Substandard Vaccination Compliance and the 2015 Measles Outbreak

The ongoing measles outbreak linked to the Disneyland Resort in Anaheim, California, shines a glaring spotlight on our nation’s growing antivaccination movement and the prevalence of vaccination-hesitant parents. Although the index case has not yet been identified, the outbreak likely started sometime between December 17 and 20, 2014. Rapid growth of cases across the United States indicates that a substantial percentage of the exposed population may be susceptible to infection due to lack of, or incomplete, vaccination. Herein, we attempt to analyze existing, publicly available outbreak data to assess the potential role of suboptimal vaccination coverage in the population.

Methods | Without vaccination, measles is a highly contagious disease; estimates of the basic reproductive number ($R_0$) from the prevaccination era range from 11 to 18. $R_0$ is the mean number of secondary infections per infectious agent that occurs during the course of the entire infectious period in a population that is 100% susceptible at time 0. However, when a portion of the population is immune to a given disease, effective reproductive number ($R_E$) is observed instead of $R_0$. When historical values of $R_0$ are available and $R_E$ can be approximated, the rate of immunity in the exposed population can be estimated. Furthermore, in situations where immunity is primarily conferred via vaccination, rate of immunity ($I$) and rate of vaccination effectiveness ($V_E$) can be used to estimate rate of vaccination ($V$) in the exposed population as follows:

$$V = V_E \cdot \frac{1 - (R_E/R_0)}{R_E} \cdot I$$

To estimate the vaccination rate in the context of the 2015 measles outbreak, cumulative incidence data were obtained via the California Department of Public Health and HealthMap media alerts. We used the incidence decay and exponential adjustment (IDEA) method to approximate the effective reproductive number ($R_E$). Historically, the serial interval (SI) associated with measles is 10 to 14 days; thus, this range was used to parameterize the model.

Results | Using nonlinear optimization, $R_E$ was solved for SI = 10, 12, and 14 days at 3.2, 4.1, and 5.8, respectively. Measles, mumps, and rubella (MMR) vaccination rates among the exposed population were then estimated using $R_E$ = 3.2, 4.1, and 5.8; prevaccination era values of $R_0$; and a vaccination effectiveness ($V_E$) of 95%. Over the range of $R_0$ = [11, 18], the estimated vaccination rates vary from 75% to 86% when $R_E$ = 3.2, from 66% to 81% when $R_E$ = 4.1, and from 50% to 71% when $R_E$ = 5.8 (Figure).
Outcomes included having any health insurance, self-reported health (excellent/very good/good vs fair/poor), access to a usual source of care, a routine checkup in the past year, and the inability to see a physician in the past year because of cost.

Multivariate linear probability models controlled for a monthly trend; state, year, and calendar month; and an indicator for the enactment period (March 30, 2010-September 22, 2010). The postexpansion period began September 23, 2010. Because economic conditions may have affected coverage rates differentially for younger and older adults, we controlled for state unemployment rates. We also controlled for race/ethnicity, sex, income, marital status, education, employment, and cellular telephone use because cellular telephones were added to the Behavioral Risk Factor Surveillance System in 2011 and the use may have differed by age. Analyses used Behavioral Risk Factor Surveillance System survey weights and accounted for the complex survey design. Two-sided $P$ values less than .05 indicated statistical significance. Analyses were performed with Stata 13 (StataCorp).

Results | The sample ($n = 456,966$) was 50.5% male and 70.8% white. Group demographics were similar across the intervention and control groups except for marital status and education (Table 1).

Compared with the control group, the dependent coverage provision was associated with an increase of 6.6 percentage points (95% CI, 5.4-7.7) in the probability of insurance coverage among individuals aged 19 to 25 years ($P < .001$) and a decrease of 0.8 percentage points (95% CI, 0.0-1.6) in fair or poor self-reported health ($P = .04$). Compared with the control group, the proportion of young adults with a usual source of care increased by 2.4 percentage points ($P < .001$; 95% CI, 1.1-3.6) while the proportion of young adults unable to see a physician because of cost declined by 1.9 percentage points ($P = .001$; 95% CI, 0.8-3.0). There was no statistically significant change in the percentage of young adults who reported a routine checkup in the previous year (Table 2). Comparison of trends before 2010 in these outcomes showed no significant differences by age group.

Discussion | We found that the dependent coverage provision was associated with improved self-reported health and access to health care among young adults aged 19 to 25 years compared with a control group of older adults who experienced worsening coverage and access to care during this period. Another recent analysis of the Behavioral Risk Factor Surveillance System reported that the provision did not significantly affect health and access; however, we found different results primarily owing to increased power from a larger sample. Our findings were consistent with previous evidence from several data sources that the Affordable Care Act's dependent coverage expansion improved self-reported health and access to care.2,5,6

A key limitation of this study was that any factors changing differentially across time for younger adults vs the control group could have biased our findings; however, our ad-