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# Behavioural Factors Affecting Infant Immunisation Take-Up: A Narrative Literature Review

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## 1. Introduction

This review discusses the behavioural factors that influence parents' vaccination decisions. The aim is to use behavioural science to help understand decision-making on infant immunisation, and to help increase take-up rates in Ireland.

The review is not a systematic review, given the large volume of existing research on childhood vaccination take-up. Instead, we draw primarily on reviews and meta-analyses on childhood vaccination factors, especially from the vaccine hesitancy literature (e.g. Corben & Leask, 2016). We also specifically consider studies on childhood vaccination from Ireland (e.g. Marron et al., 2023). Most research comes from medical science and health psychology, but often draws on behavioural science concepts. Finally, the COVID-19 pandemic led to a large increase in high-quality behavioural science research on vaccine take-up, so we are informed by this evidence (e.g. Robertson et al., 2024).

Our review draws on several frameworks used in the vaccine hesitancy literature. The "3 Cs" model of vaccine hesitancy (i.e., delaying or refusing available vaccines, MacDonald & SAGE Working Group on Vaccine Hesitancy, 2015) identifies three factors. *Confidence* is about trust – in the vaccine, the healthcare provider, or the government. *Complacency* refers to perceiving a low risk of disease, leading to deprioritisation. *Convenience* relates to the ease of getting vaccinated. Some studies use a fourth C, *Calculation*, for people weighing the risks and benefits of vaccinating (Corben & Leask, 2016), and a fifth C, *Collective responsibility*, for communal orientation (Betsch et al., 2018).

The Vaccine Hesitancy Determinants Matrix (Larson et al., 2015; MacDonald & SAGE Working Group on Vaccine Hesitancy, 2015) builds on the "3 Cs" model. It includes contextual influences (such as the communications and media environment, including influential leaders), individual and group influences (such as beliefs, knowledge, perceived risks and benefits, trust in healthcare providers, the experiences of friends and family, and social norms), and vaccine-specific influences (such as the design, schedule, or costs of the vaccination programme).

Finally, the behavioural-ecological model (Corben & Leask, 2016) maps factors influencing people's behaviour at different levels. These include the intra-personal level (e.g. self-efficacy), inter-personal level (e.g. peer pressure), institutional level (e.g. accessibility), community level (e.g. social media), and the legislative and policy level (e.g. incentives).

This literature review spans across the levels and categories identified in the above models (3 Cs model, Vaccine Hesitancy Determinants Matrix, and behavioural-ecological model), focusing on behavioural factors that contribute to these models by influencing parents' knowledge, attitudes, and/or behaviours around infant immunisation.

We present these factors using six categories: trust, which underpins other factors (section 2.1.); contextual factors such as inertia, defaults, and frictions ("sludge") (section 2.2.); social phenoma such as norms, peer and leadership effects, and collective action problems (section 2.3); factors linked to seeking and understanding information (section 2.4), including misinformation (section 2.5); and judgment under risk and uncertainty (section 2.6).

Overall, we find a large and diverse evidence base, with many studies identifying behavioural factors and related strategies to increase take-up. A pitfall in interpreting this evidence is that behavioural factors are numerous, context-specific, and interact together. In addition, different factors are relevant based on the different ways that parents make decisions. Some behavioural strategies also have a mixed or small evidence base. However, some clear and useful findings emerge from the literature. This review considers the overall evidence base and identifies the behavioural factors likely to be most important, and the interventions that are well-evidenced, or promising but requiring further research.

**2. Behavioural factors of take-up**

It is unlikely that a single powerful intervention can effectively increase infant immunisation take-up in all contexts and for all parents. Rather, successful approaches to changing behaviour are likely to involve multiple interventions, ideally tailored to different groups and contexts, due to several reasons.

First, different behavioural phenomena matter in different contexts. Parental decision-making on childhood vaccination varies by time, place, and vaccine (Corben & Leask, 2016; Larson et al., 2015; Obohwemu et al., 2022; Olson et al., 2020). Therefore, the influence of behavioural factors also likely varies by time, place and vaccine, as small changes in the "choice architecture" (decision-making environment) can disproportionately affect people's choices. Hence the relevance of individual behavioural factors is likely to vary depending on a vaccine's specific context.

Second, different parents make infant immunisation decisions in different ways. A UK review (Forster et al., 2016) found that some parents made non-deliberative vaccination decisions, as they felt they had no choice, were happy to comply, or followed the norm, while others made deliberative decisions after weighing risks and benefits and considering others' views while being impacted by emotions. Different behavioural phenomena are therefore likely at play in these two decision types. For example, biases in risk judgments only apply to the latter type. However, there are also likely factors common to both. In particular, the same review found that in both settings, trust drives choices and practical issues (frictions) hinder vaccination.

Finally, underlying motivations to get vaccinated may differ, although interventions that leverage these motivations may be effective even if they do not alter them. A review of the role of psychological science in encouraging immunisation uptake (not specific to childhood) argues that while psychological factors such as thoughts, feelings, and social processes motivate uptake, some of the most effective interventions do not try to change these psychological processes but rather focus on leveraging already positive intentions or facilitating behaviour directly, for example by providing onsite vaccinations (Brewer et al., 2017); in other words, not targeting the deliberation process itself but easing the implementation of vaccination decisions.

Keeping this interplay of behavioural phenomena in mind, the following sections highlight the most important behavioural factors of infant immunisation.

### *2.1. Trust*

Trust underpins parents' vaccination decisions, whether these decisions are non-deliberative ("going with the flow") or involve a deliberative assesssment of perceived risks and benefits (Forster et al., 2016). This is because trust impacts whether people are happy to comply with healthcare advice (see section 2.2) or follow social norms (section 2.3), how they see others' advice and experience (sections 2.4 and 2.5), and how they judge the risks and benefits (section 2.6).

New parents in Ireland generally have high levels of trust in vaccine information from healthcare professionals and the HSE, and this is a significant predictor of vaccine take-up (Marron et al., 2023). The broader vaccine hesitancy literature finds that trust in healthcare professionals, experts, and vaccines is a major factor of childhood vaccination (Balgovind & Mohammadnezhad, 2022; Ramzan et al., 2023; Wilder-Smith & Qureshi, 2020). Parents see healthcare professionals as the preferred and most trusted source of information and advice on vaccines (Balgovind & Mohammadnezhad, 2022; Campbell et al., 2017; Chung et al., 2017; Novilla et al., 2023; Olson et al., 2020; Schellenberg & Crizzle, 2020), though trust is strongest in parents who vaccinate (Novilla et al., 2023). Trust was argued to be even more important for vaccine take-up than parental knowledge in a Canadian review (Schellenberg & Crizzle, 2020).

On the flipside, lack of trust is a commonly identified barrier to childhood (and adult) vaccination, including mistrust in governments, health officials or providers, experts, pharmaceutical companies, the media, and information such as vaccine statistics (Corben & Leask, 2016; Díaz Crescitelli et al., 2020; Kaufman et al., 2021; Novilla et al., 2023; Obohwemu et al., 2022; Walsh et al., 2022; Wilder-Smith & Qureshi, 2020). Some parents also believe that doctors' advice is biased (Tickner et al., 2006).

An implication of the role of trust is to ensure vaccine information comes from trusted sources, while making these sources salient to parents. This "messenger effect" has been shown to have a significant and consistent impact on behaviour in a variety of contexts in behavioural science research (Dolan et al., 2010). A systematic review and meta-analysis of behavioural interventions (non-chilhood specific) found that health care provider recommendation was one of the most effective ways to increase vaccine uptake (Malik et al., 2023). A systematic review of US research (Olson et al., 2020) found that parents find expert opinions (such as articles written by doctors) persuasive, and are only receptive to information if they find the messenger trustworthy and credible. However, an ESRI study testing COVID-19 vaccination posters found that doctor endorsement did not increase people's vaccination intentions, highlighting the importance of pre-testing messenger interventions (Robertson et al., 2022).

Finally, another implication of the importance of trust concerns when to build trust with parents, for example from the period of pregnancy and pre-natal appointments, since parents may already start to think about immunisation decisions during that time (Corben & Leask, 2016; Olson et al., 2020).

### *2.2. Contextual factors: inertia, defaults, and sludge*

Inertia (sticking with the default) is one of the most powerful and consistent phenomena identified in behavioural science research, leading to strong default effects across policy areas (Dolan et al., 2010). However, there is little evidence on the role of inertia in childhood vaccine hesitancy, possibly because this literature mainly studies parents' reasons for (not) vaccinating, implying a decision-making process

took place, whereas inertia may be most relevant for parents who are not prompted to make a decision in the first place. Therefore, inertia is especially important to non-deliberative processes.

Inertia may influence vaccine decisions positively if vaccinating is seen as the default, for example if it is automatically scheduled for children by their schools (Corben & Leask, 2016; e.g., Health Service Executive, 2025). Parents may be more likely to perceive vaccines as the default depending on how healthcare providers discuss vaccines with them. Presenting vaccines as the default approach and part of routine healthcare can help increase parents' vaccination take-up (Olson et al., 2020), for example by using a presumptive tone ("We will do the shots") rather than a participatory tone ("What do you want to do about the shots?") (Forster et al., 2016; Novilla et al., 2023; Opel, 2023). However, parents care about feeling in control over the vaccination decision-making process, which implies a balance between offering clear recommendations by presenting vaccines as the default, while maintaining trust by also giving parents time to discuss their concerns and engaging in open discussions (Corben & Leask, 2016; Novilla et al., 2023; Olson et al., 2020).

Inertia may also influence vaccine decisions negatively, if vaccinating does not happen by default (i.e., parents have to book vaccination appointments themselves). This is amplified by forgetfulness, lack of time, and a decrease in contact with the healthcare system as the baby ages among other factors (Tickner et al., 2006). In Ireland, one relevant factor may be the timing of the immunisation schedule compared to the end of maternity leave.

Reminders can help combat inertia on infant immunisation (Balgovind & Mohammadnezhad, 2022; Frew & Lutz, 2017; Harvey et al., 2015; Jong et al., 2021; Novilla et al., 2023; Tickner et al., 2006). There is evidence on the potential of using social media for reminders (Novilla et al., 2023), using both postal and phone reminders (Harvey et al., 2015), tackling language barriers (Jong et al., 2021), using personalised calendars tailored to the baby's age and family, and reminding healthcare providers to discuss immunisation with parents (Frew & Lutz, 2017). In the context of COVID-19, an ESRI evidence review found that personalised messages and pre-booked appointments can help increase vaccine uptake (Robertson et al., 2024). Qualitative evidence from Ireland finds that parents see notification and reminder letters as useful prompts to seek vaccines, while some parents noted they did not get around to immunisation as they got no reminders (Mullen, 2004).

"Sludge", the behavioural frictions (hassles) that make it harder for people to do what they want, is another group of factors that may amplify the negative impact of inertia (Sunstein, 2019, 2022). Sludge includes the time and effort needed to search for, book, and attend an infant vaccination appointment, such as dealing with long waiting times; filling any required forms and paperwork; taking time off work to attend; travelling to the healthcare facility; needing to find a new provider if the parent moved to a new place; inconvenient appointment times, and more (Kaufman et al., 2021; Obohwemu et al., 2022; Patel et al., 2022). Even anticipating (not yet experiencing) barriers can act as a deterrent to vaccination (Larson et al., 2015). The vaccine hesitancy literature has identified many of these barriers (Balgovind & Mohammadnezhad, 2022; Wilder-Smith & Qureshi, 2020). One additional insight from behavioural science is that even seemingly small frictions (such as having to find a phone number or fill out a short form) can disproportionately impact outcomes.

Some solutions to tackle sludge include reducing the number of steps needed to access vaccines (for example, via automatic appointment bookings carried out by the GP office), adding digital options to book appointments (Patel et al., 2022), and bundling vaccination with other behaviours so that no extra effort is needed – for example by giving pamphlets in waiting rooms or mentioning vaccines during other appointments (Novilla et al., 2023). In a systematic review and meta-analysis on behavioural interventions for vaccination (not child-specific), on-site vaccination (alongside provider recommendation) was among the most effective tools (Malik et al., 2023). More broadly, while the

literature on sludge is relatively recent, it offers strategies to minimise demands on service users, including by using existing data and systems (review in Martin et al., n.d.).

### *2.3. Social phenomena: norms, peer effects, and collective action*

Social norm beliefs, such as parents' perceptions of social and professional support of vaccination (whether positive or negative), are an important factor of vaccination decisions (Larson et al., 2015). Parents are heavily influenced by both injunctive ("what should be") social norms and descriptive ("what is") social norms (Corben & Leask, 2016).

Parents' social networks, such as their partners, family members, friends, and peers strongly influence their vaccination decisions, with vaccine hesitant parents more likely to know other vaccine hesitant parents (Chung et al., 2017; Corben & Leask, 2016; Hoogink et al., 2020; Obohwemu et al., 2022). In fact, a parent's social network can even be more predictive of their vaccination decisions than their own perceptions of vaccination (Olson et al., 2020).

Social pressure and fear of social judgment can also influence decisions, both towards vaccination when it is viewed as the norm or a social responsibility in the parent's social network, or away from vaccination when there is family or social pressure against it (Forster et al., 2016; Kaufman et al., 2021; Olson et al., 2020; Wilder-Smith & Qureshi, 2020).

The main policy implication from this is to ensure parents understand that vaccination is the norm in Ireland, as anti-vaccination content inaccurately portrays hesitancy as common (Olson et al., 2020). Descriptive norm interventions have also been found to be effective in the context of COVID-19, especially when they refer to a close reference group (Ruggeri et al., 2023). However, social norm interventions that are specific to parents' social context may be most effective (Cislaghi & Heise, 2018).

Interventions that leverage peers as vaccine champions are another tool to consider (Malik et al., 2023). For example, in qualitative research in Ireland, hearing that health professionals immunise their own children was reassuring to parents (Mullen, 2004). More broadly, evidence on peer influence supports a strategy of social mobilisation, whereby communities rather than individuals are engaged on the topic (Novilla et al., 2023; Olson et al., 2020; Ramzan et al., 2023). Finally, one review suggests empowering parents to advocate for vaccination in their community (Olson et al., 2020).

Influential leaders can be an important social driver of parents' decisions (Malik et al., 2023). Religious and community leaders have proven to be effective messengers for parents both to vaccinate or not to vaccinate their children. This is especially important in groups with cultural or religious objections to vaccines (Olson et al., 2020). Hence several reviews conclude that involving trusted community leaders and personalities is a promising intervention for childhood vaccine take-up (Novilla et al., 2023; Olson et al., 2020; Ramzan et al., 2023). This is also the case in COVID-19 research, which found that trusted leaders that are credible to different audiences can be effective in raising intentions to engage in recommended health behaviours (Ruggeri et al., 2023). Influential leaders do not necessarily need to be authority figures; one example from Ireland is the HPV vaccine campaign led by activist Laura Brennan following her terminal cervical cancer diagnosis (Bowers, 2019).

Finally, vaccination is a collective action problem: most parents need to vaccinate in order to protect everyone (including unvaccinated children) from vaccine-preventable diseases. The "5 Cs" scale considers collective responsibility as one of the factors of vaccination choices (Betsch et al., 2018).

Parents may respond differently to the collective action problem of vaccination. One review found that factors for MMR vaccine uptake included a sense of responsibility towards both child and community

health (Wilder-Smith & Qureshi, 2020). A review of qualitative research in the UK found that the narrative of social responsibility for "herd immunity" often contributed pressure to vaccinate, but that parents saw protecting their own child as the most important factor, including non-immunising parents who argued that their child's safety was more important than the impact on the population (Forster et al., 2016). One experiment found no evidence of parents "free-riding" on other families' decisions to vaccinate to protect their own children, as they found a positive relationship between local and population coverage and intention to vaccinate, suggesting norms are a stronger factor (Verelst et al., 2018). However, evidence from COVID-19 also suggests that highlighting the individual benefits of vaccination may be more effective than highlighting their collective benefits (Robertson et al., 2024).

Overall, both individual and collective motivations may drive vaccination decisions, and messages promoting vaccination as a social responsibility or an individual responsibility may be effective with different groups of parents based on their underlying values, hence both messages might be used in targeted ways (Olson et al., 2020).

### *2.4. Seeking and reacting to information*

Deliberative decision-making on infant immunisation involves parents' knowledge and beliefs, which are based on the information they have access to not just from peers but from the government, media, healthcare system, and online sources. Lack of information is an important driver of parents' vaccine hesitancy (Balgovind & Mohammadnezhad, 2022; Díaz Crescitelli et al., 2020; Kaufman et al., 2021). Parents often feel that they do not have enough information, or that this information is not clear enough, and they want more interaction with healthcare providers to discuss information (Balgovind & Mohammadnezhad, 2022; Díaz Crescitelli et al., 2020; Kaufman et al., 2021; Obohwemu et al., 2022; Olson et al., 2020; Wilder-Smith & Qureshi, 2020). Therefore, behavioural factors relating to how we seek and understand information are crucial to immunisation uptake, with implications on the source, tone, presentation, and content of information provided to parents.

#### *Source*

Information sources are more effective if they are trusted messengers (Dolan et al., 2010). As discussed in earlier sections, most parents regard healthcare providers highly as preferred sources of vaccine information, but parents' social networks also strongly influence their decisions. Resources such as books, journal articles and the internet influence vaccination decisions too; the media as a source of information can have positive or negative effects on vaccination (Corben & Leask, 2016; Novilla et al., 2023; Obohwemu et al., 2022).

In terms of the medium of delivery, parents want direct interactions with healthcare providers (not just written materials) (Olson et al., 2020). In Ireland, parents in focus groups reported finding materials from health authorities reassuring but this was particularly powerful when reinforced by a healthcare provider taking time to give answers, clarifications, and reassurance (Mullen, 2004). A related consideration is the timing of information, as some evidence supports providing information before healthcare visits so that parents have a chance to prepare questions (Novilla et al., 2023).

Finally, social media and apps may provide useful sources of information. For example, new parents often use baby apps for information on keeping their child healthy. Technology evolves rapidly, however, meaning that it is important to monitor and update digital interventions (Olson et al., 2020). One review on the use of apps to promote childhood vaccinations found that evidence was often of poor to moderate quality, making it difficult to evaluate these apps' effectiveness (de Cock et al., 2020).

#### *Tone*

The tone and communication style used to give information about vaccines to parents matters. One important question is whether to use a collaborative or authoritative tone. As discussed in section 2.2, initiating the conversation with a strong recommendation and a presumptive tone (as opposed to conciliatory) is a well-evidenced approach (Opel, 2023) and studies identify provider recommendation as crucial regardless of overall style (Corben & Leask, 2016; Obohwemu et al., 2022). However, parents strongly value feeling a sense of control over the vaccination decision (Jackson et al., 2008; Opel, 2023). Therefore, while a direct communication style may help, strong or coercive language may also backfire if it undermines parents' sense of control or trust, via factors such as psychological "reactance" (a negative emotional response to feeling like one's autonomy is threatened), which could impact take-up in the short- or long-term (Corben & Leask, 2016; Ramzan et al., 2023). This is important in Ireland, as infant immunisation requires five consecutive visits.

A shared style of decision-making might help leverage provider advice without risking this backfire effect. A meta-analysis on shared decision-making (not childhood specific) found that it can increase vaccine uptake, confidence, and reduce decisional conflict (Scalia et al., 2022). The vaccine hesitancy literature often recommends "motivational interviewing" methods that encourage dialogue and validate parents' concerns (Novilla et al., 2023; Olson et al., 2020), but few studies have tested the effectiveness of these methods on parents' vaccination decisions (Corben & Leask, 2016).

Beyond healthcare providers' tone about vaccines, their general communication style affects uptake. If parents have poor communication encounters with healthcare providers (such as rudeness or a poor attitude; feeling patronised, judged, not listened to or rushed; lack of compassion or insensitivity; or more generally a bad relationship), this may deter them from coming back for the next visit (Balgovind & Mohammadnezhad, 2022; Kaufman et al., 2021; Mullen, 2004; Obohwemu et al., 2022; Olson et al., 2020). Conversely, parents with good relationships with their GP or public health nurse were more ready to accept information in focus groups in Ireland (Mullen, 2004).

***Presentation***

As suggested by the interplay of factors involved in vaccine hesitancy, there is no one-size-fits all solution for the design of communications on infant immunisation, therefore there remains uncertainty over how to best present this information to parents (Corben & Leask, 2016). Where possible, communications can be tailored to the specific audience in terms of word choice and style, use of numbers, organisation, layout and design, and use of visual aids (Olson et al., 2020).

Research on health literacy provides some best practice for presenting information. Information should be presented in a clear and engaging way. Reviews highlight the importance of simplifying information by using clear, simple, and succinct language that is science-based but avoids jargon, possibly using "gists" that convey the main message (e.g., "if you do not vaccinate your child, there is a real chance they could get sick") (Novilla et al., 2023; Olson et al., 2020).

Storytelling and emotion-based messages may be helpful. Examples include: showing visual aids like pictures, storyboards, or videos instead of text narratives; using simple and relatable metaphors and emotive anecdotes or imagery rather than dry statistical information or "verbatim" probability statements; and conveying enthusiasm and humour to avoid psychological reactance (Novilla et al., 2023; Olson et al., 2020).

Another avenue is to present information in a way that appeals to parents' values and identity, such as by pairing pro-vaccine messages with other "good parenting" advice (e.g., breastfeeding, healthy eating), which has been shown to be effective (Olson et al., 2020).

Finally, there is mixed evidence on how information is "framed" (e.g., highlighting what parents gain by vaccinating vs. what they lose by not vaccinating based on the same information), as some studies find loss-framed messages to be more effective while others find that loss- and gain-framed messages either work best in combination or do not significantly differ from each other in their impact (reviews and discussions in Azarpanah et al., 2021; Olson et al., 2020; Ramzan et al., 2023).

***Content***

The content of immunisation information given to parents is likely to be more effective if personalised, as parents want information that is tailored to their situation and concerns (Olson et al., 2020) and information needs are context-dependent (Corben & Leask, 2016). Therefore, once again there is no one-size-fits-all for preparing information on immunisation for parents. This is especially important because parents who are more vaccine-hesitant have more specific concerns and questions (Olson et al., 2020).

Personalisation may be based on: parent's reasons for and level of hesitancy; whether they are making a deliberative decision; what topics they are concerned about; the level of trust between parent and healthcare provider; the parent's context and community (e.g., social norms and common concerns in this community); and their views on individual or collective benefits (Corben & Leask, 2016; Olson et al., 2020).

Personalisation may also help prioritise information to avoid overwhelming parents with information "overload" (which one study found to reduce COVID-19 vaccination intentions; Honora et al., 2022). In general, parents' main concerns are on the risks and benefits of vaccines (including effectiveness and side effects), the science of vaccines and their ingredients, as well as various "myths" about vaccines (Olson et al., 2020).

Tools such as apps can personalise information for parents based on screening questions about their attitudes, beliefs, intentions, demographics, and source credibility (Olson et al., 2020; Salmon et al., 2019), although note the lack of strong evidence testing such apps (de Cock et al., 2020).

### *2.5. Misinformation*

Misinformation contributes to vaccine hesitancy, usually through social media and the internet, which parents (especially vaccine-hesitant parents) use and view as trusted sources of information (Campbell et al., 2017; Novilla et al., 2023; Olson et al., 2020; Ramzan et al., 2023). In the case of COVID-19, social media was identified as the main channel of misinformation that led to vaccine hesitancy (Ruggeri et al., 2023, 2024).

Olson et al.'s (2020) review argues that misinformation about childhood vaccines often focuses on questioning whether specific vaccines are safe and effective, with the most common beliefs including: that natural immunity is better than vaccine-acquired immunity; that too many vaccines "overload" the immune system; that vaccines contain harmful ingredients leading to serious side effects; that many vaccine-preventable diseases are uncommon anyway; that there are alternatives to vaccines (e.g., homeopathy); that pharmaceutical companies and medical science are not trustworthy; and that vaccines (especially in the case of the MMR vaccine) cause autism, among other beliefs (Corben & Leask, 2016; Díaz Crescitelli et al., 2020; Kaufman et al., 2021; Mullen, 2004; Novilla et al., 2023).

Behavioural factors can amplify the reach and impact of misinformation, for example via biases that influence how people take in information that they may feel emotional about or have preferences over.

Confirmation bias (a preference for information that confirms one's opinions) means people are more likely to take in misinformation on childhood vaccines when it is in line with their beliefs, which makes it tricky to dispel misconceptions, as providing information can backfire if it threatens one's worldviews (Azarpanah et al., 2021; Corben & Leask, 2016; Raj et al., 2023; Ramzan et al., 2023).

Attentional bias (people paying more attention to negative than positive information) may amplify the impact of seeing negative views about vaccines in the media (Forster et al., 2016; Raj et al., 2023).

A "mere exposure" effect (Zajonc, 1968) may lead parents to think misinformation claims are legitimate simply by being exposed to these claims (regardless of whether there is credible evidence for the claims being made). For example, Amazon's algorithm shows more anti-vaccine than pro-vaccine books when searching for vaccine-related books, and in more prominent positions (Shin & Valente, 2020), and a study on French vaccine attitudes found that most French Youtube videos about vaccines are anti-vaccine (Lahouati et al., 2020).

Another potential factor is the "false consensus" effect (Ross et al., 1977), where it appears to parents as though there is widespread concern about vaccines, when in reality the majority of parents are not vaccine-hesitant (Azarpanah et al., 2021). For example, vaccine-hesitant people strongly underestimated vaccine acceptance rates about COVID-19, showing that there was a false consensus bias about the social norm of vaccination (Vriens et al., 2023).

Influential figures who share misinformation online also play an important role (including by potentially contributing to false consensus effects). For example, a study of social media behaviour found that following right-wing influencers (and low-quality news sources) was associated with higher vaccine hesitancy (Rathje et al., 2022), and an experiment found that Trump's anti-vaccine tweets increased vaccine hesitancy among his supporters (Hornsey et al., 2020). "Expert" cues from influencers who leverage their healthcare credentials also increase the legitimacy of vaccine misinformation (Di Domenico et al., 2022), possibly through an "authority bias" (Raj et al., 2023).

This evidence on misinformation means that building not just vaccine literacy but also critical thinking - the ability to seek out the right information online given the pitfalls of social media and our own cognitive biases - is a major intervention area that requires more evidence (Olson et al., 2020). Simply providing fact-based probabilistic information about vaccines fails to increase uptake and may even backfire (Olson et al., 2020; Ruggeri et al., 2024). In addition, negative sentiments on social media may increase vaccine hesitancy faster than interventions reduce it (Ruggeri et al., 2024).

Interventions to "debunk" (fact-check specific claims that have spread online), "pre-bunk" (teach people how misinformation works before they encounter it), or "innoculate" against misinformation (warning people about misinformation tactics using non-harmful exposure as a tool to identify misinformation and using accuracy prompts on social media) have shown promise in reducing online sharing of misinformation and correcting beliefs, but their effects on vaccination uptake are less clear (Ruggeri et al., 2024).

Overall, while few misinformation reduction interventions to date have measured impact on real-world behaviour (such as vaccine uptake), evidence reviews (Ruggeri et al., 2023, 2024) found support for interventions that tailor messages to what groups know and care about, emphasise positive social norms, and go beyond simple messages about benefits and risks (as lack of trust and cultural values impact how they are interpreted), but instead affirm individual cultural values and deal with topics of importance for individuals (not only health facts). Interventions are also likely to be more effective if they ensure that the message, messenger, and provider are all trusted sources of information (e.g.,

trusted leaders and organisations). Suppressing misinformation online can backfire by driving it "underground" to even less regulated sources of information.

Finally, while debunking efforts have found mixed effects on social media, raising the quality and visibility of reliable information can help counter misinformation (also ensuring materials are engaging, e.g., via interactive or visual designs, and easy to find, e.g., via search engine optimisation) (Ruggeri et al., 2024).

### *2.6 Risk and uncertainty*

When parents make a deliberative decision on whether or not to vaccinate their baby, they need to weigh the costs (or risks) and benefits of doing so. The vaccine hesitancy literature finds that risk perceptions underlie vaccine-hesitant parents' (deliberative) choices: they see the risk and severity of vaccine-preventable diseases as low and they underestimate the benefits and safety of vaccines, including due to distrust or misinformation (Blaisdell et al., 2016; Corben & Leask, 2016; Díaz Crescitelli et al., 2020; Kaufman et al., 2021; Marron et al., 2023; Novilla et al., 2023; Obohwemu et al., 2022; Whelan et al., 2021; Wilder-Smith & Qureshi, 2020). In forming these judgments, parents use heuristics (mental shortcuts) to deal with (often emotionally charged) risk information (Corben & Leask, 2016).

Information about the risks of vaccines may be more salient than information about their benefits, or information about the risks of vaccine-preventable diseases. In the context of COVID-19, Robertson et al. (2023) found that a lack of perceived benefits (and a gap in knowledge) distinguished vaccine-hesitant from vaccine-accepting individuals. Availability bias may contribute to this. This refers to the tendency to weigh events or facts that easily come to mind more strongly in judgments, as easily recalled information feels (falsely) representative of likely outcomes (e.g., if vaccine side effects have been in the media recently) (Azarpanah et al., 2021; Casigliani et al., 2022; Chung et al., 2017; Raj et al., 2023). For example, parents who delay or refuse vaccines are more likely to know someone whose child experienced a severe reaction (Chung et al., 2017).

Risk and ambiguity aversion may also influence decisions, as a qualitative study found that vaccine-hesitant parents are not only risk-averse about the vaccine, and perceive it to be greater than the risk of disease, but they are also ambiguity averse and see vaccine information as conflicted, missing, or changing in nature (Blaisdell et al., 2016).

Regret aversion may also impact parents' choices, which may be emotionally charged and led by fear, worry, and guilt over possible outcomes; hence parents may choose the option that helps them avoid regrets in the future, should their child experience an adverse side effect or a vaccine-preventable disease (Corben & Leask, 2016), with some parents in a systematic qualitative review anticipating that they would regret vaccinating, while others anticipate regretting not vaccinating and some are torn between the two (Forster et al., 2016).

The choice of vaccinating children also has a temporal dimension: vaccinating means paying costs now (effort, risk of side effects) in exchange for benefits later (child being protected from diseases). Hyperbolic inter-temporal discounting (inconsistent time preferences where people overweigh present costs over future benefits, leading to repeated postponing of desirable actions) may contribute to vaccine delays, especially given uncertainty over future benefits. These delays may be compounded by inertia (discussed in section 2.2) and in the specific case of vaccines, inertia could be compounded by omission bias, whereby parents feel more responsibility for avoiding harms arising from taking action (vaccinating) than harms arising from inaction (Azarpanah et al., 2021; Corben & Leask, 2016).

Finally, other biases influcing vaccine hesitancy identified in the literature include overconfidence bias (parents assume they can accurately weigh the dangers of immunising, even if they lack knowledge on the topic); anchoring effects, as people may be anchored into bad information before having a chance to discuss vaccines with their healthcare provider and thus they may be excessively influenced by this anchor (Ramzan et al., 2023); compression bias (the overestimation of rare risks such as severe side effects and the underestimation of common risks such as vaccine-preventable diseases); and protected values (having a zero tolerance for vaccine risks), which may be paired with a preference for "natural" risks from diseases, compared to risks from vaccines (Corben & Leask, 2016).

Interventions seeking to debias parents' perceptions of the risks and benefits of vaccinating may help them make more informed choices. However, previous studies in the context of COVID-19 have highlighted pitfalls in risk communications and the importance of pre-testing interventions, as an experiment that provided information about disease risk found a null effect on vaccination intentions (Robertson et al., 2022). Furthermore, while fear-based messaging has contributed to spreading misperceptions about vaccines, interventions attempting to use fear-based messaging to increase vaccine take-up have more often than not been unsuccessful (review in Olson et al., 2020).

Previous sections in this review have shown that only providing factual probabilistic information is unlikely to correct misperceptions and may even backfire, but personalised and context-specific information that focuses on topics people care about and goes beyond providing "numbers" is more likely to succeed. In contexts where vaccine efficacy is under-estimated and where personal benefits are a priority, messages that emphasise efficacy and strong personal benefits may help reduce hesitancy (Robertson et al., 2024). Educational interventions about the severity of diseases and disease susceptibility (which parents may not have had first-hand experience with, reducing their salience in risk judgments) may be helpful too, as knowledge about these factors were important determinants of the vaccination status of children in a systematic review (Obohwemu et al., 2022).

Finally, decision aids that provide information about risks and benefits show considerable promise as tools to assist parents' choices (compared to standard information booklets), and online decision aids can be made even more interactive and personalised, but there are few instances or evaluations of these tools for (childhood) vaccination so far (Corben & Leask, 2016).

### *2.7. Other factors and limitations*

A number of other factors that are not discussed in detail in this review may interact with behavioural factors to influence infant immunisation take-up. For example, any material costs or incentives involved in vaccinating may interact with trust, values, social factors, and perceived risks and benefits.

Furthermore, while socio-demographic determinants of infant immunisation are not in scope for this review, they are predictive of infant immunisation (e.g., in Ireland, see Doherty et al., 2014) and likely interact with the factors covered in the review, such as trust and social norms. For example, studies with Gypsy, Roma, and Traveler (GRT) populations identified accessibility challenges for vaccination in these communities, so sludge barriers may be especially relevant (Wilder-Smith & Qureshi, 2020), while parents facing additional barriers due to their health, digital literacy, or cognitive skills may find it more difficult to find or critically evaluate vaccine information online (Corben & Leask, 2016). More broadly, research in the context of COVID-19 found that marginalised groups in society may receive different information about public health through different channels, compared to other groups, suggesting a potential benefit for targeted communication and strategies (Ruggeri et al., 2023).

Another important consideration is that, as discussed throughout the review, behavioural factors of infant immunisation take-up and potential mechanisms for interventions are highly context-specific.

Factors vary across time, place, and vaccine, and interact with each other; there is no single algorithm that determines vaccine hesitancy and little research tests how factors interact (Corben & Leask, 2016; Obohwemu et al., 2022). Different interventions may be appropriate for deliberative or non-deliberative vaccination decisions, as specified throughout.

More broadly, interventions do not always work and no single strategy was found to be effective on its own given the many interconnected factors involved in parental vaccine hesitancy, therefore tailoring and pre-testing interventions in context is crucial to maximise chances of success (Olson et al., 2020; Robertson et al., 2022; Ruggeri et al., 2024). Furthermore, there is little evidence available yet on some promising areas for intervention, such as misinformation (Ruggeri et al., 2024) or decision aids (Corben & Leask, 2016) interventions.

A final limitation in drawing on the results of the review for policy work in Ireland is that infant vaccine hesitancy in the Irish context may include patterns such as attrition after repeated appointments. There is less evidence available on this context, as many studies focus on individual vaccines rather than on gradual dropoff in the course of a year-long immunisation programme. Furthermore, given this context, factors such as inertia and sludge (section 2.2) may be especially relevant (e.g., parents are busy or not thinking about vaccines actively), yet most evidence in the vaccine hesitancy literature focuses on attitudinal factors (this may be a natural consequence of how vaccine hesitancy is defined). More broadly, vaccine hesitancy research often focuses on deliberative decisions (e.g., trying to understand or inform parents' beliefs and attitudes) but many vaccination decisions are non-deliberative (Lehmann et al., 2017) and may be driven by contextual (rather than informational) factors rather than conscious reasoning, and this may be especially relevant in Ireland as discussed above.

## 3. Conclusion

In this narrative review, we discussed the behavioural factors that contribute to whether parents vaccinate their babies. We find that a number of factors are important, such as trust, contextual factors (e.g., inertia), social factors, factors around seeking and receiving information, misinformation, and biases in making choices under risk and uncertainty. Overall, factors of vaccine take-up are context-specific, numerous, and they interact together, such that there is neither a one-size fits-all explanation for take-up, nor a one-size-fits-all intervention to increase take-up. This means that factors or interventions in the literature may not always apply to infant immunisation in Ireland.

However, a number of best practices likely to be beneficial across contexts emerge from the literature, such as building and maintaining trust, advice from healthcare providers, making vaccines a convenient default without undermining parents' sense of control, highlighting social norms and leveraging peers and leaders, presenting context-specific information from trusted sources about topics people care about in a personalised, simple, and engaging manner, and providing tailored information about risks and benefits that goes beyond "just numbers", among other well-evidenced interventions.

Finally, the review identified a number of promising areas for intervention that require more evidence to ascertain how to best design effective interventions, such tackling inertia and sludge in non-deliberative decisions, combatting misinformation, providing interactive decision aids, and pre-testing debiasing strategies about perceptions of the risks and benefits of vaccines. Research in these areas could help further identify effective interventions to increase infant immunisation uptake in Ireland.

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