Abstract

**Problem** In Sri Lanka, rabies prevention initiatives are hindered by fragmented and delayed information-sharing that limits clinicians’ ability to follow-up patients and impedes public health surveillance.

**Approach** In a project led by the health ministry, we adapted existing technologies to create an electronic platform for rabies surveillance. Information is entered by trained clinical staff, and both aggregate and individual patient data are visualized in real time. An automated short message system (SMS) alerts patients for vaccination follow-up appointments and informs public health inspectors about incidents of animal bites.

**Local setting** The platform was rolled out in June 2016 in four districts of Sri Lanka, linking six rabies clinics, three laboratories and the public health inspectorate.

**Relevant changes** Over a 9-month period, 12 121 animal bites were reported to clinics and entered in the registry. Via secure portals, clinicians and public health teams accessed live information on treatment and outcomes of patients started on post-exposure prophylaxis (9507) or with deferred treatment (2614). Laboratories rapidly communicated the results of rabies virus tests on dead mammals (328/907 positive). In two pilot districts SMS reminders were sent to 1376 (71.2%) of 1933 patients whose contact details were available. Daily SMS reports alerted 17 public health inspectors to bite incidents in their area for investigation.
Lessons learnt Existing technologies in low-resource countries can be harnessed to improve public health surveillance. Investment is needed in platform development and training and support for front-line staff. Greater public engagement is needed to improve completeness of surveillance and treatment.

Introduction
As in many other countries in Africa and Asia, rabies remains a public health problem in Sri Lanka. In 2015, 1166 animal bites (607 rabies positive and 559 rabies negative) and 26 cases of rabies virus infection in humans were reported, resulting in 24 deaths.

In 1975 the Sri Lankan Ministry of Health initiated a series of nationwide rabies prevention measures, coordinated by the public health veterinary services. These covered the introduction of dog vaccination (including stray dogs after 1997), post-exposure prophylaxis for patients presenting after an animal bite (after 1992) and sterilization of stray dogs (after 2008). In 2015 there were 1 294 529 domestic dogs and 152 404 stray dogs vaccinated and 274 405 patients started on post-exposure prophylaxis. Patients who receive a bite from a mammal can attend rabies clinics in government hospitals where post-exposure prophylaxis is provided free of charge. Public health information ensures that public awareness of rabies risk and the location of clinics is high. If the bite is low severity or the animal is known, treatment is deferred for 14 days while the animal is observed for clinical signs of rabies. Otherwise, post-exposure prophylaxis is started, which requires the patient to attend the clinic for vaccination with inactivated cell-culture-based rabies vaccine on days 0, 3, 7 and 30 following presentation. Samples of dead animals from all parts of Sri Lanka are sent to specialist laboratories which use direct fluorescent antibody testing for the presence of rabies virus.

Despite these efforts, clinical treatment, prevention initiatives and surveillance of rabies epidemiology in Sri Lanka are hindered by weaknesses in record-keeping and data collection. Clinic health records and reports to the public health inspectorate are paper-based and regional variations in completeness of record-keeping exist. Monthly reports are collated and disseminated in an electronic database. Clinicians therefore have limited access to information on a patient’s completion of post-exposure prophylaxis regimes and nationwide surveillance to ascertain the completion rate of anti-rabies treatment in Sri Lanka is poor. Similarly, there is no system for contacting patients to attend for vaccinations. This contributes to missed, delayed or duplicated vaccinations. Another problem is that feedback of laboratory results to the public health veterinary services is via manual monthly reports. This delays the ability of front-line teams to identify and respond to rabies outbreaks, locate infected animals and contact patients.
associated with animals that have tested positive. Finally, public health inspectors and the public health veterinary services have limited ability to evaluate the effectiveness of the current mammalian vaccination programme nationally and to identify regional variations in activity (e.g. urban compared with rural locations) and transmission characteristics.\(^1\)

This paper describes the creation of an electronic platform to improve the collection and sharing of data for better management and surveillance of rabies in Sri Lanka. The platform was developed by adapting existing acute and critical care platforms\(^9\) and was driven by clinicians looking for solutions to the problems outlined above.

**Approach**

The project was as a joint initiative of the public health veterinary services of the health ministry and the Network for Improving Critical Care Systems and Training Sri Lanka. It aimed to provide real-time data on: (i) the incidence and characteristics of mammal bites to humans; (ii) patient demographics; (iii) treatment decisions and patient outcomes; and (iv) the prevalence of rabies in dead mammals.

The design of the data platform was clinician-led, focusing on the information needed to improve front-line care. We conducted scoping interviews with public health veterinary services and clinical staff to determine users’ data requirements. In hospitals the required variables included patient characteristics, animal characteristics, severity of the bite and patient treatment details (Box 1). In laboratories the variables included type of animal, habitat, mode of death, vaccination status and investigation results. We developed the data collection tool using REDCap software (REDCap Consortium, Nashville, United States of America). The tool was accessible to users via the Internet from desktop computers and mobile devices. Data on each bite incident are entered by trained nursing officers when patients first present to a hospital rabies clinic. Data on animal test results are entered by clinical staff in the relevant laboratories.

Initial training was done by the central registry team at visits to rabies clinics and laboratories. During the implementation phase, ongoing clinician support was provided by the registry staff by telephone, with daily validation phone calls to the clinics to determine the numbers and motivate staff towards data entry. Laboratories were also contacted daily by the validation team of the central registry during implementation to help improve information completeness and improve staff skills.
We used a business analytics software (Tableau version 10.0, Tableau Software, Seattle, USA) to develop dashboards that would enable users to visualize the data in real-time, either as an aggregate or filtered by incident location or characteristics. The data are accessible to frontline staff (nurses and doctors), administrators, public health inspectors and laboratory teams via an online portal. Aggregated data are accessible to the general public, so that trends in bite incidence, patient demographics, mammal characteristics and laboratory test results can be identified. Individual patient data and laboratory results require a two-step authentication and are accessible only to clinicians treating the patient and public health inspectors. The data are then displayed through a dashboard via the registry platform in the secure servers of the Information Communication Technology Agency of the Government of Sri Lanka.\textsuperscript{10}

Mobile phone ownership is very high in Sri Lanka and follow-up of patients is aided by linking the post-exposure prophylaxis dashboard to a bespoke automated short message system (SMS). The clinician enters the patient’s mobile phone number and national identification number (the only unique identifier) to enable treatment episodes and outcomes to be linked. SMS alerts are sent to the patient the day before the due date of anti-rabies vaccine. Patients with treatment deferred are contacted on day 14 of the observation period of the suspected animal. Teams in rabies clinics are alerted by SMS to the numbers of patients due for anti-rabies vaccine each day, while public health inspectors are alerted to the incidence and characteristics of bites reported within their region, and any subsequent animal deaths. A schematic overview of the platform is shown in Fig. 1.

**Relevant changes**

The live platform was rolled out on 1 June 2016 across four districts in Sri Lanka (two urban and two rural: Colombo, Gampaha, Mathale and Monaragala), with a combined population of 3 224 923. It linked six hospital clinics, three laboratories (Medical Research Institute, Karapitiya and Peradeniya) and the public health inspectorate. The SMS alert system was initiated on 1 September 2016 in two of these districts which volunteered to participate.

Between 1 June 2016 and 28 February 2017, 12 121 reported incidents of animal bites from the four districts were entered into the registry, providing real-time data on the incidence, character and geographical location of mammal bites. Clinicians and public health teams were able to access data on the clinical management and outcomes of patients on post-exposure prophylaxis (9507; 78.4%) or with treatment deferred (2614; 21.6%). Five of the six clinics
reported on the completeness of post-exposure prophylaxis, showing that 293 (7.9%) of 3709 patients completed all four anti-rabies vaccinations. Data on other patient outcomes (e.g. delays in starting treatment, number of deaths) will be available in the future. Information on the characteristics of suspected vectors (60.8% dogs, 24.8% cats, 7.1% rats and other 7.4% non-domesticated mammals) enabled the public health veterinary services to evaluate current animal vaccination strategies and identify regional epidemiological variances.

Of 907 dead mammals tested, 328 (36.2%) were positive for rabies virus. The laboratories entered these data into the registry so that animal test results could be communicated rapidly to the clinic teams and the public health inspectorate responsible for individual cases.

Over the 6-month period, the SMS alert system in two districts alerted 1376 (71.2%) patients on post-exposure prophylaxis to attend their vaccination appointments; contact details were unavailable for 557 patients. Daily SMS reports alerted 17 public health inspectors to 3125 bite incidents in their region for further investigation.

Lessons learnt
This proof-of concept study illustrates how technologies that already exist in many low- and middle-income countries can be harnessed with existing staff resources to create an electronic platform for improving public health surveillance (Box 2). Maximizing the availability of information on the incidence, geographical location and outcomes of mammal bites should facilitate timely responses to incidents, and inform decisions about resource allocation and the refinement of treatment and prevention programmes. The SMS alerts health-care responders to clusters of incidents in their region and aims to improve compliance by patients on treatment; similar systems have proved effective in other health-care settings. Work is ongoing with front-line staff to improve completeness of contact information and to explore low treatment compliance in this setting.

To expand the platform within Sri Lanka, investment is needed in platform development and in training and support for clinical staff, both to address data completeness and to refine the platform before scaling up the initiative. Such investment would also allow an evaluation of the impact of the platform on reducing avoidable delays in starting post-exposure prophylaxis. It would also inform targeted animal vaccinations, using the data on where and when bites occurred. The existing media campaign may need to be boosted to raise the public’s awareness of the importance of reporting animal bites and complying with post-exposure care.
The next stage is to extend the platform to all rabies clinics nationwide to assist clinicians and administrators throughout the country to organize resources and improve the completeness rates of post-exposure prophylaxis. This information could be accessed remotely by specialists to help local teams refine prevention strategies based on regional epidemiological information and to enable clinicians to evaluate existing and future treatment protocols for rabies and other communicable diseases.

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Competing interests:

None declared.

References


Box 1. Information available on dashboards of the electronic platform for improving surveillance and treatment data on rabies in Sri Lanka

**Overview category**

- Bite incident details: geographical location, date of incident, bite severity (major or minor), mammal classification, vaccination summary, status of mammal (dead or alive).
- Bite incident reporting rates of hospitals and public health inspectors.
- Patient’s demographic and clinical data: name, age, sex, occupation, date of presentation to the hospital, bite severity, vaccination dates and completeness.
- Treatment: physician’s decision (treatment initiated or deferred), anti-rabies virus vaccine treatment regime (days 0, 3, 7 & 30), treatment completeness (including delays in vaccine doses).
- Laboratory investigations: investigation type (FAT, ICT, MIT, PCR), status of mammal (dead or alive), test result (rabies virus positive or negative), geographical location of rabies-positive vector.

**Treatment follow-up category**

- Patient’s demographic and clinical data: contact details, bite incident details (date, mammal, severity), treatment (treatment initiated or deferred).
- Patient’s appointment attendance (attended or not).
- Patient’s anti-rabies virus vaccine treatment status (vaccinated, not vaccinated, yet to vaccinate or observation of animal only).

**Laboratory testing category**

- Patient’s demographic data, bite incident details, physician’s treatment decisions.
- Biopsy test results (positive or negative), by area
- Classification of animal (dog, cat, domestic-other, wild and others)

FAT: fluorescent antibody test; ICT: immunochromatographic test strip; MIT: mouse inoculation test; PCR: polymerase chain reaction.

Box 2. Summary of main lessons learnt

- Existing technologies in low- and middle-income countries can be harnessed using minimal resources to provide a platform for improved public health surveillance.
- To expand the platform within Sri Lanka and to test its transferability to other settings, investment is needed in platform development and training and support for front-line staff.
- Greater public engagement is needed to improve completeness of surveillance and treatment.
Fig. 1. Schematic overview of the real-time SMS alert system for animal-bitten patients and health-care teams in Sri Lanka

MOH: ministry of health; MRI: magnetic resonance imaging; PHI: public health inspectorate; SMS: short message system.