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Trust in health workers and patient-centeredness of care were strongest factors associated with vaccination for Kenyan children born between 2017–2022

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ABSTRACT

Objective: Although vaccination confidence is declining globally, there is little detailed information from low- and middle-income countries about factors influencing routine vaccination behavior in these contexts.
Methods: In mid-2022, we surveyed people who gave birth in Kenya between 2017–2022, and asked them about their children's vaccination history and about hypothesized correlates of vaccination per the Behavioural and Social Drivers of Vaccination model.
Results: Of 873 children in this sample, 117 (13%) were under-vaccinated (i.e., delayed or missing vaccine dose (s)) – and under-vaccination was more common among births during the COVID-19 pandemic (2020–2022) versus pre-pandemic (2017–2019). In multi-level multivariable models, children of respondents who expressed concerns about serious side effects from vaccines had significantly higher odds of missed vaccine dose(s) (aOR 2.06, 95 % CI 1.14–3.72), and there was a strong association between having more safety concerns now versus before the COVID-19 pandemic (aOR missed dose(s) 4.44, 95 % CI 1.71–11.51; aOR under-vaccination 3.03, 95 % CI 1.28–7.19). People with greater trust in health workers had lower odds of having a child with missed vaccine dose(s) (aOR 0.85, 95 % CI 0.75–0.97). People who reported higher patient-centered quality of vaccination care had much lower odds of having children with delayed or missed vaccine dose(s) (aOR missed dose(s) 0.14, 95 % CI 0.04–0.58; aOR under-vaccination 0.27, 95 % CI 0.10–0.79).
Conclusions: These findings highlight potential strategies to improve vaccine coverage: greater focus on patient-centered quality of care, training healthcare workers on how to address safety concerns about vaccines, and building trust in the health care system and in health workers.

Introduction

Routine vaccination is an essential strategy to increase child survival [1]. In 2020, the World Health Assembly endorsed an Immunization Agenda 2030 to accelerate vaccination gains globally by strengthening vaccination service delivery, investing in further research and development, and ensuring continued demand for vaccines [2].

However, vaccine coverage has been stagnating or declining in many countries [3,4]. There were disruptions due to the COVID-19 pandemic [5–8], but in many countries (whether high-, middle- or low-income), vaccine confidence was wavering even prior to the COVID-19 pandemic [9]. Vaccine hesitancy was named a "top ten threat to global health" by the World Health Organization in 2019, and evidence suggests that the COVID-19 pandemic has worsened the situation further [3]. There is an urgent need to design and implement programs and policies to increase coverage, but many analyses of vaccination in low-

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and middle-income countries have used administrative data, and therefore are unable to assess individual-level factors that may be associated with changes to routine vaccination [10].

We previously found that Kenyan caregivers reported challenges in accessing and affording health care for their children, including immunization services [11]. Although vaccine coverage in Kenya is generally high [12], hesitancy may be on the rise [13]. In this paper, we seek to answer: what is the magnitude of on-time versus under-vaccination among Kenyan children born before and during the COVID-19 pandemic; and what caregiver-level factors are associated with children's vaccination status. Findings could inform policies and programs to raise vaccine coverage.

Methods

This was a cross-sectional survey, with respondents recruited from a population of women in Kiambu and Nairobi counties who participated in a previous study about their perinatal care experiences in 2019–2020 [14,15]. In mid-2022, we reached out to mothers from this prior study who had consented to being contacted for future research.

Survey instrument

The survey instrument included seven modules, chosen to reflect constructs from the WHO Behavioural and Social Drivers of Vaccination model [16] (Table 1). Whenever possible, the survey instrument used adapted versions of existing tools and scales as described in detail below [17–23]. The survey asked respondents to report the dates of all vaccine doses received based on a vaccination card/booklet (filled out by health workers and retained by parents); but if the card/booklet was unavailable, we asked the respondent to recall whether the child had missed any doses from each vaccine series.

The survey was developed collaboratively and iteratively by the U.S.- and Kenya-based research team, which included expertise in pediatrics, immunizations, infectious diseases, survey research, and public health. Once finalized, the instrument was translated to Swahili by bilingual members of the research team. It was programmed for use in SurveyCTO data collection software, for bilingual interviewer-administered data collection.

Survey data collection

Trained research assistants called each person who had consented to be contacted for future surveys; they informed her about the new survey opportunity, and asked if she was interested in participating. Those who expressed interest could complete the survey immediately or could ask to be re-contacted at a different day or time. All people who agreed to participate in this survey provided oral informed consent before participating. Surveys were conducted by phone between April and July 2022.

In total, 1251 respondents from the original study were contacted by phone; 28 % of numbers were not accessible (64 phones were off, 144 had no answer, and 147 were answered by the wrong respondent); there were 19 refusals and 31 incomplete surveys, leading to a final sample size of 846 completed surveys (94 % of those reached).

Table 1
Behavioural and Social Drivers of Vaccination model domains (left) and corresponding survey instrument modules (right).

Thinking and feeling	Vaccine beliefs and attitudes
Social processes	Social norms for vaccinationTrust (in health care provider)
Practical issues	Access to vaccine servicesQuality of care (patient-centeredness)
Vaccination	Vaccination status of all children in the household

Study context

Kenya is the seventh most populous nation in Africa, with a diverse population of over 55 million people. Kenya has experienced five "waves" of the COVID-19 pandemic [24]. In early 2020, the Kenyan government introduced a number of policies to address the pandemic, including limitations on public gatherings, a dusk-to-dawn curfew, an international travel ban, and border closures [25]. The health system was strained during the pandemic for many reasons, including the conversion of some health facilities into isolation centers, stockouts of medical commodities, and shortages of health workers [25]—the latter of which intensified during a health worker strike in response to challenging working conditions in December 2020-January 2021 [26]. Evidence suggests that, during the COVID-19 pandemic era in Kenya, these health workforce challenges (and particularly the strike) may have been the most impactful disruption to routine health system functioning, including immunization services [25,26].

Variable definitions

The outcome was vaccination status, which was operationalized in two ways. We combined record- and recall-based data, following methods used in settings where medical data documentation is suboptimal, as recommended by the World Health Organization [27–29]; both definitions compared the child's vaccination history to the doses due based on their age. First, we estimated whether a child had missed (not received) any vaccine dose(s). Second, we generated a binary variable of under-vaccination to capture delayed and missed vaccine dose(s). In addition to those with missed dose(s), for respondents who provided their child's immunization history using medical record data, we calculated days unprotected from vaccine-preventable illness [30] – i.e., the number of days a child was due for a vaccine dose per Kenya national guidelines but not yet vaccinated – and if a child had any days unprotected, this was considered delayed. The vaccination status outcomes included information about all doses of four key routine childhood vaccines: Bacille Calmette-Guérin (BCG), diptheria, tetanus/pertussis (DTP), pneumococcal, and rotavirus vaccines. Although the survey also asked about doses of measles/mumps/rubella (MMR) and polio vaccines, these data were not included in the analysis due to data limitations: birth doses of polio are often not recorded in this setting, and the MMR vaccination schedule varies by child's HIV status which we did not have ethical approval to collect.

We grouped the child's year of birth into a 3-level categorical variable based on timing of the COVID-19 pandemic: born in 2017, 2018 or 2019 (pre-pandemic), born in 2020 (early pandemic), or born in 2021 or 2022 (later pandemic). Our main independent variables used summary measures to capture the domains of interest. To reflect *beliefs and attitudes*, we created a vaccine attitudes score [17]: thirteen Likert questions about perceived benefits, safety, and efficacy of routine child vaccines were used to generate a summed score of hesitancy (range 12–60) [17]. To reflect *social norms*, we similarly used Likert questions to create a score [18] of pro-vaccination social norms (range 0–8). We assessed *trust in one's health care provider* [19] by assigning points to Likert questions and summing these into a final measure (range 0–13) of trust in the health system. Practical issues were captured first through a measure of *access*, which used the WHO Short Tool [23] questions of accessibility of vaccination services; and second through a *patient-centeredness*. The latter was measured using an adaptation of the Person-Centered Maternity Care Scale [20–22], and the scale was generated by aligning valence of responses, converting the frequency response options (ranging from Never to Always) to points, summing these together for each respondent, and rescaling so all values would range 0–100 for ease of interpretation. We also report on the items contributing to each of these summary measures.

Statistical analysis

Models of missed dose(s) and of delayed or missed dose(s) (i.e., under-vaccination) were estimated as multi-level models, with children nested within mothers. Adjusted models included variables representing characteristics of the child – year of birth and sex (male or female) – and of the mother – marital status (married or not), employment status (working or not), self-assessed household income sufficiency over the last year (sufficient or not), educational attainment (less than primary, primary, secondary, or beyond secondary), region of residence (Kiambu or Nairobi county), and affiliation of identity (whether ethnic/tribal more important than national identity, or not). Because the sample size was relatively small to detect statistically significant differences in nested models, we report findings using a cutoff for statistical significance of $p < 0.1$. Analysis was conducted using Stata v17.

Ethical review

This study was reviewed and approved by the Institutional Review Board at the University of California Los Angeles (#20-001421-AM-00002), and by the Kenya Medical Research Institute (KEMRI) Scientific and Ethics Review Unit (Non-KEMRI Protocol #702). The Kenya National Commission for Science, Technology & Innovation granted a research permit (#520178) for the study.

Results

In total, 707 mothers contributed data to this analysis, and they provided data on vaccination status of 873 children. Characteristics of respondents are shown in Table 2. Over half of respondents had at least a secondary education (60.7 %), and two-thirds were married or cohabitating (67.2 %). Approximately half were not working (48.8 %), and over 63 % said their household income over the past year had been insufficient to meet their expenses. Almost all (n = 646, 91.4 %) identified as Christian while 1.8 % (n = 13) identified as Muslim (data not shown). Of the 873 children included, half were born before the COVID-19 pandemic (50.3 %), 39.0 % were born in 2020 (early pandemic), and 10.8 % were born in 2021 or 2022 (later pandemic). Just over half of these children (53.8 %) were male and 46.2 % were female.

Table 2
Characteristics of respondents (n = 707) and their children (n = 873) included in this analysis.

	n (%)
Mother education: Less than primary	71 (10.0 %)
Primary	207 (29.3 %)
Secondary	306 (43.3 %)
Beyond secondary	123 (17.4 %)
Mother marital status: Married or cohabitating	475 (67.2 %)
Single	151 (21.4 %)
Widowed	11 (1.6 %)
Divorced/separated	70 (9.9 %)
Mother employment status: Employed full-time	74 (10.5 %)
Employed part-time	23 (3.3 %)
Casual laborer	100 (14.1 %)
Self-employed	158 (22.4 %)
Not employed but looking for work	280 (39.6 %)
Not employed and not looking for work	72 (10.2 %)
Mother perceived past year's household income: Allowed me to save	84 (11.9 %)
Only just met expenses	170 (24.1 %)
Was not sufficient so needed to use savings to meet expenses	80 (11.3 %)
Was not sufficient so needed to borrow to meet expenses	370 (52.3 %)
Mother more important identity: Ethnic/tribal identity	122 (17.8 %)
National identity	581 (82.2 %)
Mother county of residence: Nairobi	559 (80.9 %)
Kiambu	132 (19.1 %)
Child year of birth: 2017–2019 (pre COVID-19 pandemic)	439 (50.3 %)
2020 (early COVID-19 pandemic)	340 (39.0 %)
2021–2022 (later COVID-19 pandemic)	94 (10.8 %)
Child gender: Female	403 (46.2 %)
Male	470 (53.8 %)

Most children's vaccination status was reported based on parent recall (n = 667, 76.4 %) rather than on vaccination card data. Younger children's data more commonly came from the vaccination card: 18.0 % of children born in 2017–19, 28.2 % of children born in 2020, and 33.0 % of children born in 2021–22.

Under-vaccination in the sample

There were 117 children (13.5 % of the sample) who were under-vaccinated – i.e., any delayed or missing vaccine dose(s). This was more common among children born later in the pandemic (i.e., in 2021–22; n = 17, 18.5 % of these births) than early in the pandemic (in 2020; n = 52, 15.3 % of these births) or pre-pandemic (in 2017–19; n = 48, 11.0 % of these births). In multi-level adjusted models, children born during the pandemic (between 2020–2022) had 1.58 the adjusted odds of under-vaccination (95 % CI 0.99, 2.51) compared to those born before the COVID-19 pandemic (between 2017–2019) (p = 0.053) (Appendix). Among these under-vaccinated children, 63 were missing any vaccine dose(s), either based on parent recall or report of vaccination card data, and 71 had delayed dose(s) (mean number of days unprotected from vaccine-preventable illness among those with any unprotected days 19.6, median 8.25).

Vaccination beliefs & attitudes

Respondents were asked 13 questions about their beliefs and attitudes about routine childhood vaccination. They had the least positive attitudes about vaccine safety: for example, half of respondents said they are worried about serious side effects of childhood vaccines, and one-third of respondents thought their child might experience serious side effects (Table 3). Three-quarters of respondents said that children receive too many vaccines. Most respondents did not feel as though their attitudes toward childhood vaccines had changed due to the COVID-19 pandemic.

A respondent's vaccine confidence was not associated with her child's missed vaccine dose(s) or under-vaccination in adjusted models, nor were most of her specific vaccination/vaccine attitudes. The exceptions were agreeing that "if I vaccinate my child, he/she may have serious side effects" (children born to these respondents (n = 228) had over 200 % higher adjusted odds of a missed vaccine than those born to respondents who did not agree) and that "children receive too many vaccines" (children born to these respondents (n = 518) had 87 % higher adjusted odds of a missed vaccine dose(s) and 71 % higher adjusted odds of under-vaccination than children born to mothers who did not agree with the statement) (Table 3).

Although few mothers (3 %) felt that childhood vaccines are less safe than before the COVID-19 pandemic, in adjusted models, children born to these women had substantially higher odds of having a missed vaccine (aOR 4.44, 95 % CI 1.71–11.51) and of being under-vaccinated (aOR 3.03, 95 % CI 1.28–7.19) than children born to mothers whose opinion about vaccine safety had not changed or who now felt they were safer (Table 3).

Social factors around vaccination

Over 90 % of respondents agreed or strongly agreed with each of 8 statements about social norms around routine childhood vaccination (Table 4). The sole norm associated with under-vaccination was perceiving that health care workers believe that vaccinating children is a good idea, and this was strongly inversely associated with both missed vaccine doses and under-vaccination.

Trust in health care workers was generally high, and children born to mothers with overall higher trust in their health care provider had 15 % lower adjusted odds of a missed vaccine than children born to mothers

Table 3
Beliefs and attitudes about routine childhood vaccines, and associations with under-vaccination.

		aOR missed vaccine dose(s) (95 % CI)[3] among children (n = 63)	aOR under-vaccinated (delayed or missed dose(s)) (95 % CI)[3]among children (n = 117)
Vaccine attitudes score (can range 12–60, higher score indicates worse attitudes/ more hesitancy)	Mean: 29.2 SD: 4.4	1.04 (0.96–1.11)	1.03 (0.98–1.09)
Specific items:	**n (%) who agree or strongly agree (vs., disagree or strongly disagree)[1] among respondents (n = 707)**	**aOR missed vaccine dose(s) (95 % CI)[1] among children (n = 63)**	**aOR under-vaccinated (delayed or missed dose(s)) (95 % CI)[1] among children (n = 117)**
If I vaccinate my child, he/she may have serious side effects[2]	228 (32.4 %)	2.06** (1.14, 3.72)	1.32 (0.84—–2.08)
I am concerned about serious side effects of childhood vaccines[2]	356 (50.9 %)	0.96 (0.56–1.64)	0.95 (0.62–1.45)
New vaccines carry more risks than older vaccines[2]	412 (59.8 %)	1.00 (0.57–1.77)	1.11 (0.71–1.74)
I think childhood vaccines might cause short-term problems like fever[2]	440 (62.8 %)	0.94 (0.53–1.66)	1.22 (0.78–1.91)
Children receive too many vaccines[2]	518 (73.8 %)	1.87* (0.89–3.94)	1.71* (0.99–2.94)
Having my child vaccinated is important for the health of others in my community	674 (96.0 %)	0.76 (0.21–2.70)	0.81 (0.29–2.21)
Childhood vaccines are important for my child's health	704 (99.7 %)	n/a[4]	n/a[4]
If I do not vaccinate my child, he/she may get a disease such as measles and cause other children also to get the disease	653 (93.2 %)	0.61 (0.25–1.49)	0.78 (0.38–1.61)
All childhood vaccines offered by my child's health care provider are beneficial	683 (96.9 %)	0.50 (0.14–1.88)	0.58 (0.19–1.74)
Getting vaccines is a good way to protect my child from disease	699 (99.3 %)	0.33 (0.02–5.45)	0.73 (0.06–9.58)
Vaccines do a good job in preventing the diseases they are intended to prevent	702 (99.4 %)	0.36 (0.03–4.18)	0.31 (0.07–1.43)
Health providers in charge of vaccination have my child's best interest at heart	671 (94.9 %)	0.48 (0.19–1.18)	0.84 (0.36–1.96)
I do what my child's health care provider recommends about vaccines	684 (97.0 %)	0.88 (0.20–3.89)	0.58 (0.20–1.66)
How has the COVID-19 pandemic changed your opinion about childhood vaccines			
I now feel that childhood vaccines are less important than I used to feel (before COVID-19) (vs., more important no change)	13 (1.8 %)	0.88 (0.12–6.69)	1.52 (0.45–5.18)
I now feel that childhood vaccines are less safe than I used to feel (before COVID-19) (vs., safer or no change)	19 (2.7 %)	4.44*** (1.71–11.51)	3.03** (1.28–7.19)
I now feel that childhood vaccines are less effective than I used to feel (before COVID-19) (vs., more effective or no change)	41 (5.8 %)	0.64 (0.16–2.65)	1.32 (0.57–3.09)

1: Excludes respondents who declined to answer (fewer than 1 % of respondents for any question except "New vaccines carry more risks than older vaccines" which 2.5 % of respondents declined).
2: Indicates this variable was reverse-coded for attitudes score.
3: Adjusted odds ratio includes covariates: mother's education (less than primary/primary or secondary/beyond secondary), mother is married or cohabitating (yes/no), mother is working (yes/no), past year's household income was sufficient (yes/no), tribal/ethnic identity more important than national identity (yes/no), county, child year of birth (2017–2019/2020–2022), child gender (male/female).
4: Not estimated; n too small for multilevel model convergence.
*** p < 0.01, ** p < 0.05, * p < 0.10

with lower trust in their health care provider (Table 4). The only specific attitude significantly associated with missing vaccine dose(s) and with under-vaccination in multivariable models was "My health care provider is usually considerate of my needs and puts them first." Respondents who agreed with this statement had approximately 60 % lower adjusted odds of children with missed vaccine dose(s) and of under-vaccination than those who did not agree with the statement.

Table 4
Social factors about routine childhood vaccines, and associations with under-vaccination.

		aOR missed vaccine dose(s) (95 % CI)[3] among children (n = 63)	aOR under-vaccinated (missed or untimely) (95 % CI)[3] among children (n = 117)
Social norms score (can range 0–8, higher score indicates more pro-vaccination norms)	Mean: 7.6 SD: 0.9	0.88 (0.70–1.11)	1.04 (0.83–1.30)
Specific items:	**n (%) who agree or strongly agree (vs., disagree or strongly disagree)[1] among respondents (n = 707)**	**aOR missed vaccine dose(s) (95 % CI)[1] among children (n = 63)**	**aOR under-vaccinated (delayed or missed dose (s)) (95 % CI)[1] among children (n = 117)**
I feel that other parents in my community are getting their children vaccinated	648 (91.8 %)	1.00 (0.36–2.8)	1.35 (0.59–3.08)
I feel that my friends are getting their children vaccinated	656 (93.2 %)	0.76 (0.26–2.23)	0.97 (0.41–2.31)
I feel that other children around my child's age are getting vaccinated	658 (93.2 %)	0.52 (0.201–1.35)	0.98 (0.42–2.28)
I feel that it is/was expected of me that I should vaccinate my child	684 (96.9 %)	0.47 (0.13–1.67)	1.04 (0.30–3.57)
I feel that most of my friends think vaccinating my child is/was a good idea	668 (94.6 %)	1.07 (0.31–3.77)	1.64 (0.55–4.85)
I feel that doctors/ health care providers believe vaccinating children is a good idea	700 (99.2 %)	0.09* (0.01–1.27)	0.17** (0.04–0.81)
I feel that my child's other parent believes we should have vaccinated our child	681 (96.5 %)	1.98 (0.23–16.76)	2.11 (0.46–9.66)
I feel that my family thinks it is/was a good idea to vaccinate my child	695 (98.4 %)	n/a[4]	n/a[4]
Trust in health care provider			
Positive trust in provider score (can range 0–13, higher score indicates more trust in health care providers)	Mean: 10.7 SD: 1.8	0.85** (0.75–0.97)	0.97 (0.86–1.09)
Specific items:	**n (%) who agree or strongly agree (vs., disagree or strongly disagree)[1] among respondents (n = 707)**	**aOR missed vaccine dose(s) (95 % CI)[1] among children (n = 63)**	**aOR under-vaccinated (delayed or missed dose (s)) (95 % CI)[1] among children (n = 117)**
My health care provider is usually considerate of my needs and puts them first	627 (88.8 %)	0.40** (0.20–0.81)	0.39*** (0.23–0.66)
I have so much trust in my health care provider that I always try to follow his/her advice	669 (94.8 %)	0.76 (0.27–2.17)	0.94 (0.40–2.17)
I trust my health care provider so much that whatever he/ she tells me, it must be true	587 (83.1 %)	0.64 (0.33–1.25)	1.10 (0.63–1.92)
Sometimes, I do not trust my health care provider's opinion and therefore I feel I need a second one[3]	378 (53.5 %)	1.38 (0.79–2.43)	0.92 (0.60–1.41)
I can trust my health care provider's judgments concerning my medical care	642 (90.9 %)	0.57 (0.26–1.26)	0.78 (0.41–1.51)
My health care provider will do whatever it takes to give me the medical care that I need	650 (92.1 %)	0.57 (0.24–1.35)	0.81 (0.39–1.66)
Because my health care provider is an expert, he is able to treat medical problems like mine	649 (91.8 %)	0.72 (0.29–1.75)	0.94 (0.44–1.98)
I can trust my health care provider's decisions on which medical treatments are best for me	687 (97.3 %)	0.74 (0.15–3.61)	1.63 (0.35–7.64)
My health care provider offers me the highest quality in medical care	646 (91.4 %)	0.56 (0.25–1.23)	0.82 (0.42–1.62)
All things considered, I completely trust my health care provider	543 (91.1 %)	0.58 (0.26–1.30)	1.10 (0.52–2.31)
Health care institutions only care about keeping medical costs down, and not what is needed for my health[3]	396 (56.3 %)	1.24 (0.69–2.25)	0.92 (0.59–1.45)
Healthcare institutions provide the highest quality in medical care	613 (86.8 %)	0.62 (0.31–1.24)	0.77 (0.44–1.34)
When treating my medical problems, health care institutions put my medical needs above all other considerations, including costs	503 (71.3 %)	1.08 (0.59–1.97)	1.11 (0.69–1.77)

1: Excludes respondents who declined to answer (fewer than 1 % of respondents for any question except "New vaccines carry more risks than older vaccines" which 2.5 % of respondents declined).
2: Adjusted odds ratio includes covariates: mother's education (less than

primary/primary or secondary/beyond secondary), mother is married or cohabitating (yes/no), mother is working (yes/no), past year's household income was sufficient (yes/no), tribal/ethnic identity more important than national identity (yes/no), county, child year of birth (2017–2019/2020–2022), child gender (male/female).
3: Indicates this variable was reverse-coded for provider trust score.
4: Not estimated; n too small for multilevel model convergence.
*** p < 0.01, ** p < 0.05, * p < 0.10.

Practical issues

Most respondents (n = 580, 82.0 %) said they faced no problems when accessing routine childhood immunization services (Table 5). Among the 147 respondents who did face problem(s), the most common were: stockouts (n = 28, 22.1 % of respondents with access problems), distance to the service (n = 27, 21.3 % of respondents with access problems), the child being ill and unable to receive the vaccine (n = 25, 19.7 %), cost of transport (n = 22, 17.3 %), being turned away from services, and cost of services (each n = 15, 11.8 %). There was no significant association in these multivariable models between reporting access problems and either missing vaccine dose(s) or under-vaccination (Table 5).

Mothers overall reported high levels of patient-centeredness during routine vaccination care delivery (average of 19.2 points, possible range 0–27) (Table 5). Respondents who reported more patient-centered care had significantly and greatly lower odds of having a child with a missed vaccine (aOR 0.14, 95 % CI 0.04–0.58) or an under-vaccinated child (aOR 0.27, 95 % CI 0.10–0.79) (Table 5). In adjusted models, many specific patient-centeredness items were significantly inversely associated with missed vaccines or under-vaccination, including being treated with respect, having the vaccines explained during the visit, feeling like one could ask questions, and feeling like health workers paid attention when you needed help (Table 5).

Discussion

We found that vaccine coverage is high in this sample, but declined during the COVID-19 pandemic: almost one in five children born in 2021 or 2022 (characterized as the "later pandemic" in this analysis) had at least one delayed or missed vaccine dose. The key belief associated with under-vaccination among these respondents was concern about vaccine safety (reported by just under one-third of parents), and the key social norm was trust in health care workers. Patient-centered vaccination care appeared to be strongly protective against suboptimal vaccination. Other attitudes, perceived norms, and access factors included in this survey were not related to vaccination status.

Our finding that under-vaccination has increased—overall during the COVID-19 pandemic compared to before it, and to a greater extent later during the pandemic versus earlier—contrasts with prior studies from Kenya, which found that the COVID-19 pandemic had no effect on routine immunization [31–33]—but these studies were conducted in 2021 (one year prior to our study) so may have missed more recent impacts of the pandemic. The broader literature has similarly not reached consensus about whether, and to what extent, the pandemic disrupted vaccination programs in low- and middle-income countries [7,8,34–38]. This heterogeneity may be due to locally-specific policies, constraints, and COVID-19 caseloads [39]—and as vaccine confidence has been eroding over time [3]. A recent systematic review found only five quantitative surveys with parents in low- and middle-income countires on this topic [40] (none from Kenya), and all were conducted in mid-2020 so do not account for different stages of the pandemic.

Attitudes and beliefs about childhood vaccines were not uniformly positive in this population—approximately half of respondents expressed concerns about side effects and three-quarters said that children receive too many vaccines—and these negative beliefs were associated with missed or delayed vaccine dose(s). In addition, although

Table 5
Practical issues in accessing childhood vaccines, and associations with under-vaccination.

	n (%) among respondents (n = 707)	aOR missed vaccine dose (s) (95 % CI)[1] among children (n = 63)	aOR under-vaccinated (delayed or missed dose(s)) (95 % CI)[1] among children (n = 117)
Access			
No reported access problems	580 (82.0 %)	0.74 (0.38–1.45)	0.83 (0.49–1.43)
Among those reporting access problems:			
The vaccination clinic is too far away	27 (21.3 %)	n/a[2]	
The clinic sometimes turns people away without vaccinating	15 (11.8 %)		
Wait times are too long	9 (7.1 %)		
Vaccines are out of stock/not available	28 (22.1 %)		
Transport cost	22 (17.3 %)		
Service cost	15 (11.8 %)		
Lost wages	6 (4.7 %)		
Service is not available	3 (2.4 %)		
Child sick	25 (19.7 %)		
Patient-centeredness			
	Mean (SD)		
Patient centeredness score (can range 0–100, higher score indicates more patient-centered interaction)	70.89 (22.1)	0.14*** (0.04–0.58)	0.27** (0.10–0.79)
Specific items:	**n (%) who said ever (a few times, most of the time, or all the time) vs. never[1] among respondents (n = 707)**	**aOR missed vaccine dose (s) (95 % CI)[1] among children (n = 63)**	**aOR under-vaccinated (delayed or missed dose(s)) (95 % CI)[1] among children (n = 117)**
When you took/take your child to get immunized: … Did the doctors, nurses, or other health care providers call you by your name?	514 (77.9 %)	0.85 (0.44–1.63)	0.93 (0.55–1.58)
… Did the doctors, nurses or other staff at the facility treat you with respect?	644 (97.6 %)	0.16*** (0.05–0.56)	0.27** (0.10–0.74)
… Did the doctors, nurses or other staff at the facility treat you in a friendly manner?	566 (85.8 %)	0.57 (0.28–1.20)	0.82 (0.44–1.53)
… Did you feel like the doctors, nurses, or other staff at the facility involved you in	557 (84.4 %)	0.85 (0.40–1.78)	0.87 (0.48–1.55)

(*continued on next page*)

Table 5 (*continued*)

	n (%) among respondents (n = 707)	aOR missed vaccine dose (s) (95 % CI)[1] among children (n = 63)	aOR under-vaccinated (delayed or missed dose(s)) (95 % CI)[1] among children (n = 117)
vaccination decisions?			
… Did the doctors, nurses or other staff at the facility ask your permission/ consent before vaccination?	451 (68.3 %)	0.83 (0.46–1.49)	0.60** (0.39–0.95)
… Did the doctors and nurses explain to you why they were giving each vaccine?	571 (86.5 %)	0.46** (0.23–0.92)	0.48** (0.27–0.84)
… Did you feel you could ask the doctors, nurses or other staff at the facility any questions you had?	558 (84.6 %)	0.52* (0.27–1.03)	0.34*** (0.20–0.56)
…When you needed help, did you feel the doctors, nurses or other staff at the facility paid attention?	601 (91.1 %)	0.36** (0.16–0.82)	0.51** (0.26–0.99)
… Did you feel the doctors, nurses or other staff at the facility took the best care of you and your child (ren)?	642 (97.3 %)	0.31* (0.09–1.07)	0.24*** (0.09–0.61)

1: Adjusted odds ratio includes covariates: mother's education (less than primary/primary or secondary/beyond secondary), mother is married or cohabitating (yes/no), mother is working (yes/no), past year's household income was sufficient (yes/no), tribal/ethnic identity more important than national identity (yes/no), county, child year of birth (2017–2019/2020–2022), child gender (male/female).
2: Not estimated; n too small for multilevel model convergence.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

very few people reportedly felt like vaccines are less safe now compared to before the COVID-19 pandemic (less than 3 % of the study population), this was strongly associated with delayed and missed vaccine dose (s) in adjusted models.

While we found overall high levels of trust in health care providers, respondents with lower trust had higher adjusted odds of children with missed vaccine dose(s). This contributes to the growing literature about the importance of trust for vaccine uptake [41,42]. Health care providers can play a critical role in promoting vaccination [43,44], so it is critical to learn how to build trust in health workers and their vaccination recommendations. Trust is multi-dimensional and nuanced, so future research should seek to disentangle trust—for example, in the vaccine itself, in the messenger, in the message, and in the delivery system—and identify ways to build and leverage these different types of trust.

Less person-centered vaccination care was strongly associated with both delayed and missed dose(s) in this sample. Person-centered care is critical for ensuring continuity of care across the life course, particularly because experience during one service may impact later care-seeking [45–48]. To our knowledge, this is the first study to explore specific measures of person-centered vaccination care, which itself was based on a validated measure of person-centered maternity care in Kenya. These results, especially in conjunction with our findings around trust in health workers, suggests that more attention is needed to creating person-centered models of care for vaccination services. Future efforts could use the person-centered vaccination measure in quality improvement efforts, such as training healthcare workers to explain all vaccines in a way that parents can understand, and encouraging parents to be involved in decision-making by supporting and answering their questions. These endeavors must be locally-contextualized, and developed to be responsive to the needs and resources of each local setting. There have been recent calls for standardized measures of person-centered healthcare, including neonatal and childhood health care services [49]; we echo this recommendation, specifically for vaccination services in LMICs.

This study has several limitations that should be noted. First, most of the vaccination data were self-reported so may be subject to recall and reporting bias. However, it is common for surveys in low- and middle-income countries to rely on parent recall/report, as medical records are often unavailable [27,28,50], and studies from a range of settings have found that parent (especially mother's) recall of vaccination information is highly correlated with medical record data [51–53], suggesting that it is a valid source when records are unavailable. A second potential limitation is that this was the second or third time these respondents had been surveyed since giving birth to their child, so there may have been response fatigue and selection bias. Third, respondents came from only two areas within Kenya, and men are not represented here. Lastly, our under-vaccination outcome measure defines "delayed" vaccination as any days overdue for a vaccine dose; this combines both short delays that may not be clinically meaningful with longer delays that would put a child at risk of vaccine-preventable disease. We were unable to use a continuous measure of days overdue due to sample size, but future analyses should strive to use a continuous measure of under-vaccination as it may be more meaningful clinically and as an indicator of vaccine confidence [30]. There are many strengths to this study, including a large sample, high follow-up and response rates, the use of validated and widely-used instruments, and a highly experienced data collection team.

Conclusion

This study identified numerous intervention-amenable factors associated with suboptimal uptake of routine childhood vaccination in Kenya: addressing parents' concerns about vaccine side effects, building trust in health care workers, and improving patient-centeredness of vaccination services. We found increases in under-vaccination (delayed or missed dose(s)) during the COVID-19 pandemic compared to the pre-pandemic period, and encourage more individual-level surveys to understand the magnitude of disruptions to routine vaccination, which groups have been most affected, and how policies and programs can work to boost uptake in order to improve child survival.

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CRediT authorship contribution statement

Corrina Moucheraud: Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing. **Eric Ochieng:** Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Vitalis Ogutu:** Data curation, Investigation, Software, Writing – review & editing. **May Sudhinaraset:** Conceptualization, Methodology, Resources, Writing – original draft, Writing – review & editing. **Peter G. Szilagyi:** Conceptualization,

Methodology, Writing – review & editing. **Risa M. Hoffman:** Conceptualization, Methodology, Writing – review & editing. **Beth Glenn:** Conceptualization, Methodology, Writing – review & editing. **Ginger Golub:** Methodology, Project administration, Writing – review & editing. **Doris Njomo:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Corrina Moucheraud reports financial support was provided by Sabin Vaccine Institute. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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