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UNDERSTANDING THE IMPACT OF DIGITAL HEALTH LITERACY ON HUMAN PAPILLOMAVIRUS VACCINE UPTAKE: IMPLICATIONS FOR PUBLIC HEALTH STRATEGIES

Immunology

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ABSTRACT

Background: Human papillomavirus (HPV) is a common sexually transmitted infection linked to several cancers, including cervical, anal, and oropharyngeal cancers. Despite the availability of effective vaccines, global uptake remains inconsistent due to barriers such as misinformation, limited access, and sociocultural hesitancy. In the digital age, individuals increasingly rely on online platforms for health information, making digital health literacy (DHL) a pivotal factor in shaping vaccine awareness, attitudes, and decisions. This review explores the impact of DHL on HPV vaccination by analyzing how various digital interventions-ranging from SMS and web-based tools to social media-affect vaccine intention and uptake. The effectiveness of these tools depends heavily on content design, emotional framing, delivery mode, and user engagement. Social media exerts significant influence, where emotionally charged peer narratives can either encourage or discourage vaccination. Sociodemographic factors such as education, political beliefs, and prior digital behavior further affect how information is processed and acted upon. While digital platforms hold great promise in promoting vaccine confidence, their success requires high levels of DHL and careful attention to content format and source credibility. **Conclusion:** Digital health literacy plays a decisive role in mediating online health behaviors. Enhancing DHL is essential to combat vaccine hesitancy, improve informed decision-making, and support equitable HPV vaccine uptake globally.

KEYWORDS

Human papillomavirus, digital health literacy, vaccine uptake, social media

INTRODUCTION

Human papillomavirus (HPV) is one of the most prevalent sexually transmitted infections globally and a well-established cause of various malignancies, particularly cervical cancer. [1] Although effective vaccines are available, global immunization efforts remain suboptimal-especially in low- and middle-income countries (LMICs)-with persistent disparities in vaccine uptake across regions.[2] Robust evidence supports the vaccine's efficacy in significantly reducing cervical cancer incidence, prompting public health bodies to reconsider traditional, female-only immunization strategies. [3,4]

In recognition of broader HPV transmission dynamics and the need for inclusive protection, the World Health Organization (WHO) revised its guidelines in 2017 to recommend HPV vaccination for males and older females under certain conditions.[5] Nevertheless, challenges in implementation persist, exacerbated by inconsistent data reporting and competing health priorities in many settings.[6]

Amid these obstacles, digital platforms have gained prominence as influential tools in public health communication. With the growing ubiquity of internet access and mobile technology, digital environments present novel opportunities to disseminate accurate vaccine-related information, counter misinformation, and engage vaccine-hesitant populations.[7] Research indicates that well-designed digital interventions can positively influence knowledge, attitudes, and behavioral intentions related to HPV vaccination.[8]

Digital health literacy-the ability to access, comprehend, and apply health information via digital technologies-has emerged as a crucial determinant of how effectively individuals navigate vaccine-related content. The impact of digital interventions is shaped not only by accessibility but also by user engagement, content interactivity, emotional framing, and the demographic and cultural characteristics of target populations.[9]

This article aims to critically evaluate the influence of digital health literacy on HPV vaccine uptake. It explores how digital interventions function across diverse settings and examines their potential to improve vaccination rates by enhancing informed decision-making.

HPV Vaccine Awareness and Sociodemographic Influences

HPV remains one of the most common infections, with approximately 14 million new cases annually.[10] The virus contributes significantly to the global cancer burden and is linked to a variety of diseases, including genital warts and several cancers such as cervical, anal, penile, and oropharyngeal cancers. The introduction of HPV vaccines—Gardasil, Gardasil 9, and Cervarix—has been pivotal in preventive healthcare since their approval in 2006 for both males and females.[11,12] These vaccines are now recommended up to the age of 45, thereby expanding their protective benefits.[12] Despite their availability, vaccine uptake worldwide remains inadequate due to a range of barriers including financial constraints, misconceptions about safety, limited healthcare access, and sociocultural resistance.[13]

A study by Lama et al. found that compared to non-users, individuals who engaged in one, two, three, or four social media behaviors had progressively higher levels of HPV vaccine awareness, as shown in Figure 1. Specifically, 41.9% engaged in one social media behavior, 26.9% in two, 11.5% in three, and 5.2% in four, while 14.5% did not engage at all. This pattern demonstrates that increased social media use was associated with greater HPV vaccine awareness overall. However, significant socio-demographic gaps persist, as men, African American, Hispanic, and Asian American respondents were notably less likely to be aware of HPV or the HPV vaccine. Moreover, while social media exposure boosted general awareness, it did not increase knowledge about HPV-related cancers, underlining the need for accurate, targeted messaging to address these disparities.[14]

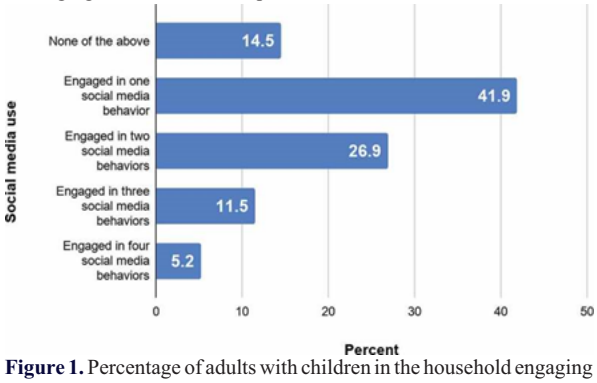


Figure 1. Percentage of adults with children in the household engaging in zero to four social media behaviors, showing the association with HPV vaccine awareness.[14]

Gaps Among Health Students And Professionals

Within health-related academic and professional groups, critical knowledge gaps persist. Many health science students remain unaware of the association between HPV and non-cervical malignancies, such as head and neck cancers.[15] Similarly, a substantial number of healthcare professionals lack adequate knowledge of HPV and its vaccine, pointing to systemic deficiencies in professional education and training.[16] These findings underscore the need for targeted

educational strategies that enhance understanding among both trainees and practicing providers.

Regional Disparities In Health Literacy

Health literacy (HL)—the capacity to access, understand, and utilize health information—is a core determinant of health behaviors, including vaccine uptake.[18] Lower HL levels correlate with decreased participation in cancer-preventive measures such as HPV vaccination.[18,19] However, HL levels vary significantly across populations and regions. In some settings, over half of university students display adequate or excellent HL, while in others, such as among Turkish women aged 30 and above, only 19.7% meet adequate HL criteria.[20] By contrast, the European Health Literacy Survey reported a 52.5% adequate HL rate.[21] These discrepancies reflect the broader social, educational, and systemic factors shaping HL across demographics.

Digital Health Literacy And Online Health Information Seeking

Digital health literacy (DHL) is increasingly vital in the modern health information landscape. Individuals with high DHL are better equipped to critically assess digital content, make informed decisions, and engage in preventive health behaviors, including HPV screening and vaccination. Conversely, inadequate DHL contributes to the spread of misinformation, vaccine hesitancy, and avoidance of preventive care.[19,22]

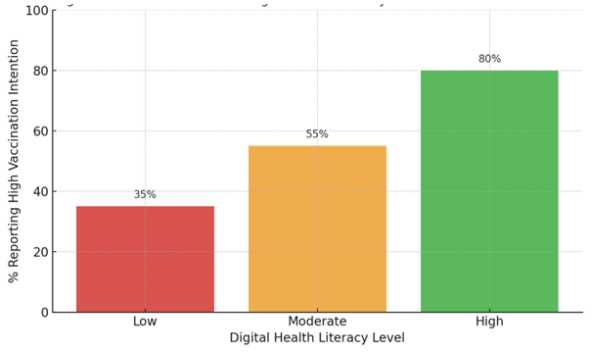
Young adults today frequently rely on the internet and social media as their primary sources of sexual health information.[23,24] Although these platforms provide easily accessible content, they also present misinformation and conflicting messages. Few students report obtaining such information from their parents, indicating gaps in family-based education. This reliance on digital platforms-both as a strength and a vulnerability-highlights the importance of DHL in shaping vaccination attitudes.

Interestingly, past use of the internet for health information correlates with a higher intention to vaccinate-especially among parents of daughters-but anticipated future use does not show the same effect, emphasizing the role of digital experience over mere access. [25]

Table 1 summarizes the variations in HPV awareness, general health literacy (HL), and digital health literacy (DHL) across different population groups. It highlights key differences in knowledge levels and digital engagement, emphasizing the need for targeted education and tailored digital interventions to improve HPV vaccine uptake Graph 1 illustrates the positive association between digital health literacy and HPV vaccination intention, emphasizing how improved digital skills may promote vaccine uptake among digitally active populations.

Table 1: HPV Awareness, Health Literacy, And Digital Health Literacy Across Different Groups [20]

Population Group	HPV Awareness	Health Literacy (HL)	Digital Health Literacy (DHL)	Key Notes
Health-related university students	Moderate to High	Moderate	Varies (higher in senior years)	Gaps in knowledge about non-cervical HPV cancers
Non-health university students	Low to Moderate	Low to Moderate	Moderate	Less formal exposure to HPV-related health education
Healthcare professionals	Variable	High	Variable	Limited continuous training on HPV and digital tools
Turkish women (age 30+)	Low	19.7% Adequate HL	Low	Sociocultural and systemic barriers impact literacy levels
European general population	Moderate	52.5% Adequate HL	Moderate to High	Varies by country and education level
Parents using internet for health info	High intention to vaccinate	Varies	High if past digital engagement	Prior online search predicts higher vaccination intention



Graph 1. Association Between Digital Health Literacy and HPV Vaccination Intention. [19,22,25]

Influence Of Message Format And Delivery Mode

The way health messages are designed and delivered is an important factor in the success of digital interventions. While text message reminders can help improve HPV vaccination rates, their effectiveness depends greatly on how often they are sent and what information they include. Messages that rely on highlighting serious health risks-such as stressing the threat of cancer or genital warts-do not consistently lead to higher willingness to get vaccinated.[26]

Video-based education, particularly in passive environments like clinic waiting rooms, appears more effective than interactive or stand-alone educational tools. These findings point to the importance of context and user engagement in the effectiveness of digital messaging strategies [27]

Web-Based Interventions: Tailored vs. Generic Content

Web-based platforms offer broad reach but require effective personalization to influence user behavior. Studies evaluating tailored digital content did not find significant advantages over generic psychosocial messages in promoting HPV vaccination. [28] In fact, the interaction between content type (e.g., narrative vs. data-driven) and its format (interactive vs. static) showed that mismatches can produce counterproductive effects on user intention. This highlights the need to align both content type and delivery style with user preferences to optimize impact.

The Dual Role of Social Media in Vaccine Decisions

Social media platforms exert significant influence on HPV vaccine-related perceptions and decisions. Group discussions on platforms like Facebook or WhatsApp have been shown to temporarily increase vaccination intention, though these effects tend to diminish over time. [29]

The nature of user comments also plays a crucial role. Emotional narrative comments-especially those expressing vaccine concerns-often have greater influence on parental decision-making than factual messages. These narratives can sometimes paradoxically increase vaccination intention while simultaneously intensifying concerns. [30] Positive messages on social media are associated with more favorable attitudes and stronger vaccination intention, whereas negative or mixed content can delay or discourage vaccination. [31,32]

A study by Llavona-Ortiz et al. confirmed that exposure to vaccine-related content-especially negative content encountered passively-strongly influences parental choices. Favorable content was often attributed to reputable medical organizations, whereas anti-vaccine narratives typically came from other parents, emphasizing the power of peer influence. [32]

Parents who actively engaged with content (e.g., liking, commenting, or sharing) were also more likely to support content moderation policies such as fact-checking. These findings stress the importance of visually engaging, emotionally resonant, and evidence-based communication in public health messaging. Liebermann et al. conducted a survey study that showed social media also plays a complex role in shaping HPV vaccine hesitancy among mothers of adolescents. Their national survey found that while Facebook use was linked with reduced vaccine hesitancy, uncertainty about the truthfulness of social media messages was associated with higher hesitancy. This underscores how the type of platform and trust in content can strongly influence parents' decisions about HPV

vaccination, further highlighting the need for clear, credible communication to counter misinformation online.[33]

Perceived Influence of Digital Media and Visual Content

Parents who perceived visual content—such as infographics and images—as most influential were more likely to express strong intent to vaccinate their children.[34] Although this association lacks statistical adjustment, it still underscores the role of media format preferences in shaping vaccine attitudes. The visual presentation of information can be a key driver in shaping user engagement and trust, further reinforcing the need to tailor digital interventions to audience preferences.

Interventions Using Digital Tools: Mixed Outcomes

Digital interventions using websites, mobile apps, text messaging, and social media platforms have been widely employed to influence HPV vaccination behavior. While over half of randomized trials report statistically significant improvements in vaccination intention through such interventions, others show no substantial impact. [9] These mixed outcomes suggest that digital access and literacy are necessary but not sufficient. Intervention success depends heavily on message design that resonates with users' motivations, values, and emotions.

Educational Interventions And Policy Recommendations

Research consistently shows that students in early years of university education possess lower levels of HPV-related knowledge compared to senior students. [35,36] This trend points to the need for structured HPV education early in academic curricula. Moreover, persistent cultural taboos surrounding sexual health further hinder awareness and vaccine acceptance.

To address these gaps, public health strategies should prioritize integrating digital health literacy education within university programs. Empowering students with the skills to navigate digital health information will enhance their capacity to evaluate online content and support informed decision-making. These efforts are essential to fostering vaccine confidence and combating misinformation at both individual and community levels.

CONCLUSION:

Digital health literacy plays a pivotal role in shaping HPV vaccine attitudes and decisions, particularly through engagement with online content and social media. While digital platforms offer powerful tools to promote vaccination, their impact depends on message design, credibility, and user interpretation. Enhancing digital health literacy can help individuals navigate misinformation, build trust in evidence-based sources, and support informed vaccine choices. Integrating these strategies into public health initiatives is essential to improve HPV vaccine uptake globally.

List Of Abbreviations

1. HPV – Human Papillomavirus
2. LMICs – Low- and Middle-Income Countries
3. WHO – World Health Organization
4. DHL – Digital Health Literacy
5. SMS – Short Message Service
6. U.S. – United States

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