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A critical review of measures of childhood vaccine confidence☆

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The World Health Organization and global partners sought to identify existing measures of confidence in childhood vaccines, as part of a broader effort to measure the range of behavioural and social drivers of vaccination. We identified 14 confidence measures applicable to childhood vaccination in general, all published between 2010 and 2019. The measures examined 1–5 constructs and included a mean of 12 items. Validation studies commonly examined factor structure, internal consistency reliability, and criterion-related validity. Fewer studies examined convergent and discriminant validity, test-retest reliability, or used cognitive interviewing. Most measures were developed and validated only in high-income countries. These findings highlight the need for a childhood vaccine confidence measure validated for use in diverse global contexts.

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The need to assess and track the drivers of vaccination

For countries to receive the full benefit of immunization, maintaining high vaccination coverage is vital [1]. Many factors affect childhood vaccination including policies, systems, health services, access, and social and political influences. Parents' confidence in vaccines and vaccination is one determinant of vaccination, contributing in-part to both persistently low population coverage and sudden declines [2–5]. Negative vaccine attitudes and beliefs are also associated with delayed and missed childhood vaccination [6,7].

Some vaccine preventable diseases have surged in geographically concentrated areas [8••]. As a result, several countries recently lost their measles elimination status. Many children missed vaccination during the Covid-19 pandemic [9,10], and now questions exist around how to achieve high uptake of Covid-19 vaccines. The Global Vaccine Action Plan (GVAP) outlined goals for the 'decade of vaccines' (2011–2020), emphasizing the need for all countries to develop comprehensive national vaccine confidence management strategies, encompassing regular assessment of local hesitancy, trust building, and emergency response planning [11]. The Immunization Agenda 2030 then expanded upon these objectives [12].

Characterizing the multiple reasons for low vaccination can enable direct comparisons among different factors, and help guide the development, implementation, and monitoring of interventions to improve vaccination. An important part of this work is vaccine confidence monitoring, which should build on standardized and validated measures. Here we use the term 'confidence' broadly to encompass a range of factors relevant to vaccine acceptance.

The World Health Organization (WHO) and global partners are developing tools for the assessment of the range of factors that influence children's vaccination across diverse global contexts in low-income, middle-income, and high-income countries. The tools are a quantitative

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survey, qualitative in-depth interview guides, and user guidance for these tools. The aim is to support vaccine programme managers, implementation partners and funders to systematically assess the drivers of routine immunization uptake among parents and caregivers (hereafter caregivers) of children under five years of age and to provide consistent and comparable data over time [13••]. To develop these tools, WHO established the 'Measuring Behavioural and Social Drivers of Vaccination' (BeSD) working group, which includes partners from the Vaccination Demand Hub; UNICEF; Gavi, The Vaccine Alliance; the US Centers for Disease Control and Prevention; and the Bill and Melinda Gates Foundation.

We report here on the first stage of the BeSD work informing the development of the Childhood Immunization Survey. The aim is to measure caregivers' experiences and perspectives that affect vaccine uptake, of which one is confidence. We report on the findings of a critical literature review aimed at identifying a comprehensive set of key measures of vaccine confidence. Specifically, we 1) identified available measures of vaccine confidence; 2) described and compared the development methods, scope, replication, and psychometric validity of these measures; and 3) identified gaps in the available measures to be addressed by the Childhood Immunization Survey.

A critical review provides an opportunity to assess the available evidence and a starting point for the conceptual development of a novel tool [14]. We carried out the search in April 2019, before a BeSD working group meeting to agree on overall constructs. We searched PubMed using terms related to vaccination (vaccine, immunization, immunisation), confidence (attitude, belief, confidence, trust) and measurement (psychometric testing, measure, scale, validation) for articles in English published in the peer-reviewed literature with no date restriction. Experts from the working group and author team supplemented the search with further relevant confidence measures. Citations and reference lists of the included articles were then searched to locate additional measures and relevant validation studies. Inclusion criteria for articles were general measures of confidence in childhood vaccination and related concepts. Articles were excluded if they pertained only to a specific vaccine or if they only measured vaccine knowledge. The evidence synthesis process focused on identifying (1) the publication year and country in which measure development took place, (2) the method used to develop a measure, (3) the main underlying constructs in the measures, (4) the questions and response options used to measure these constructs, and (5) the psychometric methods used to examine the validity and reliability of measures.

Available measures of vaccine confidence

We identified 14 published measures of caregivers' confidence in childhood vaccination, all published between 2010 and early 2019 (Table 1). The measures were all developed in high-income countries, except the Caregiver Vaccination Attitudes Scale, which was developed in Ghana, a middle-income country (Table 1). For half of the measures (n = 7), the developers explicitly reported the use of theoretical or conceptual frameworks that informed the development of their tools.

The methods used to create or select items were reported for 11 of the 14 measures. Developers of all 11 of these measures reviewed the literature for items used in previous surveys. Most also used at least one other method to refine or confirm items, including expert consultation (n = 5), conducting cognitive interviews (n = 3), evaluating qualitative themes from interviews or focus groups (n = 3), and pilot testing items (n = 7). Measures were relatively short, with a mean of 12 items (range = 4–39) (Table 1). Four measures had long and short forms. Short forms of measures included a maximum of 10 items.

The survey items and associated constructs appear in Table S1. Measures included one to five constructs each. The most common constructs were beliefs in the benefits or importance of vaccination; trust in vaccines, healthcare providers, the scheduling of vaccines, and trust in the legitimacy of authorities to require vaccination; vaccination harms; and perceived risks of infectious disease. The measures typically assessed each construct using one or two items.

Developers of the measures used conceptually overlapping terms such as attitudes, beliefs, confidence, hesitancy, and acceptance in ways that were often inconsistent and unclear [15]. For example, three measures included 'behaviour', 'behavioural intention' or 'past behaviour' as attitudinal constructs assessed with items such as 'have you ever delayed having your child get a shot for reasons other than illness or allergy?'. However, what people think (e.g. attitudes) and what they do (behaviour) are conceptually distinct, representing cause and effect. Clear conceptualization is critical to achieve meaningful measures. The BeSD working group adapted and proposed definitions of key terms, as shown in Table 2.

The psychometric properties, including reliability and validity, of the 14 measures, were examined in 29 studies conducted in the United States (n = 15), Europe (n = 6), Canada (n = 3), China (n = 1), Malaysia (n = 1), Guatemala (n = 1), Ghana (n = 1), or across multiple countries (n = 1) (Table 3, Table S2). The majority of validation studies focused on the Parent Attitudes about Childhood Vaccines (PACV) measure (n = 10). The other 13 measures had few validation studies, with a mean of 1.4 studies per

Table 1

Measures of childhood vaccination confidence identified through literature review, developed from 2010–2019

Name of measure	Authors	Year published (# of citations)	Country	Development method as described by the authors NOT REPORTED · EXISTING LITERATURE · EXPERT CONSULT · COGNITIVE INTERVIEW · QUAL/FG INTERVIEW · PILOT TESTED	Conceptual basis	Constructs included in the final measure, as named by the authors	Number of items
The Immunisation Beliefs and Intentions Measure (IBIM) [30] [a]	Tickner *et al.*	2010 (34)	England	EXISTING LITERATURE · COGNITIVE INTERVIEW · PILOT TESTED Developed using initial items based on central components of the Theory of Planned Behaviour, which were refined through cognitive interviews and pilot testing.	Theory of Planned Behaviour	1. Behavioural intention (3 items) 2. Attitude (8 items) 3. Subjective norm (3 items) 4. Perceived behavioural control (2 items) 5. Beliefs (23 items): a) Behavioural beliefs (6 items), Normative beliefs (3 items), and Control beliefs (14 items)	39 items
Parent Attitudes about Childhood Vaccines (PACV) survey [19,31]	Opel *et al.*	2011 (205)	United States	EXISTING LITERATURE · EXPERT CONSULT · EXPERT CONSULT · COGNITIVE INTERVIEW · PILOT TESTED Developed using a four-step process: a) Review of previous studies and surveys on parental health beliefs to develop content domains and draft initial survey items (17 items, 12 from previous instruments and 5 constructed *de novo*); b) Two focus groups of parents and two of pediatricians generated additional themes and survey items (10 additional items, 27 items total); c) Six immunization experts reviewed the items and ranked them on a 1–5 scale. The lowest third of ranked items were dropped (18 items); d) The revised survey was pretested with 25 parents to assess face validity, usability and item understandability. Psychometric evaluation of the measure resulted in 15 items.	Health Belief Model	1. Safety and efficacy (4 items) 2. General attitudes (9 items) 3. Behaviour (2 items)	15 items in long form, 5 items in short form
Vaccine Confidence Scale (VCS) [32] [b]	Gilkey *et al.*	2014 (71)	United States	EXISTING LITERATURE · PILOT TESTED Developed using items that were drawn from an existing large national survey (2010 National Immunization Survey-Teen). Eleven items were conceptualised according to the Health Belief Model, with two items of the Parental Attitudes Module assessing parents' relationship with healthcare providers also included. Psychometric evaluation using data from a nationally representative sample of parents of adolescents reduced items to 8, corresponding to three constructs.	Health Belief Model	1. Benefits of vaccination (4 items) 2. Harms of vaccination (2 items) 3. Trust in healthcare providers (2 items)	8 items in long form, 4 items in short form

Table 1 (*Continued*)

Name of measure	Authors	Year published (# of citations)	Country	Development method as described by the authors NOT REPORTED · EXISTING LITERATURE · EXPERT CONSULT · COGNITIVE INTERVIEW · QUAL / FG INTERVIEW · PILOT TESTED	Conceptual basis	Constructs included in the final measure, as named by the authors	Number of items
Vaccine Conspiracy Beliefs Scale (VCBS) [33] [b]	Shapiro *et al.*	2014 (45)	Canada	EXISTING LITERATURE Developed by conducting a scan of the literature. Six items were drawn from existing study on vaccine-specific conspiracy beliefs [34] and one item added by the authors [33].	Not reported	1. Vaccine conspiracy beliefs (7 items)	7 items
Concerns, attitudes, beliefs and intentions of parents about vaccines for their child (CABI-V) [35] [a]	Shoup	2015 (205)	United States	EXISTING LITERATURE · EXPERT CONSULT · COGNITIVE INTERVIEW · PILOT TESTED Developed in three phases: (1) literature review, expert consultation and cognitive interviews; (2) pilot test with 120 pregnant women, followed by revisions; (3) revised survey administered to pregnant women and parents of children under twelve months of age, and psychometrically evaluated.	Theory of Planned Behavior and Health Belief Model	1. Beliefs about vaccinating (6 items) 2. Evaluation of vaccine-preventable diseases (VPD)/ vaccine adverse events (VAE) (8 items) 3. Subjective norms about vaccinating (5 items) 4. Perceived control of vaccinating decisions (4 items)	23 items
Vaccine Hesitancy Scale (VHS) [36,37] [b]	The SAGE Working Group on Vaccine Hesitancy	2015 (216)	Switzerland	EXISTING LITERATURE · EXPERT CONSULT · PILOT TESTED Developed by conducting a systematic review of existent research, piloting questions in the WHO UNICEF Joint Reporting Form, and through expert consultation. Three different types of survey questions were included: Core Closed Questions; Likert-type Scale Questions (evaluated below); and a set of Open-Ended Questions.	Health belief Model and Theory of Planned Behaviour; gaps in these models also identified	1. Confidence (7 items) 2. Risks (2 items)	10 items (9 in subsequent validation)
Vaccination Scale (VS) [38]	Horne *et al.*	2015 (221)	United States	NOT REPORTED Method of development not described. Intention of this study was not specifically to develop a measure but to evaluate intervention o counter antivaccination attitudes.	Not reported	1. General vaccine attitudes (5 items)	5 items
Vaccine Confidence Project™ [39]	Larson *et al.*	2016 (498)	67 countries	NOT REPORTED The measure is adapted from the ten-question Likert-type survey proposed by SAGE. Intention of this study was not specifically to develop a measure but to develop a global monitoring tool. It has been applied in multiple countries; the data are publicly available (www.vaccineconfidence.org).	Not reported	1. Vaccine importance (1 item) 2. Vaccine safety (1 item) 3. Vaccine effectiveness (1 item) 4. Religious compatibility (1 item)	4 items

Table 1 (*Continued*)

Name of measure	Authors	Year published (# of citations)	Country	Development method as described by the authors	Conceptual basis	Constructs included in the final measure, as named by the authors	Number of items
Vaccination Psychological Empowerment Scale (VPES) [40,41]	Fadda *et al.*	2017 (5)	Italy	EXISTING LITERATURE; EXPERT CONSULT; QUAL / FG INTERVIEW; PILOT TESTED Developed an initial item list by examining previous qualitative data (on themes of meaning, competence, impact, and self-determination), literature about psychological empowerment, existing validated empowerment scales and feedback from expert psychologists. The initial item pool was evaluated for content and face validity by a panel of experts in 2015 (57 items). A pretest reduced the initial pool to 9 items, eliminating items without an endorsement frequency between 0.2 and 0.8, and those items without an item-total value higher than 0.3. Three additional items were excluded due to their loading on multiple factors in the principal component analysis.	Empowerment Theory	1. Perceived influence of personal and family experience (2 items) 2. Desire to know peers' opinion and experience (2 items)	4 items
The Vaccination Attitudes Examination (VAX) Scale [42]	Martin and Petrie	2017 (33)	United States	EXISTING LITERATURE; QUAL / FG INTERVIEW Developed an initial item-list pool (45 items) by conducting: 1) three 30-min focus groups (one with a group of individuals who favoured vaccination and two with groups of individuals who identified as vaccine-hesitant) recruited from GP waiting rooms, and organized responses into themes; 2) literature review on attitudes towards vaccination; and 3) informal evaluation of the content of anti-vaccination websites and blogs. Developed items underwent psychometric evaluation and they retained the three items that best reflected each subscale.	Not reported; Used Necessity-Concerns Framework to frame findings	1. Mistrust of vaccine benefit (3-items) 2. Worries about unforeseen future effects (3-items) 3. Concerns about commercial profiteering (3-items) 4. Preference for natural immunity (3-items)	12 items
5C Antecedents of Vaccine Acceptance (5C) [43] [b]	Betsch *et al.*	2018 (81)	Germany	EXISTING LITERATURE Developed using definitions derived from psychological theories, health behaviour models and existing measures, an item pool (of 35 items) was developed and underwent psychometric evaluation.	Health Belief Model, Theory of Planned Behaviour, 3Cs, 5As	1. Confidence (1 or 3 items) 2. Constraints (1 or 3 items) 3. Complacency 1 or 3 items) 4. Calculation (1 or 3 items) 5. Collective Responsibility (1 or 3 items)	15 items in long-form and 5 items in short form

Table 1 (*Continued*)

Name of measure	Authors	Year published (# of citations)	Country	Development method as described by the authors	Conceptual basis	Constructs included in the final measure, as named by the authors	Number of items
Vaccine Acceptance Instrument (VAI) [44]	Sarathchandra *et al.*	2018 (24)	United States	EXISTING LITERATURE, PILOT TESTED Developed by reviewing literature on existing instruments used to measure vaccine confidence, employing expertise in an iterative fashion to identify most important facets of vaccine acceptance or hesitancy, and producing a set of Likert-type scale items that tap five theoretical and empirical dimensions of vaccine acceptance. Each dimension is measured by 4-item subscale of forward-worded and reversed-worded statements. Pilot tested instrument with 196 American adults in 2015.	Not reported	1. Perceived safety of vaccines (1 or 2 items) 2. Perceived effectiveness and necessity of vaccines (1 or 2 items) 3. Acceptance of the selection and scheduling of vaccines (1 or 2 items) 4. Positive values and affect toward vaccines (1 or 2 items) 5. Perceived legitimacy of authorities to require vaccinations (1 or 2 items)	20 items in long-form and 10 items in short form
Caregiver Vaccination Attitudes Scale (CVAS) [45•]	Wallace *et al.*	2019 (7)	Ghana	EXISTING LITERATURE, EXPERT CONSULT, PILOT TESTED Developed items in a multi-step process: 1) initial draft developed with expert study team; 2) review of existing measures; 3) addition of six items based on discussions with immunization professionals with expertise in African countries; 4) input from caregiver focus group discussions; 5) final review by Ghana Health Service immunization program focal points; 6) pilot tested (reducing 11-item version to 6-items based on validity testing).	Not reported	1. Vaccine benefits (2 items) 2. Past vaccination behaviour (2 items) 3. Vaccine efficacy and safety (2 items)	6 items
Emory Vaccine Confidence Index (EVCI) [46•]	Frew *et al.*	2019 (6)	United States	NOT REPORTED Classified 30 individual survey items as they corresponded to the constructs 'Information Environment', 'Trust', 'Healthcare Provider', 'Attitudes and Beliefs', and 'Social Norms', key components of vaccine confidence as defined by the United States National Vaccine Advisory Committee. Methods for developing the specific items are not described. These 30 items were narrowed to 8 items using factor analysis, assessment of coefficients of variation, and the deliberate retention of items related to healthcare providers in order that the measure remained aligned with the advisory committee's definition.	Not reported; items classified according to the advisory committee's definition of vaccine confidence	1. Trust 2. Importance 3. Confidence	8 items

Note. This table includes only measures for childhood vaccination in general (and not for specific vaccines such as measles, mumps, and rubella). Number of citations from Google Scholar as of January 30, 2021.

[a] Measure added to our review based on expert feedback.

[b] Measures that authors of this review developed.

Table 2

Definitions of key terms used in vaccine confidence measures

Term	Definition
Thinking and feeling	
Disease risk appraisal	Thoughts and feelings about potential health problems caused by infectious agents. Includes perceived risk, worry, fear, and anticipated regret.
Confidence	Attitudes and beliefs that vaccines work, are safe, and are part of a trustworthy medical system. Includes perceived importance and effectiveness of vaccines and concerns about vaccines being unsafe.
Motivation	
Hesitancy	Motivational state of being conflicted about, or opposed to, getting vaccinated; includes intentions and willingness.
Intention	Aim or plan to get vaccinated.
Behaviour	
Acceptance	Willing receipt of vaccination.
Coverage	Estimated percentage of individuals who received specific vaccines. Low coverage reflects both individuals who will never be vaccinated and those for whom vaccination is delayed but eventually occurs.
Delay	Receiving a vaccination after the recommended age. Delay can be the result of a deliberate choice, passive inaction, or forces external to the individual, such as a vaccine shortage.
Refusal	Declining to receive a vaccine when offered.
Un-vaccinated	Has not received any of the recommended vaccines for their age.
Under-vaccinated	Has received some, but not all, of the recommended vaccines for their age.
Uptake	Receipt of a vaccine.

Sources: Adapted from Refs. [1,13••,47,48].

measure. The studies most often examined internal consistency ($n = 13$), criterion-related validity (i.e. correlation with vaccination intentions or behavior, $n = 12$), and factor structure ($n = 11$). Fewer studies examined convergent and discriminant validity ($n = 7$), used cognitive interviewing to confirm the meaning that participants ascribe to survey items matches that intended by the researchers ($n = 3$), and assessed test-retest reliability ($n = 3$). Notably, psychometric validation may be especially informative when adapting measures to other languages or for new populations [16,17]. For example, after adapting the PACV for adolescent vaccination, Roberts *et al.* found it was not associated with adolescent vaccination [18], though it had been associated with vaccination of young children [19,20].

Shortcomings of reviewed measures

Existing confidence measures have important shortcomings. These measures were developed within and for specific geographic populations with none developed in a low-income country and only one developed in a middle-income country. Psychometric validation and replication were also limited for most measures and largely conducted in high-income settings. The BeSD Working Group will develop and psychometrically validate the Childhood Immunization Survey to be useful in different cultures and languages in low-income, middle-income, and high-income country settings. Ongoing review of emerging evidence and evaluation of tool implementation will be needed to ensure the tools continue to improve.

Measures of vaccine confidence examine what people think and feel, but this is only one aspect of a holistic approach to understand the causes of coverage gaps. Studies focusing on other factors such as practical issues have found coverage is affected by available vaccine supply, cost of vaccination, and time to access services [21]. To address some of these shortcomings, the BeSD working group developed a comprehensive framework of vaccine uptake that includes what people think and feel, social processes, motivation, and practical issues (Figure 1). In this framework we present beliefs and behaviour as distinct and separable constructs, with confidence belonging to the 'thinking and feeling' domain [13••]. Social processes illuminate the gender barriers to vaccination such as travel and decision autonomy as well as the role of healthcare provider recommendation. Social processes also include family and community norms. Motivation refers to the intention or hesitancy to receive recommended vaccines. Practical factors include awareness of when and where to get a vaccine and the number of vaccinations children should receive, ease of access to a clinic, opportunity costs, and clinic experiences such as waiting time and quality of service, as well as respect from health workers towards caregivers. The caregiver journeys model which charts the process before, during, and after an immunization encounter assisted the development of these practical factors [13••].

This review highlighted that not all potentially relevant confidence constructs have been identified and included in previous measures of vaccine confidence or comprehensively investigated in large, representative, population-based studies. Many existing measures were developed by scanning items used in previous published surveys. Items and constructs measured in earlier tools may have held greater input in the development of later

Table 3

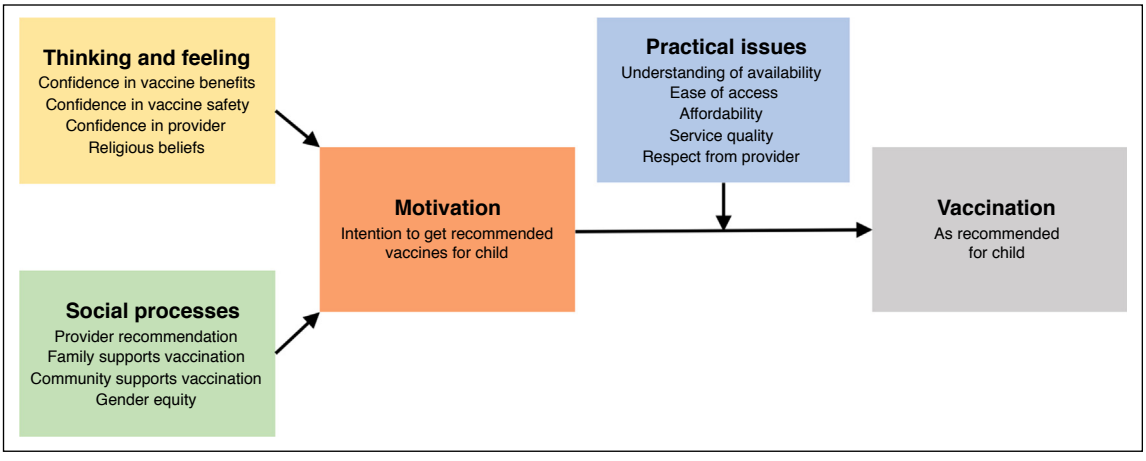
Psychometric properties examined in studies establishing childhood vaccine confidence measures

Vaccine confidence measure, year published	Factor structure	Internal consistency reliability	Test-retest reliability	Cognitive interviewing	Convergent and discriminant validity	Criterion validity
The Immunisation Beliefs and Intentions Measure (IBIM), 2010 [30] [a]	✖	✓	✖	✓	✖	✓
Parent Attitudes about Childhood Vaccines (PACV) survey, 2011 [19,20,31,49–56]	✓	✓	✓	✓	✓	✓
Vaccine Confidence Scale (VCS), 2014 [32,57,58] [b]	✓	✓	✖	✖	✖	✓
Vaccine Conspiracy Beliefs Scale (VCBS), 2014 [33] [b]	✓	✓	✖	✖	✓	✓
Concerns, attitudes, beliefs and intentions of parents about vaccines for their child (CABI-V), 2015 [35] [a]	✓	✓	✓	✓	✖	✓
Vaccine Hesitancy Scale (VHS), 2015 [36,37,59–61] [b]	✓	✓	✖	✖	✓	✓
Vaccination Scale (VS), 2015 [38]	✖	✓	✖	✖	✖	✓
Vaccine Confidence Project™, 2016 [39]	✖	✖	✖	✖	✖	✖
Vaccination Psychological Empowerment Scale (VPES), 2017 [40,41]	✓	✓	✖	✖	✓	✓
The Vaccination Attitudes Examination (VAX) Scale, 2017 [42,62]	✓	✓	✓	✖	✓	✓
5C Antecedents of Vaccine Acceptance (5C), 2018 [43] [b]	✓	✓	✖	✖	✓	✓
Vaccine Acceptance Instrument (VAI), 2018 [44]	✓	✓	✖	✖	✓	✖
Caregiver Vaccination Attitudes Scale (CVAS), 2019 [45•]	✓	✓	✖	✖	✖	✓
Emory Vaccine Confidence Index (EVCI), 2019 [46•]	✓	✓	✖	✖	✖	✓

Note. ✓ = Examined in at least one study. ✖ = Not examined. *Internal consistency reliability:* Examined a measure of the average correlations between pairs of items in the measure. *Test-retest reliability:* Examined the correlation of the measure administered at two different times. *Cognitive interviewing*: Used cognitive interviewing techniques to see whether participants assigned the same meaning to the items that researchers intended (see Table 1). *Convergent and discriminant validity:* Examined whether the measure correlated with conceptually similar scales and not with conceptually unrelated measures. *Criterion validity:* Examined the correlation of the measure with vaccination intention or behaviour. These definitions came primarily from two sources [47,48]. The codes are based on two coders independent evaluation of the studies. Supplementary Material S2 provides more information on the measures' reliability and validity. *Factor structure:* Examined whether the measure had subscales.
[a] Measure added to our review based on expert feedback.
[b] Measure that authors of this review developed.

tools with certain constructs (e.g. perceived risk, perceived vaccine benefits, perceived vaccine harms, and trust) receiving greater emphasis due to precedence rather than established validity (e.g. relationship with vaccine uptake). The prominence of these constructs may also be due to their emphasis in well-regarded health psychology theoretical models (i.e. the Health Belief Model). Existing reviews of the qualitative literature on vaccine confidence and behaviour [22,23], in consultation with the BeSD Working Group, revealed

Figure 1



The Behavioural and Social Drivers of Vaccination Framework.
Source: The WHO BeSD Working Group [13••]. Based on the Increasing Vaccination Model [1].

additional constructs relevant to vaccine confidence, such as profit (i.e. whether vaccination is motivated by financial gain of pharmaceutical companies or other entities), compatibility of vaccination with religious beliefs and cultural practices, moral intuitions of purity (i.e. disgust in vaccination) and liberty, self-efficacy (i.e. belief in one's capability to receive a vaccine) as well as descriptive and subjective social norms. These additional constructs were included in the initial development of the BeSD tools to establish their relevance and whether they are distinct constructs of vaccine confidence [13••].

Surveys can quantify the relevant factors but cannot provide an in-depth and contextualised understanding of how people perceive and experience vaccination for their children. Therefore, qualitative methods are needed to provide a complementary understanding of how people experience vaccination and their reasons for under-vaccination [24]. The BeSD tools will also include qualitative childhood immunization in-depth interview guides. Accumulation of emerging qualitative evidence assessed over time with similar methods will also help to refine future versions of the Childhood Immunization Survey with new or modified constructs of relevance that may have been missed or not fully captured.

Other aspects that are important to evaluate in the future development and piloting of quantitative measures, that were not consistently reported upon in available confidence measures, include the average length of time to complete the measure, readability (reading level), central tendencies and distribution of the measure in the population (with particular attention to ceiling or floor effects), non-systematic presentation of items, and counterbalancing endpoints to reduce response bias. Furthermore, response options used by many of the confidence measures (i.e. response scales with multiple options) may not be appropriate for use in some low-income settings for sociocultural and linguistic reasons, among other considerations [25].

Review strengths and limitations

Our critical review identified measures of vaccine confidence, related constructs, and items from the recent literature. The review has informed the adaptation of the BeSD Framework from the Increasing Vaccination Model by Brewer *et al.* [1] to include the main factors informing uptake of childhood vaccines (Figure 1). Our review is only one aspect of developing the BeSD tools [13••]. We conducted needs assessment interviews with regional and in-country stakeholders, reviewed the grey literature and qualitative measures of under-vaccination, and enlisted expert feedback in the development and reduction of items. In addition, we completed cognitive interviews in the United States, Australia, and Sierra Leone, and elicited feedback on the translatability of items from WHO and UNICEF regional and country offices [13••]. Additional efforts are planned to test these tools in diverse countries—in Pakistan, India, Nigeria, Democratic Republic of the Congo, Angola, and Ethiopia—to assess the psychometric properties of the Childhood Immunization Survey, and ascertain global feasibility, suitability, and comparability.

Our review identified measures of childhood vaccine confidence but was not a systematic review. The review also excluded confidence measures for specific vaccines. While such measures can predict vaccine intentions and coverage beyond general vaccine confidence [1], we aimed for the Childhood Immunization Survey to be usable in many contexts and for many vaccines. In addition, the search date excluded more recently developed measures such as the Vaccine Attitudes Scale, which was developed in Pakistan [26•]. Two scoping review protocols in the past two years have identified the need to synthesize measures of what the authors describe as vaccine hesitancy [27] and vaccination-related psychosocial factors [28], though neither have published their findings to-date. Lastly, we noted the presence or absence of psychometric data for the measures but did not evaluate these findings.

Conclusions

Vaccination is a pivotal health intervention in preventing disease, morbidity, and mortality [29]. Global demand is strong for a standardized, high-quality measure to understand the social and behavioral drivers of vaccination, including vaccine confidence. Our review of vaccine confidence measures and their psychometric validation can support the advancement of vaccination research and interventions to increase childhood vaccination.

Our review has guided the development and validation approach of the BeSD tools which include what people think and feel (including confidence and other constructs) as well as social processes, motivation, and practical issues (Figure 1). Development of the BeSD Childhood Immunization Survey will consider additional potentially relevant confidence constructs not commonly included in previous measures of vaccine confidence. Lastly, the field needs measures validated for use in multinational, multiregional, and multicultural contexts for inclusive and equitable approach to measurement. BeSD tools will be designed for global usability.

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of the author(s) and not necessarily those of the funders or author(s') affiliated institutions.

Conflict of interest statement

NB is a paid consultant on vaccination for Merck, CDC and WHO. GSF's husband is a minority owner of a consulting firm that does some work for Eli Lilly. NS is the director of the London Safety and Training Solutions Ltd, which offers training in patient safety, implementation solutions and human factors to healthcare organisations and the pharmaceutical industry, including Sanofi-MSD and Merck. NS also holds an unrestricted educational research grant by Sanofi Pasteur for the project 'Social and psychological determinants of vaccination uptake – Linking attitudinal and behavioural data to policy analysis and implementation', 2021–24. CW is a Vaccines' Section Editor for Current Opinion in Immunology, but he was not involved in the assessment of the suitability of this article for publication. All other authors report no conflict of interests.

Appendix A

The BeSD Working Group

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Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.coi.2021.04.002.

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- • of special interest
- •• of outstanding interest

1. Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A: **Increasing vaccination: putting psychological science into action**. *Psychol Sci Public Interest* 2017, **18**:149-207.

2. Tafuri S, Gallone MS, Calabrese G, Germinario C: **Adverse events following immunization: is this time for the use of WHO causality assessment?** *Expert Rev Vaccines* 2015, **14**:625-627.

3. Leask J: **Should we do battle with antivaccination activists?** *Public Health Res Pract* 2015, **25**:e2521515.

4. Offit PA: *Deadly Choices: How The Anti-vaccine Movement Threatens Us All*. New York (NY): Basic Books; 2011.

5. Freed GL, Clark SJ, Butchart AT, Singer DC, Davis MM: **Parental vaccine safety concerns in 2009**. *Pediatrics* 2010, **125**:654-659.

6. Smith LE, Amlôt R, Weinman J, Yiend J, Rubin GJ: **A systematic review of factors affecting vaccine uptake in young children**. *Vaccine* 2017, **35**:6059-6069.

7. Schmid P, Rauber D, Betsch C, Lidolt G, Denker ML: **Barriers of Influenza vaccination intention and behavior - a systematic review of influenza vaccine hesitancy, 2005-2016**. *PLoS One* 2017, **12**:e0170550.

8. •• World Health Organization: *Worldwide Measles Deaths Climb 50% from 2016 to 2019 Claiming over 207 500 Lives in 2019*. New York: World Health Organization; 2020.
This report found that measles cases increased worldwide in 2019, with increases in all WHO regions, claiming over 207 000 lives in 2019.

9. McDonald HI, Tessier E, White JM, Woodruff M, Knowles C, Bates C, Parry J, Walker JL, Scott JA, Smeeth L *et al.*: **Early impact of the coronavirus disease (COVID-19) pandemic and physical distancing measures on routine childhood vaccinations in England, January to April 2020**. *Euro Surveill* 2020, **25**:2000848.

10. Chandir S, Siddiqi DA, Mehmood M, Setayesh H, Siddique M, Mirza A, Soundardjee R, Dharma VK, Shah MT, Abdullah S *et al.*: **Impact of COVID-19 pandemic response on uptake of routine immunizations in Sindh, Pakistan: an analysis of provincial electronic immunization registry data**. *Vaccine* 2020, **38**:7146-7155.

11. World Health Organization: *2017 Assessment Report of the Global Vaccine Action Plan Strategic Advisory Group of Experts on Immunization*. Geneva: World Health Organization; 2017.

12. World Health Organization: *Immunization Agenda 2030: A Global Strategy to Leave No One Behind*. World Health Organization; 2020.

13. •• World Health Organization: *Development of Tools to Measure Behavioural and Social Drivers (BeSD) of Vaccination: Progress Report*. World Health Organization; 2020. June.
This report describes the BeSD work as of May 2020, and summarizes key steps in the BeSD tool development process, including evidence reviews, expert input, partner consultations, and initial efforts to refine and test the BeSD tools.

14. Grant MJ, Booth A: **A typology of reviews: an analysis of 14 review types and associated methodologies**. *Health Info Libr J* 2009, **26**:91-108.

15. Betsch C, Bach Habersaat K, Deshevoi S, Heinemeier D, Briko N, Kostenko N, Kocik J, Böhm R, Zettler I, Wiysonge CS *et al.*: **Sample study protocol for adapting and translating the 5C scale to assess the psychological antecedents of vaccination**. *BMJ Open* 2020, **10**:e034869.

16. Bedford H, Attwell K, Danchin M, Marshall H, Corben P, Leask J: **Vaccine hesitancy, refusal and access barriers: the need for clarity in terminology**. *Vaccine* 2018, **36**:6556-6558.

17. Clark LA, Watson D: **Constructing validity: New developments in creating objective measuring instruments**. *Psychol Assess* 2019, **31**:1412-1427.

18. Roberts JR, Thompson D, Rogacki B, Hale JJ, Jacobson RM, Opel DJ, Darden PM: **Vaccine hesitancy among parents of adolescents and its association with vaccine uptake**. *Vaccine* 2015, **33**:1748-1755.

19. Opel DJ, Taylor JA, Mangione-Smith R, Solomon C, Zhao C, Catz S, Martin D: **Validity and reliability of a survey to identify vaccine-hesitant parents**. *Vaccine* 2011:6598-6605.

20. Opel DJ, Taylor JA, Zhou C, Catz S, Myaing M, Mangione-Smith R: **The relationship between parent attitudes about childhood**

vaccines survey scores and future child immunization status: a validation study. *JAMA Pediatr* 2013, **167**:1065-1071.

21. Ozawa S, Yemeke TT, Evans DR, Pallas SE, Wallace AS, Lee BY: **Defining hard-to-reach populations for vaccination**. *Vaccine* 2019, **37**:5525-5534.

22. Dube E, Gagnon D, MacDonald N, Bocquier A, Peretti-Watel P, Verger P: **Underlying factors impacting vaccine hesitancy in high income countries: a review of qualitative studies**. *Expert Rev Vaccines* 2018, **17**:989-1004.

23. White T: *Systematic Review into Factors Underlying Parental Decisions about Childhood Vaccinations*. London: Imperial College London; 2014. MSc in Health Policy Thesis.

24. Larson HJ, Jarrett C, Eckersberger E, Smith DM, Paterson P: **Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007-2012**. *Vaccine* 2014, **32**:2150-2159.

25. Hruschka DJ, Munira S, Jesmin K, Hackman J, Tiokhin L: **Learning from failures of protocol in cross-cultural research**. *Proc Natl Acad Sci U S A* 2018, **115**:11428-11434.

26. • Yousafzai MT, Riaz A, Omer SB, Husain S, Nisar I, Mahesar W, Omar Imam D, Wallace A, Ali A: **Development and validation of parental vaccine attitudes scale for use in low-income setting**. *Pediatr Infect Dis J* 2019, **38**:e143-e148.

This manuscript describes the development and validation of a measure to assess childhood vaccine related attitudes in Pakistan, a low-income country setting. The authors validated the measure with 901 parents of children 4–12 months of age, and examined the internal validity, factor structure, and criterion validity. The final measure had two subscales that the authors named vaccine perceptions and concerns and vaccine preventable disease salience and community benefit.

27. Oduwole EO, Pienaar ED, Mahomed H, Wiysonge CS: **Current tools available for investigating vaccine hesitancy: a scoping review protocol**. *BMJ Open* 2019, **9**:e033245.

28. Kaufman J, Ryan R, Betsch C, Parkhill A, Shapiro G, Leask J, Menning L, Tugwell P, Costa DS, Danchin M *et al.*: **Instruments that measure psychosocial factors related to vaccination: a scoping review protocol**. *BMJ Open* 2019, **9**:e033938.

29. World Health Organization: *WHO Vaccine-preventable Diseases: Monitoring System 2017 Global Summary*. World Health Organization; 2017.

30. Tickner S, Leman PJ, Woodcock A: **The Immunisation Beliefs and Intentions Measure (IBIM): predicting parents' intentions to immunise preschool children**. *Vaccine* 2010, **28**:3350-3362.

31. Opel DJ, Mangione-Smith R, Taylor JA, Korfiatis C, Wiese C, Catz S *et al.*: **Development of a survey to identify vaccine-hesitant parents: the parent attitudes about childhood vaccines survey**. *Hum Vaccines* 2011, **7**:419-425.

32. Gilkey MB, Magnus BE, Reiter PL, McRee AL, Dempsey AF, Brewer NT: **The vaccination confidence scale: A brief measure of parents' vaccination beliefs**. *Vaccine* 2014, **32**:6259-6265.

33. Shapiro GK, Holding A, Perez S, Amsel R, Rosberger Z: **Validation of the vaccine conspiracy belief scale**. *Papillomavirus Res* 2016, **2**:167-172.

34. Jolley D, Douglas KM: **The effects of anti-vaccine conspiracy theories on vaccination intentions**. *PLoS One* 2014, **9**:e89177.

35. Shoup JA: *Concerns, Attitudes, Beliefs and Intentions of Parents about Vaccines for Their Child: Development and Evaluation of a Survey Instrument in an Integrated Health Care System in Colorado*. University of Colorado at Denver; 2015.

36. Larson HJ, Jarrett C, Schulz WS, Chaudhuri M, Zhou Y, Dube E *et al.*: **Measuring vaccine hesitancy: the development of a survey tool**. *Vaccine* 2015, **33**:4165-4175.

37. Shapiro GK, Tatar O, Dube E, Rhonda A, Knauper B, Naz A, Perez S, Rosberger Z: **The vaccine hesitancy scale: psychometric properties and validation**. *Vaccine* 2018:660-667.

38. Horne Z, Powell D, Hummel JE, Holyoak KJ: **Countering antivaccination attitudes**. *PNAS* 2018, **112**:10321-10324.

39. Larson H, de Figueiredo A, Xiahong Z, Schulz WS, Verger P, Johnston IG, Cook AR, Jones NS: **The state of vaccine confidence 2016: global insights through a 67-country survey**. *EBioMedicine* 2016, **12**:295-301.

40. Fadda M, Galimberti E, Romanò L, Faccini M, Senatore S, Zanetti A, Schulz PJ: **Validation of a scale to measure parental psychological empowerment in the vaccination decision**. *J Public Health Res* 2017, **6**.

41. Fadda M, Galimberti E, Carraro V, Schulz PJ: **What are parents' perspectives on psychological empowerment in the MMR vaccination decision? A focus group study**. *BMJ Open* 2016, **6**: e010773.

42. Martin LR, Petrie KJ: **Understanding the dimensions of anti-vaccination attitudes: the Vaccination Attitudes Examination (VAX) scale**. *Ann Behav Med* 2017, **51**:652-660.

43. Betsch C, Schmid P, Heinemeier D, Korn L, Holtmann C *et al.*: **Beyond confidence: development of a measure assessing the 5C psychological antecedents of vaccination**. *PLoS One* 2018, **13**:e0208601.

44. Sarathchandra D, Navin MC, Largent MA, McCright AM: **A survey instrument for measuring vaccine acceptance**. *Preventive Med* 2018:1-7.

45. • Wallace AS, Wannemuehler K, Bonsu G, Wardle M, Nyaku M, Amponsah-Achiano K, Dadzie JF, Sarpong FO, Orenstein WA, Rosenberg ES *et al.*: **Development of a valid and reliable scale to assess parents' beliefs and attitudes about childhood vaccines and their association with vaccination uptake and delay in Ghana**. *Vaccine* 2019, **37**:848-856.

This manuscript describes the development and validation of a measure to assess childhood vaccine attitudes in Ghana, a middle-income country. The authors conducted a cluster survey of 373 households with children aged 12–35 months, and examined the internal consistency, factor structure, and criterion validity and used cognitive interviewing. The final measure had three factors that the authors named vaccine benefit, past vaccination behaviour, and vaccine efficacy and safety.

46. • Frew PM, Murden R, Mehta C, Chamberlain AT, Hinman AR, Nowak G, Mendel J, Aikin A, Randall LA, Hargreaves AL *et al.*: **Development of a US trust measure to assess and monitor parental confidence in the vaccine system**. *Vaccine* 2019, **37**:325-332.

This manuscript describes the development and validation of a measure to assess parental confidence towards childhood immunization in the United States, a high-income country setting. The authors conducted a web-based national poll of 893 parents of children less than age 7 years, and examined the internal consistency, factor structure, and criterion validity. The final measure had three factors that the authors named trust, importance and confidence.

47. Leong FTL, Austin JT (Eds): *The Psychology Research Handbook: A Guide for Graduate Students and Research Assistants*, edn 2. London: Sage Publications; 2006.

48. *APA Dictionary of Psychology*. Washington, DC: American Psychological Association; 2020.

49. Roberts JR, Thompson D, Rogacki B, Hale JJ, Jacobson RM, Opel DJ, Darden PM: **Vaccine hesitancy among parents of adolescents and its associationwith vaccine uptake**. *Vaccine* 2015, **33**:1748-1755.

50. Strelitz B, Grittona J, Kleina EJ, Bradforda MC, Follmera K, Zerra DM, Englunda JA, Opel DJ: **Parental vaccine hesitancy and acceptance of seasonal influenzavaccine in the pediatric emergency department**. *Vaccine* 2015, **33**:1802-1807.

51. Williams SE, Morgan A, Opel D, Edwards K, Weinberg S, Rothman R: **Screening tool predicts future underimmunization among a pediatric practice in Tennessee**. *Clin Pediatrics (Phila)* 2016, **55**:537-542.

52. Hofstetter AM, Simon TD, Lepere K, Ranade D, Strelitz B, Englund JA, Opel DJ: **Parental vaccine hesitancy and declination of influenza vaccination among hospitalized children**. *Hosp Pediatr* 2018, **8**:628-635.

53. Bianco A, Mascaro V, Zucco R, Pavia M: **Parent perspectives on childhood vaccination: how to deal with vaccine hesitancy and refusal?** *Vaccine* 2019, **37**:984-990.

54. Dube E, Farrands A, Lemaitre T, Boulianne N, Sauvageau C, Boucher FD *et al.*: **Overview of knowledge, attitudes, beliefs, vaccine hesitancy and vaccine acceptance among mothers of infants in Quebec, Canada**. *Hum Vaccines Immunother* 2019, **15**.

55. Mohd Azizi FS, Kew Y, Moy FM: **Vaccine hesitancy among parents in a multi-ethnic country, Malaysia**. *Vaccine* 2017, **35**:2955-2961.

56. Cunningham RM, Kerr GB, Orobio J, Munoz FM, Correa A, Villafranco N, Monterrey AC, Opel DJ, Boom JA: **Development of a Spanish version of the parent attitudes about childhood vaccines survey**. *Hum Vaccin Immunother* 2019, **15**:1106-1110.

57. Gilkey MB, Reiter PL, Magnus BE, McRee AL, Dempsey AF, Brewer NT: **Validation of the vaccination confidence scale: a brief measure to identify parents at risk for refusing adolescent vaccines**. *Acad Pediatr* 2016, **16**:42-49.

58. Gilkey MB, McRee AL, Magnus BE, Reiter PL, Dempsey AF, Brewer NT: **Vaccination confidence and parental refusal/delay of early childhood vaccines**. *PLoS One* 2016, **11**:e0159087.

59. Domek GJ, O'Leary ST, Bull S, Bronsert M, Contreras-Roldan IL, Bolaños Ventura GA, Kemp A, Asturias EJ: **Measuring vaccine hesitancy: field testing the WHO SAGE working group on vaccine hesitancy survey tool in Guatemala**. *Vaccine* 2018, **36**:5273-5281.

60. Ren J, Wagner AL, Zheng A, Sun X, Boulton ML, Huang Z, Zikmund-Fisher BJ: **The demographics of vaccine hesitancy in Shanghai, China**. *PLoS One* 2018, **13**:e0209117.

61. Luyten J, Bruyneel L, van Hoek AJ: **Assessing vaccine hesitancy in the UK population using a generalized vaccine hesitancy survey instrument**. *Vaccine* 2019, **37**:2494-2501.

62. Wood L, Smith M, Miller CB, O'Carroll RE: **The internal consistency and validity of the vaccination attitudes examination scale: a replication study**. *Ann Behav Med* 2018:1-6.