium, oil spillages, contaminated ash, and unexploded ordnance (24). For example, according to US military officials, about 3–5% of bombs, shells, and rockets fail to explode—a rate that may be as high as 15% in areas with soft sand, according to the United Nations Environment Program. However, the population health impact of this contamination was never determined.

Forced Migration

The primary source of data on forced migration has been the UNHCR: The UN Refugee Agency. It determined, for example, that, during the first 4.5 years after the onset of the Iraq War, 2.2 million refugees fled Iraq (38, 39). Humanitarian-aid and other organizations have estimated the number of Iraqis who have been internally displaced; for example, ReliefWeb reported in 2008 that, by then, an estimated 2.7 million Iraqis had been internally displaced (29), many of whom have experienced greater health risks because of inadequate shelter, lack of security, and other problems, as compared with refugees, who were able to flee the country.

Violations of Human Rights and Their Health Consequences

Reports of violations of human rights and their health consequences have come mainly from nongovernmental human rights organizations and journalists' accounts. Human rights violations have included many instances of enhanced interrogation of prisoners of war, an approach deemed by many experts to be torture under international law (36). Physicians for Human Rights documented that enhanced interrogation techniques occasionally led to death and frequently led to health problems among detainees, including mental health problems (28).

Diversion of Human and Financial Resources

Reports on the diversion of human and financial resources and the consequences of this diversion have come from nongovernmental organizations and academic institutions. For example, the National Priorities Project has reported that the United States, since 2003, has spent $818 billion to fund the war (26). The ultimate cost of the war to the United States could be $3 trillion (2).

NEW AND EVOLVING ISSUES

A number of new evolving issues are affecting and will likely continue to affect the documentation of the effects of armed conflict on population health, including the following:

1. Impact of climate change on collective violence. Increasing evidence demonstrates that climate change is exacerbating the likelihood of collective violence, such as by increasing temperatures, changing patterns of precipitation, raising sea level, and creating environmental refugees (10, 11, 21, 25, 43). Climate change is a risk multiplier—increasing collective violence in regions of the world where collective violence is already prevalent—so this impact is likely to be greatest in low-income countries where armed conflict is occurring or has recently occurred. Given the challenges of documenting the effects of war on population health in low-income countries and the additional challenges of documenting the effects of climate change, it will continue to be difficult to document the impact of climate change on collective violence.
2. Use of remotely controlled weapon systems. Remotely controlled weapon systems, such as unmanned armed drones, enable users to avoid personal danger. Although unmanned armed drones can pinpoint targets and kill targeted individuals and groups with great accuracy, drone attacks often kill noncombatant civilians. Distinguishing combatants and noncombatants will continue to be challenging.
3. Nonstate actors. ISIS (the Islamic State in Iraq and Syria) and other nonstate actors represent significant challenges to peace and security in many parts of the world. The nature of the armed conflict in which they are involved makes it exceedingly difficult to document adverse effects on population health.
4. Cyber warfare. Cyber warfare, which disrupts the functioning of computers and information networks, can have widespread effects on population health.

POTENTIAL WAYS OF IMPROVING THE DOCUMENTATION OF THE EFFECTS OF ARMED CONFLICT ON POPULATION HEALTH

Documenting the adverse effects of armed conflict on population health has often been done without adequate resources, adequate coordination among entities, and adequate mechanisms to prevent bias. There needs to be an independent, nonpartisan mechanism, established and maintained by a United Nations agency or a multilateral organization, to investigate, document, and report on the health consequences of armed conflict. This mechanism needs to include the development, evaluation, and improvement of methodologies to document these consequences. In addition, a surveillance mechanism needs to be established to identify population-based risk factors that signify the likelihood of imminent armed conflict, which could lead to interventions to prevent violence. Finally, programs need to be established by academic institutions and governmental and nongovernmental humanitarian-aid organizations to educate and train individuals in methodologies to investigate, document, and report on the effects of armed conflict on population health.

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