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Association between caregiver opposition to topical fluoride and COVID-19 vaccines

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ABSTRACT

Purpose: Caregivers who oppose topical fluoride in dental settings may be opposed to other preventive health treatments, including COVID-19 vaccines. The study objective was to examine the association between caregiver opposition to topical fluoride and COVID-19 vaccines.
Methods: The study took place at the University of Washington in Seattle, WA. English-speaking caregivers of children aged < 18 years were eligible to participate. An 85-item REDCap survey was administered from February to September 2021. The predictor variable was topical fluoride opposition (no/yes). The outcome was COVID-19 vaccine opposition (no/yes). The models included the following covariates: child and caregiver age; caregiver race and ethnicity, education level, dental insurance type, parenting style, political ideology, and religiosity; and household income. Logistic regression models generated odds ratios (OR) and 95 % confidence intervals ($\alpha = 0.05$).
Results: Six-hundred-fifty-one caregivers participated, and 403 caregivers with complete data were included in the final regression model. Mean child age was 8.5 years (SD 4.2), mean caregiver age was 42.1 years (SD 9.1), 53.0 % of caregivers were female, 57.3 % self-reported as white, and 65.5 % were insured by Medicaid. There was a significant positive association between topical fluoride and COVID-19 vaccine opposition (OR = 3.13; 95 % CI: 1.87, 5.25; $p < 0.001$). Other factors associated with COVID-19 vaccine opposition included conservative political views (OR = 2.77; 95 % CI: 1.26, 6.08; $p < 0.011$) and lower education (OR = 3.47; 95 % CI: 1.44, 8.38; $p < 0.006$).
Conclusions: Caregivers opposed to topical fluoride in dental settings were significantly more likely to oppose COVID-19 vaccines for their child. Future research should identify ways to address both topical fluoride and vaccine opposition to prevent diseases in children.

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1. Introduction

Vaccines help prevent and reduce transmission and severity of infectious diseases like severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), but many parents and caregivers are vaccine hesitant or opposed to childhood vaccines. Although vaccine hesitancy and opposition are long-standing public health challenges, the development of vaccines for children targeting the novel coronavirus disease 2019 (COVID-19) have put the issue at the center of preventive care decision making in recent years. The COVID-19 vaccine was authorized for emergency use by the United States (U.S.) Food and Drug Administration (FDA) initially in May 2021 for adolescents ages 12 to 15 years and then in November 2021 for children ages 5 through 11 years [1,2]. The vaccine most recently became available in June 2022 for children 6 months through 5 years old [3]. As of July 2022, data from the U.S. Centers for Disease Control and Prevention indicate that 30.5 % of eligible children ages 5 to 11 years old and 60.4 % of children ages 12 to 17 years old in the U.S. are fully vaccinated against COVID-19 [4]. Even smaller proportions of children under age 5, who are now eligible for the COVID-19 vaccine, are likely to be vaccinated [5]. Consequently, pediatric COVID-19 prevalence in the U. S. remains high. Of the total cumulative COVID-19 cases in the U.S., 18.6 % are attributed to children [5,6]. As individuals under the age

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of 18 comprise approximately 22.1 % of the total population in the U.S., this is an essential group to vaccinate [6,7]. These relatively low rates of vaccination highlight the importance of understanding why caregivers are hesitant and/or opposed to childhood vaccines.

The reasons for vaccine hesitancy and opposition are multifactorial. Consistent with past research on non-COVID-19 childhood immunizations, recent studies suggest that COVID-19 vaccine hesitancy and opposition may stem from similar beliefs, such as distrust in vaccine safety and efficacy, fear of adverse reactions or unknown long-term effects, low perceived severity of COVID-19 in children, and growing distrust of medical and healthcare providers [5,8]. Surveys of U.S. caregivers also indicate that COVID-19 vaccination intention and acceptability for children is lower among caregivers with less formal education, a conservative political ideology, and at least at the outset of the pandemic among non-white racial and ethnic groups [9,10]. Racial disparities persist, particularly among Black populations, leaving minoritized caregivers more hesitant about the COVID-19 vaccine compared to caregivers from other racial subgroups [5,11].

Analogous to the way in which vaccines prevent systemic diseases, fluoride helps prevent dental caries (tooth decay or cavities). Recent evidence affirms the effectiveness of topical fluoride in reducing the incidence of dental caries in high-risk children [12]. Yet one study found that 13 % of caregivers opposed topical fluoride treatment for their children during dental care visits and even larger proportions are likely to be hesitant about topical fluoride [13]. Drawing on the vaccination hesitancy literature, topical fluoride hesitancy is defined as a delay in acceptance, thoughts of refusal, or refusal of topical fluoride despite availability [14]. Although the caries risk of children whose caregivers refuse topical fluoride has not yet been formally studied, anecdotal evidence suggests that a substantial proportion of these children are not at low risk for caries and may have high levels of untreated, preventable tooth decay [15].

Previous work reported a significant association between opposition of topical fluoride and childhood vaccines, but there has been no recent research, especially during the COVID-19 pandemic [16]. The goals of the current study were to (1) evaluate whether caregiver opposition to topical fluoride was specifically associated with opposition to COVID-19 vaccines and (2) identify other factors associated with COVID-19 vaccine opposition. Knowledge gleaned from this study is expected to support development of public health and chairside strategies addressing caregiver opposition to preventive care for their children.

2. Materials and methods

2.1. Study Design, population and procedures

A single-site, observational cross-sectional study was conducted at the at the University of Washington Center for Pediatric Dentistry (UW CPD) in Seattle, Washington. All English-speaking parents and caregivers of children aged < 18 years who were current UW CPD patients of record were eligible to participate. An 85-item electronic survey created through Research Electronic Data Capture (REDCap) was administered. Caregivers were approached by study staff during routine patient care visits, defined as a dental checkup or treatment visit, and were asked to participate in the voluntary study. Participant recruitment took place between February 1, 2021 and September 30, 2021. A priori, a Monte Carlo simulation study was conducted and a proposed sample size of 500 caregivers was estimated to provide sufficient power for our measurement model. Participants could take the survey on their own electronic device, or a study-provided tablet. One caregiver per household was permitted to participate. For participants with multiple children, the index child was specified as the participant's youngest child. Informed consent for the study was requested through the electronic survey and obtained from participating caregivers prior to enrollment. All survey questions were optional, and participants could discontinue the survey at any time. If the survey could not be completed during their child's visit, participants were given the option to securely access and complete the survey later. All participants who submitted an electronic survey were entered into a raffle for the chance to win a prize, including an Apple iPad, a pair of Philips Sonicare toothbrushes, a $150 Amazon gift card, one of two $75 Amazon gift cards, or a $50 Target gift card, as a thank you for participation. The study was approved by the University of Washington Institutional Review Board.

2.2. Survey development

Survey development was informed by formative qualitative research conducted with caregivers that focused on understanding the causes of topical fluoride opposition [15]. The survey included questions on oral health knowledge, beliefs and reasons for opposition to topical fluoride, and beliefs about and opposition to COVID-19 vaccines. The goal of these questions was to understand reasons why caregivers were opposed to topical fluoride and COVID-19 vaccines. The survey was initially evaluated with caregivers using cognitive interviewing methods, pre-tested with caregivers and dentists, revised, and finalized. A final copy of the 85-item survey is available (see Supplemental Materials – Appendix A).

2.3. Predictor variable

The predictor variable was whether the caregiver expressed any opposition to topical fluoride. Topical fluoride was defined, and examples provided. Caregivers were asked, "On a scale of 0 to 10 with '0' being 'not at all opposed' and '10' being 'totally opposed,' how opposed are you to topical fluoride for your children?" Responses were recoded into a binary variable with those indicating no opposition (0) versus those indicating any opposition ($\geq$1). This is consistent with published conceptualizations of topical fluoride opposition [13].

2.4. Outcome variable

The outcome variable was whether the caregiver expressed any opposition to COVID-19 vaccines. Caregivers were asked "On a scale of 0 to 10 with '0' being 'not at all opposed' and '10' being 'totally opposed,' how opposed are you to a COVID-19 vaccine for your child/children?" Consistent with our predictor variable, responses were recoded into a binary variable with those indicating no opposition (0) versus those indicating any opposition ($\geq$1).

2.5. Covariates

The following caregiver-reported variables were model covariates: index child age; caregiver age, gender, race, ethnicity, education level; index child dental insurance type; caregiver parenting style, political ideology, religiosity; and household income.

Both child age and caregiver age were reported in years. Caregiver gender was included as male (reference group), female, non-binary, or other [17]. Caregiver race was included as white (reference group) or non-white based on caregivers' self-reported race in one or more categories adopted from the U.S. Census Bureau classification (white, Black, Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, other) [18]. We included caregiver ethnicity as either non-Hispanic (reference

group) or Hispanic. Caregiver education categories were: high school diploma or less, some college, four-year college degree, or more than a four-year degree [19]. The four-year college degree group served as the reference group. Child dental insurance type was included as: private insurance (reference group), insured by Medicaid, or no insurance [20]. We included caregiver parenting style using caregivers' responses to an item from the Parenting Sense of Competence Scale [21]. This item asked whether caregivers strongly agreed or agreed (reference group) or strongly disagreed or disagreed with the statement, "Children are likely to grow up happy and healthy without much intervention from their parents." Caregiver political ideology was included as: conservative or very conservative, moderate, or liberal or very liberal; with liberal or very liberal serving as the reference group [22]. We included caregiver religiosity ("how important is religion in your life") as very important, somewhat important, not too important, or not at all important; with not too important or not at all important serving as the reference group [23]. Finally, we included annual household income using four categories from the Behavioral Risk Factor Surveillance System Questionnaire: <$25,000, $25,000 to < $50,000, $50,000 to <$75,000, and ≥ $75,000. Greater than or equal to $75,000 served as the reference group [24].

2.6. Statistical analyses

Descriptive statistics and frequencies were generated to describe the study population and were reported as means and percentages. Multiple variable logistic regression models were used to evaluate the unadjusted and covariate-adjusted relationship between caregiver opposition to topical fluoride for their child/children and caregiver opposition to the COVID-19 vaccine for their child/children. The regression models produced odds ratios (OR) and 95 % confidence intervals (CI). We adopted an a priori model building approach in which all covariates were conceptualized as being associated with COVID-19 vaccine opposition, and therefore all covariates were included in the final regression model. We treated probability values<0.05 as statistically significant. All analyses were conducted using Stata version 15.0 statistical software.

3. Results

3.1. Participant demographics

A total of 651 caregivers responded to the survey. We excluded 248 caregivers because of missing data on any of the study variables, resulting in a final analytical sample of 403 caregivers (Table 1). Of the survey respondents, the mean age of the index child was 8.48 years (SD 4.2), the mean age of caregivers was 42.1 years (SD 9.1), 53.0 % of caregivers were female, 57.3 % were white, 52.2 % completed a four-year degree or more, and 65.5 % of the index children were insured by Medicaid. About 12.7 % of caregivers reporting being politically very conservative or conservative and 45.9 % were liberal or very liberal.

3.2. Opposition to topical fluoride and COVID-19 vaccines

One-hundred-ninety-four caregivers (32 %) expressed opposition to topical fluoride and 235 (46 %) expressed opposition to the COVID-19 vaccine. The survey responses for caregivers who expressed opposition to topical fluoride had a median of 0 and an interquartile range of 0 to 3. The survey responses for caregivers who expressed opposition to the COVID-19 vaccine had a median of 0 and an interquartile range of 0 to 5. Table 2 presents the bivariate relationships between COVID-19 vaccine opposition and each covariate. There was a significant association between topical fluoride opposition and COVID-19 vaccine opposition (OR = 3.52; 95 % CI: 2.22, 5.58; $p < 0.001$). After adjusting for covariates, caregivers who opposed topical fluoride were 3.13 times as likely to oppose COVID-19 vaccines for their child (95 % CI: 1.87, 5.25; $p < 0.001$) compared to those that did not oppose topical fluoride (Table 3).

3.3. Model covariates and opposition to COVID-19 vaccines

In the covariate-adjusted regression model, two covariates were significantly associated with caregiver opposition to the COVID-19 vaccine: education level and self-reported political ideology. Compared to caregivers who complete more than four years of college, an education level of a high school diploma or less was significantly associated with COVID-19 vaccine opposition (OR = 3.47; 95 % CI: 1.44, 8.38; $p < 0.006$). Having a moderate or conservative political ideology was also significantly correlated with COVID-19 vaccine opposition compared to parents who were liberal or very liberal (OR = 2.03; 95 % CI: 1.20, 3.44; $p < 0.008$ and OR = 2.77; 95 % CI: 1.26, 6.08; $p < 0.011$ respectively). Child or caregiver's age, gender, ethnicity, dental insurance type, parenting style, religiosity, and annual household income were not significantly associated with COVID-19 vaccine opposition in the covariate-adjusted regression model.

4. Discussion

In this observational cross-sectional study, we evaluated the association between caregivers' opposition to topical fluoride and to COVID-19 vaccines. There were two main findings: (1) there was a significant positive association between caregiver opposition to topical fluoride in dental settings and opposition to COVID-19 vaccines for children; and (2) caregivers' education level and conservative political ideology were other factors associated with opposition to COVID-19 vaccines.

The first finding is that caregiver opposition to topical fluoride is significantly associated with opposition to COVID-19 vaccines. Besides prior work indicating a significant association between topical fluoride opposition and opposition to general childhood immunizations, there is no other published material to which we can compare our current findings [25]. Caregivers who are concerned about topical fluoride may generally be more hesitant or opposed to other preventive care offered during healthcare visits [25,26]. While hesitancy may be fluid and variable, and thus amenable to a behavioral intervention, opposition to topical fluoride and COVID-19 vaccines are thought to be more rigid and may be more difficult to change [13,27]. Concerns underlying attitudes about topical fluoride and COVID-19 vaccines may be rooted in fears about safety and perceived long-term health impacts on children [5,8,26,28,29]. Opposition to preventive measures may also be an indicator of lower health literacy among caregivers, reinforcing the need for targeted public health efforts to reduce childhood diseases [29–32]. Future research should identify the specific mechanisms by which opposition to topical fluoride and COVID-19 vaccines are linked.

The second finding from our study is that other factors, including education level and political ideology, were significantly associated with caregiver COVID-19 vaccine opposition. This is consistent with previous research on reasons for COVID-19 vaccine hesitancy and opposition [5,9,11,32]. Regarding education level, we found that caregivers who had a high school diploma or less were more likely to oppose COVID-19 vaccines for their children than those who had completed more than four years of college. Current data show that adults in the U.S. who remain unvaccinated

Table 1
Description of Sociodemographic Characteristics of Caregivers Who Participated in a Survey Study on Topical Fluoride Opposition at the University of Washington (N = 403).

	Overall	Topical Fluoride Opposition		COVID-19 Vaccine Opposition	
	Mean (SD)%	Not Opposed Mean (SD)%	Opposed Mean (SD)%	Not Opposed Mean (SD)%	Opposed Mean (SD)%
Child Age	8.48 (4.2)	8.5(4.1)	8.4 (4.5)	**9.0 (4.2)**	**7.8 (4.2)**
Caregiver Age	42.1 (9.1)	42.2 (9.1)	41.8 (8.9)	**43.3 (8.4)**	**40.4 (9.7)**
Gender					
Male	47.0	46.7	47.7	44.7	50.0
Female	53.0	53.3	52.3	55.3	50.0
Race					
White	57.3	**63.6**	**40.4**	**67.4**	**43.9**
Non-White	42.6	36.4	59.6	32.6	56.1
Ethnicity					
Hispanic	13.4	13.6	12.8	12.2	15.0
Non-Hispanic	86.6	86.4	87.2	87.8	85.0
Education Level					
High School Equivalent or Less	14.6	14.6	14.7	**9.1**	**22.0**
Some College/Two Year Degree	33.3	31.6	37.6	31.3	35.8
Four-Year Degree	25.1	23.8	28.4	25.2	24.9
More Than Four Years	27.1	29.9	19.3	34.4	17.3
Child Dental Insurance Type					
Private	29.0	31.6	22.0	**33.9**	**22.5**
Medicaid/Public	65.5	63.3	71.6	61.3	71.1
No Insurance	1.0	1.4	0	1.7	0
Other	4.5	3.7	6.4	3.0	6.4
Parenting Style					
Involved	19.1	17.7	22.9	17.4	21.4
Not Involved	80.9	82.3	77.1	82.6	78.6
Political Ideology					
Very Conservative/Conservative	12.7	**10.9**	**17.4**	**8.3**	**18.5**
Moderate	41.4	39.5	46.8	33.5	52.0
Very Liberal/Liberal	45.9	49.7	35.8	58.3	29.5
Religiosity					
Very Important	32.8	**30.3**	**39.5**	**26.1**	**41.6**
Somewhat Important	25.8	24.5	29.4	23.5	28.9
Not Very/Not Important	41.4	45.2	31.2	50.4	29.5
Annual Household Income					
<$25,000	14.1	**11.9**	**20.2**	**13.5**	**15.0**
$25,000-$50,000	24.1	20.8	33.0	18.3	31.8
$50,000-$75,000	19.9	21.1	16.5	20.0	19.7
≥$75,000	41.9	46.3	30.3	48.3	33.5

p-values < 0.05 highlighted in boldface.

against COVID-19 generally have a lower level of formal education [9,11,31,32]. Caregivers who are unvaccinated and demonstrate hesitancy about the COVID-19 vaccine for themselves also report that they are less likely to vaccinate their child [33]. However, vaccine hesitancy may be dynamic. A recent study reported drops in hesitancy associated with COVID-19 vaccination roll outs for children in China [34]. Regarding political ideology, the COVID-19 vaccine has been politicized in the U.S., which has influenced vaccination rates [11,35,36]. Specifically, individuals who self-identify as politically conservative are more opposed to COVID-19 vaccines, which is consistent with our findings [36–38]. Because of the influence politics have had on the pandemic, it is necessary to understand opposition patterns among political conservatives and how mistrust and doubt in science, healthcare and experts affect a caregiver's decision to oppose COVID-19 vaccines for their child [39,40].

One finding from our study that warrants additional attention is how COVID-19 vaccine opposition is associated with self-reported race. As shown in Table 2, the bivariate relationship between caregiver race and COVID-19 vaccine opposition was statistically significant whereby non-whites were significantly more likely to be opposed to the COVID-19 vaccine for their children than white caregivers. However, in our covariate-adjusted model, race failed to achieve statistical significance. Past research has reported significant differences in hesitancy and opposition to the COVID-19 vaccine by race [9–11]. Our findings suggest that the effect of race may be partly driven by other factors. More specifically, attitudes about COVID-19 vaccination may be influenced by longstanding health disparities and distrust in the healthcare system rooted in historical injustices, rather than opposition to the COVID-19 vaccine itself [39,41]. Additional research is needed on how race can influence caregiver acceptance of preventive treatments like vaccines and topical fluoride.

Our study has important implications for health education and clinical practice. First, improving communication strategies between healthcare providers and caregivers is essential to address gaps in preventive care and improve health outcomes for children. A targeted approach to improve acceptability of treatments like topical fluoride and vaccines could involve training of health professional students on how to deploy effective communication strategies [42]. This training would equip future providers with strategies on how to engage with caregivers in open-ended conversations about important preventive care topics without judgement [13,42–44]. These conversations could help build trust between caregivers and providers [43,44]. A starting point to such conversations is understanding the reasons why caregivers are opposed to preventive care, like topical fluoride. This knowledge is critical in understanding barriers to acceptance of preventive treatment and can guide effective communication approaches with caregivers. Use of screening tools could help providers identify hesitant caregivers and indicate reasons for hesitancy [13].

Given the caregivers' role in making health decisions for children, topical fluoride opposition may be a bellwether for future challenges [45]. For example, in dentistry, the use of amalgam, at

Table 2
Bivariate Regression Coefficients Between COVID-19 Vaccine Opposition and Each Covariate (N = 403).

	Unadjusted Odds Ratio (95 % CI)	*p*-Value
Topical Fluoride Opposition		
Opposed	3.52 (2.22–5.58)	**<0.001**
Not Opposed*	–	–
Child Age (Years)	0.93 (0.89–0.98)	**0.01**
Caregiver Age (Years)	0.96 (0.94–0.99)	**0.002**
Gender		
Male*	–	–
Female	0.80 (0.50–1.27)	0.34
Race		
White*	–	–
Non-White	2.64 (1.75–3.97)	**<0.001**
Ethnicity		
Hispanic	1.28 (0.72–2.27)	0.41
Non-Hispanic*	–	–
Education Level		
High School Equivalent or Less	4.77 (2.42–9.39)	**<0.001**
Some College/Two Year Degree College	2.27 (1.32–3.89)	**0.003**
Four-Year Degree	1.95 (1.10–3.47)	**0.02**
More Than Four Years*	–	–
Child Dental Insurance Type		
Private*	–	–
Medicaid/Public	1.74 (1.11–2.75)	**0.02**
Other	2.00 (0.80–5.02)	0.14
Parenting Style		
Involved	1.29 (0.79–2.13)	0.31
Not Involved*	–	–
Political Ideology		
Very Conservative/Conservative	4.43 (2.30–8.50)	**<0.001**
Moderate	3.07 (1.97–4.78)	**<0.001**
Very Liberal/Liberal*	–	–
Religiosity		
Very Important	2.73 (1.70–4.39)	**<0.001**
Somewhat Important	2.11 (1.27–3.49)	**0.004**
Not Very/Not Important*	–	–
Annual Household Income		
<$25,000	1.61 (0.87–2.96)	0.13
$25,000-$50,000	2.51 (1.50–4.18)	**<0.001**
$50,000-$75,000	1.41 (0.82–2.44)	0.21
≥$75,000	–	–

p-values < 0.05 highlighted in boldface.
* Reference Group.

Table 3
Covariate-Adjusted Regression Model for Surveyed Caregivers for COVID-19 Vaccine Opposition (N = 403).

	Unadjusted Odds Ratio (95 % CI)	*p*-Value
Topical Fluoride Opposition		
Opposed	3.13 (1.87–5.25)	**<0.001**
Not Opposed*	–	–
Child Age (Years)	0.94 (0.89–1.00)	0.06
Caregiver Age (Years)	0.98 (0.96–1.01)	0.29
Gender		
Male*	–	–
Female	0.67 (0.38–1.19)	0.17
Race		
White*	–	–
Non-White	1.55 (0.94–2.54	0.09
Ethnicity		
Hispanic	0.82 (0.42–1.60)	0.56
Non-Hispanic*	–	–
Education Level		
High School Equivalent or Less	3.47 (1.44–8.38)	**0.01**
Some College/Two Year Degree College	1.85 (0.97–3.53)	0.06
Four-Year Degree	1.80 (0.92–3.52)	0.09
More Than Four Years*	–	–
Child Dental Insurance Type		
Private*	–	–
Medicaid/Public	1.15 (0.62–2.12)	0.66
Other	1.24 (0.39–3.93)	0.71
Parenting Style		
Involved	1.27 (0.72–2.26)	0.41
Not Involved*	–	–
Political Ideology		
Very Conservative/Conservative	2.77 (1.26–6.08)	**0.01**
Moderate	2.03 (1.20–3.44)	**0.01**
Very Liberal/Liberal*	–	–
Religiosity		
Very Important	1.28 (0.69–2.36)	0.44
Somewhat Important	1.37 (0.76–2.48)	0.30
Not Very/Not Important*	–	–
Annual Household Income		
<$25,000	0.58 (0.25–1.33)	0.20
$25,000-$50,000	1.05 (0.53–2.06)	0.89
$50,000-$75,000	0.81 (0.41–1.60)	0.55
≥$75,000	–	–

p-values < 0.05 highlighted in boldface.
* Reference Group.

one time a common dental filling material, has substantially declined in the past decade [46]. This stemmed from concerns about perceived environmental and health effects of mercury in amalgams [47]. Though dental amalgam is proven to be safe and effective for use in children, its use has largely been phased out in most of Europe and the U.S. because of caregiver concerns and opposition [48,49]. Topical fluoride opposition in dental settings today may lead to a similar phenomenon in the future, leaving children at high-risk for caries even more susceptible to dental disease if dentistry were to lose fluoride as a preventive strategy [13,16,26]. Untreated dental disease in high-risk children is further exacerbated by inequitable access to dental care [50]. As caregiver acceptance of preventive health interventions evolves, it is important to address underlying factors that drive opposition to care [51].

There are four main study limitations. First, our participants include a convenience sample of caregivers at a single site. Our findings may not be representative beyond the population studied and caution in generalization of our findings is warranted. Second, there may be common risk factors associated with both topical fluoride and COVID-19 vaccine opposition that were not directly tested. The common risk factor approach is an alternative conceptual model that could be used to identify the factors related to both topical fluoride and COVID-19 vaccine opposition [16,52]. Third, hesitancy is a continuous phenomenon and opposition may not be binary as modeled in our study. Future work should continue to elucidate the complex relationship between hesitancy and opposition. Fourth, nearly-one-third of survey participants were excluded from the regression analyses because of missing data, which may affect both internal and external generalizability of findings. Participants with missing data on at least one other question, but not COVID-19 vaccine opposition or topical fluoride opposition, were significantly more likely to express opposition to each (OR = 2.1 and 2.0, respectively). This suggests that missing data were not completely missing at random. Future research should continue to identify ways to reduce missing data in health surveys.

5. Conclusions

The following conclusions can be drawn from the findings of this study:

1. Caregiver topical fluoride opposition in dental settings was significantly associated with COVID-19 vaccine opposition for their children, even after adjusting for other variables.
2. Caregiver educational level and self-reported political ideology were also significantly associated with COVID-19 vaccine opposition in the covariate-adjusted regression model.

3. Additional research is needed to develop clinical interventions, including tailored and evidence-based communication strategies and a clinical screening tool for fluoride opposition.

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CRediT authorship contribution statement

Sapna J. Saini: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Adam C. Carle:** Methodology, Software, Validation, Formal analysis, Data curation, Writing – review & editing. **Anna R. Forsyth:** Investigation, Writing - review & editing. **Donald L. Chi:** Conceptualization, Methodology, Supervision, Funding acquisition, Project administration, Writing - original draft, Writing - review & editing.

Data availability

Data will be made available on request.

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.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2022.12.018.

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