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Vaccine Exemptions and Coverage

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Abstract

Falling childhood vaccination rates, the re-emergence of previously eradicated diseases, and the COVID-19 pandemic have raised important questions regarding the degree to which people may opt out of mandatory vaccination for religious or personal reasons. This paper provides novel evidence on how the scope of policies repealing non-medical vaccine exemptions affects exemptions, vaccination rates, and vaccine-hesitant information seeking behavior. First, I show that policies repealing at least some non-medical exemptions reduced the share of kindergartners with at least one exemption by 2-3 percentage points. This change was larger in states prohibiting all non-medical exemptions compared to states repealing personal exemptions but allowing for religious objections, suggesting that vaccine-hesitant parents in these latter states substituted toward religious exemptions. Indeed, these latter states experienced increased internet search activity for the phrase 'religious exemption.' Next, I show that while policies prohibiting all non-medical exemptions increased coverage of four school-entry vaccines (MMR, DTP, hepatitis B, and polio) by 1.7-2.9 percentage points, the estimates for policies repealing personal exemptions but allowing for religious objections were smaller in magnitude and often statistically insignificant. These results suggest that policymakers hoping to increase vaccine coverage should be mindful that their goals may be undermined by vaccine-hesitant parents continuing to utilize whatever exemptions remain at their disposal.

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1. Introduction

On September 9th, 2021, President Biden announced that all federal workers will be required to receive the COVID-19 vaccine and that all firms with more than 100 employees will be required to (i) mandate the COVID-19 vaccine and/or (ii) require those remaining unvaccinated to produce weekly negative COVID-19 tests. Overall, this order is expected to affect over 100 million Americans (Associated Press 2021). Meanwhile, the Los Angeles County school district – the second largest in the nation – will require eligible students to receive the COVID-19 vaccine (Los Angeles Times 2021), and school officials in other districts are seeking ways to increase take-up of traditional childhood vaccinations whose rates have fallen throughout the pandemic (Washington Post 2021). All together, these recent policy changes have raised important questions regarding the degree to which people are able to opt-out of 'mandatory' vaccination on religious or personal grounds.[1]

There is a well-documented positive relationship between vaccine mandates and take-up (Abrevaya and Mulligan 2011; Lawler 2017; Carpenter and Lawler 2019; Wen 2020; Churchill 2021a; White 2021), though less is known about how vaccine requirement opt-out provisions affect coverage rates. Some people clearly believe that increasing the costs of obtaining an exemption can increase vaccine coverage. For example, United Airlines placed employees receiving a religious exemption on unpaid leave, thereby raising the opportunity cost of such an exemption, so that the firm could develop COVID testing and safety procedures (Reuters 2021). Meanwhile, others are looking to prohibit these exemptions entirely. Responding to falling childhood vaccination rates and the re-emergence of previously eradicated diseases, four states began barring all non-medical

[1] Indeed, Appendix Figure 1 shows a dramatic spike in Google searches for 'vaccine exemption' in August 2021 as state governments and employers began announcing COVID-19 vaccine mandates.

(personal or religious) exemptions for school attendance.[2] Yet opponents of these policies worry that they will impose an undue burden on religious liberty without increasing vaccine coverage, because those wishing to remain unvaccinated may substitute toward medical exemptions which are permitted throughout the country (American Medical Association 2021).

In this paper, I provide novel evidence on how the scope of vaccine opt-out provisions affects the share of kindergarteners receiving an exemption, vaccination rates, and vaccine-hesitant information-seeking behavior. I show that policies repealing at least some non-medical exemptions reduced the share of kindergarteners receiving at least one exemption by 2-3 percentage points. Following the passage of these policies I document more frequent internet searches for the phrase 'vaccine exemption.' By leveraging variation in the scope of the exemption repeal, I show that states continuing to permit religious exemptions experienced larger increases in search intensity for the phrase 'religious exemption,' while those barring all non-medical exemptions – but still allowing medical exemptions – saw larger increases for the phrase 'medical exemption.' Consistent with these patterns, policies permitting religious exemptions were less effective at reducing non-medical exemptions than those prohibiting them entirely.

Next, I show that policies prohibiting all non-medical exemptions increased vaccine coverage of four school-entry vaccinations (MMR, hepatitis B, DTP, and polio) by 1.7-2.9 percentage points. In contrast, I find that policies repealing personal exemptions but retaining religious exemptions increased coverage by only 0.3-1.7 percentage points, and these latter estimates were often statistically insignificant. These findings are incredibly timely for policymakers and employers debating the degree to which they will permit people to opt out of

[2] The states and the academic implementation years: California (2016/17), New York (2019/20), Connecticut (2021/22), and Maine (2021/22). Two other states – Mississippi and West Virginia – have longstanding policies prohibiting all non-medical exemptions.

vaccine requirements, especially because existing work has focused on single-state policy changes that necessarily could not leverage variation in whether the exemption repeal continued to allow for religious objections (Delamater et al. 2017; Richwine et al. 2019; Churchill 2021a). Finally, I estimate the social cost of non-medical exemptions and propose an alternative policy whereby individuals are required to pay a disease-specific fee to claim a non-medical exemption.

The paper proceeds as follows: Section 2 contextualizes why and when states passed laws limiting non-medical vaccine exemptions and summarizes the existing literature on vaccine mandates and opt-out provisions. Section 3 discusses how the vaccination and Google Trends data allow me to examine both vaccine outcomes and vaccine-hesitant information seeking behavior. Section 3 also discusses my empirical identification strategy given recent developments in the difference-in-differences literature. The results are reported in Section 4, and Section 5 summarizes both their policy implications and limitations.

2. Background and Literature

2.1 Policy History

While all states allow parents to opt-out of vaccinating their children for medical reasons, states have taken recent actions to prohibit parents from claiming non-medical exemptions. In May of 2015, Vermont became the first state to repeal its personal/philosophical exemption to mandatory school vaccinations, though the policy was not implemented until the 2016/17 academic year.[3] During the 2014/15 academic year only 87.7 percent of entering kindergarteners had received their required vaccinations, placing Vermont behind 48 other states. Indeed, proponents of repealing the personal exemption noted that neighboring states without this option – such as New Hampshire and Massachusetts – had higher vaccination rates (Burlington Free Press 2015a). Vermont's bill

[3] Some states and sources use the phrase 'personal exemption' and others 'philosophical exemption' to refer to deeply held convictions against vaccination. For narrative purposes, I refer to these policies as 'personal exemptions.'

prohibiting personal exemptions continued to allow for religious objections, and some parents intentionally shifted toward these exemptions rather than vaccinate their children (Burlington Free Press 2015b). Indeed, the increase in the share of Vermont students receiving religious exemptions (Williams et al. 2019) led Vermont Representative George Till to state that he found it 'disturbing' how many people 'suddenly found religion' in the five years after the policy was implemented (Seven Days 2021).

In 2015, due to falling MMR vaccination rates, California experienced one of the most severe measles outbreaks since the disease was declared eliminated from the United States in 2000 (Worden et al. 2020). As the infections spread to neighboring states, California officials passed SB 277 which repealed all non-medical exemptions beginning with the 2016/17 academic year – joining only two other states (Mississippi and West Virginia) in prohibiting religious objections. While vaccination rates increased in subsequent years, there is both descriptive and quasi-experimental evidence that parents may have undermined the policy by substituting toward medical exemptions. Comparing changes in vaccination rates in California counties to the concurrent changes in 6 comparison states (Arizona, Connecticut, Kansas, Minnesota, Pennsylvania, and Rhode Island), a working paper by Richwine et al. (2019) found that while SB 277 reduced non-medical exemptions by 3.4 percentage points, this reduction was almost completely offset by a 2.1 percentage point increase in medical exemptions.[4] As such, the authors estimated only a 1 percentage point net decline in exemptions. In complementary analyses, Delamater et al. (2017) used the California Department of Public Heath's 1996-2016 Kindergarten Immunization Assessment reports to find that counties which had previously had the highest rates of non-medical

[4] The authors requested immunization and exemption rates from all 51 states, but only received county-level data from 30 states. After limiting their sample to states providing vaccine-specific rates, immunization rates at kindergarten entry, and possessing data before and after the policy change, they were left with 15 total comparison states and a balanced panel of 6 comparison states.

exemptions saw the largest increases in medical exemptions after the passage of SB 277, and Mohanty et al. (2018) reported physicians charging fees for medical exemptions.

Between September 2018 and July 2019, 649 cases of measles were confirmed in New York City, and over 90 percent of patients were part of the Orthodox Jewish community (Zucker et al. 2020). As infections spread throughout the state, New York passed a law prohibiting all non-medical vaccine exemptions that went into effect during the 2019/20 academic year (NPR 2019). Similarly, in May of 2019 Washington removed the personal exemption option for parents wishing to have their child forgo the MMR after experiencing measles outbreaks throughout the state. The bill took effect during the 2019/20 academic year. Importantly, it still allowed parents to claim a religious objection to the MMR vaccine and did not apply to other immunizations (Washington State Department of Health 2021).[5] I am unaware of any academic literature analyzing how these two recent policy changes affected vaccination.

2.2 Existing Literature

The United States has a long history of increasing vaccine coverage by mandating vaccination for school attendance (Orenstein and Hinman 1999). For example, Holtkamp (2020) used novel data on smallpox infections from 1900-1940 to show that early smallpox mandates tied to school attendance reduced smallpox infections, especially during epidemics. Similarly, Luca (2020) found that school vaccine mandates in the mid-20th century increased take-up of the (i) measles, mumps, and rubella (MMR) vaccine, (ii) diphtheria, pertussis, and tetanus (DPT) vaccine, and (iii) polio vaccine. Given the success of these early mandates, it is perhaps unsurprising that policymakers continually update these requirements to include new immunizations. For example, Abrevaya and Mulligan (2011) used the 1996-2007 National Immunization Survey-Child data to show that

[5] Connecticut and Maine recently implemented policies prohibiting non-medical exemptions, though I am unable to leverage these policy changes with available data.

varicella (chickenpox) mandates increased vaccine take-up by 3-6 percentage points, and Lawler (2017) used the 2003-2013 NIS-Child data to show that hepatitis A mandates increased vaccination by 8 percentage points. Carpenter and Lawler (2019) used the 2008-2013 NIS-Teen data to show that middle school Tdap booster requirements increased the likelihood of receiving a Tdap booster by approximately 14 percentage points.[6] The authors also found increased take-up of the meningococcal and human papillomavirus (HPV) vaccines, presumably by the Tdap booster requirements leading to increased contact between age-appropriate adolescents and vaccine providers.

There is also a growing literature leveraging variation in employment-related vaccine requirements – most often in the context of health care workers. Using California Department of Public Health data on hospital worker vaccination and information on hospital patient outcomes from the California Office of Statewide Health Planning and Development, White (2021) showed that county-level influenza mandates for health care workers increased vaccination by 14 percent and reduced the number of influenza diagnoses for inpatient visits by 20 percent during seasons with an effective vaccine. In related work, Carrera et al. (2021) found that state laws requiring hospitals to offer influenza vaccination reduced influenza mortality, especially among elderly individuals and during peak influenza months. Studying laws mandating that nursing home residents receive the influenza vaccine, Wen (2020) found a 6 percent increase in vaccine take-up and a 20 percent reduction in the probability that a resident experienced an influenza-like illness.

[6] DTP is an older version of the diphtheria, pertussis, and tetanus vaccine which is no longer used in the US. Currently, children 6 weeks through 6 years are recommended to receive the DTaP vaccine (or the DT vaccine which does not protect against pertussis). A Tdap booster is recommended at ages 11-12 and a Tdap or Td shot is recommended every subsequent 10 years or when an individual suffers a wound. The capitalization indicates the vaccine has the full-strength dose of that part of the vaccine (CDC 2021).

She also found suggestive evidence that mandating health care worker vaccination reduced the incidence of influenza among nursing home residents.

Given the nationwide adoption of school-entry vaccine mandates, researchers are increasingly interested in the role of policies allowing parents to opt their children out of vaccination. For example, Bradford and Mandich (2013) constructed an Exemption Law Effectiveness Index based on whether the state allowed religious or personal exemptions, required a written statement from a professional verifying a religious conflict, or required proof of immunity for medical exemptions, among other factors. They found that the most effective states had lower incidence of pertussis, compared to other states. Similarly, Blank et al. (2013) found that states with simpler exemption procedures had the highest rates of non-medical exemptions, and Yang and Debold (2014) found that states with less permissive non-medical exemption policies had lower incidence of pertussis. Examining Washington, DC's HPV vaccine requirement, Churchill (2021) showed that the movement from a one-time opt-out form to an annual requirement increased the likelihood that teen girls received the HPV vaccine by 12 percentage points. Notably, parents still retained the ability to opt their children out due to religious or personal objections.

My paper builds on the prior literature by leveraging more identifying variation than was available to prior authors and utilizing a nationwide dataset on vaccination and exemption rates. In addition to providing me with arguably more generalizable estimates, these additional policy changes allow me to exploit variation in the degree to which non-medical exemptions were restricted. This is of especial interest to policymakers weighing whether to prohibit all non-medical exemptions – like California and New York – or retain religious exemptions – like Vermont and Washington.

3. Data and Methodology

3.1 Exemption and Vaccination Rates: 2011-2019 CDC Annual School Assessment Reports

I obtain information on kindergarten exemption and vaccination rates between the 2011/12 and 2019/20 academic years from the Centers for Disease Control and Prevention's *Vaccination Coverage Exemptions among Kindergarteners* data. Each year, state immunization programs conduct kindergarten assessments to monitor school-entry vaccination coverage. These data are then compiled and made available to researchers via the CDC SchoolVaxView platform. While they offer one of the few nationwide sources on vaccine exemptions, these data are subject to some notable limitations. First, there is variation between states and year-over-year in how the state-level rates are determined (i.e., a census of kindergarteners, a random sample, a stratified cluster sample, etc.). Second, not all snapshots occur on the first day of school. Some states collect the information within the first several months, while others report it on a rolling basis throughout the year. I explore the robustness of my results to these limitations in the appendix.

From these data, my dependent variables related to vaccine exemptions include the share of kindergarteners with at least one (i) vaccine exemption, (ii) non-medical exemption, and (iii) medical exemption.[7] Appendix Table 1 shows that 2.6 percent of students nationwide received at least one vaccine exemption throughout my sample period, and this share was larger in states which ever repealed a portion of their non-medical exemption policies relative to comparison states (3.2 percent vs. 2.6 percent).[8] Figure 1 separately plots the shares of kindergarteners with at least one vaccine exemption in California (Panel A), New York (Panel B), Vermont (Panel C), and

[7] Data on non-medical exemptions are not reported for states prohibiting them (California after 2016, New York after 2019, Mississippi, and West Virginia), so I assign these values 0.

[8] The data also includes information on varicella coverage, but states differentially report whether students received 1 or 2 doses of the vaccine, limiting the ability to draw comparisons over time. California reported the share of students receiving 1 dose from 2011-2018 and then began reporting the share receiving 2 doses. New York reported the share with 1 dose from 2011-2013 and the share with 2 doses from 2014-2019. Both Vermont and Washington always reported the share receiving two doses.

Washington (Panel D) compared to the remaining states. After California and New York prohibited all non-medical exemptions, the share of kindergarteners receiving *any* exemption fell to less than 1 percent. In contrast, while the share of children with a vaccine exemption fell after Vermont outlawed personal exemptions – but not religious exemptions – it remained above the national average. Similarly, Washington's narrow policy repealing personal exemptions for the MMR vaccine was not associated with any apparent change in the exemption rate. Appendix Table 1 also reports vaccination rates for four common school-entry vaccines: (i) MMR, (ii) DTP, DTaP, or DT, (iii) hepatitis B, and (iv) polio. In each case, the descriptive statistics indicate a 1.3-2.0 percentage point increase in vaccination in states which passed laws limiting non-medical exemptions coincident with the policy change.

3.2 Internet Search Behavior: 2011-2019 Google Trends

I use Google Trends data from 2011 to 2019 to measure the salience of policies limiting non-medical exemptions and to explore whether they affected vaccine-related information-seeking behaviors. For each state, Google takes a random sample of all searches performed during each period and divides the number of searches for a specific term or phrase – such as 'religious exemption' – by the total number of searches. The period when the state's search rate is maximized is indexed to 100, and the remaining values are determined by the ratio of that period's search rate relative to the maximum search rate. These data have been used to explore a variety of topics including racism (Stephens-Davidowitz 2014), media exposure (Kearney and Levine 2015; Lindo et al. 2020), and vaccination (Oster 2018; Carpenter and Lawler 2019; Churchill 2021b). While these data do not reveal who is performing the searches, they provide insights into the relative search intensity of various terms.

3.3 Empirical Strategy: Difference-in-Differences

Recent developments in the difference-in-differences literature have highlighted the dangers of using states treated in period *t* as comparison units for states treated in period *t+1* (Sun and Abraham 2020; Goodman-Bacon 2021). As such, I examine how policies repealing at least some non-medical exemptions affected both exemption and vaccination rates using Callaway and Sant'Anna's (2021) proposed estimator which (i) explicitly excludes previously treated states from the comparison group and (ii) estimates average treatment for each timing group at any given point in time.[9] I then aggregate the average treatment effects based on length of exposure to the policy. These event study figures allow me to assess the validity of the unconditional parallel trends assumption during the pre-period and determine whether the treatment effects varied over time. Standard errors are clustered at the state level (Bertrand et al. 2004).

Given the small number of treated clusters in my sample, I also perform a traditional two-way fixed effects analysis, using equation (1), and report wild bootstrapped p-values (Cameron et al. 2008; Cameron and Miller 2015):

$$Y_{st} = \alpha + \beta \cdot \text{REPEALED NON-MEDICAL EXEMPTION}_{st} + \theta_s + \tau_t + \varepsilon_{st} \quad (1)$$

The dependent variable, Y_{ist}, is the vaccination-related outcome in state *s* during year *t*. The independent variable of interest, REPEALED NON-MEDICAL EXEMPTION_{st}, is an indicator for whether the state implemented a policy limiting parents' ability to claim a non-medical exemption for their children. The vector θ_s includes a full set of time-invariant state fixed effects, and τ_t includes a full set of location-invariant year fixed effects.

When there is variation in treatment timing, time-varying covariates can inadvertently contribute to identification (Goodman-Bacon 2021), and Callaway and Sant'Anna's (2021)

[9] In this context, California and Vermont comprise a '2015 timing group' and New York and Washington a '2019 timing group.'

unconditional parallel trends assumption does not include any state-level time-varying covariates. The sparse specification in equation (1) best approximates this setup. However, I show in the appendix that the results are robust to controlling for the state unemployment rate, the state child poverty rate, and whether the state expanded Medicaid as part of the Affordable Care Act. I also include controls intended to capture changing local attitudes toward vaccination, including indicators for whether the state adopted a Tdap booster mandate, a meningococcal booster mandate, a secondary school meningococcal education mandate, a post-secondary meningococcal education mandate, a post-secondary meningococcal mandate, as well as whether the state mandated HPV vaccination for adolescent girls, HPV vaccination for adolescent boys, and whether the state received CDC funding to improve HPV vaccination. Finally, I show that the results are robust to accounting for time-varying spatial heterogeneity through the inclusion of state-specific linear time trends or via Census division-by-year fixed effects.

Finally, I test whether there were differential effects based on the extent to which states prohibited non-medical exemptions using equation (2):

$$\begin{aligned} Y_{st} = \alpha + \beta_1 \cdot \text{REPEALED ALL NON-MEDICAL EXEMPTIONS}_{st} \\ + \beta_2 \cdot \text{REPEALED SOME NON-MEDICAL EXEMPTIONS}_{st} \\ + \theta_s + \tau_t + \varepsilon_{st} \end{aligned} \quad (2)$$

where REPEALED ALL NON-MEDICAL EXEMPTIONS is an indicator if the state prohibited both religious and personal exemptions and REPEALED SOME NON-MEDICAL EXEMPTIONS is an indicator for whether the state prohibited personal exemptions but allowed for religious objections.

4. Results

4.1 Vaccine Exemptions

Figure 2 plots the event study coefficients and their 95 percent confidence intervals showing how policies repealing non-medical vaccine exemptions affected the share of kindergarteners covered by these exemptions. The estimates are obtained using the Callaway and Sant'Anna (2021) estimator. Panel A shows that the share of kindergarteners receiving at least one vaccine exemption was not differentially trending in the treated states prior to the policy change; the point estimates are small in magnitude and statistically insignificant during the pre-period. However, once states repealed at least some of their non-medical exemptions, the share of kindergarteners receiving at least one vaccine exemption fell by 2-3 percentage points. Consistent with the policies' goal, Panel B indicates large reductions in the share receiving a non-medical exemption. However, Panel C provides suggestive evidence that parents may have offset the benefit of these policies by substituting toward medical exemptions.[10]

Table 1 reports the estimates obtained from estimating equation (1) via OLS. Each column is a separate regression, and the dependent variable is listed in the column header. In line with the Callaway and Sant'Anna (2021) event study estimates, Panel A column 1 shows that the share of kindergarteners receiving at least one vaccine exemption fell by 2 percentage points in states repealing at least some of their non-medical exemptions.[11] Notably, this change – leveraging 3 additional policy changes and a broader set of comparison states – is twice as large as prior estimates focused solely on California's policy change (Richwine et al. 2019). Yet I show in Appendix Table 3 that the pattern is robust to iteratively excluding each of the four treated states.

[10] This pattern is also consistent with medical exemptions being underutilized prior to the policy change.

[11] Appendix Table 2 shows that the pattern is robust to including state-level time-varying covariates, state-specific linear time trends, and Census division-by-year fixed effects. Across these three specifications, I continue to find a 1.1-2.1 percentage point reduction in the share receiving a vaccine exemption, and the wild bootstrap p-values range from 0.09 to 0.16, suggesting that the policies did in fact reduce the share of kindergarteners receiving a vaccine exemption.

By separately accounting for the scope of the repeal, Table 1 Panel B column 1 shows that policies prohibiting all non-medical exemptions reduced the share receiving an exemption by 2.3 percentage points, while those continuing to allow for religious objections reduced the share by only 1.7 percentage points. This difference is particularly stark in Panel B column 2. Policies prohibiting all non-medical exemption reduced the share receiving a non-medical exemption by 2.7 percentage points, while those retaining religious exemptions reduced the share by 1.7 percentage points – consistent with these latter parents substituting from the now-prohibited personal exemptions toward still-allowed religious exemptions. However, Panel B column 3 suggests that parents also responded to the more stringent policies by seeking out medical exemptions. In support of these possibilities, columns 4-6 show that states permitting religious exemptions saw larger increases in internet search activity for the phrase 'religious exemption' (11.8 vs. 5.6 percentage points) and those prohibiting all non-medical exemptions saw larger increases for the phrase 'medical exemption' (20.3 vs. 13.5 percentage points).[12,13]

4.2 Vaccination Coverage

The prior evidence indicates that state policies repealing at least some non-medical exemptions reduced the share of kindergarteners receiving vaccine exemptions. Figure 3 tests whether there was a corresponding increase in vaccine take-up. Again, the circles denote the point estimates from the Callaway and Sant'Anna (2021) estimator and the vertical lines represent the 95 percent confidence intervals. Panel A shows that MMR coverage was trending similarly in the treated and comparison states prior to the policy change. However, after states repealed at least some of their non-medical exemptions, MMR coverage increased by approximately 2 percentage points. Panel B

[12] There was inadequate search activity for the phrase 'vaccine exemption' in Maine during my sample period to generate a Google Trends Index. Similarly, there was inadequate activity for the phrase 'medical exemption' in one of my treated states (Vermont) and three of my comparison states (Alaska, North Dakota, and Wyoming).

[13] Appendix Figure 2 plots the Callaway and Sant'Anna (2021) event study estimates to examine how internet search behavior changed in relation to these laws. The panels indicate that the increase was limited to the post-period.

indicates a 1.5 percentage point increase in hepatitis B coverage, and Panel C shows a 2-percentage point increase in DTP coverage in the post-period. Finally, Panel D suggests that repealing non-medical exemptions increased polio vaccination by approximately 1.5 percentage points, though the relationship is less precisely estimated. Overall, Figure 3 presents compelling evidence that prohibiting at least some non-medical exemptions improved vaccine coverage.[14]

Table 2 examines how these policies affected vaccination using the two-way fixed effects specification from equations (1) and (2). Consistent with the event study, Panel A column 1 indicates that state policies repealing at least some non-medical exemptions increased MMR coverage by 2.3 percentage points. Likewise, column 2 shows a 1.3 percentage point increase in hepatitis B coverage, column 3 a 2.0 percentage point increase in DTP coverage, and column 4 a 2.0 percentage point increase in polio coverage. Notably, all the estimates are statistically significant after accounting for the small number of treated clusters, and Appendix Table 2 shows that these patterns are robust to including state-level time-varying covariates, state-specific linear time trends, and Census region-by-year fixed effects. For example, after including these covariates, Appendix Table 2 row 5 indicates that these policies increased hepatitis B coverage by 1.4-2.1 percentage.[15]

Panel B – which separately accounts for the scope of these policies – indicates that the increase in vaccination was most pronounced in states banning all non-medical exemptions. In contrast, the point estimates for those retaining religious exemptions are smaller in magnitude and

[14] Appendix Figures 3-6 plot the descriptive statistics for these outcomes for each of the treated states. Consistent with the event study estimates, the descriptive trends indicate that vaccination was not differentially trending in the pre-period relative to the comparison states. However, there were meaningful increases in vaccination after states implemented their policies repealing non-medical exemptions.

[15] Appendix Table 3 shows that these estimates are robust to iteratively excluding each of the treated states, and Appendix Table 4 shows that the relationships are robust to limiting the sample to only observations obtained from a census of kindergarteners (instead of, for example, a simple random sample). Indeed, the vaccination estimates in Appendix Table 4 are uniformly larger in magnitude.

often statistically insignificant. Column 1 shows that MMR coverage increased by 2.9 percentage points after states implemented policies prohibiting all non-medical exemptions. In contrast, there was only a 1.7 percentage point increase in states which banned personal exemptions but continued to allow for religious objections. Similarly, columns 2-4 indicate that states prohibiting all non-medical exemptions experienced 1.7-2.9 percentage point increases in coverage of the hepatitis B, DTP, and polio vaccines, while the estimates for those allowing religious exemptions were statistically insignificant.[16]

5. Conclusion

Faced with falling childhood vaccination rates, the re-emergence of previously eradicated diseases, and the COVID-19 pandemic, policymakers and employers are grappling with how to best structure vaccine mandates to increase coverage while respecting individual choice. In this paper, I show that policies prohibiting personal exemptions but permitting religious exemptions were largely ineffective at increasing vaccine coverage among kindergarteners. One explanation is that vaccine-hesitant parents could easily substitute toward religious exemptions, and indeed I find evidence that people in these states more intensively searched for the phrase 'religious exemption.' In contrast, I find that policies prohibiting all non-medical exemptions led to meaningful increases in vaccine take-up – ranging from 1.7 to 2.9 percentage points – despite evidence that some parents sought out and received medical exemptions for their children. Overall, these findings suggest that policymakers hoping to increase vaccine coverage should be mindful that their goals may be undermined by vaccine-hesitant parents continuing to utilize whatever exemptions remain at their disposal.

[16] Again, Washington's policy only applied to the MMR vaccine, while the remaining treated states' policies applied to all vaccines. Therefore, it is perhaps unsurprising that the point estimate is largest for MMR coverage.

The public health response to the 2019 US measles outbreak – which primarily occurred in in Michigan, New York, and Washington – is estimated to have cost $42 million USD (Pike et al. 2020). This figure does not account for productivity losses or the direct medical costs of measles, though other work has found that the public health response to measles comprises 68 percent of the full social costs (Pike et al. 2021).[17] Making this adjustment yields a total social cost of approximately $62 million ($42 million/0.68). At the time of the outbreak, all three states permitted religious and personal exemptions, with 4.5 percent of Michigan kindergarteners, 1.1 percent of New York kindergarteners, and 4.3 percent of Washington kindergarteners receiving non-medical exemptions. If these rates held for older students enrolled in public schools, they would imply 144,500 students receiving non-medical exemptions in these states (National Center for Education Statistics 2021).[18] Assuming that the entire outbreak would have been prevented if these exemptions were eliminated yields an upper bound cost of approximately $541 per claimed non-medical exemption for the MMR vaccine ($62 million/114,500).[19] Of course, policymakers need to weigh the cost of all *potential* outbreaks for a larger set of vaccine preventable diseases than just measles when deciding whether to prohibit non-medical exemptions, and it is likely that the social value to preventing outbreaks of other diseases – such as COVID-19 – is considerably higher. However, these figures suggest an alternative policy choice whereby individuals are required to pay a fee to claim a disease-specific non-medical exemption.

By leveraging recent policy changes in New York and Washington – as well as older policy changes in California and Vermont – this paper provides the most up-to-date evidence on the importance of the scope of policies repealing exemptions for required vaccinations. However, it is

[17] The 2019 Washington measles outbreak is estimated to have cost $3.4 million USD. This includes $2.3 million for the public health response, $1.0 million in productivity losses, and $76,000 in medical costs.
[18] 67,500 in Michigan; 29,700 in New York; 47,300 in Washington.
[19] It is worth noting that some people might value having the exemption option even if they do not in fact utilize it.

subject to some notable limitations. For one, the estimates are based on kindergarten vaccination data, so while they may be informative to school districts seeking to combat falling childhood vaccination rates attributable to the pandemic, they may less easily generalize to employer-based vaccine requirements. Moreover, the school vaccines I examined are long-established, having each been around for over 40 years. In contrast, the novelty of the COVID-19 vaccine may induce a greater share of vaccine-hesitant individuals to undermine the mandates by obtaining allowable exemptions. Despite such limitations, these results provide the most comprehensive evidence on how policies limiting the scope of non-medical exemptions affect exemption-related information seeking behavior, vaccine exemptions, and vaccine coverage.

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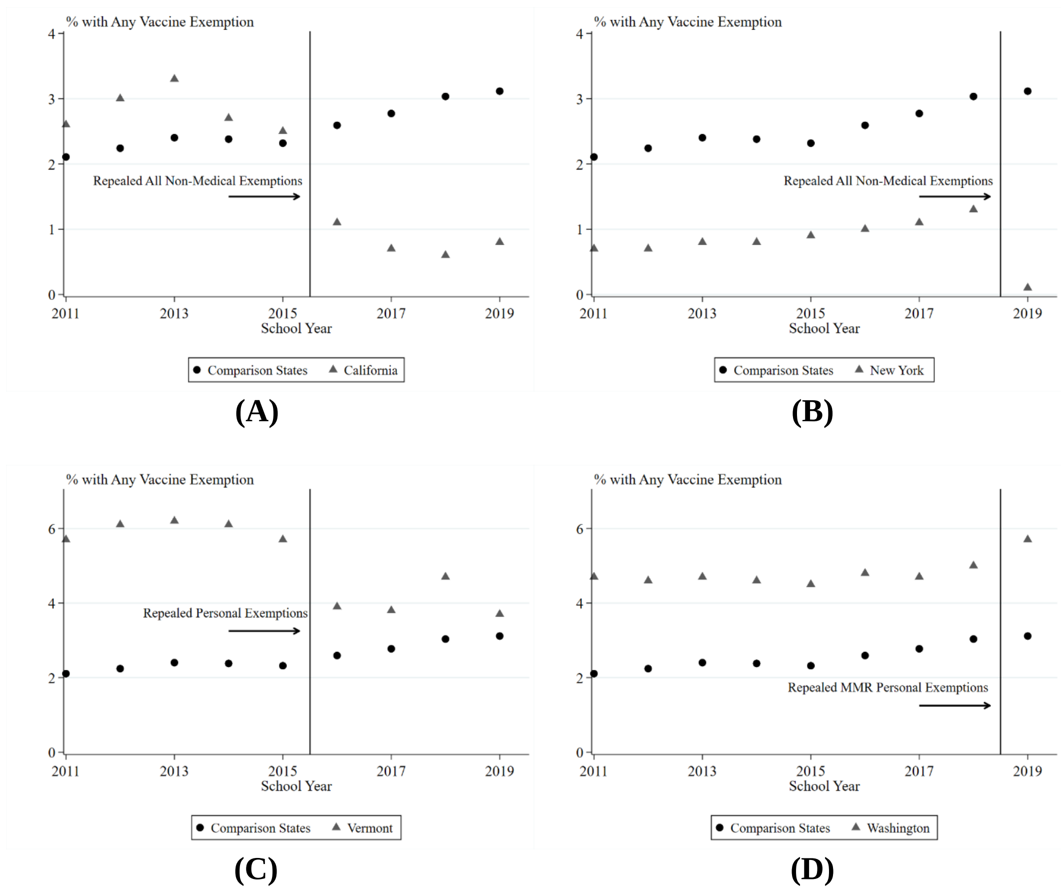
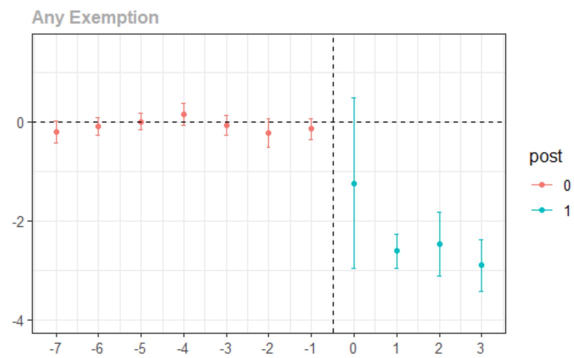
Figure 1: Share of Kindergarteners with at Least One Vaccine Exemption



Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019
Note: The panels plot the share of kindergarteners with at least one vaccine exemption. Panel A compares the share in California – which repealed all non-medical exemption in 2016 – against the share in the states which did not repeal vaccine exemptions. Panel B plots the share in New York – which repealed all non-medical exemptions in 2019 – against the share in the comparison states. Panel C plots the share in Vermont – which repealed personal exemptions in 2016 – against the share in the comparison states. Panel D plots the share in Washington – which repealed personal exemptions for the MMR vaccine in 2019 – against the share in the comparison states.

Figure 2: Repealing At Least Some Non-Medical Vaccine Exemptions Reduced the Share of Kindergarteners Receiving Exemptions



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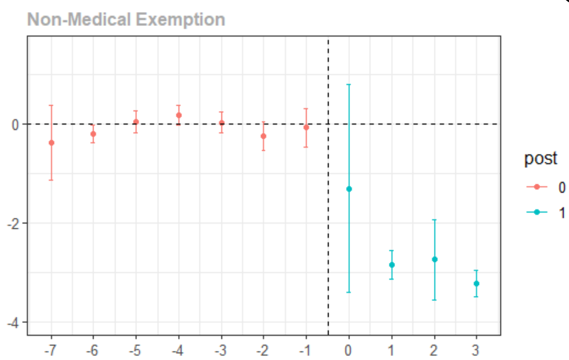

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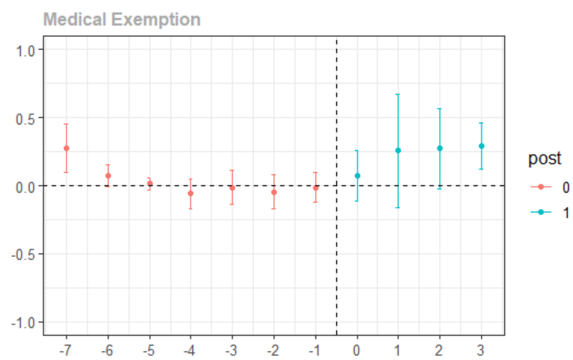
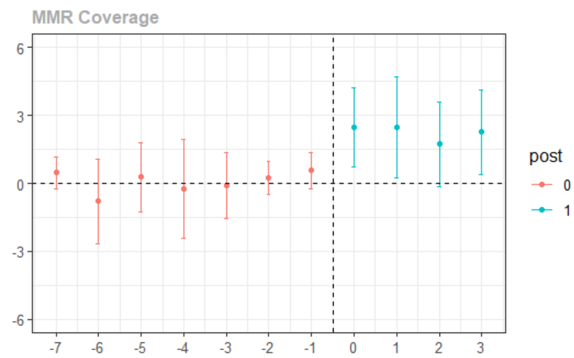


(C)

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019
Note: Each panel plots the Callaway and Sant'Anna (2021) event study coefficients obtain from a separate regression. The independent variable of interest is an indicator for whether the state implemented a policy prohibiting at least some non-medical exemptions. The dependent variable in Panel A is the share of kindergarteners receiving at least one medical exemption for a required school vaccine, in Panel B the share receiving at least one non-medical exemption, and in Panel C the share receiving at least one medical exemption. The circles denote the point estimates and the vertical lines the corresponding 95 percent confidence intervals.

Figure 3: Limiting Non-Medical Vaccine Exemptions
Reduced the Share of Kindergarteners Receiving Exemptions



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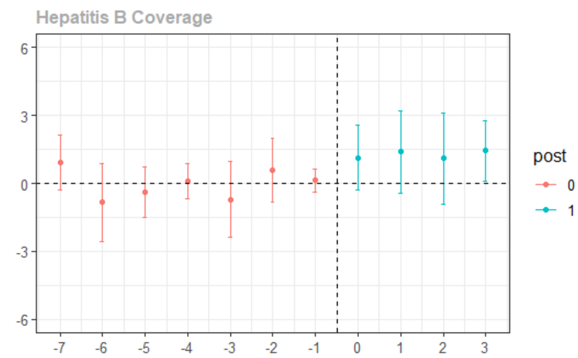

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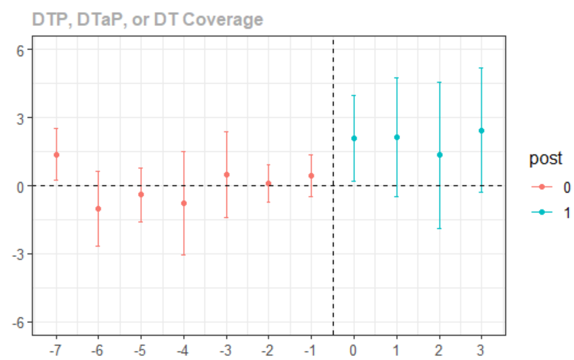

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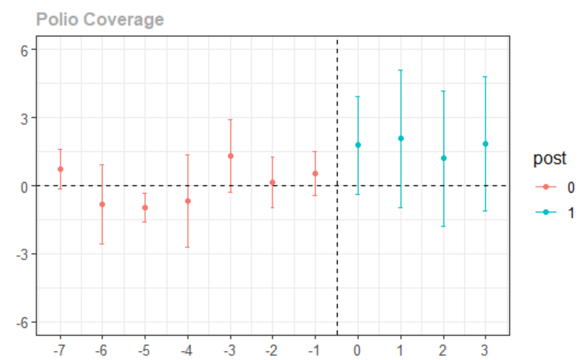


(D)

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019
Note: Each panel plots the Callaway and Sant'Anna (2021) event study coefficients obtain from a separate regression. The independent variable of interest is an indicator for whether the state implemented a policy prohibiting at least some non-medical exemptions. The dependent variable in Panel A is the share of covered by the MMR vaccine, in Panel B the share covered by the hepatitis B vaccine, and in Panel C the share covered by the DT, DTaP, or DT vaccines, and in Panel D the share covered by the polio vaccine. The circles denote the point estimates and the vertical lines the corresponding 95 percent confidence intervals.

Table 1: Limiting Non-Medical Exemptions Reduced Vaccine Exemptions And Increased Exemption-Related Google Searches

	(1)	(2)	(3)	(4)	(5)	(6)
	Any Exemption	Non-Medical Exemption	Medical Exemption	‘Vaccine Exemption’	‘Religious Exemption’	‘Medical Exemption’
Panel A						
Repealed a Vaccine Exemption	-2.004***	-2.173***	0.146	12.839*	8.683**	18.816***
	(0.499)	(0.586)	(0.154)	(6.874)	(3.885)	(3.652)
	[0.160]	[0.119]	[0.747]	[0.112]	[0.043]	[0.039]
Panel B						
Repealed All Non-Medical Exemptions	-2.293***	-2.650***	0.352**	13.462***	5.596	20.316***
	(0.375)	(0.533)	(0.148)	(0.860)	(4.452)	(3.815)
	[0.150]	[0.105]	[0.263]	[0.093]	[0.231]	[0.151]
Repealed Some Non-Medical Exemptions	-1.715*	-1.696*	-0.059	12.217	11.769**	13.468***
	(0.913)	(0.951)	(0.061)	(13.601)	(5.067)	(1.169)
	[0.642]	[0.642]	[0.346]	[0.596]	[0.246]	[0.378]
CDC Data?	Y	Y	Y			
Google Trends Data?				Y	Y	Y
Treated States with Missing Data	-	-	-	-	-	VT
Control States with Missing Data	CO, DE, DC, IL, MN, MO, SC, TX, WY	CO, DE, DC, IL, MN, SC, WY	AR, CO, DE, DC, IL, MN, MO, SC, TX, WY	ME	-	AK, ND, WY
Mean	2.616	2.322	0.281	10.156	10.963	9.822
Observations	420	422	417	450	459	423

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019

Note: The dependent variable in column 1 is the share of kindergarteners receiving at least one exemption for a required school vaccine, in column 2 the share receiving a non-medical exemption, and in column 3 the share receiving a medical exemption. The dependent variable in column 3 is the Google Trends Index for the phrase ‘vaccine exemption,’ in column 5 the phrase ‘religious exemption,’ and in column 6 ‘medical exemption.’ The independent variable of interest in Panel A is an indicator for whether the state implemented a law repealing at least some non-medical exemptions. The regression includes the controls from equation (1) and is estimated via OLS. The independent variables in Panel B are indicators for whether the state implemented a policy prohibiting all non-medical exemptions or at least some non-medical exemptions, and the regressions in Panel B are estimated using equation (2) via OLS. Standard errors, shown in parentheses, are clustered at the state level. Wild bootstrap p-values are reported in brackets.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 2: Limiting Non-Medical Exemptions Reduced Exemptions and Increased Vaccine Coverage

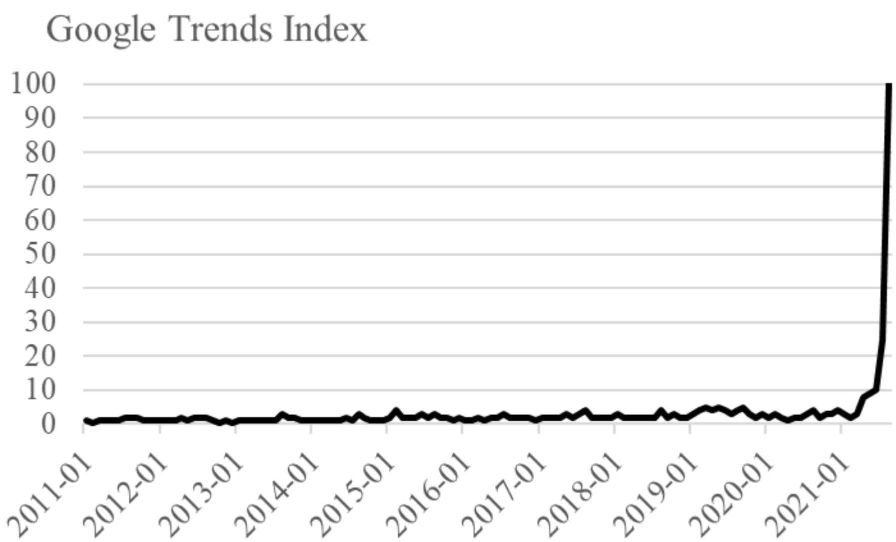
	(1)	(2)	(3)	(4)
Dependent Variable →	MMR Coverage	Hepatitis B Coverage	DTP, DTaP, or DT Coverage	Polio Coverage
Panel A				
Repealed a Vaccine Exemption	2.316***	1.292**	1.960**	2.036**
	(0.809)	(0.594)	(0.839)	(0.945)
	[0.040]	[0.049]	[0.056]	[0.096]
Panel B				
Repealed All Non-Medical Exemptions	2.939***	1.721***	2.683**	2.856***
	(0.741)	(0.545)	(1.191)	(0.693)
	[0.228]	[0.232]	[0.453]	[0.453]
Repealed Some Non-Medical Exemptions	1.692*	0.792	1.390	0.322
	(0.845)	(0.544)	(0.743)	(0.557)
	[0.239]	[0.245]	[0.228]	[0.228]
Treated States with Missing Data	-	-	-	-
Control States with Missing Data	AK, DE, DC, HI, NH, NJ, NC, OK, WY	AL, AK, DE, DC, HI, IL, ME, MT, NH, NJ, NC, OK, WY	AK, DE, DC, HI, NH, NJ, NC, OK, PA, WY	AK, DE, DC, HI, NH, NJ, NC, OK, WY
Mean	94.137	95.474	94.355	94.460
Observations	430	394	424	430

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019

Note: The dependent variable in column 1 is the share of kindergarteners covered by the MMR vaccine, in column 2 the share covered by the hepatitis B vaccine, in column 3 the share covered by the DT, DTaP, or DTP vaccines, and in column 4 the polio vaccine. The independent variable of interest in Panel A is an indicator for whether the state implemented a law repealing at least some non-medical exemptions. The regression includes the controls from equation (1) and is estimated via OLS. The independent variables in Panel B are indicators for whether the state implemented a policy prohibiting all non-medical exemptions or at least some non-medical exemptions, and the regressions in Panel B are estimated using equation (2) via OLS. Standard errors, shown in parentheses, are clustered at the state level. Wild bootstrap p-values are reported in brackets. *** p < 0.01, ** p < 0.05, * p < 0.10

7. Appendix

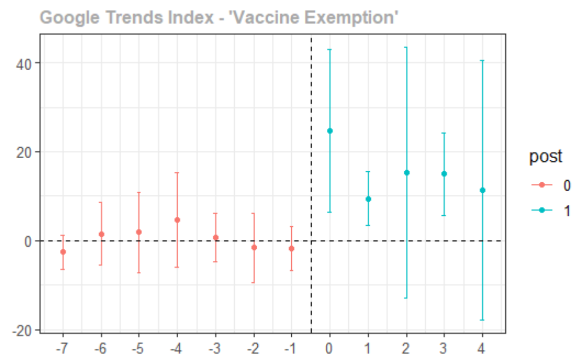
Appendix Figure 1: Google Searches for 'Vaccine Exemption'



Source: Google Trends 2011-2021

Note: The solid dark line plots the Google Trends Index for the term 'Vaccine Exemption.' The Index is constructed by first taking a random sample of Google searches and determining what share of those searches were for the term 'Vaccine Exemption.' The year-month when this ratio was maximized is set equal to 100. The remaining values are constructed by taking each year-month ratio divided by the ratio at the maximum point.

Appendix Figure 2: Repealing At Least Some Non-Medical Vaccine Exemptions Increased Vaccine-Hesitant Information Seeking Behavior



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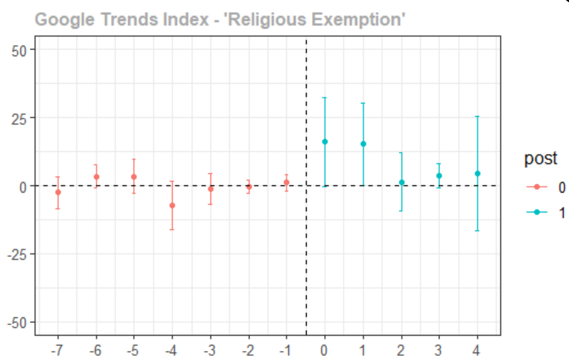
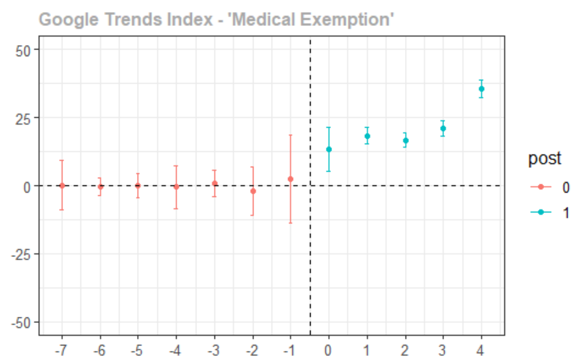


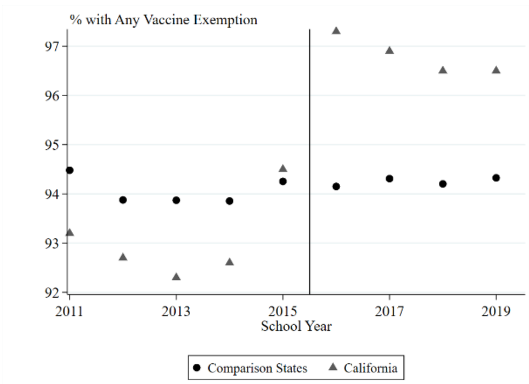
(B)



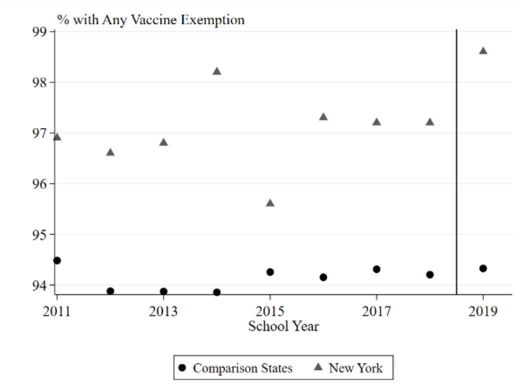
(C)

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019
Note: Each panel plots the Callaway and Sant'Anna (2021) event study coefficients obtain from a separate regression. The independent variable of interest is an indicator for whether the state had passed a policy prohibiting at least some non-medical exemptions. The dependent variable in Panel A is the Google Trends Index for the phrase 'vaccine exemption,' in Panel B the Google Trends Index for the phrase 'religious exemption,' and in Panel C the Google Trends Index for the phrase 'medical exemption.' The circles denote the point estimates and the vertical lines the corresponding 95 percent confidence intervals.

Appendix Figure 3: MMR Coverage



(A)



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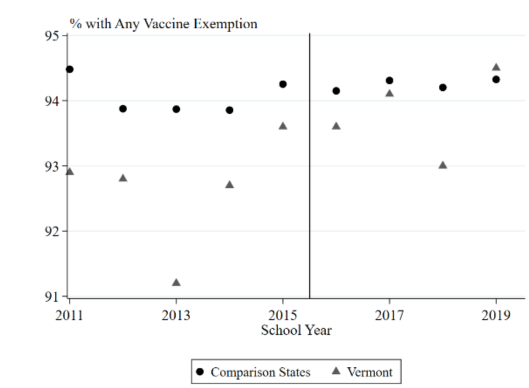

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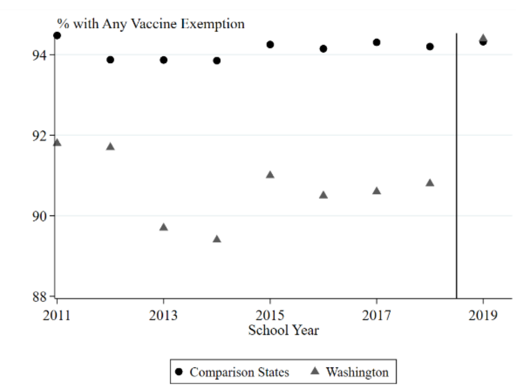
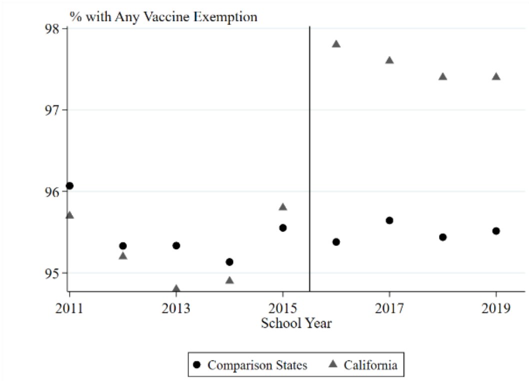


(D)

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2021
Note: The panels plot the share of kindergarteners receiving the MMR vaccine. Panel A compares the share in California – which repealed all non-medical exemption in 2016 – against the share in the states which did not repeal vaccine exemptions. Panel B plots the share in New York – which repealed all non-medical exemptions in 2019 – against the share in the comparison states. Panel C plots the share in Vermont – which repealed personal exemptions in 2016 – against the share in the comparison states. Panel D plots the share in Washington – which repealed personal exemptions for the MMR vaccine in 2019 – against the share in the comparison states.

Appendix Figure 4: Hepatitis B Coverage



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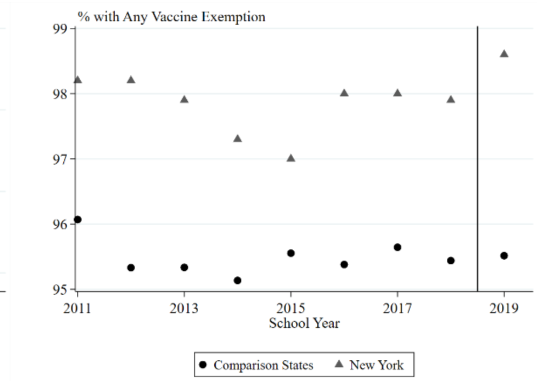

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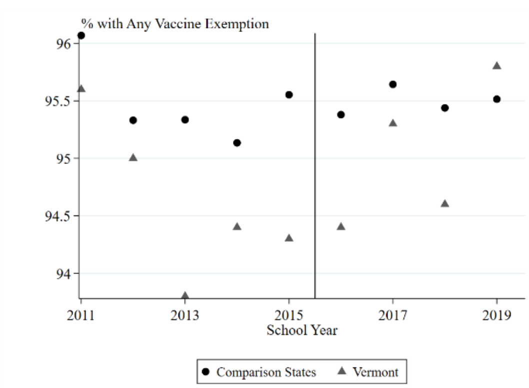
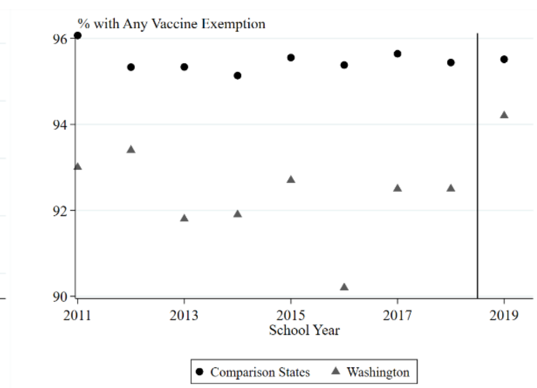


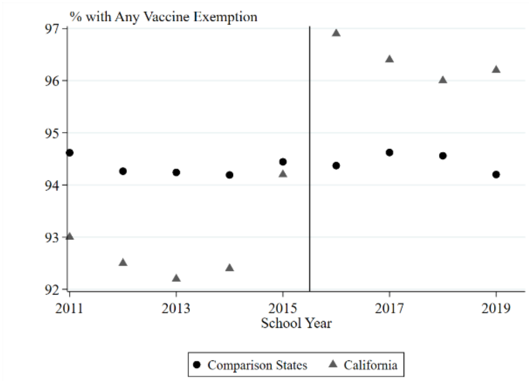
(C)



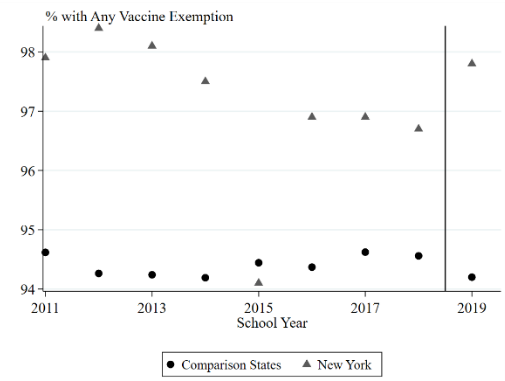
(D)

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2021
Note: The panels plot the share of kindergarteners receiving the hepatitis B vaccine. Panel A compares the share in California – which repealed all non-medical exemption in 2016 – against the share in the states which did not repeal vaccine exemptions. Panel B plots the share in New York – which repealed all non-medical exemptions in 2019 – against the share in the comparison states. Panel C plots the share in Vermont – which repealed personal exemptions in 2016 – against the share in the comparison states. Panel D plots the share in Washington – which repealed personal exemptions for the MMR vaccine in 2019 – against the share in the comparison states.

Appendix Figure 5: DTP, DTaP, or DT Coverage



(A)



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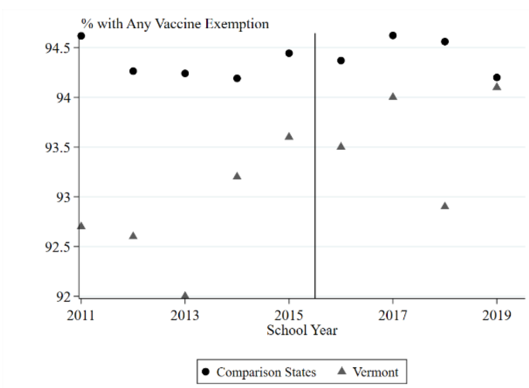

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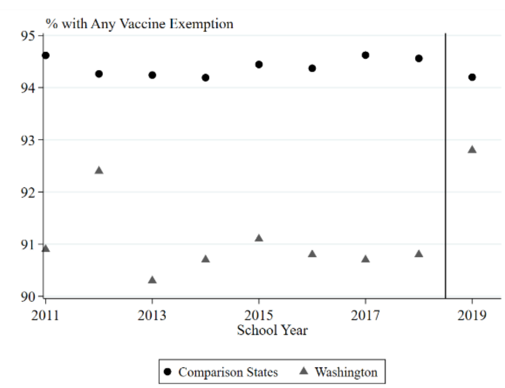
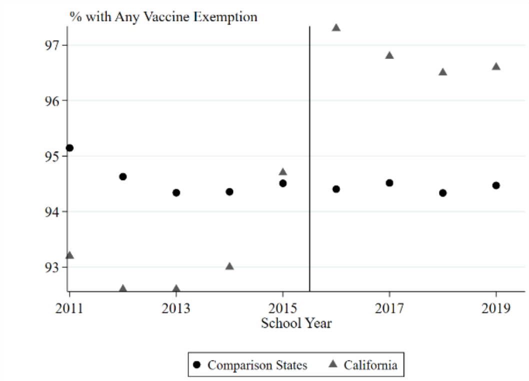


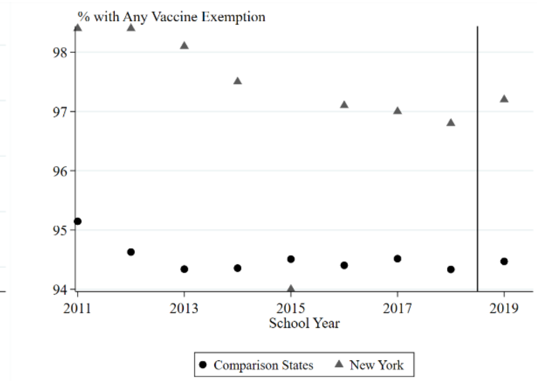
(D)

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2021
Note: The panels plot the share of kindergarteners receiving the DTP, DTaP, or DT vaccines. Panel A compares the share in California – which repealed all non-medical exemption in 2016 – against the share in the states which did not repeal vaccine exemptions. Panel B plots the share in New York – which repealed all non-medical exemptions in 2019 – against the share in the comparison states. Panel C plots the share in Vermont – which repealed personal exemptions in 2016 – against the share in the comparison states. Panel D plots the share in Washington – which repealed personal exemptions for the MMR vaccine in 2019 – against the share in the comparison states.

Appendix Figure 6: Polio Coverage



(A)



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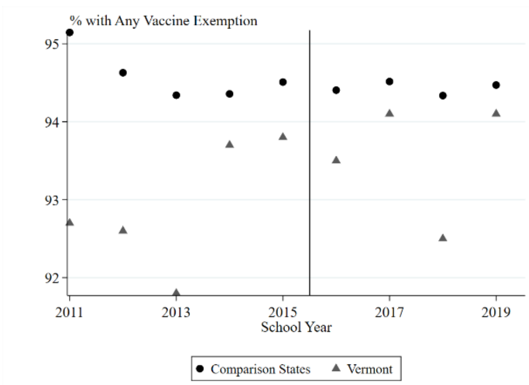
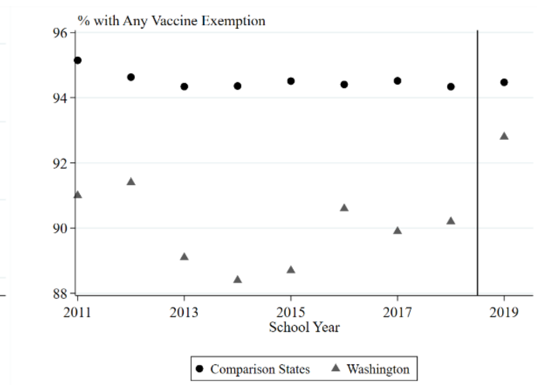


(C)



(D)

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2021
Note: The panels plot the share of kindergarteners receiving the DTP, DTaP, or DT vaccines. Panel A compares the share in California – which repealed all non-medical exemption in 2016 – against the share in the states which did not repeal vaccine exemptions. Panel B plots the share in New York – which repealed all non-medical exemptions in 2019 – against the share in the comparison states. Panel C plots the share in Vermont – which repealed personal exemptions in 2016 – against the share in the comparison states. Panel D plots the share in Washington – which repealed personal exemptions for the MMR vaccine in 2019 – against the share in the comparison states.

Appendix Table 1: Summary Statistics

	Full Sample	Did the State Repeal a Vaccine Exemption Policy?		Timing Among States Repealing a Vaccine Exemption Policy	
		No	Yes	Pre-Policy	Post-Policy
Any Vaccine Exemption	2.616	2.565	3.164	3.415	2.510
Non-Medical Exemption	2.322	2.282	2.764	3.027	2.080
Medical Exemption	0.281	0.268	0.414	0.412	0.420
MMR Coverage	94.137	94.147	94.033	93.454	95.540
DTP, DTaP, or DT Coverage	94.355	94.390	93.978	93.562	95.060
Hepatitis B Coverage	95.474	95.485	95.364	95.000	96.310
Polio Coverage	94.460	94.516	93.853	93.358	95.140

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019

Appendix Table 2: The Relationship between Policies Repealing Non-Medical Exemptions and Vaccine Coverage is Robust to Alternative Specifications

	(1)	(2)	(3)
	(1) + Covariates	(2) + State-Specific LTT	(2) + Census Division-by-Year FE
1. Any Exemption	-1.960***	-1.113	-2.106***
	(0.501)	(0.668)	(0.460)
	[0.164]	[0.154]	[0.093]
2. Non-Medical Exemption	-2.131***	-1.188	-2.333***
	(0.575)	(0.716)	(0.534)
	[0.132]	[0.187]	[0.073]
3. Medical Exemption	0.136	0.042	0.215
	(0.128)	(0.110)	(0.144)
	[0.630]	[0.714]	[0.351]
4. MMR Coverage	2.401**	2.022**	2.342**
	(0.906)	(0.876)	(1.141)
	[0.060]	[0.049]	[0.125]
5. Hepatitis B Coverage	1.436**	1.372**	2.130***
	(0.594)	(0.545)	(0.656)
	[0.096]	[0.051]	[0.056]
6. DTP, DTaP, or DT Coverage	2.008**	1.724**	2.360**
	(0.846)	(0.828)	(1.033)
	[0.083]	[0.167]	[0.122]
7. Polio Coverage	2.211**	1.265	2.354**
	(1.005)	(0.907)	(0.985)
	[0.124]	[0.259]	[0.119]

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019

Note: The dependent variables are listed in the table rows. The independent variable of interest is an indicator for whether the state implemented a law repealing at least some non-medical exemptions. The estimates are obtained from equation (1) using OLS. Column 1 estimates equation (1) but includes the state-level time-varying controls referenced in the context. Column 2 augments this specification with state-specific linear time trends. Column 3 augments the specification with Census division-by-year fixed effects. Standard errors, shown in parentheses, are clustered at the state level. Wild bootstrap p-values are reported in brackets.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Appendix Table 3: The Relationship between Policies Repealing Non-Medical Exemptions and Vaccine Coverage is Robust to Excluding Each Treated State

	(1)	(2)	(3)	(4)
	No California	No New York	No Vermont	No Washington
1. Any Exemption	-1.657**	-2.098***	-1.708**	-2.403***
	(0.729)	(0.556)	(0.754)	(0.233)
	[0.290]	[0.290]	[0.292]	[0.052]
2. Non-Medical Exemption	-1.640**	-2.297***	-1.961**	-2.615***
	(0.758)	(0.647)	(0.928)	(0.333)
	[0.301]	[0.253]	[0.298]	[0.013]
3. Medical Exemption	-0.042	0.169	0.230	0.200
	(0.048)	(0.176)	(0.191)	(0.163)
	[0.460]	[0.777]	[0.688]	[0.534]
4. MMR Coverage	1.615**	2.473***	3.076***	2.117**
	(0.664)	(0.910)	(0.583)	(0.896)
	[0.093]	[0.080]	[0.084]	[0.094]
5. Hepatitis B Coverage	1.103**	2.114**	2.632***	1.933**
	(0.457)	(0.934)	(0.734)	(0.956)
	[0.125]	[0.107]	[0.086]	[0.093]
6. DTP, DTaP, or DT Coverage	1.103**	2.114**	2.632***	1.933**
	(0.457)	(0.934)	(0.734)	(0.956)
	[0.129]	[0.090]	[0.089]	[0.104]
7. Polio Coverage	1.084*	2.360**	2.749***	1.899*
	(0.616)	(1.010)	(0.927)	(1.080)
	[0.213]	[0.084]	[0.231]	[0.201]

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019
Note: The dependent variables are listed in the table rows. The independent variable of interest is an indicator for whether the state implemented a law repealing at least some non-medical exemptions. The estimates are obtained from equation (1) using OLS. Column 1 excludes observations from California from the sample, Column 2 excludes observations from New York, column 3 excludes observations from Vermont, and column 4 excludes observations from Washington. Standard errors, shown in parentheses, are clustered at the state level. Wild bootstrap p-values are reported in brackets.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Appendix Table 4: The Relationship between Policies Repealing Non-Medical Exemptions and Vaccine Coverage is Robust to Limiting the Sample to States Conducting a Census of Kindergarteners

	(1)	(2)	(3)	(4)	(5)
Dependent Variable →	Any Exemption	MMR Coverage	Hepatitis B Coverage	DTP, DTaP, or DT Coverage	Polio Coverage
Repealed a Vaccine Exemption	-1.973***	2.500***	1.503**	2.094**	2.100**
	(0.514)	(0.836)	(0.616)	(0.883)	(0.974)
	[0.111]	[0.025]	[0.053]	[0.048]	[0.073]
Mean	2.673	94.361	95.520	94.471	94.615
Observations	319	317	284	312	317

Source: CDC Vaccination Coverage and Exemptions among Kindergartners 2011-2019

Note: The dependent variables are listed in the column headers. Column 1 examines the share of kindergarteners receiving at least one exemption for a required school vaccine, column 2 the share covered by the MMR vaccine, column 3 the share covered by the hepatitis B vaccine, column 4 the share covered by the DT, DTaP, or DTP vaccines, and column 5 the share covered by the polio vaccine. The independent variable of interest is an indicator for whether the state implemented a law repealing at least some non-medical exemptions. The estimates are obtained from equation (1) using OLS. The sample is limited to observations where the state performed a census of kindergarteners in the state. Standard errors, shown in parentheses, are clustered at the state level. Wild bootstrap p-values are reported in brackets.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$