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Dual decision-making routes for COVID-19 and influenza vaccines uptake in parents: A mixed-methods study

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Abstract

Objective: Parental decision-making for children's uptake of a relatively novel vaccine and a more common vaccine could involve different processes. This study aimed to compare the psychological processes and the relative importance of psychological factors influencing parental decision-making for children's seasonal influenza vaccination (SIV) and COVID-19 vaccination.

Design and Methods: We adopted mixed-methods approach. Study 1 was a qualitative study involving 29 parents to explore and compare their decision-making processes for children's SIV and COVID-19 vaccination. In Study 2, data from 632 parents were collected longitudinally; then, machine learning was used to quantify the relative importance of factors identified in Study 1 that were relevant to parents' decision-making for childhood vaccination decisions. Alluvial plots were used to compare the predictability of parents' baseline intention for follow-up children's SIV and COVID-19 vaccination.

Results: Study 1 revealed that parents used the influenza vaccine as an anchor to assess the COVID-19 vaccine's risks. Decision-making for children's SIV was habitual and rule-based, while for COVID-19 vaccination, it involved more deliberation influenced by negative situational cues like negative news and anecdotal experiences. Study 2 further found that, for COVID-19 vaccination, situation-varying factors including distressed emotional states and affective response to news were significant. While for SIV,

past-year vaccination behaviour was a more important factor. Baseline intention reliably predicted children's SIV but not COVID-19 vaccination.

Conclusions: The convergence of qualitative and quantitative data highlighted the distinct decision-making strategies for these two vaccines. Targeting key factors in parental decisions can enhance the effectiveness of future vaccination campaigns.

K E Y W O R D S

COVID-19 vaccination, influenza vaccination, mixed-methods, parental decision-making, psychological factors

Statement of contribution

What is already known on this subject?

- Parental decision-making for children's vaccination was influenced by various psychological factors.
- Habitual behaviours are more automatic and less deliberative in stable context.
- Initiating new behaviours requires additional deliberation and is significantly influenced by situation-varying factors in an unstable context.

What does this study add?

- Decision-making for childhood seasonal influenza vaccination (SIV) and COVID-19 vaccination are different.
- Parental decision-making for SIV is more habitual and guided by stable values, past behaviour and baseline intention.
- Parental decision-making for COVID-19 vaccination is more deliberative and affect-based.

BACKGROUND

Before the emergence of COVID-19, seasonal influenza was a significant threat to young children, with an annual attack rate of 20%–30% (Ruf & Knuf, 2014). Three to five million of these cases result in severe illness, and between 290,000 and 650,000 cases lead to respiratory deaths worldwide (World Health Organization, 2024). While COVID-19 typically caused asymptomatic or mild diseases in children, it could lead to a severe condition known as multisystem inflammatory syndrome (MIS-C) in 1 in 3200 unvaccinated previously healthy children. Notably, COVID-19 vaccination substantially reduces the risk of MIS-C (Payne et al., 2021). To mitigate the diseases burden, the American Academy of Pediatrics recommended seasonal influenza vaccination (SIV) for children aged 6 months to 17 years, preferably co-administered with other vaccines, including COVID-19 vaccines (Committee on Infectious Diseases, 2022). During and after the COVID-19 pandemic, the Hong Kong government continued to recommend SIV for children aged 6 months to 18 years, alongside COVID-19 vaccines for better personal protection (Centre for Health Protection, 2023a). Nevertheless, children's vaccination uptake remains suboptimal in Hong Kong. SIV rates have dropped from 65.8% in 2021/22 to 60.2% in

2022/23 among children aged 6–12 (Centre for Health Protection, 2023b). As for COVID-19 vaccines, only 30.9% of children aged 3–11 were fully vaccinated during the Omicron outbreak (Centre for Health Protection, 2023c). The decline in vaccination rates is not unique to Hong Kong. A recent UNICEF report indicates that 67 million children worldwide missed out on vaccinations during the pandemic from 2019 to 2021 (UNICEF, 2023). In developing countries, this decline is primarily due to supply-side barriers, such as limited resources and health worker shortages. While in more developed countries and regions, vaccine hesitancy is mainly driven by a lack of confidence in vaccines and the vaccination services (Arsenault et al., 2024). In Hong Kong, vaccine hesitancy significantly increased after the implementation of mass COVID-19 vaccination campaign, with concerns being particularly high for injection-based vaccines (Yuan et al., 2024). While most Hong Kong Chinese parents are familiar with the western biomedical model of infectious disease causes and prevention, their practices for managing child health are strongly influenced by Traditional Chinese Medicine (TCM) and related values (Lau et al., 2005). Unlike western medicine which emphasizes the role of medical technologies for disease treatment and prevention, TCM emphasizes the balance of 'Ying' and 'Yang' within a human body and the harmony between human beings and nature (Fu et al., 2021). Hence, Chinese parents commonly favour 'natural' methods such as diet therapy and herbal tea for strengthening the natural defence of their child's body for preventing infectious diseases (Ng et al., 2021). These contexts would continue to shape Hong Kong parents' decision-making for their young children's vaccination.

SIV as a habitual decision versus COVID-19 vaccination as a non-habitual decision

Parents' decision-making for SIV and COVID-19 vaccination may differ due to vaccine and disease distinctions (Karlsson et al., 2021), as well as variability in vaccination programme implementation and other contexts (Brewer et al., 2017). Influenza vaccines are more familiar to parents. In Hong Kong, annual school-based SIV programme provides familiar and stable guidelines for parents' vaccination decision (Liao et al., 2021). Parents mostly base their decisions on the previous year's choice (Chen et al., 2015; Daley et al., 2006), except when episodic events (e.g. occurrence of vaccine safety crisis or outbreaks) disrupt this pattern. Previous study found that media report on adverse events of SIV could immediately decrease uptake rates by about 2.5%, though such effect is transient (Brilli et al., 2020). On the contrary, COVID-19 vaccines are relatively new and emerged quickly for emergency use (Barrett et al., 2022). They were not recommended for young children until February 2022 in Hong Kong, and appointments for COVID-19 vaccination were less convenient, requiring visits to community centre or children's hospitals but not in schools (Centre for Health Protection, 2023c). Overall, decision-making for SIV is likely habitual, guided by established rules in stable contexts (Walsh et al., 2020), while COVID-19 vaccination decision is likely less routine due to vaccine novelty, unfamiliar booking procedures and evolving pandemic dynamics and policies (Janssen et al., 2020).

Different decision-making processes for SIV and COVID-19 vaccination

The different decision-making processes for SIV and COVID-19 vaccination in children may involve varying levels of attention, cognitive effort and emotional involvement. According to the two pathways proposition suggested by Quellette and Wood (1998), and Wood et al. (2002), stable contexts tend to promote automatic and less cognitively demanding decision-making, often guided by behaviours repeatedly practiced in the past (Brown et al., 2020; Sokol & Grummon, 2020). Once a routine is established, behaviours become habits characterized by a lack of awareness, reduced voluntary control and increased mental efficiency (Verplanken, 2006). As a result, Verplanken stated that 'Habitual behaviours were associated with less thoughts and less intense emotions than non-habitual behaviours' (Verplanken, 2006, p. 640). In contrast, non-habitual decision-making in an

uncertain context requires ongoing evaluation and adaptation and is possibly interfered by emerging difficulties, which could induce greater emotion and involve emotional information processing (Baumeister et al., 2000; Yuan et al., 2023). Furthermore, habitual behaviours are triggered by pre-existing psychological constructs (e.g. implicit values, desires and preferences) spontaneously, a process being reinforced through repeated practices (Bargh et al., 2001). Hence, for more habitual behaviours, past behaviour is a reliable predictor of future practice (Albarracin et al., 2001; Norman & Cooper, 2011). However, new behaviours lacking automatic guidance tend to rely more on situational factors during one's decision-making (Wood et al., 2002). Additionally, repeated experiences can stabilize intentions, increasing predictability for habitual behaviours (Sheeran et al., 2003). Nonetheless, intentions may not always align with actual behaviours in novel contexts, as observed in COVID-19 vaccine uptake (Dai et al., 2021). In sum, based on these theoretical perspectives, decision-making for children's SIV, which tends to be more stable and automatic due to their repeatedly delivery in a stable context over many years, is likely habitual. In comparison, decision-making for COVID-19 vaccination for children, which tends to be more deliberate and is likely influenced by situational factors, given their initial delivery in an uncertain pandemic context, is likely non-habitual. The differing contexts of SIV and COVID-19 vaccination for children provide a valuable opportunity to examine these distinct decision-making paths. Empirical testing is necessary to inform tailored communication strategies for different childhood vaccinations.

The current study

Existing studies that compare SIV and COVID-19 vaccination for children primarily focused on the differences in parental acceptance (Temsah et al., 2021; Wang et al., 2021), overlooking the underlying psychological factors and processes. While some studies observed a positive correlation between SIV and COVID-19 vaccination acceptance, suggesting that individuals who accept SIV are more likely to accept COVID-19 (Humble et al., 2021; Yılmaz & Sahin, 2021). However, this may oversimplify the decision-making processes for the two distinct vaccines. This current study employed a mixed-methods approach, combining qualitative interviews and longitudinal survey to explore and compare the different psychological processes underlying parental decision-making for children's SIV and COVID-19 vaccination. Following the mixed-methods design in health psychology research, this study employed exploratory sequential designs (Bishop, 2015). In Study 1, we used qualitative data to identify crucial factors underlying parental decisions for childhood SIV and COVID-19 vaccination. Then in Study 2, these qualitative findings guided the analysis of quantitative data to enhance our understanding of the phenomena identified in Study 1.

STUDY 1

Study 1 was conducted from 4 May to 25 June 2021, comprised in-depth interviews with 29 parents. At this time, COVID-19 vaccines were available for adults but not yet approved for children in Hong Kong. Information from the media suggested that vaccine eligibility for children would expand in the future, making this period ideal for exploring parental decision-making regarding children's SIV and future COVID-19 vaccination. Study 1 aims to address two questions:

RQ1: What factors influence parental decisions regarding their children's uptake of SIV and COVID-19 vaccination?
RQ2: How do parental decision-making processes differ for these two types of vaccinations?

Methods

Participants

Parents with children aged 6 months to 12 years old were recruited for in-depth interviews. We recruited participants from a pool of parents who had previously taken part in our study on school-based SIV programme acceptance (Dong et al., 2023). We purposively sampled participants with heterogeneous demographics (e.g. age, education, income and employment) and vaccination statuses (children's SIV and their own COVID-19 vaccination). This approach aimed to thoroughly investigate a wide range of perspectives and experiences related to parents' vaccination decisions for children. We stopped recruiting participants when data saturation was reached, meaning no new themes emerged from at least three consecutive interviews.

Procedure

The in-depth interviews were conducted individually via telephone to minimize participants' pandemic-related concerns, each lasting approximately 50 min. All interviews were recorded. The in-depth interviews were conducted in Cantonese or Mandarin, the two main Chinese spoken languages in Hong Kong. Participants received a USD 13 supermarket coupon as compensation for their time. Before formal interviews, we pretested and refined a semi-structured interview guide with a convenience sample of four mothers. This process was undertaken to ensure the use of culturally appropriate language for interviewees. This guide included questions about parental vaccination decision-making for their children's SIV and COVID-19 vaccination, exploring potential influencing factors (File S1). Participants were encouraged to openly share their thoughts, feelings and experience on these topics. Two researchers (JY and MD) joined all the in-depth interviews in a quiet room but for each interview, only one of them took the primary responsibility of interviewing the participant, while another interviewer would supplement to ask additional questions for further exploration towards the end of the interview. This was aimed to minimizing personal biases in research interests and avoid missing important areas for further exploration. After each interview, the three researchers (JY, MD and QL), who with or without prior experiences of childcare, held joint discussions about further information to be explored in the next interview. The qualitative study received ethical approval from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (reference number: UW 19-200).

Analysis

All interviews were transcribed verbatim first. Two researchers (JY and MD), who were proficient in both Cantonese and Mandarin, verified transcription accuracy and began data analysis using a thematic analysis approach. Thematic analysis is a flexible qualitative method for identifying, analysing and presenting patterns in data (Braun & Clarke, 2006). Before the formal coding stage, the two researchers read eight transcripts and recorded initial ideas to become familiar with the dataset. To develop a tentative codebook, they independently generated codes from these interviews to identify potential recurring patterns or themes. Although there are no standard guidelines for the number of interviews needed to develop a codebook, our sample size provided a rich variety of insights that were instrumental for creating a robust coding framework to guide further analysis, while also being manageable for initial analysis. Throughout the initial coding, they maintained ongoing discussions with a third researcher (QL) and resolved disagreements by revisiting the data and refining the codes. The resultant tentative codebook was then used by JY to code all interview transcripts. While the tentative codebook served as a guide for formal coding, the researcher stayed open to

the emergence of new codes during the process. Regular team meetings were held to continuously refine the codebook. After JY completed all the coding, MD cross-coded 52% of the data to check the reliability of coding. Using Miles and Huberman formula, reliability was calculated as the ratio of the number of agreements to the total number of agreements plus disagreements, resulting in a reliability level of 86%. This indicates an adequate level of agreement (Miles & Huberman, 1994). Any discrepancies or uncertainties were resolved by referring to the raw data and through joint discussion. Finally, QL conducted a critical review of all codes and jointly discussed with JY to develop categories and research themes.

Results

Participants' characteristics

Totally, 29 participants completed the in-depth interviews, consisting of 28 mothers and one father. Among these participants, 23 were aged 35–44 years; 17 had attained tertiary or higher education; 13 were employed full-time; and 13 had a monthly household income at the population's median level (HKD30,000; equivalent to ~USD3900) or below. In terms of vaccination uptake, six reported that their children did not receive SIV in the past year. Of the 29 participants, 18 had not received any COVID-19 vaccines for themselves at the time of the interview. Participants' characteristics are provided in Table S1.

Overview of the research themes

The qualitative data revealed distinct parental decision-making routes for childhood COVID-19 vaccination versus SIV. Table 1 illustrates the major themes and their associated descriptions through thematic analysis. In our interviews, most parents refused or hesitated to accept a COVID-19 vaccine for their children. Consequently, we identified four research themes concerning parents' hesitancy regarding children's COVID-19 vaccination uptake. These themes illustrate a process that anchored to influenza vaccines and was influenced by negative situational cues. In comparison, four research themes were related to parents' decision-making for children's SIV uptake, suggesting an experiential and rule-based decision-making process. Quotations examples for these research themes and categories can be found in Table S2.

COVID-19 vaccination decision: Anchoring to SIV and being driven by negative situational cues

Influenza vaccines as an anchor to judge the risk of COVID-19 vaccines
Participants used influenza vaccines as a familiar reference point when discussing COVID-19 vaccines. They attempted to comprehend COVID-19 vaccines and assess the risks and benefits based on their existing knowledge and experiences with SIV. By comparing the risks of a novel vaccine to those of well-known influenza vaccines, participants often concluded that taking a COVID-19 vaccine was riskier because they rarely heard of death cases following SIV, and influenza vaccines were not developed in a short period (e.g. Table S2, quote 1.1). This comparison reduced parents' confidence in the safety of the new COVID-19 vaccine for their children.

Focusing on the negative situational cues
When making decisions for their own and their children's COVID-19 vaccination, participants often re-called negative situational cues. These cues included news reports of adverse events, particularly deaths

TABLE 1 Comparison of research themes and their descriptions relating to parental decision-making for children's SIV and COVID-19 vaccination.

Parents' COVID-19 vaccination decision		Parents' SIV decision	
Theme	**Description**	**Theme**	**Description**
Influenza vaccines as an anchor to judge the risk of COVID-19 vaccines	Parents attempted to comprehend COVID-19 vaccines and assess the risks and benefits based on their existing knowledge and experiences with SIV	Little deliberation on SIV decisions	Parents often based their decisions for children's SIV on past experiences without extensive deliberation
Focusing on the negative situational cues	Parents often recalled negative situational cues when making decisions for their own and their children's COVID-19 vaccination	Being invulnerable to negative situational cues	Parents were less influenced by negative situational cues from the media or friends
High simulation of negative vaccine consequences	Parents tended to envision grim post-vaccination scenarios and vividly described fatal consequences	Realistic expectations about the vaccines	Participants held realistic expectations about the effectiveness and safety of SIV
Waiting for a changing norm	Parents preferred to observe others' vaccination experiences before deciding on their children's COVID-19 vaccination	Sticking to established norms and routines	Following the majority's behaviours or maintaining past practices was a significant strategy for children's SIV uptake

following COVID-19 vaccination, and their friends' negative experiences with vaccine side effects. These negative cues contributed to an unrealistic expectation regarding the safety and effectiveness of COVID-19 vaccines and reduced parents' willingness to accept the potential side effects, especially for their children whose body status was perceived to be more vulnerable.

> Actually, I do not want to get the COVID-19 vaccine because I saw my friends who were feeling so uncomfortable… Children are more vulnerable, they should not suffer these.
>
> (PS24)

High simulation of negative vaccination consequences
Participants emphasized the negative reports and experiences of others concerning COVID-19 vaccines, which led to their own fears of potential negative outcomes, such as the fear of 'dying soon'. Some parents went further by envisioning grim post-vaccination scenarios and vividly describing these consequences. These events triggered strong emotional reactions in parents, prompting parents to avoid the vaccine risks for their children.

> After reading the news…Your information is that not getting it (COVID-19 vaccine) equals to not dying as soon, just like that. I won't put my family at risk.
>
> (PS08)

Waiting for a changing norm
The negative-cue-driven processing evoked great emotional distress in parents, heightening their uncertainty about COVID-19 vaccine safety. The absence of a clear norm based on majority behaviour amplified this uncertainty, leading many parents to adopt a 'wait-and-see' approach. They preferred to observe others' vaccination experiences before deciding on their children's COVID-19 vaccination (e.g. Table S2, quote 4). Among the 29 participants, only five expressed positive attitudes towards childhood COVID-19 vaccination. The most frequently cited reasons were the incentive of being able to travel with a vaccine pass in the future ($N=2$) and the influence of friends and family who showed positive attitudes towards the COVID-19 vaccines ($N=2$). One person mentioned that the vaccine provides hope for ending the pandemic.

Influenza vaccination decision: An experiential and rule-based process

In contrast to their approach to COVID-19 vaccination decisions, participants displayed a higher level of familiarity with influenza vaccines due to their past experiences with the vaccines. As a result, they had established beliefs about SIV, making their decision-making for children's SIV more routine and rule-based. This process was relatively stable and less vulnerable to disruption by situational cues.

Little deliberation on SIV decisions
Parents often based their decisions for children's SIV on past experiences. Their choices for the upcoming influenza season were largely influenced by the previous year's vaccination status, reflecting a habitual decision-making pattern. For children who had received SIV before, the decision for the next year depended on whether those experiences were positive. Additionally, parents whose children's schools provided school-based SIV programmes often cited these programmes as influential. For example, parents mentioned the repeated procedures of how vaccines were provided at schools and their habits of following the procedures to give consent for their children's SIV uptake at schools. Conversely, parents whose children had not received SIV before typically continued to refuse the vaccine.

> We didn't vaccinate him (her children) before because he has to vaccinate again after a certain period. Besides, the virus could keep changing…thus, we would rather to remain conservative and not getting the influenza vaccine.
>
> (PS09)

Parents' repeated experiences with influenza vaccination have made the process being rule-based. That is, taking or not taking SIV for children was a routine practice, requiring little deliberation.

> Because when we were little child, we also got vaccinated like that, I didn't think much because it is so normal. And it was (arranged) by school, it should be so rest assured. (I) didn't pay special attention to the information they provided.
>
> (PS17)

Being invulnerable to negative situational cues

No matter parents held a positive or negative attitude towards the SIV, parents appeared to be less swayed by negative situational cues from the media or friends. During our interviews, a negative event occurred (dozens of Korean citizens died after receiving SIV in the 2020/2021 season) (Cha, 2020), and we explored parents' opinions regarding this event. Parents with positive attitudes about SIV trusted the school's arrangements and were not particularly concerned about the negative event. While parents with negative attitudes towards SIV mentioned that their hesitancy was not influenced by news reports or negative experiences from friends but rather stemmed from their personal values, such as a preference for natural immunity over vaccination.

> Actually, I'm not worried (about the mentioned news). I just believe children themselves already have some immunity. If I can make sure they are (children) eating heathy and exercise regularly, I believe such natural defense could be better. This is my personal belief.
>
> (PS06)

Realistic expectations about the vaccines

Participants had more realistic expectations about the effectiveness of SIV compared to COVID-19 vaccines. They acknowledged that while SIV might not prevent infection entirely, it could protect against severe complications. Moreover, they considered the side effects of SIV to be minor and acceptable, unlike their tendency to overestimate the side effects of COVID-19 vaccines (e.g. Table S2, quote 7).

Sticking to established norms and routines

Participants mentioned lacking a clear norm to guide their COVID-19 vaccination decision but highlighted a well-established norm for children's SIV. Many vaccinated their children because it was a regular practice or because they believed 'everyone else was doing it'. Following the majority's behaviours or maintaining past practices was a significant strategy for children's SIV uptake (e.g. Table S2, quote 8.1). Some expressed a preference for continuing SIV for their children, even if the school-based SIV programme was unavailable or involved financial cost.

Discussion

Our qualitative data revealed distinct parental decision-making routes for children's COVID-19 vaccination and SIV. Decision-making for childhood SIV was guided by habits and rules, with past vaccination experiences playing a significant role, making it an automatic and non-deliberative process less susceptible to the disruption by negative vaccine-related news. While hesitant parents tended

to refuse SIV for their children due to their pre-existing values. Furthermore, parents held realistic expectations about SIV's efficacy and safety, reassured by routine school-based SIV programmes. In contrast, decision-making for children's COVID-19 vaccination was more deliberative. COVID-19 vaccines were perceived as novel, lacking clear normative cues from the community or past experiences. As an alternative strategy, parents used influenza vaccines as an anchor to evaluate COVID-19 vaccines, often overestimating the risks due to focusing on differences rather than similarities. Overall, they were more cautious about a novel vaccine, with negative information triggering a stronger emotional response and influencing their decisions regarding future uptake for their children. The few positive perceptions of childhood COVID-19 vaccination were primarily driven by extrinsic motivation, while intrinsic motivation was lacking. While social norms appear to be a motivating factor behind parental vaccination decisions. Although SIV is more habitual and less susceptible to negative cues, it appears that parents who stick to their non-vaccination habits may be influenced by their preference for natural immunity (Yuan et al., 2024). This preference for natural body defence or natural immunity, widely identified in other studies (Amin et al., 2017; Reich, 2016), may be particularly strong among Hong Kong parents, upheld by the culture of favouring TCM and its related values (Ng et al., 2021). Overall, our qualitative findings aligned with the dual-pathways theory (Wood et al., 2002), indicating that habitual behaviours, such as taking SIV for children, were influenced by stable contextual and attitudinal factors formed through repeated experiences. In contrast, non-habitual behaviours, such as children's COVID-19 vaccination, were performed in novel and stressful contexts, making them more susceptible to situation-varying factors.

STUDY 2

Study 2 sought to augment the insights gained from Study 1 by providing additional evidence to support the influences of different factors on parents' decision-making for the two types of vaccinations. Data in Study 2 were collected among a sample of parents in two waves: the baseline assessment from 21 December 2020 to 17 June 2021, and the follow-up assessment from April 28 to May 26 in 2022. The baseline and follow-up assessments occurred before and after the approval of COVID-19 vaccines for use in children as young as 3 years old in Hong Kong. Building upon the findings of Study 1, our hypotheses for Study 2 are:

> **H1.** *Past-year influenza vaccination, baseline vaccination intention and pre-existing attitudinal factors (medical preference and vaccine-hesitant attitudes) will have greater impact on predicting children's SIV uptake compared to COVID-19 vaccination uptake.*

> **H2.** *Situation-varying factors (anxiety/depression levels and emotional response to news) will have greater impact on predicting children's COVID-19 vaccination uptake compared to SIV uptake.*

> **H3.** *Intention to take vaccination can better predict SIV uptake than COVID-19 vaccination uptake.*

Methods

Participants

We aimed to recruit Hong Kong parent with at least one child aged 6 months to 12 years at the baseline. This age range corresponds to the government's recommendation for SIV eligibility, which begins at 6 months (Centre for Health Protection, 2023b). During the follow-up, COVID-19 vaccination

eligibility was extended to include children aged 3 and above (Centre for Health Protection, 2023c). Consequently, we slightly adjusted the eligibility criteria for our analysis to only parents who had at least one child aged between 3 and 12 years old. Most eligible parents were drawn from our previous random digital dialling survey (~87%). A small proportion (13%) joined through convenience sampling (e.g. participants invited their friends to join). Participants were required to be able to read the online traditional Chinese questionnaire and confirm that their children had no medical contraindications for vaccination.

Procedures

From December 2020 to June 2021, participants were invited via mobile with an explanation of the survey's purpose and a link to the Qualtrics-based questionnaire. The informed consent form was embedded in the cover page of the online survey, and participants had to select 'Agree to participate' before proceeding. The baseline survey took about 20 min to complete. At the end of the baseline survey, participants were asked if they wished to be contacted for a follow-up. Those who consented were recontacted in April 2022. To boost response rates, reminder messages were sent in four consecutive days to non-completers. Participants who completed both surveys received supermarket coupons valued at USD 6.37 each. The study obtained ethical approval from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (reference number: UW 22-102).

Measures

Variables selection was based on the findings from Study 1. We found that parents' decisions regarding children's SIV were influenced by pre-existing attitudes, values and past SIV behaviours, whereas decisions about COVID-19 vaccination for children were driven by situational factors, such as negative information processing and psychological distress. Guided by these findings, the baseline measurement included two pre-existing attitudinal factors: (1) Parental vaccine-hesitant attitudes measured by the short form of parent attitude about childhood vaccines (PACV) instrument (Opel, 2014); (2) parental medical preference was assessed by the adapted medical maximizer–minimizer scale (MMS) (Scherer et al., 2016); (3) and one situation-varying factor: parental anxiety/depression levels were measured with the patient health questionnaire (PHQ-4) (Kroenke et al., 2009). Baseline intention was determined by participants' willingness to accept childhood SIV and COVID-19 vaccination, respectively, in the next 12 months. Past-year vaccination behaviour was based on their target children's SIV uptake in the year prior to the survey. Additionally, demographic characteristics such as participants' gender, age, education, monthly household income and the number of children under 18, as well as the target child's gender and age were collected. The target child for assessing parental decisions for SIV and COVID-19 vaccination was the youngest child eligible for these vaccines at the time of our survey.

In the follow-up survey, we only measured situation-varying factors and their target child's vaccine uptake status. Parents reported their child's SIV and COVID-19 vaccination uptake in the past 12 months. To measure parental probable anxiety/depression, we used the same PHQ-4 items. Additionally, parents read three news items about the pandemic and rated the affective valence and their feelings of optimism or pessimism after each item on a 7-point slider, ranging from −3 to 3. Lower aggregated scores on valence and affect indicated a focus on negative cues in the news. These news items were designed to contain both positive and negative content, and they were pretested to ensure clarity (File S2). The complete details of the study measurements are provided in Table S3.

Analysis

We assessed non-response bias by comparing key demographics between participants who completed and those who did not complete the follow-up survey using Pearson chi-squared tests. To test H1 and H2, we examined the relative importance of factors contributing to the reported uptake of SIV and COVID-19 vaccination for target children in the follow-up survey. We categorized the 15 predictors into five sets: past-year vaccination uptake, baseline intention, pre-existing attitudinal factors (including medical preferences and vaccine-hesitant attitudes), situation-varying factors (anxiety/depression levels and emotional response to news) and demographic characteristics.

To assess the relative importance of these factors, we used the XGBoost (eXtreme Gradient Boosting) algorithm (Chen & Guestrin, 2016), a widely used decision tree-based classification method for predicting vaccination behaviour (Cheong et al., 2021; Hartonen et al., 2023). Compared to other machine learning methods like Random Forest, boosting methods are more efficient with high predictive accuracy because they train models sequentially, each new model helping to correct errors made by the previous models, leading to progressive improvement in overall performance (Chen & Guestrin, 2016). We chose XGBoost because it can provide multiple options for feature importance, making it easier for intuitive comparison (Chen & Guestrin, 2016). XGBoost is also robust in handling multicollinear, nonlinear and nonparametric data, making it more suitable than logistic regressions when the assumptions of logistic regression do not hold. This is relevant in our context, as including both baseline and follow-up anxiety/depression variables may introduce multi-collinearity while assessing situational emotional factors influencing parents' vaccination decisions. Second, this method allows us to identify nonlinear relationships between predictors and vaccination uptake. For example, higher levels of depression have been found to be associated with either higher or lower vaccination willingness (Alimoradi et al., 2023).

We reported the predictive accuracy of our models as the percentage of correctly predicted observations. To determine if a model is good, we compared its accuracy to the no-information rate. This rate serves as a baseline, representing the level of accuracy achieved by consistently predicting the most common outcome. A model that demonstrates significantly higher accuracy than this baseline indicates successful predictive performance. The importance of each predictor was quantified by 'gain' metric in XGBoost model. Gain measures the average increase in predictive accuracy when using the predictor for splitting a decision tree. It captures how much of the observed vaccine uptake can be explained by a particular predictor compared to other predictors. These importance values will be normalized to sum up to 1, meaning each value represents the proportion of the total impact on vaccine uptake that can be attributed to that specific factor. For more details on the prediction models, please refer to File S3.

For H3, we hypothesized that baseline intention might be a more stable predictor for SIV uptake compared to COVID-19 vaccination uptake, given that intention for a novel vaccine can be more susceptible to change over time due to situation-varying factors. To test this hypothesis, we visually presented the path participants took from their baseline intention to their children's follow-up vaccination status for both influenza and COVID-19 vaccines. We used alluvial plots for visual illustration (Siegler et al., 2021). All the analyses were conducted using R statistical software version 4.2.3.

Results

Participants characteristics

A total of 843 parents completed the baseline survey, among whom, 632 eligible participants completed the follow-up survey, a follow-up rate of 75.0%. There were no significant differences in the socio-demographics between participants who completed the follow-up survey and those who did not, except for a slightly higher likelihood of male participants being lost to follow-up ($p = .013$). Additionally, because we also excluded participants whose child were ineligible for COVID-19 vaccine uptake at the

time of our follow-up survey ($N = 15$), the eligible children in this subsample of participants were older (Table 2).

Relative importance of factors for predicting SIV and COVID-19 vaccination in children

XGboost model achieved 83% prediction accuracy for both COVID-19 vaccination uptake (No information rate [NIR]: .66, $p < .001$) and SIV uptake (No information rate [NIR]: .60, $p < .001$). Figure 1a categorizes factors into five groups to improve visualization and ranks the relative importance of predictors for each vaccine. Figure 1b displays the top five factors and their relative importance in predicting vaccine uptake. It shows that situation-varying factors were the most crucial for predicting children's COVID-19 vaccination uptake, explaining 33.3% of the observed uptake. Demographic factors came next, accounting for 25.2%. The third most significant predictor was baseline intention, which explained 20.3% of the COVID-19 vaccine uptake. In comparison, baseline vaccination intention was the most important predictor for children's SIV uptake, explaining 27.9% of total observed uptake. Past-year SIV uptake was the second most important factor for SIV uptake (18.5%), while being the least important for COVID-19 vaccination (5.3%). Parental age was the most important demographic predictor for children's COVID-19 vaccination but not for SIV uptake (File S3).

How well can baseline intention predict future vaccination uptake in children?

Figure 2 displays alluvial plots demonstrating the translation of parents' baseline vaccination intention into their children's follow-up vaccination uptake, with band widths indicating observed proportions. The plots reveal that the path from baseline intention to COVID-19 vaccination uptake in children was more unstable compared to SIV uptake. Among the 632 parents with eligible children for COVID-19 vaccination at follow-up, the majority initially expressed low intention for their children's COVID-19 vaccination (65.9%, 95% CI: 62.0%–69.6%). Surprisingly, among these hesitant parents, 57.2% (95% CI: 52.4%–61.9%) reported that their child receiving the COVID-19 vaccine at the follow-up. In contrast, baseline vaccination intention performed better for predicting SIV uptake in children. Of the 214 parents with low intention for their children's SIV, the majority maintained their initial stance at follow-up (71.5%, 95% CI: 65.2%–77.2%). Of the remaining 418 parents with high intention for SIV, 75.8% (95% CI: 71.6%–79.8%) translated their initial intention into their children's actual SIV uptake at the follow-up.

Discussion

Our Study 2 revealed distinct patterns in the relative importance of predictors for childhood SIV and COVID-19 vaccination. We confirmed H1 and H2, while intention was a significant factor for the uptake of both vaccinations, it contributed a greater explained variance for SIV compared to COVID-19 vaccination uptake. In addition to baseline intention, past vaccination behaviour was also more crucial for predicting SIV uptake. In comparison, situation-varying factors played a greater role in predicting children's COVID-19 vaccination uptake. Furthermore, H3 was supported as baseline intention was more stable in predicting SIV uptake compared to COVID-19 vaccination uptake. The changing situational factors may help explain the gap in intention and behaviour related to COVID-19 vaccination. According to what we found in Study 1, parents generally had low intention for COVID-19 vaccination, when the COVID-19 vaccines just became available in the community, and parents were waiting for a changing norm for accepting COVID-19 vaccines and evidence to ensure the safety of COVID-19 vaccines. During the follow-up survey conducted about 1 year after the baseline and the qualitative study

TABLE 2 Comparison of sociodemographics of parents who completed and did not complete the follow-up survey using Pearson chi-squared tests.

Characteristics	Total (N=843), no. (%)	Participants who completed followed up (N=632), no. (%)	Participants who were lost or ineligible in follow-up (N=211), no. (%)[a]	p Value[b]
Participant's sex				
Female	707 (83.9)	541 (85.9)	166 (78.7)	.013
Male	134 (15.9)	89 (14.1)	45 (21.3)	
Participant's age (years)				
18–34	222 (26.3)	159 (25.3)	63 (30.1)	.164
35–44	496 (58.8)	384 (61.0)	112 (53.6)	
≥45	120 (14.2)	86 (13.7)	34 (16.3)	
Participant's educational attainment				
Secondary or below	367 (43.5)	278 (44.1)	89 (42.2)	.634
Tertiary or above	475 (56.3)	353 (55.9)	122 (57.8)	
Participant's household monthly income (HKD)[c]				
Monthly household income at the population's median level or below	354 (42.0)	267 (42.3)	87 (41.2)	.783
Monthly household income above the population's median level	488 (57.9)	364 (57.7)	124 (58.8)	
Participant's occupational status				
Homemaker	340 (40.3)	254 (40.2)	86 (40.8)	.913
Employed[d]	482 (57.1)	364 (57.4)	119 (56.4)	
Unemployed/seeking job	21 (2.5)	15 (2.4)	6 (2.8)	
Number of children aged ≤18				
One	347 (41.2)	258 (40.8)	89 (42.2)	.291
Two	431 (51.1)	320 (50.6)	111 (52.6)	
Three or above	65 (7.7)	54 (8.5)	11 (5.2)	
The target child's age for SIV				
6 months to 2 years	151 (18.0)	97 (15.3)	54 (25.6)	.002
3–5 years	283 (33.6)	226 (35.8)	57 (27.0)	
6–12 years	409 (48.5)	309 (48.9)	100 (47.4)	
The target child's gender for SIV				
Female	411 (48.8)	316 (50.1)	95 (45.5)	.246
Male	429 (50.9)	315 (49.9)	114 (54.5)	
The target child's age for COVID-19 vaccination[d]				
3–5 years	373 (45.4)	297 (47.0)	76 (36.0)	<.001
6–12 years	448 (54.5)	335 (53.0)	113 (53.6)	
The target child's gender for COVID-19 vaccination[e]				
Female	402 (50.9)	314 (49.8)	100 (47.6)	.590
Male	418 (49.0)	317 (50.2)	110 (52.4)	

[a]Participants whose child were ineligible for COVID-19 vaccine uptake were excluded from the follow-up sample.

[b]p-Values were calculated using a Pearson chi-squared test between those who completed the follow-up and those who did not complete the follow-up.

[c]1 HKD = .13 USD. Population's median level is HKD30000; equivalent to ~USD3900.

[d]Employed included part-time employment and full-time employment.

[e]Participants were asked to answer their child's vaccine uptake status based on their youngest eligible child. The lowest eligible age for SIV was above 6 months, while the lowest eligible age for COVID-19 vaccination was above 3 years old at the time of our survey.
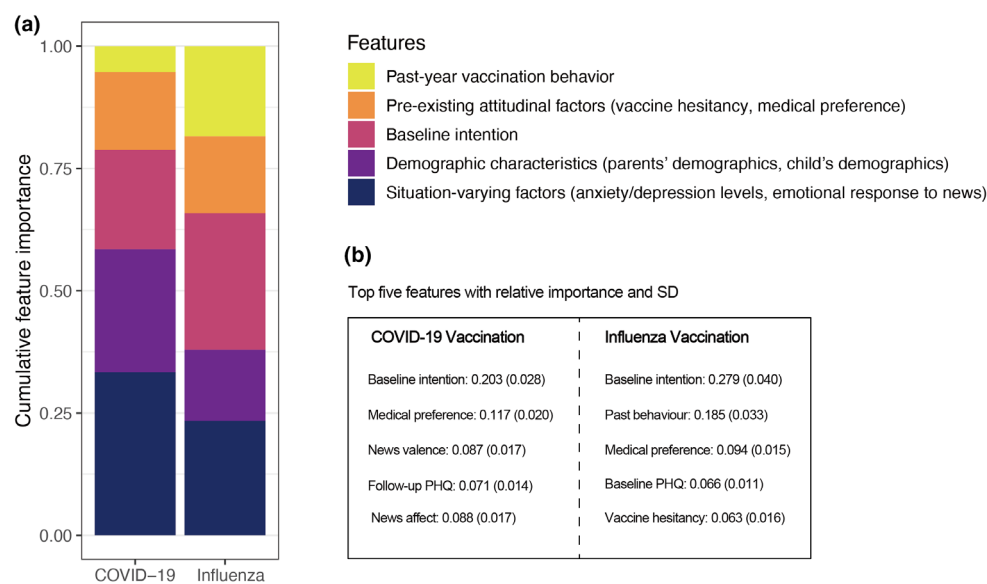
(a)

Features
- Past-year vaccination behavior
- Pre-existing attitudinal factors (vaccine hesitancy, medical preference)
- Baseline intention
- Demographic characteristics (parents' demographics, child's demographics)
- Situation-varying factors (anxiety/depression levels, emotional response to news)

(b)

Top five features with relative importance and SD

COVID-19 Vaccination	Influenza Vaccination
Baseline intention: 0.203 (0.028)	Baseline intention: 0.279 (0.040)
Medical preference: 0.117 (0.020)	Past behaviour: 0.185 (0.033)
News valence: 0.087 (0.017)	Medical preference: 0.094 (0.015)
Follow-up PHQ: 0.071 (0.014)	Baseline PHQ: 0.066 (0.011)
News affect: 0.088 (0.017)	Vaccine hesitancy: 0.063 (0.016)

FIGURE 1 Relative importance of factors in predicting SIV and COVID-19 vaccination in children. Panel (a) shows the cumulative importance of different factors in the two models calculated by the gain function in XGboost algorithm. For better comparison, all the factor importance values are normalized and will be summed up to 1. Panel (b) lists the top five most important factors for each model along with their relative importance mean values and standard errors. For instance, 'Baseline intention' for influenza vaccination has a relative importance value of .279, indicating that it explains 27.9% of the total observed SIV uptake in children.

(Study 1), the evolving norm of increasing acceptance of COVID-19 vaccines, along with changes in vaccine-related policies and incentives (e.g. widespread vaccination campaigns), likely bolstered parents' confidence in vaccinating their children, especially among those who were initially hesitant about children's vaccination.

GENERAL DISCUSSION

Our qualitative and quantitative data provide a cohesive picture that parents used distinct approaches when deciding on children's SIV and COVID-19 vaccination. For childhood SIV, parents predominantly relied on established rules and past behaviour, resulting in a habitual, stable and automatic decision-making process. In contrast, situational factors played a greater role when parents deciding on children's COVID-19 vaccination, making the process less habitual, involve more deliberation and driven more by affect. As a result, baseline intention plays a less stable and important role in predicting COVID-19 vaccination uptake in children.

Contemporary approaches to studying habitual behaviours emphasize the mental processes involved in habit formation and enactment. A recent study utilized qualitative methods to explore how laypeople perceive habitual behaviours (Brown et al., 2020). Similarly, we employed qualitative methods to examine the psychological processes underlying parental habitual and non-habitual vaccination behaviours. Our Study 1 aligns with recent qualitative finding suggesting that habitual behaviours often occur without deliberate thought. We discovered that parents' decisions for SIV were largely automatic and unaffected by recent negative news. Parents followed specific decision-making rules that had been consistently applied in a stable context, including past vaccination behaviour, school vaccination arrangements and previous vaccination experiences. The school-based SIV programme in Hong Kong offers stable contextual cues, including consistent time, setting and procedures, which alleviate parental concerns and facilitate habitual decision-making (Dong et al., 2023; Liao et al., 2021). In contrast, the
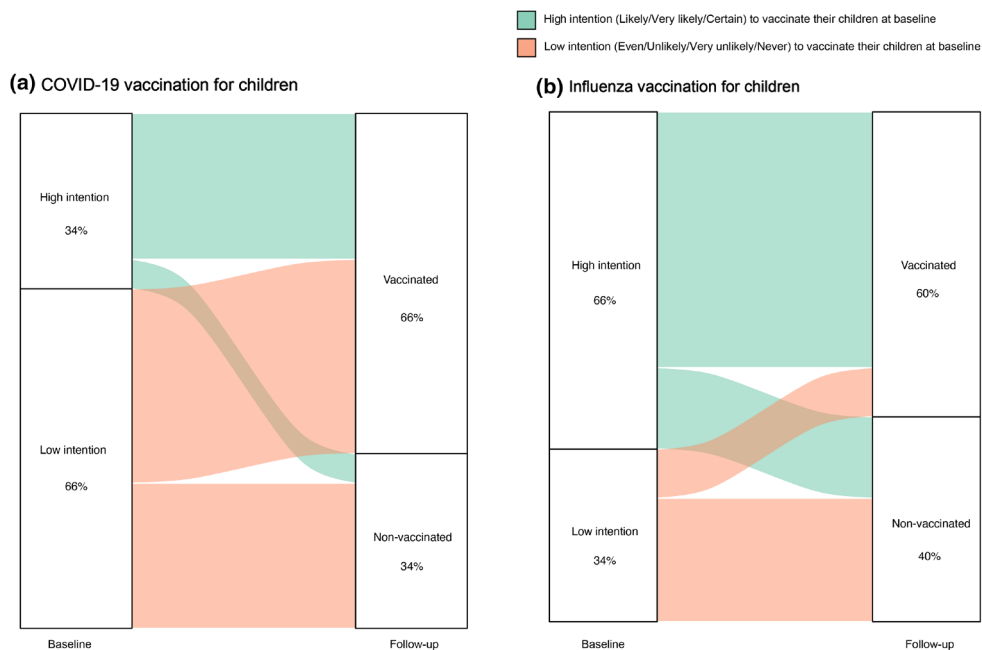
FIGURE 2 Alluvial plot paths from parental baseline intention to follow-up children's vaccine uptake status between COVID-19 vaccination and SIV. The baseline was collected from 21 December2020 to 17 June 2021, and follow-up was collected from 28 April to 26 May 2022. Panel (a) shows COVID-19 vaccination path for children; Panel (b) shows SIV path for children. Percentage was rounded to integers. Parents who reported likely/very likely/certain to take a vaccine at baseline were categorized as high intention; parents who reported even/unlikely/very unlikely/never to take a vaccine at baseline were categorized as low intention.

non-habitual nature of COVID-19 vaccination entails constant evaluation of emerging information in an unstable context. Recent studies show that media reports can reduce COVID-19 vaccination uptake but not SIV uptake (Pinna et al., 2022). Our qualitative results indicate two potential cognitive biases in parents' decision-making for children's COVID-19 vaccination. First, parents tended to compare the safety and effectiveness of the COVID-19 vaccines to influenza vaccines, focusing on differences than similarities, leading to unrealistic expectations about COVID-19 vaccines. This aligns with findings from other studies, where COVID-19 vaccines were perceived as 'new' and 'unknown' compared to other routine vaccines (Paul et al., 2022). Second, parents exhibited negativity biases, selectively focusing on negative information about COVID-19 vaccines. These biases were amplified by vivid and personally relevant mental simulations, heightening concerns about COVID-19 vaccination. Literature suggests that cognitive biases, including anchoring biases and negativity biases, can negatively influence vaccination decision-making (Lazić & Žeželj, 2022; Saleska & Choi, 2021). These biases are particularly impactful in a non-habitual vaccination context, where individuals continuously assess emerging information and experience heightened emotional distress (Wood et al., 2002).

   The quantitative data supplement our qualitative results. Consistent with a recent meta-analysis by Hagger et al. (2023), our Study 2 found that past behaviour and baseline intention were the most significant predictors of future childhood SIV. Additionally, the findings by Hagger et al. (2023) suggest that past behaviour becomes more influential when the opportunity to initiate the behaviour is high and complexity is low. This aligns with our findings of the high predictive power of past vaccination behaviour in the SIV uptake model. The consistently implemented school-based SIV programmes in Hong Kong significantly reduce barriers to children's SIV uptake, facilitating the formation of the SIV habit. However, these factors were less influential for COVID-19 vaccination, likely because past-year SIV

data were used to predict both vaccinations uptake, as COVID-19 vaccines were not available before the pandemic. Our data indicate that situation-varying factors played a more significant role in predicting children's COVID-19 vaccination, aligning with our qualitative findings that parents' decisions were strongly influenced by negative situational cues and emotional distress. Existing studies show that cumulative stressors can deplete attentional resources, causing reliance on heuristics for complex decisions (Albery et al., 2021; Finucane et al., 2000). Negative processing of information (Yılmaz & Sahin, 2021; Zhou et al., 2022) and heightened parental distress (Derdemezis et al., 2022; Xu et al., 2021) are associated with parental vaccine hesitancy. This highlights the need to address parents' negativity biases in information processing and psychological distress to support their decision-making for a novel vaccine, particularly amid a stressful pandemic.

Our findings highlight the intention-behaviour gap between a well-established routine vaccine and a relatively new vaccine. For habitual vaccinations, parents' intentions aligned with their long-standing values and preferences from repeated experiences (Sheeran et al., 2003). Minimal motivation suffices to convert intention into actual vaccine uptake (Gardner et al., 2020). However, changing baseline hesitancy is challenging due to parental deeply rooted psychological factors (Hornsey et al., 2018). By comparison, the intention-behaviour gap is more pronounced for COVID-19 vaccination, especially when intentions are measured before the vaccines' availability. Parents' intentions fluctuate in a dynamic context with various stressors competing for their attention, necessitating constant adaptation of their vaccination decisions (Evans et al., 2021; Xu et al., 2021).

Practical implications for vaccination promotion

The current study provides several valuable implications. Rather than adopting a 'one-type-fits-all' approach, we used SIV and COVID-19 vaccination as examples to illustrate that tailoring interventions to the most influential factors can enhance the promotion of different vaccines in the target population. These insights can be generalized to other similar vaccination contexts. For instance, other routine childhood vaccinations have also experienced a declining trend (UNICEF, 2023). To increase the uptake of a more familiar vaccine in children, information-based intervention has showed limited effectiveness (Webb & Sheeran, 2006). Our qualitative study found that SIV hesitancy was primarily driven by their underlying values rather than negative information, suggesting that value-based interventions could better address parental hesitancy in the uptake of a more familiar vaccine for children (Chen et al., 2023). Enhancing the saliency of contextual cues is also crucial. School programmes should train staff to improve their skills and confidence in communicating with parents about SIV and other routine vaccines (Liao et al., 2021). Looking ahead, as the world faces an increasing number of newly emerging pandemics, the uptake of novel pandemic vaccines becomes crucial to protecting vulnerable groups. For these relatively novel pandemic vaccines like the COVID-19 vaccine, interventions should focus on fostering positive affect and attitudes through gain-framed messages that highlight either the personal or social benefits of receiving a COVID-19 vaccine (Penţa & Băban, 2017). A recent meta-analysis proposed evidence-based strategies to address the gap between intention and behaviour in parent-for-child health behaviours (Hamilton et al., 2020). Specifically, creating action plans could help parents overcome obstacles to initiating new vaccination behaviours. This can be achieved by involving trusted sources, such as healthcare workers, to discuss the vaccination plan with parents (Cassidy et al., 2021). Additionally, social influences can be particularly persuasive in promoting new vaccination behaviours (Hamilton et al., 2020). Our qualitative results show that parents were more willing to accept the new vaccine when they observed an increasing social norm. Therefore, utilizing normative influences, such as encouragement from close friends and family, could be a promising strategy (Head et al., 2022).

Limitations

Our study has several limitations. First, both qualitative study and longitudinal surveys cannot provide causal inferences. Second, our qualitative study was conducted during the early stage of the COVID-19 vaccination programme, potentially limiting the ability to capture evolving parental attitudes. Second, parent may base SIV and COVID-19 vaccination decisions on their different child's situation because COVID-19 vaccination only became available in our follow-up survey. This timing discrepancy could lead to variations in parental perceptions of childhood vaccine uptake. However, we incorporated different sets of target child demographics into the SIV and COVID-19 vaccination models to mitigate the potential effect. Last, not all potential variables were incorporated into the XGboost. Nevertheless, variables included for quantitative analyses were comparable for both vaccines, informed by our qualitative findings, and guided by the dual-pathway theory. This is an important strength of this study. Future studies could leverage advanced machine learning algorithms to enhance the prediction of vaccination uptake, so as to inform more specific vaccination communication strategies.

CONCLUSIONS

Our findings enhance understanding on parental decision-making strategies for different childhood vaccinations. Both qualitative and quantitative analyses revealed that parents' decision-making for childhood SIV was more automatic and rule-based, relying on cues from past vaccination behaviour and following baseline intentions consistently. In contrast, parents' decision-making for their children's COVID-19 vaccination was more deliberative and influenced by dynamic situational factors rather than baseline intentions and past behaviour. Parents exhibited anchoring bias and negativity bias when assessing the risks of COVID-19 vaccines for children. Tailored risk communication is essential for promoting high vaccination uptake rates for different types of vaccines in children.

AUTHOR CONTRIBUTIONS

Jiehu Yuan: Conceptualization; methodology; data curation; investigation; formal analysis; visualization; project administration; writing – original draft. **Meihong Dong:** Project administration; writing – review and editing; data curation; validation. **Dennis Kai Ming Ip:** Funding acquisition; writing – review and editing. **Hau Chi So:** Writing – review and editing. **Qiuyan Liao:** Conceptualization; methodology; investigation; supervision; validation; funding acquisition; writing – review and editing.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The qualitative data associated with this study are available from the corresponding author upon request due to privacy and ethical consideration. The quantitative data set and corresponding codes used to produce the study's major results are openly available in OSF at: https://osf.io/5m4tp/?view_only= 50076cfd274f4116b395f70273da6dc8.

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REFERENCES

Albarracin, D., Johnson, B. T., Fishbein, M., & Muellerleile, P. A. (2001). Theories of reasoned action and planned behavior as models of condom use: A meta-analysis. *Psychological Bulletin*, *127*(1), 142–161.

Albery, I. P., Spada, M. M., & Nikčević, A. V. (2021). The COVID-19 anxiety syndrome and selective attentional bias towards COVID-19-related stimuli in UK residents during the 2020–2021 pandemic. *Clinical Psychology & Psychotherapy*, *28*(6), 1367–1378.

Alimoradi, Z., Lin, C., & Pakpour, A. H. (2023). Worldwide estimation of parental acceptance of COVID-19 vaccine for their children: A systematic review and meta-analysis. *Vaccine*, *11*(3), 533. https://doi.org/10.3390/vaccines11030533

Amin, A. B., Bednarczyk, R. A., Ray, C. E., Melchiori, K. J., Graham, J., Huntsinger, J. R., & Omer, S. B. (2017). Association of moral values with vaccine hesitancy. *Nature Human Behaviour*, *1*(12), 873–880. https://doi.org/10.1038/s41562-017-0256-5

Arsenault, C., Lewis, T. P., Kapoor, N. R., Okiro, E. A., Leslie, H. H., Armeni, P., & Kruk, M. E. (2024). Health system quality and COVID-19 vaccination: A cross-sectional analysis in 14 countries. *The Lancet Global Health*, *12*(1), e156–e165.

Bargh, J. A., Gollwitzer, P. M., Lee-Chai, A., Barndollar, K., & Trötschel, R. (2001). The automated will: Nonconscious activation and pursuit of behavioral goals. *Journal of Personality and Social Psychology*, *81*(6), 1014–1027.

Barrett, A. D. T., Titball, R. W., MacAry, P. A., Rupp, R. E., von Messling, V., Walker, D. H., & Fanget, N. V. J. (2022). The rapid progress in COVID vaccine development and implementation. *NPJ Vaccines*, *7*(1), 20.

Baumeister, R. F., Muraven, M., & Tice, D. M. (2000). Ego depletion: A resource model of volition, self-regulation, and controlled processing. *Social Cognition*, *18*(2), 130–150.

Bishop, F. L. (2015). Using mixed methods research designs in health psychology: An illustrated discussion from a pragmatist perspective. *British Journal of Health Ssychology*, *20*(1), 5–20.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Brewer, N. T., Chapman, G. B., Rothman, A. J., Leask, J., & Kempe, A. (2017). Increasing vaccination: Putting psychological science into action. *Psychological Science in the Public Interest*, *18*(3), 149–207.

Brilli, Y., Lucifora, C., Russo, A., & Tonello, M. (2020). Influenza vaccination behavior and media reporting of adverse events. *Health Policy*, *124*(12), 1403–1411.

Brown, D. J., Hagger, M. S., & Hamilton, K. (2020). The mediating role of constructs representing reasoned-action and automatic processes on the past behavior-future behavior relationship. *Social Science & Medicine*, *258*, 113085.

Cassidy, C., Langley, J., Steenbeek, A., Taylor, B., Kennie-Kaulbach, N., Grantmyre, H., Stratton, L., & Isenor, J. (2021). A behavioral analysis of nurses' and pharmacists' role in addressing vaccine hesitancy: Scoping review. *Human Vaccines & Immunotherapeutics*, *17*(11), 4487–4504. https://doi.org/10.1080/21645515.2021.1954444

Centre for Health Protection. (2023a). *Scientific Committee on Vaccine Preventable Diseases issues recommendations on seasonal influenza vaccination for 2023–24 season in Hong Kong*. CHP. https://www.info.gov.hk/gia/general/202304/19/P2023041900245.htm

Centre for Health Protection. (2023b). *Statistics on vaccination programmes in the past 3 years*. CHP. https://www.chp.gov.hk/en/features/102226.html

Centre for Health Protection. (2023c). *COVID-19 vaccination programme*. CHP. https://www.chp.gov.hk/en/features/106934.html

Cha, S. (2020). *Five South Koreans die after getting flu shots, sparking vaccine fears*. Reuters. https://www.reuters.com/article/health-coronavirus-southkorea-flushots-idUSL4N2HC0QA

Chen, C. H., Chiu, P. J., Chih, Y. C., & Yeh, G. L. (2015). Determinants of influenza vaccination among young Taiwanese children. *Vaccine*, *33*(16), 1993–1998.

Chen, C., Cui, Z., & Chen, Y. (2023). A randomized controlled trial of an information intervention to bolster COVID-19 vaccination intention among people with purity concerns. *Health Psychology*, *42*, 686–697.

Chen, T., & Guestrin, C. (2016). *XGBoost: A scalable tree boosting system*. Paper presented at the Proceedings of the 22nd ACM SIGKDD international conference on knowledge discovery and data mining, San Francisco, California, USA.

Cheong, Q., Au-Yeung, M., Quon, S., Concepcion, K., & Kong, J. D. (2021). Predictive modeling of vaccination uptake in US counties: A machine learning–based approach. *Journal of Medical Internet Research*, *23*(11), e33231.

Committee on Infectious Diseases. (2022). Recommendations for prevention and control of influenza in children, 2022–2023. *Pediatrics*, *150*(4), e2022059275. https://doi.org/10.1542/peds.2022-059275

Dai, H., Saccardo, S., Han, M. A., Roh, L., Raja, N., Vangala, S., Modi, H., Pandya, S., Sloyan, M., & Croymans, D. M. (2021). Behavioural nudges increase COVID-19 vaccinations. *Nature*, *597*(7876), 404–409.

Daley, M. F., Crane, L. A., Chandramouli, V., Beaty, B. L., Barrow, J., Allred, N., Berman, S., & Kempe, A. (2006). Influenza among healthy young children: Changes in parental attitudes and predictors of immunization during the 2003 to 2004 influenza season. *Pediatrics*, *117*(2), e268–e277.

Derdemezis, C., Markozannes, G., Rontogianni, M. O., Trigki, M., Kanellopoulou, A., Papamichail, D., Aretouli, E., Ntzani, E., & Tsilidis, K. K. (2022). Parental hesitancy towards the established childhood vaccination programmes in the COVID-19 era: Assessing the drivers of a challenging public health concern. *Vaccine*, *10*(5), 814.

Dong, M., Ip, D. K. M., Yuan, J., So, H. C., Cowling, B. J., & Liao, Q. (2023). Assessing the longitudinal effects of the continuation and discontinuation of the school-located influenza vaccination programme on parental vaccine hesitancy in Hong Kong. *Journal of Public Health*, *45*(3), fdad018. https://doi.org/10.1093/pubmed/fdad018

Evans, S., Klas, A., Mikocka-Walus, A., German, B., Rogers, G. D., Ling, M., Fernando, J. W., Kothe, E., & Westrupp, E. M. (2021). "Poison" or "protection"? A mixed methods exploration of Australian parents' COVID-19 vaccination intentions. *Journal of Psychosomatic Research*, *150*, 110626.

Finucane, M. L., Alhakami, A., Slovic, P., & Johnson, S. M. (2000). The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making*, *13*(1), 1–17.

Fu, R., Li, J., Yu, H., Zhang, Y., Xu, Z., & Martin, C. (2021). The Yin and Yang of traditional Chinese and Western medicine. *Medicinal Research Reviews*, *41*(6), 3182–3200.

Gardner, B., Lally, P., & Rebar, A. L. (2020). Does habit weaken the relationship between intention and behaviour? Revisiting the habit-intention interaction hypothesis. *Social and Personality Psychology Compass*, *14*(8), e12553.

Hagger, M. S., Hamilton, K., Phipps, D. J., Protogerou, C., Zhang, C., Girelli, L., Mallia, L., & Lucidi, F. (2023). Effects of habit and intention on behavior: Meta-analysis and test of key moderators. *Motivation Science*, *9*(2), 73–94. https://doi.org/10.1037/mot0000294

Hamilton, K., Van Dongen, A., & Hagger, M. S. (2020). Promoting scientific integrity through open science in health psychology: Results of the synergy expert meeting of the European health psychology society. *Health Psychology Review*, *15*(3), 333–349. https://doi.org/10.31234/osf.io/mv4fc

Hartonen, T., Jermy, B., Sõnajalg, H., Vartiainen, P., Krebs, K., Vabalas, A., FinnGen, Estonian Biobank Research Team, Leino, T., Nohynek, H., Sivelä, J., Mägi, R., Daly, M., Ollila, H. M., Milani, L., Perola, M., Ripatti, S., & Ganna, A. (2023). Nationwide health, socio-economic and genetic predictors of COVID-19 vaccination status in Finland. *Nature Human Behaviour*, *7*, 1–15.

Head, K. J., Zimet, G. D., Yiannoutsos, C. T., Silverman, R. D., Sanner, L., & Menachemi, N. (2022). Factors that differentiate COVID-19 vaccine intentions among Indiana parents: Implications for targeted vaccine promotion. *Preventive Medicine*, *158*, 107023. https://doi.org/10.1016/j.ypmed.2022.107023

Hornsey, M. J., Harris, E. A., & Fielding, K. S. (2018). The psychological roots of anti-vaccination attitudes: A 24-nation investigation. *Health Psychology*, *37*(4), 307–315.

Humble, R. M., Sell, H., Dubé, E., MacDonald, N. E., Robinson, J., Driedger, S. M., Sadarangani, M., Meyer, S. B., Wilson, S., Benzies, K. M., & Lemaire-Paquette, S. (2021). Canadian parents' perceptions of COVID-19 vaccination and intention to vaccinate their children: Results from a cross-sectional national survey. *Vaccine*, *39*(52), 7669–7676.

Janssen, L. H., Kullberg, M. L. J., Verkuil, B., van Zwieten, N., Wever, M. C., van Houtum, L. A., Wentholt, W. G., & Elzinga, B. M. (2020). Does the COVID-19 pandemic impact parents' and adolescents' well-being? An EMA-study on daily affect and parenting. *PLoS One*, *15*(10), e0240962.

Karlsson, L. C., Soveri, A., Lewandowsky, S., Karlsson, L., Karlsson, H., Nolvi, S., Karukivi, M., Lindfelt, M., & Antfolk, J. (2021). Fearing the disease or the vaccine: The case of COVID-19. *Personality and Individual Differences*, *172*, 110590. https://doi.org/10.1016/j.paid.2020.110590

Kroenke, K., Spitzer, R. L., Williams, J. B., & Löwe, B. (2009). An ultra-brief screening scale for anxiety and depression: The PHQ–4. *Psychosomatics*, *50*(6), 613–621.

Lau, T. F., Leung, P. C., Wong, E. L., Fong, C., Cheng, K. F., Zhang, S. C., Lam, C. W., Wong, V., Choy, K. M., & Ko, W. M. (2005). Using herbal medicine as a means of prevention experience during the SARS crisis. *The American Journal of Chinese Medicine*, *33*(3), 345–356. https://doi.org/10.1142/s0192415x05002965

Lazić, A., & Žeželj, I. (2022). Negativity in online news coverage of vaccination rates in Serbia: A content analysis. *Psychology & Health*, *39*, 1–19.

Liao, Q., Dong, M., Yuan, J., Lam, W. W. T., Cowling, B. J., So, H. C., & Ip, D. K. M. (2021). A mixed-methods study to evaluate elementary school Staff's acceptability, delivery challenges, and communication regarding the implementation of school-located influenza vaccination program in Hong Kong. *Vaccine*, *9*(10), 1175. https://doi.org/10.3390/vaccines9101175

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Sage Publications.

Ng, T. K., Lo, M. F., & Fong, B. Y. (2021). Knowledge, attitude, utilisation and satisfaction of traditional Chinese medicine in Hong Kong. *International Journal of Pharmaceutical and Healthcare Marketing*, *16*(1), 123–137. https://doi.org/10.1108/ijphm-08-2020-0068

Norman, P., & Cooper, Y. (2011). The theory of planned behaviour and breast self-examination: Assessing the impact of past behaviour, context stability and habit strength. *Psychology & Health*, *26*(9), 1156–1172.

Opel, D. (2014). *Identifying, understanding and talking with vaccine-hesitant parents.* https://www.fondation-merieux.org/wp-content/uploads/2017/03/from-package-to-protection-how-do-we-close-global-coverage-gaps-to-optimize-the-impact-of-vaccination-2014-douglas-opel.pdf

Paul, K. T., Zimmermann, B. M., Corsico, P., Fiske, A., Geiger, S., Johnson, S., Kuiper, J. M., Lievevrouw, E., Marelli, L., Prainsack, B., & Spahl, W. (2022). Anticipating hopes, fears and expectations towards COVID-19 vaccines: A qualitative interview study in seven European countries. *SSM-Qualitative Research in Health*, *2*, 100035.

Payne, A. B., Gilani, Z., Godfred-Cato, S., Belay, E. D., Feldstein, L. R., Patel, M. M., Randolph, A. G., Newhams, M., Thomas, D., Magleby, R., & Hsu, K. (2021). Incidence of multisystem inflammatory syndrome in children among US persons infected with SARS-CoV-2. *JAMA Network Open*, *4*(6), e2116420.

Penţa, M. A., & Băban, A. (2017). Message framing in vaccine communication: A systematic review of published literature. *Health Communication*, *33*(3), 299–314. https://doi.org/10.1080/10410236.2016.1266574

Pinna, M., Picard, L., & Goessmann, C. (2022). Cable news and COVID-19 vaccine uptake. *Scientific Reports*, *12*(1), 16804.

Quellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: the multiple processes by which past behavior predicts future behavior. *Psychological Bulletin*, *124*(1), 54.

Reich, J. A. (2016). Of natural bodies and antibodies: Parents' vaccine refusal and the dichotomies of natural and artificial. *Social Science & Medicine*, *157*, 103–110. https://doi.org/10.1016/j.socscimed.2016.04.001

Ruf, B. R., & Knuf, M. (2014). The burden of seasonal and pandemic influenza in infants and children. *European Journal of Pediatrics*, *173*(3), 265–276.

Saleska, J. L., & Choi, K. R. (2021). A behavioral economics perspective on the COVID-19 vaccine amid public mistrust. *Translational Behavioral Medicine*, *11*(3), 821–825.

Scherer, L. D., Caverly, T. J., Burke, J., Zikmund-Fisher, B. J., Kullgren, J. T., Steinley, D., McCarthy, D. M., Roney, M., & Fagerlin, A. (2016). Development of the medical maximizer-minimizer scale. *Health Psychology*, *35*(11), 1276–1287.

Sheeran, P., Trafimow, D., & Armitage, C. J. (2003). Predicting behaviour from perceived behavioural control: Tests of the accuracy assumption of the theory of planned behaviour. *British Journal of Social Psychology*, *42*(3), 393–410.

Siegler, A. J., Luisi, N., Hall, E. W., Bradley, H., Sanchez, T., Lopman, B. A., & Sullivan, P. S. (2021). Trajectory of COVID-19 vaccine hesitancy over time and association of initial vaccine hesitancy with subsequent vaccination. *JAMA Network Open*, *4*(9), e2126882-e2126882.

Sokol, R. L., & Grummon, A. H. (2020). COVID-19 and parent intention to vaccinate their children against influenza. *Pediatrics*, *146*(6), e2020022871. https://doi.org/10.1542/peds.2020-022871

Temsah, M. H., Alhuzaimi, A. N., Aljamaan, F., Bahkali, F., Al-Eyadhy, A., Alrabiaah, A., Alhaboob, A., Bashiri, F. A., Alshaer, A., Temsah, O., & Bassrawi, R. (2021). Parental attitudes and hesitancy about COVID-19 vs. routine childhood vaccinations: A national survey. *Frontiers in Public Health*, *9*, 752323.

UNICEF. (2023). *New data indicates declining confidence in childhood vaccines of up to 44 percentage points in some countries during the COVID-19 pandemic*. UNICEF. https://www.unicef.org/rosa/press-releases/new-data-indicates-declining-confidence-childhood-vaccines-44-percentage-points-some

Verplanken, B. (2006). Beyond frequency: Habit as mental construct. *British Journal of Social Psychology*, *45*(3), 639–656.

Walsh, M. M., Parker, A. M., Vardavas, R., Nowak, S. A., Kennedy, D. P., & Gidengil, C. A. (2020). The stability of influenza vaccination behavior over time: A longitudinal analysis of individuals across 8 years. *Annals of Behavioral Medicine*, *54*(10), 783–793.

Wang, Q., Xiu, S., Zhao, S., Wang, J., Han, Y., Dong, S., Huang, J., Cui, T., Yang, L., Shi, N., & Liu, M. (2021). Vaccine hesitancy: COVID-19 and influenza vaccine willingness among parents in Wuxi, China—A cross-sectional study. *Vaccine*, *9*(4), 342.

Webb, T. L., & Sheeran, P. (2006). Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. *Psychological Bulletin*, *132*(2), 249–268.

Wood, W., Quinn, J. M., & Kashy, D. A. (2002). Habits in everyday life: Thought, emotion, and action. *Journal of Personality and Social Psychology*, *83*(6), 1281–1297.

World Health Organization. (2024). *The burden of influenza*. WHO. https://www.who.int/news-room/feature-stories/detail/the-burden-of-influenza

Xu, Y., Zhang, R., Zhou, Z., Fan, J., Liang, J., Cai, L., Peng, L., Ren, F., & Lin, W. (2021). Parental psychological distress and attitudes towards COVID-19 vaccination: A cross-sectional survey in Shenzhen, China. *Journal of Affective Disorders*, *292*, 552–558.

Yılmaz, M., & Sahin, M. K. (2021). Parents' willingness and attitudes concerning the COVID-19 vaccine: A cross-sectional study. *International Journal of Clinical Practice*, *75*(9), e14364.

Yuan, J., Dong, M., Wong, I. O. L., Cowing, B. J., Lam, W. W. T., Ni, M. Y., & Liao, Q. (2023). Can psychological distress account for the associations between COVID-19 vaccination acceptance and socio-economic vulnerability? *Applied Psychology. Health and Well-Being*, *15*(4), 1583–1602.

Yuan, J., Li, L., Dong, M., So, H. C., Cowing, B. J., Ip, D. K., & Liao, Q. (2024). Parental vaccine hesitancy and influenza vaccine type preferences during and after the COVID-19 pandemic. *Communications Medicine*, *4*(1), 165. https://doi.org/10.1038/s43856-024-00585-w

Zhou, X., Wang, S., Zhang, K., Chen, S., Chan, P. S. F., Fang, Y., Cao, H., Chen, H., Hu, T., Chen, Y., & Wang, Z. (2022). Changes in parents' COVID-19 vaccine hesitancy for children aged 3–17 years before and after the rollout of the national childhood COVID-19 vaccination program in China: Repeated cross-sectional surveys. *Vaccine*, *10*(9), 1478.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.