Smartphone application-based school absenteeism reporting system for infectious disease surveillance in Hong Kong schools: abridged secondary publication

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KEY MESSAGES

Smartphone application-based surveillance system is a feasible approach for infectious disease surveillance. Specific percentage of influenza-related sick leave may improve the surveillance performance of non-specific all-cause absent rate in terms of sensitivity, specificity, and positive predictive value. Epidemic peaks of influenza season as reflected by the rescaled school absenteeism data precede those shown by traditional surveillance data by 2 to 3 weeks.

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Introduction

Young children are susceptible to various infectious diseases, and thus schools are at constant risk for communicable disease (CD) transmission and institutional outbreaks.[1] School-based CD surveillance system using absenteeism data is useful for CD surveillance and is increasingly used as a core component of influenza surveillance systems in many countries. However, in Hong Kong, there is no prospective surveillance system for the routine and continuous monitoring of CD activity among schools. We previously developed a smartcard-based electronic surveillance system to automatically capture absenteeism data in primary and secondary schools in Hong Kong. Despite the good acceptability, its limitations included suboptimal specificity (owing to the paucity of cause-specific absenteeism data), workload implication for their ascertainment, potential delay in data submission, and data gaps during school holidays and school closure.[2] The current prove-of-concept study aims to explore the feasibility of a smartphone application platform for CD surveillance in a school setting.

Methods

We developed the Hong Kong University Disease Surveillance, which is a smartphone application of an electronic school administration system for the regular and prospective capturing of the nature, cause, and symptom details of sickness absence in Hong Kong schools. Three different data reporting models were developed: (1) making absence application and data submission by parents directly through the app, (2) submitting data by responding to the embedded link in a reminder push message generated and sent to the parent's smartphone when absence of the student was registered by the smartcard-based eAttendance system, and (3) reporting the data in a designated online platform by teachers. These three models were adopted to different extents by the 13 participating schools, according to their different experience and practice in using app-based administrative platform. All schools were also using the smartcard-based eAttendance system for tracking student attendance when students present their cards on entering their schools, which captured the number of all-cause absence, without detail on its nature or reason.

A summary list of absenteeism record of individual students was automatically updated for parents' easy reference, as was reporting of health/illness status during school holiday or closure by push message prompting parents to report in regular cross-sectional time points during the school break.

All surveillance was encrypted and anonymised for data transfer, automatically cleaned, and analysed using scripts in the software R. Alert signal is issued for 10 common infectious diseases of epidemic potential if their number reaches the corresponding threshold, to enhance early awareness and timely triggering of appropriate follow-up steps by the school. The activity trend of influenza infection was disseminated via an Influenza Surveillance Dashboard developed and maintained by the School of Public Health, The University of Hong Kong.

The performance of the surveillance system was evaluated according to the guideline proposed by the Center for Disease Control and Prevention of the United States in terms of its data quality, sensitivity, specificity, positive predictive value, timeliness,

acceptability, simplicity, flexibility, and stability. Sensitivity, specificity and positive predictive value were assessed by comparing the classification of weekly influenza epidemic status (epidemic/non-epidemic) using the gold-standard composite index (sentinel general practitioner influenza-like illness consultation rate × influenza isolation rate, both from the Centre for Health Protection), with a threshold of 30% of its annual peak rate,[3] and by the school absenteeism data with a threshold exceeding the 50 percentile (the median), using a standard two-by-two contingency table. Survey questionnaires were used to collect feedback on attitude, acceptability, and user experience from teachers and parents.

Results

Data were collected from November 2016 to June 2018. Our surveillance covered a total of 7711 students in 13 schools. All their absence episode were captured through the eAttendance system. For the seven schools adopting the Hong Kong University Disease Surveillance (S1-S7), 24.1% (975/4042) of parents consented for their app-based data to be used for informing disease surveillance in the present study.

A total of 95 412 person-days of absence was registered over the study period. Data completeness of absence episode data reported through the Hong Kong University Disease Surveillance (2621 person-days) and Teacher's Module (4162 person-days) were 100%, with full capturing of nature, cause, and symptoms. Among data submitted through the Hong Kong University Disease Surveillance, 67% were reported when the leave application was made by the parent through the app, and 33% were reported through reminder push message. Five rounds of holiday push messages were issued during the study period, with the response rate increased from 0.04% in the first round to 7.96% in the last round, and up to 27.23% in individual schools. A total of 55 alert signals had been issued to the corresponding schools, with 15 alerts for upper respiratory tract infection and 15 for hand, foot and mouth disease.

The temporal pattern of influenza-like illness activity was much better delineated by the all-cause absence rate (calculated as the number of absence / total number of students) than the reference gold standard of the Influenza virus activity in Hong Kong. For the peak in summer epidemic season of 2017 and winter season of 2018, the pattern of the epidemic peaks shown by the Hong Kong University Disease Surveillance preceded the peaks shown by the influenza virus activity in Hong Kong by 2 to 3 weeks (Fig 1). Rescaling of all-cause absent rate by the percentage of sick leave caused by upper respiratory tract infection (upper respiratory tract infection / sick leave) improved the performance of the surveillance system in terms of sensitivity (from 68.4% to 73.7%), specificity (from 55.8% to 57.7%), and positive predictive value (36.1% to 38.9%), and more accurately reflected the epidemic status compared with the gold-standard data (Fig 2). When using additional symptom data to define and estimate the percentage of influenza-related sick leave, including adding influenza-like illness (fever and cough) or respiratory infections (≥2 respiratory symptoms) to upper respiratory tract infection, gave the same amount of improvement in surveillance performance.

Most teachers and parents found the surveillance system stable, simple, and easy to use, and it is useful for monitoring absenteeism, understanding increased influenza activity, and

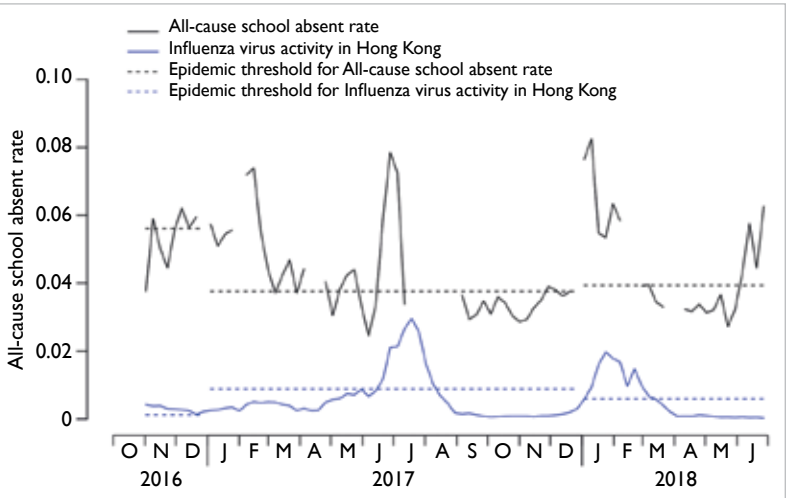

FIG 1. All-cause absent rate and influenza virus activity in Hong Kong from November 2016 to June 2018

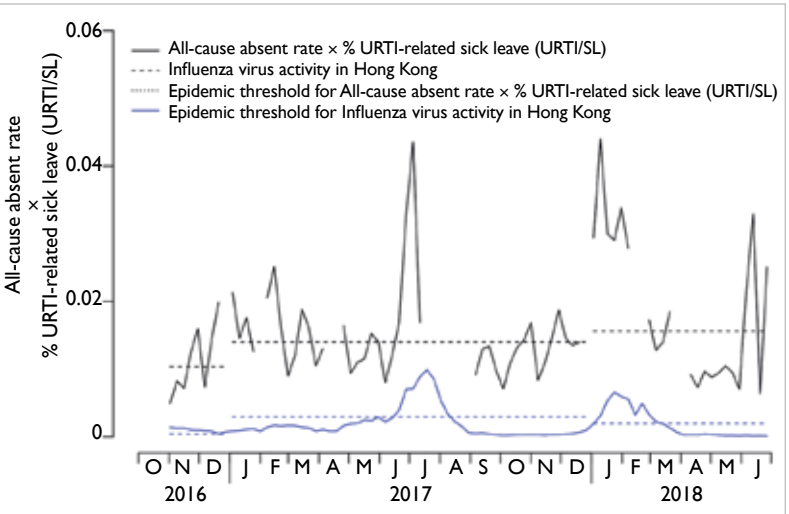

FIG 2. Rescaling of all-cause absent rate by its product with the percentage of upper respiratory tract infection among all sick leave

detecting influenza outbreaks among students. Most teachers and parents opined that using a mobile app-based approach for sick leave application is a trend, and that the app-based surveillance system should be introduced to more schools in Hong Kong.

Regarding the use of app-based platform for sick leave application and submitting surveillance data, 62.8% of parents had no particular concern but 20.7% expressed concern about privacy. 52.9% of teachers regarded the traditional paper-based method to be more reliable, and 11.8% regarded app-based technology may not be mature enough, but none expressed concern about data privacy.

Discussion

This project is the first school-based disease surveillance system using smartphone application technology in the world. There are benefits to using an app-based platform for capturing school absenteeism data for community disease surveillance. There is no trade-off between data specificity and timeliness. Our approach achieved an improvement in both data specificity and timeliness. The shifting of reporting duty from teachers to parents helped to reduce workload of teachers and avoided the usual problem of surveillance fatigue from data reporters. As parents have the best knowledge and incentive to strive for data precision, this contributes to better data accuracy and system sustainability.

The app-based influenza-like illness surveillance system was stable, giving good quality and timely data for prospective disease surveillance. It is feasible for capturing nature, cause, and symptom data of absence for informing prospective disease surveillance.

Collection of more specific data is useful for refining the existing system of monitoring the trend of influenza diseases activity. The improvement in sensitivity, specificity, and positive predictive value suggested that simple rescaling of a general and non-specific data (all-cause absent rate) by a more specific data (percentage of influenza-related sick leave), even if available only from a limited sample size, may improve the surveillance performance of the system. This observation is compatible with our previous finding in the smartcard-based system that symptom-specific data gave a better surveillance performance when compared with less-specific data.

Currently most schools are trying to familiarise with the usage and working out solutions for different technical and logistical issues. None is ready to rely exclusively on app-based platform for handling absence application. The usage pattern is expected to be improved once more schools have passed the initial phase of learning. Other potential areas for improvement include the concerns about reliability by teachers and privacy by parents. A more comprehensive assessment is needed after the system is implemented on a larger scale for a longer time.

Conclusions

The app-based surveillance system provided good quality and timely data by capturing nature, cause, and symptom data of absence for informing prospective disease surveillance. Most teachers and parents found the system simple and easy to use and learn. Simple rescaling of the non-specific all-cause absent rate by the specific percentage of influenza-related sick leave considerably improved the sensitivity, specificity, and positive predictive value of the system. Epidemic peaks of influenza season as reflected by the rescaled school absenteeism data preceded those shown by traditional surveillance data by 2 to 3 weeks. The system achieved an improvement of both data specificity and timeliness. It helped to reduce the workload of teachers and avoid the usual problem of surveillance fatigue.

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