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MINI-REVIEW

Revisiting the 2014-15 Disneyland measles outbreak and its influence on pediatric vaccinations

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ABSTRACT

The 2014–15 Disneyland measles outbreak that began at the California theme park in December 2014 sparked an international conversation regarding measles, vaccine hesitancy, and vaccine policies. The outbreak capped a year with the highest number of measles cases reported in two decades and came amidst increasing trends in nonmedical vaccine exemptions in California and elsewhere. Because of its sensational story line and spread among unvaccinated populations, the outbreak received a high level of media coverage that focused on vaccine hesitancy as a primary driver of the outbreak. This media coverage and the ostensible public support for vaccines that followed led some to hypothesize that the outbreak might have a "Disneyland effect," or a positive influence on the uptake of pediatric measles vaccine. This article reviews the facts of the outbreak and its context, and explores the evidence for the Disneyland outbreak causing an influence on U.S. pediatric vaccine-related beliefs and behaviors.

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Introduction

The 2014–15 Disneyland measles outbreak that began at the California theme park and spread to 7 U.S. states, Canada, and Mexico sparked an international conversation regarding measles, vaccine hesitancy, and vaccine policies.[1–8] The highly publicized outbreak captivated the public's attention – not only due to its sensational story line – but also because the outbreak spread among the intentionally unvaccinated, and affected vulnerable populations, ineligible to receive measles vaccine.[1,2,6] Together, these circumstances worked to shape a media narrative that focused on the dangers of the "anti-vaxx" movement and the importance of community vaccination to achieve herd immunity and protect vulnerable populations.[2,6–9] In parallel with news coverage of the outbreak, there were large increases in "pro-vaccine" posts and content on several social media platforms.[10–13] In fact, coverage of the outbreak and ostensible public support for vaccines led some researchers and health-care providers to hypothesize that the outbreak might lead to a "Disneyland effect," or a positive influence on the uptake of pediatric measles vaccine.[2,9,14]

In this article, we examine the 2014–15 Disneyland measles outbreak as a potential catalyst for change in U.S. measles vaccine uptake. We review the outbreak's facts and context, media coverage, and evidence for its effects on vaccine-related beliefs and behaviors. We conclude by discussing these findings in the context of the vaccine hesitancy literature, with potential application to other vaccine-preventable diseases.

Facts and context of the outbreak

The 2014–15 Disneyland measles outbreak began with an exposure at the California theme park in December 2014.[3,15] The outbreak capped a high year of 667 U.S. measles cases in 2014, or the largest number reported in the prior two decades.[16,17] Public health authorities were alerted to the outbreak on January 5, 2015, when an unvaccinated 11-year-old California resident was hospitalized for measles.[3] The child's only significant travel history during their incubation period was a visit to the Disneyland theme park between December 17–20, 2014.[3] In the days that followed, the California Department of Public Health (CDPH) was alerted to 8 additional measles cases with epidemiological linkages to the theme park and issued a press release on January 7, 2015.[15] In February 2015, the Centers for Disease Control and Prevention (CDC) published additional details of the outbreak in its *Morbidity and Mortality Weekly Report*.[3] The report attributed 125 U.S. measles cases to the outbreak across 7 U.S. states, with most cases (n = 110) occurring among California residents.[3] Epidemiological linkages to the outbreak were also reported to cases in Canada and Mexico.[3] In fact, the Public Health Agency of Canada subsequently reported that a single, imported case from the U.S. Disneyland outbreak was the source of a large, Canadian outbreak of more than 150 measles cases.[18] The U.S. Disneyland outbreak was not declared over until mid-April 2015.[19]

Reports of the outbreak revealed a clear theme of un(der) vaccination.[3,15,18] The CDC reported that among California cases with a known vaccination status, more than 75% were

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unvaccinated.[3] Among unvaccinated cases who were eligible for vaccination, 76% were unvaccinated due to personal beliefs or the intentional delay of measles vaccination.[3] In Canada, nearly all cases were unvaccinated, with most cases occurring in a non-immunizing religious community.[18] Cases were also reported among U.S. and Canadian infants who were too young to be vaccinated, a vulnerable population that relies on herd immunity for protection against disease.[3,18] Approximately 20% of U.S. cases and 10% of Canadian cases were hospitalized.[3,18]

Research examining the transmission dynamics of the outbreak concluded that undervaccination likely played a key role in its promulgation.[20] Given waning of specific antibody levels and secondary vaccine failure, measles requires high, two-dose vaccine coverage of approximately 90 to 95% to maintain herd immunity in the population.[21,22] Prior to the outbreak, increasing rates of nonmedical vaccine exemptions (including measles vaccine) were found in California[22–26] and to some extent, nationally.[27–30] Spatial analyses also revealed clustering of vaccine exemptions, leading to underimmunized communities, which are especially vulnerable to vaccine-preventable disease outbreaks, even when overall vaccine coverage is high.[22,25,30,31] Analyses of measles vaccine coverage at California schools revealed that 25% had vaccine coverage lower than levels required for herd immunity; this included several schools in Orange County, California, where the Disneyland theme park was located.[4,22,32,33]

Media and public attention to the outbreak

The outbreak received considerable public attention, with major media outlets devoting multiple articles to the outbreak and its developments over several months.[1,2,4,6–8] International and domestic news coverage of the outbreak tended to heavily focus on vaccine hesitancy as a key driver of the outbreak.[2,6–9,32,33] The outbreak also coincided with large increases in pro-vaccine posts, content, and shares on social media platforms, Facebook and Twitter, which greatly exceeded anti-vaccine posts during the same period.[10–13] Further, analyses of Google search trends found that the Disneyland outbreak coincided with the highest level of activity for the search term "measles" in more than a decade.[34]

National surveys estimated that more than 50% of the public was aware of the outbreak.[8,35–37] Estimates ranged from 53% to 80% awareness across representative samples of U.S. adults[36] and relevant adult subpopulations, such as parents with young children.[9,35,37]

Measles vaccine uptake: a Disneyland effect?

The collective attention to the Disneyland outbreak and support for vaccination in the news and social media led some researchers and healthcare providers to hypothesize that the outbreak might have a "Disneyland effect," or a positive influence on the uptake of pediatric measles vaccination.[2,14] Interestingly, data examining vaccine-related retweets on Twitter in February and March 2015 indicated that many Twitter users may have shared the same sentiment, with the most common retweet being a post of a *Forbes* news article that positioned the outbreak as a "turning point in the vaccine wars."[38,39] The article suggested that the Disneyland outbreak differed from previous measles outbreaks because the general public was "angry" and motivated to defend vaccinations.[38] However, other researchers deemed a Disneyland effect unlikely, due to the difficulty in changing vaccine-hesitant beliefs.[40]

While it is not the focus of this review, it is important to note that perhaps the primary evidence for a Disneyland effect was the passage of California Senate Bill (SB) 277, or the legislation that repealed the California personal belief vaccine exemption.[41,42] Although it is difficult to "causally" link the bill's success to the Disneyland outbreak, the timing of the outbreak was likely a factor in its introduction. Indeed, the bill was put forward in February 2015 and the ongoing outbreak was cited during a press conference introducing the bill.[41] Further, the outbreak likely facilitated the bill's passage by increasing the salience of vaccines and risks of vaccine-preventable diseases, helping to frame the bill's narrative.[4,5,41]

Moving beyond the apparent link of the outbreak to SB 277, there is relatively little research investigating the effect of the Disneyland outbreak to modify U.S. measles vaccine opinions or uptake.[8,9,34,35,37,43] This is likely because the U.S. has not historically had a consistent and reliable measure to track vaccine hesitancy over time among the general population, making it difficult to study population changes.[44–47] Nonetheless, we identified 6 studies that investigated the effects of the outbreak on vaccine-related outcomes.[8,9,34,35,37,43] In general, these studies fell into two design categories: (i) cross-sectional designs that asked participants to self-report changes in vaccine-related outcomes as a result of the outbreak,[8,37,43] or (ii) pre/post or time-series designs that compared vaccine-related outcomes between a time period before and after the Disneyland outbreak.[8,9,34,35,43] We summarize the evidence for a Disneyland effect in each of these categories separately, since designs in category (ii) are more methodologically rigorous to investigate the outbreak's causal role on vaccine-related outcomes.

Evidence from cross-sectional designs

Several cross-sectional surveys evaluated participant-reported changes in vaccine outcomes due to the outbreak.[8,37,43] Specifically, Cataldi et al. surveyed a convenience sample of 343 predominantly White and highly educated mothers in Colorado between April to June 2015;[8] Quinn et al. surveyed a nationally-representative sample of 1,657 African American and White adults in March 2015;[37] and Mohanty et al., surveyed 270 pediatrians from practices in Delaware, Hawaii, or Pennsylvania, three months after the outbreak.[43]

In general, results from these studies were fairly consistent.[8,37,43] Quinn et al. and Cataldi et al. found that nearly half of respondents reported more favorable views of vaccinations as a result of the outbreak, and a small percentage (1–3%) reporting less favorable views.[8,37] Cataldi et al. also found that approximately one-third of mothers reported a greater interest in measles vaccine due to the outbreak, with 2% of mothers reporting less interest.[8] This is in line with Mohanty et al.'s findings that 38% of pediatricians reported receiving fewer parental alternative vaccination schedule requests, while 2% reported receiving more.[43] Separately,

Mohanty et al. also found that 20% of pediatricians reported adoption of stricter office vaccination policies due to the outbreak.[43]

Quinn et al. also found several notable differences in vaccine outcomes by race, education, and income.[37] In univariable analyses, they found a higher percentage of "more favorable" views of vaccinations among White participants, participants earning a college degree or higher, and participants with higher incomes.[37] The researchers also found that participants who earned less than a high school degree were more likely to report "less favorable" views of vaccines than college-educated parents (7% and 1%, respectively) as a result of the outbreak.[37] Separately, Mohanty et al. also found that pediatricians who reported a decline in alternative vaccination schedule requests were more likely to have a practice with a higher proportion of college-educated parents, a data point that corroborates Quinn et al.[43] Cataldi et al. did not examine their survey results by subpopulation.[8]

In sum, the results from cross-sectional studies suggested that a high proportion of participants felt more favorably toward pediatric vaccinations following the Disneyland outbreak, and a survey of pediatricians corroborated these findings.[8,37,43] However, there was also evidence to suggest that the associations observed in the studies may vary by subpopulation.[37,43] In particular, higher parental education level was associated with more favorable views or decreases in alternative vaccine schedule requests in two surveys identified,[37,43] while one study found evidence that White participants and people with higher incomes were subpopulations that were also associated with an increase in favorable views of vaccinations.[37]

Evidence from pre/post outbreak or time series designs

While the results of cross-sectional surveys can be used to examine associations between the Disneyland outbreak and vaccine-related outcomes, more rigorous analyses are required to assess causality. We found four studies that compared a vaccine-related outcome between pre- versus post-outbreak periods, with varying levels of methodological rigor.[9,34,35,43] Specifically, Doll et al. (a coauthor of this mini-review) compared the relationship between the Disneyland outbreak and U.S. pediatric measles vaccine uptake among a nationally representative sample of children using 2012 to 2017 CDC National Immunization Survey-Child (NIS-Child) data;[34] Cacciatore et al. compared vaccine confidence and intention to vaccinate between two nationally representative samples of parents surveyed before (November 2014) and after (May to June 2015) the outbreak;[9,35] and studies by Cataldi et al.[8] and Mohanty et al.[43] discussed above, also included several measures comparing data from pre- and post-outbreak periods.

Unlike other studies, Doll et al. directly examined the effect of the Disneyland outbreak on vaccine *uptake*, instead of a surrogate vaccine outcome, such as beliefs or intentions.[34] Their analyses used time series data and a quasi-experimental difference-in-differences design with a negative control group to examine the outbreak's effect on both measles vaccine coverage and age at first measles vaccination, as outcomes of interest.[34] Overall, they found that the outbreak was associated with a 1% increase in U.S. pediatric measles vaccine coverage.[34] However, in multivariable analyses that included an interaction term for parental education, they observed 4% higher measles vaccine coverage among children of college-educated mothers, and 3% lower measles vaccine coverage among children of mothers earning less than a high school degree following the outbreak.[34] Their analyses also found that the outbreak was associated with a 7-day decrease in the average age of measles vaccine administration, which was similar across levels of parental education (range 6 to 9 days).[34]

Cacciatore et al. compared vaccine-related beliefs and intentions among different nationally-representative samples of 1,000 young parents surveyed before and after the Disneyland outbreak.[9,35] They found that the outbreak was associated with overall increases in the confidence of vaccines, including among parents of children who were not fully vaccinated.[9] While they did not analyze changes in pre- versus post-outbreak surveys by participant demographics, they found that the magnitude of changes in vaccine confidence and other outcomes varied based upon the child's vaccination status and parental interest in vaccinations.[9] In a separate manuscript using the same data set, Cacciatore et al. examined how parental awareness of the outbreak potentially modified parental vaccination views and intentions in comparison with the pre-outbreak period.[35] In general, they found that parents with no awareness of the outbreak had significantly higher levels of vaccine concerns and were less likely to vaccinate their children in the post-outbreak period compared with the overall population in pre-outbreak period.[35] In contrast, parents who had high awareness of the outbreak were more likely to report greater confidence in vaccines and intention to vaccinate their child following the outbreak, compared with the overall population in the pre-outbreak period.[35] However, these data should be interpreted with caution, since it is plausible that parents who felt more or less favorably toward vaccinations prior to the outbreak may have differentially followed media coverage of the Disneyland outbreak; thus, the overall study population from the pre-outbreak period may not be a reliable control group for these analyses.[35]

Finally, Cataldi et al. and Mohanty et al. presented several measures that compared pre- and post-outbreak data.[8,43] Cataldi et al. found that 1 of 27 (3.7%) mothers who indicated their intention to use a non-recommended measles vaccine plan in the pre-outbreak period changed their mind in the post-outbreak period.[8] This compared to only 2 of 279 (0.7%) mothers who changed from a recommended to a non-recommended vaccine plan following the outbreak.[8] Mohanty et al. also found decreases in the percentage of pediatricians who were willing to delay measles vaccination or consider an alternative vaccine schedule over time comparing pre- and post-outbreak time points; however, these differences were not significant after adjustment for practice characteristics.[43]

In general, evidence from more rigorous study designs to examine the Disneyland effect was sparse.[9,34,35,43] However, the study by Doll et al. was methodologically strong, and largely corroborated the associations between the outbreak and surrogate vaccine outcomes examined in cross-sectional studies,

including differences by education.[8,34,37,43] Further, while analyses by Doll et al. and Cacciatore et al. were not directly comparable, both suggested that the Disneyland effect was dependent on population subgroup.[9,34,35]

A Disneyland effect: lessons learned

While there exist relatively few studies that examined the Disneyland effect,[8,9,34,35,37,43] there are several important points that can be inferred with broader context from the vaccine literature.

First, a subset of the population appeared to be "activated" by the Disneyland outbreak reporting or experiencing changes in at least one vaccine-related outcome.[8,9,34,35,37,43] Given high public awareness, it is reasonable to assume that the outbreak acted as a medium of influence for at least some people considering vaccinations. This finding is also consistent with other studies that have demonstrated the media's influence on health-related behaviors, including vaccine uptake.[48–50] However, among studies that examined the effect of other outbreaks on vaccine coverage, most have assessed changes in local populations, geographically proximal to an outbreak.[48,49,51] Importantly, the national findings observed for the Disneyland outbreak demonstrate that sustained media coverage of an outbreak can also serve to influence the actions of a broader geographic population as well.

Second, "activated" participants were generally more likely to report a qualitatively positive change in a vaccine-related outcome over a qualitatively negative change.[8,9,34,35,37,43] This finding may reflect the largely pro-vaccine mainstream media coverage of the outbreak, which likely increased the salience of measles, and promoted measles vaccination as a safe and effective measure to prevent disease.[2,6–9,40] These themes are in line with behavior change constructs posited by the Health Belief Model.[6,7,14,52] The coverage of the outbreak may have also supported vaccination as a social norm, which can promote vaccine uptake.[52] Together, this coupled with the previous finding – that the outbreak had an effect on national audiences – is of particular relevance for the development of interventions to improve vaccination rates.

Nonetheless, a subset of the population also reported increases in qualitatively negative vaccine outcomes.[8,9,34,35,37,43] These apparent differences may reflect the reactions of a diverse, vaccine-hesitant population, and the complexity of trying to find a "one-size-fits-all" approach to address vaccine-hesitant concerns.[52] Further, increased U.S. polarization may mean that subsets of the population had a different probability of encountering vaccine-hesitant content following the outbreak.[53] Indeed, analyses of social media posts on Facebook and Twitter revealed large increases in vaccine-hesitant posts coinciding with the passage of SB 277,[10] which may have influenced results of some of the studies examined herein. Further, according to analyses of vaccine-opposed content on Facebook, the Disneyland outbreak and passage of SB 277 were associated with large increases in the proportion of content that framed vaccine opposition as a civil liberties and/or government overreach issue.[54] These arguments have been found to be effective to drive vaccine hesitancy, even in situations where a person perceives a vaccine as safe and effective.[54]

The diversity of vaccine-hesitant beliefs may also help to explain why the existence, direction, and magnitude of a Disneyland effect varied by population subgroup.[9,34,35,37,43] In particular, persons with a college education were more likely to report a qualitatively positive change in vaccine-related outcomes associated with the outbreak.[34,37,43] Quinn et al. found similar, positive trends in attitudes toward vaccinations among White participants and participants with a higher income.[37] Interestingly, these demographics match those of parents who in past research, have been found to be more likely to seek a vaccination exemption for their child.[37,43,55,56] This may indicate that the outbreak was more effective to address vaccine-hesitancy in these subsets of the population. On the other hand, subpopulations with qualitatively negative changes toward vaccinations following the outbreak included parents who were not aware of the outbreak,[9] and children of parents with less than a high school education.[34,37] It is possible that these subgroups may be more susceptible to vaccine opposed content in social media and/or the framing of opposition as a civil liberties issue,[57] which both increased following the outbreak.[10,54]

Finally, it is important to note the role that healthcare providers may have played to create a Disneyland effect. Mohanty et al. found that 20% of pediatricians reported stricter office policies following the outbreak, and several providers provided qualitative feedback that the outbreak presented an opportunity to counsel their patients about vaccinations.[43] Providers also reported vaccinating at an earlier age from the recommended measles vaccine time window.[43] This supports findings by Doll et al. that found an average decrease in the age of measles vaccine uptake that did not vary by population subgroup.[34]

Conclusion

Media coverage of the 2014–15 Disneyland outbreak was likely effective to drive increases in favorable vaccine-related beliefs and behaviors among the general population. However, the existence, direction, and magnitude of a "Disneyland effect" appeared to differ by educational status and potentially other demographic variables.[34,37,43] While higher education was associated with positive changes in vaccine-related outcomes, lower education had the opposite effect.[34,37] Future studies are needed to better understand these complex dynamics. Furthermore, continued investment in reliable measures to track vaccine hesitancy over time is essential to facilitate research regarding the influence of current and dynamic events on vaccine decisions.[44–46,52]

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