MAJOR ARTICLE

Seroprevalence of Cytomegalovirus Infection in the United States, 1988–1994

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(See the editorial commentary by Demmler on pages 1152–3)

Background. Cytomegalovirus (CMV) is a leading cause of congenital illness and disability, including hearing loss and mental retardation. However, there are no nationwide estimates of CMV seroprevalence among pregnant women or the overall population of the United States.

Methods. To determine CMV prevalence in a representative sample of the US population, we tested serum samples for CMV-specific immunoglobulin G from participants aged ⩾6 years ($n = 21,639$) in the third National Health and Nutrition Examination Survey (1988–1994).

Results. The prevalence of CMV infection was 58.9% in individuals ⩾6 years old. CMV seroprevalence increased gradually with age, from 36.3% in 6–11-year-olds to 90.8% in those aged ⩾80 years. CMV seroprevalence differed by race and/or ethnicity as follows: 51.2% in non-Hispanic white persons, 75.8% in non-Hispanic black persons, and 81.7% in Mexican Americans. Racial and/or ethnic differences in CMV seroprevalence persisted when controlling for household income level, education, marital status, area of residence, census region, family size, country of birth, and type of medical insurance. Among women, racial and/or ethnic differences were especially significant; between ages 10–14 years and 20–24 years, seroprevalence increased 38% for non-Hispanic black persons, 7% for non-Hispanic white persons, and <1% for Mexican Americans.

Conclusions. On the basis of these results, we estimate that each year in the United States ~340,000 non-Hispanic white persons, 130,000 non-Hispanic black persons, and 50,000 Mexican American women of childbearing age experience a primary CMV infection. Given the number of women at risk and the significance of congenital disease, development of programs for the prevention of CMV infection, such as vaccination or education, is of considerable public health importance.

Cytomegalovirus (CMV) is a leading cause of congenital infection in the United States, affecting between 0.2%–2.2 % of all newborns [1]. Each year in the United States, ~35,000 infants are born infected with CMV, with ~8,000 of these infants experiencing sequelae including vision loss, hearing loss, mental retardation, other neurologic abnormalities, and death [2, 3].

Risk of congenital infection is higher for seronegative women who have a primary CMV infection during pregnancy than it is for seropositive women who experience a reactivation or reinfection [3, 4]. Adolescents and adults can be infected with CMV through sexual contact [5] and nonsexual, close contact with infected individuals, especially children [6]. Children can be infected with CMV in utero, during delivery, and through blood transfusions, breast feeding, and contact with other children who are excreting CMV [7–11].

Estimates of CMV seroprevalence in the United States vary widely, ranging from 21% to 95% of the population [12–18]. These estimates have a limited ability to be generalized to the US population, because most are derived from relatively small convenience samples selected from special populations (e.g., pregnant women or persons attending sexually transmitted diseases clinics) in limited geographic areas. Robust estimates of CMV seroprevalence in the United States are needed to assess the burden of infection, to identify groups at special risk, and to design future vaccine strategies.

To estimate CMV seroprevalence and its relationship

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with age, sex, racial and/or ethnic group (hereafter referred to as race/ethnicity), and household income level among the US population, we analyzed data from the National Health and Nutrition Examination Survey (NHANES) III. To our knowledge, this is the first study in the United States with a nationally representative, population-based sample to examine CMV seroprevalence.

MATERIALS AND METHODS

Design and sample. For participants of NHANES III aged ⩾6 years ($n = 21{,}639$), we tested serum samples for the presence of CMV-specific IgG. We also tested serum samples obtained from a limited number of 4- and 5-year-olds ($n = 1175$). However, because of the large percentage (56%) of missing serum samples in this age group, study results for 4- and 5-year-olds were not nationally representative. The study protocol was approved by the institutional review boards at the Centers for Disease Control and Prevention (CDC) and Emory University (Atlanta, GA).

NHANES III was designed to provide national estimates of common diseases and their risk factors for the noninstitutionalized, civilian population of the United States. NHANES III was conducted by the National Center for Health Statistics of the CDC from 1988 to 1994 and was a complex, stratified, multistage probability cluster sample of the US population [19]. Persons <5 or >60 years of age, non-Hispanic black persons, and Mexican Americans were sampled at a higher frequency than other groups to obtain adequate sample sizes to more accurately evaluate these subgroups. The complete methodology and response rates of NHANES III have been published previously [20].

Demographic characteristics. To best fit the needs of each analysis, age was categorized in several ways. As recommended by the National Center for Health Statistics, it was categorized in 10-year age groups in the age-adjusted analysis [20]. For model stability, it was reduced to 15-year age groups in the multivariate analysis. To examine age-related seroprevalence in detail, age was analyzed in 5-year categories in the analysis of women of childbearing ages. None of the study results were dependent on the choice of age categorization.

Race/ethnicity was defined from self reports as non-Hispanic white, non-Hispanic black, or Mexican American (excluding Hispanic persons of other origins). Participants who self-identified as other races/ethnicities were excluded from analyses that assessed race/ethnicity and CMV seroprevalence [20].

Household income level was calculated by dividing total family income by the annual poverty threshold (on the basis of family size), as defined by the US Census Bureau [21]. On the basis of the US Department of Agriculture's food assistance program's cut points for school lunches, household income level was then divided into 3 categories: low (0.0–1.3), middle (1.301–3.5), and high (>3.5) [20, 22].

In addition to the main variables of interest—age, sex, race/ethnicity, and household income level—other demographic risk factors were selected for analysis on the basis of a priori information: education, marital status, area of residence, census region, household size, family size, number of rooms in the home, crowding index, country of birth, and type of medical insurance. To assess education, we created a 7-category variable that indicated how a participant's education level conformed to the expected level for his or her age. This allowed us to distinguish children who were in the appropriate grade for their age from adults who had dropped out of school at that grade. Area of residence was defined by the 1993 US Department of Agriculture's Rural-Urban codes (http://www.ers.usda.gov/Data/RuralUrbanContinuumCodes/1993/). Participants living in central or fringe counties of metropolitan areas of ⩾1 million people were classified as living in an urban area of residence, and all other participants were classified as living in a nonurban area of residence.

Serologic testing. We tested serum samples for CMV IgG at the CDC. To achieve a high specimen throughput, we used the Triturus robot (Grifols USA) with SeraQuest enzyme-linked immunosorbent assay reagents (Quest International). On the basis of in-house validation of the SeraQuest assay, specimens that tested within a narrow range around cutoff value were confirmed using the Vidas ELISA (bioMérieux). Concordant positive and negative results were reported as such. Discordant results were resolved with an immunofluorescence assay (Bion Enterprises). Using this algorithm, we achieved 98% sensitivity and 99% specificity.

Statistical analysis. The responses of participants were weighted by the National Center for Health Statistics to represent the total US population and to account for oversampling and for nonresponses to the household interview and physical exam [23, 24]. In most age, race/ethnicity, and sex groups, >90% of the participants of NHANES III had serum samples available for testing for CMV-specific IgG. Slightly fewer of the youngest and oldest age groups and the "other" race/ethnicity group had available serum samples. Because of these differences in serum sample availability, we multiplied the weights assigned by the National Center for Health Statistics to each participant by the weighted proportion of available serum samples for that participant's age, race/ethnicity, and sex group. We used these adjusted weights in SUDAAN software, version 9.01 (RTI International) for all analyses [25].

Logistic regression was used to determine whether the key demographic variables (age, sex, race/ethnicity, and household income level) were risk predictors of CMV seroprevalence when adjusting for age only (10-year age category) and when adjusting for other demographic risk factors and interaction terms

involving age, sex, and race/ethnicity. Interaction terms that were statistically significant ($P < .05$) were retained in the model. Numbers of rooms in the home and household size, which are components of the crowding index, were not included in the multivariate model. Because we were especially concerned with congenital CMV infection, we also performed the final model among women of childbearing age only. Results are reported in prevalence estimates and prevalence ratios (formed by dividing the prevalence estimate for the exposure group by the prevalence estimate for the reference group).

RESULTS

The age-adjusted CMV seroprevalence for individuals ⩾6 years old in the United States was 58.9% (95% CI, 57.1%–60.7%) (table 1). Seroprevalence increased steadily from 36.3% among 6–11-year-olds to 90.8% in those ⩾80 years old. Among the nonnationally representative sample of children aged 4 and 5 years, 37.9% (95% CI, 34.7%–41.2%) were seropositive. Among women of childbearing age (15–44 years), CMV seroprevalence was 58.3% (95% CI, 55.3%–61.4%). Within the entire sample population, female subjects (63.5%) were more likely than male subjects (54.1%) to be CMV seropositive when adjusting for age only (prevalence ratio, 1.17) and when adjusting for the other demographic risk factors (prevalence ratio, 1.17) (tables 1 and 2). Household income level was inversely associated with CMV seroprevalence in age-adjusted analysis (table 1). However, this strong association with household income level was not found in multivariate analysis (table 2).

When adjusting for age only, CMV seroprevalence differed substantially by race/ethnicity: 51.2% among non-Hispanic white persons, 75.8% among non-Hispanic black persons, and 81.7% among Mexican Americans (table 1). After adjusting for demographic risk factors, important racial/ethnic differences persisted (table 2, figure 1). In the youngest nationally representative age group (6–14 years), CMV seroprevalence was higher for Mexican Americans than for non-Hispanic white persons and non-Hispanic black persons. For age groups 15–29 years through 60–74 years, non-Hispanic white persons had lower seroprevalence, compared with non-Hispanic black persons and Mexican Americans, who had similar seroprevalences in these age groups. All 3 racial and/or ethnic groups had 85%–90% seroprevalence among persons ⩾75 years old. For non-

Table 1. Age-adjusted cytomegalovirus (CMV) seroprevalence in the noninstitutionalized, civilian population of the United States, aged ⩾6 years.

Characteristic	Sample size[a]	Age-adjusted prevalence estimate (95% CI)	Age-adjusted prevalence ratio (95% CI)
Total	21,639	58.9% (57.1%–60.7%)	
Age, years			
6–11	2679	36.3% (32.8%–40.0%)	1.0
12–19	2918	41.7% (38.3%–45.3%)	1.15 (1.03–1.29)
20–29	3302	49.3% (45.8%–52.8%)	1.36 (1.18–1.57)
30–39	3156	54.2% (50.3%–58.1%)	1.49 (1.33–1.67)
40–49	2483	64.5% (60.6%–68.2%)	1.78 (1.60–1.97)
50–59	1800	74.2% (70.7%–77.4%)	2.04 (1.85–2.26)
60–69	2257	83.0% (80.3%–85.4%)	2.29 (2.08–2.52)
70–79	1721	88.8% (85.7%–91.2%)	2.44 (2.21–2.70)
⩾80	1323	90.8% (88.4%–92.7%)	2.50 (2.27–2.76)
Sex			
Male	10,243	54.1% (52.0%–56.1%)	1.0
Female	11,396	63.5% (61.4%–65.5%)	1.17 (1.14–1.21)
Race/ethnicity			
Non-Hispanic white	8212	51.2% (49.2%–53.2%)	1.0
Non-Hispanic black	6228	75.8% (74.7%–76.9%)	1.48 (1.42–1.54)
Mexican American	6296	81.7% (80.2%–83.1%)	1.60 (1.53–1.66)
Household income level			
Low	7247	70.8% (68.3%–73.1%)	1.0
Middle	8524	60.5% (57.5%–63.4%)	0.85 (0.81–0.91)
High	3835	46.6% (44.2%–49.1%)	0.66 (0.62–0.70)

NOTE. Data are from the Third National Health and Nutrition Examination Survey, 1988–1994.

[a] Samples sizes are actual sample sizes, unweighted.

Table 2. Multivariate analysis of cytomegalovirus (CMV) seroprevalence in the noninstitutionalized, civilian population of the United States, aged ⩾6 years (n = 21,639).

Characteristic	Adjusted prevalence estimate (95% CI)	Adjusted prevalence ratio (95% CI)
Age, years, by racial/ethnic group		
6–14		
Non-Hispanic white	41.2% (36.1%–46.5%)	1.0
Non-Hispanic black	42.0% (37.6%–46.6%)	1.02 (0.88–1.18)
Mexican American	54.7% (49.0%–60.2%)	1.33 (1.16–1.52)
15–29		
Non-Hispanic white	40.3% (37.1%–43.6%)	1.0
Non-Hispanic black	64.3% (60.3%–68.0%)	1.59 (1.45–1.76)
Mexican American	58.7% (54.8%–62.4%)	1.46 (1.32–1.61)
30–44		
Non-Hispanic white	49.3% (44.3%–54.2%)	1.0
Non-Hispanic black	77.8% (73.5%–81.5%)	1.58 (1.44–1.73)
Mexican American	72.0% (67.3%–76.2%)	1.46 (1.31–1.63)
45–59		
Non-Hispanic white	66.0% (62.0%–69.7%)	1.0
Non-Hispanic black	88.9% (85.0%–91.9%)	1.35 (1.26–1.44)
Mexican American	84.7% (76.3%–90.5%)	1.28 (1.18–1.40)
60–74		
Non-Hispanic white	78.2% (74.0%–81.9%)	1.0
Non-Hispanic black	90.2% (85.6%–93.4%)	1.15 (1.08–1.23)
Mexican American	91.1% (84.0%–95.3%)	1.17 (1.08–1.25)
⩾75		
Non-Hispanic white	84.5% (78.9%–88.8%)	1.0
Non-Hispanic black	88.7% (79.1%–94.2%)	1.05 (0.96–1.14)
Mexican American	91.5% (59.5%–98.7%)	1.08 (0.90–1.30)
Sex		
Male	51.5% (49.2%–53.7%)	1.0
Female	60.3% (57.9%–62.6%)	1.17 (1.13–1.22)
Household income level		
Low	58.9% (55.3%–62.4%)	1.0
Middle	57.3% (54.3%–60.3%)	0.97 (0.91–1.05)
High	53.0% (50.4%–55.7%)	0.90 (0.84–0.97)

NOTE. Data are from the Third National Health and Nutrition Examination Survey, 1988–1994. Analyses were adjusted for age, race/ethnicity, age and race/ethnicity interaction, sex, household income level, education, marital status, area of residence, census region, family size, country of birth, and type of medical insurance.

Hispanic white persons and Mexican Americans, CMV seroprevalence was relatively stable between the age groups 6–14 years and 15–29 years (figure 1). In contrast, CMV seroprevalence dramatically increased between these age groups for non-Hispanic black persons (difference in seroprevalence, 22.3%).

Among women of childbearing age only, changes in CMV seroprevalence by age also differed substantially among racial/ethnic groups (figure 2). CMV seroprevalence increased sharply from ages 10–14 years (40.9%) to 20–24 years (78.7%) in non-Hispanic black women; for these same age groups, CMV seroprevalence for non-Hispanic white and Mexican American women increased only slightly. Mexican American women had a large seroprevalence increase between the age groups of 20–24 years and 25–29 years (seroprevalence difference, 17%). For non-Hispanic white women, the largest increase in seroprevalence was from 25–29 years to 35–39 years old (seroprevalence difference, 17%).

Several other demographic risk factors were associated with CMV seroprevalence (table 3). An inverse association was observed between a higher level of education and CMV seroprevalence. Geographically, the southern states had the highest CMV seroprevalence (66.2%) and the northeastern states had

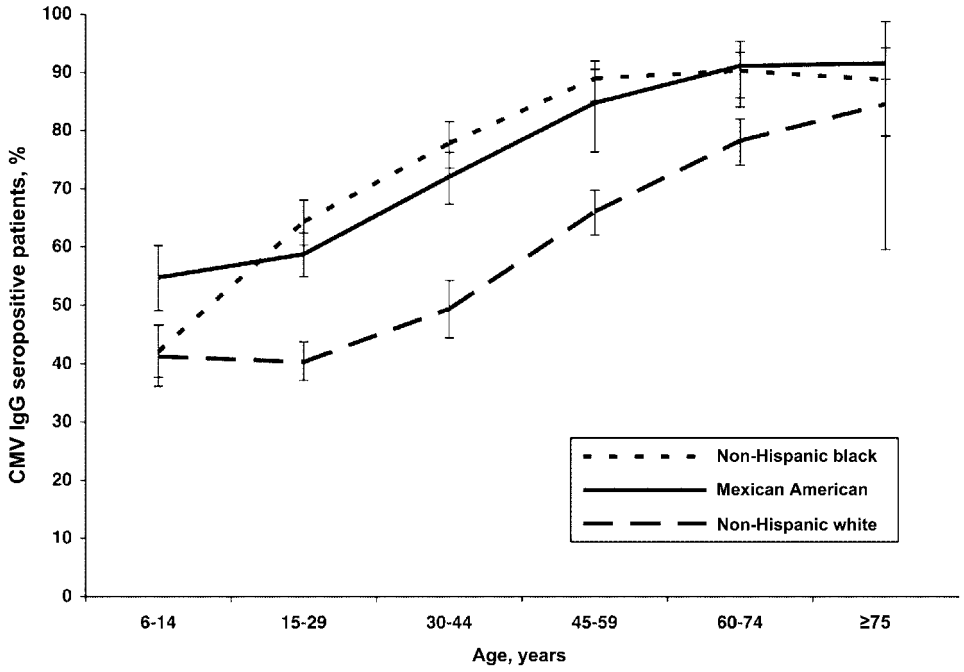

Figure 1. Data from the Third National Health and Nutrition Examination Survey, 1988–1994, showing results of testing for seroprevalence of cytomegalovirus (CMV), by age and race. Data were adjusted for sex, household income level, education, marital status, area of residence, census region, family size, country of birth, and type of medical insurance.

the lowest (50.3%). Family size was associated with CMV seroprevalence when adjusting for age only, but not when adjusting for other demographic risk factors. Individuals born in other countries were more likely to be CMV seropositive than those born in the United States. Individuals who had government-sponsored medical insurance (64% were Medicaid recipients) were more likely to be CMV seropositive than those who had private medical insurance.

DISCUSSION

We estimate that, in the United States, 58.9% of individuals ages ⩾6 years have been infected with CMV. This seroprevalence is similar to that estimated for England [26] and Germany [27]; much lower than what is estimated for India [28], Israel [29], Chile [30], Peru [31], and Saudi Arabia [32]; and higher than what is estimated for Canada [33]. To bring perspective to the US estimates, by age 11 in Israel [29] and Saudi Arabia [32], nearly 100% of the population is CMV seropositive, compared with ~40% in the United States. Thus, large percentages of women in the United States enter their childbearing years susceptible to a primary CMV infection. These CMV-seronegative individuals would benefit from public health interventions to prevent congenital CMV infection in their children.

We observed a gradual increase in CMV seroprevalence by age, from 36.3% in 6–11 year olds to 90.8% in those ⩾80 years old. By the ninth decade of life, nearly all individuals had been infected with CMV, consistent with research performed by Stackhouse et al. [17] during the same years. When considered with findings from cohort studies [6, 34], these data suggest that CMV infection can occur at any age.

Because this study had a cross-sectional design, a birth cohort effect may contribute to observed differences between age groups. For example, in the early part of the 20th century, when living conditions and hygienic practices were different, CMV infections may have been more common. If this is true, CMV seroprevalence in the oldest birth cohorts in this study may be higher than seroprevalence will be in the 6–11-year-old birth cohort when these individuals reach similar ages. On the other hand, CMV infection may be more common among those aged 6–11 years than it was for those aged 50–59 years when they were children, because child day care center attendance (a risk factor for CMV infection [10]) has increased dramatically [35]. In these ways and others, it is possible that a birth cohort effect accounts for some differences across age groups; however, a cohort effect cannot explain differences within age groups, such as between racial/ethnic groups of the same age.

We observed a wide disparity in CMV seroprevalence by race/ethnicity. In 15–59-year-olds, CMV seroprevalences in Mexican Americans and non-Hispanic black persons were comparable, and were 30%–60% higher than CMV seroprevalence in non-Hispanic white persons. These racial/ethnic differences were

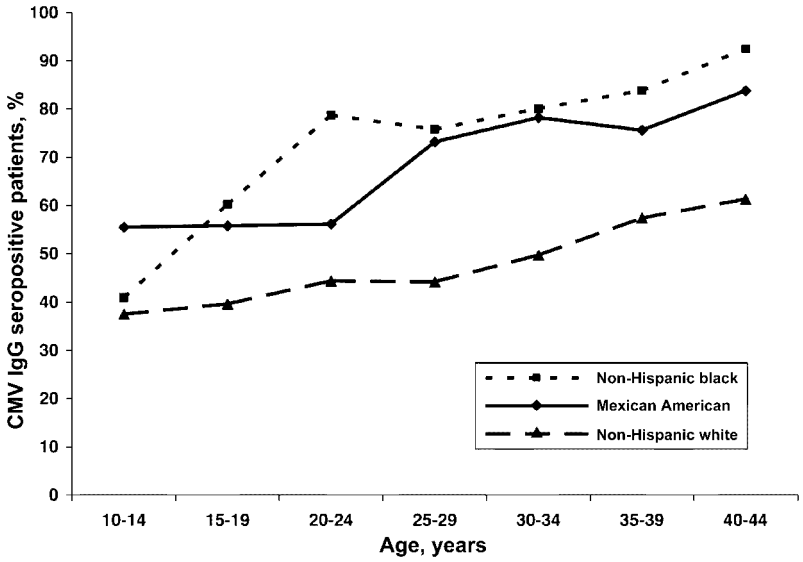

Figure 2. Data from the Third National Health and Nutrition Examination Survey, 1988–1994, showing results of testing for seroprevalence of cytomegalovirus (CMV) in women of childbearing age, by age and race. Data were adjusted for household income level, education, marital status, area of residence, census region, family size, country of birth, and type of medical insurance.

observed to a lesser extent in 60–74-year-olds, where Mexican Americans and non-Hispanic black persons had a 15% higher CMV seroprevalence than non-Hispanic white persons. All 3 racial/ethnic groups had comparable CMV seroprevalences for those aged ⩾75 years.

The most striking age-related finding was a large seroprevalence difference (22.3%) between 6–14-year-old and 15–29-year-old non-Hispanic black persons (figure 1). The other racial/ethnic groups had fairly stable seroprevalence estimates between these age groups. Among women only, the increase in CMV seroprevalence among non-Hispanic black subjects was even more pronounced. Between ages 10–14 and 20–24 years, CMV seroprevalence increased 38% for non-Hispanic black women, compared with an increase of 7% for non-Hispanic white women and <1% for Mexican American women (figure 2). In contrast, the period of greatest seroprevalence increase for Mexican American women was from 20 to 29 years old, and was from 25 to 39 years old for non-Hispanic white women (figure 2). Thus, CMV prevention strategies should take into account these age-related racial/ethnic differences.

The observed disparities in CMV seroprevalence by race/ethnicity cannot be explained fully by household income level, education, marital status, area of residence, census region, family size, country of birth, or type of medical insurance. Some of the disparities may be explained by differential exposure to CMV through differences in sexual behavior. Evidence from other studies indicate that non-Hispanic black persons are more likely to experience onset of sexual activity during early adolescence than are non-Hispanic white persons or Mexican Americans [36, 37]. In addition, among sexually active adolescents, more black girls (1 in 5) report having experienced a sexually transmitted infection than white girls (<1 in 10) [37].

Differential exposure to young children may also contribute to CMV seroprevalence differences by race/ethnicity. One way exposure to young children may differ by race/ethnicity is through differential birth rates. Non-Hispanic black women aged 10–14 years have birth rates that are 10 times higher than non-Hispanic white women and 2 times higher than Mexican American women of the same ages [38]. Thus, non-Hispanic black women may be exposed to their own children at younger ages, consistent with the large increase in CMV seroprevalence during adolescence. Identifying exposures associated with CMV infection during childbearing years should be the goal of further research; specifically, studies should investigate the risk of CMV infection from sexual behaviors and child care responsibilities.

Large percentages of women are CMV seronegative during childbearing years, and many primary CMV infections occur in women during this time (figure 2). Assuming that temporal trends in CMV infection rates were small, the differences in CMV seroprevalence by age provide a good approximation of overall seroconversion during these years. Thus, by the time women who are initially seronegative at 15 years of age reach the end of their childbearing years (age, 40–44 years), seroconversion would have occurred in 38.1% of non-Hispanic white persons, 87.3% of non-Hispanic black persons, and 63.6% of Mexican Americans.

To assess the number of women who are at risk of having a child with a congenital CMV infection, we estimated the number of annual primary CMV infections in women of childbearing age. Using the assumption that the rate of infection

Table 3. Other demographic risk factors and cytomegalovirus (CMV) seroprevalence in the noninstitutionalized, civilian population of the United States, aged ⩾6 years ($n = 21,639$).

Characteristic	Sample size[a]	Age-adjusted prevalence estimate (95% CI)	Age-adjusted prevalence ratio (95% CI)	Adjusted[b] prevalence estimate (95% CI)	Adjusted[b] prevalence ratio (95% CI)
Education					
Completed 8th grade or less[c]	3926	85.0% (81.4%–87.9%)	1.0	67.6% (63.3%–71.6%)[d]	1.0[d]
Completed some high school[c]	2494	70.5% (66.4%–74.4%)	0.83 (0.78–0.88)	…	…
1–4 years behind	739	66.6% (60.5%–72.1%)	0.78 (0.71–0.86)	52.0% (48.0%–56.1%)[e]	0.77 (0.69–0.85)[e]
Completed all grades	5469	55.8% (51.6%–60.0%)	0.66 (0.60–0.72)	…	…
Completed high school	4244	62.9% (59.4%–66.3%)	0.74 (0.70–0.78)	61.0% (57.9%–64.1%)	0.90 (0.86–0.95)
Completed some college	2639	52.9% (49.4%–56.4%)	0.62 (0.58–0.67)	51.7% (48.9%–54.5%)[f]	0.77 (0.72–0.81)[f]
Completed college	1988	46.1% (42.3%–49.9%)	0.54 (0.50–0.59)	…	…
Marital Status					
Never married[g]	8012	57.2% (54.1%–60.3%)	1.0	54.1% (50.5%–57.7%)	1.0
Married/living as married	9631	58.1% (55.8%–60.5%)	1.02 (0.95–1.08)	56.7% (54.0%–59.4%)	1.05 (0.97–1.13)
Married, spouse not living in household	309	79.3% (68.9%–86.9%)	1.39 (1.24–1.55)	66.3% (55.2%–75.8%)	1.22 (1.03–1.45)
Widowed	1806	65.7% (61.1%–70.0%)	1.15 (1.04–1.26)	57.8% (54.0%–61.5%)[h]	1.07 (0.97–1.18)[h]
Divorced or separated	1823	66.1% (62.5%–69.6%)	1.15 (1.07–1.25)	…	…
Area of residence					
Nonurban	11,117	57.8% (55.3%–60.3%)	1.0	55.4% (53.0%–58.0%)	1.0
Urban	10,522	60.0% (57.0%–63.0%)	1.04 (0.97–1.12)	56.6% (53.8%–59.2%)	1.02 (0.96–1.08)
Census region[i]					
Northeast	2778	50.3% (46.4%–54.2%)	1.0	48.3% (44.1%–52.6%)	1.0
Midwest	4184	53.5% (50.4%–56.6%)	1.06 (0.97–1.17)	53.0% (50.0%–56.1%)	1.10 (0.99–1.21)
South	9400	66.2% (63.4%–68.8%)	1.32 (1.21–1.44)	63.2% (60.5%–65.8%)	1.31 (1.19–1.44)
West	5277	61.1% (56.5%–65.4%)	1.21 (1.09–1.35)	54.5% (50.0%–58.9%)	1.13 (1.01–1.26)
Family size, no. of persons[j]					
1	2854	54.6% (51.4%–57.8%)	1.0	55.9% (51.6%–60.1%)	1.0
2–4	12,221	56.3% (54.2%–58.3%)	1.03 (0.98–1.09)	55.0% (52.8%–57.1%)	0.98 (0.91–1.06)
5–7	5266	66.0% (62.9%–69.0%)	1.21 (1.13–1.30)	58.7% (55.3%–62.0%)	1.05 (0.96–1.15)
⩾8	1298	80.2% (74.8%–84.7%)	1.47 (1.35–1.60)	62.9% (52.7%–72.1%)	1.13 (0.96–1.32)
Country of birth					
United States	17,610	55.2% (53.4%–56.9%)	1.0	54.8% (52.8%–56.8%)	1.0
Mexico	2593	93.5% (92.2%–94.6%)	1.69 (1.64–1.75)	83.0% (78.5%–86.8%)	1.51 (1.43–1.60)
Another country	1377	82.2% (79.2%–84.9%)	1.49 (1.43–1.55)	71.6% (64.4%–77.8%)	1.31 (1.19–1.43)
Type of medical insurance[k]					
Private	10,054	53.8% (51.7%–55.9%)	1.0	54.6% (52.4%–56.8%)	1.0
Medicare and private	2594	59.4% (50.6%–67.7%)	1.10 (0.95–1.28)	60.8% (54.2%–66.9%)	1.11 (1.00–1.24)
Medicare	948	72.4% (60.0%–82.0%)	1.35 (1.16–1.56)	63.3% (58.9%–67.6%)[l]	1.16 (1.08–1.24)[l]
Medicaid	2040	76.0% (71.8%–79.7%)	1.41 (1.32–1.51)	…	…
Military or VA	208	70.5% (52.4%–83.9%)	1.31 (1.05–1.64)	…	…
No insurance	3667	68.3% (65.2%–71.3%)	1.27 (1.20–1.35)	56.6% (53.2%–60.0%)	1.04 (0.97–1.10)

NOTE. Data are from the Third National Health and Nutrition Examination Survey, 1988–1994.

[a] Sample sizes are actual sample sizes, unweighted.

[b] Analyses were adjusted for age, race/ethnicity, age and race/ethnicity interaction, sex, household income level, education, marital status, area of residence, census region, family size, country of birth, and type of medical insurance.

[c] All participants in these categories are at least 5 years behind the appropriate grade for their age.

[d] Values are for the combined categories "Completed 8th grade or less" and "completed some high school."

[e] Values are for the combined categories "1–4 years behind" and "completed all grades."

[f] Values are for the combined categories "Completed some college" and "Completed college."

[g] All participants aged ⩽14 years were assumed to be unmarried.

[h] Values are for the combined categories "Widowed" and "Divorced or separated."

[i] Northeast is considered to be Connecticut, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; the Midwest is Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; the South is Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; and West is Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

[j] Family size includes all of the members of blood and family relations (including through marriage, through adoption, and foster children) living in a household.

[k] Participants reporting multiple types of medical insurance, other than both Medicare and private medical insurance, were excluded.

[l] Values are for the combined categories "Medicare," "Medicaid," and "Military or VA."

was constant, we multiplied the percentage of women who experience CMV seroconversion each year by the number of women aged 15–44 years in 1988 [39]. We estimate that each year ~340,000 non-Hispanic white, ~130,000 non-Hispanic black, and ~50,000 Mexican American women aged 15–44 years experience a primary CMV infection. A more formal, model-based approach for estimating incidence of primary CMV infection is beyond the scope of this article.

Consistent with previous research [12, 13, 18], we found that markers of low socioeconomic status are strongly associated with high risk for CMV infection. Various components of socioeconomic status, including household income level, educational level, race/ethnicity, and type of medical insurance, were associated with CMV seroprevalence when adjusting for age only (tables 1 and 3). When adjusting for all demographic risk factors, the associations persisted for all these factors except household income level, suggesting that most of the variation in CMV seroprevalence by household income level was explained by other covariates (table 2 and 3).

A major strength of this study was the use of a nationally representative sample to estimate CMV seroprevalence in the United States. Another strength was the large sample size, which allowed for the simultaneous adjustment of important demographic risk factors in multivariate analyses. In addition, because of the vast amount of information collected for NHANES III, we were able to assess demographic factors in depth; for example, we were able to assess multiple measures of socioeconomic status, including education level, household income level, and type of medical insurance. An important limitation of this study is its cross-sectional design. For example, we could not determine the age at which seropositive individuals became infected with CMV. Furthermore, for some risk factors, such as household income level and family size, current individual status may not reflect past exposure. However, most risk factors were independent of age, suggesting that their observed relationships with CMV seroprevalence are real.

Many women in the United States enter their childbearing years susceptible to CMV infection. Large percentages of these women experience a primary CMV infection during their childbearing years, with a disproportionate burden on non-Hispanic black and Mexican American women. In accordance with the goals of the US Department of Health and Human Services's Healthy People 2010 initiative [40], immediate steps should be taken to reduce these racial/ethnic disparities. Prevention strategies of proven efficacy are necessary to accomplish this. Several candidate vaccines are in various stages of testing; however, an effective vaccine will likely not be available for years [41]. For current prevention efforts, the CDC recommends counseling pregnant women about simple hygienic steps, such as hand washing, to decrease exposure to body fluids from young children (http://www.cdc.gov/cmv/index.htm) [42]. Until successful prevention programs are implemented, each year ~500,000 women of childbearing age will experience a primary CMV infection, thereby putting their infants at risk of serious disease.

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