Pertussis in Florida, 2000–2006: Trends in a Historically Low-Incidence State

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SYNOPSIS

Objective. Florida, the fourth most populous state in the nation, has had historically low incidence rates of pertussis, the only vaccine-preventable disease with increasing numbers of reported cases. We compared the epidemiology and incidence rates of pertussis in Florida with other states and the United States.

Methods. We used Florida and federal surveillance data from 2000 through 2006.

Results. Reported incidence of pertussis in Florida, numbers of cases, and proportions of adolescents and adults all increased during the seven-year study period. Florida incidence rates increased from 0.44 to 1.28, but the state's incidence was always ranked 45th or lower among the states. Reported pertussis cases and those among adolescents and adults in Florida increased during the study period. Ten counties, containing 60% of Florida's population, reported two-thirds of the state's cases.

Conclusions. Pertussis reported from Florida mirrored national trends with increasing incidence, numbers of cases, and proportions of adolescent and adult cases. Despite the increases, Florida maintained its historic pattern of pertussis incidence rates that are consistently lower than national figures. Limited laboratory diagnostics and a focus on the pediatric population likely contributed to the lower rates of pertussis in Florida. More emphasis on surveillance of adolescent and adult cases is needed.

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Pertussis is the only vaccine-preventable disease whose reported numbers have been increasing in the United States. Florida, like many other states, experienced increased numbers of reported pertussis cases and outbreaks from the late 1990s to the early 21st century.¹ Florida's 18 million residents make it the fourth most populous state,² but it has had historically low pertussis incidence rates (IRs) compared with most other states and the nation as a whole. Florida has a unified public health structure, with a county health department (CHD) in each of the state's 67 counties. CHDs are all administratively part of the Florida Department of Health (FDOH).

METHODS

We combined data for this analysis from four sources to characterize pertussis cases from 2000 through 2006 by demographic characteristics, reported symptoms, source of case report, geographic distribution, and laboratory testing and results. We calculated IRs for Florida's 67 counties, and then compared the counties' and state's rates with those calculated by the Centers for Disease Control and Prevention (CDC) for other states and the nation. We examined timeliness of reporting to assess local capacity to implement control measures around a specific case of pertussis.

Pertussis cases in Florida are characterized as confirmed or probable according to CDC and the Council of State and Territorial Epidemiologists (CSTE) case definitions.³ Clinically, pertussis is defined as a cough illness lasting at least two weeks that is characterized by paroxysms of coughing or an inspiratory "whoop," or post-tussive vomiting, without other apparent cause. A confirmed case either (1) is culture positive with an acute cough illness of any duration, (2) meets the clinical case definition and is confirmed by positive polymerase chain reaction (PCR), or (3) meets the clinical case definition and is epidemiologically linked directly to a laboratory-confirmed case. A probable case meets the clinical case definition but lacks laboratory confirmation or an epidemiologic link to a laboratoryconfirmed case.

For this analysis, a case was considered outbreak related if the CHD had checked a reporting form indicating the case was part of an outbreak. We categorized the race/ethnicity of case patients as white, non-Hispanic; black, non-Hispanic; Hispanic; or other. Age was categorized as infant (<1 year of age), toddler (1–5 years of age), elementary school (6–9 years of age), adolescent (10–19 years of age), and adult (\geq 20 years of age).

To calculate timeliness of reporting, we used an

incubation period of 20 days, as CDC has done previously;⁴ timely reporting is key to case investigation and control efforts. Two intervals were calculated: reporting to the CHD and reporting to the state. The local interval was the time between the first event in a case (e.g., onset of symptoms, diagnosis, or laboratory testing) and reporting to the CHD. The state interval was the time between reporting to the CHD and reporting to FDOH.

Data sources

Data used in this analysis of reporting between 2000 and 2006 were gathered from three state sources and one national source and combined. The state sources were the reporting, outbreak, and surveillance information system called Merlin; EpiCom, the secure, moderated epidemiologic information exchange and notification system; and Florida Community Health Assessment Resource Tools Set (CHARTS), a portal operated by FDOH's Office of Planning and Evaluation. We obtained calendar-year pertussis IRs for individual states and the U.S. from the National Center for Immunization and Respiratory Diseases (NCIRD) at CDC.

Merlin, first implemented in 2001 on a county-bycounty basis, is FDOH's Web-based system⁵ for disease surveillance, reporting, and outbreak management.⁶ Merlin users can link outbreak cases, including cases in multiple counties, and then complete disease reporting.⁷ The outbreak module has been used in dozens of outbreaks, including a pertussis outbreak during the 2004 hurricane season⁸ and a multicounty outbreak of *Escherichia coli*/hemolytic uremic syndrome linked to one petting zoo.⁹

EpiCom, begun in 2003 on a limited basis, is FDOH's Web-based electronic epidemiology information exchange and emergency alerting system.¹⁰ It provides a secure, moderated information exchange for reporting and tracking outbreaks and reaches 1,300 active users. A pertussis forum was started in late 2004.

Florida CHARTS is a Web-based system operated by the FDOH Office of Planning, Evaluation, and Data Analysis and provides data on vital statistics, population estimates, and communicable and chronic disease case numbers and rates.¹¹ We used CHARTS population estimates to calculate Florida county IRs.

Surveillance methods

Pertussis cases in Florida are investigated at the local level in the 67 CHDs, locally entered into Merlin, and then reported to the state. Case reviewers in the state's Bureau of Epidemiology and Bureau of Immunization review each case to ascertain that it meets the pertussis case definition³ and the report is complete. Case

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reports are sent back to the county electronically for any needed information.

Pertussis cases are reported by health-care providers and public health departments to the National Notifiable Diseases Surveillance System, a passive surveillance system at CDC.^{1,12} Each year, NCIRD uses those reports to calculate pertussis IRs for each of the 50 U.S. states and nationally. We obtained copies of state and national IRs for the seven-year period, 2000–2006.^{12–20}

RESULTS

Incidence rates

Table 1 shows the annual pertussis IRs per 100,000 population in Florida and other reporting jurisdictions in the U.S. during the seven-year study period, 2000–2006.¹²⁻¹⁹ During this period, Florida IRs increased from 0.44 to 1.28, and the state's IR ranked 45th to 48th among the 50 U.S. states. The national IR ranged from 2.7 to 8.8 during the period, and the range of CDC-calculated IRs annually for the 50 U.S. states and the District of Columbia varied from an 88-fold difference to a 373-fold difference.

Only two of the state's 67 counties exceeded the national IR at any point during the seven-year study period. In 2005, Alachua County (Gainesville) reported a rate of 9.9 per 100,000 when an outbreak occurred in a religious community. For 2004, the year during which the outbreak related to Hurricane Ivan occurred, Santa Rosa County reported an IR of 19.9.

Surveillance summary

Florida reported 735 pertussis cases from 2000 through 2006; 455 (62%) were confirmed and 280 (38%) were probable. Another 117 possible cases were investigated but were excluded after not meeting surveillance case definitions. A mean of 105 confirmed and probable cases was reported annually (range: 33–218). Cases were reported from 47 (70%) of the state's 67 counties; only six (8%) counties reported pertussis cases each year. In each year, numbers of reported cases peaked between May and August.

Three counties—Hillsborough (Tampa), Pinellas (St. Petersburg), and Duval (Jacksonville)—each reported at least 10% of the cases. Another three counties—Orange (Orlando), Dade (Miami), and Polk (Lakeland)—each reported at least 5% of the cases. Four other counties—Palm Beach (West Palm Beach), Broward (Fort Lauderdale), Lee (Fort Myers), and Escambia (Pensacola)—each reported 3% of the cases. Collectively, these 10 counties reported 66% (487) of the Florida cases and contained 60% of the state's population. IRs in those 10 counties were always lower than the annual reported national IRs.

More than half of the case patients were female (n=389, 53%) and most were white, non-Hispanic (n=479, 64%) or Hispanic (n=130, 18%). Fewer cases were reported among black, non-Hispanic (n=87, 12%) or other groups (n=51, 7%). The portion of cases in the various racial/ethnic groups remained consistent during the seven-year study period. Calculated pertussis IRs per 100,000 population were 0.04 for white people, 0.03 for black people, and 0.04 for Hispanic people. The mean age of case patients was 10.7 years and the median age was 3.1 years (range: 7 months–90.8 years). Two fatal cases were reported, both in males younger than three months of age.

The most frequently reported cases (n=326, 44%) overall were in infants younger than one year of age, but starting in 2001 (Table 2), adolescents and adults formed a greater proportion of cases. During the seven-year study period, the proportion of cases that were in infants declined from 57% in 2000 to 34% in 2006, the proportion of cases in adults increased from 12% to 21%, and the proportion of cases in adolescents increased from 12% to 26%.

About one-third of case patients (n=256, 35%) were admitted to the hospital, most frequently infants younger than one year of age. The proportion of case patients admitted to the hospital ranged from 51% in 2000 to 28% in 2006.

Of the total 735 cases, 298 (41%) were in children aged two months to 10 years (age-eligible for immunization). Of those 298 children, 91 (31%) had no recorded immunizations with a vaccine containing a pertussis component and 207 (69%) had at least one documented vaccine dose. Of those 207 vaccinated, 121 (58%) had complete, age-appropriate immunizations recorded. The proportion of children reported annually who had received age-appropriate immunization varied from 21% to 37%, and no trends over time were noted.

The most common reporting sources for all cases were hospitals (n=219, 28%), physician offices/clinics (n=187, 25%), and laboratories (n=62, 8%). Most cases reported by hospitals were in infants (172/219, 79%). Among the 187 cases reported by physicians, the practice specialty could be identified in 131 cases. Pediatricians reported 69% of those 131 cases and other specialties reported 31% of the cases. Half of the laboratory cases were reported by the FDOH laboratory.

	Reporting year								
Reporting area	2000	2001	2002	2003	2004	2005	2006		
Alabama	0.45	0.83	0.82	0.42	1.08	1.81	2.33		
Alaska	3.22	2.45	1.09	10.41	2.14	24.26	13.71		
Arizona	2.98	14.38	13.14	3.87	4.84	19.29	8.55		
Arkansas	1.67	32.61	18.01	3.39	3.45	11.66	4.03		
California	1.94	2.17	3.19	3.57	3.09	8.87	4.84		
Colorado	11.71	9.33	10.32	8.25	25.73	30.06	15.22		
Connecticut	1.64	0.73	0.87	2.23	1.91	2.43	3.59		
Delaware	1.17	0.00	0.50	1.11	1.93	1.93	0.36		
District of Columbia	0.57	0.19	0.35	0.70	2.35	1.99	1.09		
Florida	0.44	0.19	0.32	0.68	0.76	1.20	1.28		
Georgia	0.66	0.29	0.34	0.42	0.32	0.54	1.12		
Hawaii	3.26	3.34	2.41	0.96	2.38	12.91	6.82		
Idaho	4.75	12.69	11.26	6.11	4.74	15.79	6.16		
Illinois	1.10	1.61	1.83	2.55	12.22	7.25	4.61		
Indiana	2.53	1.92	2.97	1.69	5.84	6.35	4.46		
lowa	2.31	4.79	5.35	5.65	36.08	37.44	11.63		
Kansas	1.57	1.16	2.32	1.69	9.14	19.81	11.29		
Kentucky	1.58	2.40	2.52	1.29	2.36	3.74	1.41		
Louisiana	0.47	0.27	0.16	0.25	0.51	1.13	0.53		
Maine	3.65	1.75	1.62	7.03	14.88	4.18	13.17		
Maryland	2.52	1.00	1.25	1.72	2.88	3.94	2.71		
Massachusetts	22.76	8.66	9.37	25.98	26.46	18.19	19.35		
Michigan	1.31	1.54	0.62	1.39	3.00	3.17	6.24		
Minnesota	11.90	6.38	8.55	4.12	26.82	30.80	6.23		
Mississippi	0.14	0.18	0.31	0.52	0.59	2.14	1.27		
Missouri	1.75	1.93	2.59	3.67	10.34	11.40	5.31		
Montana	3.68	5.68	1.10	0.55	9.06	63.22	12.29		
Nebraska	1.64	0.47	0.52	0.93	5.56	16.88	5.74		
Nevada	0.80	2.19	2.21	1.61	2.27	2.14	2.94		
New Hampshire	12.99	2.53	6.12	9.33	10.31	14.31	17.25		
New Jersey	0.68	0.28	0.40	2.19	2.56	2.21	3.45		
New Mexico	4.89	7.37	10.78	4.20	8.30	10.30	7.62		
New York	2.12	0.96	2.31	9.57	17.67	5.89	9.71		
New York City	1.23	0.81	0.30	1.87	2.42	1.37	1.38		
North Carolina	1.66	0.96	0.55	1.73	1.18	1.49	3.85		
North Dakota	1.36	1.66	1.42	1.10	119.33	26.48	6.75		
Ohio	3.44	2.89	3.86	2.87	6.68	10.34	5.62		
Oklahoma	1.78	1.27	3.86	3.03	3.41	3.60	1.80		
Oregon	3.24	1.68	5.34	12.44	17.44	17.22	3.08		
Pennsylvania	2.36	1.62	1.57	2.85	4.51	4.14	4.72		
Rhode Island	2.81	0.90	2.06	5.14	4.90	4.90	9.38		
South Carolina	1.63	0.88	1.17	5.06	4.91	9.65	4.68		
South Dakota	1.42	0.64	1.05	0.92	21.92	23.74	3.35		
Tennessee	0.80	1.24	2.14	1.43	2.93	3.68	2.88		
Texas	1.63	3.06	5.69	3.08	5.26	9.89	4.17		
Utah	2.13	3.53	4.96	5.48	11.55	25.87	31.54		
Vermont	41.17	18.31	27.90	11.51	28.97	14.48	17.66		
Virginia	1.92	3.89	2.30	3.00	5.36	4.87	2.92		
Washington	/.82	3.14	9.47	13.91	13.57	16.88	6.00		
West Virginia	0.16	0.33	1.94	1.55	2.81	2.92	3.63		
VVISCONSIN	2.63	3./4	3.31	12.81	102.40	19.//	3.99		
VVyoming	0.76	0.19	2.21	26.01	6.91	10.46	16.30		
United States (total)	2.79	2.69	3.39	4.04	8.80	8./2	5.27		

Table 1. Pertussis incidence rates in the U.S. per 100,000 population, by reporting area, 2000–2006

Source: Centers for Disease Control and Prevention (US). Pertussis annual summaries, 2000–2006.

Reporting times

The mean local reporting interval to the CHD (between date of onset if available, or date of first laboratory test, and date of reporting to the CHD) during the seven-year study period was 30.4 days; annual means ranged from 24.5 to 48.4 days.

Mean time for reporting from the local CHD to the state was 11.6 days, and annual means ranged from 4.9 to 26.9 days. Total reporting time (from initial event at the CHD to completed state reporting) was a mean of 42.4 days; annual means ranged from 37.4 to 53.2 days. No trends over time were noted.

Overall, mean local reporting times among the 47 Florida counties reporting cases ranged from 11 to 147 days. Among the 10 counties reporting 3% or more of the Florida cases, mean local reporting times ranged from 23.2 to 46.6 days; nine of the 10 counties had local reporting times within one to two incubation periods.

Case confirmation and laboratory testing

At least one laboratory test (culture, PCR, serology, or direct fluorescent antibody [DFA]) was ordered for 539 (73%) cases; use of at least one of the four laboratory tests began to increase in 2003, when testing was conducted for 66% of cases. By 2006, laboratory testing was ordered at either the state public health laboratory or a commercial laboratory for 89% of cases.

Based on data entry in Merlin, about one-third (n=256, 36%) of cases had laboratory evidence of pertussis by PCR and/or culture without epidemiologic links to another case. Another 146 (20%) cases without positive laboratory results were epidemiologically linked to another confirmed case, and 49 (8%) had both laboratory confirmation and an epidemiologic link to a confirmed case. Nonstandard laboratory methods (DFA or serology) were used to confirm 155 (21%) cases, and for 122 (17%) cases, information was insufficient to classify the confirmation method.

Culture was most often done for infants younger than one year of age (159/276, 70%) and was positive 77% of the time (n=141 cases). Increased use of both PCR and serology was noted beginning in 2003. Overall, serologic testing was ordered in about one of every five cases (n=159, 22%). Most serologic testing was done for adolescents (n=71, 45%) or adults (n=45, 28%).

The state public health laboratories had only culture available as a confirmatory test until late 2005. During the study period, 40% of requested culture media went to hospitals for pediatric patients, another 50% to CHDs, and 10% to other facilities.

Pertussis outbreaks

Overall, about one-fourth of reported cases (n=192, 26%) were associated with outbreaks, and 19 Florida counties (28%) reported outbreak cases. Such cases accounted for more than half of the reported cases in three counties: Alachua (Gainesville), 90%; Escambia (Pensacola), 57%; and Duval (Jacksonville), 56%. More than 80% of outbreak cases were epidemiologically linked to another laboratory-confirmed case. Most outbreak cases were in infants younger than one year of age (20%), adolescents (28%), or adults (27%). Outbreak cases were mostly in females (n=109, 55%) and mostly in white, non-Hispanic people (n=135, 70%). The proportion of outbreak cases in a given calendar year ranged from 21% to 31%, and no trends were noted.

The first EpiCom postings in 2004 described a pertussis cluster discovered and investigated during the aftermath of Hurricane Ivan, which hit Escambia, Santa Rosa, and other counties in the Florida Panhandle on September 15, 2004. A three-month-old infant with a positive culture was among three families that sheltered together in the same house during and after the hurricane.⁸ Because of infrastructure disruption, it took three weeks to identify 22 additional cases after

				Year				
	2000	2001	2002	2003	2004	2005	2006	Total
Age (in years)	n=67 N (percent)	n=33 N (percent)	n=53 N (percent)	n=118 N (percent)	n=138 N (percent)	n=218 N (percent)	n=108 N (percent)	n=735 N (percent)
<1	38 (57)	23 (70)	33 (61)	50 (42)	55 (40)	90 (41) 20 (9)	37 (34)	326 (44)
1–3 5–9 10–19 ≥20	4 (6) 8 (12) 8 (12)	1 (3) 3 (9) 2 (6)	4 (8) 8 (15) 4 (8)	9 (8) 25 (21) 20 (17)	11 (8) 30 (22) 24 (17)	17 (8) 54 (25) 37 (17)	15 (14) 28 (26) 23 (21)	61 (8) 156 (21) 118 (16)

Table 2. Age	distribution	of Florida	pertussis	cases,	2000-	-2006
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Source: Florida Department of Health. Surveillance data, Merlin.

the index infant. Of the 23 cases, seven were culture confirmed, eight were epidemiologically linked, and eight were probable cases. Onset dates were between May and October 2004; the median age of patients was 13 years (range: three months–67 years). Complete characterization of this outbreak was hampered by a lag time of weeks between request and receipt of culture media.

DISCUSSION

Reported cases of pertussis in Florida between 2000 and 2006 mirror reported U.S. trends, both with more cases, especially among adolescents and adults, and increasing IRs.^{20–22} Despite the increased incidence, Florida's rankings of 45th to 48th among the U.S. states match its historic low rates for pertussis. The state has higher disease burdens for other reportable conditions. In 2006, Florida IRs and ranks were 120.9 and 16th for gonorrhea; 275.2 and 39th for chlamydia;²³ and 5.7 and sixth for tuberculosis.²⁴

The range of CDC-calculated IRs for pertussis by state was wide in each year of the study, ranging from an 88-fold difference to a 373-fold difference. Even in four states where CDC supported active surveillance, the reported IRs ranged from 0.46 to 12.56, a 27-fold difference.²⁵ The impact of active surveillance has been well documented in Massachusetts, where active, school-based surveillance is conducted. At one point, Massachusetts reported 28% of the U.S. cases among people 10 years of age or older, but only 2% of the U.S. population lived there.²¹

Pertussis surveillance in Florida is a passive system, supplemented by active case finding and control measures when a suspected outbreak is being investigated. The 2004 investigation in the aftermath of Hurricane Ivan is an example of how active surveillance can be conducted. The 10 counties reporting most of the state's pertussis cases have reporting that is timely enough—within one to two incubation periods—to permit intervention if needed.

The state may have a low IR because Florida surveillance has been focused on the pediatric population and laboratory diagnostics have been limited. Pediatricians in Florida reported two-thirds of the physician-reported cases where a specialty could be identified. A review of state laboratory records indicates that 40% of pertussis culture media was furnished to hospitals for pediatric patients. Given the increase in Florida cases among adolescents and adults, more surveillance should be aimed at providers seeing adolescents and adults. Surveillance in those groups may be difficult because pertussis in older patients has been considered a zebra diagnosis.²⁶ Studies in Massachusetts,²⁷ Australia,²⁸ and Quebec²⁹ have all determined that adults often make multiple visits to doctors before pertussis is diagnosed.

Even when pertussis is considered, Florida and other states may have difficulty obtaining reports of cases. A Utah study of urgent care providers has documented a lack of knowledge about requirements for pertussis reporting and the prevention and control measures that public health can use to control pertussis.³⁰

Laboratory diagnosis of pertussis is challenging and Florida-specific issues contribute to the state's low IR. Until a validated PCR (using IS481) test was introduced in late 2005, the state had only culture available for diagnosis. Cases were undoubtedly missed because pertussis culture techniques are demanding, and sensitivity is typically estimated at between 30% and 60%.³¹ In Florida, cultures were often conducted only after active encouragement from public health officials.

The validated PCR at the state laboratory is an important tool; pertussis cases reported in Florida increased to 211 in 2007 and 314 in 2008. Florida's pertussis IRs were 1.12 in 2007 and 1.66 in 2008. The increased use of PCR and decreased use of culture throughout the U.S. has been suggested as a partial explanation for the increased reporting of pertussis.³²

More than 100 PCR protocols have been reported and vary by deoxynucleic acid purification, primers, and detection methods.³³ However, PCR assays for pertussis are not standardized, and no pertussis PCR has been approved by the U.S. Food and Drug Administration; this means sensitivity and specificity will vary by laboratory.³⁴ Utah researchers have found that 10% of pertussis cases with positive PCRs tested in one laboratory did not meet the current CDC case definition for pertussis and suggested a revised definition.³⁵

An additional challenge for pertussis diagnosis is the use of serologic testing, which was ordered for more than 20% of Florida cases, especially in adolescents and adults. Such testing is currently not included in the CDC case definition for pertussis. Pertussis incidence is six to 14 times higher among adolescents and adults in Massachusetts than elsewhere in the U.S. The difference in Massachusetts' incidence has been attributed to use of a validated serological test (the only one in the U.S.) and intensive school-based surveillance.²²

Some researchers have suggested that the laboratory diagnosis of pertussis may require different test methods—PCR, serology, and culture—depending on a patient's age, stage of cough, vaccination status, and antibiotic therapy.^{36,37}

Control of pertussis is also difficult because surveillance programs and diagnostic testing differ greatly among the states. In this study, we have documented the increased cases and IRs in Florida and suggested possible reasons for this low incidence.

Pertussis is a wily disease that did not disappear or decline after introduction of vaccines as did meningitis (caused by *Streptococcus pnuemoniae*³⁸ and *Haemophilus influenzae*)³⁹ and measles.⁴⁰ Many public health officials think that childhood immunization can control disease caused by *Bordetella pertussis* (*B. pertussis*), but that it does not stop infection.⁴⁰ This theory is supported by the declining pertussis incidence without any changes in the cyclical pattern of pertussis.⁴¹ Controlling pertussis will require a better understanding of how booster vaccine doses in adolescent and adult populations impact the circulation of pertussis⁴² and of the impact of the *B. pertussis* strains with specific toxins linked to increased incidence in Europe.⁴³

Surveillance of pertussis is a complicated venture and how it is conducted will likely change. Experts debate whether the increase in cases reflects true increases in incidence, more complete reporting, the impact of new laboratory diagnostic methods that are more sensitive than culture, and increasing awareness of pertussis among physicians who see adults.⁴⁴ Updating the case definition for pertussis, which has not been changed for two decades, has been suggested.³⁵ Any such update will need to consider changing laboratory diagnostic testing and the need for standardization of PCR and other testing methods, and increased numbers of cases among adolescents and adults.

CONCLUSIONS

Florida has mirrored U.S. trends in pertussis surveillance with increased incidences, numbers of cases, and proportions of cases among adolescents and adults. The state's IRs increased in 2007 and 2008, but remain lower than the reported national IRs; however, calculated IRs among the 50 U.S. states vary greatly. Numbers of reported pertussis cases in Florida are likely to increase because the state has improved laboratory capacity to permit more testing to be conducted, and more physicians are aware of cases among adolescents and adults.

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