Correlation of Vaccine-Preventable Illness and Community Vaccination Rates in Colorado

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Abstract

- Colorado has low vaccination rates for varicella, DTaP, and PCV13 relative to the rest of the US [3,4,5]; low vaccine coverage is a risk for vaccine preventable diseases (VPDs) in children and adults [2,7]
- We hypothesize that geographic areas with lower vaccination rates will show higher rates of corresponding VPDs and that newly available data from Colorado schools can be used to demonstrate and monitor this association
- Vaccination rates and VPD incidence are assessed geographically and temporally via Spearman correlation and univariate and multivariable modeling
- We found fluctuating vaccination rates and increasing cases of pneumococcal disease. Correlation and linear modeling did not reveal significant relationships between vaccination and VPD rates, or they were not meaningful in context
- Limitations to the validity and scope of these data, in addition to confounding variables that are more difficult to account for, likely hindered this study
- Vaccination data from schools likely still has utility in more localized discussions regarding data collection

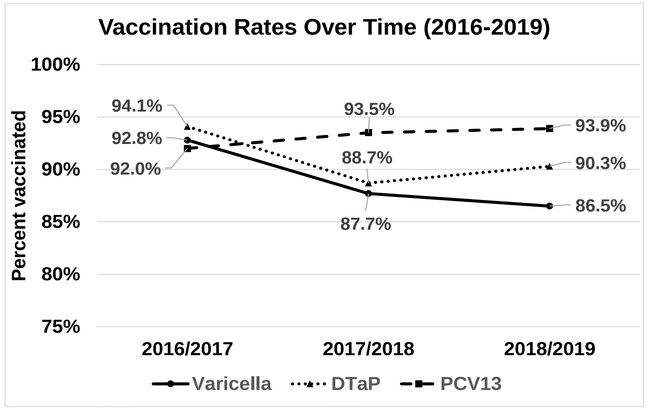
Introduction

- Colorado has low pediatric vaccination rates for varicella, DTaP, and PCV13 as compared to US as a whole [3,4,5]
- Gaps in vaccination coverage are a risk for vaccine preventable disease (VPD) in both children and adults; vaccine exemptions are known to cluster geographically [8]
- Pediatric PCV13 vaccination has been shown to provide indirect protection to adults for invasive pneumococcal disease [1,6]
- Vaccination data collected in Colorado schools has only been publicly available as of 2016. If an association between vaccination rates and disease risk is found, these data could be a cost-effective way for Colorado disease prevention programs to monitor risk of VPDs
- We hypothesized that existing secondary data sources could be used to demonstrate and monitor a relationship between vaccination rate and VPD incidence

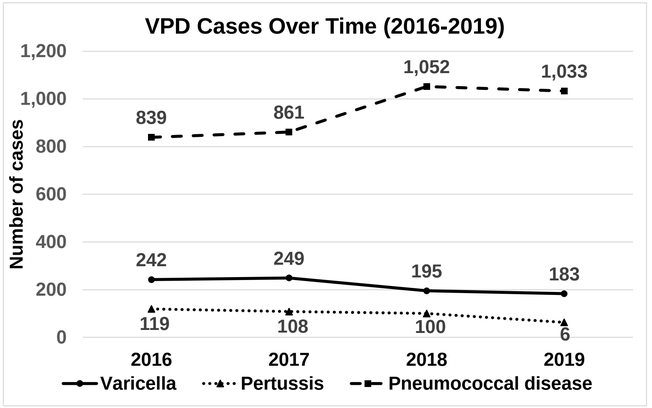
Methods

- Used available data from the Colorado Department of Public Health and Environment (vaccinations) and the Colorado Hospital Association (VPDs)
- Excluded counties with < 5 VPD cases (CDPHE restriction)
- Vaccination rates for varicella, DTaP, and PCV13 were compared to corresponding VPD incidence to assess for both geographic (county-level) and temporal relationships
- Spearman correlations were initially used, followed by both univariate and multivariable modeling
- Other independent variables assessed include kindergarten population, population density, hospital density

Results



Abbreviations: DTaP: diphtheria, tetanus, pertussis; PCV, pneumococcal conjugate vaccine



Abbreviation: VPD, vaccine preventable disease

Univariate Spearman rho correlation analysis for association between select variables and case rates of varicella, pertussis, and pneumococcal disease among the 0-10 age group, 2016-2019

	Varicella (n = 351) r (95% CI) (p-value)	Pertussis (n = 145) r (95% CI) (p-value)	Pneumococcal disease (n = 172) r (95% CI) (p-value)
Kindergarten or Preschool/childcare population per 1,000 by county†	-0.159 (-0.653, 0.429) (0.60)	-0.095 (-0.750, 0.653) (0.82)	-0.442 (-0.838, 0.259) (0.21)
Percent of children vaccinated by county	0.038 (-0.524, 0.577) (0.90)	-0.286 (-0.824, 0.525) (0.49)	0.103 (-0.563, 0.688) (0.78)
Population density*	0.049 (-0.516, 0.585) (0.87)	-0.047 (-0.728, 0.680) (0.91)	-0.321 (-0.791, 0.387) (0.38)
Hospitals per 100 square miles	-0.165 (-0.656, 0.425) (0.59)	-0.357 (-0.848, 0.464) (0.39)	-0.297 (-0.781, 0.409) (0.42)

Univariate Spearman rho correlation analysis for association between select variables and case rates of pneumococcal disease among the 20+ age group, 2016-2019

	Pneumococcal disease (n = 3,457) r (95% CI) (p-value)
Preschool/childcare population per 1,000 by county	-0.32 (-0.58, -0.01) (0.042)
Percent of children in preschool/childcare vaccinated by county	0.29 (-0.02, 0.55) (0.07)
Population density*	-0.26 (-0.53, 0.05) (0.10)
Hospitals per 100 square miles	-0.14 (-0.43, 0.18) (0.40)

† Kindergarten population for varicella and pertussis, preschool / childcare population for pneumococcal disease
*Population density was calculated as total population divided by county square miles

Univariate and multivariable linear regression model results for case rates of varicella, pertussis, and pneumococcal disease among the 0-10 age group, 2016-2019

Varicella	Univariate Estimate (95% CI)	P-value	
Kindergarten population per 1,000 by county	-5.6 (-12.6, 1.3)	0.11	
Percent of children in kindergarten vaccinated by county	0.3 (-5.6, 6.2)	0.92	
Population density*	0.0 (-0.1, 0.1)	0.87	
Hospitals per 100 square miles	0.5 (-10.8, 11.8)	0.93	
Pertussis	**Univariate Estimate (95% CI)**	**P-value**	**Multivariable Estimate (95% CI)**	**P-value**
Kindergarten population per 1,000 by county	-9.8 (-16.7, -3.0)	0.005	-8.5 (-14.9, -2.2)	0.008
Percent of children in kindergarten vaccinated by county	-4.5 (-9.7, 0.8)	0.10	-3.0 (-7.0, 1.0)	0.14
Population density*	0.0 (-0.2, 0.1)	0.61	N/A	N/A
Hospitals per 100 square miles	-5.9 (-24.2, 12.4)	0.53	N/A	N/A
Pneumococcal Disease	**Univariate Estimate (95% CI)**	**P-value**		
Preschool/childcare population per 1,000 by county	-0.9 (-2.5, 0.7)	0.27		
Percent of children in preschool/childcare vaccinated by county	1.1 (-2.5, 4.8)	0.53		
Population density*	0.0 (-0.1, 0.0)	0.33		
Hospitals per 100 square miles	-2.2 (-6.7, 2.3)	0.33		

Univariate and multivariable linear regression model results for case rates of pneumococcal disease among the 20+ age group, 2016-2019

	Univariate Estimate (95% CI)	P-value	Multivariable Estimate (95% CI)	P-value
Preschool/childcare per 1,000 by county	-4.3 (-9.4, 0.8)	0.10	-4.6 (-9.5, 0.3)	0.07
Percent of children in preschool/childcare vaccinated by county	4.5 (-0.6, 9.6)	0.08	4.8 (-0.1, 9.7)	0.055
Population density*	0.0 (0.0, 0.0)	0.76	N/A	N/A
Hospitals per 100 square miles	-3.7 (-19.8, 12.4)	0.65	N/A	N/A

Limitations

- We included a significant number of counties with very low case numbers over 4 years, limiting detectable effect
- We may have overestimated VPD incidence when determining the power needed to detect a significant difference. Our use of existing secondary data and censoring of counties with < 5 cases likely limited this study's power
- Secondary data sources may be limited by inconsistent coding for VPDs and inconsistencies in school-based record collection
- Confounders not accounted for, including geographic clustering of presentation for VPDs based on access to care, could have altered measurement of the outcome. Vaccination status is known to cluster similarly [8]. Lesser populated areas might be more impacted by this clustering, even while accounting for population density and total population
- We did not account for older children or adult vaccinations, which also give some degree of protection from VPDs

Conclusions

- Longitudinal presentation of these data identified fluctuating vaccination rates in Colorado, in addition to increasing cases of pneumococcal disease
- Our modeling either did not reveal significant associations between vaccination and disease incidence or identified associations that were not meaningful in context, even accounting for confounders
- Despite this study not demonstrating our hypothesized relationship, general scientific knowledge assures us that this relationship exists. Vaccines are known to decrease the rate of VPDs in a community [9]
- School-based vaccination data may still prove useful for public health purposes, but future investigations may consider alternative uses in addition to prospective data collection. This research could be used as a communication tool and highlight the importance of local data collection to key community members

References

1. Ahmed SS, Pondo T, Xing W, et al. Early Impact of 13-valent Pneumococcal Conjugate Vaccine Use on Invasive Pneumococcal Disease among Adults with and without Underlying Medical Conditions-United States [published online ahead of print, 2019 Aug 12]. Clin Infect Dis. 2019.
2. Atwell JE, Van Otterloo J, Zipprich J, et al. Nonmedical vaccine exemptions and pertussis in California, 2010. Pediatrics. 2013;132(4):624-630.
3. Centers for Disease Control and Prevention, SchoolVaxView. "Estimated vaccination coverage among children enrolled in kindergarten by state and the United States, School Vaccination Assessment Program, 2018-19 school year". 10 September. 2019.
4. Centers for Disease Control and Prevention, SchoolVaxView. "Pneumococcal Conjugate Vaccine (PCV) coverage among children 19-35 months by State, HHS Region, and the United States, National Immunization Survey-Child (NIS-Child), 2017." 11 October. 2018.
5. Centers for Disease Control and Prevention. "Tetanus-diphtheria toxoids (Td) or tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccination coverage among adolescents 13-17 years by State, HHS Region, and the United States, National Immunization Survey-Teen (NIS-Teen), 2018". 22 July. 2019.
6. Ciruela P, Broner S, Izquierdo C, et al. Indirect effects of paediatric conjugate vaccines on invasive pneumococcal disease in older adults [published correction appears in Int J Infect Dis. 2020 Feb;91:206]. Int J Infect Dis. 2019;86:122-130.
7. Omer SB, Enger KS, Moulton LH, Halsey NA, Stokley S, Salmon DA. Geographic clustering of nonmedical exemptions to school immunization requirements and associations with geographic clustering of pertussis. Am J Epidemiol. 2008;168(12):1389-1396.
8. Pottinger HL, Jacobs ET, Haenchen SD, Ernst KC. Parental attitudes and perceptions associated with childhood vaccine exemptions in high-exemption schools. PLoS One. 2018;13(6):e0198655. Published 2018 Jun 14.
9. Tran CH, Sugimoto JD, Pulliam JR, et al. School-located influenza vaccination reduces community risk for influenza and influenza-like illness emergency care visits. PLoS One. 2014;9(12):e114479. Published 2014 Dec 9.

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