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The association of COVID- 19 parental immunization and transmission of disease to offspring: a retrospective study

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Abstract

Background The Omicron variant has heightened COVID- 19 infections among children under six, emphasizing the need to understand the role of parental immunization and demographic factors in disease transmission within households.

Methods This retrospective observational study included 2321 children under six-year-old from February to May 2022 in Isfahan, Iran. Data were sourced from the recorded PERSIAN Birth Cohort data and telephone interviews, focusing on demographic information, child's COVID- 19 exposure during follow-up, infection, and vaccination status of each family member.

Result Out of 2321 children, the incidence rate of COVID- 19 during the sixth peak was determined to be 46%. Both maternal (X^2: 1237.0; *p*-value < 0.001) and paternal (X^2: 1003.1; *p*-value < 0.001) COVID- 19 infections were identified as significant risk factors for infection of children.

Although paternal vaccination showed a statistically significant association with reduced infection rates among children ($p = 0.036$), maternal immunization did not demonstrate a significantly correlation. After Adjusting covariates, higher odds of child COVID- 19 incidence were associated with maternal infection (OR = 37.74, 95%CI: 24.86- 57.27), paternal infection (OR = 6.50,95% CI: 4.74–8.92), and maternal age older than 30 years old (odds ratio: 0.58, 95% CI: 0.49 to 0.68). Additionally, lower odds of infection were related to living at homes with optimal cleanness (odds ratio: 0.8, 95% CI: 0.6 to 0.9). Although in a crude model, the odds of infection of children in low-income families was 60% more than in moderate- or high-income families; this probability was not statistically significant in the adjusted model.

Conclusion This study underscores the significant role of parental transmission and paternal immunization in child COVID- 19 infections and the dimension of infection rates during the Omicron peak. Regarding the occupational conditions of fathers in our society and the characteristics of the COVID- 19 virus, paternal immunization should be prioritized over maternal immunization to mitigate disease transmission. Also, the sanitation of the home is crucial to prevent of risk of infection in children.

Keywords COVID- 19, Vaccination, Transmission, Demographic Factors

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Background

Although at the onset of the COVID- 19 pandemic, the most severely affected people were in the elderly age, the progressive trend of infected children captured interest regarding the transmission of the disease and its unknown effects during childhood [9].

Amidst the global dynamics of the sixth peak in the COVID- 19 pandemic, the Omicron variant has significantly influenced infection rates, hospitalizations, and mortality across various age groups [37]. Notably, the mortality rates, although lower than previous peaks, raised concerns as the virus became the second leading cause of death in January 2022 in the United States [21]. In Iran, the peak witnessed a surge of over 39,000 new cases in a single day, with a total of about 375,000 active cases by mid-February 2022 [37].

Although children in comparison to other age groups are less vulnerable to COVID- 19 [10], almost two years into the pandemic, the Omicron strain surfaced causing a surge in infections in this age group [14]. This variant, characterized by increased affinity to host cell receptors and ability to evade immunity, poses a substantial threat to children [2], They experience symptoms from subclinical to severe manifestations [10, 30], ranging from fever, cough, and vomiting to severe complications like seizures and multisystem inflammatory syndrome in children (MIS-C) [3, 4, 7, 33].

Preventive strategies for COVID- 19 in young children involve protecting pregnant and breastfeeding individuals to restrict neonatal infections; maintaining hand hygiene and mask use to minimize horizontal spread; and ensuring universal immunization of at-risk groups [32, 37]. Studies have shown a high probability of disease transmission in household connections [8, 22, 26]. Other studies pointed to the high prevalence of secondary infection rate of 30.5% especially in overcrowded environments [43], and highlighted household transmission for 25.1% to 38.5% of the total infections [46].

Vaccination has played a crucial role in preventing severe cases, hospitalizations, and deaths, particularly among children aged five and older(Jeané [6, 18, 24]). However, the result of a systematic review has pointed to the efficacy of SARS-CoV- 2 vaccination from 16–95% reduction of transmission in most studies irrespective of the type, and number of doses of vaccine [31], the effectiveness of the Omicron variant raised concerns about transmissibility due to the declining rate (16–31%) in comparison to the pre-delta and delta variants [2, 13, 31]. On the other hand, studies indicate that two doses of vaccination may offer limited protection, emphasizing the significance of booster doses in providing substantial defense against both mild and severe disease [41].

In Iran, vaccination against COVID- 19 was initiated in February 2021 for the high-risk group with Sputnik V vaccine and continued for other population groups gradually with Sinopharm, AstraZeneca, COVIran Barakat [29]. As children under five years old are excluded from the national vaccination program, they face heightened vulnerability. Their exposure to the disease during this latest peak is influenced by the immunity status of other family members. On the other hand, with the heightened transmissibility of the Omicron variant and notable clusters of infections within families, many of these children may face increased exposure to disease and retransmission of it in society. The PERSIAN Birth cohort offers a unique opportunity to investigate the impact of parents' vaccination and prior infection of family members on the susceptibility of these children, who are under six years old and have not received the vaccine. On the other hand, Given the uncertain characteristics of the prolonged impact of COVID- 19 on the health of children, it is crucial to focus on its occurrence among children. The aim of this study was to investigate the association between Parents' immunization and other demographic characteristics with the presence of COVID- 19 among the Isfahan birth cohort.

Materials and methods

Study design and population

This retrospective cohort study was conducted among 2,321 children under six years of age during the sixth epidemic peak of COVID- 19 in Isfahan, Iran, from February 2022 to May 2022. The study is a sub-study of the PERSIAN Birth Cohort [45] in Isfahan, which initially included 3,146 children born during the cohort study period. Participants were included if they met the following criteria: (1) children under six years of age whose parents consented to participate in the study, (2) completion of the telephone interview within the specified time frame (February 2022 to May 2022), and (3) availability of complete data on COVID- 19 infection status (confirmed, suspected, or negative) for both the child and their parents. Children were excluded if they had missing or incomplete data on key variables (e.g., vaccination status, infection status, or demographic information) if their families declined to participate or were unreachable during the data collection period, or if they had pre-existing conditions that could confound the association between parental immunization and COVID- 19 transmission (e.g., immunocompromised status or chronic respiratory diseases). The clinical diagnosis of COVID- 19 included a comprehensive evaluation encompassing epidemiological history, clinical manifestations, and confirmation via a positive Polymerase Chain Reaction (PCR) test. A suspected case pertains to an individual presenting

symptoms aligning with COVID- 19, irrespective of their vaccination status. Conversely, a negative diagnosis applies to those who either display no symptoms or return a negative result on the PCR test [19]. Additional variables, such as household cleaning frequency (classified as more than once a week, once a week, monthly, or occasionally) and breastfeeding quality, were collected through interviews with mothers.

Data collection

The data for this retrospective cohort study were obtained from two sources of the PERSIAN Birth Cohort database related to Isfahan; and telephone interviews during the sixth peak of the COVID- 19 epidemic from 3146 children. Demographic information, including age, gender, socioeconomic status (assessed using family income and parental education levels), and parental occupations, was retrieved from these sources. These demographic factors were included in the analysis to assess their potential impact on COVID- 19 transmission and to control for confounding in statistical models. Additionally, information regarding the child's exposure to the disease during follow-up, as well as details related to the infection status of each family member (categorized as suspected, negative, or confirmed) and their vaccination status (classified as one dose, two doses, or completed with a booster dose) based on registered data in National Covid- 19 vaccination registration system from https://salamat.gov.ir/. To maintain data integrity, meticulous procedures were employed during the extraction process, ensuring both accuracy and reliability. This involved adherence to detailed protocols and the implementation of rigorous quality control measures to identify and rectify any discrepancies or errors in the collected data.

Study endpoints

This study has been done to assess the incidence rate of COVID- 19 and its association among children under six years with the vaccination and infection status of other family members. The incidence rate will be calculated using a well-established formula, taking into account the number of new cases within the specified population in the defined time frame, which spans from February 2022 to May 2022.

Ethical considerations

The study strictly adhered to the ethical principles outlined in the Declaration of Helsinki 2013. Ethical approval for the study protocol was obtained from the Ethics Committee of Isfahan University of Medical Science. All participants willingly provided their informed consent in person.

Statistical analysis

This study conducted a comprehensive descriptive analysis, summarizing demographic variables and key study parameters, along with presenting categorical variables in frequency tables. To investigate factors associated with child incidence of COVID- 19, Chi-squared (χ^2) tests were employed for categorical variables. Additionally, a logistic regression model was constructed to assess the association between COVID- 19 incidence in children and various factors. Odds ratios (OR) with corresponding confidence intervals (CI) were calculated to quantify the level of effect, and potential confounding variables were adjusted as necessary. Model diagnostics and validation, including goodness-of-fit tests, were performed. The statistical analysis was carried out using SPSS version 26. A 2-sided P value of less than 0.05 was considered to indicate statistical significance.

Results

The final participants comprised 2,321 children with their parents. The study population's baseline characteristics are presented in Table 1.

According to it, the mean age of children who participated was 56.5 ± 7.2 months, and the lowest incidence of infection was related to children below 36 months. The majority of cases fell within the 48–60 months category (57.4%), followed by 60–72 months (33.1%). Exclusive breastfeeding was predominant (72.81%), with varied evaluations of breastfeeding quality from their mother's perspective. Interestingly, a considerable number of subsequent infections had been reported with a lack of clarity on specific diagnostic symptoms. The prevalence of infection among children for the 1 st, 2nd, 3rd, more than 3^{ed} were respectively 35.6, 14.2, 5.3, 2.9%. Home remedies prevailed as a post-infection treatment (93.5%), and complications were observed only in 2.8% of cases. Overall, the incidence rate of COVID- 19 in this cohort, within the specified timeframe in children under 6 years of age was 46% with the most of mild symptoms.

The essential baseline and demographic characteristics of the parents are summarized in Table 2.

Maternal COVID- 19 infection was prevalent in 57.9% of cases, with multiple occurrences noted. Regarding maternal vaccine status, 52% received two doses, 27% three doses, and 7.9% one dose. The most common vaccine types were Sino pharm, AstraZeneca, and COV Iran Barakat.

A significant portion (55.9%) of fathers had a COVID-19 infection. Paternal vaccine status showed a distribution similar to maternal status (Table 2). The transmission of the virus from other family members occurred in

Table 1 Baseline Characteristics of Children who participated in the study ($N = 2321$)

	N (%)
Gender	
Boy	**1123 (48.38)**
Girl	**1198 (51.61)**
Age	
24–36 months	**6 (0.3)**
36–48 months	**214 (9.2)**
48–60 months	**1333 (57.4)**
60–72 months	**768 (33.1)**
Type of Breastfeeding	
Exclusive Breastfeeding	**1690 (72.81)**
Formula	**205 (8.8)**
Both	**426 (18.35)**
Quality of Breastfeeding (Maternal Attitude)	
Poor	**120 (5.2)**
Fair	**181 (7.8)**
Adequate	**1441 (62.1)**
Excellent	**579 (24.9)**
Usage of anti-allergic drug	
Yes	**97 (4.18)**
No	**2224 (95.82)**
COVID- 19 infection in child	
Yes	**1069 (46.1)**
No	**1252 (53.9)**
Number of COVID- 19 Infections diagnosed by physicians	
Not referred to physician	**976 (42)**
1 Time	**826 (35.6)**
2 Time	**329 (14.2)**
3 Time	**123 (5.3)**
More than 3 times	**67 (2.9)**
Type of COVID- 19 diagnosis for the1 st infection	**1066 (45.93)**
Symptoms with negative PCR	**3 (0.13)**
Suspicious PCR	**1010 (43.52)**
Diagnosis at home without a physician's examination	**13 (0.056)**
Symptoms and positive PCR	**36 (1.55)**
Positive PCR without symptoms	**4 (0.17)**
Initial COVID- 19 infection	**1001 (43.13)**
Before the 1 st time of parents' vaccination	**961 (41.40)**
After the 1 st **1 st, 3rd** parents' vaccination	**20 (0.86)**
Before the **2nd** of parents' vaccination	**16 (0.69)**
After the **2nd** time of parents' vaccination	**4 (0.17)**
Before or after the **3rd** of parents' vaccination	**0 (0.00)**
Type of COVID- 19 diagnosis for **2nd** time	**1049 (45.20)**
Symptoms with negative PCR	**7 (0.3)**
Suspicious PCR	**1022 (44.03)**
Diagnosis at home without a physician's examination	**0 (0.00)**
Symptoms and positive PCR	**19 (0.82)**
Positive PCR without symptoms	**1 (0.04)**
Treatment type after 2nd infection	**1049 (45.20)**
Home Remedy	**644 (27.75)**
Outpatient treatment	**403 (17.36)**
Hospitalization	**2 (0.09)**
Type of COVID- 19 diagnosis for the 3ed infection	**234 (10.08)**
Symptoms with negative PCR	**2 (0.09)**
Suspicious PCR	**149 (6.42)**
Diagnosis at home without a physician's examination	**0 (0.00)**
Symptoms and positive PCR	**83 (3.58)**
Positive PCR without symptoms	**0 (0.00)**
Subsequent COVID- 19 infection (3rd time)	**234 (10.08)**
Before the 1 st time of parents' vaccination	**214 (9.22)**
After the 1 st time of parents' vaccination	**6 (0.26)**
Before the 2nd time of parents' vaccination	**12 (0.52)**
After the 2nd time of parents' vaccination	**2 (0.09)**
Before or after the 3rd time of parents' vaccination	**0 (0.00)**
Treatment type after 3rd infection	**234 (10.08)**
Home Remedy	**82 (3.53)**
Outpatient treatment	**152 (6.55)**
Hospitalization	**0 (0.0)**
Complications after Infection	
Yes	**64 (2.8)**
No	**2257 (97.2)**
Infection of other children	
Unknown	**964 (41.5)**
Single-child family	**493 (21.2)**
Yes	**555 (23.9)**
No	**309 (13.3)**
Family income	
Low	**577 (24.9)**
Moderate	**1630 (70.2)**
High	**114 (4.9)**
Cleaning house	
Never	**4 (0.2)**
Less than once a week	**184 (7.9)**
Every week	**958 (41.3)**
More than once a week	**1175 (50.6)**

35.1% of cases, indicating the potential role of family dynamics in the spread of COVID- 19.

Child age, gender, and newborn weight did not show statistically significant associations with COVID- 19 incidence. As shown in Table 3, maternal infection status regardless of the number of infections exhibited a strong correlation with child COVID- 19 infections (X^2: 1237.0; p-value < 0.001). While maternal vaccine status, including the number of doses and the type of vaccine received, did not show a statistically significant association with child COVID- 19 incidence. The paternal COVID- 19 infection status demonstrated a strong correlation with

Table 2 Demographic Characteristics of Parents in the study($N = 2321$)

	Maternal N (%)	Paternal N (%)
Educational level		
illiterate or ≤ 5 year	**109 (4.7)**	**156 (6.7)**
Between 6–12 year	**1445 (62.3)**	**1856 (80)**
Academic education	**767 (33)**	**309 (13.3)**
Employment status		
Retired or Jobless/Housewives	**199 (9.37)**	**2124 (91.52)**
Occupied	**2122 (90.63)**	**197 (8.48)**
Childcare status		
Home (By mothers)	**1264 (54.45)**	
Kindergarten Or Other relatives	**1057 (45.55)**	
COVID- 19 infection		
Yes	**1344 (57.9)**	**1297 (55.9)**
No	**977 (42.1)**	**1024 (44.1)**
Number of COVID- 19 Infection diagnosed by physicians		
Not Infected	**976 (42)**	**1029 (44.3)**
1 Time	**826 (35.6)**	**15 (0.6)**
2 Times	**329 (14.2)**	**953 (41.1)**
3 Times	**123 (5.3)**	**17 (0.7)**
More than 3 times	**67 (2.9)**	**299 (12.9)**
Type of COVID- 19 diagnosis for 1 st infection		
Symptoms with negative PCR	**22 (0.9)**	**183 (7.9)**
Suspicious PCR	**1138 (49.0)**	**1206 (52.0)**
Diagnosis at home without a physician's examination	**981 (42.3)**	**627 (27.0)**
Symptoms and positive PCR	**174 (7.5)**	**296 (12.7)**
Positive PCR without symptoms	**6 (0.3)**	**9 (0.4)**
Initial COVID- 19 infection		
Diagnosis without a physician's examination		
Before the 1 st time of vaccination	**1008 (43.4)**	**1619 (69.8)**
After the 1 st time of vaccination	**92 (4.0)**	**156 (6.7)**
Before the 2nd time of vaccination	**40 (1.7)**	**181 (7.8)**
After the 2nd time of vaccination	**50 (2.2)**	**315 (13.6)**
Before the 3rd time of vaccination	**0 (0.0)**	**50 (2.1)**
After the 3rd time of vaccination	**143 (6.2)**	
Treatment type after 1 st maternal infection	**2321 (100)**	**1479 (63.7)**
Not referred	**992 (42.7)**	**138 (5.9)**
outpatient	**1313 (56.6)**	**165 (7.1)**
General Admission	**11 (0.5)**	**495 (21.4)**
Hospitalization	**5 (0.2)**	**44 (1.9)**
Type of COVID- 19 diagnosis for 2nd infection		
Unknown	**1796 (77.4)**	**1046 (45)**
Symptoms with negative PCR	**8 (0.3)**	**15 (0.6)**
Suspicious PCR	**493 (21.3)**	**953 (41.1)**
Symptoms and positive PCR	**24 (1.0)**	**299 (12.9)**
Positive PCR without symptoms	**0 (0.0)**	**8(0.4)**
vaccination status		
1 Dose	**183 (7.9)**	**177 (7.6)**
2 Doses	**1206 (52.00)**	**1126 (48.5)**
3 Doses	**627 (27.00)**	**722 (31.1)**

Table 2 (continued)

	Maternal N (%)	Paternal N (%)
Doubtful the number of Vaccination	**296 (12.8)**	**287 (12.4)**
Not vaccinated	**9 (0.4)**	**9 (0.4)**
The 1 st-dose vaccine type		
Sinopharm	**1739 (74.9)**	**1619 (69.8)**
AstraZeneca	**82 (3.6)**	**156 (6.7)**
COVIran Barakat	**116 (5.0)**	**181 (7.8)**
Unknown	**316 (13.6)**	**315 (13.6)**
Others	**68 (2.9)**	**50 (2.1)**
The 2nd-dose vaccine type		
Sinopharm	**1598 (68.8)**	**1479 (63.7)**
AstraZeneca	**63 (2.7)**	**138 (5.9)**
COVIran Barakat	**102 (4.4)**	**165 (7.1)**
Unknown	**501 (21.6)**	**495 (21.4)**
Others	**57 (2.5)**	**44 (1.9)**
The 3rd-dose vaccine type		
Sinopharm	**488 (21.0)**	**514 (22.1)**
AstraZeneca	**35 (1.5)**	**40 (1.7)**
COVIran Barakat	**27 (1.2)**	**66 (2.1)**
Unknown	**1701 (73.3)**	**1615 (70.4)**
Others	**70 (3.0)**	**86 (3.7)**

Table 3 Association between Maternal and Paternal Factors and children's COVID- 19 infection incidence

Variable		
Infection Status	Maternal	Paternal
COVID- 19 infection	X^2: 1237.0*	X^2: 1003.1*
The 1 st infection	X^2: 1.4 *	X^2: 2.5 *
The 2nd infection	X^2: 540.6*	X^2: 220.6*
the 3rd infection	X^2: 220.5*	X^2: 110.5*
Vaccination Status		
Number of vaccine doses	X^2: 3.7(p = 0.440)	X^2: 10.3(p = 0. 0.036)
Type of initial vaccine	X^2: 16.1(p = 0. 0.095)	X^2: 15.9(p = 0. 0.01)
Type of 2nd vaccine	X^2: 13.0(p = 0. 0.160)	X^2: 13.8(p = 0. 0.02)
Type of 3rd vaccine	X^2: 8.9(p = 0. 0.351)	X^2: 12.3(p = 0. 0.05)

* : *P* value ≤ 0.001

child COVID- 19 infections (X^2: 1003.1; *p*-value < 0.001). Regarding paternal immunization status, the number of paternal vaccine doses exhibited a statistically significant association with child infection incidence (X^2: 10.3; *p*-value 0.036) (Table 3). Overall, we observed a declining rate of infection after paternal vaccination.

The logistic regression model (Table 4) illuminates key factors associated with the incidence of COVID- 19 in children. Maternal COVID- 19 infection emerges as a significant risk factor, indicating approximately a 38-fold increase in the odds of infection in children (adjusted OR: 37.74, 95% CI: 24.86 to 57.27, *p*-value < 0.001). Similarly, paternal COVID- 19 infection substantially contributes to the risk, showing a 6.5-fold increase in the odds of infection in children (adjusted OR: 6.50, 95% CI: 4.74 to 8.92, *p*-value < 0.001). The frequency of cleaning the house demonstrates a protective effect, with those cleaning more than once a week exhibiting lower odds of infection in children (adjusted OR: 0.75, 95% CI: 0.61 to 0.93, *p*-value = 0.007). Exclusive breastfeeding for up to 6 months demonstrated a protective effect, reducing 20% the odds of COVID- 19 incidence (odds ratio: 0.8, 95% CI: 0.7 to 0.9) in the crud model. Notably, parent's age, exclusive breastfeeding, and family income did not demonstrate a significant association with COVID- 19 infection in children.

Discussion

In the present study, the incidence rate of COVID- 19 and its association among children under six years old during the peak of the Omicron variant were assessed. We found the significance of disease transmission from parents to children, irrespective of parents' immunization. We observed a higher prevalence of COVID- 19 infection among children residing in households with suboptimal cleanliness. Our finding also revealed a lower incidence rate of COVID- 19 among children whose fathers had

Table 4 Associations between Demographic Factors and Child COVID- 19 Infection incidence

Variable	Crude		Adjusted	
	Crude OR (95% confidence interval)	***P*-value**	**Adjusted OR (95% confidence interval)**	***P*-value**
Maternal COVID- 19 infection	96(66—139)	< 0.001*	37.74(24.86- 57.27)	< 0.001*
Paternal COVID- 19 infection	29(23—38)	< 0.001*	6.50(4.74—8.92)	< 0.001*
Father's age				**0.770**
≤ 30 years	**Ref**			
> 30 years			**0.996(0.972–1.021)**	
Mother's age		**0.03***		0.04*
≤ 30 years	**Ref**			
> 30 years	**0.8(0.6 to 0.9)**		**0.6(0.3- 0.7)**	
Type of Breastfeeding		**0.001***		**0.186**
Exclusive Breastfeeding	**Ref**			
Non-exclusive Breastfeeding	**0.8(0.7–0.9)**		**0.89(0.74- 1.06)**	
Quality of Breastfeeding		**0.189**		**0.327**
Adequate or excellent	**Ref**			
Poor or fair	**1.2(0.9 to 1.4)**			
Family income		**< 0.001***		**0.127**
Low	**Ref**			
Moderate or high	**0.58(0.49–0.68)**		**0.81(0.62–1.06)**	
Cleaning house		**0.009***		0.007*
More than once a week	**0.8(0.7–0.9)**		**0.75(0.61–0.93)**	
Less than once a week	**Ref**		**Ref**	

Models were adjusted with Age, Weight, Gender, Quality of Breastfeeding, Paternal education and occupation, Paternal age, Use of anti-allergic drugs, parental vaccination, Presence of chronic disease in parents, Disease and Hospitalization of children before 2 months

been vaccinated, highlighting the potential protective effect of paternal vaccination.

Our findings revealed the likelihood of contracting COVID- 19 in children in the presence of mothers and fathers infected was 37.73, and 6.5 times respectively compared to mothers and fathers who were not infected. One explanation for a higher rate of association between maternal COVID- 19 infection and infection in offspring in comparison to fathers is linked to a more intimate physical connection with their children during quarantine. In agreement with our findings, a community-based study emphasizes the correlation between the presence of disease and infection risk in household contacts [11]. Overall, in accordance with other studies, shared living spaces have a critical role in the diffusion of disease [8, 22, 26, 35]. In a study conducted by Maltezou et. al. in Greece, an examination of 23 familial clusters showed that adults were the initial case of the disease, thereby focusing on the progression of the disease from adult to the child rather than vice versa [27].

In addition, vaccination is a preventive strategy to transmit disease not only to adults but also to their children [35]. According to our findings, the immunization of fathers, rather than the type of vaccine, played a more critical role than that of mothers in the prevention of infection. As shown in Table 2, the majority of mothers were housewives, and although near half of them cared for their children out of home, the closure of kindergartens, and quarantine conditions forced them to keep their children with themselves. This observation may be attributed to the socio-cultural context in Iran, where fathers have higher occupational exposure to COVID-19 due to working outside the home more than mothers, increasing the likelihood of being the virus carrier. On the other hand, the majority of pediatric subjects were approximately five years old, and the role of importance of mothers'vaccination is highlighted during gestation and lactation through passive transfer of antibodies [5]. On the other hand, mothers' immunization did not correlate with the progression of disease in children who were involved in the current study aged 2–6 years old with a predominant concentration in the 4–6 years range group. Consistent with our result, conflicting studies suggest limited protective effects of parental vaccination, attributing this to various factors, including changes in pandemic policies, decreased humoral response after the second vaccine dose, and the prevalence of the delta variant [36, 44]. Additionally, one systematic review has

pointed to the restrictive protective vaccination against the Omicron variant [31]. The indirect effectiveness of vaccines on household transmission receives attention [1], especially concerning unvaccinated children. However, limitations, such as a lack of data on biological and behavioral mechanisms, underscore the need for further research to pinpoint the observed reduction in infections among unvaccinated adult household members.

Practical implications include interventions such as frequent handwashing, surface cleansing, and mask usage were established preventive measures in evidence [11, 38].

In our study, the odds of child COVID- 19 infection were 20% higher in households with inadequate cleanliness. Recent studies have highlighted that SARS-CoV- 2 primarily transmits through droplets and aerosols, but contaminated surfaces also pose a potential risk [28, 47]. The virus can persist on various surfaces, such as cardboard, plastic, and stainless steel, for extended periods, making surface disinfection crucial [16, 23]. Environmental factors like temperature, humidity, and UV radiation significantly influence the virus's survival on surfaces [20, 40, 42]. Studies reveal that proper use of disinfectants, regular home cleaning practices, and ensuring fresh air circulation are crucial in protecting children from respiratory tract infections [25]. Notably, the heightened attention to home cleanliness during the COVID- 19 pandemic underscores its significance as a preventive measure [15]. Considering the probability of a high viral load on contaminated surfaces can explain this significant association.

Unlike previous studies, family income was not correlated to COVID- 19 infection. The majority of reports confirmed the heightened susceptibility of the low level of income families to COVID- 19 infection. Previous studies in other countries explained an impaired immune system due to the high possible exposure to viral infection, poor hygiene conditions, lower health literacy, and not maintaining social distancing and food security [12, 34, 39]. The difference observed in our study compared to other studies can be attributed to the public health programs in our country, which guarantee free accessibility to healthcare services from diagnosis to follow-up. This system allows individuals from all socioeconomic backgrounds to receive amenities at no cost [17]. However, the potential for residual confounding due to unmeasured demographic factors (e.g., health literacy or access to preventive measures) cannot be ruled out. Future studies should explore these factors in greater detail to better understand their role in COVID- 19 transmission within households.

Beyond vaccination campaigns, targeted interventions addressing parental and demographic factors are imperative. Considering future viral infections in children, our study's mechanistic insights emphasize the importance of tailored public health strategies. Recognizing the intricate relationships between parental, demographic factors, and infection risk is crucial for developing effective interventions.

Acknowledging study limitations, the unknown vaccination status and COVID history of non-participants introduce potential non-responder bias. Additionally, While this study examined key demographic factors such as socioeconomic status, parental education, and parental occupation, the duration of childcare, parental presence at home it did not assess other social components of health, such as family entertainment activities or health literacy. These factors could influence disease transmission dynamics within households and should be explored in future research. For example, parents with occupations requiring prolonged exposure to the public (e.g., healthcare or essential workers) may have a higher risk of introducing the virus into the household. Similarly, the amount of time parents spend at home or the nature of family interactions (e.g., shared meals or recreational activities) could play a role in transmission but were beyond the scope of this analysis. Future studies should incorporate these social determinants of health to provide a more comprehensive understanding of COVID- 19 transmission within families.

Conclusions

Our study not only highlights the elevated incidence of COVID- 19 among children under 6 during the Omicron peak but also unravels the intricate web of factors shaping this phenomenon. Paternal vaccination was associated with reduced child infection rates, likely due to higher occupational exposure of fathers, paternal immunization and sanitation of homes should be more emphasized to prevent of transmission of disease to offspring.

Abbreviations

MIS-C	Multisystem inflammatory syndrome in children
PCR	Polymerase Chain Reaction
OR	Odds Ratio
CI	Confidence Interval

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Authors' contributions

RK, ShD, and MK contributed to the conception or design of the work; MM and ShD contributed to data acquisition; ShD conducted data analysis; all authors contributed to data interpretation; all the authors participated in drafting the work or revising it critically for important intellectual content. All the authors approved the version for publication and agreed to be accountable for all aspects of the work in ensuring that questions related to the

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Data availability
Data will be presented upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate
The study protocol was approved by the Ethics Committee of Isfahan University of Medical Science (IR.ARI.MUI.REC.1401.197) and conformed to the ethical guidelines of the Declaration of Helsinki informed consent to participate in the study obtained from participants for their children and themselves.

Consent for publication
Written informed consent for publication was obtained from the authors.

Competing interests
The authors declare that they have no conflict of interest.

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