

Continuing Decline in Varicella Incidence After the 2-Dose Vaccination Recommendation—Connecticut, 2009–2014

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Background. Varicella is a highly contagious vaccine-preventable illness. In 1996, the Advisory Committee for Immunization Practices recommended 1 dose of vaccine for children, and in 2006 it recommended 2 doses; Connecticut required 1 dose for school entry in 2000 and 2 doses for school entry starting in 2011. Connecticut varicella incidence overall and among persons aged 1–14 years declined during 2005–2008. We analyzed varicella surveillance data for 2009–2014 to characterize overall and age group-specific trends in the setting of the 2-dose requirement.

Methods. Passive surveillance was used to collect data and identify incidence trends and changes in proportions, and these were assessed by χ^2 tests for trend and proportion, respectively.

Results. Varicella incidence decreased from 13.8 cases/100 000 persons during 2009 to 5.1 cases/100 000 persons during 2014 ($P < .001$); significant declines in incidence occurred among children aged 1–4, 5–9, and 10–14 years ($P < .01$ for each age group). Cases classified as preventable decreased from 44% during 2009 to 25% during 2014 ($P < .01$); significant declines in percentages of preventable cases occurred only among those aged 5–9 years ($P < .05$) and 10–14 ($P < .01$) years.

Conclusions. Varicella incidence continued to decline in Connecticut in the setting of the 2-dose school-entry program. Continued surveillance is needed to assess the full influence of the 2-dose recommendation.

Keywords. immunization; vaccine; varicella.

Varicella, also known as chickenpox, was a universal childhood disease until a live-attenuated vaccine was licensed in 1995. In 1996, the Advisory Committee on Immunization Practices (ACIP) recommended 1 vaccine dose for all children aged 12–18 months and a 2-vaccine dose given at least 3 months apart for persons aged ≥ 13 years without a history of varicella infection [1]. By 2000, vaccination coverage levels had increased to approximately 80% among children aged < 35 months, and varicella incidence, hospitalization, and mortality had substantially decreased [2, 3]. However, during 2001–2005, incidence plateaued and school

outbreaks continued to occur [2, 4]; 1-dose vaccine effectiveness was estimated at 80%–85% for varicella prevention [2]. In 2006, the ACIP recommended 2 vaccine doses: the first administered at age 12–15 months and the second administered at age 4–6 years [5]. A second dose was recommended for all persons previously vaccinated with 1 dose, and 2 doses were recommended for unvaccinated persons without a history of previous infection [5]. The effectiveness of 2 doses is estimated at 98% for varicella prevention [6].

In Connecticut, beginning in 2000, proof of 1 varicella vaccine dose or history of disease was required for entry into kindergarten or grade 7. During 2009, approximately 86.6% ($\pm 7.3\%$) of children aged 19–35 months and 98.4% of children entering kindergarten had received ≥ 1 varicella vaccine dose, and 62.6% (range, 53.4%–71.0%) of adolescents aged 13–17 years had received ≥ 2 doses [7–9]. During 2010, a total of 2 varicella vaccine doses were required in Connecticut for college entry, and starting with the 2011–2012 school year, 2 doses were required for entry into kindergarten

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and grade 7. By the 2013–2014 school year, 96.7% of children entering kindergarten had received >2 doses of varicella vaccine [10]. Among adolescents aged 13–17 years surveyed by the National Immunization Survey-Teen in 2013, 99.1% (± 1.0) and 95.8% ($\pm 3.2\%$) of adolescents aged 13–17 years with no history of varicella infection reported receipt of ≥ 1 dose and ≥ 2 doses, respectively [11, 12].

Varicella was made a reportable disease in Connecticut during 2001. Previous analyses reported that Connecticut's overall varicella incidence during 2001–2005 was stable, although the proportion of cases occurring among persons aged ≥ 5 years had increased [4]. During 2005–2008, which included the first 2 years after ACIP's 2-dose recommendation, overall varicella incidence had decreased from 48.7 cases/100 000 persons to 24.5 cases/100 000 persons, and school outbreaks had declined [13], but incidence among infants, adolescents aged ≥ 15 years, and adults increased. We analyzed Connecticut varicella surveillance data for 2009–2014 to characterize overall and age group-specific incidence trends and to determine whether incidence continues to decline in the 2-dose school-entry program setting.

MATERIALS AND METHODS

Since 2001, healthcare providers, childcare centers, schools, health departments, and laboratories have been required to report varicella cases to the Connecticut Department of Public Health. Varicella surveillance is passive, and laboratory confirmation of infection is not required. Probable cases are those meeting the clinical case definition of an acute illness characterized by a maculopapular vesicular rash; confirmed cases are those having either an epidemiologic link to a confirmed or probable case or laboratory confirmation. From the Connecticut Electronic Disease Surveillance System for all confirmed and probable varicella cases reported during 2009–2014, we extracted age, reporting source, vaccination dates, onset date, previous history of varicella, and number of lesions. Disease severity was defined by the number of lesions reported and categorized as mild (<50 lesions), moderate (50–249 lesions), or severe (≥ 250 lesions). Persons were classified as up-to-date if the reported vaccination history was consistent with ACIP guidelines (ie, 1 dose for children aged 1–6 years and 2 doses for persons aged ≥ 7 years). Potentially preventable cases were those among persons not up-to-date on vaccination and with no history of varicella infection. Cases were considered not preventable if the patient was aged <1 year; onset was ≥ 42 days after vaccination in a person with up-to-date vaccination status; or a history of varicella infection was reported. Breakthrough disease was defined as varicella infection in a patient up-to-date on vaccination with an onset ≥ 42 days after vaccination. Persons lacking varicella history, vaccination history, or onset date were excluded from preventability and breakthrough

disease analyses. Outbreaks among childcare, school, or group residential settings were conservatively defined as ≥ 5 cases among patients aged <12 years or ≥ 3 cases among patients aged ≥ 12 years [4, 13].

Data were analyzed by using SAS version 9.3 (SAS Institute, Inc., Cary, NC) and Epi Info 7 (Centers for Disease Control and Prevention [CDC], Atlanta, GA). Overall and age-specific incidences were calculated by using annual population estimates from the US Census Bureau. The Mantel-Haenszel χ^2 test was used to determine statistical significance of incidence trends during 2009–2014. Clinical and epidemiologic characteristics and preventability of cases reported during 2009 and 2014 were compared by using the Mantel-Haenszel χ^2 test.

This study was designated by the CDC's Human Subjects Review as public health surveillance, not research.

RESULTS

During 2009–2014, a total of 1780 varicella cases were reported in Connecticut. The annual number of reported cases decreased 56%, from 486 in 2009 to 182 in 2014; incidence decreased from 13.8 cases/100 000 persons to 5.1 cases/100 000 persons ($P < .001$; Table 1). Significant declines in incidence occurred among children aged 1–4, 5–9, and 10–14 years ($P < .01$ for each; Table 1); decreases overall and among children aged 1–14 years were steady during the 5 years. The percentage of patients with a history of varicella infection was stable (from 7% to 4%; $P = .3$). In clinical settings, the proportion of patients with mild varicella illnesses decreased from 68% during 2009 to 52% during 2014 ($P < .01$); patients with severe varicella illnesses decreased from 9% to 4% ($P = .03$); and patients with moderate varicella illnesses increased from 23% to 44% ($P < .01$) (Figure 1). During 2009–2014, the proportion of all patients with varicella reported as having received 1 vaccine dose decreased (from 52.9% to 26.9%; $P < .001$), whereas the proportion reporting no vaccine history increased (22.8% vs 42.9%; $P < .01$). Although much of this increase occurred among those aged 5–9 years (from 10% to 21%, $P = .06$), the actual number of unvaccinated cases decreased in all age groups >1 year old. The proportion of patients with breakthrough varicella decreased from 69.3% during 2009 to 60.9% during 2014 ($P = .05$). Although overall receipt of 2 doses was stable (24.3% vs 30.2%; $P = .12$), the proportion of patients with reported receipt of 2 doses increased among those aged 5–9 years (from 40% to 72%; $P < .01$) and 10–14 years (from 28% to 77%; $P < .01$) and increased non-significantly among those 15–19 years (from 16% to 40%; $P < .13$). Cases classified as preventable decreased from 44% during 2009 to 25% during 2014 ($P < .01$); significant declines in percentages of preventable cases occurred only among those aged 5–9 years ($P < .05$) and 10–14 ($P < .01$) years (Table 2; Figure 2). Severity, preventability, vaccination number, and reporting source are displayed in Table 2 by age group.

Table 1. Reported Varicella Cases and Incidence Rates (per 100 000 Population), by Age Group—Connecticut, 2009–2014

Age group (yrs)	2009		2010		2011		2012		2013		2014		P Value ^a
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	
<1	20	48.5	20	52.6	31	83.1	26	70.8	12	32.7	26	69.5	.75
1–4	138	81.5	106	64.7	74	46.3	82	52.3	77	49.1	57	36.9	<.01
5–9	176	80.1	88	39.6	89	40.6	73	33.5	52	23.9	39	18.1	<.01
10–14	102	44.2	55	22.9	50	21.0	27	11.5	34	14.5	22	9.5	<.01
15–19	19	7.5	23	9.2	13	5.1	19	7.4	13	5.1	10	3.9	.19
20–29	8	1.8	15	3.4	16	3.6	13	2.9	14	3.1	8	1.7	.43
≥30	23	1.1	20	0.9	31	1.4	26	1.2	13	0.6	20	0.9	.28
Total	486	13.8	327	9.15	304	8.5	266	7.4	215	6.0	182	5.1	<.01

^a χ^2 test for trend.

The proportion of cases reported by healthcare providers, including physicians and hospitals, increased from 51% during 2009 to 62% during 2014 ($P < .05$), whereas the proportion reported by schools and childcare centers decreased from 44% to 33% ($P < .05$). Three outbreaks were reported among persons living at adult residential facilities, but no school-based or childcare center-associated outbreaks occurred during 2009–2014.

DISCUSSION

Reported varicella incidence declined substantially in Connecticut during 2009–2014 and has not yet plateaued. Substantial declines in incidence have occurred exclusively among children aged 1–14 years, the population targeted by the 2006 recommendation for 2 varicella vaccine doses. Proportions of preventable cases among children aged 5–9 and 10–14 years also

decreased. However, although incidence declined among children aged 1–14 years, proportion of cases that occurred among infants, adolescents aged 15–19 years, and adults increased, which might explain the observed increase in proportion of persons reported with moderate varicella. Older adolescents and adults who are unvaccinated might be more likely to experience moderate disease; this pattern of increases in proportion of cases among older adolescents and adults and of moderate cases has been noted in other studies [14, 15]. Vaccinated children with breakthrough disease are more likely to experience mild disease [14].

Middle school (eg, grade 7) vaccination entry requirement policies have been demonstrated to be strong predictors of 2-dose varicella vaccination and of uptake of other vaccines [16, 17]; data from the National Immunization Survey-Teen reported an increase in 2-dose coverage among adolescents aged 13–17 years in Connecticut during 2009–2013 [7, 12]. Our findings indicate the increase in 2-dose coverage, enhanced by the school-entry requirement enacted during 2011 and expeditiously implemented, was associated with a reduced incidence among school-aged children by 2014. Although the overall proportions of patients having had 2 vaccine doses or who experienced breakthrough disease remained stable in our analysis, the proportion of patients with receipt of 2 vaccine doses increased among those aged 5–19 years, an expected finding. The varicella vaccination program goal is to achieve 100% varicella vaccination coverage levels for 1 dose by age 18 months and 2 doses by age 7 years. If this goal is reached, persons with reported varicella, if any, should have a history of being up-to-date for varicella vaccination. However, we also found an increase in the percentage of cases among persons aged 5–9 years reporting no history of vaccination. It is reassuring to note, however, that it was only the percentage that increased: the number of unvaccinated cases in this (and other) age group decreased. Data were unavailable to determine whether these persons were unvaccinated because of refusals or medical contraindications to vaccination. The stable incidence during 2009–2014

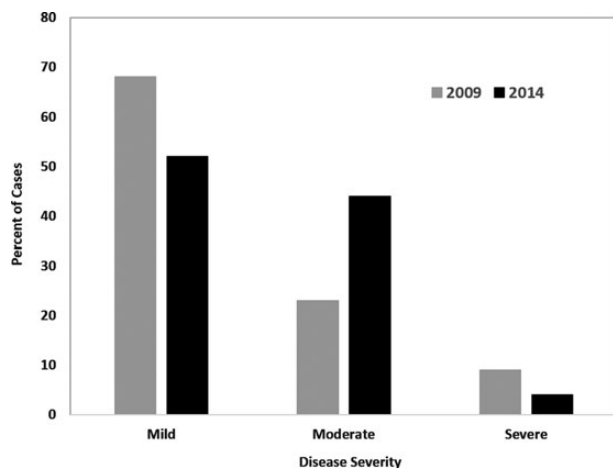


Figure 1. Change in percentage of cases reported as mild (<50 lesions), moderate (50–249 lesions), or severe (≥250 lesions) between 2009 and 2014.

Table 2. Varicella Severity, Preventability, Number of Varicella Vaccinations Received, and Reporting Source of Varicella Cases, by Age Group—Connecticut, 2009 and 2014^a

Disease Factor	Age Group (yrs)													
	<1		1–4		5–9		10–14		15–19		20–29		≥30	
	2009 No. (%)	2014 No. (%)	2009 No. (%)	2014 No. (%)	2009 No. (%)	2014 No. (%)	2009 No. (%)	2014 No. (%)	2009 No. (%)	2014 No. (%)	2009 No. (%)	2014 No. (%)	2009 No. (%)	2014 No. (%)
Severity														
Mild	13 (76)	15 (60)	90 (75)	33 (58) ^a	118 (75)	20 (54) ^a	56 (58)	14 (74)	8 (61)	3 (30)	0	2 (25)	6 (33)	4 (21)
Moderate	3 (18)	10 (40)	19 (16)	23 (40) ^a	28 (18)	15 (41) ^a	28 (29)	4 (21)	4 (31)	6 (60)	5 (83)	6 (75)	10 (56)	13 (68)
Severe	1 (6)	0	11 (9)	1 (2)	12 (7)	2 (5)	12 (13)	1 (5)	1 (8)	1 (10)	1 (17)	0	2 (11)	2 (11)
Varicella vaccination														
No vaccine	17 (85)	25 (96)	21 (15)	12 (21)	17 (10)	8 (21)	17 (17)	3 (14)	11 (58)	4 (40)	8 (100)	7 (88)	20 (87)	19 (95)
1 dose	2 (10)	1 (4)	102 (74)	40 (70)	88 (50)	3 (8) ^a	57 (56)	2 (9) ^a	1 (26)	2 (20)	0	0	3 (13)	1 (5)
2 doses	1 (5)	0	15 (11)	5 (9)	71 (40)	28 (72) ^a	28 (28)	17 (77) ^a	2 (16)	4 (40)	0	1 (12)	0	0
Preventable	20 (100)	24 (100)	26 (24)	15 (32)	69 (46)	7 (23) ^a	60 (64)	5 (25) ^a	5 (46)	1 (20)	7 (100)	3 (75)	9 (75)	4 (80)
Reporting source														
Healthcare provider	14 (70)	23 (88)	94 (71)	39 (72)	65 (38)	15 (39)	48 (48)	11 (50)	8 (44)	1 (10)	2 (29)	6 (75)	8 (35)	15 (75)
School or childcare	5 (25)	3 (12)	38 (28)	14 (26)	99 (58)	22 (56)	50 (49)	11 (50)	7 (39)	8 (80)	3 (43)	0	5 (22)	1 (5)
Other ^b	1 (5)	0	1 (1)	1 (2)	7 (4)	2 (5)	3 (3)	0	3 (17)	1 (10)	2 (29)	2 (25)	10 (43)	4 (20)

^a $P < .05$ for χ^2 test for difference in proportions, 2014 vs 2009.

^b Includes health departments, laboratories, and other categories.

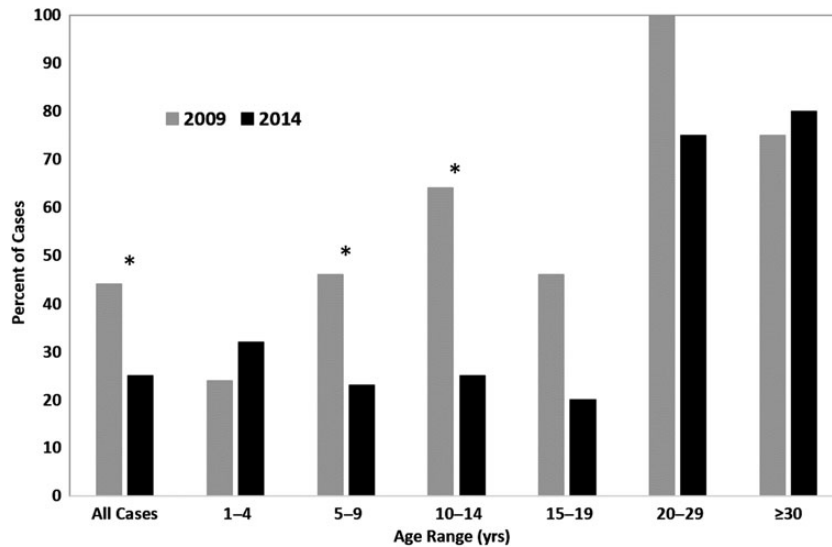


Figure 2. Change in percentage of cases classified as preventable between 2009 and 2014 in all persons and by age group for cases in persons ≥ 1 year of age. Cases in persons < 1 year of age are considered unpreventable. Age groups with statistically significant differences ($P < .05$ for χ^2 test for difference in proportions, 2014 vs 2009) are indicated with an asterisk.

among persons aged 15–19 years might reflect an aging of the first cohort to receive 2 vaccine doses under the 2006 recommendations. Furthermore, a goal of the 2-dose recommendation, reduction of school-based outbreaks, has been achieved.

During 2009–2014, an increasing proportion of cases were reported by healthcare providers, whereas the proportion reported by schools and childcare centers decreased to approximately one third of cases. In contrast, in 2001, when varicella first became reportable in Connecticut, over half of varicella cases were reported by schools and childcare centers. As varicella becomes less common and disease presentation milder among school aged children, it might be less likely to be identified by school nurses and childcare centers. However, recognition of mild cases in schools and childcare centers is essential to prevent transmission in these settings. Infants and adults, who represent an increasing proportion of cases occurring annually, also likely shifted the proportion of reporters to healthcare providers.

The school vaccination requirement corresponded to ongoing decreases in incidence among target groups and is likely to sustain high vaccination rates among elementary- and middle school-aged children in Connecticut. However, incidence has remained stable among infants, older adolescents, and adults, which indicates that improved vaccination levels of school children alone has not resulted in additional herd immunity beyond that gained after widespread implementation of the 1-dose recommendation. This may be because the incidence of varicella was already low due to the previous 1-dose school-entry requirement; when a 2-dose policy was introduced in a high-incidence setting, rapid reductions in incidence in

nonvaccinated populations were documented [18]. Data obtained from systematic surveillance should be continually analyzed to determine whether varicella prevention among school-aged children reduces incidence among infants as overall varicella incidence further declines and among adults as the vaccinated population ages. The increase in proportion of patients reporting no vaccination warrants additional data collection during surveillance to determine why persons are unvaccinated for varicella. Additional prevention opportunities include identifying and fully vaccinating susceptible persons, including older adolescents, adults, and women before pregnancy or postpartum.

This study has certain limitations including the following: data were from a passive reporting system, laboratory confirmation for varicella was not required, history of varicella was self-reported, and there was no baseline data on the percentage of 4–6 year olds who were receiving a second dose in 2009. As varicella infection has become clinically milder and less common, the possibility of false-positive diagnoses has increased. The rate of false-positive reports cannot be estimated, but it is unlikely to have changed more rapidly than varicella incidence. Underreporting might occur, but amount and geographic distribution of underreporting is also unknown. The limited numbers of cases among certain age groups might result in insufficient power to detect trends over time. Although we were able to document the increase in percentage of adolescents who received 2 doses of varicella vaccine between 2009 and 2014, we were unable to do so for 4–6 year olds. However, that 96% of the 2013–2014 entering kindergarten cohort had received 2 doses suggests adherence to the 2-dose requirement implemented several years earlier.

CONCLUSIONS

Reported varicella incidence has declined steadily in Connecticut during 2009–2014. Varicella has declined substantially among children aged 5–14 years, ages targeted by the 2-dose school-entry requirement that began during 2011, whereas incidence among infants and adults has remained stable. Continued surveillance is needed to monitor incidence among all age groups, and targeted vaccination efforts will further reduce varicella incidence among vulnerable populations.

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