Trend of Fever screen and Evaluation of Quarantine Effectiveness among International Passengers to Taiwan during 2003-2007

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Abstract

The infrared thermography has been set up at the international ports in Taiwan since May 2003 to automatically screen inbound passengers for abnormal body temperature. In the mean time, the policy related to filling out questionnaires for infectious disease surveillance system was modified several times. We therefore aimed to evaluate the outcome of international ports surveillance system and looked into possible epidemiological estimation and trend from those symptomatic and febrile inbound passengers.

We found a significant increase in the number of cases of Notifiable diseases from the quarantine procedure after applying the infrared fever screening measure in international ports. The identified disease pattern also changed from gastrointestinal diseases to vector borne infectious diseases. The infrared fever screening measure also had a higher detection sensitivity compared to filling out the infectious disease survey questionnaire.

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There was no significant difference among the monthly rates of symptomatic passengers to asymptomatic passengers from July, 2003 through June, 2007. However, the new quarantine measure has made a significant change in the trend of the rates (0.51% to 0.11%). From July 2005 to June 2007, there were two peaks of fever cases, June-September and December-March next year. The fever peak during Jun.-Sept. has matched the peak season for important identified Notifiable diseases and gastrointestinal bacterial diseases. The winter fever peak (Dec.-Mar. next year) was found to be similar to the influenza epidemic pattern in Northern Hemisphere.

Keywords: infrared thermography, fever screening, quarantine, imported cases

Background

Due to spreading of severe acute respiratory syndrome (SARS) outbreak in Taiwan, from April 2003, the Taiwan Centers for Disease Control (TW-CDC) has initiated a policy for all inbound passengers to have body temperature monitored and fill out SARS Survey Form (SSF) [1]. The infrared thermography has also been used in international ports since May 2003 to screen inbound passengers for abnormal body temperature. After global SARS outbreak has reached the end in July 2003, we then collected specimens from symptomatic inbound passengers based on clinical presentations and travel history for laboratory examinations of diseases, such as dengue fever, malaria, shigellosis, etc. [2, 3]. Even though SARS outbreak has been controlled for quite a while now, we are still under a big threat from imported infectious diseases due to the increasing global traffic and business passengers to Taiwan. As a result, TW-CDC has modified the SSF into Communicable Disease Survey Form (CDSF) and has initiated surveillance to all inbound passengers since April, 2004 [1].

Filling out the CDSF and infrared thermography at the international airports for all inbound passengers have been effective in screening for imported infectious diseases [1, 2]. However, such method might not be cost effective in terms of printing out large amount of questionnaires and increasing workload for public health staff at the airports. Therefore, we have discarded the use of questionnaire screening as a prerequisite for all inbound passengers since December, 2004 and leave the questionnaires for those symptomatic passengers.

Currently only Japan [4], China [5, 6] and Hong Kong [7] are using fever screening surveillance for international passengers. Passengers who wish to enter Japan or China are required to fill out “Questionnaire” [4] or “Health and Quarantine Declaration Form on Entry” respectively [5, 6]. The Hong Kong government does not require passengers to fill out Health Declaration [7].

When passengers were required to fill out Health Declaration during the period of 1995 to 1999, the rate for symptomatic international passengers was 0.37% [8]. This study was aimed to analyze the change in the rate for symptomatic and febrile international passengers before and after using infrared thermography. Through such data analysis and application, we are expected to find out possible underlying factors for such change and hence evaluate the effectiveness of the quarantine measure in the hope to act as a reference for future international surveillance policy in international ports.

Material and Method

Data sources: The data sources used for this study included the Statistics of Communicable Diseases and Surveillance Report in Taiwan area (2003-2006), CDC National Notifiable Disease Surveillance System and international port surveillance data of symptomatic and febrile passengers from Jul. 2003 to Jun.

2007.

a. Notifiable infectious disease data from international airports: Data were collected from Statistics of Communicable Diseases and Surveillance in Taiwan area from 2003 to 2006 and Symptom Surveillance System.

b. Numbers of inbound passengers and symptomatic passengers: Data were collected from Statistics of Communicable Diseases and Surveillance Report from 2003 to 2006 and Symptom Surveillance System for international passengers from Jan. to Jun. 2007.

c. Numbers of febrile passengers: Temperature of febrile passengers detected by infrared thermography should be confirmed by ear thermometer and then those with temperature higher than 38℃ were classified as febrile cases. Relevant statistical data of the febrile cases were provided by all international ports.

Data statistics: The following data were calculated from the data sources: Number of important Notifiable infectious diseases identified by the surveillance system at international ports from 1997 to 2006, trend analysis of monthly identified important Notifiable disease cases and gastrointestinal bacterial disease agents from Jul. 2003 to Jun. 2007, trend analysis for the rate of symptomatic passengers from Jul. 2003 to Jun. 2007, and weekly/monthly trend analysis of febrile passengers.

Analysis methods: We used Microsoft Excel 2000 program for data entry, cleansing, verification and plotting.

Result

Tendency change in the number of important Notifiable infectious diseases detected by international port surveillance from 1997 to 2006 (as shown in Table 1)

Number of cases had gradually increased since 2003 and peaked in 2004. Over the last 10 year period, 72.6% (225/310) of the cases were detected during 2004 - 2006.

Gastrointestinal infectious diseases (e.g. bacillus diarrhea, typhus, paratyphus, hepatitis A, etc.) were the main diseases detected during 1997-2003 (64.7%, 55/85). However, the disease patterns changed to vector borne diseases (e.g. dengue, malaria, etc.) during 2004-2006 (69.8%, 157/225).

Table 1. Detection numbers of important Notifiable infectious diseases from international ports from 1997 to 2006.

Notifiable diseases	Year									
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Shigellosis	4	6	1	0	1	4	37	43	10	13
Dengue Fever	3	5	0	2	0	1	17	57	46	48
Malaria	0	1	0	0	0	0	1	3	1	1
Typhoid Fever & Paratyphoid Fever	0	1	0	0	0	0	0	0	0	1
Cholera	0	0	0	0	0	0	0	1	0	0
Acute viral hepatitis type A	0	0	0	1	0	0	0	0	0	0
Japanese encephalitis	0	0	0	0	0	0	0	0	1	0
Total	7	13	1	3	1	5	55	104	58	63
Percentage	1.9%	4.2%	0.3%	1.0%	0.3%	1.6%	17.8%	33.7%	18.8%	20.4%
Quarantine Measure	Health Declaration		Inward Passenger's Declaration		Symptom Declaration		1 Questionnaire* 2 Fever Screening		1 Questionnaire ** 2 Fever Screening	

Data Source: Data in 1998 was collected in Taiwan Epidemiology Bulletin[8] and the other data was collected from Statistics of Communicable Diseases and Surveillance Report in Taiwan area(1997-2006).
*: All passengers fill out SSF or "SARS and Other Communicable Diseases Survey Form".
**: Symptomatic passengers fill out CDSF.

Monthly trend analysis for number of important Notifiable infectious diseases from international port surveillance and positive pathogen detected rate for gastrointestinal bacterial diseases from Jul. 2004 to Jun. 2007

The use of infrared thermography has proved to be effective at the international ports during SARS epidemic ended in June, 2003. Infrared thermography has therefore been advocated to be used in all international ports. Relevant data collected from the Infectious disease statistical surveillance annual report in

2003-2006 and statistical summary for all symptomatic inbound passengers provided by each international port during Jan. - Jun. 2007 were shown in Table 2.

The statistics for monthly detected important Notifiable infectious diseases from July 2003 to June 2007 were shown in Figure 1. Apart from the sudden outbreak of bacillus diarrhea from inbound Bali tourists at the end of 2003 [13] leading to more Bacillus diarrhea cases detected at the international airports, the important Notifiable infectious disease detection peak was centralized from Jun. to Sept. The international ports also detected more gastrointestinal bacterial infections during those periods, as shown in Table 3.

According to the data from Statistics of Communicable Diseases and Surveillance from 2003 to 2006 [9-12] and symptomatic reporting system, we calculated the important Notifiable infectious disease monthly detection rate using total number of detected cases divided by total number of inbound passengers from Jul. 2003 to Jun. 2007 as shown in Figure 2. We found the peak of important Notifiable infectious disease detection rate of international ports was in Jul.-Aug. apart from the Bali tour groups outbreak of bacillus diarrhea [13].

Table 2. The Statistics of quarantine for Monthly inbound passengers from Jul. 2003 to Jun. 2007

Year	Month	Inbound Numbers	Symptomatic Numbers	Fever Numbers	Symptomatic Rate (%)	Fever Rate (%)	Pathogen were detected in ports				
							Notifiable infectious diseases				GI infections
							Dengue Fever	Shigellosis	Others	Total	
2003	Jul.	751,972	3,168	N	0.42	N	3	1	0	4	2
	Aug.	907,883	4,449	N	0.49	N	3	1	0	4	7
	Sep.	838,189	3,584	N	0.43	N	2	0	0	2	6
	Oct.	841,539	3,825	N	0.45	N	6	1	0	7	1
	Nov.	784,893	3,170	N	0.40	N	0	24	0	24	0
	Dec.	809,912	6,633	N	0.82	N	3	9	0	12	1
2004	Jan.	857,057	5,148	N	0.60	N	3	0	1	4	1
	Feb.	706,948	4,462	N	0.63	N	4	1	0	5	10
	Mar.	807,930	3,004	N	0.37	N	4	0	0	4	0
	Apr.	833,599	4,622	N	0.55	N	4	2	0	6	1
	May	820,095	5,070	N	0.62	N	4	8	0	12	8
	Jun.	927,991	5,984	N	0.64	N	4	8	0	12	14
	Jul.	1,052,427	5,740	N	0.55	N	8	9	1	18	24
	Aug.	1,066,971	6,038	N	0.57	N	8	8	1	13	32
	Sep.	875,094	4,301	N	0.49	N	6	3	0	9	8
	Oct.	910,965	3,272	N	0.36	N	4	6	0	10	3
	Nov.	846,831	2,496	N	0.29	N	3	2	1	6	9
	Dec.	883,251	752	N	0.09	N	5	0	0	5	3
2005	Jan.	798,137	963	N	0.12	N	0	0	0	0	1
	Feb.	931,526	736	N	0.08	N	0	2	0	2	0
	Mar.	890,857	1,178	N	0.13	N	0	0	0	0	1
	Apr.	963,396	1,422	N	0.15	N	3	0	0	3	2
	May	946,891	1,688	N	0.18	N	2	2	0	4	2
	Jun.	990,748	1,066	N	0.11	N	5	1	0	6	1
	Jul.	1,124,816	1,163	881	0.10	0.08	7	2	2	11	2
	Aug.	1,108,764	1,407	835	0.13	0.08	10	2	0	12	4
	Sep.	952,953	994	487	0.10	0.05	6	1	0	7	3
	Oct.	1,013,790	816	131	0.08	0.04	5	0	0	5	2
	Nov.	895,681	547	330	0.06	0.04	4	0	0	4	1
	Dec.	889,971	763	439	0.09	0.05	4	0	0	4	0
2006	Jan.	896,958	812	465	0.09	0.05	0	1	0	1	2
	Feb.	911,544	800	543	0.09	0.06	1	0	1	2	0
	Mar.	957,669	711	412	0.07	0.04	6	0	0	6	2
	Apr.	1,015,308	556	356	0.05	0.04	2	0	0	2	0
	May	978,296	522	364	0.05	0.04	4	2	0	6	5
	Jun.	1,007,410	962	622	0.10	0.06	5	0	0	5	4
	Jul.	1,169,219	1399	999	0.12	0.09	4	3	0	7	4
	Aug.	1,129,396	1021	732	0.09	0.06	5	1	1	7	15
	Sep.	955,012	720	454	0.08	0.05	5	4	0	9	2
	Oct.	1,063,851	771	520	0.07	0.05	5	1	0	6	1
	Nov.	913,799	713	473	0.08	0.05	5	0	0	5	6
	Dec.	1,000,955	983	651	0.10	0.07	6	1	0	7	1
2007	Jan.	827,594	1495	953	0.18	0.12	4	0	0	4	2
	Feb.	1,089,025	1824	1296	0.17	0.12	3	1	0	4	0
	Mar.	985,649	1475	956	0.15	0.10	1	3	0	4	2
	Apr.	1,079,352	1377	918	0.13	0.09	8	4	0	12	1
	May	1,011,669	1074	728	0.11	0.07	3	3	0	6	3
	Jun.	1,087,616	1497	1081	0.14	0.10	6	2	0	8	3

Data Source: Data was collected from Statistics of Communicable Diseases and Surveillance Report from 2003 to 2007.

Table 3. Monthly detected GI bacterial pathogens in ports from Jul. 2003 to Jun. 2007*. (excluded Notifiable diseases)

Month	Year 2003	2004	2005	2006	2007	Total	Percentage
Jan.	-	1	1	2	2	**6**	**3.0%**
Feb.	-	10	0	0	0	**10**	**5.0%**
Mar.	-	0	1	2	2	**5**	**2.5%**
Apr.	-	1	2	0	1	**4**	**2.0%**
May	-	8	2	5	3	**18**	**8.9%**
Jun.	-	14	1	4	3	**22**	**10.9%**
Jul.	2	24	2	4	-	**32**	**15.8%**
Aug.	7	32	4	15	-	**58**	**28.7%**
Sep.	6	8	3	2	-	**19**	**9.4%**
Oct.	1	3	2	1	-	**7**	**3.5%**
Nov.	0	9	1	6	-	**16**	**7.9%**
Dec.	1	3	0	1	-	**5**	**2.5%**

*: Vibrio parahaemolyticus, Salmonella, Staphylococcus aureaus et al.

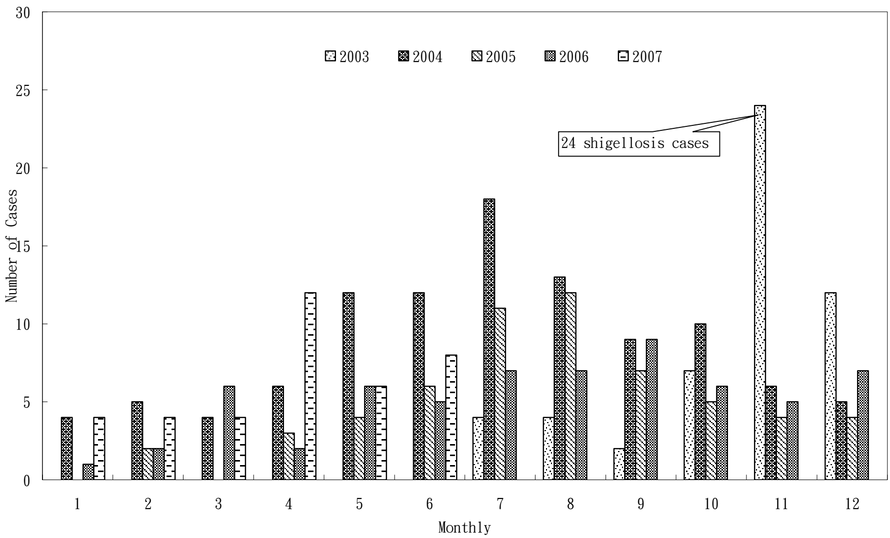
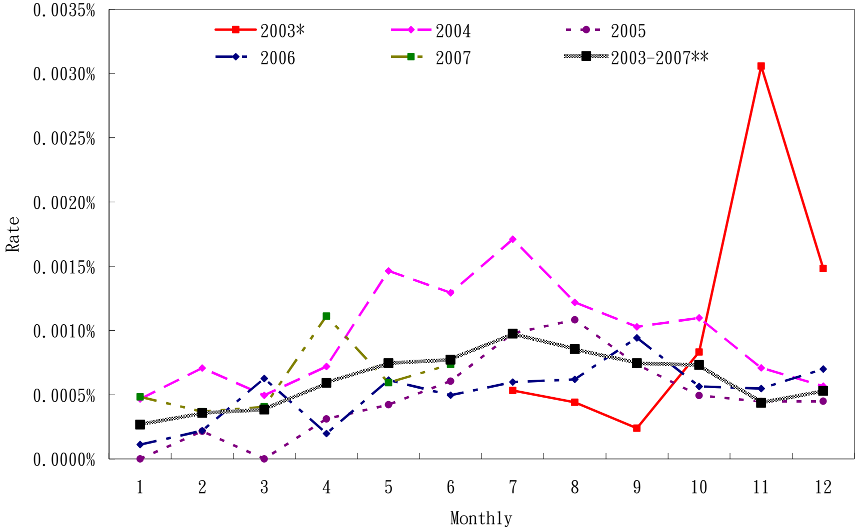


Figure 1. Number of cases of important Notifiable infectious diseases among inbound passengers detected by quarantine measures from July 2003 to June 2007.



*: The rate sharply increased in the late 2003 because there were many tourism groups with bacillus diarrhea outbreak from Indonesia Bali [13].

**: The statistics which exclude many tourism groups with bacillus diarrhea outbreak in Indonesia Bali in the late 2003[13] from Jul. 2003 to Jun.2007.

Figure 2. Monthly trend of rate of important Notifiable infectious diseases cases among inbound passengers detected by quarantine measures from July 2003 to June 2007.

Monthly rate of symptomatic inbound passengers at international ports from Jul. 2003 to Jun. 2007

Apart from the CDSF, we had launched infrared thermography since 2003 for active fever screening of all inbound passengers. However, CDSF was discarded in Dec. 2004 after considering its cost. Only symptomatic inbound passengers were required to actively fill out the CDSF and also notify the port public health staff. During this period, the monthly average rate for symptomatic inbound passengers was 0.24% (0.05% - 0.82%). However, the symptomatic rate decreased rapidly from 0.29% in Nov. 2004 to 0.09% in Dec. 2004, as shown in Figure 3.

We used Nov. 2004 as the cut point with the average rate being 0.51% (0.29%-0.82%) prior to Nov. 2004 and 0.11% (0.05%-0.18%) after Dec. 2004. Therefore, the rate dropped by 0.40% (0.51%-0.11%) after discontinuing CDSF, details as shown in Table 4 and Figure 3.

Table 4. Monthly average rate and range of cases with symptom or Fever among inbound passengers from Jul. 2003 to Jun. 2007.

period	Symptom Rate			Quarantine Measures
	average	lowest	highest	
2003/07-2004/11	0.51%	0.29%	0.82%	1. Fever screening 2. All passengers fill out questionnaire ***
2004/12-2007/06	0.11%	0.05%	0.18%	1. Fever screening 2. Symptomatic passengers fill out questionnaire CDSF****
2003/07-2007/06	0.24%	0.05%	0.82%	Above-mentioned Measures
period	Fever** Rate			Quarantine Measures
	average	lowest	highest	
2005/07-2007/06	0.07%	0.04%	0.12%	1. Fever screening 2. Symptomatic passengers fill out questionnaire CDSF

*: "Symptom" means case has one of following symptom：fever, vomiting, diarrhea, skin rash, jaundice.
**: "Fever" means the case should be detected temperature by quarantine officers and ear temperature≧38ºC.
***: All passengers should fill out questionnaire which is about communicable diseases.
****: Inbound passengers who are suspected with communicable symptoms should fill out CDSF and inform quarantine officers.

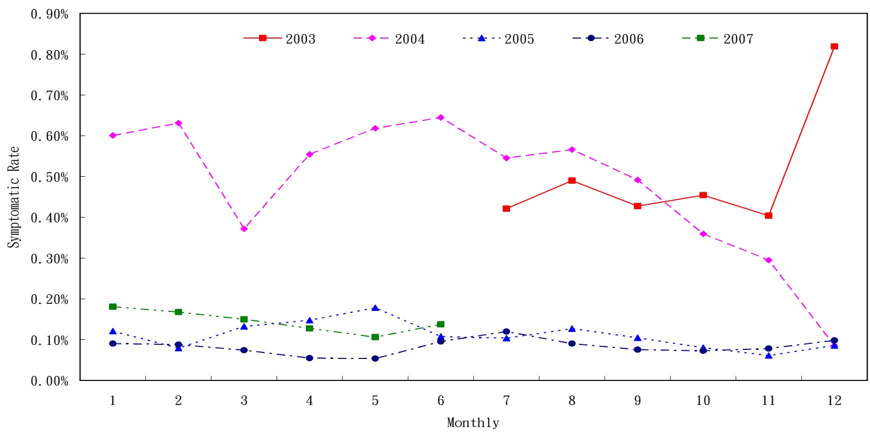


Figure 3. Monthly trend of rate of symptomatic cases among inbound passengers from Jul. 2003 to Jun. 2007.

Fever case detection rate from inbound passengers at international ports from July 2005 to June 2007

In order to effectively screen for febrile passengers, the definition for febrile inbound passengers was defined as ear temperature over 38℃. The monthly detection rate for febrile cases from July 2005 to June 2007 was shown in Table 4. The monthly average fever case detection rate was 0.07% (0.04%-0.12%) with two peaks in Jun-Sept and Nov.-next year Mar, as shown in Figure 4.

Data was analyzed weekly (shown in Figure 5). The average weekly fever case detection rate was 0.07% (0.03%-0.14%) from week 27, 2005 to week 26, 2007. The significant peaks of weekly fever case detection rate were in week 23 to week 38 and week 51 to week 10 next year, distinctly different as compared with other weeks. The peak of week 51 to week 10 next year showed more fluctuation than week 23 to week 38.

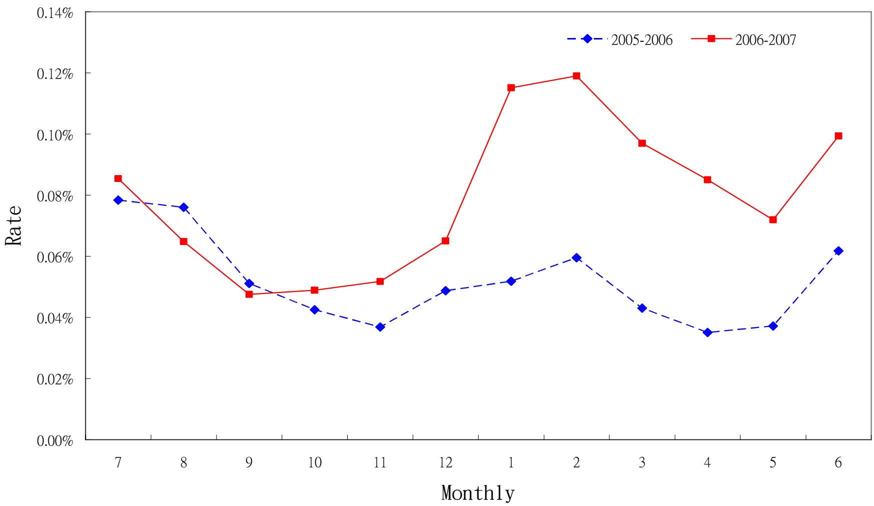


Figure 4. Monthly trend of rate of fever cases among inbound passengers from Jul. 2005 to Jun. 2007.

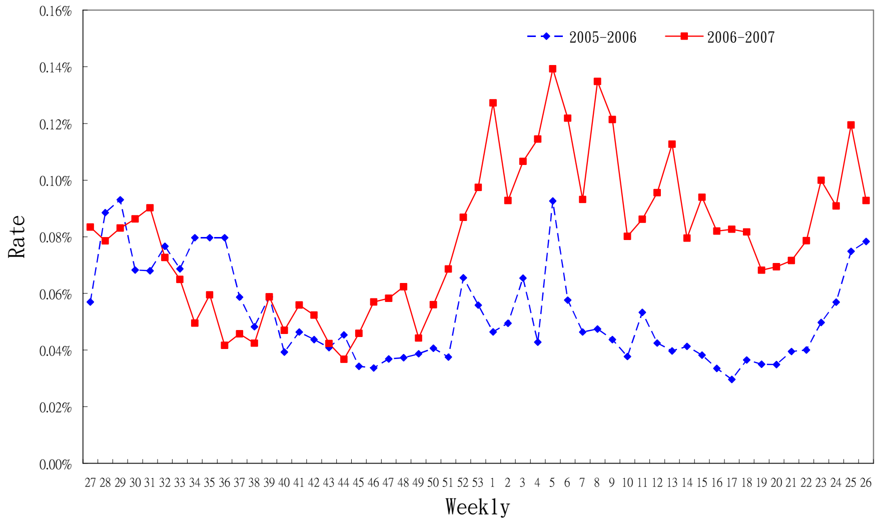


Figure 5. Weekly trend of rate of fever cases among inbound passengers from 27 week 2005 to 26 week 2007.

Discussion

According to the detection numbers of important Notifiable infectious diseases from international ports from 1997 to 2006 (Table 1), the use of infrared thermography since 2003 has significantly increased the detection rate [1]. Although we terminated the entire CDSF in Dec. 2004 with active reporting from inbound passengers instead, no Notifiable infectious disease was confirmed from 2005 to 2006. The number of detected cases was also much higher with the use of infrared thermography during 2005-2006 as compared with the number of detected cases from 1997 to 2002. It indicated that detection sensitivity was higher in infrared thermography compared to CDSF.

The highest number of detected cases for important Notifiable infectious diseases was in 2004 (Table 1) which might be related with the combination of infrared thermography and CDSF. After the discontinuation of CDSF, only bacillus diarrhea positive cases were significantly reduced, with the fact that fever might not be the presenting symptom for bacillus diarrhea. Bacillus infection was unlikely to cause an outbreak because of our well-equipped medical resources and good environmental hygiene. It was cost effective to discarded CDSF after considering the huge cost for paper printing and labor. It also fulfilled the purpose of international health regulation (IHR): effectively prevent and control the spread of imported infectious diseases and avoid un-necessary inconvenience to international transportation [15].

Imported cases for important national Notifiable infectious diseases and gastrointestinal bacterial diseases were clustered in Jun.-Sept. each year (Figure 1, Table 3). During the period of July 2003 to June 2007 (Table 2), apart from the year 2003 when SARS outbreak occurred, July and August each year from 2004 to 2006 has counted for higher number of inbound passengers. This was correlated with the international tourism in summer vacation in Taiwan [16]. It was therefore reasonable to see more imported infectious disease cases in July and August annually due to more inbound passengers. However, the detection rate for imported important national Notifiable infectious diseases (Figure 2) was also significantly higher in Jul. and Aug. 2003-2007. Such result was not consistent with the monthly trend rate using purely CDSF [8, 14]. With literature review, we found that dengue imported cases were peaked in Jul.-Aug. [16-17] or Aug.-Sept. [18]. The detection rate peak might be related to the shift of imported important Notifiable infectious diseases of GI infection (64.7%) before 2003[8] to vector borne diseases (69.8%) after the launch of infrared thermography in 2003.

Cases for important Notifiable infectious diseases and gastrointestinal bacterial diseases were clustered in Jun.-Sept. each year, with the detection rate of important Notifiable infectious diseases from inbound passengers mainly in Jul.-Aug. each year. However, there was no similar trend in the rate for symptomatic inbound passengers (Figure 3). The rate for symptomatic inbound passengers significantly decreased from 0.29% in Nov. 2004 to 0.09% in Dec. 2004, which might be due to the termination of entire CDSF with active reporting from inbound passengers instead. The fact that CDSF contained multiple symptoms (e.g. fever, diarrhea, jaundice, vomiting, and rash) rather than analyzing single symptom might account for the insignificant difference in monthly trend.

According to the inbound passengers fever detection trend from week 27, 2005 to week 26, 2007 (Figure 5), there were two significant peaks of fever cases. One peak was from week 23 to week 38 (Jun.-Sept.) which correlated with summer vacation and the other peak was from week 51 to next year week 10 (Dec.-Mar. next year.) which correlated with winter vacation, New Year and Chinese lunar new year. According to the inbound passengers important Notifiable infectious disease cases (Figure 1), the monthly number of gastrointestinal bacterial disease agents screened (Table 3), and the detection rate for important Notifiable infectious diseases detected by the international ports, we found fever peak happened during week 23 to week 38 which was compatible to the monthly trends. Vector born diseases (e.g. dengue, malaria, etc.) and GI infections which could all result in fever symptom in patients might account for such result [19]. The researches about the influenza indicated that flu epidemics usually appeared from Nov. to March next year. [20]. The number for positive influenza virus isolation was clustered from Nov. to Mar. or April next year in 2002-2006 in Japan. The positive influenza virus isolation number was mainly from Dec. to early Feb or Mar.-Apr next year in 2000-2006 in Taiwan [21, 22]. This was similar to the peak of fever detection rate in international ports (week 51 to week

10 next year).

Conclusion and Recommendation

There was no significant change in monthly trend for the detection rate of symptomatic inbound passengers, but it was highly related to the surveillance method used in international ports. The rate was reflected on the change in surveillance methods. We noticed that the number of detected Notifiable infectious diseases was increased after the termination of entire CDSF with the launch of infrared thermography. We concluded that the detection sensitivity of infrared thermography was significantly higher than the entire CDSF. Apart from the increase in the detected case numbers for Notifiable infectious diseases, the detected diseases category has also changed from gastrointestinal infectious diseases to vector borne diseases.

With the combination of entire CDSF and infrared thermography, we could detect more important imported Notifiable infectious diseases. Taking into consideration of the cost for personnel, material printing, internal public health status and international health regulation (IHR), we should be able to use only infrared thermography for surveillance when there is no serious international infectious disease outbreak (e.g. SARS, H5N1 pandemic flu, etc.) happening.

From our study, the monthly changes in detection rate for important Notifiable infectious diseases (Figure 2) were noted, but it is not the symptomatic rate(Figure 3) that may be related to the multiple choices in the CDSF. We also noted monthly differences in fever cases and its peak in Jun. - Sept. each year was correlated with the detection of important Notifiable infectious diseases and gastrointestinal bacterial disease agents. The fact that those infectious diseases (vector borne diseases, salmonella infection, etc.) usually had fever symptoms might contribute to such findings.

One of the peaks for inbound passengers fever rate was in Jun.-Sept. and was correlated with important Notifiable infectious disease and gastrointestinal bacterial disease agent detection trend. Out of these fever cases detected, only few had their disease causal agent identified. Further investigations are required for the rest of fever cases in an attempt to find out possible causes for fever.

Another fever peak was from Dec. to Mar. next year, which was similar to the flu epidemic season in Northern Hemisphere. Due to limitation of our 2-year study, we did not have enough large collecting specimens and information for related influenza surveillance. We suggested that the inbound passengers surveillance could integrate with other related research and surveillance to aim for future influenza prevention.

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