Vaccine Hesitancy

Causes, Consequences, and a Call to Action

Daniel A. Salmon, PhD,[1,2] Matthew Z. Dudley, MSPH,[2] Jason M. Glanz, PhD,[3,4] Saad B. Omer, MBBS[5]

Vaccine hesitancy reflects concerns about the decision to vaccinate oneself or one's children. There is a broad range of factors contributing to vaccine hesitancy, including the compulsory nature of vaccines, their coincidental temporal relationships to adverse health outcomes, unfamiliarity with vaccine-preventable diseases, and lack of trust in corporations and public health agencies. Although vaccination is a norm in the U.S. and the majority of parents vaccinate their children, many do so amid concerns. The proportion of parents claiming non-medical exemptions to school immunization requirements has been increasing over the past decade. Vaccine refusal has been associated with outbreaks of invasive *Haemophilus influenzae* type b disease, varicella, pneumococcal disease, measles, and pertussis, resulting in the unnecessary suffering of young children and waste of limited public health resources. Vaccine hesitancy is an extremely important issue that needs to be addressed because effective control of vaccine-preventable diseases generally requires indefinite maintenance of extremely high rates of timely vaccination. The multifactorial and complex causes of vaccine hesitancy require a broad range of approaches on the individual, provider, health system, and national levels. These include standardized measurement tools to quantify and locate clustering of vaccine hesitancy and better understand issues of trust; rapid, independent, and transparent review of an enhanced and appropriately funded vaccine safety system; adequate reimbursement for vaccine risk communication in doctors' offices; and individually tailored messages for parents who have vaccine concerns, especially first-time pregnant women. The potential of vaccines to prevent illness and save lives has never been greater. Yet, that potential is directly dependent on parental acceptance of vaccines, which requires confidence in vaccines, healthcare providers who recommend and administer vaccines, and the systems to make sure vaccines are safe.

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Introduction

Vaccine hesitancy reflects concerns about the decision to vaccinate oneself or one's children. Concerns that contribute to hesitancy may be based upon the perceived need for vaccination as well as the perceived risks and benefits of vaccination. A recent report from the Strategic Advisory Group of Experts (SAGE) on Immunization of the WHO defines vaccine hesitancy as "delay in acceptance or refusal of vaccines despite availability of vaccinations services. Vaccine hesitancy is complex and context specific, varying across time, place, and vaccines. It is influenced by factors such as complacency, convenience, and confidence."[1] Although this definition only includes people who delay or refuse vaccines, some individuals may have concerns about the decision to vaccinate while still fully vaccinating themselves and/or their children on time according to the recommended schedule or standard of care. For example, a parent may be concerned about adverse events associated with the vaccine yet recognize the value of vaccinating to protect their children from infectious diseases. This parent may vaccinate their child on time yet still have concerns, so this decision was made with hesitance.

Hesitant individuals include those who refuse some or all vaccines, delay some vaccines perhaps according to an

From the [1]Departments of International Health and Health, Behavior, and Society, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland; [2]Institute for Vaccine Safety, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland; [3]Institute for Health Research, Kaiser Permanente Colorado, Denver, Colorado; [4]Department of Epidemiology, Colorado School of Public Health, Aurora, Colorado; and [5]Rollins School of Public Health, Emory University, Atlanta, Georgia

Address correspondence to: Daniel A. Salmon, PhD, Institute for Vaccine Safety, Johns Hopkins Bloomberg School of Public Health, 615 N. Wolfe Street, Room W5035, Baltimore MD 21205. E-mail: dsalmon1@jhu.edu.

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"alternative schedule," or accept all vaccines but remain concerned. Hesitancy is on a continuum and can be measured by assessing attitudes and beliefs toward infectious diseases and the vaccines used to prevent them. Although attitudes and beliefs that measure concerns are associated with vaccine acceptance, delay, and refusal, they do not perfectly predict vaccination decisions, as other factors such as ease of access, competing priorities, social norms, and compliance with provider recommendations and vaccination requirements for school or work can also be influential. The immediate epidemiologic risks of hesitancy are a result of vaccine delay and refusal; however, parents who are vaccinating on time despite concerns may be particularly vulnerable to misinformation, with the potential of being swayed to delay or refuse future vaccines.

In this article, we review the causes, prevalence, reasons for, impact, and relevance of vaccine hesitancy. We also include a call to action to address vaccine hesitancy and improve vaccine confidence. Although our focus is on pediatric vaccines in the U.S., many of the issues discussed below also have important implications internationally.

Causes of Vaccine Hesitancy

There is a broad range of factors contributing to vaccine concerns among parents. Vaccines have been victims of their own success. Because vaccines have effectively controlled many once-common childhood infectious diseases, parents of young children are no longer familiar with these diseases. Instead, fear has shifted to alleged vaccine reactions that typically include childhood health problems that occur around the time that many vaccines are given. Thus, a coincidental temporal relationship exists between when vaccines are administered and when an adverse health outcome of concern is identified. Parents are susceptible to the logical fallacy of "post hoc ergo propter hoc" or "after this, therefore because of this." Autism is a very visible example of this phenomenon, but it is also seen with diabetes, allergies, and autoimmune diseases. Although the etiology of autism is poorly understood, it is thought to involve genetic susceptibility and an undefined environmental exposure. Parents see examples of infants who had autism diagnosed after vaccine administration. Autism diagnoses have increased in prevalence, and parents notice a population-level relationship between this increase in prevalence coinciding with an increase in the number of vaccines given, as the number of vaccines recommended before age 2 years has increased from 15 protecting against nine diseases in 1995 to 24 protecting against 14 diseases in 2015. Taken together, these factors make vaccines a natural suspect for the cause of many infant and childhood diseases.

Heuristics that impact perceptions of risk also add to parental vaccine concerns. As depicted in Table 1, the compulsory nature of vaccines for children, the inability of parents to control the risks of adverse reactions, the manmade nature of vaccines, and the unpredictability of adverse reactions, which are dreaded and seemingly exotic, result in parents perceiving the risks of vaccines to be greater than they actually are. A preference for errors of omission over errors of commission can also be a factor, that is, a preference for adverse health outcomes due to disease after not vaccinating rather than due to vaccinating.[3,4] Moreover, parents can become anguished when witnessing their infants receiving multiple injections, especially those with an aversion to needles.

A confluence of other contemporary issues further contributes to parental concerns. Trust in institutions is low, whether in the corporations that produce vaccines

Table 1. Risks Perception and the Impact on Vaccine Hesitance

Less risk		More risk	Impact on vaccine hesitance
Voluntary	versus	Involuntary	Vaccines are mandatory for school entrance
Individual control	versus	System control	Risk of adverse reactions are not in control of parent
Omission	versus	Commission	Preference for adverse health outcomes due to disease (errors of omission: not vaccinating) than vaccinating (error of commission: vaccinating)
Natural	versus	Manmade	Disease risks are "natural," whereas vaccine risks are "manmade"
Predictable	versus	Unpredictable	Difficult to predict risks of very rare but serious adverse reactions
Not dreaded	versus	Dreaded	Once-common diseases like varicella are not dreaded whereas very rare but serious adverse reactions are dreaded
Familiar	versus	Exotic	Parents are more familiar with common health problems that are alleged (without scientific support) to be caused by vaccines, like autism, than diseases they are not familiar with, such as polio, measles, and diphtheria

Note: Adapted with permission from Taylor and Francis Group LLC Books.[2]

or the public health agencies that purchase and promote them.[5] Taken together, the public has long expressed fears of the pharmaceutical–industrial complex. There is a growing parental and public interest in natural products, leading some to call for efforts to "green our vaccines."[6] The medical model is changing, whereby parents are often interested in shared decision making with pediatricians for child health rather than the more traditional paternalistic medical model whereby pediatricians tell parents what to do in the best interest of their child. The growth of the Internet has allowed allegations of vaccine injury to rapidly spread around the world.[7]

The Prevalence of Vaccine Concerns

There is no standardized tool to measure vaccine hesitancy that has been widely used; however, Opel et al.[8] recently developed and tested the validity and reliability of such a tool, and WHO's SAGE working group recently recommended a series of survey questions in order to improve the measurement of hesitancy.[1] Although these survey questions could prove useful in developing a uniform measure for vaccine hesitancy, they need to be field tested and validated. Further limiting our ability to assess the level of vaccine concerns in the U.S. is a lack of standardized methods allowing for comparisons of changes over time.

There have been a number of cross-sectional surveys over the past two decades that have measured vaccine concerns using a variety of sampling methods. A nationally representative telephone survey of parents of children aged 6 years or younger conducted in 1999 found that although a majority of parents (87%) considered immunization extremely important, a substantial minority believed that their child's immune system could be weakened by too many vaccines (25%) or that children get more immunizations than are good for them (23%).[9] The most recent published national data on vaccine concerns from the 2010 HealthStyles Panel of parents with children aged 1–6 years found that 77% of parents reported a vaccine concern.[10] Many of these concerns (not mutually exclusive) were relatively minor, such as pain related to receiving shots (38%) and the possibility of fevers (32%). However, many parents had more-serious concerns such as the number of vaccines given at one doctor's visit (36%) or during the first 2 years of life (34%); the possibility that vaccines may cause learning disabilities such as autism (30%); that vaccine ingredients may be unsafe (26%); and that vaccines are not tested enough for safety (17%). Although the majority of these parents report vaccinating with the recommended schedule (83%) or planning on doing so (11%), 5% reported selectively vaccinating and 2% reported forgoing vaccination for their children altogether. A more nuanced view of parental vaccine attitudes indicates different groups of parents such as immunization advocates (actively pursue vaccines); go along to get along parents (follow the advice of their doctors and societal expectations); health advocates (seek out vaccine information); fence sitters (are unsure of their vaccine decision); and worried parents (are very concerned about vaccine adverse reactions).[11] It is not possible to make valid comparisons of the frequency of parental concerns over time because the U.S. lacks a serial, cross-sectional survey that uses standardized sampling approaches and survey questions. The National Immunization Survey (NIS) attitudinal module discussed below could serve this purpose; however, limited data have been published so far.

Reasons for Delay and Refusal of Vaccines

Parental vaccine refusal has been associated with perceptions of susceptibility and severity of disease, safety and effectiveness of vaccines, and trust in healthcare providers and the government.[12–14] The NIS, a random-digit-dial survey of households with children aged 19–35 months followed by a mailed provider survey to obtain sampled children's provider-confirmed vaccination histories, has included an attitudinal module in select years, allowing immunization histories to be combined with parental attitudes, beliefs, and decision making. Two such modules are the Knowledge, Attitudes, and Practices[3] and the Parental Knowledge and Experiences modules, which each sampled a portion of NIS participants between 2000–2001 and 2001–2002, respectively. Published data from these modules confirmed the association between vaccine safety concerns and undervaccination, and reiterated the importance of provider recommendations and addressing these concerns even in parents who fully vaccinated their children.[4–7] NIS data from 2003 found that 21.8% of parents intentionally delayed vaccine doses. These parents reported that they delayed vaccines for reasons such as concerns about vaccine safety or efficacy (44.8%); concurrent illness (36.1%); missed appointments (7.7%); cost (5.6%); and other unspecified reasons (8.5%).[15] Intentional vaccine delay was associated with lower vaccination levels at age 19 months and reported exposure to unfavorable information about vaccines, as well as some demographic characteristics (non-Hispanic white race, married mothers, higher maternal education and age, preference for English, and higher household income). NIS attitudinal data from 2009 found that of the 39.8% of parents that delayed or refused at least one dose of vaccine, 25.8% delayed one or more dose, 8.2% refused one or more

dose, and 5.8% both delayed and refused one or more dose.[16] Vaccine delay and refusal was associated with lower perceived risk of contracting a vaccine-preventable disease, lower perceived importance of vaccine-preventable diseases as a health concern, lower perceived vaccine safety and effectiveness, and less confidence in medical professional associations. This study found a similar demographic profile for parents who refuse and delay vaccines as the 2003 study. The dramatic increase from 21.8% of parents delaying vaccines in 2003 to 39.8% in 2009 demonstrates the need to continually monitor and evaluate hesitancy using standardized instruments. More recent NIS attitudinal data could prove to be invaluable in determining vaccine-related attitudes, but so far remain unpublished.

The Impact on Vaccine Coverage

Fortunately, vaccination is a norm in the U.S. The majority of parents vaccinate their children. Vaccine coverage at preschool is measured through the NIS, and coverage at kindergarten entrance is reported from schools to states. Ad hoc studies can also contribute to understanding vaccine coverage.

In 2013, vaccination coverage measured by the NIS showed that 83.1% of children aged 19–35 months received four or more diphtheria, tetanus, acellular pertussis vaccine (DTaP) doses; 92.7% received three or more poliovirus doses; 91.9% received one or more measles, mumps, rubella vaccine (MMR) dose; 82.0% received the full series of *Haemophilus influenzae* type b vaccine (Hib); 90.8% received three or more hepatitis B vaccine (HepB) doses; 91.2% received one or more varicella dose; and 82.0% received four or more pneumococcal conjugate vaccine (PCV) doses.[17] The rates of vaccine coverage among children aged 19–35 months have increased or remained constant over the past decade. As the NIS is unable to routinely ascertain the reasons for under-vaccination, it is not possible to distinguish between preschool children who are not vaccinated for health system issues (such as access to vaccines, competing priorities, or missed opportunities) versus those whose parents decide to delay or refuse vaccines. Measuring vaccine coverage at a particular time point, such as the proportion of children receiving a vaccine series at 19–35 months of age, overlooks children who are vaccinated but are delayed in doing so. Delayed vaccination leaves young children—who are often at increased risk of serious complications—vulnerable to vaccine-preventable diseases.[18,19] In particular, it has been shown that children delayed for one or more doses of DTaP were 4.4 (2.23–8.55) times more likely to be diagnosed with pertussis than children who were age-appropriately vaccinated.

A study by the Vaccine Safety Datalink (VSD) involving eight MCOs showed that the prevalence of under-vaccinated children aged 2–24 months increased significantly from 2004 to 2010.[20] Similarly, this analysis demonstrated a significant increasing trend in the prevalence of children on a known alternative or delayed immunization schedule over the same time period.[21] In a cohort of 323,247 children, the estimated overall prevalence of under-vaccination due to parental choice was 13% (95% CI=11.9%, 14.2%), based on ICD-9-CM codes and medical record review.

In a similar analysis, recent census data analyzed by Northern California Kaiser (a VSD site) suggest that the proportion of under-vaccinated preschool children is also increasing.[22] For example, the proportion of children not receiving the 4:3:1:2:3:1:4 series (four doses DTaP : three doses inactivated polio vaccine : one dose MMR : two doses Hib : three doses hepatitis B vaccine : one dose varicella vaccine : four doses PCV) by 24 months has increased from 8.1% in the 2002–2005 time period to 12.4% in 2011–2012. Increasing numbers of children in this study seemed to be following a "shot-limiting" approach whereby they were fully immunized by 36 months of age but never received more than two injections in a day (0.7% in the 2002–2005 time period to 2.3% in 2011–2012). However, these data may not be generalizable.

Vaccine coverage is also measured at school entrance when children must meet state vaccination requirements. Every state requires that children entering kindergarten receive certain vaccines, but there is some variability in which vaccines are required and the types of exemptions to these requirements that are permitted. Schools report the number of children meeting each vaccine requirement and taking an exemption to state health departments, who in turn report these data to CDC. In the 2013–2014 school year, state median vaccination coverage was 94.7% for two doses of MMR vaccine, 95.0% for varying local requirements for DTaP vaccine, and 93.3% for two doses of varicella vaccine among those states with a two-dose requirement.[23] These data speak to the success of the U.S. immunization program in ensuring vaccine supply, reducing or removing cost as a barrier to vaccines, the strong support for vaccines by healthcare providers, and the decision of the majority of parents to vaccinate their children.

The most direct measure of vaccine refusal is the proportion of children that have a non-medical exemption to one or more school immunization requirements. These parents are actively deciding to not get some or all vaccines and are completing state requirements to fulfill the exemption option. The proportion of children

claiming non-medical exemptions has been increasing over the past decade.[24] Although the overall proportion of children in the U.S. with an exemption are very modest (median state rate in 2013–2014 was 1.7%),[23] this national estimate understates state and local estimates of vaccine refusal. For example, about 3.5% of children in Washington State had a non-medical exemption in 2013–2014; county non-medical exemption rates are as high as 9%, and school districts report rates as high as 30%–50%.[12] The clustering of exemptions at the school level has been associated with outbreaks of pertussis.[25,26] Clustering of under-vaccinated children was also found in the recent Northern California Kaiser data.[22] One of the many lessons learned from the 1989–1991 measles resurgence is the care that must be taken to not be overly confident in state and national coverage data, as they are unable to identify local levels of under-immunization. The NIS is unable to provide local-level immunization coverage, and thus school-level exemption data are the most useful for detecting pockets of low vaccine coverage in communities that are at risk of disease outbreaks. Immunization information systems in states that have higher functioning systems routinely assess coverage at the ZIP code level. Electronic health record systems in managed care environments such as Kaiser[22] can also contribute to our measure of vaccine hesitancy, particularly if they capture active refusal.

Does Vaccine Hesitancy Matter Given That Most Parents Vaccinate Their Children?

Effective control of vaccine-preventable diseases requires extremely high rates of timely vaccination. For example, about 95% of the population must be vaccinated with two doses of measles-containing vaccine in order to fully benefit from community protection and interrupt disease transmission. The level of vaccine coverage needed to optimize community protection and effectively control childhood infectious diseases varies based on the infectivity of the disease, the likelihood of disease introduction, and the effectiveness of the vaccine. The basic reproduction number (R_0), often defined as the average number of secondary infections in a completely susceptible population, is a frequently used measure of infectivity. The R_0 for measles is extremely high (12–18), yet similarly high vaccine coverage is needed for other childhood vaccine-preventable diseases. Mumps, with an R_0 of 4–7, requires vaccine coverage of about 90% to prevent outbreaks, as the mumps vaccine is a bit less effective than the measles vaccine (about 88% vs 97%, respectively, for two doses).[27,28] Even when this high level of vaccine uptake is maintained at the state or national level, pockets of low vaccine coverage can result in outbreaks.[29,30] Absent global eradication, these high levels of vaccine coverage must be maintained indefinitely.

Vaccine refusal has been associated with outbreaks of invasive *H. influenzae* type b disease,[31] varicella,[32] pneumococcal disease,[33] measles,[34,35] and pertussis.[25,26,35,36] Often, these outbreaks occur in communities with high rates of vaccine delay and refusal, as has been the case in the majority of measles outbreaks since measles elimination in 2000.[25] Vaccine refusal has also been shown to be a contributing factor to the recent pertussis resurgence, along with waning vaccine immunity.[26]

Vaccine hesitancy is an important issue that needs to be addressed given the prevalence of vaccine concerns and our need to indefinitely maintain high immunization coverage uniformly throughout the nation for many diseases. Outbreaks of disease as a result of vaccine hesitancy result in the unnecessary suffering and potential death of young children and are wasteful of limited local health department resources. Many developed countries experienced drops in immunization coverage with the whole-cell pertussis vaccine in the 1970s and 1980s, with consequent resurgence of disease.[37] There have been ongoing outbreaks of measles across Europe also attributable to vaccine hesitancy.[1] A recent measles outbreak originating in Disneyland brought national attention to the issue of vaccine hesitancy.[38] The potential of vaccines to prevent illness and save lives has never been greater, yet that potential will only be achieved if we can address vaccine hesitancy and ensure that parents vaccinate their children with confidence that they are making the healthiest decision for their children. Vaccination saves lives, not vaccines.

Call to Action: What Can Be Done to Address Vaccine Hesitancy and Improve Confidence?

The multifactorial and complex causes of vaccine hesitancy require a broad range of approaches, interventions, and system changes on the individual, provider, health system, and national levels. An improved understanding of issues of trust in healthcare providers, the healthcare system, and public health authorities and how these factors vary among different subpopulations would help inform these efforts. Standardized measurement tools such as those recommended by SAGE[1] would facilitate the quantification of hesitancy. It is necessary to have the capacity to measure the geographic clustering of hesitancy. Changes in the prevalence of hesitancy over time through serial, cross-sectional surveys using standardized questions and methods are critical. Accomplishing this

through regular attitudinal modules of the NIS would allow the linkage of vaccine attitudes and beliefs to provider-verified immunization histories. Although it is true that factors other than vaccine hesitancy impact vaccine coverage,[1] we should not simply dismiss coverage as an imperfect measurement of hesitancy. Instead, we need to improve how we measure coverage to better discern delays due to hesitancy from those due to health system issues. Accurately measuring the problem is essential for baseline characterization and to identify how health system and individual interventions could improve the situation.

Interventions are needed on the individual level for parents who have vaccine concerns. First-time pregnant women are an ideal population to target, because first pregnancy is the "teachable moment" and attitudes and beliefs about childhood vaccines are frequently not fully formed at this point. Once a parent or family has more than one child, their approach toward vaccination may already be well entrenched; this deserves further study. Individually tailoring messaging is particularly important given the range of views of parents; a one-size-fits-all approach is unlikely to be successful. A recent systematic review of evidence on interventions to decrease parental vaccine refusal and hesitancy found no convincing evidence of effective interventions; there were few studies that examined the impact of interventions on refusal rates, intention to vaccinate, and changes in attitudes toward vaccines, and most observational studies were either underpowered or only provided indirect evidence and were of low quality per WHO Grading of Recommendations, Assessment, Development and Evaluations (GRADE) criteria.[39] A study published after this systematic review suggested that pro-vaccine messages do not always work, and corrective information and messages about the risks of disease may actually backfire among people who are already hesitant, resulting in increased misperceptions and reduced intention to vaccinate.[40] Another very recent observational study of provider–parent discussions suggests that a presumptive format (i.e., presenting vaccines as part of routine care) rather than a participatory one may be more effective in gaining vaccine consent; however, the long-term impact on vaccine uptake and the patient–provider relationship was not assessed.[41] Lastly, a theory-driven social media intervention tool has been developed to help reduce parental vaccine concerns, but data on its effectiveness are lacking.[42] Interventions that are shown through rigorous evaluation to improve vaccine uptake and reduce vaccine hesitancy are clearly needed.

Healthcare providers are widely considered by parents to be the best source for vaccine information, even among parents who refuse vaccines.[9] However, pediatricians often lack the tools to effectively communicate with parents, and reimbursement for vaccination and particularly vaccine risk communication is insufficient. Adequate reimbursement for vaccine risk communication would reduce pediatricians' financial disincentive to discussing vaccination with parents. As is the case with other areas of complex medical decision making such as genetic counseling, providing reimbursement for the time it takes to counsel parents on vaccines would improve the quality and frequency of such conversations.

A recent report from the National Vaccine Advisory Committee (NVAC) highlights the importance of considering parental concerns when prioritizing vaccine safety research.[43] Although the scientific community is very confident in the safety of the immunization schedule, many parents have concerns about the number of vaccines given simultaneously and in the first 2 years of life as well as vaccine ingredients. As outlined by IOM, the safety of the immunization schedule could be further examined using existing databases such as the VSD of CDC.[44] The NVAC has also proposed a framework for studying vaccine ingredients and the importance of studying concerns of parents.[43] Unfortunately, funding for vaccine safety has not increased commensurate with public concerns. In 2009 and 2011, respectively, Cooper et al.[45] and Larson and colleagues[46] identified a crisis in public confidence in vaccines and drew attention to CDC's vaccine safety budget of about $20 million compared with the $4-billion vaccine budget. Since this time, CDC's vaccine safety budget has remained flat as new vaccines have been introduced and vaccine recommendations have been expanded. The NVAC outlined enhancements to the safety system taking advantage of the ability of large databases such as VSD and improved electronic medical records to conduct epidemiologic studies, and advances in immunology and genomics to improve our understanding of biological mechanisms and individual risk factors for vaccine adverse reactions.[47] Discerning the etiology of coincidental adverse events such as autism or encephalopathy would reduce residual suspicion of vaccines, although such advances will take a long time. Rapid, independent, and transparent review of vaccine safety data for the 2009–2010 H1N1 program may also offer a model for maintaining public confidence.[48] A robust vaccine safety system that is responsive to public concerns will help address parental vaccine hesitancy and improve public confidence in vaccines.

Conclusions

The potential of vaccines to reduce suffering, save lives, and curb healthcare spending has never been greater. Yet, that potential is directly dependent on parental acceptance of vaccines, which requires confidence in vaccines,

healthcare providers who recommend and administer vaccines, and the systems to make sure vaccines are safe. This complex problem requires a multilevel approach, including interventions at the individual and health system levels. We must act now, before a measles outbreak such as the recent one beginning in Disneyland becomes a resurgence as seen in Europe.

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