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Pacific-wide simplified syndromic surveillance for early warning of outbreaks

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The International Health Regulations require timely detection and response to outbreaks. Many attempts to set up an outbreak early warning system in Pacific island countries and territories (PICTs) have failed. Most were modelled on systems from large countries; large amounts of data often overwhelmed small public health teams. Many conditions required overseas laboratory confirmation, further reducing timeliness and completeness. To improve timeliness and reduce the data burden, simplified surveillance was proposed, with case definitions based on clinical signs and symptoms without the need for laboratory confirmation or information on symptoms, location, sex and age. After trials in three PICTs, this system was implemented throughout the Pacific. Enthusiastic adoption by public health staff resulted in 20 of 22 PICTs reporting weekly to the World Health Organization within 12 months of starting to use the system. In the first year, the system has detected many infectious disease outbreaks and facilitated timely implementation of control measures. For several Pacific countries and territories, this is the first functional and timely infectious disease surveillance system. When outbreak detection is the principal objective, simplification of surveillance should be a priority in countries with a limited public health system capacity.

Keywords: early warning; syndromic surveillance; Pacific; infectious diseases; outbreak detection; outbreak response

Background

The International Health Regulations (IHR), updated in 2005 and adopted by all World Health Organization (WHO) member states, require that countries have the capacity to detect, assess, notify and report public health events of potential international concern, including infectious disease outbreaks, in a timely fashion (World Health Organization 2008a). The feasibility of all countries acquiring the surveillance capacity to comply with this requirement has been questioned (Fidler and Gostin 2006). The 2009 influenza pandemic confirmed the limited capacity of

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many countries to meet IHR requirements, particularly with regard to surveillance and response (Wilson *et al.* 2010).

A combination of surveillance methods has been suggested as part of IHR implementation, including rumour surveillance, event-based surveillance and indicator-based surveillance. The latter category includes 'classic' notification of numbers of cases of disease or syndromes (World Health Organization 2008a). For a discussion of the different types of surveillance systems, see, for example, the textbook by Teutsch and Churchill (2000).

The Pacific Ocean covers approximately a third of the earth's surface. It contains about 3000 islands in 22 countries and territories, including several of the world's smallest independent countries: seven Pacific island countries and territories (PICTs) have fewer than 25,000 residents (World Health Organization 2010, Secretariat of the Pacific Community 2011b). Some of the remotest areas in the world are in the Pacific. The PICTs are culturally and ethnically diverse, and at vastly different levels of development. Not including New Zealand, the Pacific islands region was estimated in June 2011 to have a population of 10 million, 6.7 of whom lived in Papua New Guinea (Secretariat of the Pacific Community 2011b).

Rates of infectious diseases are high in the Pacific (Singh *et al.* 2001, World Health Organization 2008b, Gani 2009, Johnson *et al.* 2010, UNESCAP 2011). The impact of infectious disease epidemics in the Pacific is exacerbated by a limited health infrastructure, geographic isolation, infrequent transportation and an inadequate communication infrastructure (Nelesone *et al.* 2006). In addition, populations are sometimes immunologically naive to imported diseases, leading to higher attack rates and increased severity (Morens *et al.* 2004, Duffy *et al.* 2009). Rates of non-communicable diseases, such as diabetes and heart disease, are among the highest in the world as well, increasing the vulnerability to infectious diseases. Historically, epidemics have impacted the Pacific severely. The first introduction of measles resulted in 40% mortality in Fiji in 1875 (Morens *et al.* 2004) and the 1918 'Spanish Flu' caused up to 25% mortality on some islands (McLeod *et al.* 2008). Notable recent epidemics include cholera, typhoid fever, dengue and influenza.

Outbreak detection and response in PICTs are constrained by the limited availability of trained public health workers who have to divide their time between many priorities. In the past, Pacific small island nations have tried to implement ambitious disease notification systems, based on the routine notifiable disease systems that have been in use by most larger countries of the world since the first half of the twentieth century. These 'classic' surveillance systems rely on clinicians making or suspecting a diagnosis, confirming this suspicion by laboratory diagnosis and then notifying health authorities when the condition is on a predefined list. The number of notifiable conditions in Pacific island countries typically varied from 20 to over 60. Many of these conditions required overseas laboratory confirmation, and, in practice, were rarely reported. In addition, many systems required a detailed breakdown of age groups, sex, and other parameters. As an example, one PICT used a form with over 430 fields to be filled in monthly by all clinics. These large amounts of data overwhelmed national surveillance units (often just one person). Another problem noted frequently is that clinicians often are reluctant to report a suspected diagnosis before it has been confirmed by an overseas laboratory. The resulting poor sustainability, timeliness, and completeness made these systems ineffective for outbreak detection.

Syndromic surveillance has been implemented in a limited number of developing countries in Africa and Asia (Durrheim *et al.* 2001, John *et al.* 2004). Case definitions are based on clinical signs and symptoms rather than laboratory confirmation, making it particularly useful in settings with limited access to laboratories, a common feature in most PICTs. The gain in timeliness provided by a syndromic system is substantial (Nelesone *et al.* 2006).

To address the need for improved early warning, we proposed to simplify surveillance as much as possible with as little data as possible to be collected for the early warning of the most common outbreak-prone diseases.

Methods

Pilot projects

We conducted a literature review and consulted with technical experts (national counterparts, Secretariat of the Pacific Community (SPC), WHO Regional Office, regional academic institutions, and the US Centers for Disease Control and Prevention). A functional model for syndromic surveillance of outbreak-prone conditions with its core components was first trialled successfully in India and in a southern African rural setting (Durrheim *et al.* 2001, John *et al.* 2004).

The core theoretical components of these systems were adapted and trialled in Tuvalu to validate their application in a remote Pacific Island setting (Nelesone *et al.* 2006). A similar system was also trialled in Niue and Nauru. Guam and French Polynesia had independently implemented reporting systems that included disease syndromes.

During the 2009 influenza pandemic, a Pacific regional surveillance system was implemented by the WHO in collaboration with all PICTs and the SPC. This consisted of reporting of syndromic influenza-like illness (ILI) cases as well as laboratory-confirmed influenza (Musto *et al.* 2010).

At a meeting in Madang in 2009, Pacific Ministers of Health reviewed the experience with simplified syndromic surveillance and requested that the WHO and the SPC further develop a standardised simplified syndromic surveillance system (SSS) for the Pacific based on the experiences in Tuvalu, Niue, Nauru, French Polynesia and Guam.

Decision-making process

A meeting was organised in March 2010 for IHR national focal points and surveillance coordinators from all PICTs. After extensive discussions, participants selected a core set of four syndromes, agreed on procedures and timelines for reporting, and determined appropriate responses to each syndrome. It was agreed that each Pacific jurisdiction would implement the system within 12 months and that an evaluation would be conducted after one year.

Case definitions used

The agreed standardised Pacific SSS focuses on the reporting of four core syndromes: acute fever and rash, diarrhoea, ILI, and prolonged fever; all using standard case definitions (Table 1). The syndromes were selected to cover major outbreak-prone

Table 1. Case definitions for the four core syndromes.

Syndrome	Case definition	Important diseases to consider
Acute fever and rash	Sudden onset of fever,[a] with acute non-blistering rash	Measles, dengue, rubella, meningitis, leptospirosis
Diarrhoea	Three or more loose or watery stools in 24 hours	Viral and bacterial gastroenteritis including cholera, food poisoning, ciguatera fish poisoning
Influenza-like illness (ILI)	Sudden onset of fever,[a] with cough and/or sore throat	Influenza, other viral or bacterial respiratory infections
Prolonged fever	Any fever[a] lasting 3 or more days	Typhoid fever, dengue, leptospirosis, malaria, other communicable diseases

[a]Fever is defined as 38°C/100.4°F or higher. If no thermometer is available, fever or chills reported by the patient or the caregiver are also acceptable.

infectious diseases that are important for the Pacific, and which can be recognised with reasonable sensitivity and specificity by using a limited number of easy to assess signs and symptoms (Pavlin *et al.* 2010). All case definitions were based on existing internationally accepted standards and examples. An effort was made to keep the definitions practical and simple.

Integration with existing surveillance systems

The system complements existing surveillance systems and, where possible, builds on existing data-collection mechanisms, reporting pathways and response procedures. It does not replace the need for laboratories to report confirmed cases of important outbreak-prone diseases, such as leptospirosis, influenza, dengue and typhoid fever. It does, however, replace the routine collection of large quantities of data about individual patients in situations where such data would not be used for early warning purposes (World Health Organization and Secretariat of the Pacific Community 2010a).

Flexibility of implementation

To avoid overwhelming the national data management capacity, most countries chose to initially introduce the SSS at one or a few sentinel sites, usually the largest hospitals, and not to attempt population-wide coverage. The rationale was that significant outbreaks would result in increased cases presenting at the major health-care sites. The number of sentinel sites varies by PICT, from 1 to 25 (Paterson *et al.* 2012).

Data collection methodology also allowed some flexibility. Some countries rely on data extraction from outpatient department logbooks; others use a form with two to five questions posed to a patient by a triage nurse when the patient presents. Doctors and nurses interviewing and examining patients were trained on the case definitions and encouraged to note these on specific forms or in specific columns in logbooks. New Caledonia, Guam and French Polynesia already had well-functioning weekly surveillance systems and decided to retrieve the case numbers from these systems. The Cook Islands were able to add a simple entry screen to their electronic medical records system, and two countries (Fiji and Papua New Guinea) have implemented reporting using mobile phones.

Reporting pathways, feedback reporting and timing

At the beginning of each week, sentinel sites report their tallies from the previous week to the national level. National surveillance coordinators review this data and note any unexpected increase in cases. National coordinators report the numbers weekly to the WHO Pacific Support Division in Fiji, and they are actively reminded if the report is not received on time. National coordinators are also encouraged to produce a one-page surveillance bulletin every four weeks for feedback to their reporting sites and other stakeholders. Each Thursday the WHO posts information generated from the SSS on the 'PacNet' email list server (Pacific Public Health Surveillance Network 2011) and on the Internet (Secretariat of the Pacific Community 2011a, World Health Organization 2011), so that PICTs are informed about communicable disease activity in nearby jurisdictions, and to allow regional trends to be identified. An automated system has been developed using Microsoft Excel, with plans to migrate to Microsoft Access. A report table lists the number of cases of the four syndromes by PICT for the week concerned, highlighting numbers that exceed 90% of numbers reported by that country in all previous weeks (Figure 1). A set of 20 small charts shows the trend of cases of diarrhoea, ILI and prolonged fever for the last 26 weeks (i.e., half a year) in each participating PICT (Figure 2).

Pacific Syndromic Surveillance -- weekly report

Year: 2011 | Week: 47 | ending on 27 November 2011

Country / Area	Last update received	Sites reporting	Acute fever and rash Sudden onset of fever with acute nonblistering	Diarrhoea 3 or more loose or watery stools in 24 hrs	Influenza-like illness Sudden onset of fever, plus: cough and/or sore	Prolonged fever Any fever lasting 3 days or longer
American Samoa	29 Nov 2011	3	0	26	54	1
Cook Islands	29 Nov 2011	12	0	7	0	0
Federated States of Micronesia	30 Nov 2011	4	1	16	25	2
Fiji	30 Nov 2011	7	13	173	596	24
French Polynesia	30 Nov 2011	15		45	21	1
Guam	29 Nov 2011	1		1	1	
Kiribati	30 Nov 2011	2	1	54	105	17
Marshall Islands	1 Dec 2011	2	16	16	56	95
Nauru	1 Dec 2011	1	0	13	0	0
New Caledonia	30 Nov 2011	8		2	0	27
New Zealand	30 Nov 2011	21			34	
Niue	29 Nov 2011	1	1	6	16	1
Northern Mariana Islands	30 Nov 2011	2	0	6	25	1
Palau	29 Nov 2011	1	0	25	34	2
Papua New Guinea	30 Nov 2011	1	0	0	0	0
Pitcairn Islands	1 Dec 2011	0	0	0	0	
Samoa	30 Nov 2011	2	1	13	87	0
Solomon Islands	30 Nov 2011	4	6	27	44	13
Tokelau	29 Nov 2011	1	0	6	10	0
Tonga	30 Nov 2011	1	0	20	30	0
Tuvalu	1 Dec 2011	1	0	0	7	0
Vanuatu						
Wallis & Futuna	27 Nov 2011	1	0	6	8	0

Figure 1. Syndromic Surveillance weekly summary table for week 47, 2011, as distributed through the PacNet email list server. The table is generated by a Microsoft Excel spreadsheet, automatically highlighting case numbers that exceed 90% of historical values. The high numbers of cases in the Marshall Islands were caused by an epidemic of dengue.

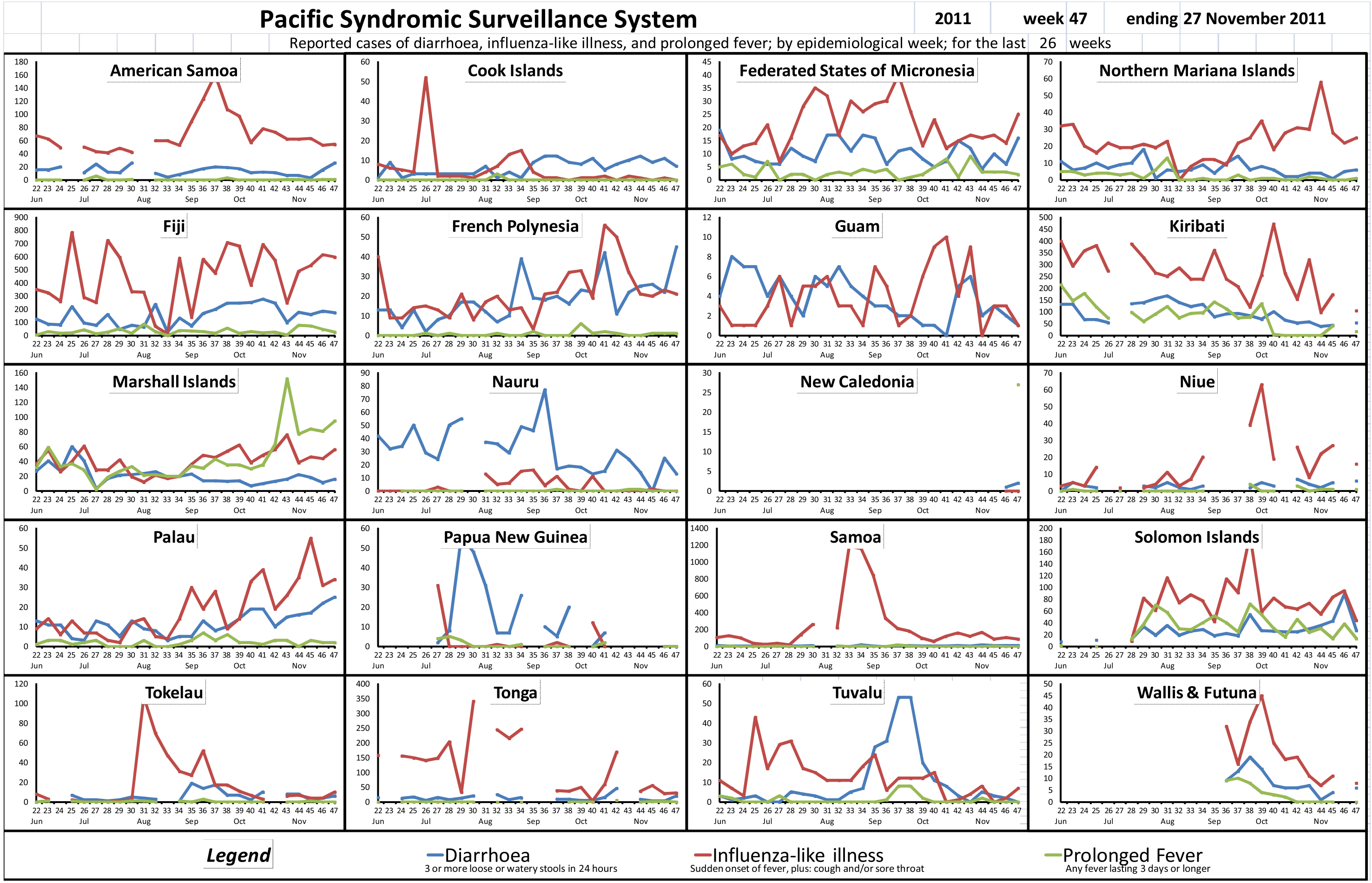

Figure 2. Pacific Syndromic Surveillance weekly summary charts for week 47, 2011, as distributed through the PacNet email list server. Influenza-like illness outbreaks are visible in Cook Islands, American Samoa, Samoa, Solomon Islands, Tokelau, Tuvalu, and Niue. Several of these were later confirmed as influenza by laboratory, and some were found to be caused by identical strains. Diarrhoeal disease outbreaks are visible in Tuvalu and Tokelau: these were related to a drought. The high numbers of prolonged fever and ILI in the Marshall Islands were associated with a dengue outbreak.

In addition, a weekly narrative is included in the email body, providing more information on current outbreaks and other public health events of concern, as provided by the national health authorities and other sources.

Implementation support

Each PICT received on-site support from the SPC or WHO to implement the system. PICTs have further been supported by remote consultation with the two agencies; for example in the establishment of thresholds or through the provision of advice for the investigation of potential outbreaks. To further facilitate the implementation and troubleshooting of the Pacific SSS, the 'Practical Guide for Implementing Syndromic Surveillance in PICTs (World Health Organization and Secretariat of the Pacific Community 2010a) was developed by the WHO and SPC and made freely available to the PICTs. A 'Pacific Outbreak Manual' (World Health Organization and Secretariat of the Pacific Community 2010b) was also developed by the two agencies in consultation with PICT representatives. This manual provides advice on dealing with outbreaks of each of the four syndromes (including differential diagnosis, confirmation strategies and control methods).

Results

Outbreak identification

When a graphic representation is used to highlight the trends, it is easy to recognise unusual increases in reported cases (Figures 2–5). After several months of data had been collected, several PICTs established thresholds based on historical averages and standard deviations, using simple formulae in computer spreadsheets. As data become available for multiple years, it will be possible to establish thresholds that take seasonal variations into account.

Three examples from Fiji, Nauru and Tuvalu illustrate the usefulness of the SSS. Two peaks in ILI cases in Fiji were later confirmed in the laboratory as influenza. The Fiji example also shows a way to account for variations in the number of reporting sites, as employed by several PICTs (Figure 3). A large outbreak of diarrhoea in Nauru at the beginning of 2011, caused by a breakdown of drinking-water disinfection, was identified by the surveillance system (Figure 4). The rapid detection enabled a timely response: the public was warned and additional chlorine was added to the reticulation system, resulting in rapid interruption of the outbreak. Figure 5 shows reported cases of ILI and diarrhoea in Tuvalu from November 2010 to September 2011. At least two peaks of ILI are visible, in weeks 6 and 19. The peak in week 6 was later confirmed as an outbreak of influenza A/H1N1; the week 19 peak was later confirmed as an outbreak of influenza B. A sharp rise in cases of diarrhoea is visible more recently and is associated with a severe drought. In all three outbreaks in Tuvalu the syndromic surveillance resulted in a timely recognition so that control measures could be implemented.

Discussion

For many PICTs, the Pacific SSS provides for the first time a well-functioning and timely reporting system that enables them to achieve some of the key capacities

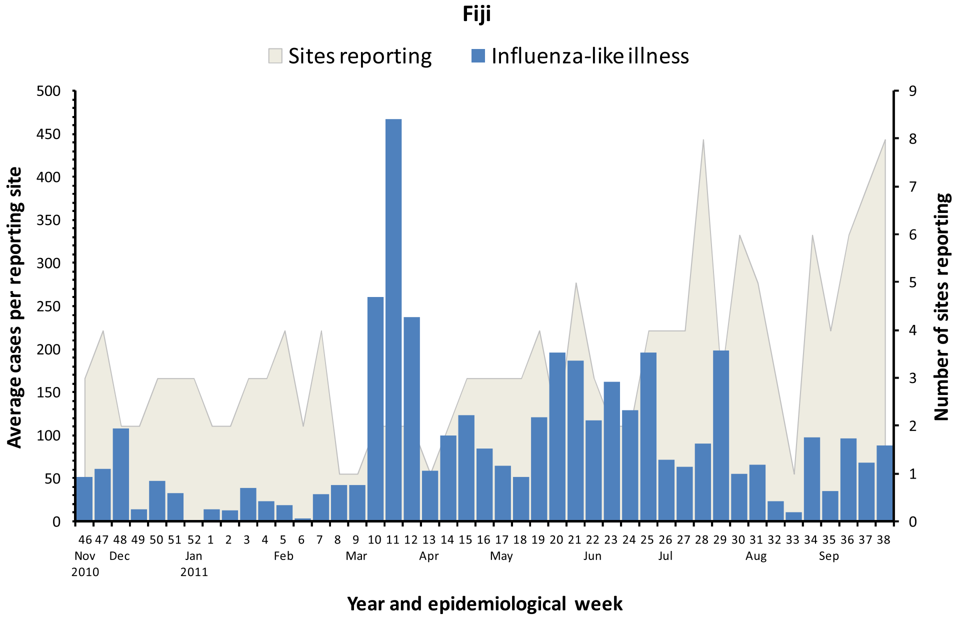

Figure 3. Cases of influenza-like illness and number of sites reporting in Fiji, from November 2010 to September 2011, by year, month, and epidemiological week. The number of sites that were reporting varied substantially, and this affected the numbers of reported cases; to adjust for this, the average number of cases per site per week is shown. An outbreak of influenza A caused the peak in week 11; the cluster between weeks 19 and 25 was caused by influenza B. (Laboratory information is courtesy of the Fiji Ministry of Health).

required under the IHR. Attaining these capacities can be challenging for countries with limited public health resources (Fidler and Gostin 2006, Wilson *et al.* 2010). Important factors in the success of the Pacific SSS are the low data burden; strong support at all levels of health ministries and departments; the piloting of SSS by a number of PICTs; flexibility of implementation; and active participation in decisions on case definitions and procedures, the latter assuring ownership by PICT health authorities.

A stand-out feature of this system, when compared to previous systems, is its simplicity and the focus on a limited number of syndromes that are relevant to the region and can be assessed easily through the use of practical case definitions. In the past, Pacific small island nations have had complicated disease notification systems that were difficult to sustain and may not have been a priority for busy public health workers. In addition, many important diseases could only be confirmed in overseas laboratories. As a result, many surveillance systems suffered long delays before the reported information was analysed and reported, significantly weakening their early warning and response functionality.

Limitations of the system are mostly related to the simplification and data-burden reduction. The exclusive reporting of syndromes means that a diagnosis will not be available at the time when an increase in cases is first noticed and reported. The omission of sex and age information, geographic location, and symptoms means that an additional investigation will be required whenever an outbreak is suspected.

In most cases, such an investigation can be straightforward and rapid, such as reviewing some patient information and discussing the cases with attending clinicians, but in some cases a full-fledged investigation with line lists, epidemic curves and specimen collection may be necessary.

Most PICTs chose to implement a sentinel surveillance model, so that only trends can be detected, but no population-based incidence rates or total number of cases estimated. If such information is needed, then this, too, will require additional surveys and investigations. Comparison of case numbers or rates between countries is not possible, because of differences in data collection methods and the absence of accurate denominator data. In PICTs with more than a few reporting sites, the number of sites reporting can vary substantially per week. To achieve good reporting completeness, active follow-up and reminders by the national surveillance coordinator is required. Some degree of adjustment for the variation in the number of reporting sites can be attempted, for example, by calculating the average number of cases per reporting site, as shown in Figure 3.

Experience with syndromic surveillance in a number of low- and middle-income countries in different regions, including Asia, Africa, and now the Pacific, has clearly demonstrated its usefulness across different epidemiological, ethno-cultural and socio-economic contexts. The generic attributes are clearly translatable and flexible to local adaptation.

In a region where infectious disease outbreaks and epidemics are not uncommon, the ability to detect outbreaks is of high public health importance. In its first year of

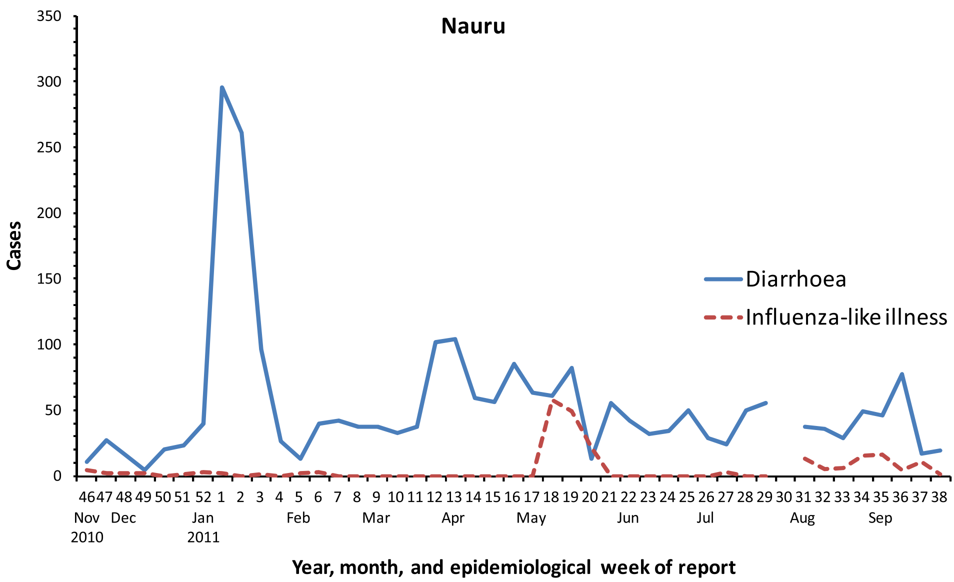

Figure 4. Cases of diarrhoea and influenza-like illness in Nauru, reported through the syndromic surveillance system. The outbreak in diarrhoeal illness in January 2011 was caused by a breakdown in water disinfection. After the health authorities were alerted by the syndromic surveillance data, they were able to quickly interrupt the outbreak by adding chlorine to the drinking water. No data was reported to WHO in week 30. (Outbreak information is courtesy of Drs Soakai, Tangitau and Soe, Nauru Ministry of Health).

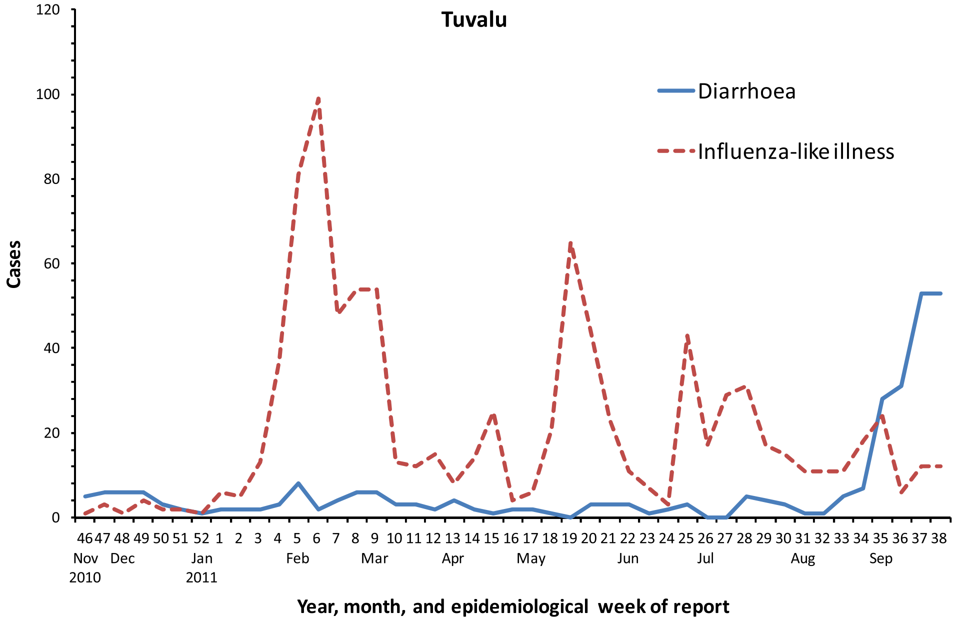

Figure 5. Reported cases in Tuvalu of influenza-like illness (ILI) and diarrhoea, November 2010 to September 2011. It clearly shows several peaks of influenza-like illness. Two of these were confirmed by laboratory as caused by the influenza virus. The outbreak of diarrhoea starting in week 35 was associated with a prolonged drought, with a resulting water shortage. (Outbreak information is courtesy of Dr Stephen Homasi, Tuvalu Ministry of Health).

implementation, the Pacific SSS has convincingly identified a number of outbreaks, enabling rapid public health responses. In addition, the system has greatly improved communication across borders on infectious disease events. The strengthened regional outbreak detection and response capacity will help reduce the impact and spread of infectious diseases within and between countries and territories in the Pacific. This system is likely to be easily adaptable to other resource-limited areas looking to improve their outbreak detection capacities.

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