



Efficient burdens decrease nonmedical exemption rates: A cross-county comparison of Michigan's vaccination waiver education efforts

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ABSTRACT

Michigan's introduction of mandatory counseling for nonmedical exemptions was associated with decreased nonmedical exemption rates. However, while each of Michigan's 45 local health departments made its own decisions about how to conduct immunization counseling, differences in the burdensomeness of counseling programs was not associated with greater or lesser changes in exemption rates. Data from a survey of Michigan local health departments (online, October 2015), epidemiological data from Michigan's Department of Health and Human Services (online, various dates), and social and economic data from the American Community Survey (online, various dates) were used in models explaining change in county-level nonmedical exemption rates. Counties that first required an education session after the December 2014 rule change had a 30% greater reduction in their nonmedical exemption rates for 2015 than did counties that already required education sessions. Michigan's experience with vaccination waiver education suggests that imposing burdens on non-medical waiver applicants decreases nonmedical waiver rates. It also indicates there may be a burden threshold beyond which incremental increases in inconvenience do not further reduce exemption rates. Thus, in a context of hyper-politicization and austerity, health departments may be wise to avoid implementing additionally burdensome processes that are politically or economically expensive to administer.

1. Introduction¹

In December 2014, Michigan changed the process by which children are exempted from daycare and school immunization mandates (Michigan Department of Public Health, 2016). The new rule required parents seeking a nonmedical exemption (NME) to attend immunization education at a local health department (LHD). Research indicates that communities with more burdensome application processes have lower NME rates (Blank et al., 2013; Omer et al., 2012; Rota et al., 2001). Michigan's experience in 2015 was consistent with this research; the NME rate declined by 35% statewide in the year after the new requirements were implemented (Mashinini et al., 2020). Michigan's NME rate decline was comparable to the NME rate declines of other states—including Washington (Omer et al., 2018) and California (Jones et al., 2018)—that recently implemented mandatory immunization counseling in their NME processes.

Michigan's statewide NME rate reduction statistic conceals

considerable variation across jurisdictions. We test five hypotheses that help explain this cross-jurisdiction variation. To harmonize available datasets, we analyze variation in county-level NME rate change between academic years 2014–15 (henceforth, 2014) and 2015–16 (henceforth, 2015). Michigan's 83 counties are served by 45 LHDs (State of Michigan, 2006). Most LHDs are coextensive with counties, but 13 LHDs serve multiple counties, and one is coextensive with a city.

Some Michigan LHDs required attendance at education sessions prior to the December 2014 rule change, so this intervention increased burdens in only some jurisdictions. We expect that *counties that first instituted education session requirements after December 2014 achieved greater reductions in NME rates than did counties already requiring education sessions* (Hypothesis 1). Many LHDs worked with other LHDs in implementing this new requirement. Such collaboration included sharing educational materials, implementation strategies and procedures, and costs (Navin et al., 2018). We expect that *counties with LHDs that collaborated with other LHDs in implementing the education session*

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¹ Acronyms used in this paper include local health department (LHD), Michigan Department of Health and Human Services (MDHHS), nonmedical exemption (NME).

requirement reported greater reductions in their NME rates than did counties with LHDs that did not collaborate (H2).

While Michigan's Department of Health and Human Services (MDHHS) provided materials and training to LHD staff (Navin et al., 2018); each LHD had discretion to implement education requirements, since Michigan's Public Health Code codifies LHDs as instruments of local government (State of Michigan, 1978). As such, some LHDs made education sessions more burdensome for parents and guardians, compared to other LHDs. We expect that *the amount of burdensome education session procedures is associated with reduction in NME rates at the county level* (H3). Further, LHDs also decided which types of informational materials (e.g., official statistics, images, stories, and videos) were used during education sessions. We expect that *the amount of different types of informational materials is associated with reduction in NME rates at the county level* (H4).

Michigan experienced a well-publicized pertussis outbreak in the second half of 2014, with lesser numbers of reported pertussis cases throughout 2015. Between July 2014 and August 2015, Michigan had over 1250 reported pertussis cases, which were distributed unevenly, representing a differential public health risk across counties. We expect that *the number of months between July 2014 and August 2015 that a county reported at least one new pertussis case is associated with reduction in NME rates at the county level* (H5).

We test each of the hypotheses above while controlling for key county-level human capital and economic vulnerability indicators. Counties with greater human capital (and lesser economic vulnerability) may foster greater capacity for timely and effective responses to public health interventions than may counties with lesser human capital (and greater economic vulnerability). Attending to such contextual factors strengthens causal inference by reducing the likelihood of spurious relationships.

2. Methods

2.1. Data sources

We tested these five hypotheses using a pooled data set that merged primary LHD-level data from a novel survey of LHD representatives and secondary county-level data from two different government sources. Table SM1 in the Supplementary Materials provides key information for each variable in the study. When merging these data sources into our pooled data set, counties served by the same LHD received the same values on LHD-level variables.

We designed a brief survey to ask Michigan LHD representatives how their departments responded to the new requirement to provide vaccination education sessions. We administered it via an online platform in August 2015, recruiting representatives from all 45 Michigan LHDs with multiple e-mails. We closed the survey in October 2015, after we achieved a 93.3% response rate with completed surveys from 42 of 45 Michigan LHDs (which supplied data for 76 counties). This survey provided novel data on the characteristics of LHDs, their educational sessions, and the materials employed in these sessions.

MDHHS provided the authors with 2014 and 2015 county-level NME rate data for each of the three sets of children for which Michigan schools collect waivers: kindergarten, seventh grade, and new entrants to a school district. These originated from MDHHS reports that were finalized in 2015 and 2016, respectively. Our outcome variables come from this data. Colleagues at the Oakland County Health Division provided a public report from the Michigan Disease Surveillance System of county-level data for "confirmed and probable" cases of Pertussis in 2014 and 2015. We collected county-level social and economic data for each Michigan county from the American Community Survey, which is available via the US Census Bureau website.

2.2. Analytical techniques

Table SM2 in the Supplementary Materials displays the percentages of students with a NME in 2014 and 2015 as well as the percentage change in these two rates for the 82 Michigan counties with available data. In this study, we aim to explain variation in the NME rate change values in the third column of Table SM2. Diagnostic statistics for this distribution of values indicate substantial positive skewness produced by three outlier counties with values more than 2.5 standard deviations above the mean: Alger = 102.93, Benzie = 157.33, and Ontonagon = 170.87. These sparsely populated Northern Michigan counties reported three of Michigan's five smallest 2014 NME rates. As such, a small increase in the number of NMEs in 2015 produced a large percentage change value in each of these three counties. The case of Ontonagon can illustrate this. This western Upper Peninsula county reported that 1 of its 93 students in 2014 (1.08%) and 3 of its 103 students in 2015 (2.91%) received a vaccination waiver—for a 170.87% increase in its vaccination waiver rate.

To deal with these outliers, and the resulting moderately positive skewness in our outcome variable, we employed three analytical strategies to examine the robustness of effects across different model specifications. First, we ran a series of ordinary least squares (OLS) linear regressions on our waiver rate change variable that was square-root transformed to reduce positive skew. Second, we ran the same series of OLS models on the original waiver rate change variable after dropping the three outlier cases of Alger, Benzie, and Ontonagon counties. Third, we ran a similar series of logistic regression models on three different dichotomized outcome variations: whether or not the waiver rate decreased; whether or not it decreased by more than 10%; and whether or not it decreased by more than 25%. The latter two percentage change targets may be intuitively meaningful for public health professionals and policy-makers.

To test the five hypotheses described above, we used a nested approach with each series of models. Briefly, we added theoretically important predictors in subsequent steps, allowing us to examine their performance as additional variables were included. While we simply report the final models below, our Supplementary Materials contain the full suite of nested models for each analytical strategy. We performed all analyses with IBM SPSS Statistics 24.0. We report our results using the conventional criterion of $p < 0.05$ to label effects that are statistically different from zero. We look for consistency in effects across varied model specifications, since such robust effects increase confidence in the validity of the results.

2.3. Variables

Across our multiple analytical models, we employ two continuous and three dichotomous outcome variables from the MDHHS data. For the former, we explain variation in the *waiver rate change*, or the percentage change between the 2014 and 2015 NME rates, and variation in the *square root of waiver rate change*, or the square-root transformation of the first outcome variable. We further explain variation in three dummy outcome variables: *rate decreased*, coded "1" for those counties with a waiver rate decrease from 2014 to 2015, and *rate decreased > 10%* and *rate decreased greater than 25%*, coded "1" for those counties with at least a 10% and 25% waiver rate decrease, respectively.

Our 2015 survey of LHD representatives provides data for four potential predictors associated with the first four hypotheses, respectively. For each predictor, data is missing for the same seven counties. Two dummy variables measure key characteristics of LHDs. *New educational session* indicates whether an LHD required an educational session as part of its waiver process prior to (coded "0") or after (coded "1") the December 2014 rule change (for H1). *Collaborated* indicates whether (coded "1") or not (coded "0") an LHD worked with other jurisdictions when implementing the December 2014 rule change (for H2).

Two summative indexes measure key features of LHDs' educational

sessions. *Session burdensomeness*, which ranges from 0 to 4, combines four items assessing how burdensome to parents or guardians the scheduling and implementation of the sessions were, with higher values signifying a greater burden (for H3). These four items include the typical length of educational sessions (*session length*) as well as whether or not LHDs: held their educational sessions at only one building (*single location*), required scheduling of appointments in advance (*scheduled only*), and offered them only during weekday business hours (*only normal hours*). *Materials presented*, which ranges from 0 to 5, measures how many of five different types of informational materials that LHD employees typically presented to parents or guardians (for H4). These include *official information* about vaccine safety and efficacy, *talking points* for responding to parents' concerns, *stories* about or *images* of children who contracted vaccine-preventable diseases, and *videos* about the dangers of such diseases.²

Another theoretically relevant predictor is *Pertussis months*, or the number of months between July 2014 and August 2015 that a county reported at least one new Pertussis case (for H5). This time frame includes the height of the 2014 Pertussis outbreak and the first eight months of 2015 before MDHHS collected the vaccination waiver data from school districts (see Fig. SM1 in the [Supplementary Materials](#)). In preliminary analyses (see Note SM1 in the [Supplementary Materials](#)), this operationalization had the strongest bivariate correlation with our outcome variables than did all other possible indicators of a Pertussis outbreak signal—offering the fairest condition for testing H5.

Finally, the American Community Survey provides county-level data for two human capital variables and two economic vulnerability variables. *College degree*, the percentage of residents with a bachelor's degree, and *insured*, the percentage of residents who have health insurance, are two indicators of the capacity for counties to effectively implement public health interventions. The *unemployment rate* for residents at least 16 years old and the percentage of families living below the *poverty level* for a year are two indicators of economic vulnerability, which may inhibit successful implementation of public health interventions.

3. Results

We first briefly report the results of linear regression models explaining the percentage change in county-level NME rates and then report the results of logistic regression models explaining whether or not a county's NME rate decreased. Notes SM2 and SM3 in the [Supplementary Materials](#) display the SPSS syntax for these linear and logistic regression models, respectively. Across both types of models, we identify the most robust patterns. We return to our five hypotheses in our Discussion.

3.1. Explaining the percentage change in county-level NME rates

As mentioned above, the rightmost column in [Table SM2](#) in the [Supplementary Materials](#) displays the percentage change in the 2014 and 2015 NME rates for the 82 Michigan counties with available data. The mean percentage change was an 18.84% decrease (median of a 27.96% decrease). Since the distribution of these values is positively skewed, we analyzed the performance of key theoretical predictors on (a) the square root of percentage change from 2014 to 2015 for all available counties and (b) the percentage change from 2014 to 2015 for all available counties minus three outliers. For each analysis, we employed a nested approach, whereby we added key predictors in successive steps until creating our final models. [Table 1](#) displays these final

Table 1

Unstandardized Coefficients (and Standard Errors) from Ordinary Least Squares Regression Models Explaining the Percentage Change in Michigan Counties' Nonmedical Exemption Rates from 2014 to 2015.

Predictors	Square Root of Percentage Change from 2014 to 2015	Percentage Change from 2014 to 2015
<u>Local Health Department Characteristics</u>		
Educational session first required after 12/2014 rule change	-2.08* (0.78)	-30.21* (10.53)
Worked with other jurisdictions to implement 12/2014 rule change	1.28* (0.59)	16.41* (8.03)
<u>Educational Session Characteristic</u>		
Educational session burdensomeness	0.13 (0.40)	0.51 (5.46)
<u>Informational Materials Characteristic</u>		
Number of informational materials used regularly in educational sessions	-0.21 (0.29)	-0.77 (3.97)
<u>Presence of Disease Outbreak</u>		
Months between 7/2014 and 8/2015 with at least one new Pertussis case	-0.03 (0.10)	-0.41 (1.41)
<u>Human Capital Indicators</u>		
Percentage of residents with at least a bachelor's degree	-0.05 (0.05)	-1.11 (0.66)
Percentage of residents with health insurance coverage	-0.01 (0.18)	2.43 (2.46)
<u>Economic Vulnerability Indicators</u>		
Percentage of residents with incomes below poverty level	-0.28* (0.13)	-0.85 (1.81)
Unemployment rate for residents 16 years old or older	0.14 (0.17)	-1.08 (2.48)
Constant	13.63 (16.61)	-176.29 (230.66)
Adjusted R ²	0.12	0.13
Mean Variance Inflation Factor (VIF)	1.64	1.64
Highest VIF	2.74	2.74
Number of Counties	75	72

Notes. Entries are unstandardized coefficients; standard errors are in parentheses. * $p < 0.05$. In the first model, eight counties with missing data on key variables are dropped: Alpena, Cass, Cheboygan, Keweenaw, Montmorency, Presque Isle, Sanilac, and Van Buren. In the second model, three additional counties are dropped: Alger, Benzie, and Ontonagon.

models, and [Tables SM3](#) and [SM4](#) in the [Supplementary Materials](#) contain the full results of each of the constituent models from this nested approach.

The two linear regression models in [Table 1](#) explain 12% and 13% of the variation in NME rate percentage change, respectively. Across these two models, only two variables account for nearly all of this explained variance. For ease of interpretation, we turn to the second model in [Table 1](#), which analyzes raw—and not transformed—data. Counties that first required an educational session after the December 2014 rule change experienced a 30.21% decrease in their NME rates from 2014 to 2015. This effect persists even when controlling for the suite of other theoretically relevant predictors and county-level contextual factors.

At the same time, it appears that working with LHDs in other counties was associated with a 16.41% increase in NME rates from 2014 to 2015. No other potential predictor had a statistically significant, consistent effect across the two models in [Table 1](#). That is, we find no evidence that the differential implementation of educational sessions (e.g., the level of burden imposed on parents or guardians or the amount of information materials used) had an impact on NME rate change in Michigan counties.

² Preliminary analyses revealed that no individual type of informational material was related to change in NME rate at the county level. Since nearly all LHDs regularly used more than one type of informational material, we explored a possible "additive" effect of such informational materials.

3.2. Explaining whether or not a county's NME rate decreased

We now turn to our third analytical strategy to deal with our three outlier cases and positive skew in our outcome variable. Briefly, we ran three series of logistic regression models, using the same nested approach and theoretically relevant predictors as in the OLS regression models, to explain whether or not the waiver rate decreased at all, by more than 10%, and by more than 25%.³ Table 2 displays these final models, and Tables SM5, SM6, and SM7 in the [Supplementary Materials](#) contain the full results of each of the constituent models from this nested approach. We present the model results as odds ratios, which we calculated by exponentiating Euler's number e to the power of the unstandardized logistic coefficient.

The three logistic regression models in Table 2 explain 59%, 40%, and 37% of the variation in whether or not a county's NME rate decreased at all, by more than 10%, and by more than 25%, respectively. Only two variables had statistically significant, consistent effects across the three models in Table 2. Across all counties in our study, the median percentage change in NME rate was a 27.96% decrease. Thus, for ease of interpretation, we focus on the third model in Table 2, which explains the likelihood that a Michigan county experienced at least a 25% decrease in its NME rate.

Counties that first required an educational session after the December 2014 rule change were 14.08 times more likely than were counties that already required them to have at least a 25% decrease in their NME rates from 2014 to 2015. Also, a 1-unit increase in the percentage of residents in a county with a 4-year college degree raised the likelihood of achieving at least a 25% decrease in NME rate by 14%. These effects persist even when controlling for the suite of other theoretically relevant predictors and county-level contextual factors. As with the linear models, we find no evidence that the differential implementation of educational sessions had an impact on NME rate change in Michigan counties.

4. Discussion

We tested five hypotheses explaining county-level variation in Michigan's 2014–2015 NME rate change. The strongest predictor was the implementation of a new education session requirement after December 2014, which supports H1 and suggests that the addition of a more burdensome process resulted in lower NME rates. Further, the results of additional analyses not reported here show that this reduction in NME rates was not offset by an increase in medical waiver rates at the county level. While some parents may have sought medical exemptions from sympathetic providers rather than secure a NME, there is no signal in our data suggesting this was a statewide pattern.

LHDs that required in-person education sessions before 2015 saw little or no change in their NME rates between 2014 and 2015, while LHDs that began requiring waiver education in 2015 experienced dramatic declines in NME rates over that period. For those 75 Michigan counties with adequate data, the 12 counties that already required waiver education had a mean of a -2.63% NME rate change, while the 63 counties that first implemented waiver education in 2015 had a mean of a -22.35% NME rate change. Our county-level analysis supports the conviction that Michigan's NME rate reductions were influenced by this new education requirement.

Collaboration with other LHDs also influenced NME rate change, though in the opposite direction expected by H2. This suggests that neither collaborating on educational materials, administration strategies, and procedures nor sharing costs produced more effective implementation of this new requirement. The fact that cross-jurisdictional collaboration was not associated with greater NME rate reductions

supports our claim that differences in the implementation of waiver education are less relevant to outcomes than is the fact that some mandatory waiver education policy was imposed.

There was substantial variation in how Michigan LHDs implemented education sessions after December 2014. H3 and H4 expected that the amount of burdensome education session procedures and the amount of different types of information materials used, respectively, would be associated with reduction in county-level NME rates. Our results do not support either hypothesis. We found no evidence that more burdensome features of education sessions, or more information presented to parents during sessions, translated into reduced NME rates. Imposing *some kind of* education requirement reduced NME rates, but it did not matter *how* the education requirement was imposed.

Finally, some urge caution about examining the influence of policy changes on NME rates during or soon after Pertussis outbreaks (Blank et al., 2013). Given Michigan's well-publicized Pertussis outbreak in the second half of 2014, we examined how new Pertussis cases affected counties' NME rates and whether accounting for new cases influenced the effect of newly required education sessions on NME rates. We found no evidence for either assertion, offering no support for H5. Counties' differential public health risks, as indicated by Pertussis cases unevenly distributed across the state, were not associated with county-level NME rate changes, which is consistent with the results of previous research (Wolf et al., 2014).

There are limitations to this study. First, some Michigan LHDs provide immunization counseling to people who are not residents of the counties that those LHDs serve. Second, we are unable to explain which individuals in Michigan counties received waivers. Yet, our county-level analysis is a valuable supplement to individual-level analyses of parents' vaccination decisions, because it demonstrates the efficacy of a simple, additional burden in decreasing NME rates. Third, we could investigate the influence of only those implementation strategies that Michigan LHDs used. Examining the potential efficacy of different low-cost burdens requires additional research.

Fourth, the publicly available datasets we used were missing data for some counties and LHDs. We tried to neutralize possible non-response bias by presenting the results of various models with different specifications and identifying the most robust results across models. Fifth, we do recognize that other scholars may have different interpretations of our selected variables and their observed effects. Finally, as with most studies employing multiple regression analyses, not all potentially influential variables could be controlled. Yet, it is unlikely that including additional county-level variables would alter our strongest and most robust results. Thus, we infer a causal influence of the new educational session requirement on NME rate reduction.

5. Conclusions

This study's findings are of particular interest in light of recent and ongoing policy changes in other political communities. California realized substantial declines in its NME rates after passing a 2012 law (Assembly Bill 2109) that required immunization counseling for NME applicants (Jones et al., 2018). However, this improvement was not enough for California legislators, who—with Senate Bill 277 (Legiscan, 2015)—eliminated their state's NME provisions, but in a way that created new challenges for local health jurisdictions (Mohanty et al., 2019). While many public health advocates have argued for the elimination of NMEs (American Medical Association, 2015; American Academy of Family Physicians, 2018; American College of Physicians, 2015), counseling requirements may be a more realistic policy reform in many communities (Navin and Largent, 2017), in light of increasing political polarization surrounding immunization policy: California's SB277 passed because Democratic lawmakers provided nearly unanimous support on a near party-line vote (Legiscan, 2015). However, there is reason to doubt whether parents who attend immunization

³ Approximately 78%, 71%, and 56% of counties achieved a NME rate decrease, a decrease of at least 10%, and a decrease of at least 25%, respectively.

Table 2

Odds Ratios (and 95% Confidence Intervals) from Logistic Regression Models Explaining Whether a Michigan County's Nonmedical Exemption Rate Decreased at all, by more than 10%, and by more than 25% from 2014 to 2015.

Predictors	Rate Decreased	Rate Decreased by > 10%	Rate Decreased by > 25%
Local Health Department Characteristics			
Educational session first required after 12/2014 rule change	267.51* (9.16, 7810.63)	21.80* (2.73, 173.90)	14.08* (2.17, 91.59)
Worked with other jurisdictions to implement 12/2014 rule change	0.01* (0.001, 0.32)	0.16* (0.03, 0.85)	0.41 (0.11, 1.51)
Educational Session Characteristic			
Educational session burdensomeness	1.73 (0.44, 6.79)	1.69 (0.57, 5.09)	1.04 (0.44, 2.45)
Informational Materials Characteristic			
Number of informational materials used regularly in educational sessions	1.64 (0.61, 4.44)	1.22 (0.60, 2.48)	1.41 (0.76, 2.61)
Presence of Disease Outbreak			
Months between 7/2014 and 8/2015 with at least one new Pertussis case	1.17 (0.82, 1.66)	1.20 (0.90, 1.58)	1.06 (0.83, 1.34)
Human Capital Indicators			
Percentage of residents with at least a bachelor's degree	1.39* (1.07, 1.82)	1.20* (1.02, 1.42)	1.14* (1.02, 1.29)
Percentage of residents with health insurance coverage	1.09 (0.65, 1.83)	0.88 (0.59, 1.32)	0.80 (0.54, 1.18)
Economic Vulnerability Indicators			
Percentage of residents with incomes below poverty level	1.37 (0.91, 2.04)	1.22 (0.90, 1.66)	1.39* (1.02, 1.89)
Unemployment rate for residents 16 years old or older	1.05 (0.65, 1.69)	0.94 (0.64, 1.39)	0.93 (0.64, 1.35)
Nagelkerke R ²	0.59	0.40	0.37
Number of Counties	75	75	75

Notes. Entries are odds ratios; 95% confidence intervals are in parentheses. * $p < 0.05$. Eight counties with missing data on key variables are dropped: Alpena, Cass, Cheboygan, Keweenaw, Montmorency, Presque Isle, Sanilac, and Van Buren.

education change their minds, or whether this policy instrument impacts NME rates only by deterring parents from applying for NMEs (Navin et al., 2019; Kirkley, 2019).

Our results warrant guarded optimism about Michigan's vaccination waiver education efforts and for similar efforts undertaken elsewhere. This study's attention to county-based differences in the introduction of education requirements supports increasing the burdensomeness of NME application policies to reduce NME rates, even while leaving intact parental rights to receive NMEs. Furthermore, this study provides evidence that there is a threshold of waiver policy burdensomeness, after which the benefits of increased burdens plateau. This result supports making education sessions short and accessible, to reduce financial costs for LHDs, and to mitigate the anger of parents and guardians, who might otherwise organize resistance to NME education requirements.

CRedit authorship contribution statement

Mark C. Navin: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Investigation. **Mark A. Largent:** Conceptualization, Methodology, Writing - review & editing, Investigation. **Aaron M. McCright:** Writing - review & editing, Formal analysis, Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2020.101049>.

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