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Development and validation of an instrument to assess public perception of cancer primary prevention information

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Abstract

Background Cancer primary prevention (CPP), particularly through evidence-based recommendations like the 4th European Code Against Cancer (ECAC4), represents a cost-effective strategy to reduce cancer burden. Dissemination and implementation (D&I) of CPP strategies remain fragmented and inconsistent, and instruments to assess dissemination of CPP are lacking. This study aimed to develop and validate an instrument to assess the public (i) perceptions of CPP message characteristics, and (ii) public perceptions of ECAC4.

Methods The validation of the 'Information on Cancer Primary Prevention' instrument was developed through a multi-stage process grounded in two D&I frameworks: McGuire's Communication-Persuasion Matrix and Rogers' Diffusion of Innovations. After literature review, items were generated for the two questions assessing message characteristics (channel preferences and source trustworthiness) and 25 items to assess ECAC4 five perceived attributes: advantage, compatibility, complexity, trialability, and observability. Validation involved cognitive interviews for message characteristics, expert validation through a two-round Delphi panel for ECAC4 attributes, and pre-testing with 240 adults recruited through an online panel. Exploratory factor analysis (EFA) was conducted to assess structural validity, and Cronbach's alpha was used to evaluate internal consistency.

Results Refinements in terminology, response scales, and item wording were implemented after cognitive interviews for the two questions of message characteristics (channel preference and source trustworthiness). EFA revealed three factors for channel preferences (Traditional broadcast media, Digital media/online interactive platforms, and Print media and interpersonal; $\alpha = 0.703\text{--}0.775$) and two factors for source trustworthiness (Official sources and Unofficial sources; $\alpha = 0.792\text{--}0.859$). The five ECAC4 attributes were evaluated in a Delphi panel with two rounds - due to participant attrition the panel was discontinued before full consensus could be reached for all items; five items were adapted based on expert qualitative feedback and included in the pre-test. All five ECAC4 attributes subscales demonstrated unidimensionality with strong factor loadings (> 0.50) and good to excellent reliability ($\alpha = 0.714\text{--}0.831$).

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Conclusions This instrument exhibits initial evidence of content and exhibits satisfactory psychometric properties, offering preliminary evidence of structural validity, and internal consistency. By operationalizing key constructs from established dissemination and implementation frameworks, it addresses critical gaps in cancer prevention communication research.

Text box 1. Contributions to literature

- Provides a validated instrument specifically designed to assess public perception of cancer primary prevention information, addressing a measurement gap in population level primary prevention research.
- Enriches knowledge by applying two relevant theoretical frameworks—McGuire's Communication-Persuasion Matrix and Rogers' Diffusion of Innovations Theory—to measure how cancer primary prevention messages are received at the population level.
- Offers a tool for public health practitioners to evaluate dissemination and implementation strategies at the population level by measuring which sources people trust, which channels they prefer, and how they perceive cancer prevention recommendations.

Background

Cancer remains a major public health challenge across Europe, with high incidence and mortality rates placing significant burden on healthcare systems and populations [1]. A substantial proportion of cases is attributable to modifiable risk factors — including tobacco and alcohol use, unhealthy diet, physical inactivity, and environmental exposures — highlighting the importance of cancer primary prevention (CPP) as a cost-effective strategy to reduce cancer burden [1, 2].

CPP strategies aim to minimize or eliminate exposure to carcinogens and promote preventive behaviours through both individual-level actions (e.g., smoking cessation, healthy diet) and population-level interventions (e.g., taxation, urban planning, and environmental health policies) [3]. Despite its recognized benefits, CPP remains underutilized and underfunded, often constrained by socioeconomic structures and short-term policy priorities [1, 3–5].

The dissemination and implementation of CPP strategies remain inconsistent and insufficiently explored [4–6]. A key example is the European Code Against Cancer, 4th edition (ECAC4), a set of 12 evidence-informed recommendations for the public to reduce individual risk of cancer [7]. Originally developed in the 1980s by the European Commission and later updated by the International Agency for Research on Cancer (IARC/WHO), ECAC4 serves as a crucial CPP education tool for the European Union. However, its real-world impact remains limited, with studies showing wide variability in public awareness and adoption across countries and population groups [7–11].

CPP may strengthen its effectiveness and long-term sustainability by ensuring consistent community engagement and applying dissemination and implementation

(D&I) frameworks to prevention efforts. The gap between the generation of scientific knowledge and its translation into public behaviours (knowledge–behaviour gap), has been tackled by D&I research [4, 6, 12]. D&I science relies on a range of theoretical frameworks that guide the translation of evidence into practice, typically focusing on different stages and features of that process [13, 14] and on the translational continuum that explains the uptake of research by individuals, organizations, and decision-makers [6, 12–15]. This continuum includes the diffusion of the natural occurring, unstructured spread of innovations, the dissemination of strategic efforts to promote uptake, and the implementation of evidence-informed practices into real-world settings [12].

Given their shared focus on determinants, complementarity, and established relevance to public health messaging, two D&I frameworks were selected to underpin this study: *McGuire's Communication-Persuasion Matrix* [16, 17] and Rogers' *Diffusion of Innovations Theory* [18]. Both frameworks address the factors and conditions affecting implementation [13, 15, 19]. McGuire's *Communication-Persuasion Matrix* [16, 17] offers a structured approach to analyse the communication process itself, i.e., how messages are constructed and conveyed to influence health behaviours [12, 15]. Input communication factors relate to the message being relayed to the audience and how it is shaped by its author(s) [20], covering components such as source and channel characteristics. The source, defined as the individual or entity delivering the message [12, 15], can be evaluated based on attributes such as demographics, attractiveness, and credibility. In turn, channel characteristics, also described in Rogers' *Diffusion of Innovations Theory*, refer to the means through which information is disseminated, such as mass media, interpersonal networks, and/or digital platforms [21].

Diffusion of Innovations Theory [18] outlines the process by which innovations spread through populations [13, 15, 21]. It explains the adoption of innovations as a process that unfolds over time and across different adopter categories—from innovators and early adopters to the majority and laggards—highlighting the social and contextual dynamics that shape how they are perceived and taken up within communities. A large proportion of the variance in adoption rates can be attributed to how the innovation's characteristics are perceived by individuals [18, 21]. Rogers identified five perceived attributes: relative advantage (degree to which an innovation is better than

alternatives), compatibility (degree to which an innovation aligns with one's beliefs and preferences), complexity (degree to which an innovation is difficult to use), observability (how frequently one sees an innovation being used and/or knows someone who uses the innovation), and trialability (degree to which one is able to use an innovation on a trial basis).

Overall, these two frameworks offer structured approaches for understanding and guiding the dissemination and adoption of innovations in cancer prevention communication, but their application in this context remains limited. Compared with other implementation efforts, like cancer screening or treatment, D&I research in CPP has received less attention, with fewer studies addressing behavioural risk factors modification at the population level [4, 6, 22].

Moreover, there is a scarcity of tools to measure D&I in CPP, especially in non-clinical, population-level prevention contexts [4, 23]. In particular, there is a lack of validated instruments to assess determinants related to the characteristics of the innovation, a critical but often neglected domain in dissemination studies [23].

To address these gaps, this study applies McGuire's and Rogers' frameworks to the development of an instrument that captures the diffusion of CPP information and how cancer prevention messages are received by the public. The main objective was to develop and validate the 'Information on cancer primary prevention instrument', designed to assess (i) perceptions of information sources and channels using McGuire's Persuasive Communication Matrix, and (ii) public perceptions of ECAC4's attributes through the lens of Rogers' Diffusion of Innovations Theory. This study aims to identify key enablers and barriers to CPP communication, thereby supporting future efforts to enhance the adoption and acceptability of CPP recommendations.

Methods

The study is part of the *Personalized CANcer Primary Prevention research through Citizen Participation and digitally enabled social innovation* (4P-CAN) project (<https://4p-can.eu/>).

The questionnaire was developed and validated through a multi-phase process comprising literature-based item generation, cognitive interviews (for message characteristics), expert validation via a Delphi panel (for ECAC4 attributes), and pre-testing to assess psychometric properties (Fig. 1).

Item development

Item development for message characteristics centred on two domains: source and channel. Within source, trustworthiness was prioritized due to its relevance to Rogers' concept of linkage agents—intermediaries such

as opinion leaders or gatekeepers who play a key role in innovation adoption [13, 18]. Channel characteristics, also described in Diffusion of Innovations Theory [21], focused on the importance of understanding communication pathways.

The item assessing source trustworthiness was adapted from the Health Information National Trends Survey 4 (HINTS 4), Cycle 4 instrument [24]. The item addressing communication channels was newly developed to capture participants' preferred methods for receiving cancer prevention information. The two items of the message characteristics used a 5-point Likert scale, as recommended for general population surveys to allow for a neutral mid-point response [25], given that participants may hold no preference for certain channels or sources:

- Preferred channels: *"How much do you like the following ways of receiving information on reducing cancer risk?"*
- Source trustworthiness: *"In general, how much would you trust the information about cancer risk reduction from each of the following sources?"*

For the innovation attributes of ECAC4, the review showed the existing instruments assessing innovation attributes are highly context specific and primarily focused on evaluating targeted interventions (e.g., drug prevention policy), clinical tools (e.g., computerized therapy, wearable activity trackers), professional practices (e.g., internet use, smoking cessation treatment), or digital health applications (e.g., eHealth tools, telemedicine apps). While not originally intended to assess comprehensive public health recommendations such as the ECAC4, items from these instruments informed the development of the 25 items generated for ECAC4 attributes: relative advantage, compatibility, complexity, trialability, and observability (Table 1). The resulting measure - ECAC4 attributes measure - comprised 25 items rated on a 5-point Likert scale (1 = "strongly disagree", 2 = "disagree", 3 = "neither agree nor disagree", 4 = "agree", 5 = "strongly agree").

Face validity

To ensure the face validity of message characteristics, cognitive interviewing was conducted. This approach enabled the identification of potential issues in wording, syntax, terminology and overall comprehension. Cognitive interviewing is a widely used technique for evaluating questionnaire items, especially in early stages of survey development, as it helps assess item validity and minimize response error [29].

Interviews were conducted with six native English speakers, who were recruited through the research team's informal networks (convenience sampling). Interviews

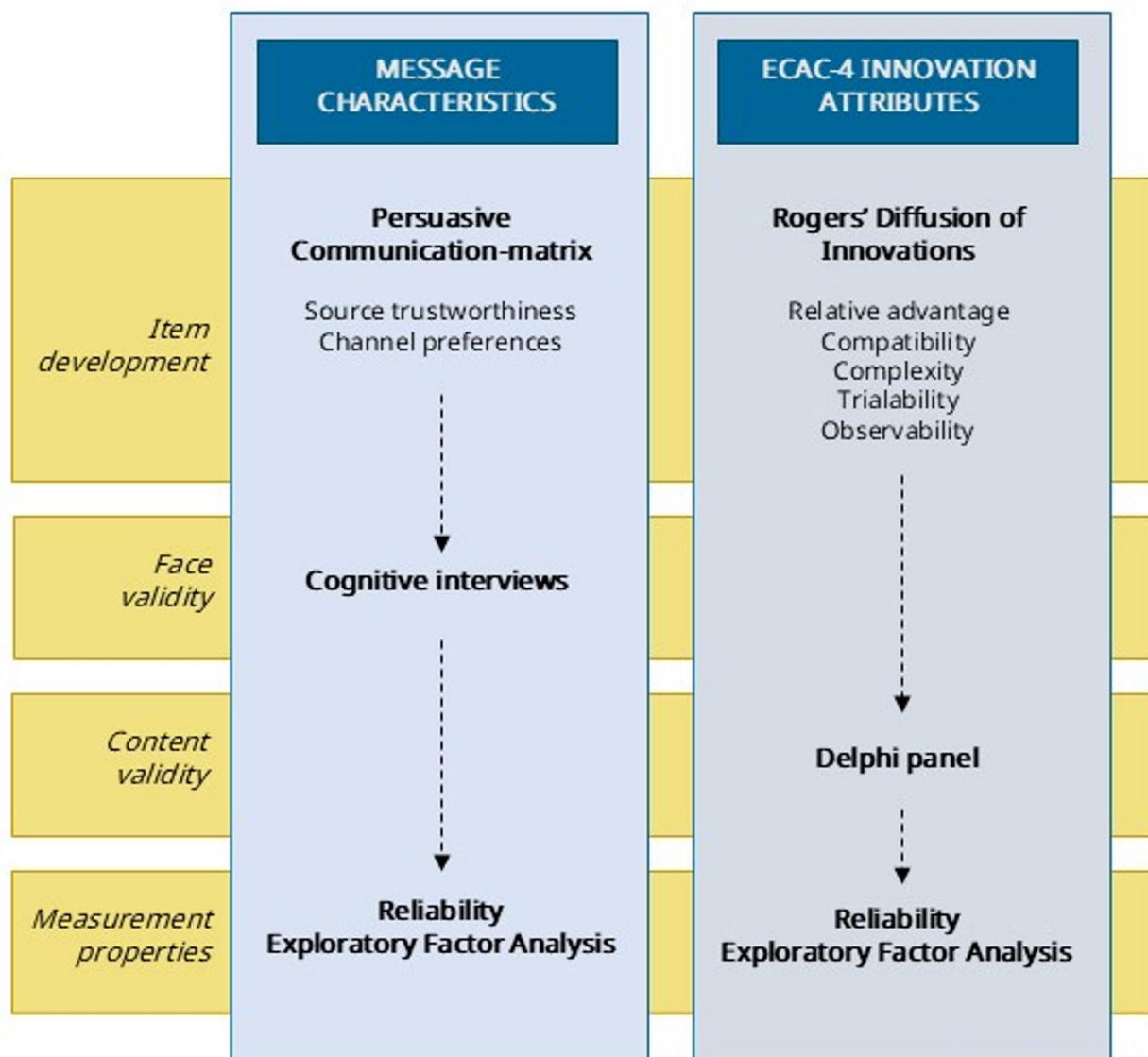


Fig. 1 Multi-phase development and validation process of the "Information on Cancer Primary Prevention" instrument

were held between October and November 2024, via video conferencing, and lasted between 50 and 86 min.

Each session was co-facilitated by two researchers (AJS, RI) who followed a structured cognitive interview script and a standardized assessment grid (Additional file 1).

Both researchers independently completed the assessment grid, took notes during the interview and discussed their assessments to ensure consistency and completeness, following each session.

Data were collected in two main formats: recorded audio files and the assessment grid. Interview data were first analysed using the grid item ratings. Items with low ratings in any of the seven assessed dimensions were flagged, and the corresponding audio recording was reviewed in detail. Participant feedback informed item

revisions, which were discussed and agreed upon by the research team. The final version of the questionnaire integrated all approved changes.

Content validity

The Delphi method was used to strengthen the content validity of the ECAC4 attributes measure: a consensus technique that systematically collects and aggregates informed judgments from a group of experts on specific issues or problems [30, 31]. This method has been widely applied to survey item refinement [31] and involves sequential rounds of evaluation, where each successive round is informed by the results of the previous one.

Purposive sampling was used to recruit 15 experts in dissemination, implementation science, or public health

Table 1 Review of instruments assessing innovation attributes and developed items of ECAC4 attributes measure

Attribute	Existing instruments		Developed items (ECA4 innovation attributes)
	Targeted attributes features	Exemplary Items	
Advantage	Measures addressed perceived effectiveness usefulness and convenience.	1. "HealthQuest is better than using workbooks or paper and pencil tests for learning about health" [26] 2. "Overall, I find the mHealth services to be useful in my life" [27], 3. "The treatment is more convenient than other therapies I have used" [28].	1. It's useful to have the main cancer prevention recommendations summarised in a single place. 2. The European Code Against Cancer can help to improve my health. 3. The European Code Against Cancer provides very useful information. 4. The European Code Against Cancer can help me to engage in healthier behaviours. 5. It is very important that the public gets to know the European Code Against Cancer.
Compatibility	Measures emphasised personal use and alignment with lifestyle or daily routines.	1. "I could see myself using computerized therapy" [43] 2. "This app fits with my lifestyle" or "I think that using a Video Consultation fits well with the way I like to manage my health care." [46, 49].	6. The European Code Against Cancer recommendations fit into my everyday life. 7. The European Code Against Cancer recommendations align with the way I manage my health. 8. The European Code Against Cancer presents information that fits the way I prefer to obtain health information. 9. Adopting the European Code Against Cancer recommendations into my day-to-day life would be met with approval by friends and family. 10. I can see myself adopting the European Code Against Cancer recommendations.
Complexity	Measures focused on the clarity of information, the knowledge or skills required and the challenge of remembering multiple components.	1. "A-CRA is hard for therapists to understand" [45] 2. "I possess the knowledge required to use the m-learning method" [44] 3. "Trying to remember all components of the SCRITP program its hard" [50].	11. The European Code Against Cancer recommendations are easy to understand. 12. The European Code Against Cancer recommendations are easy to follow. 13. The European Code Against Cancer recommendations are easy to remember. 14. The European Code Against Cancer recommendations can be adopted without too much effort. 15. The European Code Against Cancer recommendations are easy to explain to others.
Trialability	Measures included perceptions of being able to try the innovation before full implementation and opportunities to adapt it to personal needs.	1. "I believe that it is okay for me to try out a new substance use prevention program on a limited basis before fully implementing it" [47] 2. "I had the opportunity to try out TA before deciding whether to adopt them" [48].	16. The European Code Against Cancer recommendations can be tested in my day-to-day life before definitely adopting them. 17. I would like to know how the European Code Against Cancer recommendations can reduce my cancer risk. 18. The European Code Against Cancer recommendations can be gradually adopted in my day-to-day life. 19. I can decide which of the European Code Against Cancer recommendations I adopt in my day-to-day life. 20. I would like to see how others adopt the European Code Against Cancer recommendations.
Observability	Represented in items on the visibility of the benefits of using the innovation and the recognition of its impact.	1. "The benefits of using the kit with my patients are obvious/visible" [48] 2. "A-CRA had an impact on participants" [45].	21. The benefits of adopting the European Code Against Cancer recommendations are visible. 22. There is evidence that the European Code Against Cancer recommendations leads to better health results. 23. It is usual to see others adopting the European Code Against Cancer recommendations. 24. I would have no difficulty telling friends and family about the benefits of adopting the European Code Against Cancer recommendations. 25. If I adopt the European Code Against Cancer recommendations others would see changes in my overall health.

communication, identified through professional and institutional networks linked to the 4P-CAN project. The Delphi panel took place between September and November of 2024. In each round, experts independently rated 25 items using a standardized *MS Excel* form, assessing their relevance and clarity on a 4-point Likert scale - a scale format recommended in Delphi panels for content validity assessment, as it requires experts to take a clear position on item relevance [32]. Experts were encouraged

to provide comments, particularly for items rated as less relevant or unclear (scores 1 to 2), and to suggest alternative formulations. Item-Level and overall Content Validity Indexes (I-CVI and CVI) were calculated after each round. The CVI quantifies the extent of agreement among subject-matter experts, reflecting the proportion who rate an item as relevant. Based on the threshold commonly used in similar studies [32] any item receiving a relevance score of 3 or 4 from at least 70%

of respondents was considered to have reached consensus. Items below this 70% threshold were either revised, replaced or removed based on expert feedback. The modified or new items were included in the subsequent round for re-evaluation.

Psychometric evaluation

A cross-sectional study was conducted to pre-test the instrument with a sample of fluent English-speaking adults, recruited in February 2025 through an online panel administered by Dynata (<https://www.dynata.com/>), a professional survey company. The company recruited participants through its online panels using Computer-Assisted Web Interviews (CAWI), ensuring nationally representative quotas by sex and age, among adults aged 18 years and above. Inclusion criteria were: (a) being 18 years or older, (b) fluent English speaker, (c) no current or past cancer diagnosis, (d) access to the internet, and (e) the ability to complete an online questionnaire independently.

Sample size was determined based on established psychometric recommendations of a minimum of 10 participants per item for exploratory factor analysis [33]. Following the Delphi panel, two of the original 25 items from the ECAC4 attributes measure were eliminated; this resulted in a final pool of 23 items and a minimum requirement of 230 participants for psychometric evaluation. A final sample size of 240 was therefore targeted to account for potential invalid or incomplete responses. Additionally, the ECAC4 attributes measure developed in this study initially included five items per factor, exceeding the recommended threshold of 3–5 items per factor, which further supports the stability and interpretability of the factor structure [34].

The ‘Information on Cancer Primary Prevention’ section of the questionnaire included the message characteristics and ECAC4 attributes measure, assessed in earlier phases of the study. It also collected sociodemographic data, including sex, age group, marital status, urbanicity, educational attainment, employment status, and self-reported ability to make ends meet (used as a proxy indicator of income [35]).

Statistical analysis

Descriptive statistics were conducted to summarise the participants’ sociodemographic characteristics. All variables included in the analyses had complete data, with no missing values observed. Items underwent preliminary descriptive analysis prior to factor analysis. Bartlett’s test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure were used to assess data adequacy for factor analysis [36]. Bartlett’s test assesses whether the correlation matrix significantly differs from an identity matrix, with a significant result indicating that the data are suitable for

factor analysis. The KMO measure assesses the proportion of common variance across all variables, with values ≥ 0.7 generally considered acceptable [34].

Exploratory Factor Analysis (EFA) provides support for construct validity, which refers to the degree to which a scale or instrument adequately measures the theoretical construct it is intended to assess. This psychometric property is typically backed up by evidence of internal structure (e.g., factor analysis) and relationships with other variables [37]. EFA was conducted to examine the factor structure and loadings of the questionnaire items using principal axis factoring, a least-squares estimation method that makes no distributional assumptions and is suitable for smaller samples [34]. Particularly, EFA was conducted in the (i) channel preference, (ii) source trustworthiness, and to determine the factor structure of each of the five attributes of the ECAC4 attributes measure. Factor rotation was performed using Direct Oblimin, which allows correlations between factors and maximizes item loadings on a single factor [38]. The number of factors to retain was determined by considering multiple criteria including eigenvalues (>1), the proportion of variance explained, inspection of the scree plots, and the interpretability of the resulting factor structure (34,36,38). For each factor, items were retained if their absolute loading were >0.30 [38]. Finally, the internal consistency of each resulting subscale was assessed using Cronbach’s alpha (α), with α values >0.7 indicating good or acceptable internal consistency [38].

For the message characteristics items, EFA explored the latent structure, given the lack of an established underlying framework in the literature. In contrast, for the ECAC4 attributes measure—which is grounded in a well-defined theoretical structure—EFA was performed separately for each attribute. This decision was made considering the relatively small sample size, the large number of items, and the exploratory nature of the study. Analyses were performed using IBM SPSS (version 28).

Results

Message characteristics

Cognitive interview

The message characteristics two items and their corresponding response categories were assessed through cognitive interviews with a convenience sample of six participants (2 female and 4 male), aged 26–78, residing in Europe (Ireland, England, Sweden, the United Kingdom, Portugal, and France). Most participants had higher education ($n=5$), with one having completed secondary education.

Clarifying terminology The cognitive interviews focused in part on clarifying participants’ understanding and preferences regarding terminology. Participants

($n=5$) expressed a preference for the term “cancer risk reduction” over “cancer primary prevention” or “cancer prevention”, indicating that the latter two terms sounded like “*more medical health terms*”, felt “*very formal*”, and that “*cancer risk reduction is easier*” and “*makes more sense*”. Based on this feedback, all questionnaire references to “cancer primary prevention” were amended to “cancer risk reduction.”

When asked about the distinction between the ECAC4 recommendations and guidelines, participants stated it was not clear since “*there isn’t any big difference in either*”. However, four participants explicitly referred to it as a set of recommendations, suggesting this framing made it feel “*more approachable*” and “*better*” than simply calling them messages.

Regarding the terms to describe the actions people might take (e.g., follow, implement or adopt) based on ECAC4 recommendations, four participants indicated that ‘*follow*’ was most appropriate, as one expressed: “*you would want someone to follow a recommendation*”. Others noted that the terminology might depend on an individual’s current behaviour, explaining that “*if you are already doing it, you would follow it; if you are not doing it, you would implement it*.” The term ‘*adopt*’ was mentioned twice and seen as more action-oriented or “*linked to actions*”.

Item refinements Overall, participants found the message characteristics questions clear and easy to understand. Although, participants were able to answer both questions and requested no clarifications, most ($n=4$) had difficulties with the response options. Some misunderstood the scale or reversed the order of ratings, possibly because only the endpoints were initially labelled. Another difficulty in the preferred channel question was interpreting it in terms of frequency of use rather than preference (“*I almost never watch TV, so I don’t know how to answer that one*”). Similarly, the midpoint of the scale in the trustworthiness question was unclear to some. This feedback led to the revision of the rating scale and the addition of descriptive labels for each point in both questions (Table 2).

In the channels item, one participant requested the question to be repeated. The interpretation issue was related to the distinction between *Channels* and *Sources*. One participant stated, “*I don’t trust social media*”, which suggested an interpretation of source trustworthiness rather than channel preference. To address this, the order of the questions was changed so that the Source question preceded the preferred channel question.

Several interviews ($n=5$) yielded suggestions for additional response categories. For example, internet was seen as too broad (“*because one can go on the internet to look up just information from scientific institutions*”),

so a new option, ‘*general internet searches*’, was added to distinguish it from specific institutional websites. Other newly added categories included ‘*podcasts*’, ‘*digital and AI-based tools*’, and ‘*other*’.

No comprehension issues were reported regarding the source trustworthiness question. Participants easily interpreted its purpose (e.g., “*whether I can believe the message they are sharing with me, is it impartial*”). However, some participants ($n=3$) had difficulty distinguishing between non-governmental organizations and research/scientific organizations. These categories were simplified, and examples were added in parentheses.

Message characteristics psychometric analyses

The pre-test of 240 participants comprised slightly more than half women (51.7%) (Additional file 2). Most participants (53.8%) were between 35 and 64 years old, while approximately one-fourth were older than 65. More than half (56.3%) were married or in a civil partnership. Half of the participants (50%) lived in small or mid-sized towns, with only 18.3% living in rural areas. Having upper secondary education was reported by 36.3% of participants, while 59.2% were employed. More than one-fifth had difficulty or great difficulty in making ends meet.

The data of the preferred channels question were deemed suitable for factor analysis ($KMO=0.816$, Bartlett’s $\chi^2(45)=835.438$, $p<0.001$). The EFA supported the use of a three-factor solution: *Traditional broadcast media*, *Digital media/ online interactive platform*, and *Print media and interpersonal* (Table 3), accounting for 50.52% of the total variance, and presented no cross-loadings. While the three-factor solution showed negative loadings on the first two factors and positive on the third due to oblique rotation—an artefact that does not indicate inverse relationships—interpretation is based on absolute loading magnitudes exceeding 0.30, identifying three distinct channel preference dimensions.

All three factors showed good intra-scale reliability, with $\alpha=0.703$ for *Traditional broadcast media*, $\alpha=0.775$ for *Digital media/online interactive platform* factor, and $\alpha=0.752$ for *Print media and interpersonal* factor (Table 3).

The data of source trustworthiness question was also found to be suitable for EFA ($KMO=0.853$, Bartlett’s $\chi^2(55)=1108.620$, $p<0.001$) and results supported a two-factor solution: *Official sources* and *Unofficial sources* (Table 3). The selected solution accounted for 52.11% of the total variance and showed no cross-loadings.

Official sources included (i) health professional/health services, (ii) cancer non-governmental organization, (iii) government or governmental institutions, and (iv) scientific, research, or academic health institutions and organizations. Item loadings ranged from 0.541 to 0.870. *Unofficial sources* included (i) family, (ii) friends/

Table 2 Channel and source questions evaluated in cognitive interviews and pretested

ITEMS	Initial items	Pretested version
Channel question	How much do you like the following ways of receiving information on reducing cancer risk.	How much do you like the following ways of receiving information about cancer risk reduction.
Channel items	a) Television b) Radio c) Books d) Newspaper or magazines articles e) Advertisements (e.g., posters, outdoor advertisements) f) Health services handouts (e.g., leaflets, pamphlets) g) Websites h) Social media i) Newsletters j) In person/during a conversation k) None in particular	a) Television b) Radio c) General internet searches (e.g., Google or other internet search engines, Wikipedia or blogs) d) Websites e) Social media (e.g., Facebook, Instagram, TikTok, X) f) Podcasts g) Books h) Paper magazine or newspaper i) Advertisements (e.g., posters, outdoor advertisements) j) Health services handouts (e.g., leaflets, pamphlets) k) In person/during a conversation (e.g., health professional, friends, family) l) Digital and Artificial Intelligence-based tools (e.g., AI smartphone apps, chatbots, virtual assistants like Siri or Alexa) m) Others
Channel response categories	1- I don't like it at all 2 - Dislike it 3 - Neither like it nor dislike it 4 - Like it 5 - Like it a lot	1- Do not like it at all 2 - Dislike it 3 - Neither like it nor dislike it 4 - Like it 5 - Like it a lot
Source question	In general, how much would you trust information about cancer risk reduction from each of the following sources?	NO CHANGE
Source items	a) Health professional/ health services b) Family c) Friends/co-workers d) Cancer organization e) Government f) Scientific/research or academic institutions/ societies g) International public health organizations h) Religious organizations & leaders i) Internet Sources (e.g., google, Wikipedia, blogs) j) Social Media (e.g., Facebook, Instagram, TikTok) k) Journalists and traditional media (e.g., newspapers, television, radio) l) Celebrities or influencers m) Others	a) Health professional/ health services b) Family c) Friends/co-workers d) Cancer non-governmental organization (e.g., National Cancer League) e) Government or governmental institutions f) Scientific, research or academic health institutions and organizations (e.g., World Health Organization) g) Religious organizations & leaders h) General internet searches (e.g., Google or other internet search engines, Wikipedia or blogs) i) Social media (e.g., Facebook, Instagram, TikTok, X) j) Journalists and traditional media (e.g., newspapers, television, radio) k) Celebrities or influencers l) Digital and Artificial Intelligence-based tools (e.g., AI smartphone apps, chatbots, virtual assistants like Siri or Alexa) m) Others
Source response categories	1- Not at all 2 - Slightly 3 - Somewhat 4 - Moderately 5 - A lot	1- Not at all 2 - Slightly 3 - Moderately 4 - A lot 5 - Completely

Bold text indicates changes to the items included in the pre-tested version

co-workers, (iii) religious organizations & leaders, (iv) general internet searches, (v) social media, (vi) journalists and traditional media, and (vii) celebrities or influencers, with items loadings ranging from 0.402 to 0.828. Both factors showed good reliability, with $\alpha = 0.792$ for *Official sources* and $\alpha = 0.859$ for *Unofficial sources*.

ECAC4 attributes measure

Delphi panel

The 25-item ECAC4 attributes measure was assessed through a Delphi panel. Of the 15 invited, five experts

agreed to participate and completed the first round of evaluation via an online consultation. Experts were based across Europe and Oceania, with experience in implementing evidence-based interventions across a variety of healthcare settings, including primary care, hospital-based care, community health, and oncology. Fields of expertise included implementation science, applied health research, behavioural science, public health, and health services research. In the second round, one expert was unavailable, and two others withdrew from the third round due to professional obligations, reducing the

Table 3 Results of the exploratory factor analysis (EFA), separately for (A) preferences for information delivery channels and (B) source trustworthiness

	Mean (SD)	Factor loadings		
A. Preferences for information delivery channels		Traditional broadcast media	Digital media/online interactive platform	Print media and interpersonal
Television	3.53 (1.00)	-0.581	-0.233	0.039
Radio	3.50 (1.04)	-0.707	-0.018	0.094
General internet searches (e.g., Google or other internet search engines, Wikipedia or blogs)	3.79 (0.89)	-0.137	-0.860	-0.118
Websites	3.80 (0.88)	0.057	-0.710	0.155
Social media (e.g., Facebook, Instagram, TikTok, X)	3.42 (1.14)	-0.152	-0.531	0.059
Podcasts ¹	3.31 (1.09)	(-0.227)	(-0.224)	(0.284)
Books	3.79 (0.94)	0.003	-0.071	0.484
Paper magazine or newspaper	3.69 (0.94)	-0.182	0.134	0.726
Advertisements (e.g., posters, outdoor advertisements)	3.44 (1.11)	-0.245	-0.074	0.508
Health services handouts (e.g., leaflets, pamphlets)	3.76 (0.91)	0.052	0.000	0.777
In person/during a conversation (e.g., health professional, friends, family)	3.79 (0.95)	0.107	-0.284	0.376
Others	3.45 (1.10)			
B. Trust in information sources		Official sources	Unofficial sources	
Health professional/ health services	3.76 (0.98)	0.774	-0.113	
Family	3.17 (0.92)	0.290	0.402	
Friends/co-workers	3.07 (0.93)	0.132	0.630	
Cancer non-governmental organization	3.40 (0.99)	0.577	0.273	
Government or governmental institutions	3.36 (1.08)	0.541	0.273	
Scientific, research, or academic health institutions and organizations	3.83 (0.98)	0.870	-0.165	
Religious organizations & leaders	2.61 (1.19)	-0.045	0.701	
General internet searches (e.g., Google or other internet search engines, Wikipedia or blogs)	3.07 (1.00)	0.103	0.696	
Social media (e.g., Facebook, Instagram, TikTok, X)	2.86 (1.17)	-0.150	0.828	
Journalists and traditional media (e.g., newspapers, television, radio)	3.09 (1.00)	0.108	0.664	
Celebrities or influencers	2.50 (1.18)	-0.199	0.812	
Others	3.04 (1.18)			

¹ This item was excluded after the performance of a first model where it showed low loadings in every factor

Bold values indicate the highest factor loading for each item across factors

potential third-round panel to two participants. Consequently, the Delphi process was discontinued after the second round.

In the first round, 11 items achieved an I-CVI ≥ 0.70 (Table 5). Nonetheless, all items were reviewed for clarity and refined based on qualitative input from the experts. Three items (items 1, 10, and 19) required substantial revisions, involving partial rewording or rephrasing, while several others underwent minor adjustments for improved clarity and precision (e.g., items 6, 11, 12, 13, 15, 16, 18, and 21). For instance, Item 6 was revised from 'fit into' to 'are applicable to' (e.g., *The European Code Against Cancer recommendations are applicable to my everyday life*).

Despite meeting the defined I-CVI threshold, all 11 items were retained for the second round to validate their revised versions further. One item (item 20) was removed due to insufficient clarity and relevance. The remaining 13 items that did not reach the consensus threshold in

the first round were refined, amended or newly developed based on expert suggestions and included in the second Delphi round for re-evaluation.

In round 2, 24 items were evaluated. Of these, six still did not reach the 70% consensus threshold (items 6, 8, 13, 14, 22, and 23). One of them (item 23) was subsequently eliminated, while the others were further reviewed and refined based on the expert's qualitative input. As previously mentioned, a third round was not feasible due to the anticipated low response rate. Given the small sample and in line with a conservative approach to item exclusion, all 23 remaining items were retained for the pre-test phase.

Of the 24 items included in the second round, seven items remained unchanged from the second round to the pre-test version. Of the 16 revised items, five underwent substantial revisions (items 6, 13, 14, 22, and 25), most of which had an I-CVI of 0.50. Although the ECAC4 attributes measure was not evaluated through cognitive

interviews, some terminology-related insights from participant feedback were incorporated into the final version used in the pre-test. All items were revised to consistently use the term ‘cancer risk reduction’ rather than ‘cancer prevention’ or ‘primary cancer prevention’ (Table 4).

ECAC4 attributes measure psychometric analyses

The suitability of the data for factor analysis was confirmed by KMO measures, all exceeding the recommended threshold of 0.70, and by significant Bartlett’s tests of sphericity ($p < 0.001$), indicating sufficient inter-item correlations for factor structure detection.

All scales demonstrated acceptable to excellent reliability and supported the presence of a single factor for each attribute (Table 5).

Discussion

The current study aimed to develop and validate a new instrument to assess how cancer prevention information, particularly the European Code Against Cancer, fourth edition (ECAC4), is perceived and received by the public. Grounded in two well-established D&I frameworks, Rogers’ *Diffusion of Innovations Theory* [18] and McGuire’s *Communication-Persuasion Matrix* (McGuire, 1985), the study addresses two key gaps: the limited research on CPP communication, and the lack of validated instruments to assess innovation attributes in this context.

Overall, the results suggested that the newly developed instrument (Additional file 3) exhibits satisfactory psychometric properties, providing initial evidence of its content and structural validity, as well as its internal consistency. These results support its future use in assessing public perceptions of CPP information.

Message characteristics

The development of the message characteristics questions was grounded in McGuire’s *Communication-Persuasion Matrix* [16, 17] which situates channel and source trustworthiness as critical determinants of successful health communication, interacting systematically with message design and audience characteristics. For instance, Arnold and colleagues applied McGuire’s framework in a digital health campaign and found that persuasion effects—such as trust, attention, and behavioural intent, varied significantly by message source and platform [20]. Recent empirical research underscores that both perceived expertise and trustworthiness of message sources shape how individuals process and respond to public health communication, particularly in contexts such as CPP and pandemic response [39–41].

The present research found some support for the content validity of the two questions assessing channel preference and source trustworthiness, based on theoretical rationale and adaptation from relevant literature. Face

validity, as the comprehensibility component of content validity, was supported through cognitive interviews [37]. The results provided evidence that participants found the items generally clear and understandable, but also highlighted issues with response scales, terminology and category distinctions. The feedback led to refinements such as relabelling the Likert scales, clarifying terms, reordering items and adding new response categories.

EFA revealed conceptually coherent groupings with interpretable factors in both questions, with high factor loadings and internal consistency (Cronbach’s α values above 0.70 for both source and channel questions) supporting the reliability and validity of the scales. This indicates the theoretical coherence of the instrument [36]. The exclusion of one response item (podcasts) that did not load into any of the three factors does not compromise the face or content validity of the question, as the original item format and response logic were preserved, and an open-ended “Other” category ensured flexibility in capturing additional options.

ECAC4 attributes

Rogers’ *Diffusion of Innovations Theory* was used as the framework for measuring the five characteristics of ECAC4 as an innovation: relative advantage, compatibility, complexity, trialability, and observability [42]. The study developed and validated a scale that is particularly relevant for non-clinical, population-level contexts, addressing critical gaps identified by Lewis and colleagues [23], who highlighted the scarcity of instruments assessing how audiences perceive the characteristics of health innovations.

Content validity of the ECAC4 attributes measure was established through a two-round Delphi panel. Still, due to participant attrition in the second round, a common limitation in Delphi studies [30, 31], the process was discontinued before full consensus could be reached for all items. As a result, a decision was made to retain five items that had not yet met the consensus threshold; these were adapted based on expert qualitative feedback and included in the pre-test phase. Additionally, several items that had technically reached consensus were further revised based on expert comments regarding clarity and conceptual alignment. Expert comments provided substantive qualitative feedback that proved crucial for item refinement focused on alignment with Rogers’ theoretical framework and conceptual precision, rather than wholesale rejection of item content. The decision to revise the five items that did not reach the 70% consensus threshold after Round 2 was supported by: (1) alignment of item content with established operationalizations of Rogers’ innovation attributes in the literature, (2) the theoretical necessity of representing each of the five attributes (relative advantage, compatibility, complexity, trialability,

Table 4 Delphi round of the ECAC4 innovation attributes

FIRST ROUND (n = 5)				SECOND ROUND (n = 4)			PRE-TESTED VERSION
		I-CVI	Mean (SD)		I-CVI	Mean (SD)	
ADVANTAGE	*1. It's useful to have the main cancer prevention recommendations summarised in a single place.	0.8	3.2(1.3)	*1. There are so many different recommendations about preventing cancer that the European Code Against Cancer makes it easier to know which ones to follow.	1	3.5(0.6)	1. There are so many different recommendations about cancer risk reduction that the European Code Against Cancer makes it easier to know which ones to follow.
	2. The European Code Against Cancer can help to improve my health.	0.6	2.4(0.9)	*2. Compared to other sources and materials I have encountered, the European Code Against Cancer is a better way to learn about cancer prevention.	0.75	3(1.4)	2. Compared to other sources and materials I have encountered, the European Code Against Cancer is a better way to learn about cancer risk reduction .
	3. The European Code Against Cancer provides very useful information.	0.6	2.4(0.9)	*3. The European Code Against Cancer provides more useful information on cancer prevention compared to other informational material.	0.75	3.3(1.5)	3. The European Code Against Cancer provides more useful information on cancer risk reduction compared to other sources and materials.
	4. The European Code Against Cancer can help me to engage in healthier behaviours.	0.6	2.4(0.9)	*4. I find the European Code Against Cancer more practical, than other sources or materials, because it details the specific actions, I can take to decrease cancer risk.	1	3(1.4)	4. I find the European Code Against Cancer more practical than other sources or materials, because it details the specific actions, I can take to decrease cancer risk.
	5. It is very important that the public gets to know the European Code Against Cancer.	0.6	2.2(1.6)	*5. Using the European Code Against Cancer to learn about reducing cancer risk is more convenient than searching for the information myself.	1	3.3(0.5)	5. It's more convenient to use the European Code Against Cancer than to look for the information for all the different recommendations to reduce cancer risk.
COMPATABILITY	*6. The European Code Against Cancer recommendations fit into my everyday life.	0.8	3.2(0.8)	6. The European Code Against Cancer recommendations are applicable to everyday life.	0.5	2.5(0.6)	6. The European Code Against Cancer feels like it's made for someone like me.
	7. The European Code Against Cancer recommendations align with the way I manage my health.	0.6	2.8(0.8)	*7. The European Code Against Cancer recommendations address my specific concerns about cancer prevention.	0.75	2.5(1)	7. The European Code Against Cancer recommendations cover all my potential concerns about cancer risk reduction .
	8. The European Code Against Cancer presents information that fits the way I prefer to obtain health information.	0.4	2.6(1.1)	8. The European Code Against Cancer recommendations are consistent with the way I have received health-related advice in the past.	0.5	2.3(1.3)	8. The European Code Against Cancer fits with how I stay informed about health .
	9. Adopting the European Code Against Cancer recommendations into my day-to-day life would be met with approval by friends and family.	0.6	2.6(1.5)	*9. Friends and family would approve of me adopting the European Code Against Cancer recommendations into my life.	0.75	3(1.4)	9. My friends and family would approve of me following the European Code Against Cancer recommendations.
	*10. I can see myself adopting the European Code Against Cancer recommendations.	0.8	3.4(1.3)	*10. My previous experiences with health prevention information make the European Code Against Cancer recommendations feel familiar.	0.75	2.5(1)	10. My past experiences with health advice make the European Code Against Cancer recommendations feel familiar.

Table 4 (continued)

	FIRST ROUND (n=5)		SECOND ROUND (n=4)		PRE-TESTED VERSION	
		I-CVI	Mean (SD)		I-CVI	Mean (SD)
COMPLEXITY	*11. The European Code Against Cancer recommendations are easy to understand.	1	4(0)	*11. All of the European Code Against Cancer recommendations are easy to understand.	0.75	3(1.4)
	*12. The European Code Against Cancer recommendations are easy to follow.	1	3.8(0.4)	*12. The European Code Against Cancer recommendations are easy to put into practice.	1	3.8(0.5)
	*13. The European Code Against Cancer recommendations are easy to remember.	0.8	3(1.2)	*13. The European Code Against Cancer recommendations are so straightforward that are easy to remember.	0.5	2.3(1.5)
	14. The European Code Against Cancer recommendations can be adopted without too much effort.	0.6	2.6(1.5)	14. I feel confident in my ability to carry out the European Code Against Cancer recommendations without further explanation from healthcare professionals.	0.5	2.5(1.3)
	*15. The European Code Against Cancer recommendations are easy to explain to others.	0.8	3.4(0.9)	*15. The European Code Against Cancer recommendations are simple enough that I can easily explain them to others.	0.75	2.8(1.3)
TRIALABILITY	*16. The European Code Against Cancer recommendations can be tested in my day-to-day life before definitely adopting them.	1	3.8(0.4)	*16. The European Code Against Cancer recommendations can be tested for a week or a month in my day-to-day life before definitely adopting them.	1	3.5(0.6)
	17. I would like to know how the European Code Against Cancer recommendations can reduce my cancer risk.	0.4	2(1)	*17. I can easily test the European Code Against Cancer recommendations without disrupting my current lifestyle too much.	0.75	2.8(0.5)
	*18. The European Code Against Cancer recommendations can be gradually adopted in my day-to-day life.	0.8	3(1.2)	*18. I can try out the different European Code Against Cancer recommendations, one at a time, before deciding to implement any of them in my day-to-day life.	1	3.5(0.6)
	*19. I can decide which of the European Code Against Cancer recommendations I adopt in my day-to-day life.	0.8	3.4(1.3)	*19. I see myself trying to adopt the European Code Against Cancer recommendations in my day-to-day life.	1	3.5(0.6)
	20. I would like to see how others adopt the European Code Against Cancer recommendations.	0.2	2(0.7)	ELIMINATED		

Table 4 (continued)

FIRST ROUND (n = 5)				SECOND ROUND (n = 4)		PRE-TESTED VERSION	
		I-CVI	Mean (SD)		I-CVI	Mean (SD)	
OBSERVABILITY	*21. The benefits of adopting the European Code Against Cancer recommendations are visible.	0.8	3.2(1.3)	*21. The benefits of adopting the European Code Against Cancer recommendations are noticeable.	1	3.5(0.6)	21. The benefits of adopting the European Code Against Cancer recommendations to reduce cancer risk are noticeable.
	22. There is evidence that the European Code Against Cancer recommendations leads to better health results.	0.6	2.8(1.3)	22. There is clear evidence that following the European Code Against Cancer recommendations can reduce cancer risk.	0.5	2.5(1.3)	22. My healthcare providers recognize the benefits of following the European Code Against Cancer recommendations.
	23. It is usual to see others adopting the European Code Against Cancer recommendations.	0.4	2.6(1.5)	23. I am more likely to adopt the European Code Against Cancer recommendations because I have seen the positive impact of following the recommendations on others around me.	0.2	2.8(1)	ELIMINATED
	24. I would have no difficulty telling friends and family about the benefits of adopting the European Code Against Cancer recommendations.	0.6	2.6(1.5)	*24. I frequently encounter examples in the media that show the effectiveness of adopting the European Code Against Cancer recommendations on decreasing cancer risk.	0.75	2.8(1.3)	24. I frequently encounter examples in the media that show the effectiveness of adopting the European Code Against Cancer recommendations on decreasing cancer risk.
	25. If I adopt the European Code Against Cancer recommendations others would see changes in my overall health.	0.6	2.8(1.3)	*25. If I follow all the European Code Against Cancer recommendations, I believe I will significantly reduce my risk of cancer.	0.75	2.8(1.3)	25. I see that people who do not follow the European Code Against Cancer recommendations have a greater likelihood of developing cancer.

I-CVI Item Content Validity Index

* Items achieving the threshold of 70% agreement, and Bold text indicates changes to the items included in the pre-tested version

Bold values indicate the highest factor loading for each item across factors

and observability) with adequate item coverage, and (3) psychometric data of all revised items in the subsequent pre-test phase, where all five subscales demonstrated unidimensionality and acceptable-to-excellent internal consistency. While the post-Delphi may raise concerns regarding issues like the robustness of the content validity evidence, they reflect adaptive refinement aimed at improving item interpretability [31].

Structural validity was supported by the results of EFA. Each of the five innovation attributes subscales demonstrated unidimensionality, strong factor loadings (all > 0.50), and high internal consistency (α ranging from 0.714 to 0.831). The results suggest that items within each subscale converge on a common latent construct, aligning with theoretical expectations from the literature on innovation attributes, and reinforcing that the instrument is measuring what it was designed to measure.

Limitations

This study has several limitations. First, the cognitive interviews used to assess face validity involved only six participants, potentially overlooking comprehension issues across diverse populations. Second, participant attrition in the Delphi panel may have reduced the strength of content validity consensus. Although response rates between 33% and 53% have been reported in e-Delphi studies involving expert panels [30], suggesting that the initial participation rate in this study (33%) is within the range documented in similar research; content validity evidence is based on a combination of quantitative consensus metrics from the Delphi rounds and qualitative expert input, rather than full iterative validation of all final item versions. This limitation is somewhat mitigated by the psychometric data observed in the pre-test, but it nonetheless represents a constraint on the comprehensiveness of the content validation process. This caveat may be particularly relevant considering that the instrument included newly developed items, even though these

Table 5 Results of the exploratory factor analysis for ECAC4 attributes measure

	Mean (SD)	Factor loadings	α	Eigenvalue	Variance explained
A. Relative advantage			0.831	2.531	50.62%
Compared to other sources and materials I have encountered, the ECAC is a better way to learn about cancer risk reduction.	3.55 (0.92)	0.846			
There are so many different recommendations about cancer risk reduction that the ECAC makes it easier to know which ones to follow.	3.65 (0.88)	0.700			
The ECAC provides more useful information on cancer risk reduction compared to other sources and materials.	3.68 (0.81)	0.665			
I find the ECAC more practical than other sources or materials, because it details the specific actions, I can take to decrease cancer risk.	3.74 (0.88)	0.720			
It's more convenient to use the ECAC than to look for the information for all the different recommendations to reduce cancer risk."	3.67 (0.95)	0.603			
B. Compatibility			0.823	2.412	48.25%
The ECAC feels like it's made for someone like me.	3.50 (0.86)	0.700			
The ECAC recommendations cover all my potential concerns about cancer risk reduction.	3.53 (0.91)	0.734			
The ECAC fits with how I stay informed about health.	3.62 (0.91)	0.709			
My friends and family would approve of me following the ECAC recommendations.	3.65 (0.90)	0.647			
My past experiences with health advice make the ECAC recommendations feel familiar.	3.63 (0.90)	0.681			
C. Complexity			0.770	2.030	40.59%
All of the ECAC recommendations are easy to understand.	3.76 (0.87)	0.669			
The ECAC recommendations are easy to put into practice.	3.62 (0.86)	0.526			
The ECAC is a simple way to help people learn about preventing cancer.	3.88 (0.81)	0.618			
Following the ECAC doesn't require special skills or knowledge.	3.70 (0.94)	0.675			
The recommendations in the ECAC are easy to explain to others.	3.79 (0.86)	0.683			
D. Trialability			0.714	1.543	38.57%
The ECAC recommendations can be tested for a month in my day-to-day life before fully adopting them.	3.63 (0.84)	0.659			
The ECAC feels flexible enough to apply to my current way of living.	3.67 (0.86)	0.594			
I can try out the different ECAC recommendations, one at a time, before deciding to implement any of them in my day-to-day life.	3.62 (0.89)	0.646			
I see myself trying to adopt the ECAC recommendations in my day-to-day life.	3.70 (0.86)	0.582			
E. Observability			0.776	1.918	47.94%
The benefits of adopting the ECAC recommendations to reduce cancer risk are noticeable.	3.67 (0.89)	0.550			
My healthcare providers recognise the benefits of following the ECAC recommendations.	3.63 (0.81)	0.793			
In places where the ECAC is promoted, people seem more aware of how to reduce their cancer risk.	3.61 (0.87)	0.691			
I frequently encounter examples in the media that show the effectiveness of adopting the ECAC recommendations on decreasing cancer risk.	3.42 (0.96)	0.713			

ECAC European Code Against Cancer

were conceptually informed by existing instruments using Rogers Diffusion of Innovation theory. Third, the channel preference and source trustworthiness questions were not validated by experts, while the ECAC4 attributes measure was not assessed by target population in the cognitive interviews. According to COSMIN guidelines [37] content validity requires confirmation of item relevance, comprehensiveness, and comprehensibility, which may be obtained through input from experts, members of the target population, or from both.

Implications and future directions

Overall, this newly developed and validated questionnaire can be used to identify communication gaps in CPP, tailor dissemination strategies to sub-population preferences, and inform message design that optimizes source-channel alignment. This instrument can support efforts by identifying groups less likely to perceive the benefits of adopting CPP recommendations, thereby enabling campaign designers to address specific barriers.

Future research could explore how differences in the perception of innovation attributes are associated with variations in cancer literacy and health outcomes, or

how sociodemographic characteristics shape the trustworthiness of individuals in information sources and in their preferences for specific communication channels. Further validity work is also warranted, including CFA and tests of measurement invariance across key population groups (like, for instance, based on age, gender, or geographic region), to ensure the robustness and applicability of the instrument in diverse contexts. Subsequent studies can also examine how the instrument relates to outcomes such as cancer awareness or behavioural intention to test the predictive measurements of these items.

Another promising direction would be to adapt and validate the instrument in different cultural or linguistic contexts, enabling cross-country comparisons and supporting the development of more globally relevant CPP communication strategies.

Conclusion

This study presents a newly developed and validated instrument for evaluating public responses to CPP messaging. By integrating key constructs from two frameworks, and assessing both content and structural validity, the instrument addresses a critical gap in CPP communication studies. This instrument offers a robust framework to systematically measure key determinants of message uptake, including source trustworthiness, communication channels, and the perceived attributes of preventive innovations and can potentially contribute to the design and implementation of tailored dissemination strategies, thereby strengthening CPP efforts across diverse population segments.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s13690-026-01947-7>.

Additional file 1: Cognitive Interview Evaluation Grid, includes the assessment grid used by researchers when conducting the cognitive interviews.

Additional file 2: Pre-test sample characterization, includes a table with the distribution of the sociodemographic characteristics of the pre-test sample.

Additional file 3: Instrument proposed final version, includes the final version of the questions assessing channel preference, source trustworthiness and ECAC4 attributes.

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Where authors are identified as personnel of the International Agency for Research on Cancer/World Health Organization, the authors alone are responsible for the views expressed in this article, and they do not necessarily represent the decisions, policy, or views of the International Agency for Research on Cancer /World Health Organization.

Authors' contributions

AJS: Conceptualization, Methodology, Data collection, analysis and interpretation of data, Writing – original draft, review & editing. LR: Conceptualization, Methodology, Data analysis and interpretation, Writing – original draft, review & editing. HS: Methodology, Data interpretation, Writing – review & editing. CE: Methodology, Data interpretation, Writing – review & editing. RI: Methodology, Data collection and interpretation, Writing – review & editing. LV: Methodology, Data collection, Writing – review & editing. MP: Methodology, Data collection, Writing – review & editing. LB: Data analysis and interpretation, Writing – review & editing. AF: Methodology, Data interpretation, Writing – review & editing. ES: Methodology, Data interpretation, Writing – review & editing. MG: Conceptualization, Funding acquisition, Writing – review & editing. MS-U: Conceptualization, Methodology, Data collection, analysis and interpretation of data, Writing – review & editing.

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Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study followed the principles of the Declaration of Helsinki and complied with all relevant national and institutional guidelines for research with human participants. Ethical approval was granted by the Instituto Nacional de Saúde Doutor Ricardo Jorge (INSA) (163/2024). Participation was voluntary, and all participants provided informed consent before data collection. Data from the Cognitive interviews and Delphi panel was obtained respecting confidentiality, and only aggregated results are reported. Pre-test data were collected anonymously.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Tran KB, Lang JJ, Compton K, Xu R, Acheson AR, Henrikson HJ, et al. The global burden of cancer attributable to risk factors, 2010–19: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2022;400(10352):563–91. [https://doi.org/10.1016/S0140-6736\(22\)01438-6](https://doi.org/10.1016/S0140-6736(22)01438-6).
2. Hu J, Dong H, Dong Y, Zhou R, Teixeira W, He X, et al. Cancer burden attributable to risk factors, 1990–2019: A comparative risk assessment. *iScience*. 2024;27(4). <https://doi.org/10.1016/j.isci.2024.109430>.
3. Vineis P, Wild CP. Global cancer patterns: Causes and prevention. *Lancet*. 2014;383(9916):549–57. [https://doi.org/10.1016/S0140-6736\(13\)62224-2](https://doi.org/10.1016/S0140-6736(13)62224-2) PubMed PMID: 24351322.
4. Rabin BA, Glasgow RE, Kerner JF, Klump MP, Brownson RC. Dissemination and Implementation Research on Community-Based Cancer Prevention. A Systematic Review. *Am J Prev Med*. 2010;443–56. <https://doi.org/10.1016/j.amepre.2009.12.035> PubMed PMID: 20307814.
5. Roxo L, Santos A, Giralaki C, Geantă M, Sousa-Uva M. Characterizing stakeholders in cancer primary prevention in European countries: an exploration of challenges and opportunities using a penta-helix framework. *Front Public Health*. 2025;13. <https://doi.org/10.3389/fpubh.2025.1550712>.
6. Rositch AF, Unger-Saldana K, Deboer RJ, Ng'ang'a A, Weiner BJ. The Role of Dissemination and Implementation Science in Global Breast Cancer Control Programs: Frameworks, Methods, and Examples. *Cancer*. John Wiley and Sons Inc; 2020. pp. 2394–404. <https://doi.org/10.1002/cncr.32877> PubMed PMID: 32348574.
7. Schüz J, Espina C, Villain P, Herrero R, Leon ME, Minozzi S, et al. European code against cancer 4th edition: 12 ways to reduce your cancer risk. *Cancer Epidemiol*. 2015;39:S1–10. <https://doi.org/10.1016/j.canep.2015.05.009> PubMed PMID: 26164654.
8. Espina C, Yared W, Ritchie D, Lipponen S, Anttila A, Tamminiemi K, et al. Sustainability and monitoring of the European Code Against Cancer: Recommendations. *Cancer Epidemiol*. 2021;72. <https://doi.org/10.1016/j.canep.2021.101933> PubMed PMID: 33838462.
9. Espina C, Feliu A, González Vingut A, Liddle T, Jimenez-Garcia C, Olaya-Caro I, et al. Population-Based Cancer Prevention Education Intervention Through mHealth: A Randomized Controlled Trial. *J Med Syst*. 2024;48(1). <https://doi.org/10.1007/s10916-023-02026-y> PubMed PMID: 38194118.
10. Ritchie D, Mallafre-Larrosa M, Ferro G, Schüz J, Espina C. Evaluation of the impact of the European code against cancer on awareness and attitudes towards cancer prevention at the population and health promoters' levels. *Cancer Epidemiol*. 2021;71. <https://doi.org/10.1016/j.canep.2021.101898> PubMed PMID: 33611135.
11. Hultstrand C, Brynskog E, Karlsson Rosenblad A, Sunesson AL, Björk-Eriksson T, Sharp L. Low levels of awareness and motivation towards cancer prevention amongst the general public in Sweden: a cross-sectional study focusing on the European Code Against Cancer. *BMC Public Health*. 2025;25(1). <https://doi.org/10.1186/s12889-025-22803-3> PubMed PMID: 40336012.
12. Baumann AA, Hooley C, Kryzer E, Morshed AB, Gutner CA, Malone S, et al. A scoping review of frameworks in empirical studies and a review of dissemination frameworks. *Implement Sci*. 2022;17(1). <https://doi.org/10.1186/s13012-022-01225-4> PubMed PMID: 35945548.
13. Nilsen P. Making sense of implementation theories, models and frameworks. *Implement Sci*. 2015;10(1). <https://doi.org/10.1186/s13012-015-0242-0> PubMed PMID: 25895742.
14. Tabak RG, Khoong EC, Chambers DA, Brownson RC. Bridging research and practice: Models for dissemination and implementation research. *Am J Prev Med*. 2012;43(3):337–50. <https://doi.org/10.1016/j.amepre.2012.05.024> PubMed PMID: 22898128.
15. Wilson PM, Petticrew M, Calnan MW, Nazareth I. Disseminating research findings: What should researchers do? A systematic scoping review of conceptual frameworks. *Implement Sci*. 2010;5(1). <https://doi.org/10.1186/1748-5908-5-91>.
16. McGuire WJ. Attitudes and attitude change. In: Lindzey G, Aronson, editors. *The handbook of social psychology*. Random House; 1985. pp. 233–346.
17. Atkin CK, Freimuth V. Formative evaluation research in campaign design. In: Rice RE, Atkins CK, editors. *Public Communication Campaigns*. 3rd ed. Thousand Oaks, CA: Sage; 2001. pp. 125–45.
18. Rogers EM. *Diffusion of innovations*. 3rd ed. New York: Free; 1993. pp. 1–447.
19. Esmail R, Hanson HM, Holroyd-Leduc J, Brown S, Striffler L, Straus SE, et al. A scoping review of full-spectrum knowledge translation theories, models, and frameworks. *Implementation Science*. BioMed Central Ltd.; 2020. <https://doi.org/10.1186/s13012-020-0964-5> PubMed PMID: 32059738.
20. Arnold J, Bailey CP, Evans WD, Napolitano MA. Application of McGuire's Model to Weight Management Messages: Measuring Persuasion of Facebook Posts in the Healthy Body, Healthy U Trial for Young Adults Attending University in the United States. *Int J Environ Res Public Health*. 2022;19(21). <https://doi.org/10.3390/ijerph192114275> PubMed PMID: 36361162.
21. Oldenburg B, Glanz K. Diffusion of innovations. In: Glanz B, Rimer K, Viswanath K, editors. *Health behavior and health education: Theory, research, and practice*. 4th ed. San Francisco: Jossey-Bass; 2008. pp. 313–33.
22. Sivaram S, Sanchez MA, Rimer BK, Samet JM, Glasgow RE. Implementation science in cancer prevention and control: A framework for research and programs in low- And middle-income countries. *Cancer Epidemiol Biomarkers Prev*. 2014;23(11):2273–84. <https://doi.org/10.1158/1055-9965.EPI-14-0472> PubMed PMID: 25178984.
23. Lewis CC, Mettert K, Lyon AR. Determining the influence of intervention characteristics on implementation success requires reliable and valid measures: Results from a systematic review. *Implement Res Pract*. 2021;2. <https://doi.org/10.1177/2633489521994197>.
24. National Cancer Institute. National Cancer Institute. 2020. Health Information National Trends Survey 4 Cycle. Available from: https://hints.cancer.gov/docs/Instruments/HINT55_Cycle4_AnnotatedInstrumentEnglish.pdf. Cited 2024 May 30.
25. Weijters B, Cabooter E, Schillewaert N. The effect of rating scale format on response styles: The number of response categories and response category labels. *Int J Res Mark*. 2010;27(3):236–47. <https://doi.org/10.1016/j.jresmar.2010.02.004>.
26. Atkinson NL. Developing a questionnaire to measure perceived attributes of eHealth innovations. *Am J Health Behav*. 2007;31(6):612–21. <https://doi.org/10.5993/AJHB.31.6.6> PubMed PMID: 17691874.
27. Hoque MR. An empirical study of mHealth adoption in a developing country: The moderating effect of gender concern. *BMC Med Inf Decis Mak*. 2016;16(1). <https://doi.org/10.1186/s12911-016-0289-0> PubMed PMID: 27142844.
28. Cook JM, Thompson R, Schnurr PP. Perceived Characteristics of Intervention Scale: Development and Psychometric Properties. *Assessment*. 2015;22(6):704–14. doi:10.1177/1073191114561254 PubMed PMID: 25520213.
29. Willis G. *Cognitive Interviewing*. Thousand Oaks, CA: Sage; 2005.
30. Donohoe H, Stelfox M, Tennant B. Advantages and limitations of the e-Delphi technique: Implications for health education researchers. *Am J Health Educ*. 2012;43(1):38–46. <https://doi.org/10.1080/19325037.2012.10599216>.
31. Barrett D, Heale R. What are Delphi studies? *Evid Based Nurs*. 2020;23(3):68–9. <https://doi.org/10.1136/ebnurs-2020-103303> PubMed PMID: 32430290.
32. Dragostinov Y, Harðardóttir D, McKenna PE, Robb D, Nessel B, Ahmad MI, et al. Preliminary psychometric scale development using the mixed methods Delphi technique. *Methods Psychol*. 2022;7. <https://doi.org/10.1016/j.metip.2022.100103>.
33. Boateng GO, Neilands TB, Frongillo EA, Melgar-Quinonez HR, Young SL. Best Practices for Developing and Validating Scales for Health, Social, and Behavioral Research: A Primer. *Front Public Health Front Media S A*. 2018. <https://doi.org/10.3389/fpubh.2018.00149> PubMed PMID: 29942800.
34. Watkins MW. Exploratory Factor Analysis: A Guide to Best Practice. *J Black Psychol*. 2018;44(3):219–46. <https://doi.org/10.1177/0095798418771807>.
35. Artazcoz L, Cortés-Franch I, Escribà-Agüir V, Benavides FG. Financial Strain and Health Status Among European Workers: Gender and Welfare State Inequalities. *Front Public Health*. 2021;9. <https://doi.org/10.3389/fpubh.2021.616191> PubMed PMID: 34095045.
36. DeVellis RF, Thorpe CT. *Scale Development: Theory and Applications*. SAGE Publications LTD; 2021. pp. 1–320.
37. Terwee CB, Prinsen CAC, Chiarotto A, Westerman MJ, Patrick DL, Alonso J, et al. COSMIN methodology for evaluating the content validity of patient-reported outcome measures: a Delphi study. *Qual Life Res*.

- 2018;27(5):1159–70. <https://doi.org/10.1007/s11136-018-1829-0>. PubMed PMID: 29550964.
38. Field A. *Discovering Statistics Using IBM SPSS Statistics* (North American Ed). SAGE Publications LTD; 2017. pp. 1–1104.
39. Nan X, Iles IA, Yang B, Ma Z. Public Health Messaging during the COVID-19 Pandemic and Beyond: Lessons from Communication Science. *Health Commun.* 2022;37(1):1–19. <https://doi.org/10.1080/10410236.2021.1994910>. PubMed PMID: 34724838.
40. Weerakoon SM, Henson-Garcia M, Valerio-Sheemaker MA, Messiah SE, Knell G. Contributions of Trustworthiness, Health Literacy, and Self-Efficacy in Communicating With COVID-19 Vaccine-Hesitant Audiences: Web-Based Survey Study. *JMIR Form Res.* 2022;6(8). <https://doi.org/10.2196/38076>.
41. Issaka B, Allor P, Aidoo EAK, Wood SF, Amissah AA, Muturi N. Enhancing cancer prevention behaviors through social media: the role of source credibility and message characteristics in Ghana. *BMC Public Health.* 2025;25(1). <https://doi.org/10.1186/s12889-025-23693-1>. PubMed PMID: 40670961.
42. Haider M, Kreps GL. Forty years of diffusion of innovations: Utility and value in public health. *J Health Commun.* 2004;9:3–11. doi:10.1080/10810730490271430 PubMed PMID: 14960400.
43. Carper MM, McHugh RK, Murray HW, et al. Psychometric analysis of the perceptions of computerized therapy questionnaire-patient version (PCTQ-P). *Adm Policy Ment Health.* 2014;41:104–13. <https://doi.org/10.1007/s10488-012-0440->.
44. Celik I, Sahin I, Aydin M. Reliability and validity study of the mobile learning adoption scale developed based on the diffusion of innovations theory. *Int J Educ Math Sci Technol.* 2014;2(4):300–16. <https://doi.org/10.18404/ijemst.65217>.
45. Hunter SB, Han B, Slaughter ME, et al. Associations between implementation characteristics and evidence-based practice sustainment: a study of the adolescent community reinforcement approach. *Implement Sci.* 2015;10:173. <https://doi.org/10.1186/s13012-015-0364-4>.
46. Liu D, Son S, Cao J. The determinants of public acceptance of telemedicine apps: an innovation diffusion perspective. *Front Public Health.* 2023;11:1325031. <https://doi.org/10.3389/fpubh.2023.1325031>.
47. Pankratz M, Hallfors D, Cho H. Measuring perceptions of innovation adoption: the diffusion of a federal drug prevention policy. *Health Educ Res.* 2002;17(3):315–26. <https://doi.org/10.1093/her/17.3.315>.
48. Scott SD, Plotnikoff RC, Karunamuni N, Bize R, Rodgers W. Factors influencing the adoption of an innovation: an examination of the uptake of the Canadian Heart Health Kit (HHK). *Implement Sci.* 2008;3:41. <https://doi.org/10.1186/1748-5908-3-42>.
49. Viana Pereira F, Tavares J, Oliveira T. Adoption of video consultations during the COVID-19 pandemic. *Internet Interv.* 2023;31:100602. <https://doi.org/10.1016/j.invent.2023.100602>.
50. Windsor R, Cleary S, Ramiah K, Clark J, Abrams L, Davis A. The Smoking Cessation and Reduction in Pregnancy Treatment (SCRIPT) Adoption Scale: evaluating the diffusion of a tobacco treatment innovation to a statewide prenatal care program and providers. *J Health Commun.* 2013;18(10):1201–20. <https://doi.org/10.1080/10810730.2013.778358>.

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