



# Weaponizing water as an instrument of war in Syria: Impact on diarrhoeal disease in Idlib and Aleppo governorates, 2011–2019



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## ABSTRACT

**Objectives:** Investigate the weaponization of water during the Syrian conflict and the correlation of attacks on water, sanitation, and hygiene (WASH) infrastructure in Idlib and Aleppo governorates with trends in waterborne diseases reported by Early Warning and Response surveillance systems.

**Methods:** We reviewed literature and databases to obtain information on attacks on WASH in Aleppo and Idlib governorates between 2011 and 2019. We plotted weekly trends in waterborne diseases from two surveillance systems operational in Aleppo and Idlib governorates between 2015 and early 2020.

**Results:** The literature review noted several attacks on water and related infrastructure in both governorates, suggesting that WASH infrastructure was weaponized by state and non-state actors. Most interference with WASH in the Aleppo governorate occurred before 2019 and in the Idlib governorate in the summer of 2020. Other acute diarrhea represented >90% of cases of diarrhea; children under 5 years contributed 50% of cases. There was substantial evidence ( $p < 0.001$ ) of an overall upward trend in cases of diarrheal disease.

**Conclusions:** Though no direct correlation can be drawn between the weaponization of WASH and the burden of waterborne infections due to multiple confounders, this research introduces important concepts on attacks on WASH and their potential impacts on waterborne diseases.

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## Introduction

According to the World Economic Forum (WEF), water crises, alongside weapons of mass destruction, failure of climate-change mitigation, and extreme weather events, are some of the most severe threats to global health security (WEF, 2019). In its 2018

'World Humanitarian Data' report, the United Nations Office for the Coordination of Humanitarian Affairs (UN-OCHA) noted that water access played a significant role in conflicts in at least 45 countries in one or a combination of three ways: water acting as the trigger of conflict, water sources being intentional targets of attack, and weaponizing water sources themselves as a tool of conflict (UN-OCHA, 2018). In Yemen, at least 128 attacks on water systems, including attacks against the main water supply to Hodeida (Al-Hudaydah), jeopardized access to water for millions across the country (Habib, 2020). This has contributed to one of the worst recent cholera outbreaks, with over one million cases reported and

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an increase in other waterborne diseases (Camacho et al., 2018; Spiegel et al., 2019; UN, 2018). It has also impeded responses to the COVID-19 pandemic (Habib, 2020).

Since the beginning of the 20th century, Syria has faced six major droughts and, like many countries in the region, invested in infrastructure such as dams, irrigation systems, and wastewater treatment plants to source and control the movement of water towards communities and agricultural spaces (Fanack Water, 2019; Gleick, 2014). Before the conflict, Syria experienced an extreme drought from 2006 to 2011, creating population displacement and a decline in water, sanitation, and hygiene (WASH) provision, particularly in rural areas (Gleick, 2014). This led some commentators to view the Syrian conflict as a direct result of rising tensions within communities resulting from crop and economic failures caused by drought (Abel et al., 2019; Hammer, 2013). However, the origins and path of the conflict are more complex than this narrative would suggest (Fouad et al., 2017).

Syria's violent and protracted conflict, which began as a peaceful uprising against the Government of Syria (GoS) in 2011, has seriously exacerbated existing WASH challenges. Water in Syria has been weaponized by all major parties to control or inflict damage on opponents, especially civilian populations (World Bank Group, 2017). Syria relies on seven major basins to source water from rivers and lakes, supplied by annual precipitation (Fanack Water, 2019). In 2009, the Food and Agriculture Organization of the UN (FAO) counted 166 dams across Syria, most situated in Homs and Hama governorates. The largest is the Tabqa dam (also called Thawra dam), completed in 1973 near Raqqah on the Euphrates. This dam created Lake Assad, Syria's largest water reservoir, which supplies most of Aleppo's drinking water (FAO, 2008). Tishrin dam (completed in 1999) is a hydroelectric dam near Manbij on the Euphrates River, by which electricity is supplied to the Raqqah and Aleppo governorates (Figure 1) (Mroue, 2012).

Dams and water sources in Syria have been captured by different forces during the conflict. In 2012, Syrian opposition

forces seized Tishrin Dam from the government (Mroue, 2012). The Battle of Tabqa in 2017 saw the Syrian Democratic Forces (SDF) and Kurdish militia, with US military support, recapture the Tabqa dam from the Islamic State of Iraq and Syria (ISIS); however, it was damaged to the point of needing to be suspended. In 2014, the Free Syrian Army's (FSA) capture and control of the spring in Ain Al-Fijah, by which they could control water entering Damascus, provided leverage for them in negotiations with the GoS (Reznick, 2016).

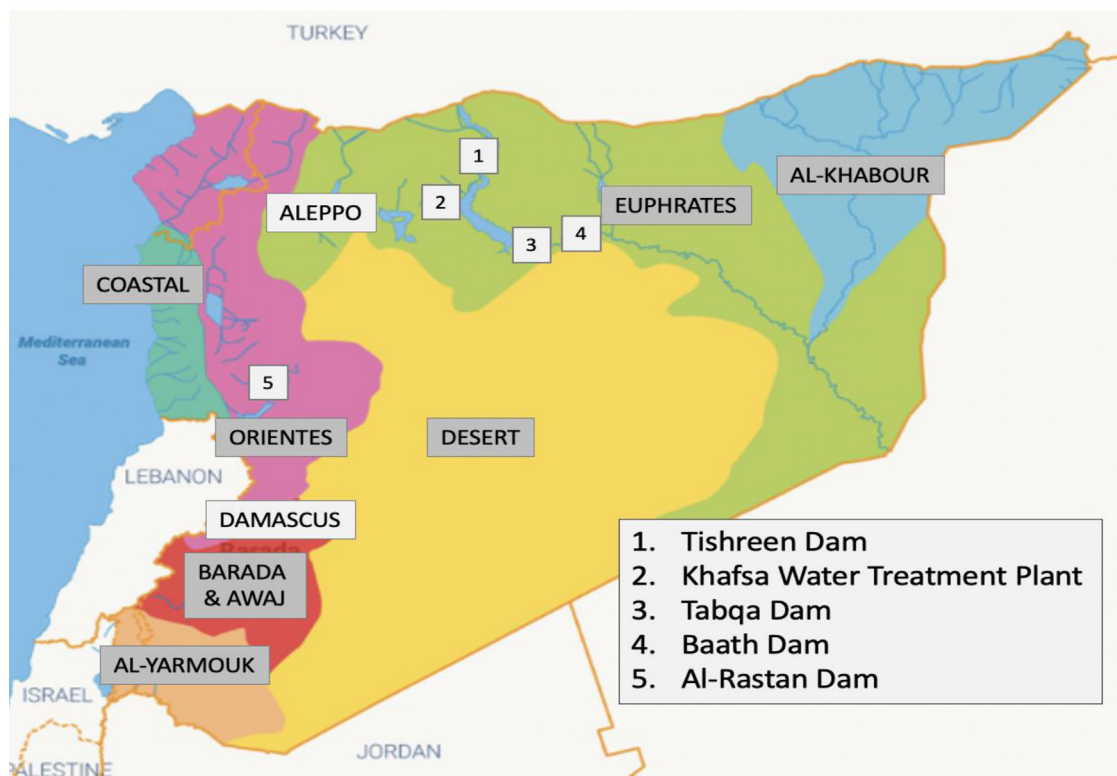
In addition to inadvertent conflict-related pollution of water sources, ISIS has deliberately contaminated drinking water in governorates including Deir ez-Zor, Raqqah, and Aleppo to expand their control over populations (CTED, 2017). Despite statements from the UN addressing the targeting of civilian infrastructure as a potential violation of international humanitarian law, GoS-backed Russian airstrikes on water sources have also been a common occurrence throughout the war and, by 2016, it was estimated that intentional attacks on water infrastructure had reduced the country's access to safe water by 50% (Vidal, 2016).

This weaponization of water in Syria by all parties in the conflict has exacerbated inadequate WASH for civilians inside Syria, increasing the risk of waterborne diseases in affected populations. This paper focuses on the Aleppo and Idlib governorates in the northwest of Syria as case studies to explore i. weaponization of water during the conflict, and ii. trends in waterborne diseases and potential correlation with attacks on WASH infrastructure.

## Methods

### Attacks on and weaponization of water sources and supplies

A literature review was conducted to obtain information on attacks on water infrastructure in Aleppo and Idlib governorates in Syria between 2011 and 2019. Keywords such as “water”, “weaponization”, “waterborne disease”, “outbreak”, “conflict”,



**Figure 1.** Map of the 7 major water basins in Syria: Coastal, Orontes, Barada and Awa, Al-Yarmouk, Desert, Euphrates, and Al-Khabour (Adapted from Fanack Water, 2019).

“Syria” were used in different combinations to search the databases of PubMed, Ovid, Embase, Global Health, HMIC Health Management Information Consortium, Scopus, and Google Scholar (see Appendix). Non-peer-reviewed grey literature was identified using multilateral organizations' web portals, including the United Nations, World Health Organization (WHO), World Bank, UN-OCHA, ReliefWeb, and non-governmental organizations including ICRC MSF, SAMS, Save the Children. Extracted information was used to compile a timeline of attacks on water infrastructure during the conflict.

### Waterborne diseases and surveillance systems

Data on cases of the diarrhoeal disease was extracted from two surveillance systems operational in Aleppo and Idlib governorates (Table 1). The Early Warning, Alert, and Response Networks (EWARN) were set up in Syria by the Assistance Coordination Unit, which formed part of the Syrian National Coalition; it received support from WHO and funding from the Bill and Melinda Gates Foundation. It works predominantly in non-government-controlled areas of Syria. EWARS (Early Warning and Response System) was established by the Syrian Ministry of Health with support and funding from WHO. In Idlib and Aleppo governorates, EWARN covers most of the population in Idlib city and the surrounding camps with some cover to the Aleppo governorate. As of the beginning of 2020, the highest population density in the Aleppo governorate is in Aleppo city, which is covered by EWARS.

Weekly reporting data included: total number of health facilities; the number of sentinel sites; the number of sites submitting weekly reports; cases of diarrhea, classified as acute bloody diarrhea (ABD), acute watery diarrhea (AWD - indicative of cholera), and other acute diarrhea (OAD); and acute jaundice syndrome (AJS - indicative of infectious hepatitis, e.g., hepatitis A). We combined all types of diarrhea into a total diarrheal disease case count for each week and plotted the weekly case count separately for Aleppo and Idlib and the two surveillance systems. Where data were missing for a single week, the number of cases was calculated as the mean of cases in the preceding and following week. Poisson regression models including sine and cosine terms for seasonality were fitted to test for evident trends in the total number of cases over the whole study period.

## Results

A timeline of major attacks and disruption of water infrastructure in Aleppo and Idlib governorates between 2011 and 2019 is shown in Figure 2.

### Attacks on WASH infrastructure in Aleppo governorate

The Aleppo governorate first entered the conflict in July 2012 with fighting between opposition forces and the GoS and its allies, Russia and Hezbollah; violence continued until December 2016, after a six-month siege that began in July 2016 GoS closed the

supply lines into Aleppo city. The first attacks on water infrastructure affecting Aleppo city occurred in September 2012 when its pipeline was damaged, depriving 3 million people of water (World Bank Group, 2017). In 2012, opposition forces held most of the east and southwestern parts of Aleppo city; by 2016, it was estimated that around 300,000 people remained in opposition-held East Aleppo and 1.5 million remained in GoS held west Aleppo city (Shaheen, 2016). During 2015, attacks by parties in the conflict (GoS, Jabhat Al-Nusra, Russia) affected water quality and supply. In December 2015, Russia bombed the al-Khafs water treatment facility in east Aleppo city, cutting off piped water to 3.5 million people (UNICEF, 2015). The tit for tat attacks on water infrastructure in September 2016 affected running water for 2 million people (UNICEF, 2016). GoS and Russian forces damaged Bab Al-Nayrab pumping station in east Aleppo city, depriving 250,000 people of water. In retaliation, opposition forces switched off Suleiman al-Halabi station; although located in east Aleppo city, it pumps water to west Aleppo city, affecting 1.5 million people. Water was subsequently restored to the western parts of the city in November 2016 (World Bank Group, 2017). This left civilians reliant on non-potable water from wells or delivered in trucks, which was expensive and for which they had to queue up, often for extended periods (World Bank Group, 2017).

### Attacks on WASH infrastructure in Idlib governorate

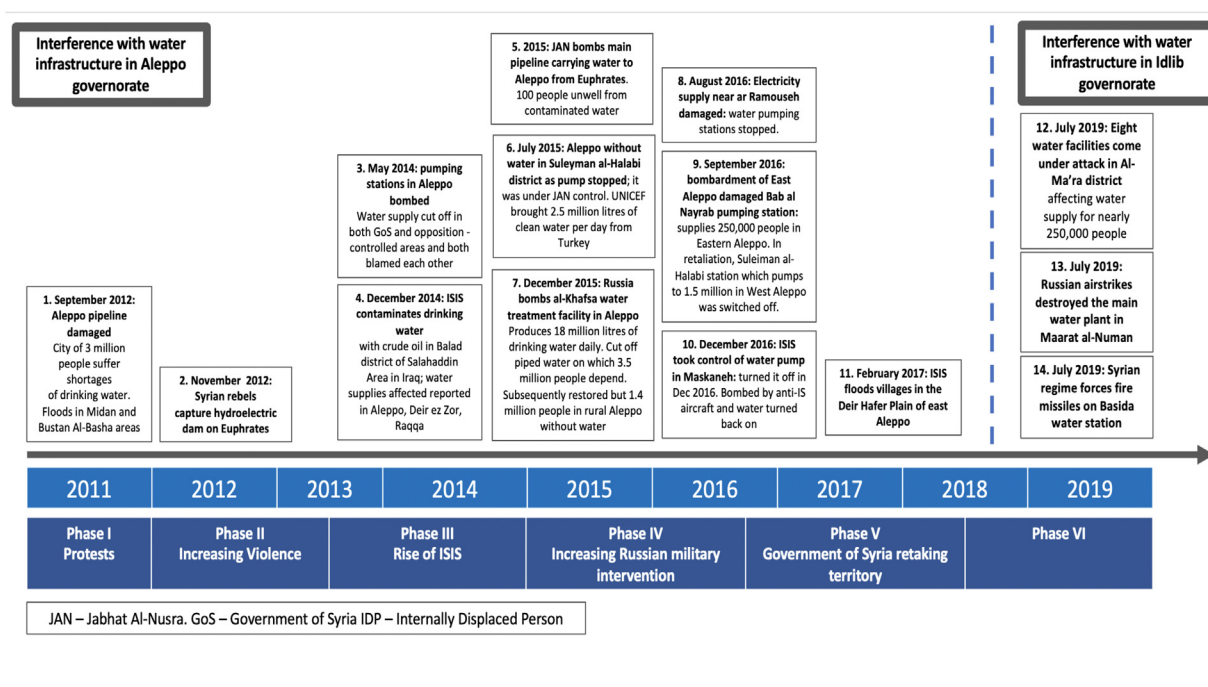
The Idlib governorate has seen constant violent clashes between GoS and opposition forces since September 2012. During 2017, violence between extremist groups Ahrar Al Sham and Hay'at Tahrir Al-Sham (HTS) eventually led to HTS and opposition forces taking control of most of the governorate by July 2018 (Ali, 2020). Idlib governorate, mainly Idlib city, saw the most significant violence between April and August 2019 and a further escalation between December 2019 and February 2020; this has displaced around 1 million civilians (80% of whom are women and children) of the 4.17 million people in the area (Abbara et al., 2020b). Significant water infrastructure damage occurred in July 2019 when eight facilities in Al-Ma'ra district (three of which are supported by the UN), including the central water station in Maarat al-Numan city in southern Idlib, were attacked by GoS, depriving 250,000 people in the area of water (Ortagus, 2019).

### Waterborne diseases

Weekly cases of diarrheal disease in Aleppo and Idlib governorates showed regular mid-year seasonal peaks corresponding to the late summer months, more pronounced in 2017 and 2019 compared to 2015, 2016, and 2018 (Figure 3a and b). The seasonality pattern was superimposed on an overall upward trend of cases reported by the two surveillance systems (Figure 3c). The upward trend was supported by solid evidence ( $p < 0.001$ ) equivalent to approximately 12–16 additional cases per week, according to the EWARN data (2015–2020), and 2–3 cases per week in EWARS data (2015–2019). Generally, there were more cases

**Table 1**  
Differences between the EWARN and EWARS systems in Syria.

| System                                 | Early Warning and Response System (EWARS)       | Early Warning and Response Network (EWARN)      |
|--|---|---|
| Administered by                        | WHO and Syrian Ministry of Health               | Assistance Coordination Unit                    |
| Administrative base                    | Damascus, Syria                                 | Gaziantep, Turkey                               |
| Operates predominantly in              | Government-controlled areas                     | Non-government controlled areas                 |
| Established                            | September 2012                                  | June 2013                                       |
| Availability of data                   | January 2014 to December 2019                   | January 2014 to April 2020                      |
| Overall completeness (weeks with data) | Aleppo 98.1% (306/312)<br>Idlib 95.8% (299/312) | Aleppo 98.8% (321/325)<br>Idlib 99.1% (322/325) |



**Figure 2.** Timeline of major attacks and disruption of water infrastructure in Aleppo governorate between 2011 and 2018 (during which there were no major attacks in Idlib governorate) and in Idlib governorate in 2019 (when there were no further major attacks in Aleppo governorate). References to the noted events are provided in the text and here, as following: Box 1 (World Bank Group, 2017). Box 2 (Boghani, 2012). Box 3 (Cockburn, 2014; Strategic Foresight Group, 2014). Box 4 (Strategic Foresight Group, 2014). Box 5 (Reznick, 2016). Box 6 (Syrian Observatory for Human Rights, 2015). Box 7 (UNICEF, 2015). Box 8 (Tokmajyan, 2016). Box 9 (Oxfam, 2016; The Guardian, 2016). Box 10 (Shapiro and Hobson, 2017; UN-OCHA, 2016). Box 11 (Alwaght, 2017; Krzymowski, 2019). Box 12 (Cappelaere, 2019). Box 13 (The New Arab, 2019). Box 14 (WFP, 2019).

reported in Idlib than in Aleppo governorate. A peak of around 9,000 cases occurred in mid-2019 in Idlib governorate, representing a one-third increase on the two previous years and a relatively larger increase compared with the Aleppo governorate. Proportions of ABD, OAD, and AJS stratified by age, <5 years and 5+ years, are shown in Figure 3d. More than 90% of cases were OAD, apportioned approximately 50:50 between the under and over 5 years age groups. Interestingly, the occurrence of ABD and AJS cases showed a gradual decline over time along with the above-mentioned seasonal peaks (Figure 3e).

## Discussion

### *The weaponization of water in Idlib and Aleppo governorates*

Aleppo and Idlib governorates in Syria have experienced some of the most extensive violence in Syria's protracted conflict; water infrastructure has been attacked and contaminated as a war strategy by both the Syrian government and non-government forces. As early as 2012, Aleppo city's water pipeline was damaged, affecting water supplies to 3 million people. In Idlib governorate, the most extensive attacks occurred in summer 2019 when 8 water facilities were bombed by GoS. WASH continues to be affected in both governorates but particularly in the Idlib governorate, which has seen a recent, further escalation of violence, leaving hundreds of thousands in northwest Syria without adequate facilities (Abbara et al., 2020b). This occurs at a time when the COVID-19 pandemic in Syria is ongoing, leaving the population, mainly internally displaced families, with inadequate facilities to protect themselves (Abbara et al., 2020a).

In general, data reported by EWARN and EWARS were incompatible, especially in Idlib governorate, most likely due to different population access. However, both systems have shown a trend of recurring late-summer surges along with a gradual year-on-year increase in reported diarrheal infections. The seasonality

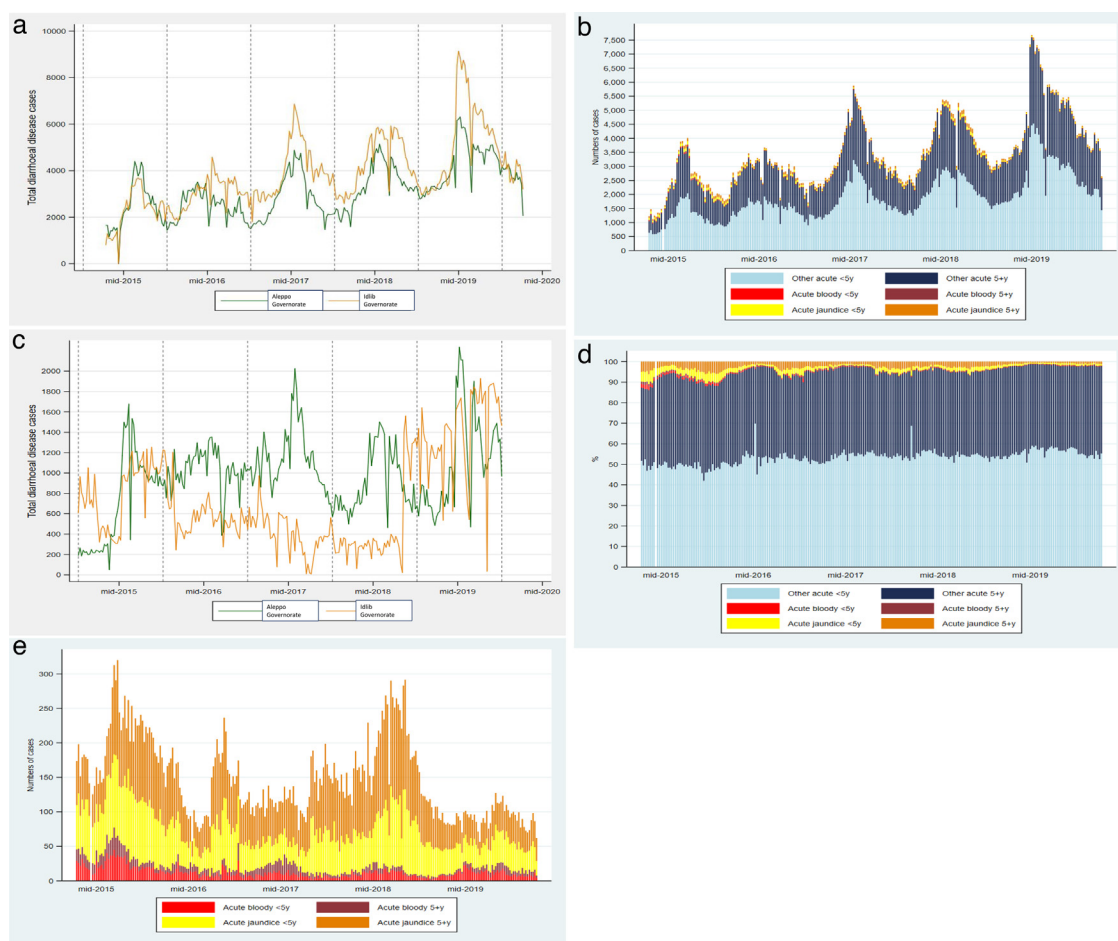
of waterborne diseases is in line with several studies from other developing countries (Kulinkina et al., 2016). For both EWARN and EWARS, there was likely a learning curve as different facilities fed into the reporting systems, and healthcare workers report that reporting accuracy may fall when attacks are at their greatest. This is also reflected in data completion, which increased from when EWARN and EWARS were first implemented to nearing 98–100% more recently.

Trends of waterborne diseases in war zones are likely to be affected by various factors, including combat and destruction events, population movements, undisclosed contamination of water (Schillinger et al., 2020). Inconsistency of reporting could also be a significant factor, especially when safety and security conditions are deficient. Though no direct correlation or cause and effect can be drawn, it is notable that the peak of diarrheal infectious occurs in mid-2019 in the Idlib governorate; this is around the time when this governorate saw the heaviest attacks on its water infrastructure as well as population movements related to an escalation of violence (Figure 3a). In the Aleppo governorate, there was an intensification of attacks on water infrastructure from August to September 2016; the peak in diarrheal cases in mid-2017 was higher than that seen in previous years (Figure 3a). However, the extent to which the disruption of WASH affects these cannot be directly correlated, particularly as mitigation and coping measures, e.g., digging wells, importing water tanks, will have an effect. In addition, the impact of damage to other infrastructure, e.g., electricity, which is required for pumps, cannot be quantified.

### *Weaponization of water in Syria*

The literature review from which the timeline is drawn identifies a number of instances in which the interruption of water (and electricity which also affects water supplies) has been used as a weapon during the conflict (World Bank Group, 2017). This weaponization of water has had detrimental effects on public





**Figure 3.** (a) Trends in total diarrheal disease cases in Idlib and Aleppo governorates, as reported by EWARN (A) and EWARS (B). (b, c, d): Figure 3b and c show the case numbers and proportions of other acute diarrhea, acute bloody diarrhea and acute jaundice syndrome in the under-5 and 5+ years age groups; Figure 3d shows case numbers for acute bloody diarrhea and acute jaundice syndrome only (excluding other acute diarrhea).

health in Syria since the start of the conflict. The lack of clean water has produced a fertile ground for communicable diseases to spread within communities, including polio, hepatitis A and diarrheal diseases (Berkley, 2017; Friedrich, 2016; Sparrow et al., 2016). In 2013, polio re-emerged for the first time in 15 years due to the decreased number of immunizations issued by compromised hospitals (WHO, 2013). Such attacks on WASH and their consequences could represent a form of indirect biological warfare where, rather than the use of biological weapons, by undermining public health measures, communicable disease outbreaks are essentially ‘weaponized’ (Bernard et al., 2020). Children under the age of 5 are 20 times more vulnerable and are more likely to die from a diarrheal disease than violence from the conflict.

More broadly, the literature identifies other indirect health impacts of attacks against water. In cases of chemical attacks such as in Damascus in 2013, the lack of water also meant individuals were inefficiently decontaminated, and thus symptoms of the nerve agent were able to persist and spread (Sparrow, 2014; UNICEF, 2019). Attacks on water sources and facilities have meant, in some cases, that drinking water was contaminated with irrigation water, and in others, the removed supply of electricity from cities that depend on hydroelectric dams (Reznick, 2016; Rudaw, 2018). The risk of malnutrition increases as crops such as wheat that relied on the main water supplies, especially during the drought, had been directly affected, and thus, their yield in 2018 reached a record low in the last 30 years (Akbarzada and Mackey, 2018).

Syria shares its main rivers (Euphrates, Tigris, Orontes, and Yarmouk) with neighboring countries and relies on the Euphrates-Tigris basin in eastern Turkey for most of its water supply; the Euphrates river and its tributaries is by far the most critical in Syria (Factbook). Water resource management in Syria faces several challenges, including the absence of a legal framework on integrated water resources management, weak institutions in charge of water resources management, and the increase in population. As such, there are multiple existing pressures on water resources in the region, including the impact of climate change; the additional destruction of WASH infrastructure, therefore, acts as an additional, exacerbating factor (Mourad and Alshihabi, 2015).

#### Strengths and limitations

For the literature review, there were few credible sources and, although we triangulated to verify particular instances, we relied on news articles or grey literature given the paucity of scholarly literature describing specific attacks. However, some reports, for example, from the World Bank and Mourad et al., provided verifiable information (Mourad and Alshihabi, 2015; World Bank Group, 2017). Additionally, most of the significant disruptions to water in Idlib and Aleppo governorates occurred in the main cities (Maarat al-Numan, Aleppo) with fewer outside of these cities; however, these cities are among the most populated in the governorates. Data from EWARN and EWARS are collected during conflict; however, despite the development of networks and

training provided to staff, there remains a risk of incorrect reporting or under-reporting, particularly when conflict flares. In addition, reported cases do not represent the likely actual figures given inadequate healthcare provision and difficulties accessing transport. However, despite limitations, the syndromic surveillance data provides a helpful indication of the burden of waterborne infections and their trends and affected age groups. Although we found a clear overall upward trend in cases of waterborne infections in the Idlib and Aleppo governorates and multiple targeted attacks on WASH infrastructure, we cannot demonstrate a statistical correlation between the two because we do not have a continuous or reliable measure of WASH provision and because we did not have population denominator data to estimate the incidence of diarrheal disease. Population numbers in Aleppo and Idlib declined over time as people were displaced by conflict or killed; therefore, the overall trend that we observed in diarrheal disease cases would have been steeper if expressed per population.

## Conclusion

We note seasonal trends in waterborne infections, with the highest reported burden being acute other diarrhea with a smaller proportion of acute bloody diarrhea and acute jaundice syndromes. We map these alongside interruptions and attacks on water infrastructure in Idlib and Aleppo governorates, two areas that have been severely affected by Syria's protracted conflict. Though we cannot draw a direct correlation between the two, this work forms a baseline to encourage further study to explore WASH in conflicts and how communities mitigate this impact on health.

## Conflict of interest

All authors declare that they have no conflict of interest.

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This research did not receive any specific grant from funding agencies in public, commercial, or not-for-profit sectors.

## Ethical approval

This secondary data analysis used publicly available surveillance data collected by ACU-EWARN for surveillance. No patient-level or identifiable patient data was used. As such, ethics approval was not sought.

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ijid.2021.05.030>.

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