
RESEARCH ARTICLES

Using the Surveillance Tool EpiWATCH to Rapidly Detect Global Mumps Outbreaks.

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Abstract

Background: Non-validated, rapid intelligence surveillance data is becoming more important in detecting and responding to public health emergencies in the absence of readily available, validated surveillance data published by reputable sources such as WHO or the CDC. There is a lack of timely mumps surveillance data, which is particularly concerning as a resurgence of mumps outbreaks seem to be occurring worldwide in fully vaccinated young adults. **Methods:** Using open-source mumps data obtained between 2016-2019 from the rapid intelligence surveillance tool EpiWATCH, a descriptive analysis was conducted to identify information about the number of confirmed/probable/suspected mumps cases and also the date, country, and location of outbreaks. **Results:** Data entries logged into EpiWATCH detected 65 mumps outbreaks worldwide with a majority of outbreaks occurring in university settings, where a majority of students had been fully vaccinated against the disease. School and university settings were identified as high-risk environments susceptible to mumps outbreaks explained by the prolonged, close-contact nature in which students interact. EpiWATCH was able to detect reported cases of mumps within days of news outlets publishing this information; far quicker than the months it takes for case data to be published by validated sources. EpiWATCH was also able to capture mumps outbreak data not previously detected by WHO or the CDC. **Conclusions:** The resurgence of mumps in fully vaccinated young adults is likely due to secondary vaccine failure and possibly genetic drift of WT mumps strains. Global and readily available mumps surveillance data is lacking; however, EpiWATCH has been successful in somewhat filling these gaps of information and, more importantly, providing surveillance data in a timely fashion. Thus, data from EpiWATCH could be used in the field to improve the speed of detection and response to mumps outbreaks.

Keywords: Mumps, mumps outbreaks, rapid intelligence, EpiWATCH, open-source data

Introduction

There has been a recent resurgence of mumps in many countries around the world, however, timely, comprehensive global surveillance data is not readily available. Traditionally, stakeholders involved in epidemic responses have relied on validated sources of disease surveillance published by governing health bodies such as the World Health Organization (WHO), the US Centres for Disease Control and Prevention (CDC), or country-specific ministries of health or health departments.¹ While these validated sources offer comprehensive surveillance data, they lack the element of timeliness.¹ Easily accessible, albeit non-validated surveillance data, can allow for timely planning and response to health emergencies, specifically infectious disease outbreaks.¹ The absence of timely mumps data is troublesome as outbreaks are occurring in fully vaccinated, young adults; a population that until recently was assumed to have life-long protection against mumps.²

Mumps primarily affects the salivary glands and usually causes mild symptoms in children, but serious complications occur in 15% of cases and are commonly observed in adults who become infected with the virus.^{3,4} Complications include meningitis,

orchitis, deafness and rarely encephalitis resulting in permanent brain damage.³

Since the 1960s, a mumps vaccine has been available and is incorporated into many national immunization programmes (NIPs) in a combined measles-mumps-rubella (MMR) vaccine.⁵ Since its implementation, the incidence of mumps has decreased. Prior to the vaccine, the incidence rate of mumps was between 100-1000 per 100,000 persons per year, with epidemic outbreaks occurring every two to five years.⁶ In most countries, an infant MMR schedule saw the incidence rate of mumps decrease to <1 case/100,000 population per year within 10 years.⁵

Several different viral strains are available for the mumps component of the MMR vaccine, which varies country to country.^{6,7} While the vaccine is nearly 90% effective after two doses, a mismatch may occur between the mumps wild-type strain isolated during an outbreak and the strain contained in the MMR vaccine.^{8,9} These mismatches may result in insufficient protection and explain why outbreaks have occurred in fully vaccinated populations.⁷ Waning vaccine-induced immunity is also possible.¹⁰⁻

The resurgence of mumps outbreaks in the last ten years have affected not only unvaccinated populations, but also adolescents and young adults who have received one or two doses of the vaccine.^{13,14} Fully vaccinated teenagers and young adults have been infected in more than 17 outbreaks of mumps worldwide during this time^{8,15-28} These recent outbreaks have several factors in common, including occurring in densely populated settings with prolonged face-to-face contact of young people, such as in school and university environments.^{8,15,19,20,26} Not only do the dense living and working settings in educational institutions increase their risk of exposure to mumps, but the age range of high school and university students usually represents people >10 years since the second dose of the MMR vaccine was administered.^{18,24-26}

Due to a shortage of readily available global data on mumps and the inability of current surveillance systems to publish reported cases in real-time, techniques such as media scanning, search queries, social media, and other internet-based, open-source data can be used as public health surveillance tools to help detect new or emerging infectious disease outbreaks in a timely manner.²⁹⁻³² EpiWATCH is a rapid intelligence surveillance tool, that uses open-source, internet-based data, such as online news items to provide a global description of outbreaks and an analysis of epidemic patterns as they occur.³³ In this paper, EpiWATCH data from 2016-2019 was used to identify and describe mumps outbreaks around the world.

Aim

The aim of this study was to identify and describe the occurrence of mumps outbreaks around the world using data obtained from EpiWATCH between 2016-2019.

Methods

EpiWATCH is a semi-automated outbreak data collection and analysis observatory that monitors and provides critical analysis of global outbreaks and epidemics of public health significance, by using publicly available sources, such as online news items.³³ It is created and run by the Australian NHMRC Centre for Research Excellence, Integrated Systems for Epidemic Response (ISER).³³ The database has logged over 10,000 news items from 2016 onward that can be searched on disease, date, location and other key words. It is curated, cleaned and enhanced by weekly reviews as new data is collected.³³

A database of EpiWATCH Outbreak Alerts was retrieved for the disease keyword “mumps”, dated between 26 August 2016 to 7 May 2019. Geolocation tags were obtained and mapped. Online news items were logged into EpiWATCH between one to six days after they were published online. These news items were published on legitimate online news sites, and reported information about mumps cases were either from statements made by official health authorities, or statements quoted directly from schools and universities regarding confirmed cases of mumps on campus. News

items were screened by extracting information about the number of confirmed/probable/suspected mumps cases and also the date, country, and location of outbreaks. News items that were not related to mumps and any duplicates of news articles were excluded. News items that were classified as ‘duplicates’ were excluded for one of two reasons: they were either an identical copy of an earlier EpiWATCH logged item published on a different website, or the news item contained identical information regarding confirmed/probable/suspected cases of mumps to an item published and logged in EpiWATCH at an earlier date.

For the analysis, all reported cases were grouped according to geolocation and the date in which they occurred. A descriptive epidemiologic analysis was conducted using Microsoft Excel to identify the number of news items within EpiWATCH pertaining to each outbreak, the total number of reported cases, the length of each outbreak and the location of each outbreak (school, university, general community, etc). If the information was available, the vaccination status of the affected population, the public health response to the outbreak and links to other outbreak reports were also included. Public domain data from WHO³⁴ and the CDC³⁵ were used as comparators to EpiWATCH data to identify the strengths and weaknesses of the EpiWATCH system as a rapid intelligence surveillance tool.

Results

A total of 257 news items for mumps were logged into EpiWATCH for the period of 26 August 2016 to 7 May 2019. Of these, 27 items were excluded as duplicates and 2 news items were excluded for being non-mumps related, resulting in 228 items for analysis. The 228 news items described 65 different outbreaks reported worldwide between 2016-2019. The United States (USA) had the highest number of mumps-related news items with 170 logged entries, and the highest number of identified outbreak clusters (table 1).

Table 2 shows a comparison of mumps reported cases picked up by EpiWATCH and mumps reported cases published by WHO between the years 2016-2019,³⁴ illustrating how EpiWATCH was able to provide outbreak information for several countries for which outbreaks were not reported from WHO, including the USA, Mexico, Brazil, Malaysia, The Marshall Islands and Tonga. Neither EpiWATCH nor WHO captured data for Ireland for the year 2016. The USA data was available from the US CDC website, however, annual notifiable disease data were only updated to the year 2017 when checked in mid-July 2019.³⁵

Iraq, USA and Mexico experienced the highest number of reported mumps cases in the study period, and Australia, Malaysia, Spain, Portugal, Ireland and the Netherlands all had less than 100 reported cases each (table 2).

Table 1: EpiWATCH logged news items (n = 228) by country 2016-2019. Some data are presented as ‘more than’, ‘several’ or ‘approximately’ where specific case numbers were not defined in online news items.

WHO region	Country	Number of EpiWATCH news items	Number of outbreaks	Number of reported cases (2016-2019)
Americas	USA	170	44	>5,697
Americas	Canada	22	6	>1,505
Americas	Mexico	1	1	>2,619
Americas	Brazil	3	1	>400
Western Pacific	New Zealand	18	1	>1,000
Western Pacific	Australia	2	1	20
Western Pacific	Malaysia	1	1	21
Western Pacific	Marshall Islands	2	1	~3,000
Western Pacific	Tonga	1	1	>1,600
Europe	Spain	2	2	45
Europe	Portugal	1	1	14
Europe	Ireland	1	1	‘several’
Europe	Netherlands	1	1	8
Europe	England	2	2	713
Eastern Mediterranean	Iraq	1	1	>3,400

Table 2: EpiWATCH total reported cases of mumps, by country 2016-2019, compared to WHO total reported cases of mumps, by country 2016-2018 (WHO data last updated 15 July 2019)³⁴.

WHO region	Country	2019		2018		2017		2016	
		EpiWATCH	WHO	EpiWATCH	WHO	EpiWATCH	WHO	EpiWATCH	WHO
Americas	USA	180		>1,304		>643	6,109	>3,570	6,369
Americas	Canada			20	723	>1,480	2,157	5	309
Americas	Mexico			>2,619					3,646
Americas	Brazil					>400			
Western Pacific	New Zealand			>1,000	442		1,337		20
Western Pacific	Australia				634	20	806		800
Western Pacific	Malaysia			21					103
Western Pacific	Marshall Islands					~3,000			
Western Pacific	Tonga				0	>1,600			0
Europe	Spain				9,129	45	10,082		4,999
Europe	Portugal				106	14	179		138
Europe	Ireland	‘several’			575		318		
Europe	The Netherlands	8			73		46		71
Europe	The United Kingdom and Northern Ireland	263			1,398	45	2,360		974
Eastern Mediterranean	Iraq				17,334		36,367	>3,400	73,939

Blank spaces indicate no available data. Some data are presented as ‘more than’, ‘several’ or ‘approximately’ where specific case numbers were not defined in online news items.

The majority of the reported mumps outbreaks occurred in universities (35 of the 65 outbreaks),

followed by the general community (14/65), a combination of primary/high schools + universities (9/65), primary/high schools only (4/65), immigration and customs enforcement (ICE) facilities (2/65), and one outbreak in a Quebec hospital setting (table 3).

Table 3: EpiWATCH outbreaks (n=65) by location.

Location	Outbreaks
Universities only	35
General community	14
Both schools and universities	9
Schools only	4
ICE facilities	2
Hospitals	1

Reported mumps cases that were extracted from new items logged in EpiWATCH in the USA between 2016-2017 (figure 1a in appendix) offer a comparison to official mumps notifications as published by the CDC for the same time period (figure 1b in appendix). According to CDC data³⁵, mumps notifications occurred in 49 states between 2016-2017; EpiWATCH detected reported cases of mumps in 22 of those states (and reported cases in 26 states for the period of 2016-2019). The highest number of reported cases occurred in Arkansas, with 2,300 reports, similarly illustrated by CDC data, with Arkansas also experiencing the highest number of mumps notifications for the country, with 2,953 notifications.

Discussion

A global resurgence of mumps has occurred in the last ten years, despite high vaccination rates in many affected countries.^{13,14} Particularly in the USA, this resurgence appears to be due to secondary vaccine failure.¹² Contrasting evidence exists regarding the length of protection offered by the MMR vaccine.¹⁰⁻¹² Some studies suggest that people become susceptible to mumps infection approximately 13 years following vaccination with the second dose of MMR. Whereas, other studies propose that vaccine-induced immunity appears to last approximately 27 years (95% CI 16 to 51 years) after receiving the last dose of the vaccine.¹⁰⁻¹² Despite differing evidence on the exact length of protection offered, several papers confer that the MMR vaccine does not offer life-long protection against mumps virus.¹⁰⁻¹² Additionally, several wild-type (WT) strains of the virus are known to circulate in the same geographic region simultaneously, making it challenging to produce an effective vaccine.⁶ Genetic drift of WT mumps strains and secondary vaccine failure coupled with densely populated environments thereby are two potential explanations of why a resurgence of outbreaks has been observed.^{12,19}

Table 2 contains many missing data points from both WHO and EpiWATCH surveillance systems. The lack of

data points from WHO, especially for the years 2018 and 2019, illustrates the delay of mumps case information and further emphasises that timely, comprehensive global surveillance data from official sources are not readily available.

In some instances, EpiWATCH was able to collect reported mumps cases and outbreak events that were not captured by official WHO surveillance data. As shown in table 2, no mumps data was captured by the WHO for Brazil and the Marshall Islands in the last three years. However, EpiWATCH data showed reports of a 2017 outbreak in Brazil resulting in over 400 reported cases of mumps. EpiWATCH data also captured an outbreak of over 3,000 reported cases of mumps in 2017 in the Marshall Islands. This outbreak was reportedly linked to an imported case of mumps from a 2016 outbreak of mumps in Arkansas, USA.³⁶ During the Arkansas outbreak, the Marshallese population residing in Arkansas were greatly affected because of their close-knit living quarters.³⁷ WHO surveillance data did not have reports for Tonga in 2017, however, EpiWATCH news items indicate a mumps outbreak of over 1,600 reported cases that occurred on the island. The lack of data points from EpiWATCH compared to WHO data show that it is not a perfect surveillance system and must be corroborated to be actionable and relevant. However, it succeeds in providing some information related to epidemic intelligence in the absence of official surveillance data.

Surveillance data published by WHO is based on data reported in the Joint Reporting Form (JRF); a questionnaire sent to the Ministry of Health of all WHO member states.³⁸ Gaps in WHO surveillance data for Tonga in 2017, and for the last three years in Brazil and the Marshall Islands, is due to the absence of mumps surveillance data in the JRF of those countries.³⁸ National reporting practices and laws differ between countries and the routine reporting of many infectious diseases does not occur due to the burden it would place on under-resourced health services.³⁹ Some developing

countries may also entirely lack surveillance systems for certain infectious diseases. This could explain the absence of WHO mumps surveillance in Tonga, Brazil and the Marshall Islands. EpiWATCH is able to somewhat fill this information gap in countries where official surveillance data are not available. While EpiWATCH data must be corroborated to be actionable and relevant, it succeeds in providing a general foundation of timely information related to epidemic intelligence in the absence of official surveillance data. It is particularly important to identify reported cases and potential outbreaks of disease in developing countries lacking suitable surveillance systems and/or in countries that have strong surveillance systems but are unwilling to report the existence of an outbreak because of potential backlash to tourism, politics and trade.⁴⁰

Published CDC data showing annual mumps notifications in the USA were only available up until the year 2017 (when checked in mid-July 2019), illustrating a lag in the publication of data for the year 2018.³⁵ The only mumps data available for 2018 is illustrated in a single bar graph indicating 2,251 notifications occurred that year. Thus far, 1,799 notifications have occurred in 2019.⁴¹ However, this data was only made available in late-July 2019, is classified as 'preliminary' and is subject to change, and has not been officially published in the CDC's Morbidity and Mortality Weekly Report (MMWR) summary of infectious diseases.⁴¹ It is important to note that despite this delay, the CDC is exceptional compared to many other countries in providing comprehensive mumps surveillance data and was able to detect more mumps notifications than those logged in EpiWATCH.

During the period 2016-2017, EpiWATCH detected mumps reports in 22 states of USA, compared to CDC data, which showed that notifications occurred in 49 states (figure 1a and 1b in appendix)³⁵. This illustrates that in a high income country with good surveillance systems, more complete data is available through formal surveillance.

Combined data from WHO and EpiWATCH both failed to capture mumps reports for Mexico in 2017, Brazil in 2016 and 2018, Malaysia in 2017, and Ireland in 2016. Despite EpiWATCH capturing some events in these countries in years that WHO was not able to, large surveillance gaps continue to exist globally in capturing reports of mumps, particularly in non-English speaking countries. This illustrates the importance to further develop open-source data systems to become more sensitive in capturing reports globally. Doing so could improve early detection and response to emerging infectious disease events, not only in low-resource, non-English speaking countries, but also in developed, English speaking countries, such as Ireland.

The majority of identified mumps outbreaks occurred in primary schools, high schools and universities, and affected teenagers and young adults. Several reported cases identified through EpiWATCH highlight that these outbreaks occurred in many partially and fully vaccinated students. In school and more so in university settings, students have prolonged, close contact with one

another, creating an environment where disease can rapidly spread.¹⁹ This reinforces the notion that two doses of the vaccine does not offer adequate protection against outbreaks in close-contact environments, presenting school and especially university settings as high-risk environments for mumps.¹⁰ Several schools and universities affected by outbreaks reportedly implemented public health interventions to control the situation. These included offering a third dose of the MMR vaccine free of charge to university students and forcing unvaccinated students at affected schools to remain home for 26 days (one day more than the maximum incubation period for mumps) from the onset of the outbreak.^{42,43} Some states in the USA also implemented free MMR clinics for catch-up doses of the vaccine.⁴⁴

Of the EpiWATCH detected outbreaks, 14 of them occurred in the general population (i.e. not occurring in schools and universities), affecting unvaccinated, partially vaccinated and fully vaccinated adults. Recently updated CDC guidelines state that two doses of the MMR vaccine seem to be sufficient for mumps control in the general population, however this does not appear to be the case.¹⁰ Two of the most severe outbreaks within the USA, that occurred in Alaska and Hawaii, did not occur in schools or universities, and reportedly affected many fully vaccinated adults.^{45,46} EpiWATCH data (figure 1a) showed that more than 44 confirmed and probable reports of mumps occurred in Alaska in a 2017 outbreak, which continued into 2018 and resulted in a total of 251 reported cases. Additionally, over 1,009 confirmed reports of mumps occurred in the general Hawaiian population in an outbreak lasting 19 months between 2017-2018.⁴⁶

It is important to note that some of the identified outbreaks occurred because of low vaccination rates in the general population.^{47,48} EpiWATCH detected an imported case of mumps into New Zealand in 2017 which quickly resulted in an outbreak. Transmission of the disease rapidly spread from the North Island to the South Island, resulting in over 800 confirmed and probable reports of mumps in Auckland, and over 200 confirmed and probable reports in Otago.^{49,50} Despite 50%-70% of these reported cases occurring in people aged 10-19 years, over 60% of these reports occurred in the under-vaccinated or unvaccinated Indigenous population.⁵¹ Data from the New Zealand Ministry of Health indicate that 87.8% of children at five years of age are up to date with immunisations, with this rate dropping as low as 48.1% within some ethnic populations in the country, giving claim to news items logged in EpiWATCH that the 2017 outbreak in New Zealand did occur due to low population vaccination rates.⁵²

EpiWATCH detected two outbreaks which occurred in ICE facilities in Texas in February 2019, resulting in 27 reported cases of mumps. It is unclear how many of these reported cases affected detainees and what number affected staff of these facilities. It is also unknown whether these outbreaks were due to low vaccination rates or waning immunity, as immunization records are

usually unavailable for detainees in ICE facilities.⁵³ Limited published studies exist on disease outbreaks within US detention centres, however, one study which examined a 2016 measles outbreak in an Arizona detention centre determined that a high proportion of detainees had received at least one dose of MMR.⁵³ Additionally, most of the detainees in US detention centres originate from the Americas, where median vaccination coverage has been >90% since the 1990s.⁵³ The two mumps outbreaks which occurred in ICE facilities were therefore likely due to close living quarters, resulting in high exposure rates, coupled with either under-vaccination or waning immunity in cases.⁵³

The mumps outbreak occurring in a hospital in Quebec is particularly concerning. Reportedly, five confirmed and probable cases of mumps occurred in health care workers (HCWs) at a hospital in Quebec.⁵⁴ It is unclear how this outbreak began, though it can be assumed that the HCWs were fully vaccinated against mumps, as it is standard practice for all HCWs to be protected and up to date with immunizations. This suggests the need for a third dose of the vaccine for HCWs and other people deemed high-risk for mumps.

EpiWATCH was successfully able to identify outbreaks in low- and middle-income countries (Brazil, Tonga and the Marshall Islands) that were not captured by official reporting systems such as the WHO. News items logged into EpiWATCH came from reputable sources such as ProMED and social media accounts run by National Health Departments of those countries. It is unknown why these cases were not officially reported to the JRF which would allow WHO to publish this data. There could be a failure of official surveillance systems to capture these events due to limited resources in the country of origin to effectively report on outbreaks in a timely manner. Additionally, the failure of these countries to officially report cases of mumps could be due to an unwillingness to be publicly associated with such outbreaks for fear of large national and private-sector costs or concern that it could impact tourism.⁴⁰

Several limitations exist, most importantly that EpiWATCH uses open source, unvalidated data. Therefore, a prominent media-driven bias exists and must be acknowledged when analysing the data. Ascertainment bias also occurs, as there are significantly more data entries logged from high-income, English-speaking countries, despite outbreaks commonly being more frequent and severe in low-income, non-English speaking countries. This is observed in the USA's significantly higher number of news items logged compared to Iraq, where tens of thousands of cases occur annually.³⁴

EpiWATCH data cannot estimate vaccination status of affected populations, does not provide information about the WT strain of mumps responsible for outbreaks and does not provide information about the severity of reported cases. For example, information about hospitalisations and deaths from reported mumps cases were not specified. EpiWATCH appears to be more successful at capturing large-scale, outbreak events and

fails to detect smaller, yet equally important events. Lastly, EpiWATCH is a reasonably new surveillance tool so information about its attributes is not currently available.

Conclusion

A global resurgence of mumps has been observed in the last 10 years, and is particularly concerning as outbreaks of the disease are occurring in fully vaccinated populations. This resurgence is likely due to secondary vaccine failure and possibly genetic drift of WT mumps strains. Timely global surveillance of the disease is lacking, particularly in low-income countries, highlighting the need for a more comprehensive reporting system. For example, while Annual Health Reports published by the Ministry of Health for the Marshall Islands and Tonga are available online, the most recently published report was in 2016 for Tonga and 2011 for the Marshall Islands.^{55,56} Furthermore, these Annual Reports contained no data on mumps.^{55,56} EpiWATCH fills gaps such as these by using open-source data to provide a general foundation of timely information related to epidemic intelligence in the absence of immediate, official surveillance data. While validated data from sources such as WHO, the CDC and national ministries of health are most widely used for global outbreak news, these sources are less timely than rapidly available, open-source data.¹ Open-source data improves early detection and therefore planning and response to emerging infectious disease events.⁵⁷ The importance of EpiWATCH stems from the need for timely and reliable epidemic intelligence to detect outbreaks, particularly in developing countries with a high infectious disease burden. EpiWATCH acts as a low-cost but effective form of surveillance to rapidly detect and monitor global emerging and reemerging infectious disease threats, including those which could become public health emergencies of international concern.

Supplemental Information

Supplemental figures for this article can be found [here](#):

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