

Actions Taken to Prevent Dengue Fever during the 2007 National Games and the Results

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Summary

The first localized outbreak of dengue fever in the summer of 2007 occurred in the Annan district of Tainan City. The virus then spread to the city's northern and eastern districts. As host of the 2007 National Games from 20 - 25 October, Tainan was getting ready to welcome up to 15,000 athletes and staff members. To protect visitors against infection, and to avoid further spread of the disease when they returned to their home cities, the Executive Yuan set up a National Games Dengue Fever Prevention Task Force. This was made up of associated departments of the central government and local city councils. The mission of the Task Force was to help the Tainan City Government take the necessary steps to prevent dengue fever. These steps included continuous eradication and monitoring of larval and adult mosquitoes. The Task Force also supplied athletes and staff with repellent, as well as brochures to educate them about self-protection. From 16 October 2007, the Centers for Disease Control (CDC) sent a commander and 41 disease controllers to live onsite and administer dengue fever prevention tasks and monitor the health of staff and athletes. As part of the onsite monitoring

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process, they also captured mosquitoes and tested them for the dengue virus. Thanks to the cooperation of all those involved, none of the athletes, staff and judges were infected with dengue fever. It was ‘mission accomplished’.

Keywords: dengue fever, games, vectors breeding sources, surveillance

Introduction

Dengue fever is the most widely-spread insect-borne disease. At the moment there are about 2.5 billion people living in areas affected by dengue fever[1]. Taiwan contains both subtropical and tropical areas, with high temperatures and high humidity. This is the perfect breeding environment for mosquitoes.

Aedes aegypti and *Aedes albopictus* are the two major vectors of the dengue virus. *Aedes aegypti* mosquitoes like to stay indoors and often breed in water containers indoors. They cannot fly further than 100 meters and are found mainly at altitudes below 1,000 meters[2]. *Aedes albopictus* prefer the outdoors. They can be found anywhere in Taiwan, from the plains to altitudes of up to 1,500 meters[3].

In the 1950s and 60s, the US used dichlorodiphenyltrichloroethane (DDT) to eliminate *Aedes aegypti* in its territories and control dengue fever. No better mosquito vector control strategy has emerged since then[4]. Mosquito control is the main method of dengue prevention at the moment. *Aedes* mosquitoes live among humans, fly for short distances and often breed in artificial containers. So limiting and draining such containers are the most effective ways to control the spread of the disease. Insecticides tend to have limited effectiveness[5].

Although it is still debatable whether or not dengue fever has become endemic to Taiwan, most recent local dengue outbreaks have been caused by foreign strains that have migrated to the country[3].

Tainan lies south of the Tropic of Cancer. The Central Weather Bureau records Tainan's year-round average temperature for the past five years as 23.2 - 23.6°C, with October temperatures averaging 25 - 27.2°C. The mild weather of Tainan offers *Aedes* mosquitoes the perfect environment in which to breed. As a result, the city had suffered four serious dengue fever outbreaks in recent years according to the record of Disease Reporting System of the Centers for Disease Control: in 1998 (134 cases), 2000 (109 cases), 2002 (66 cases) and 2005 (57 cases). Forty-seven percent of these cases occurred in October and November. When the 2007 summer arrived, the index case of dengue fever appeared in the Annan District. The outbreak spread to the northern and eastern districts. By 18 October, confirmed cases were increasing by 20 to 30 a day. Hot zones included 43 villages and 6 competition grounds. The total number of confirmed cases had reached 720.

Although Tainan was still the city most affected, there was no sign of the virus's spread being contained. Yi Lan Hsien, Tao Yuan Hsien, Miao Li Hsien and Chung Hwa Hsien all reported cases of residents becoming infected with dengue fever after visiting the south. Hence, there was a real risk of further outbreaks caused by citizens visiting dengue-prone areas and carrying the virus back to their home towns.

Big sporting events always attract large numbers of people and increase the chance for diseases to spread. Viruses can spread in competition grounds, practice grounds, medical care centres and grandstands. Not only athletes, but also judges and spectators can contract a disease[6]. Epidemic monitoring can not only predict and detect possible outbreaks of infectious diseases or biological terrorist attacks during big events, it can also improve the quality of public health and medical services. Epidemic monitoring systems have been set up during many

international games to monitor possible disease outbreaks. The epidemic monitoring system used at the 2000 Sydney Olympics in Australia included an epidemic reporting system, an emergency monitoring system, yacht monitoring, an accident reporting system, an environmental surveillance system, food safety surveillance system, and global epidemic surveillance system. This system was based on a system designed in 1991 by a group of general practitioners, hospitals, laboratories, schools and childcare centres. As epidemic reporting tends to be passive, the organiser also chose another 22 diseases for active monitoring[7].

The 2007 National Games was the highest level of sporting event in Taiwan. It was opened on 19 October in Tainan City and included 35 different competitions, held in 43 separate sporting facilities. Up to 15,000 athletes and staff were due to attend. In order to protect the participants from being infected by attending the Games, and to avoid further spread of the disease from visitors carrying the virus back to their home cities, the Executive Yuan decided to set up a National Games Dengue Fever Prevention Task Force at its 3061st meeting. The Task Force was a joint effort by the Department of Health, the Department of Environmental Protection Administration, the Sports Affairs Council, the Ministry of National Defense, the Ministry of Education and the Tainan City Government to control and prevent further dengue fever infection during the National Games. This report summarizes the actions taken during the Games to prevent dengue fever infections.

Actions Taken to Prevent Dengue Fever - and Results

From 16 October 2007, the Centers for Disease Control sent a commander and 41 onsite disease controllers to live at the competition grounds and athletes' villages.

Table 1. List of venues and Onsite disease controllers

Name	Competition	Venue	District
Shang			
Kuan,Li-Chen/ Chen,Wem-Bin	Road Cycling	Si Cao Avenue	Annan
Huang, Xiu- mian	Athletes' Villages	Lu Er Men Tian Ho Temple	Annan
Tsai, Kun-hsien/ Lin, Liang-Dao	Rowing	Lu Er Men River (destination)	Annan
Wu, Mei-Ling	Kayaking	Lu Er Men River (Beginning)	Annan
Lin, Chiao-Wen	Hockey	Leader University playground	Annan
Chiu, Hsien-Ya	Beach Volleyball	Andian Elementary School	Annan
Yang,Yung-Lung	Athletes' Village	Lu Er Men Ma Tsu Temple	Annan
Lin, Hsiu-Kuci	Wrestling	An Sun Junior High School Gym	Annan
Chen,Wen-Ying	Archery	He Shun Liao Exercise Park	Annan
Yang, Jui-Chuj	Softball	He Shun Liao ExercisePark	Annan
Ko, Hai-Yun	Rhythmic Gymnasitics	Gongyuan Elementary School Gym	North
Yu, Ming-Hung/ Lee, Gi-Fu	Judo	Min De Junior High School Gym	North
Huang, Yu-Fen	Baseball	Xiao Bei Baseball Field	North
Chen, Wan-Ching	Weightlifting	Tainan Municipal Weightlifting Stadium	East
Hsu, Yu-Jen	Gymnastics	Hou Jia Junior High School Gym	East
Wu, Ying-Hao	Table Tennis	Tainan Munical Table Tennis Court	East
Chen, Su-Chin	Men and Women's Basketball	Dong Guang Elementary School Gym	East
Hung, Su-Chu / Fu, Chiou-Ling	Bowling	Gold Bowling Alley	East
Lu, Shu-Rong	Billiard	Chong Syue Elementary School Gym	East
Chen, Chu-Tzu	Athletes' Village	Chong Ming ElementarySchool	East
Wang, Jen-Hsin	Boxing	Fu Sing Junior High School Gym	East
Pan, Swu-Ling/ Lee, Shiann-Lan	Handball	Ta Chung Junior High School Gym	South
Wen, Chiu-Hsiang	Women's Volleyball	Hsin Hsing Elementary School Hsin Hsing Court	South
Ye, Hui-zhu	Fencing	Young Hwan Primary School Gym	South
Hou, Chun-Shen	Sailing	Golden Seashore	South
Liang, Chao-Hua	Equestrian	Golden Seashore Qin Shui Park	South
Yu, De-Rong	Karate	An Ping Junior High School Gym	Anping
Cheng, Yu-Hsin	Athletes' Village	An Ping Ten Ho Temple	Anping
Liu, Meil-Ying	Road Cycling	Lin Mo Niang Park	Anping
Ko, Yin-Feng	Taekwondo	Jin Cheng Junior HighSchool Gym	West-Central
Chen, Mei-Rong	Bodybuilding	National Tainan Living Art Center	West-Central
Lee, Pei-Ling	Wushu	Sie Jin Primary School Gym	West-Central
Chen, Mei-Ju	Men's Volleyball	Jhough Shan Junior High School Jhough Shan Court	West-Central
Chen, Yu-Hsin	Athletes' Village	Da Tan Ho Temple	West-Central
Kao, Chuan Yin/ Lee, Yin-Hsin	Athletes' Village	National Tainan Girls' Senior High School	West-Central
Wang, Cheng-Haw	Cross-Country Cycling	Tainan Municipal Track Cycling	South
	Baseball	Tainan Municipal Baseball Field	South
Tsai, Yu-Chi	Track Cycling	Tainan Municipal TrackCycling	South
	Shooting	Tainan Municipal Shooting Gallery	South
Shih, Tsung-Chen	Soft Tennis	Tainan Municipal Soft Tennis Court	South
	Swimming	Tainan Municipal Labor Swimming Pool	South
Huang, Chen-Chie	Men's Soccer	Tainan Municipal Football Field	South
	Tennis	Tainan Municipal Tennis Court	South
Tsai, Pi Fei	Rugby	Tainan Municipal Rugby Field	South
	Badminton	Tainan Municipal Badminton Field	South
Yang, Cheng-Huang	Track and Field	Tainan Municipal Gym	South

They followed routine dengue fever prevention tasks at each venue and monitored the health of staff working onsite. They also captured mosquitoes onsite and tested them for the dengue virus. Every morning at 8.30am, the Centers for Disease Control called a special meeting, after which they updated the Executive Yuan on the Task Force's progress.

Supply Self-Protection Instructions

To educate Games staff, athletes and judges about the symptoms of dengue fever, its transmission path, and ways to protect against the disease, the Centers for Disease Control helped the Tainan City Government produce 15,800 Dengue Fever Personal Prevention Kits. Each Kit contained a dengue fever educational brochure and repellents. They were given to individual members when they arrived and registered for the Games.

Eliminate mosquito breeding grounds

From 16 - 17 October, 477 water-collecting containers were found indoors and outdoors. Of these, 131 tested positive for mosquitoes (Figure 1).

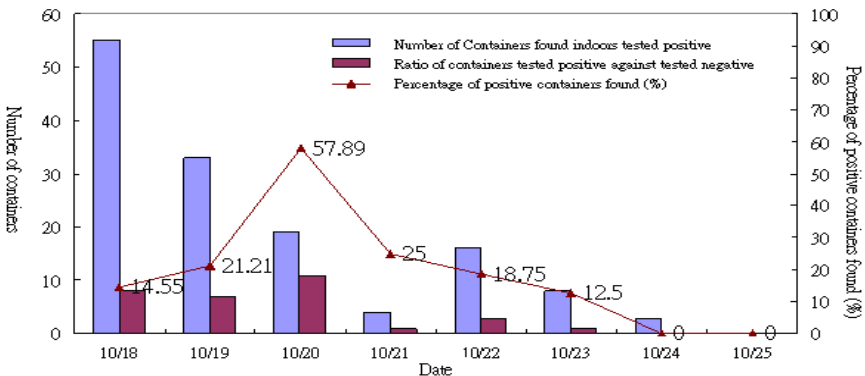


Figure 1. Daily number of water collecting containers found indoors and removed by onsite disease controllers

From 18 - 25 October, 2124 water-collecting containers were found. Of these, 138 were outdoors (31 positive), and 1,896 indoors (544 positive) (figure 2).

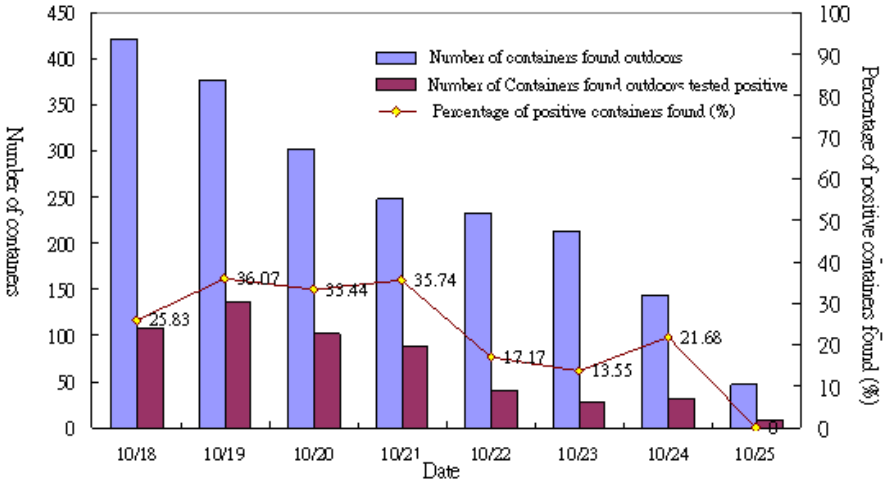


Figure 2. Daily number of water collecting containers found and removed outdoors by onsite disease controllers

Data shows that containers collected outdoors significantly outnumbered containers found inside. Containers outside were more likely to test positive. But the gradual decrease in containers collected since onsite disease controllers moved in, showed that they had been effective in reducing possible breeding grounds for mosquitoes.

Capture adult mosquitoes

From 16 - 17 October, 208 adult mosquitoes were captured. From 18 - 25 October, a total of 1,911 *Aedes* mosquitoes were captured. Of these, 334 were *Aedes aegypti* and 1,577 *Aedes albopictus*.

Of the *Aedes* mosquitoes captured from 22 - 23 October, 646 were captured outside (133 *Aedes aegypti* and 513 *Aedes albopictus*) and 6 inside (5 *Aedes aegypti* and only 1 *Aedes albopictus*). This result showed that more *Aedes albopictus* existed outdoors.

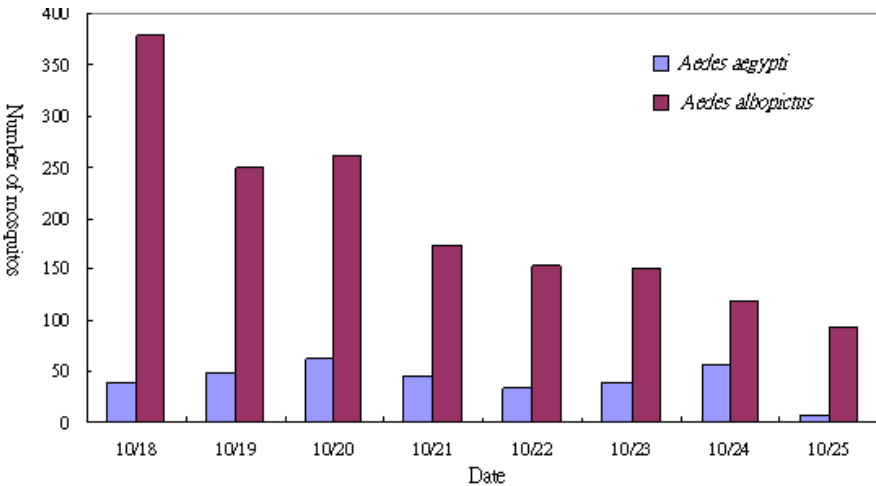


Figure 3. Quantity of mosquitoes captured by onsite disease controllers

Dengue Fever virus testing in mosquitoes

Onsite disease controllers captured mosquitoes at every Games venue and all athletes' villages. They sent their daily captures to the Vector Biology Laboratory, CDC for dengue fever virus testing. From 18 - 25 October, the Laboratory tested 1,575 mosquitoes in 376 lots. None of them showed a positive result.

Health monitoring

Onsite disease controllers also monitored attendants' health daily. From 18 - 25 October, nobody showed any signs of concern.

Attendants' Self-Protection

The National Games Dengue Fever Prevention Task Force asked all contestants, staff and judges to follow routine self-protection procedures during the Games, and to self-monitor for another 10 days after the games. By 4 November 2007, none of the participants had been infected with dengue fever.

Discussion

The worldwide distribution of dengue viruses and their mosquito vector have increased the frequency of dengue outbreaks. Epidemics caused by multiple serotypes have become more frequent, and dengue hemorrhagic fever has emerged in new areas. According to the World Health Organization, dengue fever has become a major international public health concern[9].

Dengue outbreaks have become more and more difficult to control. For five main reasons: more people are now living in urban areas; it is getting harder to eliminate and control mosquito vectors; the climate is changing; the virus is evolving; and more people are travelling between countries[10].

Visitors to dengue-infected areas are highly likely to become infected with the dengue virus, no matter what the purpose of their visit. Travellers are more likely to contract dengue virus than malaria, or even Hepatitis A or *Salmonella* Typhoid[11].

The risk of dengue infection while travelling varies according to the time of travelling, the season and the destination[12]. A higher temperature reduces the dengue virus's incubation period so it increases the risk of the virus being transmitted by *Aedes* mosquitoes[13].

The Central Weather Bureau records show that in October 2007 western Taiwan suffered a lot of rain dumped by Typhoon Krosa. Tainan's October

temperature averaged 26.4°C (maximum 33.9°C, minimum 20.6°C), higher than its historic average.

At 35°C, it takes 7.2 ± 0.2 days for *Aedes* mosquitoes to incubate. However, when the temperature cools down to 15°C, the time required extends to 39.7 ± 2.3 days. The most suitable temperature for *Aedes* mosquitoes to survive is 20 - 30°C, when their life cycle is about 30 days[15].

The Disease Reporting System of the Centers for Disease Control also records that localized dengue outbreaks tend to peak between October and November[figure 4].

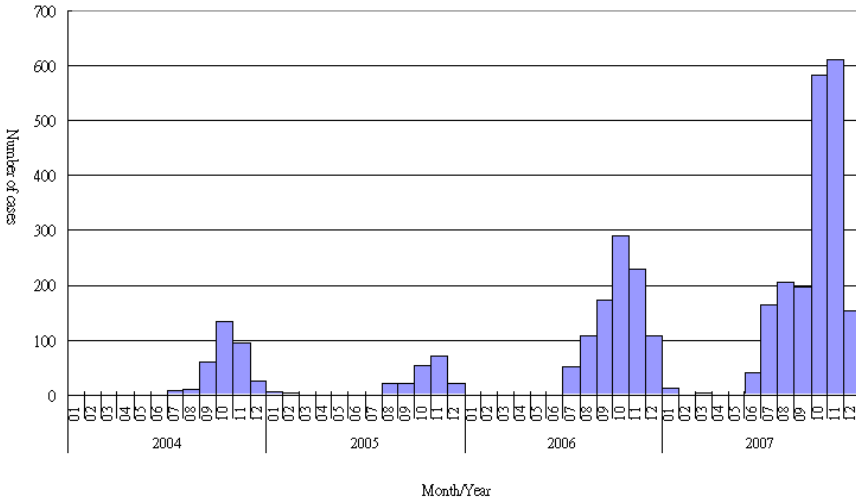


Figure 4. Epidemic Curve of Localized Dengue Fever in Taiwan between 2004-2007

The first thing to consider when planning for an epidemic prevention and control strategy during large scale sports event is to identify the risk profile of participants and spectators[16]. All the information showed that there was a high

risk of dengue fever infection for contestants, staff and judges who participated in the 2007 National Games.

In the 1950s and 60s, the US used DDT to eliminate *Aedes aegypti* and control dengue fever. No better control strategy has emerged since then [4].

Successful dengue control depends on containing the mosquito vectors that carry the virus around. Mosquitoes live among humans and prefer to lay eggs in artificial water collecting containers. So limiting and draining such containers are the most effective ways to control the mosquito vectors. Insecticides tend to have limited effectiveness[5].

The strategy used to prevent dengue fever during the 2007 National Games was to eliminate water containers at competition venues and athletes' villages. The target was to have zero breeding grounds for mosquitoes. At the same time, all participants were given educational brochures to show them how to protect themselves.

It is important that visitors to dengue-infected areas learn about the risk of dengue infection, its symptoms and ways to prevent it[11]. So the 2007 National Games supplied an educational brochure and repellent to all participants and staff.

When visiting endemic areas, it's better to wear light colored clothes with long sleeves and trousers and put DEET (Diethyltoluamide) on exposed skin to avoid mosquito bites. DEET is one of the two repellents recommended by the Centers for Disease Control and Prevention, USA.

A search of the Department of Health's Medicines, Medical Equipments and Cosmetics Licensing Database found that currently there are five DEET-based repellent products that are approved by the Department. Another repellent recommended by the US Centers for Disease Control and Prevention was picaridin, but it's not yet available in Taiwan.

Plant oils, like lemon eucalyptus, have a similar repellent effect to low level DEET[18]. However, most repellents from plants have little or no effect in protecting against mosquitoes. *Aedes* mosquitoes mainly bite during the day, 4 hours after sunrise and 4 hours before sunset. So it's better to use repellent during the day, especially in the morning and at dusk[11].

The effectiveness of DEET depends on its concentration level. A higher concentration lasts longer. On average, a 23.8% concentration of DEET lasts about 5 hours (3-6 hours) and a 6.65% concentration lasts 2 hours (1.5-2.8 hours). But it is also affected by the environment. Temperature and wind can all make a difference to its effectiveness[17].

The 2007 National Games supplied DEET-based repellents to participants for their self-protection. It protected them from mosquito bites, ensured none of the dengue viruses was carried home by the participants, and stopped the outbreak from spreading further.

Eliminating mosquitoes' breeding grounds is the most effective way to control dengue fever. If an area is sprayed with insecticide but water-collecting containers are not replaced or drained, these containers will soon become breeding grounds for mosquitoes[11]. As *Aedes* mosquitoes can fly up to 100 meters, onsite disease controllers were also responsible for areas within 100 meters of each venue.

To ensure a safe, mosquito-free environment, the Tainan City Government asked the Ministry of National Defense for manpower to clear out containers and spray insecticide. From 11 - 19 October, the Ministry mobilized 2,430 soldiers to clean and spray 32 competition grounds and athletes' villages, a total area of 2,752,118 square meters.

The experience learned from the 2002 dengue fever prevention project in

Pi-Tong City showed that the only effective way to eliminate adult mosquitoes is to combine chemical spraying with a determined effort to remove mosquitoes' breeding grounds[20]. Dengue virus testing and monitoring of captured mosquitoes can also help with the early detection of dengue outbreak risks[21]. All of the mosquitoes captured during these games tested negative for dengue fever.

The analysis of public health risk profiles from the 2004 Athens Olympic Games showed that diseases transmitted through contaminated food or water posed the highest risks, followed by airborne diseases and those transmitted by sneezing or coughing, especially those easily transmitted indoors, like flu, tuberculosis, meningitis, whooping cough, measles and legionnaires' disease[22].

Turbeville collected 59 articles dated between 1922 and 2005 that reported infectious disease outbreaks during sport events. The sports included soccer (20 reports, or 34%), wrestling (19 reports, 32%), rugby (10 reports, 17%), swimming and basketball. The most common infections were caused by *Herpes simplex* viruses (13 cases, or 22%) and *Staphylococcus aureus* (13 cases, 22%). The second most common viruses were coxsackieviruses and echoviruses. None of the athletes in those articles was infected with West Nile virus, even though those events happened in the seasons when mosquitoes were most active[6, 16]. Other than sport events, there were also reports about outbreaks during religious pilgrimages, most notably the outbreak of serogroup W-135 meningococcal disease during the 2000 Hajj in Saudi Arabia[23].

Dengue fever broke out island-wide in Taiwan in 1915, 1931, and 1942. In 1995, there were dengue outbreaks in Chungho City and Taichung City. In 1996, Taipei also suffered a localized dengue outbreak. Dengue fever epidemics are a real risk everywhere in Taiwan. If participants were not monitored by the dengue fever surveillance system after the National Games ended, the virus could have

spread further.

After the 2007 National Games, health authorities used multiple surveillance systems to monitor possible outbreaks. These systems collected and reported cases of statutory infectious diseases, acute illness, infectious diseases in populated organizations and schools, cases of certain symptoms, and high fevers for unknown reasons. The general public were also encouraged to self-monitor and report possible infections through a variety of channels. These included the public self-monitoring and reporting system, contacting the Centers for Diseases Control, and dialing the 1922 helpline.

To complete the surveillance network, there were also other systems for active health monitoring, and to monitor and test adult mosquitoes for dengue virus.

Although there was no report of outbreaks due to the Games, health authorities still take dengue prevention tasks very seriously to protect the health of the public.

Conclusion

Although the Games were held in a dengue-prone environment, none of the participants in the 2007 National Games were infected with dengue fever. This success was due to the full cooperation between government departments, their determination to eliminate mosquitoes' breeding grounds at the venues, an effective surveillance system, and the complete self-protection instructions offered to participants.

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