A Representativeness Assessment of Taiwan's Sentinel Physician Surveillance System

Chia-Luen Tsai, Cheng-Yi Lee, Ya-Feng Cheng, Shu-Hui Tseng
Fifth Division, Taiwan CDC

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In order to understand the distribution and the level of representativeness of sentinel physicians (SPs) in Taiwan, this study utilized relevant data extracted from Taiwan CDC's Sentinel Physician Surveillance System (SPSS) Databank, Ministry of the Interior's Population Statistics File, and the Outpatient Prescription and Detailed Treatment File from the National Health Insurance (NHI) Program Databank, for the purposes of determining whether our SP population coverage meets the standards set by other developed countries, and whether there is a universal ratio among all counties and cities in Taiwan between the number of visits to the clinics taking part in the SPSS and the number of visits to all outpatient care spots in the area. The level of representativeness of the SP distribution is also evaluated based on a comparison between disease prevalence trends derived from the SPSS data and from data provided by the School-based Communicable Disease Surveillance System (SCDSS). The findings are: each of our SP clinics has an average population coverage of 43 thousand residents, and in comparison with the United States, Canada, France, Italy, Germany, Hong Kong and Japan, our coverage is second only to that of Japan, which has 27 thousand residents sharing one SP on average. The comparison between the SPSS data in the past coupled with related information extracted from NHI files and the SCDSS data shows almost identical disease prevalence trends, which indicates that the information reported through the SPSS possesses a satisfactory level of representativeness. Looking at the overall results of this study, our conclusion is that some minor adjustments in the SP distribution appear necessary for Taipei City, Taipei County. Taichung City, Tainan County, and Pingtung County. These proposed changes would improve their population coverage situation and representativeness level.

Keywords: sentinel physicians, surveillance, representativeness assessment

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Correspondence author: Ms. Chia-Luen Tsai; Address: No. 6 Linshen South Rd, Zhongzheng District, Taipei City, Taiwan, R.O.C.
E-mail: ellen@cdc.gov.tw

Introduction

Back in 1989, the then National Quarantine Service (NQS, which merged in 1999 with the Bureau of Communicable Disease Control, or BCDC, and the National Institute of Preventive Medicine, or NIPM, to form the present Centers for Disease Control, or Taiwan CDC) wanted to patch up two major flaws in the notifiable disease reporting system at that time, as a good portion of the legitimate cases were somehow either not reported at all, or the reporting was often way too much delayed. On top of that, they also wanted to make an assessment of the impact on the community caused by outbreaks of communicable diseases, so they set up a new nation-wide network called Sentinel Physician Surveillance System (SPSS). Beginning from the following year (1990), they made use of the system to monitor a series of outbreaks including chicken pox, mumps, measles, rubella, and bacterial gastroenteritis. The NQS looked into the actual prevalence situations of communicable diseases in Taiwan from time to time and adjusted the system's priority list of disease items accordingly. For instance, they added enteroviruses (including hand, foot and mouth disease or HFMD and herpangina) to the target list in 1998, and launched a surveillance campaign of influenza-like illnesses in 1999. More recently between 2002 and 2006, the SPSS surveillance items designated by the newly formed Taiwan CDC were influenza-like illnesses, enteroviruses (including hand, foot and mouth disease and herpangina), chicken pox, and diarrhea. Due to the fact that data gathered in the very system have always been treated as an indication of the prevalence of infectious diseases in the community and are often used as an vital reference for the health authorities in their disease control policy making, the distribution of sentinel physicians (SPs) and their population coverage situation need regular attention and assessment in order to up-keep the level of stability and representativeness of the surveillance data the system produces.

The initial selection of SPs in Taiwan targeted internists, pediatricians, and family medicine practitioners whose job locations preferably covered each and every geographic district in Taiwan region and who were willing to carry out the notification routines. Between its inception and the end of 1999, the number of SPs in Taiwan had been maintained at a level of 700 to 800, and their job locations represented about 80% of all rural areas, towns, and city districts in the Taiwan-Fukien region. Starting from 2000, in order to more efficiently utilize the system's human resources, the number of SPs in each district was reassessed and readjusted, resulting in a new arrangement comprised of about 450 local clinics (including 472 physicians) and 90 hospitals [3]. So far the total number of SPs has

been kept somewhere around 650 to 700 (they are mainly physicians in the fields of internal medicine, pediatrics, family medicine, and otolaryngology) and they spread out all over the Taiwan-Fukien region, representing 70% of all the rural areas, towns, and city districts.

When it comes to other countries, the American SP surveillance ring is a major force in the concerted global influenza monitoring effort. There are 2200 active SPs in the United States alone [6] and another 202 in Canada [7].

In France, their version is called the "Sentinelles Network," which started operating in 1984. The network follows the guidance of and answers to a host of parties including the French National Department of Health, local health bureaus, and many kinds of medical, biological, and epidemiological institutions in the country. The diseases they are keeping an eye on include influenza, viral hepatitis, acute urethritis, measles, and rubella. As to the process of their SP selection, it is a prerequisite for a candidate physician to be equipped with a communication terminal that must be functional and available 24 hours a day for data-transmitting purposes, and such a candidate can only qualify when judged to be representative demographically of fellow French physicians (that is, representative in the aspects of age, sex, geographic location, and expertise in practice). Furthermore, after candidates are duly selected and appointed SPs, they are still subject to a set of screening rules [3, 4], which would determine whether or not the data reported by a certain SP are worthy to be analyzed, or if any SP is qualified as an "Active Doctor" in any given circumstances. Currently, France has a total of 1270 SPs dealing with 14 surveillance items [4].

Italy, on the other hand, has established a rather commonplace medical and epidemiological surveillance system. The essence of their system is to set up a computer network to link up a group of physicians with representative qualifications. The main purpose of this new team and network is to collect usable data from on-going routine medical diagnoses and treatments to reinforce the effectiveness of epidemiological surveillance in Italy and make case comparison studies possible [3]. Italy has about 850 SPs taking part in the surveillance and reporting of influenza activity in the country [11].

In Germany, an influenza SPSS was organized in 1997. The participating physicians would transmit their surveillance data regularly to a special central website through the use of their own PCs each week [3]. At present time Germany has about 780 SPs [11].

In Japan, SP reporting efforts are divided into four categories, and they are

influenza sentinels (there are about 4700 clinics across Japan specialized in pediatrics and internal medicine taking part in this reporting category), child disease sentinels (about 3000 pediatric clinics in Japan are involved in monitoring the prevalence of 13 assigned pediatric diseases), eye disease sentinels (about 600 Japanese ophthalmic clinics are in this reporting category aiming at two particular eye diseases), and venereal disease sentinels (about 900 Japanese clinics specialized in obstetrics, gynecology, urology, and/or dermatology have taken up the reporting duty, and their current subjects cover 4 kinds of venereal diseases) [8].

In Hong Kong, there is a sentinel surveillance system made of general outpatient clinics and private physicians. Their current notifiable diseases include influenza, HFMD, acute conjunctivitis, and acute enteric infectious diseases. Taking influenza surveillance as an example, there are now 64 general outpatient clinics and 40 private physicians taking part in the effort [10].

SPs in Taiwan, just like those in other places in the world, are all volunteers, and they do the reporting chores purely out of their own will. Therefore, the actual distribution of SPs and their average population coverage situation would for sure affect the reliability and representativeness of the information submitted by them. In this study we assume that in each county and city in the Taiwan-Fukien region, the number of people visiting physicians in a given time period would highly correlate to the population of that county or city. In other words, a place with more residents would have simply more people to see a doctor for health problems. If our assumption is true, then it would be quite reasonable to use the population as an index to decide how many SPs are needed in a county or city.

Materials and Methods

The objective of this study is to figure out the proper distribution of Taiwan SPs and their population coverage situation in each county and city. We shall look into the surveillance data submitted to Taiwan CDC by SPs and population statistics published by Ministry of the Interior to estimate the average population coverage of one SP in each county or city of the Taiwan-Fukien region, and to see if such a coverage figure meets the standards set by other developed countries. Besides, we shall make use of the National Health Insurance (NHI) database (outpatient prescription and detailed patient treatment file in particular) to find out if the number of outpatient visits to CDC SPs as a percentage of all outpatient visits to available medical service spots shows a similar pattern across counties and cities as a positive indicator of the level of representativeness of the SPSS. Moreover, we shall compare the prevalence trends of influenza-like illnesses and enterovirus based on the

SPSS-reported data coupled with relevant information in the NHI file against the trends developed from data collected through a separate network called the School Communicable-based Disease Surveillance System (SCDSS) to see how well the outcomes of the two systems resembled each other, or in other words, how representative the SPSS is at least when these two disease are considered.

1. Data sources

Data used in this study are extracted from the following government documents:

(1) Population Statistics Section in 2005 Taiwan-Fukien Demographic Facts Year Book promulgated by Ministry of the Interior;

(2) 2004 Outpatient Application Registration File of All Primary Health Care Clinics in the National Health Insurance Program Database;

(3) Taiwan CDC Sentinel Physician Surveillance System Notification Records for 2005 and 2006;

(4) Taiwan CDC School Communicable Disease Surveillance System Reporting Records for 2006.

2. Study methods

This study takes advantage of the officially documented population and the number of SPs in each county and city in Taiwan region to figure out the distribution of SPs and their respective average population coverage in that particular county or city. We shall make an assessment of its rationality and may raise some suggestions for improvement on the SP distribution based on the results of this study.

Because most SPs in Taiwan practice their profession at local or primary health care clinics, in this study we shall only deal with this majority of SPs working at local clinics. Besides, since almost all diseases being monitored by the SPSS belong to the realms of internal medicine and pediatrics, plus all SPs are primarily specialized in internal medicine, pediatrics, or family medicine, we shall choose to examine the "Outpatient Prescription and Treatment Details" section of the NHI file and refer to its data under the organization category of "Primary Western Medicine Clinics" with the outpatients registered in the departments of internal medicine, pediatrics, family medicine, and general medicine. We shall use such records to calculate the annual total number of visits (that is, the total number of registrations made) to all medical facilities and compare it with the number of visits to the clinics featuring SPs. From such analyses, we hope to be able to come up with some ideas of how to improve the distribution of SPs.

As to examining the representativeness of the content of notification submitted by SPs, we shall refer to the data given in the final report of the "Establishment of a

Disease Forecast Model for Influenza-like Illnesses and Enterovirus," a Taiwan CDC commissioned research project carried out by a research team at National Health Research Institutes in 2005, which made a comparison between two sets of prevalence trends of enterovirus and influenza-like diseases in terms of case numbers in 2000-2003, with one set based on SP notifications and the other on the NHI data. The project made a choice to look into ICD9-CM code predominately in the NHI database. Its selections relative to influenza-like illnesses are 464.10, 464.50, 465.8, 465.9, 487.0, and 487.1, while those relative to enteroviruses are 074.3, 074, 079.2, 047.0, 074.0, 074.1, 074.2, 074.20, 074.21, 074.22, 074.23, 074.3, and 074.8. In addition, we shall also make use of data extracted from Taiwan CDC's SCDSS files to compare with similar data from the SPSS in terms of disease prevalence trends.

Results

In order to verify our assumption in the beginning of this study that the population and number of visits to a doctor in a geographic area are highly correlated, we did a comparison between the population of each county and city in the Taiwan-Fukien region and the total number of visits made to primary health care clinics in a specific time period. The results show that except for Taipei City, all other counties and cities have pretty much the same ratio, and the correlation coefficient of the distribution turned out to be as high as 0.97 out of a possible 1.0 (see Figure 1).

According to Taiwan CDC's SPSS data and population statistics in the 2005 Taiwan-Fukien Demographic Facts Year Book, it is found that the national average population coverage of a single SP clinic is some 43 thousand people, and the range of 90% confidence interval turned out to be approximately 6,000-66,800 persons per one SP. That means only the population coverage of Taipei County (82,402 persons per SP) and that of Taipei City (77,132 persons per SP) are a bit higher than the upper limit of the 90% confidence interval, while the remaining counties and cities in the studied region are all inside the range (for details see Table 1).

As to the comparison between the two kinds of frequency of visit — visits to the Taiwan CDC SP clinics versus visits to all outpatient care facilities (including the former) in one county or city, we looked at the annual number of visits of both types in this study. What we have found is that the average percentage of the former, as part of the latter, was 18.7%. If we believe that the ideal number of visits received by SPs in an area during a certain time period should account for somewhere within the range of 10%-30% of the total number of visits to any physician in the same area

and same time period, then we would find Taipei County, Tainan County, Pingtung County, Taichung City, and Taipei City fail to meet this standard (for details see Table 2).

Finally, we have made a comparison between the SPSS and the SCDSS. Since individuals getting infected with enterovirus during outbreaks are predominately elementary school pupils and younger children, the age range of the subjects coincides with the target group of SCDSS, and that is the reason we chose the prevalence trend of enterovirus on which to base our comparison of the two different surveillance systems. The finding shows the trends based on the data gathered through the two systems turned out to be extremely close to each other (Figure 2).

Discussion

From the above results, we conclude that the average population coverage of a Taiwan SP clinic is 43 thousand people, which is lower than the sampled foreign countries and regions of the United States, Canada, France, Italy, Germany, and Hong Kong, and only Japan has a better average coverage of 27 thousand people. It is to say that we are second only to Japan in this particular group, and that the number of our SPs would need no big increase.

According to our analysis results, there appears to be a very high correlation coefficient (0.97) between a county or city's population and the visit frequency of people seeking physicians' help in that county or city. It means in a county or city with a bigger population, more people would patronize the outpatient facilities in that county or city. Therefore, using population distribution as a guideline to install SPs within each and every county and city proves to be quite rational. Here, let us aim to have 2% of all working physicians to be appointed SPs, and based on the recommendation of Bureau of Medical Affairs under the Department of Health, we should have one physician for every 750 people. That is, we should have a total of 605 SPs or SP clinics. Then we would need to adjust the number of SPs in every county or city to match up with its respective population. However, doing so would not only lead to dramatic changes across all places, but especially those counties and cities with lower population density would require big cut-downs on their SP numbers to pump up their population coverages, which would be very difficult to execute.

Therefore, a more viable approach would be to maintain the current SP distribution to the best we can and avoid changing SP structure significantly to affect the willingness of the existing SPs, but at the same time make some small adjustments in the number of SPs and their locality distribution based on the following statistical results of this study:

From the perspective of population coverage of the existing SPs in each county and city of Taiwan-Fukien region, we see the national average stands at about 43

thousand people for each SP clinic, and we have found such coverage distribution has a 90% confidence interval ranging approximately from 6 thousand to 66.8 thousand people per SP. We see there are only one county and one city situating outside the range. Taipei City should have at least 40 SP clinics and thus, 6 additional SP clinics are needed. Taipei County should have at least 56 SP clinics, therefore 11 additional SP clinics are needed to lower down their coverage rates into the range.

According to the findings in the final report of the "Establishment of a Disease Forecast Model for Influenza-like Illnesses and Enterovirus," a 2005 Taiwan CDC commissioned research project, the 2002-2003 SPSS notified case numbers of enterovirus and influenza-like illnesses demonstrate almost identical trends when comparing with the NHI records on the registrations of the same diseases at all primary clinics nationwide [2]. This indicates that the SPSS notifications, at least in the surveillance of enterovirus and influenza-like illnesses, do sufficiently reflect the nationwide disease prevalence trends. When the country was divided into northern, central, southern, and eastern regions, with each of them being used independently as an entity for the same comparison, the prevalence trends from the two sources still match each other roughly. However, if we just look at Taipei City by itself, we shall find the trends of influenza-like diseases are having more variations between them, and so is in the case of Taipei County [2]. This demonstrates that the SP representativeness in both Taipei City and Taipei County might be a bit on the shy side.

Also from Taiwan CDC SPSS and NHI data, we obtained the number of visits to the SP clinics as a percentage of the total outpatient visits in an area, and we saw that those figures for Taipei City, Taipei County, Taichung City, Tainan County, and Pingtung County failed to stay inside an arbitrary target range of 10%-30%, or more precisely less than 10%, which means the above mentioned five counties and cities may have insufficient SP numbers. This problem can be easily solved by either adding more SP clinics in those areas, or simply replacing some existing but not-so-active SP clinics of low patronizing frequencies with other more active ones or ones with higher such frequencies.

There is no doubt that disease case number statistics registered in the NHI database are the closest thing to the real situations, but such statistics do not allow the health authorities to enact disease control measures in time, and this is where swift and accurate surveillance efforts such as the SPSS come into play. Other than SPSS, there is another disease surveillance system of similar nature but different approach, and that is the newer SCDSS. SCDSS was started in February 2001 as a trial project, and the size of the system became larger and larger afterwards. By February 2003, there were at least one participating public elementary school in every rural area, town, or city district in 25 counties and cities. They are willing to participate and were

recommended by their local Education Bureaus to join the system. There is now a total of 448 elementary schools (about 17% of the total), including their affiliated kindergartens, taking part in the SCDSS. The system is thought to be better than the SPSS as it covers one hundred percent of all rural areas, towns, and city districts across Taiwan [12]. However, when we compare the disease trends over the past few years as depicted by the SPSS data with the ones depicted by the NHI data and SCDSS file, we have found all the prevalence trends do not vary much from one another. This gives us plenty confidence that the SPSS data have a basic level of representativeness to say the least.

Summarizing the above described results, we find there is a need for adjustment of SP numbers in five counties/cities, i.e. Taipei City, Taipei County, Taichung City, Tainan County, and Pingtung County, in order to improve their population coverage situations and representativeness.

Since the analytical comparisons and the representativeness assessment in this study are based solely on descriptive statistics in different but related government documents, the evidence leading to the conclusion is a little insufficient to be honest. We recommend in the future, such study on representativeness assessment should be entertained with views from more angles as they become available, such as establishing an integrated assessment index specifically for this purpose, combining SPSS with Geographic Information System (GIS), setting up a computerized automatic assessing mechanism, etc., so the system can be assessed regularly and improved gradually. All such efforts are necessary steps to maintain the stability and representativeness of SP surveillance data.

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Table 1. Average population coverage by each sentinel physician in every county/city of Taiwan

County/city	Population	No. of SP clinics	Population coverage by each SP
Total	**22,689,122**	529	**42,891**
Taipei City	**2,622,472**	34	**77,132**
Taipei County	**3,708,099**	45	**82,402**
Yilan County	**462,286**	20	**23,114**
Keelung City	**392,337**	13	**30,180**
Taoyuan County	**1,853,029**	29	**63,898**
Hsinchu City	**386,950**	14	**27,639**
Hsinchu County	**467,246**	13	**35,942**
Miaoli County	**560,643**	18	**31,147**
Taichung City	**1,021,292**	26	**39,280**
Taichung County	**1,527,040**	34	**44,913**
Changhua County	**1,316,762**	36	**36,577**
Nantou County	**538,413**	15	**35,894**
Yunlin County	**736,772**	29	**25,406**
Chiayi City	**270,341**	17	**15,902**
Chiayi County	**557,903**	13	**42,916**
Tainan City	**754,917**	17	**44,407**
Tainan County	**1,105,674**	24	**46,070**
Kaohsiung City	**1,512,677**	36	**42,019**
Kaohsiung County	**1,238,925**	28	**44,247**
Pingtung County	**900,199**	20	**45,010**
Penghu County	**91,808**	7	**13,115**
Taitung County	**240,373**	18	**13,354**
Hualien County	**349,149**	19	**18,376**
Kinmen County	**64,456**	3	**21,485**
Lienchiang County	**9,359**	1	**9,359**
Minimum coverage			9,359
Maximum coverage			82,402
Mean value			36,391
Upper limit of 90% CI*			66,784
Lower limit of 90% CI			5,999

*CI: confidence interval

Table 2. A comparison between the numbers of visits to sentinel physician clinics and that to all clinics located in the specified county or city (based on BNHI statistical data)

County/city	No. of all visits to	No. of visits to	(B/A)×100
Total	**107939848**	**13386127**	**12.4**
Taipei City	7784643	761970	9.8
Taipei County	16492102	1285591	7.8
Yilan County	2444403	534385	21.9
Keelung City	1857041	211172	11.4
Taoyuan County	8538149	887601	10.4
Hsinchu City	1386997	277939	20.0
Hsinchu County	1975477	321760	16.3
Miaoli County	2713426	443306	16.3
Taichung City	5628838	477192	8.5
Taichung County	8250945	901868	10.9
Changhua County	6587002	994967	15.1
Nantou County	3129295	443653	14.2
Yunlin County	4,438,219	804,870	18.1
Chiayi City	1670046	441530	26.4
Chiayi County	2580759	372931	14.5
Tainan City	3783479	455199	12.0
Tainan County	5871615	564036	9.6
Kaohsiung City	7169448	838581	11.7
Kaohsiung County	6766875	801884	11.9
Pingtung County	4803509	422954	8.8
Penghu County	922021	223046	24.2
Taitung County	1031695	334581	32.4
Hualien County	1782578	386417	21.7
Kinmen County	291455	157243	54.0
Lienchiang County	13730	8044	58.6
Minimum			7.8
Maximum			58.6
Mean value			18.7

Table 3. Number of sentinel physicians (SPs) and population in selected foreign countries and regions

Country/region	No. of SPs	Total population	Average coverage by each SP
USA	2200	c. 280×10^6	12.7×10^4
Canada	202	c. 32.27×10^6	16.0×10^4
France	1270	c. 62.00×10^6	4.9×10^4
Italy	850	c.58.00×10^6	6.8×10^4
Germany	780	c. 82.00×10^6	10.5×10^4
Japan	4700	c. 128×10^6	2.7×10^4
Hong Kong	40	c. 6.97×10^6	17.4×10^4

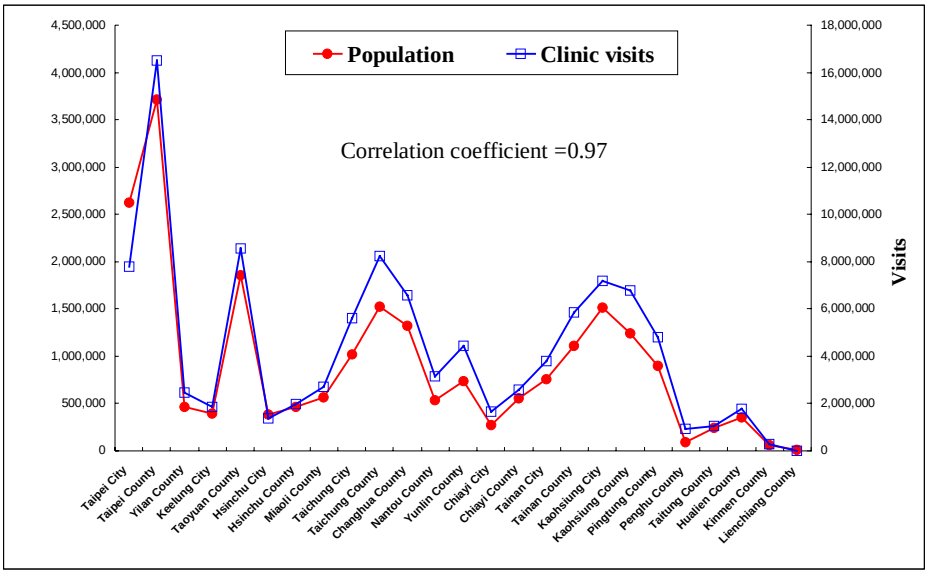

Figure 1. Comparison between the population and annual number of clinic visits in each county or city according to the National Health Insurance file

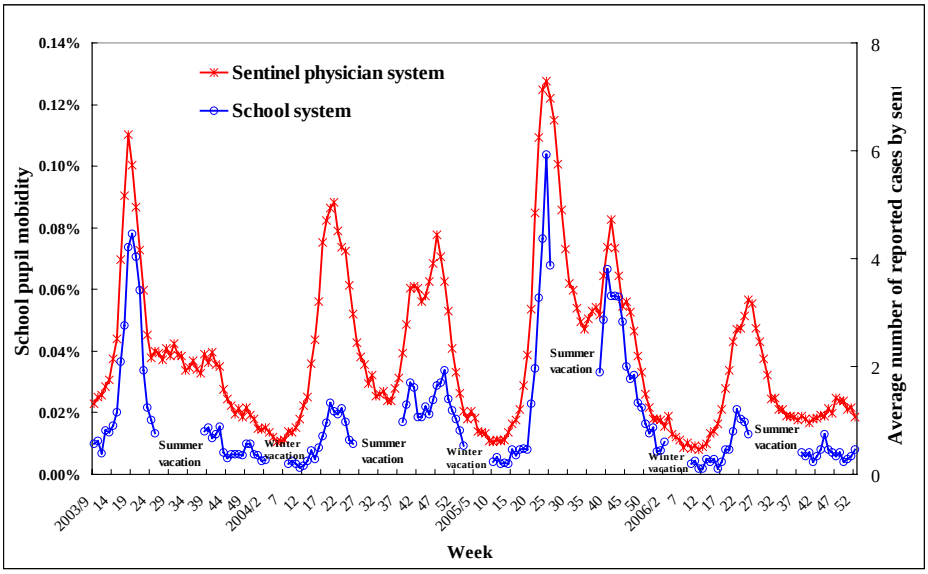

Figure 2. A comparison between two enterovirus trend assessments, one derived from data collected by the sentinel physician surveillance reporting system and the other from the school-based infectious disease surveillance reporting system