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Impact of publicly available vaccination rates on parental school and child care choice

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ABSTRACT

Objective: Several states require schools and child cares to report vaccination rates, yet little is known about the impact of these policies. Our objectives were to assess: (1) predicted impact of vaccination rates on school/child care choice, (2) differences between vaccine hesitant and non-hesitant parents, and (3) differences by child's age.
Methods: In 2016, a cross-sectional email survey of Colorado mothers with children ≤12 years old assessed value of vaccination rates in the context of school/child care choice. A willingness-to-pay framework measured preference for schools/child cares with different vaccination rates using tradeoff with commute time.
Results: Response rate was 42% (679/1630). Twelve percent of respondents were vaccine hesitant. On a scale where 1 is "not important at all" and 4 is "very important" parents rated the importance of vaccination rates at 3.08. Respondents (including vaccine-hesitant respondents) would accept longer commutes to avoid schools/child cares with lower vaccination rates. Parents of child-care-age children were more likely to consider vaccination rates important.
Conclusions: This study shows parents highly value vaccination rates in the context of school and child care choice. Both hesitant and non-hesitant parents are willing to accept longer commute times to protect their children from vaccine-preventable diseases.

1. Introduction

Parental concerns about vaccines lead to delay and refusal of vaccinations and cause some parents to seek vaccination exemptions for their children. Strategies to improve childhood vaccination rates include legislative and policy interventions and efforts to improve communication with parents about vaccinations and to promote vaccination as a social norm [1,2]. One approach is increased public reporting of vaccination rates, which displays vaccination as the prevalent behavior in most settings. The desired effects of public reporting are to influence parental decisions about vaccination and encourage schools and child cares to ensure children are fully immunized, however it is unknown whether these goals are achieved.

Recent legislative approaches to strengthen vaccination have focused on eliminating non-medical exemptions or making exemptions more difficult to obtain [3,4], often sparking public debate [5]. In the United States, recommended childhood vaccinations are enforced through school and child care entry requirements [6]. Higher rates of non-medical exemptions show spatial patterns and have been associated with private schools and other socio-demographic factors [7–12]. Higher exemption rates are also associated with increased incidence of vaccine preventable diseases (VPDs) [13–15], echoing the increased risk of VPDs in unvaccinated individuals and communities in general [16,17]. Public reporting of vaccination and exemption rates at schools and child care centers makes vaccination behavior locally transparent and could promote understanding of vaccination in the context of community while framing vaccination as a social norm. All states report statewide kindergarten vaccination rates, often based on school surveys, to the Centers for Disease Control and Prevention (CDC) [18], however public reporting of vaccination rates on a local level does not occur in every state.

Abbreviations: PACV, Parental Attitudes about Childhood Vaccination; VPD, vaccine preventable disease.

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Several states have passed or are considering passing legislation to make school/child care vaccination rates publicly available [19–21]. Past educational policy research identifies several common factors in school choice including academic quality, safety, convenience, racial and ethnic composition, and school environment [22,23]. While health could be considered part of safety, the impact of vaccination rates on school or child care choice has not been studied specifically. Understanding how parents currently value and respond to reporting of vaccination rates may inform public health officials and policy-makers considering measures to increase transparency of vaccination information and could help schools and child cares determine how to best implement and communicate their vaccination policies.

The goal of this study was to test the hypothesis that parents value reporting of vaccination rates for schools and child cares in the context of school/child care choice. Our specific objectives were to assess: (1) predicted impact of vaccination rates on school/child care choice, (2) differences between vaccine hesitant and non-hesitant parents, and (3) differences between parents of child-care-age and school-age children. We hypothesized that non-hesitant parents would value reporting vaccination rates more strongly than vaccine hesitant parents and that parents of child-care-age children would value reporting vaccination rates more strongly than parents of school-age children.

2. Methods

2.1. Study setting

Colorado is in the process of implementing a law passed in 2014 requiring schools and licensed child care centers to report their vaccination rates publicly [19]. A cross-sectional email survey was conducted among mothers in Colorado from August-October 2016. Inclusion criteria were having a child under twelve years of age who would attend school or child care outside of the home and being able to answer the survey in English. Data were collected from a web-based survey and stored in Research Electronic Data Capture (REDCap) [24]. This study was approved by the Colorado Multi-Institutional Review Board.

2.2. Study population and survey administration

Participants were recruited from a group of patients at nine obstetrics and gynecology (OB/GYN) practices in Colorado who had participated in a prior study and agreed to contact for future surveys. The sample was selected randomly from past participants who had provided valid email addresses. Duplicate entries were eliminated and additional invalid addresses were removed after distribution of an introductory email. Introductory emails described the survey, included information identifying the OB/GYN practice from which the participant was recruited, and allowed recipients to opt out. Initial invitations were sent within one week of the introduction, followed by weekly, then biweekly reminder emails allowing for up to eight emails during twelve weeks of recruitment. Respondents received a $5 electronic gift card after survey completion.

One thousand seven hundred twenty-eight women were invited to participate to target a sample of n = 600 based on sample size calculations for an experimental randomized-controlled trial portion of the study that is not the focus of this manuscript.

2.3. Survey design

Outcomes assessed included predicted impact of vaccination rates on school/child care choice measured in two different ways. The impact of vaccination rates on school/child care choice was measured using a willingness-to-pay framework and by assessing importance of vaccination rates in context of other factors related to school/child care choice. Willingness-to-pay is a utility measure used to assess preference for different health states. Respondents are asked what amount they would pay to be free of a certain undesired condition, and those 'prices' are compared across different health conditions to measure preference [25]. To avoid asking about monetary cost, which may influence school/child care choice outside a hypothetical situation, we developed a novel measure using a willingness-to-pay framework to assess willingness-to-drive (or commute). Participants were asked how much longer of a commute they would accept to avoid having their child attend a school/child care with different rates of unvaccinated children. This was repeated with three scenarios with different school/child care vaccination rates. Responses were recorded using a sliding scale for commute time ranging from no longer commute to commute time of 30 min or longer (Fig. 1). Participants were asked to rate the importance of six different factors related to school/child care choice (listed in Table 3) using a four-point Likert scale where 1 is "not at all important" and 4 is "very important."

Vaccine hesitancy was measured using a five-item, short-form of the Parental Attitudes about Childhood Vaccination (PACV) [26,27]. The short-form PACV measures agreement with four statements about vaccinations, for example "Children get more shots than are good for them," and includes the question "Overall, how hesitant about childhood shots would you consider yourself?". Demographic information collected to better characterize respondents included age in years, education (response choices less than high school, high school, vocational school, college, or advanced degree), household income (<$50,000, $50,000–74,999, $75,000–99,999, $100,000–149,999, ≥$150,000), insurance type (Medicaid, Child Health Plan plus, private insurance, Colorado Indigent Care Program, no insurance), race/ethnicity (White, Black, Asian, American Indian or Alaskan Native, Hispanic or Latino, Native Hawaiian or other Pacific Islander, other), primary language (English, Spanish, other), and type of school (public, private, charter, other).

This survey was piloted among mothers of young children to assess for clarity. The full survey is available upon request.

2.4. Analysis

Descriptive statistics were generated for all survey items. Willingness-to-drive was measured as a continuous variable between zero and 30 min. Responses indicating willingness to accept a commute time of 30 min or longer were recorded as 30 min. Hesitancy was calculated as an average of Likert responses from the five PACV items, with a score ≥3 categorized as hesitant (scale 0–5). The validation study of the full PACV used a cut-off score of 50 (scale 0–100) to identify 15% of respondents as hesitant [28]. For the short-form PACV, we applied a cutoff of 3 to responses in prior work and identified 11% of participants as hesitant in a population similar to the one presented in this study [29]. Demographic response categories were collapsed based on distribution of the data.

Vaccine hesitancy and child's age (child-care-age vs school-age) were used as predictor variables for comparative analyses of the value of reporting vaccination rates in the context of school/child care choice. Vaccine hesitancy was chosen as a predictor because hesitant parents have different attitudes about vaccination and thus would likely value the reporting of vaccination rates differently from non-hesitant parents. Child's age was assessed as a predictor because younger children are more susceptible to exposure to and illness from VPDs, thus parental value for reporting vaccination rates might be different based on child age.

Many parents have several options when choosing a child care or school for their child. For the following questions, imagine you are choosing a school or child care and are deciding between two different options. You have heard good things about both places and they are the same when it comes to classroom size, number of teachers or care providers, teaching and test scores, cleanliness, books, toys, supplies and all other factors.

We would like to know how information about immunizations might effect your choice.

For the following questions, consider this information about immunizations:
Highest risk- When more than 10% of children are NOT immunized, there is a high risk of certain infectious diseases spreading.
Medium risk- When 3 to 10% of children are NOT immunized, there is a medium risk of certain infectious diseases spreading.
Lowest risk- When 0 to 3% of children are NOT immunized, there is a low risk of certain infectious diseases spreading.

You have two options for your child's school:

School A:
-1% of children are NOT immunized
-Low risk
-Farther from your home.

School B:
-11% of children are NOT immunized
-Medium risk
-Closer to your home.

How much longer of a commute or drive would you be willing to take for your child to attend School A?

Would not accept any longer travel time — 30 minutes longer or more

(Place a mark on the scale above)

Fig. 1. Willingness to pay survey item. Survey of mothers in Colorado, 2016.

Repeated measures one-way analysis of variance (ANOVA) was calculated on willingness-to-drive responses to assess within versus between subjects variance for all respondents and to then to assess within versus between groups variance with respondents grouped by hesitancy. Means were compared using two-tailed t-tests, and medians compared using Wilcoxon signed rank tests. Analyses were performed in Stata (version 11.2). $P \leq 0.05$ was considered significant, except in cases of multiple comparisons where Bonferroni correction was applied.

3. Results

3.1. Study population

Of 1728 women invited to participate, ten opted out and 88 email addresses were invalid. The response rate was 42% (679/1630 potential respondents). Two-hundred fifty-seven respondents were ineligible because they did not have a child under 12 years old or their child was home-schooled, leaving 422 eligible respondents. Twenty-three respondents completed insufficient portions of the survey to be included in descriptive or comparative analyses.

Respondents were mostly young, white women who were overall highly educated, relatively wealthy, and privately insured (Table 1). Based on Colorado census data, survey respondents were less racially and ethnically diverse, more highly educated, and wealthier than the general population of Colorado [30].

Mean vaccine hesitancy score was 1.7 [n = 418, standard deviation (SD) 1.0] on a scale from zero to five where five is most hesitant. Twelve percent of respondents were classified as vaccine hesitant [95% confidence interval (CI) 9–16%].

3.2. Predicted impact of vaccination rates on school/child care choice

Repeated measures one-way ANOVA of willingness-to-drive responses for all respondents was significant ($F = 5.92$, $p < 0.001$). Subsequent main effects analyses showed that respondents were willing to accept progressively longer commute times to avoid having their children attend schools/child cares with higher rates of unvaccinated children (Table 2).

Table 1
Respondent characteristics (n = 382). Survey of mothers in Colorado, 2016.

	Variable	% (n) unless otherwise noted	Colorado census data (2016)[a]
Maternal age [mean (SD)]		36 years (6)	
Race/ethnicity	White	86% (327)	87.5%
	Hispanic	8% (32)	21.3%
	Asian	2% (8)	3%
	Black	1% (2)	4.5%
	American Indian / Alaska Native, Native Hawaiian / Pacific Islander, Other	3% (10)	4.8%
Education	College grad /advanced degree	78% (297)	38.7%[b]
Income	<$50 k/yr	13% (49)	Median household income $62,520
	$50–100 k/yr	33% (126)	
	>$100 k/yr	50% (189)	
Insurance	Private	87% (332)	
Type of School (n = 164 respondents with school-age children)	Public	72% (118)	
	Private	10% (17)	
	Charter	15% (25)	
Primary language	English	97% (371)	

[a] American Community Survey: QuickFacts Colorado. *U.S. Census Bureau.* 2016.
[b] Proportion of individuals age 25 and older with a bachelor's degree or higher education, 2012–2016.

When asked to rate the importance of six factors related to school/child care choice, vaccination rates had the fourth highest rating for importance, after safety, academics, and size (Table 3).

3.3. Differences between vaccine hesitant and non-hesitant parents

One-way ANOVA of willingness-to-drive responses between groups of hesitant versus non-hesitant respondents was significant ($F = 49.29$, $p < 0.001$). Like non-hesitant parents, vaccine hesitant parents would accept longer commute times to avoid schools/child cares with higher rates of unvaccinated children, although the median commute times that hesitant parents would accept were lower than those that non-hesitant parents would accept (Table 2).

When analyzed by vaccine hesitancy, vaccination rate was the factor rated lowest in importance for school/child care choice among vaccine hesitant parents, although 40% of these parents still considered it moderately or very important. The importance of vaccination rate was rated lower by vaccine hesitant parents [2.24, 95% CI (1.95, 2.54)] than non-hesitant parents [3.19 (3.11, 3.28), $p < 0.001$] – the only factor among the six assessed to differ by vaccine hesitancy status (Table 3).

3.4. Differences between parents of child-care-age and school-age children

Parents with child-care age children rated vaccine rate as more important for school/child care choice than parents with school age children did [mean rating 3.21 (3.10, 3.32) vs. 2.90 (2.76, 3.03), $p < 0.001$]. In contrast, parents of child-care age children rated academics as less important than parents of school age children did [3.77 (3.71, 3.84) vs. 3.89 (3.84, 3.94), $p = 0.0008$]. The importance of other factors related to school/child care choice did not differ between the two groups.

4. Discussion

In one of the first studies to assess the value of publicly reporting vaccination rates, we found that parents, including vaccine hesitant parents, highly value this information in the context of school and child care choice. Moreover, we developed and tested a willingness-to-pay framework that is a practical measure of parental preferences related to school/child care vaccination rates. Responses to this framework suggest that reporting vaccination

Table 2
Value of school and child care exemption rates measured by willingness-to-pay framework using commute time. Survey of mothers in Colorado, 2016. Respondents were asked: "If you had a choice between two schools (child cares) that were similar in all other ways, how much longer of a commute would you be willing to accept for your child to attend the school (child care) with 1% of children unvaccinated."

Unvaccinated rate of comparator school or child care	Median commute time parents would accept for their child to attend a school or child care with 1% of children unvaccinated [Interquartile range (IQR)]			Proportion of parents who would accept commute increased 30 min or longer, % (n) [95% CI] N = 390
	Hesitant N = 45	Non-hesitant N = 345	All respondents N = 390	
5%	6 min[a,b] [2–17]	15 min[a,b] [8–21]	14 min[a] [7–21]	5.6% (22) [3.3–7.9%]
11%	15 min[a,b] [5–21]	19 min[a,b] [13–24]	19 min[a] [12–24]	6.2% (24) [3.8–8.5%]
80%	20 min[a,b] [8–27]	26 min[a,b] [20–30]	26 min[a] [20–30]	22.3% (87)[c] [18.2–26.5%]

[a] $p < 0.01$ by Wilcoxon signed rank test for each pairwise comparison across the three items within each column.
[b] $p < 0.0005$ by Wilcoxon rank-sum test for each pairwise comparison between hesitant and non-hesitant groups within the same row.
[c] $p < 0.0005$ by chi-square comparison of proportions. Proportion of respondents who would accept an increased commute of 30 min or longer was higher when avoiding a school with 80% unvaccinated children compared to when trying to avoid a school with 11% unvaccinated and compared when trying to avoid a school with 5% unvaccinated children.

Table 3
Importance of vaccination rate and other factors for school/child care choice.

School/child care characteristic	Mean Importance Rating[a] (95%confidence interval)						
		Hesitancy			Child's Age		
	All respondents (n = 385)	Hesitant (n = 45)	Non-hesitant (n = 340)	p-value (*t*-test)	School age (n = 157)	Childcare age (n = 228)	p-value (*t*-test)
Safety	3.90 (3.87, 3.93)	3.82 (3.69, 3.95)	3.91 (3.88, 3.94)	0.08	3.90 (3.85, 3.95)	3.90 (3.86, 3.95)	0.87
Academics	3.82 (3.78, 3.86)	3.76 (3.61, 3.90)	3.83 (3.78, 3.88)	0.29	3.89 (3.84, 3.94)	3.77 (3.71, 3.84)	0.008[b]
Size	3.43 (3.37, 3.50)	3.44 (3.22, 3.67)	3.43 (3.36, 3.50)	0.91	3.43 (3.26, 3.54)	3.43 (3.35, 3.52)	0.99
Vaccination Rate	3.08 (3.00, 3.17)	2.24 (1.95, 2.54)	3.19 (3.11, 3.28)	<0.001[b]	2.90 (2.76, 3.03)	3.21 (3.10, 3.32)	<0.001[b]
Distance	2.99 (2.91, 3.07)	3.13 (2.92, 3.35)	2.97 (2.89, 3.05)	0.17	2.97 (2.85, 3.10)	3.00 (2.91, 3.09)	0.74
Diversity	2.60 (2.51, 2.70)	2.71 (2.40, 3.02)	2.59 (2.49, 2.69)	0.41	2.57 (2.42, 2.73)	2.62 (2.50, 2.74)	0.61

[a] Range 1–4 where 1 is "not at all important" and 4 is "very important".
[b] $p < 0.0083$ is significant using Bonferroni correction for multiple comparisons.

rates in schools/child cares might result in tangible changes in parental behavior related to vaccination and school choice.

Responses to the willingness-to-pay tradeoff between vaccination rates and commute time demonstrated parental value for vaccination rates and the internal validity of this novel utility measure. Parents, including those who were vaccine hesitant, accepted progressively longer commute times to avoid schools/child cares with higher rates of unvaccinated children, suggesting a "dose-response" to vaccination rates in parental willingness-to-drive. Parents rated vaccination rates and distance as similarly important in choosing a school/child care, suggesting that tradeoff between vaccination rates and distance (commute time) is a plausible choice. In contrast, academics was rated as much more important, thus a tradeoff between vaccination rates and academic success might not be a sensitive utility measure as parents would be unlikely to sacrifice academic achievement.

The willingness-to-pay measure was written to minimize the influence that other school-related factors might have on willingness to accept a longer commute time (Fig. 1), however respondent characteristics might influence willingness to accept a longer commute as well. For example, a family's ability to accept a longer commute to school may be greater for those with higher income or may be limited by a parent's work schedule or the needs of other children. Some families may not have a choice in school or child care due to monetary considerations or limited number of choices in certain geographic areas. These additional factors might differentially influence parental behavior in response to vaccination rates in the context of school and child care choice. It is difficult to know whether these factors also influenced survey responses to the hypothetical willingness-to-drive measure or whether these survey responses would overestimate parental value of school/child-care vaccination rates compared to their value in actual parental decision-making outside of the survey.

Willingness-to-pay utility measures have been used in numerous other studies related to vaccination [31,32]; however we only found one example in the published literature on school choice, which was a study that evaluated how students valued different aspects of post-graduate education [33]. Most vaccination studies have used willingness-to-pay to predict the amount of money that people would pay for a new vaccine [34–37]. Several other studies have used willingness-to-pay to determine the relative value of different characteristics of a vaccine or a vaccination program, for example how do people value safety, effectiveness, cost, and convenience of vaccination [38–43]. In the only published example to use this type of utility measure to relate distance to vaccination, willingness-to-pay methods were used to assess tradeoffs in vaccine price, travel distance, and other variables in a model of typhoid vaccination demand in China [44]. A willingness-to-pay framework that incorporates commute time in the context of school/child care choice is innovative, may be a helpful utility measure to assess parental value for vaccination rates and should be tested in other populations.

Promoting vaccination as a social norm positively influences individual decisions about vaccines [45], although it might also encourage people to forgo vaccination and rely on herd immunity [46]. While hesitant parents were less likely to rate vaccination rates as an important factor for school choice, their responses to the willingness-to-pay measure suggest that information about vaccination rates may influence their behavior. The commute times that hesitant parents would accept were lower than those accepted by non-hesitant parents, although the dose-response relationship of the tradeoff was maintained, showing that hesitant parents still value higher vaccination rates. Hesitant parents have concerns about vaccination for their own child, however they may still recognize the value of vaccination in a school or child care setting. Another way to interpret the responses of hesitant parents is that the willingness to commute longer for a school with higher vaccination rates reflects free-riding behavior. Other studies related to herd immunity and vaccination intentions have shown that free-riding (foregoing vaccination due to a perceived protection from herd immunity) is an uncommon approach [47] but that this behavioral intention can be influenced by how vaccination information is communicated [48]. The attitudes of vaccine hesitant parents have some commonalities with non-hesitant parents but warrant careful monitoring for potential negative reactions to the public reporting of vaccination rates.

Public reporting of vaccination rates can promote vaccination as a social norm. This norm can be promoted through visibility of overall high vaccination rates in the community and encouraging community dialogue about vaccination. Social norms have been a successful strategy in promoting vaccination in developing countries [1]. Application of social norms has showed some success for other health behaviors, however there is comparatively little literature on social norms and vaccination [49,50]. In an observational study, physician communication that presupposes parents will vaccinate their children, a form of a social norm, was associated with increased vaccine acceptance [51]. However, the use of social norms to promote vaccination needs further exploration beyond the medical office setting including more study of how public reporting influences perceived social norms.

Vaccination rates may be particularly important in the context of child care. Parents of child-care-age children rated vaccination rates as more important for school or child care choice than parents of school-age children did. Our findings align with those of a national poll that found that 66% of parents think they should be informed of the number of children at their child care center who are not fully vaccinated [52]. Because parents are likely to be more concerned about vaccination when their children are young, policies focused on reporting vaccination rates among child cares may garner more parental and public support than those focused on schools.

This study should be considered in context of several limitations. Recruiting participants from OB/GYN practices may have been biased the study sample toward less vaccine hesitant parents as more strongly hesitant parents might seek care from midwives or non-traditional practitioners. Respondents may have had more favorable vaccination attitudes compared to non-respondents. A previous study from a similar cohort found that respondents were more likely than non-respondents to have received recommended adult vaccinations [53]. Use of a convenience sample limits the ability to infer that the survey sample and responses are representative of the parents in Colorado or elsewhere. Our sample was less racially and ethnically diverse, wealthier, and more educated than the general adult population in Colorado. There is increasing recognition of vaccine hesitancy across racial, ethnic, and socioeconomic groups, thus the size and characteristics of our sample limit conclusions about parental attitudes across a diverse population. The willingness-to-pay measure reflects preference for schools/child cares with different vaccination rates, but may not reflect the actual tradeoff that parents would make in commute time. Parental preferences related to vaccination rates may not result in behavioral change in settings where choice of school or child care is limited by geography or cost. Vaccine hesitancy was measured using a short-form of the PACV, rather than the full PACV. The full PACV has been validated for association with vaccination behavior [28], whereas the short-form has been validated only in comparison to another scale for categorizing vaccination attitudes and reported (but not measured) vaccination behavior [27]. In addition, survey respondents had email access and were English-speaking, and our response rate was below 50%.

5. Conclusions

Parents, including vaccine hesitant parents, highly value reporting of vaccination rates in the context of school and child care choice and this information may influence behavior. Most parents consider vaccination rates important in the context of school/child care choice and most parents stated that they would sacrifice commute time to a school/child care for higher vaccination rates. Noting that parents of child-care-age children value and may respond to reporting of vaccination rates more than parents of school-age children, public health and legislative efforts should focus on strengthening capacity for reporting vaccination rates among child cares. As states implement public reporting of school/child care vaccination rates, parental attitudes and behaviors should be measured and compared to predicted behaviors from this early analysis.

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8. Potential conflicts of interest

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Contributors' statement

Dr. Allison helped to conceptualize the study, refined the survey instrument, and critically reviewed the manuscript.

Dr. Dempsey and Dr. O'Leary conceptualized the study, refined the survey instrument, supervised data collection and analysis, and reviewed and revised the manuscript.

Dr. Cataldi designed the survey instrument, coordinated data collection, carried out analyses, drafted the initial manuscript, and reviewed and revised the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work. All authors attest they meet the ICMJE criteria for authorship.

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