

An Adenovirus Outbreak Associated
with a Swimming FacilitySung-Hsi Wei^{1,2*}¹Department of Public Health, China Medical University, Taiwan (R.O.C)²Department of Emergency, China Medical University Children's Hospital, Taiwan (R.O.C)

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*Corresponding author

Sung-Hsi Wei, Department of Public Health, China Medical University, Taiwan (R.O.C.), Email: epediat@gmail.com

Distributed under Creative Commons CC-BY 4.0**Keywords** Swimming Pool; Adenovirus; Taiwan; Tropical; Conjunctivitis**Article DOI** 10.36876/smtmj.1007

Abstract

Adenovirus outbreaks have been reported to be associated with recreational water over the past decades. An outbreak of respiratory tract infection in a primary school in central Taiwan occurred in September 2011. The laboratory tests showed that it was an outbreak of adenovirus infection. Epidemiological investigations revealed that the outbreak was associated with a swimming facility outside the school. Our report emphasized the potential threat of adenovirus infection associated with swimming facilities, especially in a community adenovirus epidemic setting.

The study

Adenovirus is a double-stranded DNA virus that infects hosts across a broad spectrum of vertebrates [1]. Since its first isolation from human adenoid tissue and named for the tissue of origin in 1953, there have been more than 50 genotypes identified worldwide [2,3]. Adenovirus infection causes a variety of diseases with some genotype predisposition, including conjunctivitis, gastroenteritis, respiratory tract infection, and cystitis [4,5]. The clinical presentation ranges from mild self-limited illness to fatal infection [6]. A primary adenovirus infection may convey genotype-specific lifelong immunity to the human host [7].

Adenovirus was one of the major viral pathogens associated with acute respiratory tract conditions. It has been reported to be the most common agent associated with pharyngitis and tonsillitis in Taiwan [8]. Adenovirus genotype 3 was the predominant genotype in Taiwan in the past 3 decades [9,10]. An epidemic of adenovirus infection occurred in Taiwan in 2011. The predominant genotypes associated with the epidemic were genotype 3 and genotype 7, which was rarely isolated from clinical specimens in the preceding years in Taiwan and was associated with severe clinical manifestation [10-12].

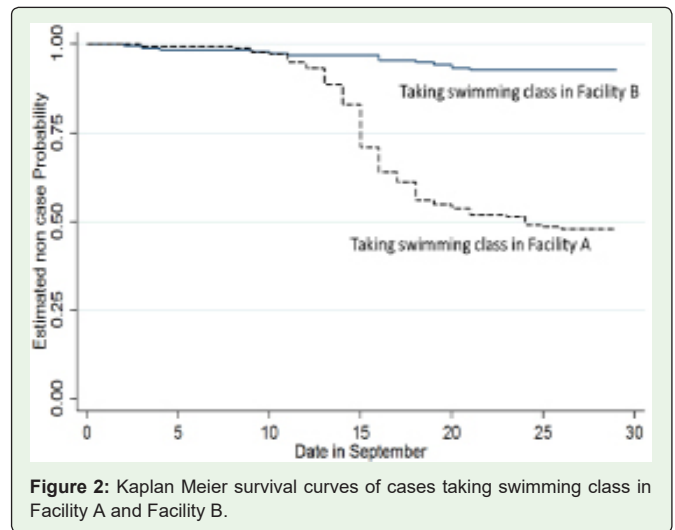
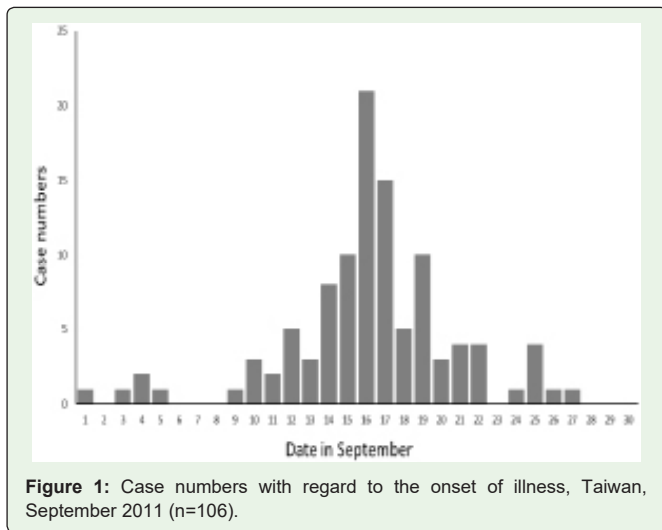
Adenovirus outbreak associated with swimming pool water was first reported in the 1950s [13,14]. In recent decades it was reported to be the 2nd largest cause of outbreaks associated with recreational water in the literature [15]. However, most of the outbreaks occurred in western countries above 40 degrees of latitude [15,16]. Here, we report an outbreak of adenovirus infection associated with swimming in Taiwan, a tropical and subtropical country in Asia.

The public health authority was notified of a respiratory tract infection outbreak in a primary school in central Taiwan on September 15, 2011. The affected students presented with fever and symptoms of upper respiratory tract infection from early September. After the outbreak was identified, the affected students were encouraged to take sick leaves or to use surgical masks on campus. Moreover, school staff was asked to use bleach to disinfect the desks and chairs daily in classes where affected students might have contacted.

To use the laboratory resources efficiently, public health authorities were requested to submit no more than 10 specimens for one outbreak for laboratory investigation by Taiwan Centers for Disease Control. Ten throat swabs of affected students were submitted to the laboratory in Taiwan Centers for Disease Control for etiological study. The multiplex real-time Polymerase Chain Reaction (PCR) technique was used to detect potential pathogens including influenza virus, adenovirus, respiratory syncytial virus, coronaviruses (229E, OC43, NL63, HKU1, MERS-CoV), metapneumovirus, parainfluenza type 1-4, and herpes simplex virus [17-22]. All 10 students tested positive for adenovirus and negative for the other viruses. Because genotype was associated with clinical manifestation and severity for adenovirus infection, another PCR genotype analysis was conducted targeting a 956-bp region of the adenovirus hexon gene to study the genotype, with all 10 samples testing positive for adenovirus genotype 7 [23]. The majority of the affected students were 5th and 6th graders who had swimming class in two swimming facilities, Facility A and Facility B, outside the school. The preliminary investigation showed that the incidence of illness seemed higher in the classes in which students attended swimming class in Facility A than that in Facility

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B. The swimming class was temporarily suspended to prevent further outbreak. Public health personnel obtained the regular test results performed by the county government in August 11, 2011 and found the chlorine level was 2.8 and 2.3 parts per million (ppm) in Facilities A and B, respectively. The maintenance logs in both facilities were inspected and both showed the daily chlorine level measured by the facility staff to be between 1.0 to 2.0 ppm in August and September. No record of chlorine level less than 1.0 ppm had been identified in either facility. Because of logistic barriers, water samples were not obtained from either facility for virological or chlorine level analysis.

Between September 26th and 30th, a paper-and-pencil questionnaire was initiated among the 5th and 6th graders to explore the clinical manifestation and epidemiological features of the outbreak. The case definition in the outbreak was defined as concurrent presence with fever and one of the following respiratory tract infection symptoms in September 2011: cough, sore throat, headache, rhinorrhea, nausea or vomiting, diarrhea, conjunctivitis, or skin eruption. Fever was defined as a measured body temperature of greater than 37.5 degrees Celsius.

Of the 385 students in grade 5 and grade 6, 373 (96.9%) completed the questionnaire. Of the 373 students, 112 (30.0%) developed fever and 106 (28.4%) satisfied the requirements of the case definition. With regard to the onset of illness, the case number peaked on September 16th and gradually decreased stepwise thereafter (Figure 1). In addition to fever, case students presented with sore throat (80/106, 75.5%), headache (65/106, 61.3%), cough (55/106, 51.9%), rhinorrhea (51/106, 48.1%), diarrhea (42/106, 39.6%), vomiting (22, 20.8%), skin eruption (5/106, 4.7%), and conjunctivitis (3/106, 2.8%). Sixty-nine (65.1%) of the 106 case patients had taken sick leave and 4 (3.8%) had been hospitalized. All the case patients recovered

completely without long-term sequelae. Survival analysis with Stata software (version 13, Stata Corp LP, College Station, Texas, USA) was carried out for risk factor analysis. Potential risk factors included the facilities in which students attended swimming class, gender, and grade. Taking swimming class in Facility A was the only risk factor significantly associated with becoming case students in univariate and multivariate analysis ($p < 0.001$) (Table 1). Kaplan-Meier survival curves were constructed based on taking swimming class in the facilities (Figure 2).

Our investigation demonstrated that the outbreak was associated with attending swimming class in Facility A, of which the maintenance log showed the chlorine level was between 1.0 to 2.0 ppm in August and September. The result was inconsistent with a previous review that 69% of swimming pool outbreaks were associated with inadequate chlorination with free chlorine less than 1 ppm [15]. Harley has reported an adenovirus outbreak associated with a swimming pool which chlorine concentration was 1.0 ppm [24]. Because the chlorine might be exhausted within hours in hot days, the common circumstances in tropical countries, he asserted a chlorine concentration of not less than 2.0 ppm would be appropriate [24]. In addition, the records in the maintenance log were maintained by the facility staff and were obtained days after the outbreak was identified, resulting in the disputable credibility of the records in both facilities. The water used in the shower room might also have contributed to the adenovirus infection. However, no records for the chlorine level of shower water in either facility were available during the investigation.

During swimming class, students might contract adenovirus infection through direct contact with contaminated water or

Table 1: Univariate and multivariate analysis of potential risk factors for becoming case students in the outbreak.

characteristics	Case (n=106) (%)	Non-case (n=267)(%)	Univariate analysis			Multivariate analysis		
			Hazard ratio	95%CI [†]	pvalue	Hazard ratio	95%CI [†]	pvalue
Facility A	92 (86.8)	86 (32.2)	9.33	5.31-16.39	<0.001	9.62	5.46-16.96	<0.001
Male	56 (52.8)	143 (53.6)	0.99	0.68-1.45	0.96	1.18	0.81-1.74	0.39
Grade 5	54 (50.9)	143 (53.6)	0.99	0.67-1.45	0.96	1.16	0.79-1.71	0.44

[†]CI indicates Confidence Interval.

inhalation of aerosolized droplets from the swimming pool. The increasing number of infected children might further increase the outbreak scale exponentially when they attended the swimming class in facility A. Students who attended swimming class in Facility A attended other classes together in school, potentially further facilitating droplet transmission through close contact with case students. In addition to swimming class suspension in the swimming facilities, taking sick leaves or using surgical masks on campus might halt the adenovirus transmission, contributing to the decrease in number of cases since September 16th.

The laboratory tests demonstrated that the outbreak was associated with adenovirus genotype 7, which had caused an epidemic in Asia between 2011 and 2013 [10,16,25]. Previous study showed that the hexon gene sequences had high similarity among that of adenovirus isolated in Singapore, China, and Taiwan during the aforementioned epidemic [25]. Although adenovirus genotype 7 has been implicated in severe infection in the community epidemic setting, the case students in our outbreak did not present with severe clinical manifestation and all recovered completely [10].

Our report was limited by the low number of clinical specimen tested and absence of laboratory investigation for swimming pool water; nevertheless, our report emphasized the potential threat of adenovirus infection associated with swimming facilities, especially in a community adenovirus epidemic setting.

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