HHS Public Access

Author manuscript

Epidemiol Infect. Author manuscript; available in PMC 2015 October 20.

Published in final edited form as:

Epidemiol Infect. 2014 May ; 142(5): 1002–1007. doi:10.1017/S095026881300174X.

Varicella Zoster Virus in American Samoa: Seroprevalence and Predictive Value of Varicella Disease History Among Elementary and College Students

A. Mahamud[1,2], **J. Leung**[1,*], **Y. Masunu-Faleafaga**[3], **E. Teshale**[4], **R. Williams**[2,4], **T. Dulski**[5,6], **M. Thieme**[1], **P. Garcia**[1], **D.S. Schmid**[1], and **S.R. Bialek**[1]

[1]National Center for Immunization and Respiratory Diseases, Centers for Diseases Control and Prevention, 1600 Clifton Rd, Atlanta, GA 30333, United States

[2]Epidemic Intelligence Service, Centers for Disease Control and Prevention, 1600 Clifton Rd, Atlanta, GA, 30333, United States

[3]Immunization Program, American Samoa Department of Health, LBJ Tropical Medical Center, Pago Pago, American Samoa 96799, United States

[4]National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention, Centers for Diseases Control and Prevention, 1600 Clifton Rd, Atlanta, GA 30333, United States

[5]National Center for Injury Prevention and Control, Centers for Diseases Control and Prevention, 1600 Clifton Rd, Atlanta, GA 30333, United States

[6]CDC Experience Applied Epidemiology Fellowship, CDC Foundation, Atlanta, GA 30303

Summary

The epidemiology of varicella is believed to differ between temperate and tropical countries. We conducted a varicella seroprevalence study among elementary and college students in the US-territory of American Samoa before introduction of a routine varicella-vaccination program. Sera from 515 elementary and 208 college students were tested for the presence of varicella-zoster virus (VZV) IgG antibodies. VZV seroprevalence increased with age from 76.0% in the 4–6 year-olds to 97.7% in those ≥23 years-old. Reported history of varicella disease for elementary students was significantly associated with VZV seropositivity. The positive and negative predictive values of varicella disease history were 93.4% and 36.4% in elementary students and 97.6% and 3.0% in college students. VZV seroprevalence in this Pacific island appears to be similar to that in temperate countries and suggests endemic VZV circulation.

[*]Corresponding author for questions and request for reprints: Jessica Leung, US Mail: Centers for Disease Control and Prevention, NCIRD, 1600 Clifton Rd, Mail-Stop A-34, Atlanta, GA 30333, Phone: 404-639-6067, Fax: 404-315-2486, JLeung@cdc.gov.

Disclosures:

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

DECLARATION OF INTEREST: None

INTRODUCTION

Varicella is a highly infectious disease caused by the varicella zoster virus (VZV) [1]. Although varicella is usually self-limiting in children, infants less than one year of age, adults, and immunocompromised persons are at greater risk for severe complications that can result in death or require hospitalization [2]. Although VZV infections occur worldwide, the epidemiology has been reported to differ between countries with tropical climates compared to those with temperate climates [3]. In temperate climates, varicella is a nearly universal disease of preschool and school-aged children with peak incidence occurring during late winter and early spring [4]. Varicella seroprevalence studies from temperate countries, such as the United States [5] and western Europe [6], report seropositivity rates of >90% among persons >15 years old. However, in tropical countries, a greater proportion of adolescents and young adults have been found to be seronegative for antibodies to VZV [3]. As a result, these populations remain at risk for varicella at an older age, when it can result in higher rates of complications, hospitalizations, and deaths [1].

The varicella immunization program in the United States has resulted in a 90% reduction in varicella incidence in all age groups [7], >65% decline in varicella-related hospitalizations [8], and 96% decline in varicella-related deaths in persons <50 years [9]. American Samoa (AS), an unincorporated territory of the United States, plans to introduce varicella vaccination as part of their routine immunization program although the specific timeline is unknown; varicella vaccine is not available in the public or private sector in AS at this time. With limited varicella surveillance data from the Pacific Islands, there is little known about the epidemiology of varicella in this region. We conducted a VZV seroprevalence study in AS among elementary and college students to provide baseline data to monitor the impact of a future vaccination program on the epidemiology of varicella in AS.

METHODS

Study Location

American Samoa (AS) consists of six islands located between Hawaii and New Zealand in the South Pacific Ocean [10]. It lies at a latitude of 14°20’S and a longitude of 170°00'W. AS is a tropical island with an average temperature of 26.7 °C (80 °F), high humidity throughout the year, and average monthly rainfall of 9.91 in (251mm). In 2010, the population of AS was 55519 with an estimated annual birth cohort of 1260 children; 95% of the population resides on the main island of Tutuila [11].

Study Participants

The AS Department of Health in collaboration with AS Department of Education invited principals of all private and public elementary schools on the main island of Tutuila to participate in a seroprevalence study of vaccine-preventable diseases to assess immunity against hepatitis B, measles, mumps, rubella, and varicella among first-grade students. We also invited all students from the community college in AS, all of whom only attend college on the island, to participate in a study assessing varicella seroprevalence and measuring the anamnestic response to single dose of hepatitis B vaccination.

This study was reviewed by the AS Department of Health Institutional Review Board and the CDC NCIRD Human Subjects Office. Written informed consent was obtained from participating college students and from parents of elementary students.

Study Questionnaire, Specimen Collection and Laboratory testing

A standard questionnaire, written in both English and Samoan, was distributed to parents/guardians of first-grade students of participating elementary schools and participating college students to collect demographic information, and self-reported varicella disease and vaccination histories. Varicella disease history was based on parental/guardian report for elementary school students, while this information was based on self-report for college students. Information on varicella vaccination history was also retrieved from immunization cards.

Five to ten milliliters of venous blood were collected in April–May 2011 from study participants. The blood samples were centrifuged and the sera was stored at −20°C at the main hospital in AS. Sera were transported on dry ice to the CDC National VZV Laboratory in Atlanta, GA and tested for VZV-specific immunoglobulin G (IgG) antibodies by using CDC's standard protocol. Specimens were tested by whole-cell enzyme-linked immunosorbent assay (ELISA); samples that yielded negative results were retested using the more sensitive IgG glycoprotein (gp) ELISA, as previously described [12, 13].

Analysis

Data were analyzed using SAS (Version 9.3; Cary, NC). We used Pearson's $\chi 2$ or Fisher's exact test to analyze categorical variables. A significant association was defined as one with a two-sided P-value of <.05. We calculated 95% exact binomial confidence intervals. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of self-reported history of varicella in comparison with VZV IgG results were calculated for elementary and college students separately.

RESULTS

Among the 36 elementary schools in Tutuila Island, students in 27 (75%) schools agreed to participate in the study. Adequate samples for VZV testing were collected from 39% (515/1310) elementary and 12% (208/1787) college students. The median age of participants was 6 years (range, 4–9 years) for elementary school students and 20 years (range, 17–35 years) for college students. There were 18 (3.5%) elementary students and 1 (0.5%) college student participant with 1-dose of varicella vaccination documented.

VZV seroprevalence increased from 76% in the 4–6 year-olds to 98% in those ≥23 years-old. History of prior varicella disease for elementary school students was significantly associated with VZV seropositivity (Table 1).

A total of 651 study participants (89% (458/515) elementary school students and 93% (193/208) college students) provided information on varicella disease history (Table 2). The PPV and NPV of varicella disease history for VZV IgG positivity for elementary school students based on parental/guardian report was 93.4% (95% CI: 89.1%–96.3%) and 36.4%

(95% CI: 30.4%–42.8%) respectively. The PPV and NPV of VZV IgG positivity for college students based on self-report was 97.6% (95% CI: 93.3%–99.5%) and 3.0% (95% CI: 0.4%–10.5%) respectively. For elementary school students, the sensitivity of reported disease history was 55.7% (95% CI: 50.3%–60.9%) and specificity was 86.5% (95% CI: 78.5%–92.4%); for college students, sensitivity was 66.0% (95% CI: 58.7%–72.7%) and specificity was 40.0% (95% CI: 5.3%–85.3%).

DISCUSSION

This is the first published report describing VZV seroprevalence in AS. Rates of VZV seropositivity were high for all age groups tested and increased substantially with age, with >97% of ≥17 year-olds VZV seropositive. As in other studies of varicella seroprevalence conducted in populations prior to introduction of varicella vaccine, reported varicella disease history was highly predictive of VZV seropositivity for both elementary and college students in AS, whereas a negative history was a poor predictor of VZV seronegativity.

The high varicella seroprevalence rates we report for AS are similar to those found in recent studies from temperate countries [5, 6] and comparable to seroprevalence rates in the United States before the implementation of the 1-dose routine varicella vaccination program in 1995, although U.S. seroprevalence was lower in children aged 4–10 years-old compared to this population [14]. The varicella sero-epidemiology in AS reported in this study is higher than that in serosurveys conducted in other tropical island populations [3, 15–18]. A serosurvey conducted among young adult military recruits found that 38% from the Pacific Island nations of the Federated States of Micronesia and the Republic of the Marshall Islands during 1988–1990 were VZV seronegative, as were 42% from Puerto Rico during 1986–1987 [17, 18]. There are several possible explanations for differences in the seroepidemiology in AS compared to that previously reported for other islands and regions with similar climates. Daycare attendance by young children in AS has become quite common and high seroprevalence in AS could be facilitated by increased opportunities for transmission among young children attending daycares [4, 19]. Sera for some of the seroprevalence studies conducted in tropical climates were collected 20–30 years ago [16–18] and may not be reflective of the VZV epidemiology today. Finally, results from our study may not be directly comparable to earlier studies that used less sensitive VZV serological assays [13].

Because our study included participants from a limited number of birth cohorts, we cannot fully describe the epidemiology of varicella in AS. The high rates of VZV seropositivity in AS that we found may be related to endemic VZV transmission or the result of periodic epidemics of varicella which could result in nearly all susceptibles in this island population becoming infected. Although varicella is not a reportable condition in AS, Department of Health staff report that varicella appears to circulate continuously in this small island population and that there have been no large outbreaks of varicella observed in recent years.

We found that parental recall of prior varicella disease history was not a reliable indicator for VZV seroprevalence in AS, with only 46% of parents recalling history among elementary school students, yet a VZV seroprevalence rate of almost 80%. The discrepancy

in parental report of varicella history and VZV seroprevalence that we found in our study may be due to off-island varicella vaccination history not captured by our study, survey question translation into the local language, lower parental recognition of varicella in AS, or asymptomatic disease. Additional studies to evaluate the validity of parental recall in this population with laboratory testing may help to identify susceptible populations who should be vaccinated and prevent un-needed vaccinations. However, we did find a high positive predictive value for reported history of varicella disease and VZV seropositivity for both elementary and college-aged students. These data suggest that report of prior varicella disease history in this population may be a reliable indicator of VZV seropositivity if a varicella vaccination program is implemented in American Samoa.

There were several limitations to this study. We used a convenience sampling methodology that was limited to selected age groups and information was not available for non-participants. However, given the relatively small population of AS, we believe that the VZV seroepidemiology we report is likely to be broadly reflective of the age groups tested. Because American Samoans can travel to and work freely in the United States, it is possible that some VZV seropositive participants who reported no varicella disease history may have received doses of varicella vaccine while residing temporarily off-island that were not captured in AS immunization records. We were unable to collect information about place of birth from the college students and therefore it is possible that exposure to VZV for some students may have occurred outside of AS.

The findings of our study demonstrate that there is high VZV seroprevalence in AS, even among the young, suggesting that the epidemiology of varicella in this tropical island country may be similar to that seen in more temperate climates. Varicella complications, although rare, have the potential to be fatal. In addition, varicella can result in lost days of school and work for affected families and require substantial public health resources to control outbreaks and manage severe disease [20]. With a safe and highly effective vaccine available, introduction of a routine varicella vaccination program can significantly reduce varicella disease burden as well as costs, resources, and time allocated for managing varicella cases and outbreaks [8, 9, 20–22].

ACKNOWLEDGEMENTS

We would like to thank Dr. Jane Seward for her thoughtful review of the manuscript.

Financial support: T.D. was funded through the CDC Experience Applied Epidemiology Fellowship program, a public/private partnership supported by a grant to the CDC Foundation from External Medical Affairs, Pfizer, Inc.

REFERENCES

1. Gershon, AA.; Takahashi, M.; Seward, J. Varicella vaccine. In: Plotkin, SA.; Orenstein, WA.; Offit, PA., editors. Vaccines. 5th ed.. Philadelphia: Saunders; 2007. p. 915-958.
2. Arvin AM. Varicella-zoster virus. Clinical Microbiology Review. 1996; 9:361–381.
3. Lee BW. Review of varicella zoster seroepidemiology in India and Southeast Asia. Tropical Medicine & International Health. 1998; 3:886–890. [PubMed: 9855401]
4. Wharton M. The epidemiology of varicella-zoster virus infections. Infectious Disease Clinics of North America. 1996; 10:571–581. [PubMed: 8856352]

5. Reynolds MA, et al. Varicella seroprevalence in the U.S.: data from the National Health and Nutrition Examination Survey, 1999–2004. Public Health Reports. 2010; 125:860–869. [PubMed: 21121231]
6. Nardone A, et al. The comparative sero-epidemiology of varicella zoster virus in 11 countries in the European region. Vaccine. 2007; 25:7866–7872. [PubMed: 17919788]
7. Guris D, et al. Changing varicella epidemiology in active surveillance sites--United States, 1995–2005. The Journal of Infectious Diseases. 2008; 197(Suppl 2):S71–S75. [PubMed: 18419413]
8. Lopez AS, et al. Varicella-related hospitalizations in the United States, 2000–2006: the 1-dose varicella vaccination era. Pediatrics. 2011; 127:238–245. [PubMed: 21199857]
9. Marin M, Zhang JX, Seward JF. Near Elimination of Varicella Deaths in the US After Implementation of the Vaccination Program. Pediatrics. 2011; 128:214–220. [PubMed: 21788222]
10. Central Intelligence Agency. [Accessed 6 September 2012] CIA-The World Factbook: American Samoa. (https://www.cia.gov/library/publications/the-world-factbook/geos/aq.html).
11. U.S. Census Bureau. [Accessed 11 June 2012] 2010 Census Population Counts for American Samoa. (http://2010.census.gov/news/releases/operations/cb11-cn177.html).
12. Maple PA, et al. Performance of a time-resolved fluorescence immunoassay for measuring varicella-zoster virus immunoglobulin G levels in adults and comparison with commercial enzyme immunoassays and Merck glycoprotein enzyme immunoassay. Clinical and Vaccine Immunology. 2006; 13:214–218. [PubMed: 16467328]
13. Schmid DS, Jumaan AO. Impact of varicella vaccine on varicella-zoster virus dynamics. Clinical Microbiology Reviews. 2010; 23:202–217. [PubMed: 20065330]
14. Kilgore PE, et al. Varicella in Americans from NHANES III: implications for control through routine immunization. Journal of Medical Virology. 2003; 70(Suppl 1):S111–S118. [PubMed: 12627498]
15. Bartoloni A, et al. Seroprevalence of varicella zoster and rubella antibodies among rural populations of the Chaco region, south-eastern Bolivia. Tropical Medicine & International Health. 2002; 7:512–517. [PubMed: 12031073]
16. Garnett GP, et al. The age of infection with varicella-zoster virus in St Lucia, West Indies. Epidemiology and Infection. 1993; 110:361–372. [PubMed: 8386097]
17. Longfield JN, et al. Varicella outbreaks in Army recruits from Puerto Rico. Varicella susceptibility in a population from the tropics. Archives of Internal Medicine. 1990; 150:970–973. [PubMed: 2158774]
18. Withers BG, et al. Vaccine-preventable disease susceptibility in a young adult Micronesian population. The Southeast Asian Journal of Tropical Medicine and Public Health. 1994; 25:569–574. [PubMed: 7777928]
19. Kudesia G, et al. Changes in age related seroprevalence of antibody to varicella zoster virus: impact on vaccine strategy. Journal of Clinical Pathology. 2002; 55:154–155. [PubMed: 11865016]
20. Zhou F, et al. An economic analysis of the universal varicella vaccination program in the United States. The Journal of Infectious Diseases. 2008; 197(Suppl 2):S156–S164. [PubMed: 18419391]
21. Marin M, Meissner HC, Seward JF. Varicella prevention in the United States: a review of successes and challenges. Pediatrics. 2008; 122:e744–e751. [PubMed: 18762511]
22. Rozenbaum MH, et al. Cost-effectiveness of varicella vaccination programs: an update of the literature. Expert Review of Vaccines. 2008; 7:753–782. [PubMed: 18665775]

Epidemiol Infect. Author manuscript; available in PMC 2015 October 20.

Table 1

Seroprevalence of varicella in AS for Elementary and College Students, 2011, by selected variables

Variable	Elementary School Students			College Students		
	No. students	Seroprevalence, % (95 CI)	P-Value	No. students	Seroprevalence, % (95 CI)	P-Value
Sex[a]			0.454			1.000
Female	258	77.5 (72.4–82.6)		127	96.1 (92.7–99.5)	
Male	248	81.9 (77.1–86.7)		73	97.3 (93.5–100.0)	
Age[b]			0.388			1.000
4–6 yrs	304	76.0 (73.3–82.6)		NA	NA	
7–9 yrs	205	79.5 (75.6–86.4)		NA	NA	
17–19 yrs	NA	NA		80	97.5 (94.1–100.0)	
20–22 yrs	NA	NA		83	96.4 (92.4–100.0)	
≥23 yrs	NA	NA		43	97.7 (93.2–100.0)	
Region[c]			0.093			0.672
Central	91	73.6 (63.4–82.3)		58	96.6 (88.1–99.6)	
East	68	83.8 (72.9–91.6)		26	96.2 (80.4–100.0)	
Midwest	249	80.3 (74.8–85.1)		86	95.4 (88.5–98.7)	
West	105	70.5 (60.8–79.0)		37	100.00 (90.5–100.0)	
Place of birth[d]			0.277			
AS	463	77.5 (73.5–81.3)		NA	NA	
Outside AS[e]	21	90.5 (69.6–98.8)		NA	NA	
History of varicella disease			<.001			1.000
No	247	63.6 (57.2–69.6)		66	97.0 (89.5–100.0)	
Yes	211	93.4 (89.1–96.3)		127	97.6 (93.3–100.0)	
Documented history of 1-dose of varicella vaccine			0.141			1.000
Yes	18	94.4 (72.7–100.0)		1	100.0 (2.5–100.0)	
No	467	77.5 (73.5–81.2)		149	98.0 (94.2–100.0)	

Note: CI=Confidence interval; AS= American Samoa

[a]Excludes 16 students with missing information on gender.

[b] Excludes 8 students with missing information on birth date or date of serum collection.

[c] Excludes 1 student with missing information on region.

[d] Place of birth was only availablefor 484 elementary school students.

[e] 18 students were born in the United States, 1 student was born in Marshall Islands, 1 student was born in Australia, and 1 student in Tonga.

Table 2

Comparison of reported varicella disease history and VZV seropositivity status by reporting source, AS, 2011.

		VZV IgG Antibodies		
Reporting Source of Disease History	**Reported Varicella Disease History**	**Positive #(Row %, 95% CI)**	**Negative #(Row %)**	**Total**
Elementary School Students[a]	Positive	197 (93)	14 (7)	211
	Negative	157(64)	90 (36)	247
	Total	354 (77)	104 (23)	458
College Students[b]	Positive	124 (98)	3 (2)	127
	Negative	64 (97)	2 (3)	66
	Total	188 (97)	5 (3)	193

[a] Varicella disease history for elementary school students was based on report by parents or guardians of students.

[b] Varicella disease history for college students was based on self-report.