Measles Vaccination Coverage and Cases among Vaccinated Persons

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To the Editor: In December 2014, a measles outbreak that had started at Disneyland Park in Anaheim, California, USA, and subsequently spread to numerous states garnered substantial media attention in the United States. In 2014, the US Centers for Disease Control and Prevention reported the highest number of measles cases (644) since the disease had been declared eliminated from the United States in 2000 (1). This number is still relatively lower than the numbers reported from 30 countries of the European Union and the European Economic Area; the highest numbers of measles cases in 2013 were from the Netherlands (2,499 cases), Italy (2,216), the United Kingdom (1,900), and Germany (1,772) (2). There is widespread concern that increasing hesitancy to vaccinate might lead to outbreaks as large as the ones in Europe.

Measles vaccine is highly effective, and analyses of large measles outbreaks at a school in Germany have shown that receipt of ≥1 doses of vaccine can prevent infection in up to 99% of persons (3,4). One might therefore be tempted to think that the proportion of measles case-patients who had been vaccinated must be very small. However, when vaccination rates are high, most persons exposed to an infected person will have received ≥1 doses of vaccine. As a consequence, the expected proportion of persons who had received ≥1 doses of vaccine among reported measles case-patients will be substantially higher than 1%.

One can derive a simple quantitative relationship between vaccination coverage and the proportion of case-patients who had been vaccinated. Assuming vaccination coverage of \( v \) and vaccine effectiveness of \( \alpha \), the proportion of the population who are susceptible to measles infection is \( 1 - \alpha v \). If all susceptible persons are at the same risk of getting infected, the proportion of vaccinated persons among all case-patients will be \( v(1 - \alpha)/(1 - \alpha v) \). This equation is similar to the screening method that has been used to calculate vaccine effectiveness on the basis of the proportion of case-patients who were vaccinated and vaccination coverage (5). Perhaps somewhat counterintuitive at first, the proportion of vaccinated measles case-patients increases with vaccination coverage (Figure).

We hypothesized that the observed proportion of measles case-patients who had been vaccinated can be used to infer the vaccination coverage in a population at risk (Figure). To this end, we assume a vaccine effectiveness of 99% among persons who had received ≥1 doses (3,4). In 2013, countries in the European Union/European Economic Area reported 9,708 measles case-patients for whom vaccination status was known (2). Of those, 11.8% had received ≥1 doses of measles vaccine. On the basis of the relationship derived above, this proportion corresponds to an expected vaccination coverage of 93.1% who had received ≥1 doses, which is consistent with reported numbers. Switzerland reported 3,850 measles case-patients with known vaccination status from August 2006 through June 2009; of these, 7.0% had been vaccinated with ≥1 doses (8). The inferred vaccination coverage of 88.3% is very close to the reported national level of 87.0% for receipt of ≥1 doses at 2 years of age (8). In contrast, the most recent numbers from the United States suggest that vaccination coverage for receipt of ≥1 doses is still well over 90%.

Various complexities might affect the relationship between vaccination coverage in a community and the proportion of case-patients who had been vaccinated. First, we assume a vaccine effectiveness of 99% among persons who received ≥1 doses. Other estimates indicate that...
Lassa fever is a zoonosis caused by the Lassa virus (LASV; family Arenaviridae, genus Lassavi-
rus). The primary reservoir of LASV is the multimammate rat (Mastomys natalensis), which is found throughout sub-Saharan Africa. LASV outbreaks among humans occur only in West Africa in 2 noncontiguous areas: 1 in Guinea, Liberia, and Sierra Leone; and 1 in Nigeria. Rare cases and evidence of exposure of humans have been documented in neighboring countries (i.e., Benin, Burkina Faso, Côte d’Ivoire, Ghana, Mali, and Togo) (1). LASV RNA has been detected in only 4 patients: 1 in Germany who had traveled in Burkina Faso, Côte d’Ivoire, and Ghana (2); 1 in the United Kingdom who had returned from Mali (3); and 2 in...