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HPVoice: a single-blind three-arm RCT on social media communication strategies among adolescents in Tuscany, Italy

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ABSTRACT

Introduction: Cervical cancer is the first cancer potentially eliminable through widespread HPV vaccination. In Italy, despite free access, vaccine coverage among adolescents remains low. Psychological factors such as information avoidance (IA), the tendency to ignore threatening information, can influence vaccine decisions and contribute to vaccine hesitancy (VH). While social media offers new avenues for health communication, their effectiveness in reducing VH is uncertain. This study investigates the impact of Instagram-based communication strategies on adolescents' HPV knowledge and VH.

Methods: A three-arm randomized controlled trial was conducted in 22 high school classes in Tuscany, involving 526 students. Classes were randomized to follow one of three Instagram pages for one month: a neutral control, an information-based account, or a bias-aware account designed to address cognitive biases related to vaccination decisions.

Data were collected through online surveys at three time points: baseline (T1), after the intervention (T2), followed by in-class lesson, and at three-month follow-up (T3). HPV knowledge and VH were assessed at all time points, whereas cognitive biases, including IA, were measured only at T1.

Results: The final analysis included 301 students (mean age 15.2, 74% female). Overall, no significant changes in VH or knowledge were found between T1 and T2 overall. However, in students with low IA the info-based page reduced VH significantly compared to the control (−6.9%, $p = .009$). In contrast, among high-IA students, the same intervention increased VH (estimated: +8.9%, $p = .002$). Willingness to seek information increased in the info group among low-IA students (logg odds $\beta = +1.639$ vs. control, $p = .034$). At T3, we measured significant increase in knowledge compared to T1 despite the smaller sample collected.

Conclusion: Social media campaigns showed limited effects on VH reduction in adolescents and can even backfire among high-IA individuals. Future strategies should incorporate personalized, bias-aware and interactive tools to address VH and HPV vaccine uptake effectively.

1. Introduction

1.1. Public-health burden of HPV and value of vaccination

Cervical cancer is the first type of cancer that could potentially be eliminated, since almost all cases are caused by Human Papillomavirus (HPV), and vaccination against HPV is available. Currently, cervical cancer is the eighth most prevalent cancer worldwide, with 662,301 new cases reported in 2022 [1]. In Italy, 2365 new cases of cervical cancer were estimated in 2020, making it the fifth most frequent cancer among women aged 0–49 years [2]. HPV infection is also responsible for several other cancers, specifically 88% of anal cancers, 70% of vaginal cancers, 50% of penile cancers, 43% of vulvar cancers, and 26–30% of head and neck cancers [3].

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Vaccination against the HPV carcinogenic types is the most effective tool for preventing HPV infection and associated cancers. Recognizing the global public health burden of cervical cancer, the World Health Organization (WHO) has adopted the Global Strategy for Cervical Cancer Elimination, with a target of 90% of girls fully vaccinated against HPV by the age of 15 [4]. Similarly, the EU has prioritized vaccine-preventable cancers, including HPV-related cancers, as part of Europe's Beating Cancer Plan [5] and the Council Recommendation published in June 2024 [6].

1.2. Vaccine hesitancy and suboptimal adolescent coverage in Italy

HPV vaccination is more effective when administered at a younger age, before the onset of sexual activity [7], and with a gender-neutral approach. However, when the vaccine was launched, it was only offered to girls [8,9]. In almost all European countries, including Italy, the HPV vaccination is generally recommended for adolescents, both girls and boys, at the age of 11 years. In 2017, Italy introduced free HPV vaccination for males in the National Vaccination Prevention Plan 2017–2019 [10].

The vaccination schedule includes two doses at 0 and 6 months (for individuals up to 14 years) while older individuals receive three doses at 0, 1–2 and 6 months. Despite significant progress since the pandemic, HPV vaccine coverage in Italy remains suboptimal, reaching 73% for the first dose and 64% for the full cycle among 15-year-old females in 2023. Among males of the same age, coverage reaches 63% for the first dose and 53% for the final dose [11]. In the Tuscany region, where the present study takes place, coverage aligns with national figures, with 69.3% of girls and 57.1% of boys having received at least one dose [11].

1.3. Role of psychological mechanisms in hesitancy

Vaccine hesitancy (VH), defined as “a psychological state of indecisiveness that people may experience when deciding on vaccination” [12], may contribute to suboptimal vaccine uptake. Because vaccination is proposed at a young age, addressing parental VH is crucial to improving coverage [13]: in European countries studies have identified, as the main reasons for VH, the lack of information, the fear of side effects, and the mistrust of health authorities, including health professionals, although significant differences between countries were observed [14]. The perception that the HPV vaccine is intended only for girls or women, and that it could promote promiscuity or early sexual activity, has also been identified as a factor contributing to vaccine hesitancy [15].

Among adolescents, levels of knowledge regarding vaccine-preventable diseases, vaccine confidence levels, and involvement in the decision-making process are correlated with higher uptake rates. However, adolescent VH has been less studied, highlighting the need for further research to identify its determinants [16]. Additionally, adolescents' involvement in the vaccination decision-making process is often limited, and they frequently receive inadequate information about vaccines, with their attitudes being significantly influenced by their parents [17].

Behavioral and psychological factors also shape VH across all age groups. In particular, cognitive style and biases were found to play a relevant role in parents' attitudes toward HPV vaccination [18]. According to the widely adopted dual-process theory of reasoning and decision-making, humans process information through two cognitive systems, leading to so-called “fast” and “slow” thinking styles [19]. System 1 is intuitive, fast, and automatic, while System 2 is analytical, slow, and effortful. System 1 relies on heuristics, which, in some circumstances, can lead to biases and errors if uncontrolled by System 2. This interplay can influence reasoning and decision-making, including VH. Indeed, an intuitive, System 1 based cognitive style has been associated with higher anti-vaccination attitude, in recent studies on the COVID-19 pandemic [20]. A review by Gong et al. [21] reported a possible, albeit weak, effect on communication framing on improving attitude and intention toward HPV vaccination, underlining the necessity of further investigation and the development of high-quality content to sustain individual motivation.

Focusing on HPV vaccination decisions, Pomares et al. [22], identified several cognitive biases associated with parents' VH, including: *information avoidance (IA)*, the tendency to ignore available but unpleasant information and *present bias*, where immediate benefits are prioritized over long-term outcomes. Similarly, Wang et al., [23] linked the moderating role of IA to health literacy and HPV vaccine intention using a digital information tool, underscoring the importance of individual ability to manage and retain stressful information in a virtual environment. Recent theoretical work reframes IA as a structured psychological process rather than random behavior. Foust and Taber [24] propose a comprehensive model identifying cognitive, affective, and situational antecedents that shape whether individuals engage with or avoid information. According to their framework, avoidance arises when exposure threatens emotional balance, challenges prior beliefs, or exceeds perceived coping capacity. This model provides a useful lens for interpreting differential engagement with health information, particularly in digital and social media contexts.

A better understanding of IA, of present bias and of other cognitive biases is thus essential both to study their influence on vaccination decisions and to design tailored interventions to counteract VH.

1.4. Promise of social media tools and interventions

Although no studies have specifically examined the role of adolescents' cognitive biases in relation to HPV vaccination to date, the importance of psychological factors, particularly those related to the reception and comprehension of information, is fundamental in determining vaccine confidence. Various strategies to enhance vaccine coverage, including digital interventions, have been explored taking the target population's age into account. Health education plays a relevant role in increasing HPV vaccine uptake [25] and can be promoted by digital interventions that can cost-effectively increase HPV awareness [26]. Among these interventions, social media platforms are being increasingly recognized as a promising tool for health promotion; however, evidence on the effectiveness of social media interventions is scarce [27], even if some studies have demonstrated that they may help counteract misinformation [28].

A recent scoping review by Bravo et al. [29] highlighted that, despite the increasing use of social media for HPV and cervical cancer communication, experimental studies remain limited, particularly on newer platforms such as Instagram and TikTok. The review also emphasized the need to identify which message features, visual elements, and behavioral techniques most effectively promote engagement and improve knowledge and screening behaviors.

Recent interventions have demonstrated the potential of social media to promote HPV vaccination in diverse settings. For instance, Adegboyega et al. [30] showed that a Facebook-based campaign (#HPVVaxTalks) among young Black adults in the United States improved HPV knowledge and reduced VH; Agha et al. [31] reported that a multimedia campaign in Bangladesh significantly increased HPV vaccine uptake among adolescent girls; and Bose et al., [32] found that influencer-led social media initiatives in Nigeria effectively enhanced awareness and vaccination intentions, particularly by addressing misinformation and cultural barriers.

Furthermore, a participatory approach, based on co-design, has proven to positively contribute to the effectiveness of digital interventions, including on social media [33], suggesting that using peer perspectives could be strategically beneficial.

1.5. Study objective

Our study aimed to assess: (a) whether Instagram-based

interventions improve HPV-related knowledge, (b) whether they reduce VH, and (c) whether IA moderates these effects among adolescents in Tuscany.

2. Methods

2.1. Study design

This study employs a three-arm randomized controlled trial (RCT) with class-level randomization to evaluate the effectiveness of different social media communication strategies in promoting HPV vaccination among Italian adolescents (Fig. 1). The interventions consisted of three Instagram pages: (1) the official page of the Italian National Institute of Health for the control group, (2) an information-based page providing factual content on HPV risks and vaccination procedures for the first treatment group, and (3) a cognitive bias-targeted page designed to counteract specific biases affecting adolescents' risk perception and decision-making regarding vaccination for the second treatment group. The information-based and cognitive bias-targeted Instagram pages were co-designed with health professionals and students aged 16–18 from a high school in Florence to ensure relevance and engagement, following the Social Challenge methodology [33,34]. After this phase, 22 classes from 8 high schools (mainly from the first and second years of lyceums and technical institutes) from four provinces (Lucca, Massa Carrara, Pisa, Grosseto) in Tuscany region were randomly assigned to one of the three groups, ensuring a balanced distribution based on

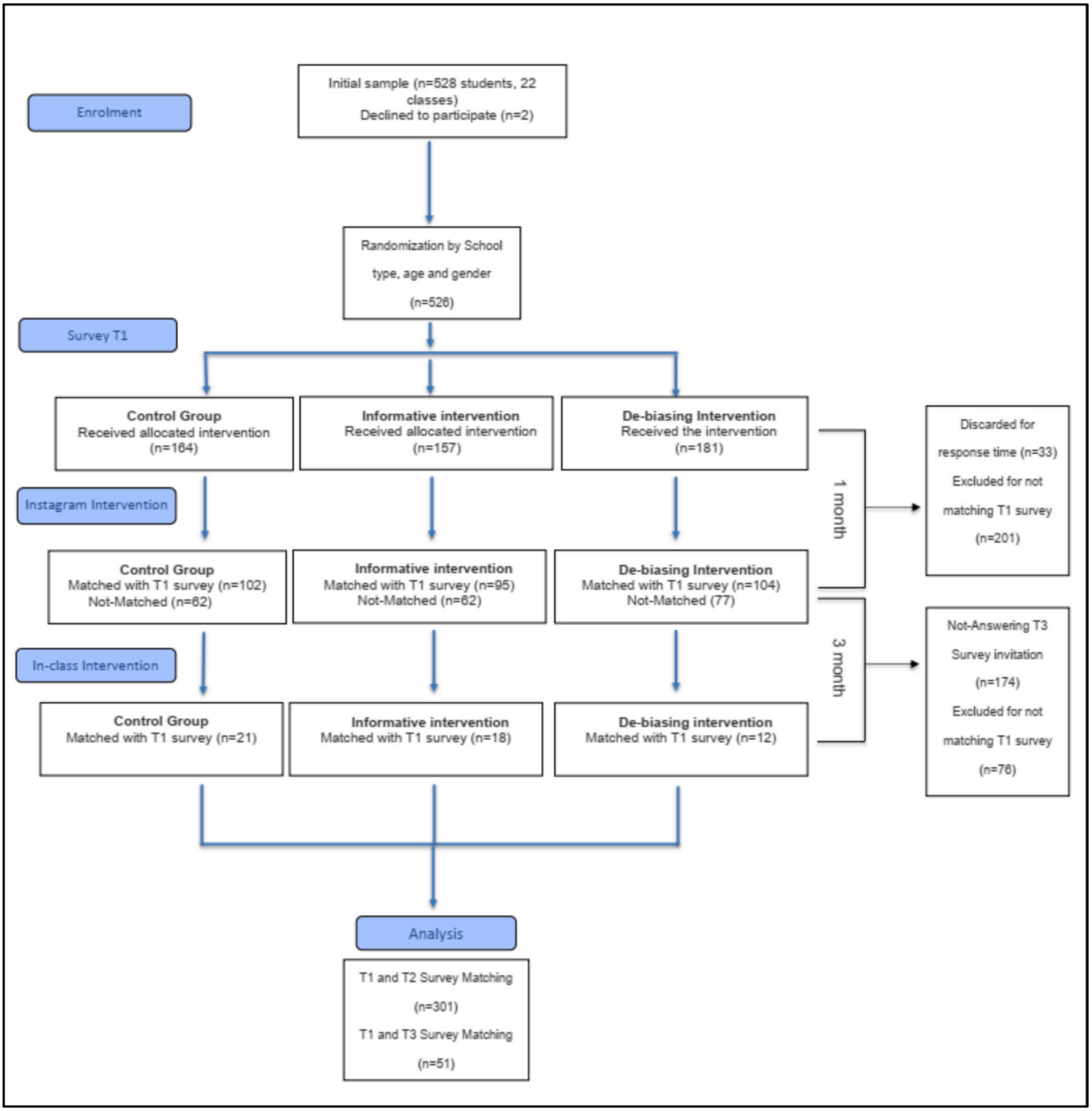

Fig. 1. CONSORT flow diagram of participant enrolment, allocation, and analysis.

gender, age and type of school. Both students and teachers were blinded to group allocation to minimize bias. The study was conducted in three phases (T1, T2, and T3) during the school year 2023/2024, with online surveys administered at each stage to assess changes in vaccination attitudes, knowledge, and cognitive biases:

- T1 (Baseline): After completing an online survey in Qualtrics via QR code, students were redirected to one of the three Instagram profiles. They were asked to follow the assigned profile throughout the project and engage with its content.
- T2 (Intervention Assessment – 1 month later): Students completed a second online survey. Subsequently, all participating classes, regardless of their assigned group, attended a two-hour in-class session on sexually transmitted infections and affectivity to provide additional educational reinforcement.
- T3 (Follow-up – 3 months later): A final online survey was administered to assess the effects of the in-class session and long-term effects of the intervention.

2.2. Study setting and recruitment

The study was conducted in high school settings and involved a total of 526 students. The decision to implement the intervention within schools was based on two main factors. First, schools provide a structured and accessible environment to reach adolescents, ensuring high participation rates. Second, the school setting facilitates the integration of the interventions with a complementary in-class educational session, allowing for a multi-modal approach that combines digital engagement with direct learning experiences. The schools were selected through an online call to action promoted by the Tuscany Health-Promoting Schools Network (https://www.retespstoscana.it/). The invitation to participate was sent to the schools presented in the network and the teachers expressed their willingness to take part in the project.

2.3. Co-creation phase

We employed a co-creative methodology to develop the content (posts) for the information-based Instagram page and the cognitive bias-targeted Instagram page. Co-creation is a collaborative process involving diverse stakeholders widely used in healthcare to design interventions addressing target population needs [29].

On February 29, 2024, a two-phase workshop was held at a high school in Florence. The first phase featured a two-hour session by public health experts covering reproductive health, HPV, and vaccination. The second phase involved a three-hour interactive session using the Social Challenge methodology [34], where students, divided into teams, designed Instagram posts to raise HPV awareness and voted for the three best posts. Based on their preferences, some posts were selected and subsequently reviewed by experts and researchers to ensure the accuracy of the information. The posts were then adapted to be informative for the project's Instagram account 1 and to counter cognitive biases on account 2. The classes involved in the co-creation phase were not included in the study sample.

2.4. Study population

The initial sample of 526 students consisted of 74% female, 24% male, and 2.7% identified as other. In terms of age distribution, 45% were 14 years old, 22% were 15, 16% were 16, and 18% were 17 or older. Additionally, 56% of students reported having received at least one dose of the HPV vaccine. By the end of the second survey (T2), longitudinal data from 334 students (63.5%) were successfully matched. With a significance level $\alpha = 5\%$ and power $(1 - \beta) = 80\%$, this sample is able to detect a small-to medium effect size (Cohen's $d \geq 0.3$ for pooled treatments versus control and $d \geq 0.35$ for treatment comparison). In the follow-up phase of the study only 51 participants were matched with the initial sample (9.8%). Matching procedures are described in the "Analysis" section, while attrition effects are discussed in the "Results" section below.

2.5. Survey design

We conducted a narrative synthesis of the existing literature on VH and cognitive biases related to HPV, which served as the foundation for survey development. We designed 3 surveys implemented in Qualtrics®, one for each study phase (T1, T2, and T3). For T1, the survey consisted of 6 sections with an estimated completion time of 10–15 min.

1) **Vaccination status and opinion**: A 10-item section assessing respondents' parents' attitudes toward HPV vaccination, their own HPV vaccination status, compliance with mandatory vaccinations (e.g., measles, mumps, rubella), willingness to receive the HPV vaccine, and whether they would recommend HPV vaccination to a friend.
2) **Youth Attitude to Vaccination (YAV)**: 6 items measuring VH among young individuals, regardless of gender, using an adapted version of **YAV-5** [35].
3) **HPV knowledge**: 23 items adapted from Marlow et al., 14 testing knowledge about the virus, 2 testing knowledge about the diagnostic tools, and 7 testing knowledge about the vaccine [36].
4) **Biases and heuristics**: 23 items assessing three categories of cognitive biases, based on insights from Howell, Pomares and Berthet:
   - 7 items on Present Bias (Pomares et al., 2020) [22].
   - 8 coupled items on Gain-Loss Framing (Berthet et al., 2023) [37].
   - 8 items on IA (Howell et al., 2016) [38].
5) **Sexual behaviors**: 6 items exploring aspects of adolescent sexual behaviors and the familiarity and willingness to contact a reproductive center for advice related to sexual topics.
6) **Socio-demographics**: 4 items on age, gender, sex, family socio-economic status.

The single blocks of the fourth section were randomized to avoid order effects through specific tasks. For the T2 and T3 survey administrations, the sections on biases and heuristics, family socio-economic status and sexual behaviors were removed. At T2, the survey included a knowledge question testing students' compliance to the instructions to follow the Instagram page ("Which Instagram page did you visit during the project?" by clicking the logo of the corresponding account).

2.6. Intervention design

The two Instagram pages used for the intervention had an identical structure, each consisting of nine posts with equivalent format. All posts were available from the beginning of the intervention period, while Instagram stories were used to promote periodic engagement among students, with a frequency of two per week.

The two experimental interventions differed in both message content and underlying communication strategy employed in the Instagram pages and derived from the co-creation ideas.

The information arm delivered factual, visually appealing content about HPV, its modes of transmission, and vaccine efficacy. Posts included infographics on HPV prevalence, carousel explanations of the two-dose vaccination schedule, and neutral messages emphasizing the safety and benefits of immunization. The communication tone was informative and evidence-based, aiming to increase awareness and knowledge through straightforward, health-promoting messages.

In contrast, the bias-reduction arm was designed to activate reflection on psychological mechanisms that may underlie VH. Contents in this condition maintained a similar visual format but adopted a more self-referential and motivational tone, explicitly addressing cognitive tendencies such as IA and present bias or using specific content frame. The messages acknowledged these tendencies and encouraged students

to overcome them through information and a sense of empowerment linked to greater health awareness. Other contents highlighted the advantages of receiving the vaccine "on time," emphasizing that vaccination is offered free of charge within their age group.

These elements were incorporated as debiasing strategies aimed at reducing defensive emotional reactions and clarifying the temporal benefits of vaccination. Messages were designed to counteract mechanisms related to present bias and IA, while framing epidemiological information in ways intended to balance potential loss aversion associated with HPV risk. For example, gain–loss reframing messages highlighted collective responsibility (*"By getting vaccinated, you protect not only yourself but the people you care about—skipping the shot increases everyone's risk"*), while *present-bias* prompts encouraged timely action, for example by highlighting that getting vaccinated now, while the vaccine is freely available, prevents future risks and missed opportunities. To counter IA, other posts invited students to face uncertainty directly (*"Don't be afraid of the dark—being informed helps you take control of your health"*), emphasizing that knowledge reduces fear and builds autonomy.

The control group was exposed to content from the official Instagram page of the Italian National Institute of Health, which reported different health related topics and was not specifically designed to address or elicit any particular bias.

2.7. In-class intervention

The in-class intervention consisted of a brief, structured educational session on HPV and HPV vaccination, delivered by trained facilitators during regular school hours. The session, lasting approximately two hours, provided factual information about HPV transmission, related diseases, and the benefits and safety of vaccination.

2.8. Analyses

2.8.1. Data matching and scoring algorithm

To ensure anonymity, respondents provided a code based on their birthdate, the first two initials of their father's name, and the last two digits of their phone number. To mitigate the occurrence of low numbers of exact matches resulting from errors between T1 and T2, a scoring system was developed to evaluate the coding similarity. The algorithm followed four phases. First, codes were split into three components. Exact matches were assigned a score of 4. When an exact match was unavailable, alternative combinations were considered: (1) Birthdate & Father's Name (3 points, or 2.5 if the phone number was missing), (2) Father's Name & Phone Number (3 points, or 2.5 if the birthdate was missing), and (3) Birthdate & Phone Number (2.5 points). Additional 0.5 points were awarded for each match on gender and province. The final match was determined by selecting the highest-scoring pair for each record, ensuring consistent linkage between datasets. Matches with a score lower than 3 were excluded from the analysis.

2.8.2. Vaccine hesitancy scale adaptation

We based our adaptation on the Youth Attitudes about Vaccines (YAV-5) scale validated by Olarewaju et al. [35], which provides a youth-oriented framework derived from the Parent Attitudes about Childhood Vaccines short form. In our study, we use an Italian adaptation from Kiener et al. [39], and we included an additional item capturing concerns about vaccine necessity and over-vaccination perception, consistent with recommendations to contextualize attitudinal measures for male and female adolescent populations. The resulting six-item version maintained conceptual coherence with the original YAV-5 and showed acceptable psychometric properties (Cronbach's $\alpha\,\alpha = 0.611$; McDonald's $\omega = 0.623$) with a single-factor structure.

2.8.3. Cognitive biases and treatment effect

Before proceeding to test the effects of the treatments, we examined whether the biases measured in the first survey (IA, gain-loss framing, and present bias) were significant predictors of attitudinal and behavioral outcomes related to HPV. We specified four statistical models including the standardized scores of the three biases and gender, which we included because of the gender perspective on the issue. The raw scoring of the Cognitive Bias measures are described in the Supplementary Materials.

To estimate the effect of the promotional accounts we used a difference-in-differences (DID) approach, i.e. comparing changes in the key variables between the treatment and control groups. Pairwise contrasts were computed using estimated marginal means (Lenth, 2023) [40] to compare the change from T1 to T2 across groups. Contrasts compared the joint effect of treatments to the control, and the effect of the two treatments. For continuous variables, such as knowledge scores, we employ a linear mixed-effects model, whereas, for responses on Likert scales, we employ an ordinal mixed-effects model (Model 1). All models include student ID as a random intercept. Tests were conducted using the canonical 5% significance level. Contrasts comparing individual treatments with control are corrected for multiple comparisons using Dunnett's method (Dunnett, 1955) [41]. Main analyses were preregistered at osf.io/gdba4.

Then, we conducted a series of exploratory models to test the effect of several covariates, including demographics like school type (lyceum, technical institute), age, and gender (Model 2), if students correctly identified the social media page that was displayed at the end of T1 (Model 3), and IA (Model 4). IA (Cronbach's $\alpha = 0.815$; standardized score between 0 and 1) was included because it predicted several outcome variables at T1.

Finally, we tested the differences between T1 and T3 for VH, Knowledge score and the propensity of students to contact a sexual and reproductive services for issues matching the subject who responded to the survey in both the phases. Differences were computed at the sample level, since the number of students in this phase ($N = 127$) were too small to allow treatment comparisons.

Analyses were conducted in R (R Core Team, 2022) [42].

2.9. Ethical approval

The RCT received approval from the Pediatric Ethics Committee of Meyer IRCCS Hospital, Florence, Italy (practice number: CET_15/2023, September 12, 2023). For minor participants, parental consent was obtained after parents were informed about the study. Additionally, students willing to participate were required to provide their consent before starting the survey by selecting either "yes" or "no". If a student selected "no", the survey automatically terminated, excluding the participant from the study. Data was collected anonymously through coded identifiers; no personal or social media account information was recorded, and all datasets were stored on secure university servers. Participation was permitted only when both parental consent and individual assent were obtained.

3. Results

From the sample of students matched between the T1 and T2 phases ($N = 334$), 33 students were dropped because their responses on one of the two surveys were evaluated unreliable due to fast/slow response times (faster than ¼ of the median completion time or slower than 4 times the median completion time) or because the responses were implausibly regular (> 90% of responses on the same rating across scales, even for reverse-scored items). This resulted in a sample size of $N = 301$ students, although for some analyses, the sample size was smaller to exclude cases that did not fit the analysis (e.g., students who had already been vaccinated for vaccination intention) or that reported impossible behaviors (e.g., reporting vaccination and then not reporting it in the second survey for vaccination status analyses). For the sample at T3 (number of respondents: 127), we conducted the same matching with

responses at T1, which resulted in a sample size of $N = 51$.

Table 1 shows the demographics and responses to the bias inventories of the matched sample at T2, disaggregated by treatment.

3.1. Information avoidance predicts all the main HPV outcome variables before treatment

A linear regression examined the effect of treatments at T1 on standardized knowledge scores. Higher IA scores significantly predicted lower knowledge scores, $\beta = -0.299$, SE = 0.062, $t = -4.78$, $p < .001$. Gender, gain-loss framing bias, and present bias were all non-significant (all ps >0.174).

Three ordinal logistic regressions analyzed intention-related outcomes. For vaccination intention, higher IA predicted lower odds of vaccine intention ($\beta = -7.80$, SE = 1.28, Z = −6.09, $p < .001$), while higher susceptibility to gain-loss framing bias predicted higher intention, ($\beta = 0.33$, SE = 0.15, Z = 2.22, $p = .026$). For vaccine advice to friends, higher IA predicted a greater likelihood to recommend vaccination ($\beta = -5.57$, SE = 0.79, Z = −7.06, p < .001). No other predictors (including gender) reached significance. For the intention to contact sexual and reproductive health service for advice on sexuality, males showed lower willingness than females ($\beta = -0.94$, SE = 0.28, Z = −3.31, $p = .001$), while higher IA predicted lower likelihood of seeking advice ($\beta = -3.20$, SE = 0.74, Z = −4.32, $p < .001$). Gain-loss framing effects and time spent viewing content remained non-significant.

3.2. The treatments reduced vaccine hesitancy among information seekers but increased it among information avoiders

To test the impact of the Instagram pages on VH (model 1), we examined the changes in this variable across groups. The pre-registered analyses indicated no significant differences in the change over time between the treatments and control ($\beta = 0.000$, 95% CI [−0.026, 0.027], t(299) = 0.031, $p = .976$). The same result appeared even when looking at treatments separately (informative communication: $\beta = 0.003$, 95% CI [−0.032, 0.038], t(298) = 0.222, $p = .954$; de-biasing: $\beta = -0.002$, 95% CI [−0.037, 0.032], t(298) = −0.157, $p = .974$).

The subsequent exploratory models to test the effect of covariates showed no significant results for demographics (Model 2, gender, age, and school type; all ps > 0.054), and for students with a correct or incorrect recollection (Model 3; all ps > 0.113). Model 4, however, revealed a significant three-way interaction between IA, pooled treatments, and time ($\beta = 0.225$, SE = 0.077, t(297) = 2.904, $p = .004$). We thus estimated the marginal means effects for different levels of IA: very low (10th percentile: 0.03), low (1st quartile: 0.09), medium (median: 0.22), high (3rd quartile: 0.375), and very high (90th percentile: 0.50). Fig. 2 illustrates the interaction between information avoidance and treatment effect. These results show that, as IA decreases, treatments effectively reduce VH by several percentage points (10th percentile: −4.9%); at the same time, however, as IA increases, exposure to the Instagram pages effectively increases VH (90th percentile: +5.6%). When looking at the effect of the individual treatments, these differences can still be observed in the traditional information group, but not in the debiasing group, suggesting that the effect is driven mainly by the former treatment.

As an additional exploratory analysis, we tested whether the interaction between treatment and IA could be replicated for another variable related to information seeking, namely the propensity of students to contact a sexual and reproductive services for issues related to sexuality. Similarly, to VH, we found no main effect for treatments, pooled or individually (all ps > 0.213), nor any effect of demographics (including gender) or recollection of the Instagram page (all ps > 0.054). IA again revealed a three-way interaction ($\theta = -4.852$, SE = 2.171, z = −2.234, $p = .025$, Fig. 3). Consistent with the findings for VH, lower levels of IA were associated with a greater propensity to seek sexual and reproductive health services. In contrast, high levels of IA did not significantly predict a decrease in the uptake of counselling services across treatments. Contrasts across individual treatments again suggest that this effect is primarily driven by the traditional information treatment.

Table 1
Descriptive statistics by treatment group. Mean (SD); frequencies are in percentages.

Treatment $N = 301$	Control $N = 102$	Informative $N = 95$	De-biasing $N = 104$
Gender			
Female	65%	80%	77%
Male	31%	17%	22%
Other	3.9%	3.2%	1%
Age	15.30 (1.26)	15.34 (1.46)	14.85 (1.24)
Information avoidance	0.26 (0.17)	0.23 (0.18)	0.21 (0.17)
Gain-loss framing ($N = 297$)	0.57 (1.22)	0.19 (1.36)	0.36 (1.07)
Present bias	1.03 (1.92)	0.94 (1.66)	1.09 (1.75)
Vaccine status			
Yes	52%	56%	60%
No/don't know	48%	44%	40%
Sexual experiences			
No experience	75%	58%	65%
Non-penetrative sex	7.8%	21%	15%
Penetrative sex	18%	21%	19%
Vaccination intention ($N = 138$)	**Control** $N = 49$	**Informative** $N = 45$	**De-biasing** $N = 44$
Certainly not	0%	2.2%	2.3%
Probably not	0%	8.9%	14%
Don't know	35%	42%	30%
Probably yes	37%	33%	41%
Certainly yes	29%	13%	14%

Following the other pre-registered hypotheses, we tested whether, relative to control, our treatments increased students' ability to respond to a knowledge test related to HPV and sexual education, their vaccination intentions, the likelihood of recommending the vaccination to a friend, and whether the participants suggested their unvaccinated students to get vaccinated.

Our results, however, revealed no significant influence of our treatments relative to control. First, of the entire sample, only one student in the traditional treatment reported booking a vaccination between the first and second surveys. For Hypothesis 2, knowledge about HPV and vaccination did not differ between treatments and control (pooled: $\beta = -0.004$, 95% CI [−0.04, 0.03], t(299) = −0.242, $p = .809$; traditional: $\beta = 0.003$, 95% CI [−0.04, 0.05], t(298) = 0.158, $p = .974$; de-biasing: $\beta = -0.01$, 95% CI [−0.06, 0.04], t(298) = −0.551, $p = .792$). The only significant increase observed was in the traditional treatment for the HPV vaccination subscale ($\beta = 0.064$, 95% CI [−0.009, 0.119], t(298) = 2.277, $p = .047$). All other contrasts for the remaining subscales and treatments were non-significant (all $p > .151$). Similarly, Hypothesis 3 showed no increase in vaccine recommendation likelihood (pooled: $\theta = -0.09$, 95% CI [−0.81, 0.62], z = −0.260, $p = .795$; traditional: $\theta = -0.50$, 95% CI [−1.45, 0.45], z = −1.176, $p = .398$; de-biasing: $\theta = 0.28$, 95% CI [−0.64, 1.21], z = 0.680, $p = .712$).

Exploratory analyses indicated non-significant effects for vaccination intention (pooled: $\theta = -0.91$, 95% CI [−2.08, 0.26], z = −1.521, $p = .128$; traditional: $\theta = -1.43$, 95% CI [−2.99, 0.13], z = −2.031, $p = .079$; de-biasing: $\theta = -0.44$, 95% CI [−1.96, 1.07], z = −0.650, $p = .731$) and parent communication (pooled: $\theta = 0.22$, 95% CI [−0.31,

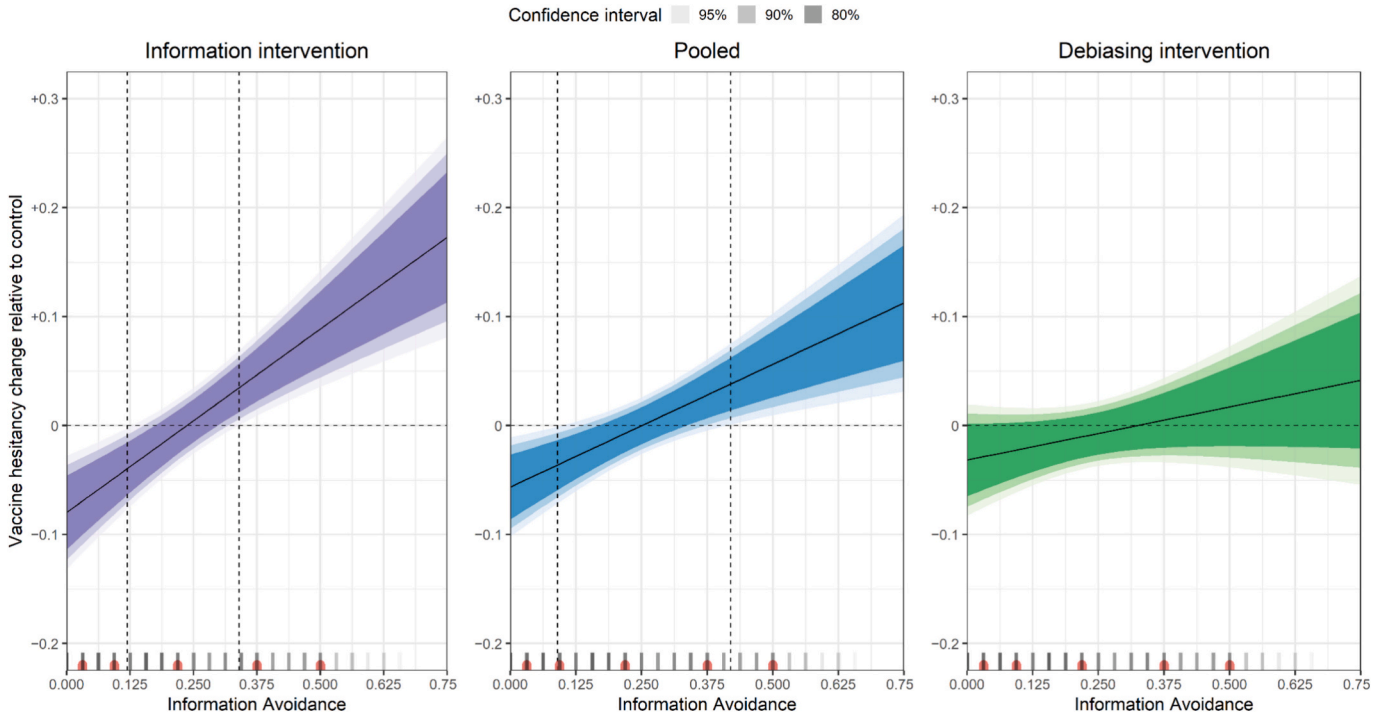

Fig. 2. The impact of information avoidance on positive treatment effects: reduced vaccine hesitancy. These Johnson–Neyman plots show that a successful reduction in vaccine hesitancy (relative to control) only occurs at low levels of information avoidance. In contrast, high levels of information avoidance are associated with a negative treatment effect (an increase in hesitancy compared to the control group). Vertical dashed lines separate the values where the treatment effect is significant from the non-significant ones. The rag plot at the bottom shows the distribution of information avoidance values. The relevant quantiles are coloured red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

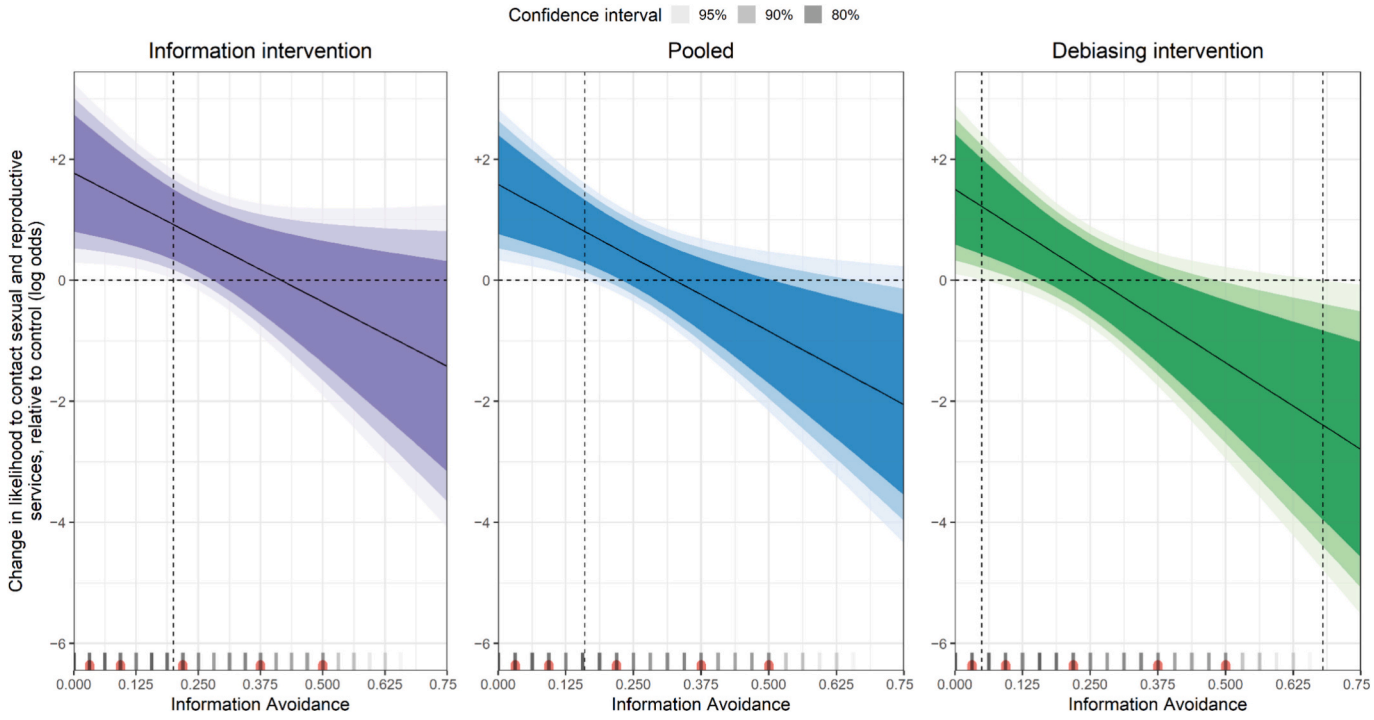

Fig. 3. The impact of information avoidance on positive treatment effects: the propensity to seek health counselling. These Johnson-Neyman plots show that treatment increases the likelihood of seeking counselling only at low levels of information avoidance. Vertical dashed lines separate the values where the treatment effect is significant from the non-significant ones. The rag plot at the bottom shows the distribution of information avoidance values. The relevant quantiles are coloured red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

0.76], z = 0.822, $p = .411$; traditional: $\theta = 1.08$, 95% CI [−0.58, 2.04], z = 0.236, $p = .949$; de-biasing: $\theta = 1.44$, 95% CI [−0.72, 2.87], z = 1.162, $p = .406$). We additionally tested whether covariates such as demographics, recollection of the Instagram page, and IA interact with

our treatment effects. All results turned out to be non-significant (all ps > 0.062).

3.4. In-class intervention

To assess the effect of the classroom lecture, we compared all treatment groups pooled together across timepoints before and after the in-class session. Specifically, we analyzed data from students who completed both the baseline (T1) and post-intervention (T3) surveys and were confirmed to be present during the in-class intervention (T2), which consisted of the educational lecture.

The final matched sample included 51 participants (17% from T1) (of whom 42 were female). Despite the small sample, results revealed a significant increase in knowledge scores following the lecture intervention $\beta = 0.158$, 95% CI [0.101, 0.214], t(49) = 5.600, $p < .001$). Subscale analysis showed that this improvement was primarily driven by questions on the HPV virus ($\beta = 0.201$, t(50) = 6.249, p < .001) and the vaccine ($\beta = 0.123$, t(50) = 3.763, p < .001), rather than the diagnostic tests ($\beta = 0.069$, t(50) = 1.224, $p = .227$). These results, however exploratory due to high attrition, suggest classroom lectures may be effective, but larger samples are needed for confirmation.

3.5. Attrition does not affect results

As around 30% of responses could not be matched between T1 and T2, and the number of classes involved in T3 was small, we repeated the main analyses using inverse-probability weighting (IPW). For T2 analyses, we first compared matched and unmatched participants to check for potential differences. Matched participants were more likely to be female (76% versus 61%, $\chi^2(1) = 10.56$, $p = .001$), slightly less information avoidant (0.24 vs. 0.28, $t(350) = 2.197$, $p = .029$), more knowledgeable regarding HPV vaccination (29% correct vs. 25%, $t(379) = 2.610$, $p = .009$), more willing to vaccinate ($t = 3.102$, $p = .002$), and more inclined to recommend vaccination ($t(97) = 2.672$, $p = .008$) at T1. Despite these differences, however, repeating the analyses using IPW does not reveal any significant differences compared to the preregistered analyses (all $p > .251$). For T3 analyses, T3 respondents are slightly younger (14.8 vs. 15.3, $t(82) = 3.473$, $p < .001$) and more female (83% vs. 69% $\chi^2(1) = 4.183$, $p = .041$) than the rest of the sample. However, IPW weights again do not reveal significant differences compared to the original analyses: there is still a significant increase in knowledge compared to T1 ($t(98) = 3.457$, $p = .001$).

3.6. Engagement with the intervention

While individual-level interaction with the Instagram pages was not directly assessed, engagement can be inferred from aggregate page metrics. Each experimental account attracted over 40 followers within its assigned group, with individual posts receiving approximately 10–40 likes. Despite these numbers, story visualizations achieve higher metrics with an average number of 40–50 viewers on both pages, equivalent to approximately half of the participants in each intervention.

4. Discussion

The availability of free HPV vaccination in Italy constitutes a key public health resource for cancer prevention among younger generations, particularly when administered early, before the onset of sexual activity. However, despite this opportunity, vaccination uptake among adolescents remains below the target set by the Italian National Vaccination Plan (PNPV) [11]. The Plan provides HPV vaccination for all females up to the age of 25, with no age limit for men who have sex with men and other specified groups, including individuals living with HIV. Regional authorities may further expand this offer; for instance, in Tuscany, females are eligible to receive the HPV vaccine free of charge up to the age of 30. After turning 18, adolescents may independently decide to be vaccinated without parental consent, which enhances the potential for informed decision-making.

Nevertheless, the Italian context presents distinctive challenges for HPV vaccination uptake. Since the vaccine's introduction, its initial restriction to females, the strong parental role in adolescent health decisions, and cultural concerns associating vaccination with early sexual activity have shaped public perceptions. The initial presentation of HPV vaccination as a means of primarily preventing cervical cancer has also contributed to the so-called 'feminization' of HPV prevention, whereby HPV-related communication has traditionally been directed at girls more than boys [43]. This historical framing may result in adolescents having different levels of familiarity with HPV-related information and vaccination messages, with girls potentially being more exposed to these messages than boys. Furthermore, the absence of a national school-based delivery system and regional variability in health service organization contribute to unequal access and engagement [44]. These structural and cultural barriers may partly explain why vaccination coverage remains suboptimal despite free availability, and why social media–based interventions face additional obstacles compared with countries adopting centralized or school-based approaches (e.g., Northern Europe, Australia).

This discrepancy between the free offer and suboptimal coverage rates highlights the need for more innovative and tailored communication strategies, including the use of social media platforms. At the same time, it is essential to investigate how psychological factors, such as IA, intended as a stable tendency to avoid learning information [38], and other cognitive biases, may act as barriers to vaccination, both in general and specifically in the context of digital communication campaigns. Since vaccination choices are often guided more by intuitive thinking than deliberate reasoning, addressing these psychological mechanisms is crucial to increasing vaccine coverage [18].

Yet, few Italian studies have investigated HPV VH among adolescents, reflecting a broader lack of robust national evidence on this topic. Overall, the available observational evidence shows that adolescents often display limited knowledge and awareness regarding HPV vaccination, as well as regional differences in vaccine access and uptake, highlighting the need for targeted educational and communication interventions to strengthen vaccine confidence in this age group [16,45].

In this context, our study implemented and evaluated a social media intervention in high school settings using a dedicated Instagram account to communicate about HPV vaccination. The goal was to improve both knowledge and vaccination intention among adolescents, while observing how different communication strategies might influence psychological attitudes such as VH and health-avoidance behavior. The intervention was structured as a balanced RCT, allowing us to examine the effect of two messaging strategies: a purely informational approach and one explicitly addressing cognitive biases. Notably, the contents were co-designed with adolescents themselves to ensure that the tone was approachable, relatable, and consistent with peer communication. This represents one of the first attempts to explicitly integrate debiasing techniques within a social media-based health campaign for adolescents [46]. A key innovation of this RCT is the use of Instagram as an intervention platform. Adolescents primarily seek health information on Instagram, TikTok, and Snapchat, while parents rely on Facebook and X (Twitter) [47]. Remarkably, HPV-related discourse varies by platform: Instagram hosts more pro-vaccine (55.8%) than anti-vaccine (42.2%) posts, yet anti-vaccine content receives greater engagement [48].

Although in our study exposure to the Instagram content did not significantly improve participants' factual knowledge or perceived vaccine intention at the aggregate level, our results revealed important insights into the psychological dynamics influencing communication effectiveness. Most notably, we found that the intervention's impact varied depending on students' tendency to avoid health-related information. This finding is consistent with a growing body of evidence that factual messages often fail to persuade individuals with entrenched skepticism or distorted or approximate knowledge of vaccine risks [49].

This divergence illustrates a well-known phenomenon described by theories of motivated reasoning and confirmation bias whereby individuals who distrust or avoid health messages may respond defensively when confronted with them [39]. In such cases, rather than encouraging critical reflection, health communication may prompt counter-argumentation or psychological disengagement – a phenomenon known as the backfire effect in psychology. In our study this pattern was particularly evident among students exposed to the informational treatment, which was more likely to polarize responses based on prior predisposition. Notably, IA in our study refers to a trait-level stable tendency to avoid health information, whereas the observed backfire effect among high-IA individuals manifests as situational message resistance (e.g., defensive counter-arguing triggered by corrective information), consistent with motivated reasoning theories.

Another RCT with web channels by Wang et al. [23] found that HPV IA increases with low information literacy, recommending interactive narratives to enhance engagement. While the mere consumption of the content (posts and stories) in our intervention indicates an adequate level of message fruition among participants, the passive exposure to contents in our study may explain the impact of avoidance tendencies in participants' attitude toward vaccination. This suggests also that informative interventions, even when presented in an ecological environment such as social media, may not be equally effective for all subgroups. Hong and Kim [50] findings align with the evidence that IA in the HPV vaccination context is shaped by perceived uncertainty and affective reactions. Negative emotions and low perceived control can trigger avoidance, particularly when vaccine risks are seen as ambiguous, a pattern consistent with our results on defensive responses to factual information on social media. However, their study did not target adolescents but an older sample of young female participants.

Interestingly, our findings also indicated that the moderating effect of IA extended beyond vaccine attitudes. A similar pattern emerged for students' willingness to seek advice from sexual and reproductive health services: receptiveness to vaccine-related content significantly predicted an increase in help-seeking intention after the interventions, particularly in the informative intervention. In this sense, IA seems motivated more from a global emotional reaction triggered by health-related topics or risk uncertainty than from mistrust in health institutions or overconfidence in perceived knowledge by the young participants.

Importantly, the debiasing treatment, designed to counteract cognitive distortions common in vaccine discourse, did not show stronger effects than the more traditional information-based approach. Contrary to our pre-registered hypothesis, the bias-correcting content did not significantly alter knowledge, intent, or attitudes either independently or through interaction with psychological covariates. Previous qualitative observations may explain it, as simpler, fact-based messages consistently attracted more attention than abstract or cognitively framed ones [51,52].

Moreover, the context in which the intervention was delivered likely influenced how the messages were received. Because the Instagram pages were presented as part of a school project, some students may have interpreted the initiative as an extension of classroom instruction [53]. This framing could have reduced perceived spontaneity and personal relevance potentially explaining the lack of knowledge gained at the post-exposure stage (T2). Although the sample size was small and potentially affected by selection bias, the more interactive in-class sessions significantly improved knowledge, reinforcing the importance of traditional and participatory education in consolidating learning.

Despite these limitations, the intervention had several positive implications. First, it confirmed the feasibility of co-designed social media content to engage adolescents on complex health topics such as vaccination. Second, it showed that even brief digital exposures can influence attitudes among receptive individuals. Third, the study shed light on the structural psychological barriers, such as IA, that must be addressed to improve the reach and effectiveness of health campaigns targeting youth.

The stronger effect of the purely informational page also suggests that simplicity and directness may be more effective than content perceived as overly persuasive or analytical. A recent European study [54] found that 20% of adolescents are vaccine-hesitant, primarily due to fear of side effects, a concern closely linked to IA. This further reinforces our conclusion that addressing avoidance tendencies is key to promoting vaccination in this population. Similarly, Kreps et al. [55] highlighted that VH, across HPV and other vaccines, is often reinforced by deliberate IA driven by overload or cognitive dissonance. This pattern aligns also with the framework proposed by Foust and Taber [24], who describe IA as an intentional, affect-driven strategy to manage potentially threatening information, in particular in a crowded digital environment like the one in social media. In this light, students with higher avoidance tendencies may have disengaged from HPV-related content to regulate negative emotions or preserve cognitive consistency, which could explain the reduced effectiveness of factual messages within this subgroup.

Taken together, our findings suggest that social media interventions, while promising, are filtered through pre-existing attitudes and cognitive bias. Their effectiveness depends not only on message design but also on how adolescents perceive the platform, the messenger, and the intent of the communication. Although our intervention strategy incorporated both posts and stories, the relatively limited engagement observed among participants may be attributable to the need for a greater volume of interactive contents, more frequent updates on the pages, and the provision of timely and appropriate feedback to followers.

Passive exposure through digital accounts, particularly when embedded in institutional settings, may not be sufficient to have an impact on behaviors or beliefs [53]. Instead, a more effective strategy may involve combining simple, peer-relevant content with interactive formats and clear calls to action. Personalization and perceived authenticity should be central to future campaigns [56,57].

This perspective is particularly relevant when considering the broader age range for which HPV vaccination is offered free of charge in Italy. Our findings suggest two distinct yet complementary directions for future intervention. First, there is a clear opportunity to develop social media content for adolescents and young adults beyond the age of compulsory schooling, and especially those without a strong IA. Second, sexual health promotion should be embedded into standard educational offerings in school settings. Combining these approaches could help bridge the gap between digital engagement and lasting behavioral change.

This study has some limitations. Students' interaction with the Instagram content could not be tracked, making it impossible to measure engagement levels. The Instagram pages used in this study were designed to be static, ensuring that all participants received identical content. However, usually, social media pages include more dynamic elements, such as Instagram quiz. These differences in design may have limited the intervention's engagement potential [24]. Moreover, the T3 survey was completed by a small number of students limiting conclusions about long-term effects and generalizability. Further studies should compare the effectiveness of digital versus in-person interventions using larger and more diverse samples.

In sum, although the intervention did not lead to broad changes in knowledge or intentions, it provided meaningful insights into the conditions under which adolescent VH can be reduced. It also underscored the critical role of psychological processes in moderating the success of health communication and pointed to new directions for refining digital strategies targeting youth. Future efforts should complement content delivery with approaches that reduce avoidance and foster active engagement, particularly among those most resistant to conventional health messaging.

5. Conclusion

This study highlights the complexity of using social media to address HPV VH among adolescents. While the intervention had a small effect on knowledge or attitudes, it revealed a crucial moderating role of IA in shaping VH. For students open to information, the campaign reduced hesitancy and encouraged health-seeking behavior; however, for those prone to avoiding health messages, the same content reinforced resistance. These findings suggest that one-size-fits-all communication may backfire. Future strategies should move beyond static information, focusing instead on personalized, engaging content that overcomes psychological barriers and speaks authentically to youth.

CRediT authorship contribution statement

D. Menicagli: Writing – original draft, Project administration, Methodology, Investigation, Conceptualization. **V. Casigliani:** Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **F. Panizza:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation. **S. Gandolfi:** Writing – original draft, Methodology, Investigation. **E. Betti:** Writing – original draft, Methodology, Investigation. **D. Petrone:** Writing – original draft, Software, Methodology. **M.G. Di Nino:** Investigation. **L. Bonaldo:** Investigation. **M. Torrisi:** Investigation. **E. Mammolenti:** Investigation. **L. Cecconi:** Methodology, Investigation. **E. Macri:** Methodology, Investigation. **L. Tavoschi:** Writing – review & editing, Supervision, Methodology. **G. Cevolani:** Writing – review & editing, Supervision, Methodology.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dario Menicagli reports article publishing charges was provided by MSD Italia S.r.l. The authors declare that they have no financial or personal relationships with any organizations or partners that could inappropriately influence (bias) the work reported in this paper. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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