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RESEARCH ARTICLE

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Measuring outcomes of training in Empathetic Refutational Interviewing (ERI) for vaccine communication: Development and validation of the ERI Skills Inventory (ERISI)

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ABSTRACT

Considering the complex nature of vaccine hesitancy and the vast amount of misinformation surrounding vaccination, training healthcare professionals (HCPs) in vaccine communication is important to ensure high vaccine uptake. Recently, a new vaccine communication approach, known as the Empathetic Refutational Interview (ERI), was developed to help HCPs in conversations with patients who have vaccine concerns. In the present study, we developed and validated the ERI Skills Inventory (ERISI) for assessing learning outcomes of training in ERI. The ERISI measures are (1) ERI-related knowledge, (2) ERI-related skills, and (3) confidence in using the ERI. A sample of 103 HCPs who took part in ERI training responded to the ERISI, as well as questions about their self-efficacy in vaccine consultations and preparedness to refute arguments against vaccination, before and after the training. At two follow-ups, they also reported their understanding and use of the ERI. Results showed that the ERISI is sensitive to positive changes in ERI knowledge and confidence as a result of training. Participants also showed increased use post-training of ERI skills to demonstrate empathy toward patients. However, no change was observed for ERI skills that refute misconceptions and inform patients using factual information, which participants tended to already use at pretest. ERI knowledge correlated positively with ERI skills at posttest. ERI confidence demonstrated both concurrent and predictive validity. The ERISI questionnaire is a valuable tool for assessing ERI training outcomes that can guide training development to ensure learning and future skill application.

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Introduction

Vaccination is a cornerstone of global health, protecting individuals and communities from infectious diseases.[1] Healthcare professionals (HCPs) play a key role in ensuring high vaccine uptake, as they discuss vaccinations directly with the public. Nevertheless, hesitancy related to vaccines – and the fact that such hesitancy is complex and fueled by misinformation – can make discussing vaccination challenging.[2,3] In the European Immunization Agenda 2030, the WHO Regional Office for Europe[4] highlights the importance of HCPs having "the capacity to effectively communicate the benefits of immunization and address questions and concerns raised by the public" (p. 13). This can be achieved by member states ensuring access to training in vaccine communication to their health workforce.[5] A communication approach known as the Empathetic Refutational Interview (ERI)[6] has recently been developed to offer guidance to HCPs in situations when patients express concerns regarding vaccination, particularly those encompassing misconceptions about vaccines. In the present study, we developed and validated a tool for evaluating learning outcomes of ERI training among HCPs.

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The ERI incorporates insights from research within cognitive science, communication, and vaccine hesitancy. It is inspired by and shares many fundamental principles and techniques with Motivational Interviewing (MI) – an empathetic counseling technique, which has been successfully applied in vaccination settings.[7–10] Like the MI, the ERI is patient-centered and focuses on guiding individuals in their decision-making process while considering their unique needs and respecting their motivations and beliefs.[6,11] To this, the ERI adds a framework for understanding different reasons behind vaccine concerns (known as attitude roots), advice on how to tailor communication depending on these reasons, and guidance on how to effectively address vaccine misconceptions.[6] The ERI has shown positive outcomes among vaccine-hesitant individuals in both large-scale online experiments and a field study with HCPs and vaccine-hesitant patients, when compared with control conditions.[6,12] These outcomes include increased receptivity to vaccine-related information, greater willingness to get vaccinated, and more positive perceptions of the consulting HCP. In particular, in the field study, patients who had a vaccine consultation with an ERI-trained physician displayed significant improvement in their willingness to have a vaccine compared to non-trained physicians (with effect size of $b = 0.50$). Further, 78% of the ERI-trained physicians' patients booked a vaccination appointment after consultation, compared to 50% of non-trained physicians' patients (this difference was not, however, statistically significant [$p = .064$]).[12]

Training HCPs in using the ERI thus has the potential to improve vaccine uptake by enhancing HCPs' preparedness to address vaccine-related concerns and their skills in doing so. To be able to evaluate learning outcomes of ERI training, we developed the ERI Skills Inventory (ERISI), as no tool for this purpose has previously been available. The ERISI was developed based on the Motivational Interviewing Skills in Immunization questionnaire (MISI).[13] MISI measures learning outcomes from training in MI in the vaccination context. The MISI has shown good internal consistency and test-retest reliability, and is sensitive to training-related change.[13] Reliable evaluation of training outcomes provides information for research and clinical practice about the effects of training that can be expected, as well as about aspects of training that need improvement.

In the present study, we used a pre-post design to validate the ERISI as a tool for assessing learning outcomes of ERI training. Data was collected in the UK from HCPs who took part in ERI training and responded to the ERISI before (pretest) and after (posttest) the training. To assess the relationship between the ERISI and more general outcomes of training in vaccine communication, HCPs also responded to questions related to self-efficacy in communicating with vaccine-hesitant patients and preparedness to refute arguments against vaccination. We conducted two follow-up data collections at one and three months after the training. In the follow-ups, we assessed understanding and use of the ERI.

We investigated the internal consistency of the relevant measures and assessed the sensitivity of the ERISI to capture training-related change. We also assessed the associations between ERISI scores, self-efficacy and refutation preparedness. Lastly, we examined whether ERISI posttest scores predicted HCPs' follow-up reports of understanding and using the ERI.

Materials and methods

Development of the ERISI

The ERISI (see Supplementary Material) was created by experts who had previously been involved in developing the MISI (AG, PV).[13] They drew on the three-part structure of the MISI to create a corresponding version of the ERISI. This structure and proposals for assessment questions were reviewed by experts who developed the ERI (DH, SL). The three parts are: 1) assessment of knowledge acquisition, 2) assessment of skill application, and 3) assessment of confidence in using the approach in clinical practice. Each part is described in detail below.

For the ERISI, six questions related to *knowledge* acquisition were created, of which three focused on theoretical knowledge (all multiple-choice questions; e.g., "In your opinion, what are the two key components in refuting false information?"). Two of these questions had one correct answer each (scored as 1 for correct and 0 for incorrect), while one question had multiple correct answers (scored by adding up all correct choices, subtracting the incorrect ones, and dividing the result by 11 [the number of response alternatives] to give this question similar weight to the other questions). The three remaining questions in

the knowledge subscale were connected to a case scenario (one open-response question and two multiple-choice questions; e.g., "Which of the following options demonstrates an affirmation that is appropriate to [the patient's] context?"). Three case scenarios were formulated to be able to vary the scenarios between measurement points and participants if needed (one scenario per administration). The multiple-choice questions were scored such that each question received 1 point for a correct answer and 0 points for incorrect answers. For the open-ended response question, which asked participants to correctly identify an attitude root displayed by the patient in the case scenario and explain their answer, two points were allocated, with one point for correct identification of an attitude root and one point for an explanation. Open-ended responses were each coded by two research assistants according to a framework. The coding process and framework are described in more detail the Supplementary Materials.

Like the MISI, the ERISI included a final open-response question asking respondents to write a dialogue between themselves and a patient relating to a case scenario, to assess their ability to apply the ERI *skills*. The scenarios were the same as in the knowledge-acquisition section. These responses were also each coded by the two research assistants. A coding scheme for the open-response questions, as well as coding reliability of the present study, can be found in the Supplementary Material.

Confidence in using MI in clinical practice is in the MISI assessed with six questions. For the ERISI, seven corresponding questions were created relating to the ERI context (e.g., "To which extent do you feel prepared to conduct an ERI?"), with a 10-point response scale with the anchors *low* and *high*.

Ethics and open science statement

Before data collection, the study received approval by the University of Bristol School of Psychological Science Ethics committee (reference: 12008) and the UK Health Research Authority (reference: 318853). Informed consent to participate in the study was obtained from all participants.

Data availability statement

Materials, data and the code used to derive the reported analyses are shared on the Open Science Framework (OSF; https://osf.io/n9gpv/).

Participants

Participants were recruited from among 106 HCPs who attended one of 10 ERI training workshops conducted in the UK between October 2023 and November 2024. Participants were invited to the workshop through invitations issued through mailing lists of regional health and public health organizations, and by snowballing the invitations among HCPs. Each workshop was held over two days and conducted by two experienced researchers from the JITSUVAX team (DH, EA, or LK) with the objective to pilot an ERI training model for HCPs in the UK who had a workforce education remit within their vaccination roles. Participation was voluntary, and participants did not receive compensation for taking part in the study. We received 103 training questionnaires that included post-training data from at least one of the three ERISI parts (essential to the validation analyses below). These 103 individuals constitute the total sample in the present study.

Participant characteristics are presented in Table 1. Participants' mean age was 43.73 years (SD = 11.64, median = 44, range = 22–71), and their average clinical experience was 16.47 years (SD = 13.29, median = 12, range = 0–50).

Procedure

On the first day of each workshop, participants received a questionnaire including the ERISI, a measure of self-efficacy in communication with vaccine-hesitant patients, and a measure of preparedness to refute arguments against vaccination. They completed this questionnaire after introductions from the trainers and the sharing of the workshop background, context, and goals, but before teaching about the ERI commenced

Table 1. Participant ($N = 103$) characteristics.

Variable	*n*	%
Responded to post-test ERISI*, of which:	103	
Responded to pre-test ERISI	101	98
Responded to Follow-up 1 (one month post-training)	47	46
Responded to Follow-up 2 (3 months post-training)	38	37
Professional role		
Nurse	32	31
Midwife/maternity care	26	25
GP	4	4
Public health	15	15
Health manager/co-ordination/administrator	14	14
Health associate/assistant	3	3
Other roles**	3	3
Not reported	6	5
Gender		
Female	87	85
Male	10	10
Not reported	6	5
Ethnicity		
White	57	55
Black, African, Caribbean or Black British	17	17
Asian or Asian British	10	10
Mixed and other ethnic groups	8	8
Prefer not to say/not reported	11	10
Vaccination role involves***		
Scheduling appointments	47	46
Prescribing vaccines	6	6
Administering vaccines	19	18
Answering questions about vaccines	13	13
No vaccination role	12	12
Not reported	6	6
At least one influenza vaccination during the last 3 years		
Yes	73	71
No	23	22
Not reported	7	7

Note. *Participants recorded as having responded to an ERISI part if they answered at least one question in that part. **Other roles were vaccine researcher and medical student. ***Multiple roles possible for each participant.

(pretest). Participants completed the same questionnaire on the second day, after receiving the ERI training program, but before they entered the final training module on developing their own training (posttest).

Participants accessed the questionnaires by scanning a QR code on their phone to complete the quantitative measures online. The open-ended responses were completed using paper questionnaires. Written responses were transcribed verbatim into an Excel file by a research assistant (RC) for analysis. Participants received one of the three available case scenarios at pretest, and a different case scenario at posttest.

After the workshop, follow-up questionnaires of approximately 5–10 min completion time were sent to participants by e-mail with a link to complete the questionnaire online. Participants received these e-mail links at two time points: one month and three months after the completion of their training session. Participants received three reminders to complete each follow-up questionnaire, once a week following each initial invitation with the follow-up questionnaire link.

Each questionnaire was preceded by an information sheet and consent form requesting permission to use participants' data for research purposes. Participants ticked a box to indicate their informed consent for participation.

Measures

Beyond the ERISI (presented above and available in full in the Supplementary Material), which was administered to the HCPs at pre- and posttest, the HCPs were presented with the measures listed below. A complete list of items and response alternatives can be found at OSF (https://osf.io/n9gpv/).

Self-efficacy in communication with vaccine-hesitant patients

We used two questions from the I-Pro-VC-Be scale.[14–16] The I-Pro-VC-Be measures a broad range of aspects related to confidence in vaccines and vaccine-related work among HCPs. The two items we used related to self-efficacy in communication with vaccine-hesitant patients ("I feel comfortable discussing vaccines with my patients who are highly hesitant about vaccination" and "I feel sufficiently trained on how to bring up the question of vaccines with hesitant patients"). Response alternatives ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). This measure was administered in each data collection, but for the purpose of this study, only pre- and posttest measures are included.

Refutation preparedness

To measure HCPs' perceived preparedness to refute arguments against vaccination, we presented them with 11 anti-vaccination arguments (see),[17] and the following instructions: "Please imagine that you are interacting with an individual who gives that argument against having a vaccine. Please indicate how prepared you feel to respond to the individual who said this." HCPs indicated their preparedness in relation to each argument on a scale from 1 (*very unprepared*) to 5 (*very prepared*). This measure was administered in each data collection, but only pre- and posttest measures are included in the present study.

Perceived understanding of ERI

At the follow-ups, HCPs were asked how well they understand six of the ERI techniques on a scale from 1 to 5 (1 = *I have not heard of it*; 2 = *I have heard of it but do not understand it*; 3 = *I understand it but have not used it*; 4 = *I understand it and have used it but would like to become more comfortable with it*; 5 = *I understand it and am comfortable using it*).

Self-reported ERI use

At each follow-up, and for the same six ERI techniques as above, HCPs were asked how frequently they had used the technique when talking to individuals with immunization concerns during the past 3 months. Response alternatives ranged from 1 to 5 (1 = *Rarely/Never [0–25%]*: 2 = *Sometimes [26–50%]*; 3 = *Often [51–75%]*; 4 = *Most of the time [>75%]*), with the additional option to indicate that they had not talked to any individuals with immunization concerns (responses to this additional option were removed from the analyses).

Results

All statistical analyses were conducted in R version 4.5.0.[18] Missing data were handled by removing incomplete cases on an analysis-by-analysis basis. A p-value of $< .05$ was considered statistically significant.

Internal consistency

We first investigated the internal consistency of ERI confidence, self-efficacy, refutation preparedness, perceived understanding of ERI, and self-reported use of ERI. Internal consistency was not assessed for ERI knowledge and skills, as these were not intended to measure a general knowledge or skill construct, but rather to assess learning related to different components of the ERI. We used Cronbach's alpha for all measures, except for self-efficacy, which contained only two items. Following the literature on two-item scales,[19] we calculated the Spearman-Brown coefficient for this measure. The internal consistency for the measures ranged from acceptable to excellent (Table 2).[20] Composite scores were created for subsequent analyses by averaging the items within each measure.

Table 2. Internal consistency of scales.

		Coefficient [95% CI]			
Measure	*N* items	Pretest	Posttest	Follow-up 1	Follow-up 2
ERISI					
ERI confidence	7	0.94 [0.92; 0.96]	0.95 [0.93; 0.96]	–	–
Self-efficacy	2	0.70 [0.51; 0.82]	0.86 [0.65; 0.94]	–	–
Refutation preparedness	11	0.93 [0.91; 0.95]	0.92 [0.90; 0.94]	–	–
Understanding of ERI	6	–	–	0.89 [0.86; 0.92]	0.92 [0.90; 0.94]
Use of ERI	6	–	–	0.86 [0.81; 0.90]	0.91 [0.88; 0.94]

Note. "–"indicates the measure was not administered at that time point, or not included in the present study.

Comparison between pre- and posttest ERISI scores

We then tested whether the ERISI was sensitive to change as a result of training by analyzing differences between pre- and posttest items. We used paired samples *t*-test for continuous measures and McNemar's Chi-squared test for dichotomous measures.

The results showed that all ERI knowledge items were significantly higher at posttest compared to pretest (see, Table 3 for results related to the continuous measure and Table 4 for results related to dichotomous variables). Concerning ERI skills, participants described the techniques elicit concerns and affirmations significantly more often in their open responses at posttest compared to pretest. However, there was no significant difference in the use of refutations and facts between pre- and posttest. ERI confidence was higher at posttest compared to pretest on all seven items.

Table 3. Comparison between pre- and posttest of the HCPs' responses to the continuous variables of the ERISI.

	M (*SD*)				
Measure	Pretest	Posttest	*t*(*df*)	*p*	*d*
ERI knowledge					
Item 1	0.43 (0.18)	0.82 (0.22)	15.00 (92)	<.001	1.56
ERI confidence					
Item 1	5.48 (2.20)	8.05 (1.29)	11.87 (90)	<.001	1.24
Item 2	6.11 (2.05)	7.97 (1.40)	9.57 (87)	<.001	1.02
Item 3	5.81 (2.06)	8.27 (1.42)	11.25 (87)	<.001	1.20
Item 4	5.69 (1.93)	7.79 (1.41)	11.90 (88)	<.001	1.26
Item 5	6.21 (1.84)	8.45 (1.21)	12.12 (86)	<.001	1.30
Item 6	6.33 (1.87)	8.19 (1.36)	10.23 (88)	<.001	1.08
Item 7	5.09 (2.16)	7.93 (1.32)	12.73 (89)	<.001	1.34

Table 4. Comparison between pre- and posttest of the HCPs' responses to the dichotomous variables of the ERISI.

		n (%)			
Measure	*Total n*	Pretest	Posttest	χ^2 (*df* = 1)	*p*
ERI knowledge					
Item 2	94	21 (22.3)	59 (62.8)	32.6	<.001
Item 3	89	38 (42.7)	81 (91.0)	37.5	<.001
Item 4a root	83	25 (30.1)	72 (86.7)	37.1	<.001
Item 4a explain	83	12 (14.5)	33 (39.8)	12.1	<.001
Item 4b	79	42 (53.2)	67 (84.8)	17.5	<.001
Item 4c	74	34 (45.9)	60 (81.1)	16.4	<.001
ERI skills					
Elicit	76	23 (30.3)	47 (61.8)	17.6	<.001
Affirm	76	27 (35.5)	52 (68.4)	18.6	<.001
Refute	76	48 (63.2)	44 (57.9)	0.27	.607
Facts	76	63 (82.9)	64 (84.2)	0.00	1.00

Note. For ERI knowledge, *n* (%) refers to *n* individuals providing correct answers, whereas for ERI skills it refers to *n* individuals who demonstrated the skill. Total *n* refers to number of participants who completed the measure both at pretest and posttest.

Correlations between measures

We analyzed the correlations (Pearson's *r*) between the ERISI subscales, self-efficacy, and refutation preparedness at posttest. For this, we summed scores for the ERI knowledge and skills measures, respectively, representing participants' overall performance. For all measures, we also created change scores by subtracting the pretest scores from the posttest scores (larger change score represents more positive change) to investigate whether the change as a result of training correlated between measures.

Results showed that, at posttest, higher ERI knowledge was significantly related to higher ERI skills (Table 5). Furthermore, higher ERI confidence was significantly related to higher self-efficacy and refutation preparedness.

Concerning change scores, increase in ERI confidence as a result of training was significantly related to increase in self-efficacy and refutation preparedness (Table 6). The significant correlations related to ERI confidence, self-efficacy, and refutation preparedness can be seen as supporting the concurrent validity of the ERI confidence measure.

Predictive validity

Predictive validity was assessed by investigating whether the ERISI subscales at posttest predicted perceived understanding and self-reported use of the ERI at the two follow-ups. This was examined with simple regression analyses. Results showed that higher ERI confidence significantly predicted greater perceived understanding and self-reported use at both follow-ups (Table 7). Nevertheless, *n* was small for these analyses as a limited number of individuals had completed the follow-ups.

Table 5. Pearson correlations between ERISI measures, self-efficacy, and refutation preparedness at posttest.

	1.	2.	3.	4.	5.
1. ERI knowledge	**1.00**				
2. ERI skills	**.39**	**1.00**			
3. ERI confidence	.00	−.02	**1.00**		
4. Self-efficacy	−.07	.01	**.51**	1.**00**	
5. Refutation preparedness	−.12	−.11	**.66**	**.40**	**1.00**

Note. Bolded correlation coefficients are significant at $p < .05$. *n* varies between 81 and 101.

Table 6. Correlations between ERISI measures, self-efficacy, and refutation preparedness change scores.

	1.	2.	3.	4.	5.
1. ERI knowledge	**1.00**				
2. ERI skills	.24	**1.00**			
3. ERI confidence	−.25	−.10	**1.00**		
4. Self-efficacy	−.09	.12	**.43**	1.**00**	
5. Refutation preparedness	−.05	−.08	**.55**	.17	**1.00**

Note. Bolded correlation coefficients are significant at $p < .05$. *n* varies between 81 and 101.

Table 7. Standardized results from simple regression analyses with ERISI subscales as predictor of perceived understanding and self-reported use of ERI at follow-ups 1 and 2.

	Follow-up 1					Follow-up 2				
Measure	*n*	*β*	*SE*	*t*	*p*	*n*	*β*	*SE*	*t*	*p*
Perceived understanding of ERI										
ERI knowledge	35	−0.10	0.18	0.57	.574	29	−0.15	0.18	0.82	.419
ERI skills	37	−0.00	0.17	0.02	.988	30	−0.35	0.19	1.87	.071
ERI confidence	44	**0.51**	**0.13**	**4.10**	**<.001**	37	**0.55**	**0.13**	**4.21**	**<.001**
Self-reported use of ERI										
ERI knowledge	34	0.03	0.17	0.16	.876	26	0.07	0.17	0.44	.662
ERI skills	36	0.13	0.17	0.77	.448	27	−0.31	0.17	1.82	.081
ERI confidence	43	**0.40**	**0.13**	**3.00**	**.005**	34	**0.51**	**0.14**	**3.67**	**<.001**

Note. Bolded correlation coefficients are significant at $p < .05$.

Sensitivity analyses

As 38 HCPs (37%) reported direct involvement in vaccine discussions (prescribing vaccines, administering vaccines, or answering questions about vaccines), analyses were rerun in this subsample to check the robustness of the results in this group most relevant to vaccine communication. However, the analyses related to predictive validity were not rerun, as the sample was too small ($n = 8–17$). The results of these sensitivity analyses are reported in the Supplementary Material (Tables S4–S8), and they were qualitatively similar to the results within the full sample (the same direction of all relationships and only a few tests no longer reaching significance, possibly as a consequence of the reduced sample size).

Discussion

In the present study, we developed and validated the ERISI for evaluating learning outcomes of training in the vaccine communication approach ERI. The developed tool consists of three parts: (1) assessment of ERI-related knowledge (five multiple-choice and one open-response question), (2) assessment of ERI-related skills (one open-response question), and (3) confidence in using the ERI (seven Likert-scale questions).

The results showed excellent internal consistency for the ERI confidence construct. Furthermore, participants scored significantly higher on all ERI knowledge items after the training compared to before the training. This indicates that the items are sensitive to measuring increased ERI knowledge as a result of training. When it comes to ERI skills, a significantly higher proportion of participants elicited concerns and provided affirmations after training compared to before. Nevertheless, refutations and provision of facts were approximately as prevalent after and before training. This might be due to an existing tendency for HCPs to provide information, in line with what they may have learned during clinical training[3,21] and to use their knowledge to counter patients' misconceptions directly. This is supported by our data, as participants at pretest refuted misconceptions and provided facts more frequently (63% and 83%, respectively) than they elicited concerns and provided affirmations (30% and 36%, respectively). In this context, the increases in using eliciting concerns and affirmations suggest that participants were able after training to bring in these novel steps to support other skills in refutation and provision of facts within the framework of the ERI.

Our results also showed that individuals with greater ERI knowledge at posttest demonstrated better ERI skills, indicating that these subscales tap into similar learning domains. However, the increase in knowledge between pre- and posttest did not significantly correlate with the increase in skills. This could be because the change between pre- and posttest was very small for two of the measured skills (refutations and facts provision). Furthermore, pretest scores for knowledge might be unsystematic, as participants were unlikely to have previous knowledge about the ERI, and correct responses might have occurred at random. Randomness might therefore play a larger role in the amount of change in ERI knowledge than ERI skills, leading to a lower correlation between the change measures than between the posttest measures.

As expected, participants' confidence in using the ERI increased as a result of training. Interestingly, however, ERI confidence was not related to ERI knowledge and skills. Speculatively, confidence is more strongly related to individual differences than actual knowledge or skills. This has been demonstrated in other areas where confidence is not always related to HCPs' knowledge or skills during clinical training.[22] In fact, over the process of learning, confidence levels may at times move in opposite directions to knowledge and skill levels, as learners become aware of previously unknown deficits in their knowledge, before they grow confident in the new knowledge (e.g.,).[23,24] These measures may thus function as separate constructs related to learning.

The ERI confidence measure demonstrated concurrent validity, as it correlated with theoretically related measures of self-efficacy in vaccine conversations and preparedness to refute arguments against vaccination. ERI confidence also showed predictive validity, as participants with higher confidence at posttest were more likely to perceive that they understand the ERI and report that they use the ERI at one and three months after the training. This suggests that building confidence in using the ERI is an essential part of training in order for ERI to be put into practise. As understanding and use of ERI were measured by self-reports at follow-ups in the present study, this nevertheless requires further research on actual understanding and use. ERI knowledge and skills did not significantly predict perceived understanding and self-reported use of the ERI after the training. Important to note is that the sample available for the regression analyses was small, which limits generalizability of the results.

The results of the sensitivity analyses showed that the interpretation remained consistent within the subsample of individuals with direct involvement in vaccination discussions (Tables S4–S8). The only exception was that the pre-post comparisons for three items in the ERI knowledge scale did not reach statistical significance. However, the proportion of correct responses was 15–21% points higher at posttest than at pretest, indicating that the non-significance was likely due to the small sample size ($n = 27–33$, depending on item).

Practical implications

The ERISI is a useful tool for assessing outcomes of training in ERI, such as learning related to basic ERI knowledge and skills, as well as participants' confidence in using the ERI in their practice. Assessing item-level change can provide insights into training components requiring more attention in future training. Our results also suggest that participants' confidence in using the ERI measured after the training can be used by trainers to estimate the extent to which the ERI will be applied by participants after training and, as such, work as a predictor of training impact.

Making training evaluation an integral part of the training session enables training development and ensures provision of high-quality training. Such training gives HCPs the necessary knowledge and skills to be able to apply the ERI in their conversations with vaccine-hesitant patients. As the ERI has been shown to increase patients' willingness to get vaccinated,[12] proper application of the ERI has great potential to lead to positive public health outcomes in the form of increased vaccine uptake. Having a standardized tool such as ERISI is essential from a public health perspective in order to assess the skills acquired by professionals trained in ERI in different contexts and with different teaching formats. The ERISI questionnaire can be found in the Supplementary Material and accessed at OSF (https://osf.io/n9gpv/), along with the measures of self-efficacy in communicating with vaccine-hesitant patients and refutation preparedness. Individuals interested in accessing training in the ERI can visit https://jitsuvax.info for more information.

Limitations

A limitation of the current study is that we did not include a control group receiving no training. We are thus unable to take test-retest or other confounding effects into account, which might threaten the internal validity of the study. The sample size was also small for some of the analyses, and thus, replications in larger samples would strengthen the results. Furthermore, the follow-up measures assessed participants' perceived understanding of the ERI and their self-reported use of the approach. These measures might not accurately reflect their actual knowledge and use of the ERI. Future research is needed to assess the longevity of learned knowledge and skills, actual use of the ERI in HCPs' vaccine discussions with their patients, as well as the evolution of ERI skills with practice. Also, external validity should be evaluated by testing the ERISI in diverse HCP populations, and with ERI training provided by trainers other than those who trained the HCPs in the present study. As only 38 HCPs in the present sample reported having direct involvement in vaccination discussions, an important focus for such evaluation are HCP populations with direct vaccination roles. An additional area for future research is whether higher ERI knowledge and skills as measured by the ERISI are related to better outcomes of ERI application, such as a greater number of vaccine consultations resulting in patient vaccine acceptance.

Conclusions

The ERISI is a questionnaire for assessing outcomes of training in the ERI vaccine communication approach. These outcomes are (1) ERI-related knowledge, (2) ERI- related skills, and (3) confidence in using the ERI. The questionnaire demonstrated good ability to capture increases in these outcomes as a result of training. In addition, the ERI confidence measure showed the potential to predict perceived understanding and self-reported use of the ERI after training. The questionnaire is thus a valuable tool for assessment of ERI training which can guide training development to ensure learning and future skill application.

Author contributions

CRediT: **Linda C. Karlsson:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – reviewing & editing; **Dawn Holford:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing; **Emma Anderson:** Conceptualization, Investigation, Methodology, Validation, Writing – review & editing; **Pierre Verger:** Conceptualization, Funding acquisition, Methodology, Validation, Writing – review & editing; **Arnaud Gagneur:** Conceptualization, Funding acquisition, Methodology, Validation, Writing – review & editing; **Ron Cheng:** Data curation, Writing – review & editing; **Dionne Engmann:** Data curation, Writing – review & editing; **Anna Soveri:** Conceptualization, Funding acquisition, Validation, Writing – review & editing; **Stephan Lewandowsky:** Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing.

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