European Cancer Organisation

Call for Evidence response

Cancer prevention - action to promote vaccination against cancer-causing viruses

6 February 2023

The European Cancer Organisation, supported by its HPV Action Network, recommends for inclusion in the upcoming EU Council Recommendation on vaccine-preventable cancers, sections and commitments related to:

1) Accelerating the achievement of HPV cancer elimination through gender-neutral vaccination.
2) Increasing coverage of HBV vaccination including for new-borns, children and risk-groups.
3) Ensuring an inequalities focus throughout the recommendation.
4) Actively tracking and monitoring progress towards the achievement of HPV and HBV cancers elimination goals.
5) Enhancing EU level action against misinformation and disinformation about vaccination on social media.
6) Supporting a stable supply environment for HPV and HBV vaccines across Europe.
7) Creating synergies between the European Commission and the World Health Organisation in implementing policies and strategies for the elimination of all cancers and diseases caused by HPV and HBV.
8) Urging Member States to adopt public health strategies that include multi-stakeholders educational campaigns.
9) Committing Member States to further facilitate access to vaccination and to implement coordinated vaccination catch-up programmes among the population.
10) Securing long-term commitment by the European Union to the funding of vaccine-preventable cancers research.

The European Cancer Organisation (ECO) welcomes the present public call for evidence aimed at assisting the European Commission in its preparation of a proposal for a Council Recommendation on vaccine-preventable cancers.

The European Cancer Organisation emphasises the following points for inclusion in the upcoming Recommendation:

1) **Accelerating the achievement of HPV cancer elimination through gender-neutral vaccination.**

Human papillomavirus is one of the most widespread sexually transmitted infections worldwide and is commonly acquired soon after onset of sexual activity, both in girls and boys.

Vaccination is key to the prevention of a range of cancers caused by HPV. The vaccination of young girls against HPV types 16 and 18 is now known to have reduced the incidence of HPV infections and the incidence of cervical pre-cancer and cancer. It is expected that, in time, vaccination will also impact significantly on the incidence of cancers caused by HPV in other sites, including the vulva, vagina, anus, penis, head and neck. Up to 30% of HPV-caused cancers in Europe are in males. Screening is capable of reducing cervical precancer and cancer but does nothing to address cancer in other organs for which no screening programmes are currently available.

However, vaccination rates in Europe, and elsewhere, currently vary widely. Data for the European region shows that only two countries achieved a 90% uptake of girls receiving all their vaccine doses. While several managed over 70% uptake, other countries had coverage rates of below 50% and at least two currently vaccinate fewer than 10% of girls.[1] There are also in-country variations in uptake linked to socio-economic status, ethnicity and religious beliefs. For instance, important data on inequalities show Dutch girls with parents born in Morocco are only half as likely to have received the HPV vaccine as those whose parents were born in the Netherlands. [2]

Europe's Beating Cancer Plan recommends eliminating cervical cancer and other cancers caused by human papillomavirus by vaccinating at least 90% of EU target population of girls, and to significantly increase the vaccination of boys by 2030. Moreover, the European Parliament 2022 Report on *Strengthening Europe in the fight against cancer – towards a comprehensive and coordinated strategy* (BECA report) calls for a **gender-neutral and publicly financed HPV vaccination** programme to be implemented in all Member States in order to ensure the elimination of all HPV-related cancers.

In order to achieve this ambitious goal, the European Cancer Organisation stresses the **importance of increasing vaccination rates for all genders and recommends the adoption of a gender-neutral uptake target of 90%.** Gender-neutral vaccination protects everyone against all the cancers caused by HPV and makes vaccination programmes more resilient against falls in uptake caused by events

[1] European Cancer Organisation (2021), *Improving HPV Vaccine Uptake in Children, Adolescents, and Young Adults.* Available at: https://www.europeancancer.org/resources/255:hpv-vaccine-uptake.html.

[2] EuroHealthNet (2023), *Improving Vaccine Equity, Addressing barriers and building capacity to improve equitable vaccine uptake across Europe*. Available at: https://eurohealthnet.eu/wp-content/uploads/publications/2023/2301_pp_vaccineequity.pdf.

such as the COVID-19 pandemic or anti-vaccination campaigns based on misinformation and 'fake news'. The pandemic is estimated to have led to a 42% drop in HPV vaccine coverage.

Furthermore, as indicated in a recent study from Finland, HPV gender-neutral vaccination actively contributes towards achieving herd immunity, including in countries with lower female uptake.

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore:

- Include a fresh shared commitment by EU Member States to achieving together the goal of HPV cancer elimination, as contained in Europe's Beating Cancer Plan and via the WHO Cervical Cancer elimination strategy.
- Indicate clearly that the goal of HPV cancer elimination should be achieved by policies of gender-neutral vaccination, including surpassing the Europe's Beating Cancer Plan uptake target by aiming for 90% vaccination coverage for all genders.
- Recommend EU Member States implement best practices on HPV vaccination uptake, including through the implementation of the forthcoming recommendations from the Joint Action PERCH (PartnERship to Contrast HPV), and the EU co-founded project PROTECT-EUROPE coordinated by the European Cancer Organisation.

2) Increasing coverage of HBV vaccination including for new-borns, children and risk-groups.

Viral hepatitis is an infection causing inflammation of the liver. It can be caused by different viruses, including hepatitis B virus (HBV) and hepatitis C virus (HCV). Both HBV and HCV can lead to acute and chronic infections and are leading causes of liver cirrhosis and hepatocellular carcinoma.

The hepatitis B vaccine is an important tool for hepatitis B prevention, but only 50% of EU/EEA countries with universal childhood vaccination have reached the target of 95% hepatitis B vaccination coverage.[3]

Providing free HBV vaccination policies is crucial. This should include coverage of key adult populations, migrants, people who inject drugs (PWID), people in prisons, people living with HIV, men who have sex with men (MSM), transgender people, and healthcare workers addressing the inequities in access.

However, a particular focus should be given to increase coverage of HBV vaccination for new-borns and children, especially given the concerning declines in vaccine coverage observed in some countries in recent years.

[3] ECDC (2022), *Prevention of hepatitis B and C in the EU/EEA*, Available at: https://www.ecdc.europa.eu/sites/default/files/documents/Evidence%20brief%20hepatitis%20B%20and%20C.pdf

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore:

- Recommend that all EU member states provide free HBV vaccination.
- Encourage EU Member State to implement strategies to increase HBV vaccination coverage for new-borns, children, and risk-groups.
- Target HBV vaccination to ensure also key adult populations receive coverage, including migrants, PWID, people in prisons, people living with HIV, gay, bisexual, and other men who have sex with men, transgender people, and healthcare workers.

3) Ensuring an inequalities focus throughout the recommendation.

The EU Council Recommendation on vaccine-preventable cancers provides a major opportunity for the development of a comprehensive set of recommendations to, and support for, Member States that aim to address inequalities in HPV and HBV vaccination between EU countries.

Data show that almost all (85-90%) of sexually active women and men will acquire HPV at some point in their lives. There are around 200 different types of HPV. 12 of these HPV types are associated with a high risk of cancer. In some European countries, the prevalence of high-risk HPV infection exceeds 15% in women. One study of oncogenic HPV types in men found a prevalence rate of 12%. In men who have sex with men (MSM) specifically, the prevalence rate of HPV types 16 or 18 could be as high as 20%.10. High-risk oral HPV infection specifically has been found to be much more prevalent in men than women.[4] Consideration is also required in respect to transgender women, transgender men and non-binary people.

Data also show a high prevalence of HPV infection (particularly with high-risk types) in female and transgender women sex workers who have a great susceptibility to the development of cervical and vaginal cancers. Furthermore, sex workers may transmit their infection to their clients, which may result in a high prevalence of HPV and the incidence of HPV-associated malignancies among the general population.

Moreover, given the prevalence of ongoing transmission and HBV infection in high-risk adult population groups, careful consideration of a targeted HBV vaccination strategy is required in respect of pregnant women, men who have sex with men, transgender women, persons who inject drugs, prisoners, and migrant populations, healthcare workers, diabetics, people on haemodialysis, and people with chronic liver disease. For instance, the EASL-Lancet Commission document recommends that all European countries implement universal childhood HBV vaccination and monitor its compliance, particularly in neonates of marginalised populations, migrants, refugees, and asylum seekers.

[4] European Cancer Organisation (2020), *Viral Protection: Achieving the Possible. A Four Step Plan for Eliminating HPV Cancers in Europe,* Available at: https://www.europeancancer.org/resources/159:viral-protection-achieving-the-possible-a-four-step-plan-for-eliminating-hpv-cancers-in-europe.html

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore:

- Develop a comprehensive set of recommendations to, and support for, Member States that aim to address inequalities in HPV and HBV vaccination between EU countries. This should include urging all EU Member States to provide a strategic HPV and HBV plan to address inequalities in vaccination in order to protect all the population against these preventable cancers.
- Address the need for targeted interventions to tackle infections in specific high-risk groups, including MSM, transgender people, and sex workers.

4) Actively tracking and monitoring progress towards the achievement of HPV and HBV cancers elimination goals.

The achievement of an ambitious goal in any domain requires monitoring of progress.

For this reason, the European Cancer Organisation calls for the establishment of an HPV Vaccine Tracker to be hosted by the European Centre for Disease Prevention and Control (ECDC). This monitoring system would help to monitor progress towards the Europe Beating Cancer Plan's goals, flag up where progress is slower and where additional support may be required, and help to encourage Member States to adopt best practice and maintain momentum. The Tracker would map the recovery of programmes from the COVID-19 pandemic and also show how the EU as a whole is contributing to the global effort to eliminate the cancers caused by HPV.

Moreover, the ECDC recently highlighted the presence of gaps in the available data on hepatitis prevention activities across the EU/EEA, mentioning the need for countries to prioritise the collection of more complete monitoring data to properly assess progress towards the elimination targets.[5]

Therefore, ECO advises for a stronger collaboration between the European Commission and Member States to gather and monitor data through national registries for HPV and HBV vaccination, with the development of key indicators regarding coverage.

Timely data monitoring on vaccination can therefore allow National and European authorities to take immediate action towards elimination of vaccines-preventable cancers.

[5] ECDC (2022), *Prevention of hepatitis B and C in the EU/EEA*, Available at: https://www.ecdc.europa.eu/sites/default/files/documents/Evidence%20brief%20hepatitis%20B%20and%20C.pdf

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore include:

- An agreement by EU Member States to mandate the European Centre for Disease Prevention and Control to put in place a monitoring system for HPV vaccine uptake across the EU.
- Recommendations to EU Member States in respect of achieving commonality in national registry systems to support such monitoring and tracking.
- A commitment to annual EU level reporting on the progress towards the HPV and HBV cancers elimination targets.
- Recommended common indicators for such reporting.

5) Enhancing EU level action against misinformation and disinformation about vaccination on social media.

The fight against misinformation and disinformation is a joint effort involving all European Member States and it can save millions of lives.

The Council Recommendation on vaccine-preventable cancers would be remiss if they did not include measures to stimulate further European level policy action against vaccine misinformation and disinformation.

In this respect, we congratulate the European Commission on the activities conducted on this topic so far including the 2022 publication of Guidance on Strengthening the Code of Practice on Disinformation.

Ongoing monitoring of the implementation and impact of both the Guidance, and the Code of Practice, should be conducted, including reflections on social media platforms that have so far not signed up to the Code. An open mind should be retained towards any need to evolve the Code further towards a regulatory solution in future.

Moreover, the European Cancer Organisation highlights the importance of sharing of good practice on tackling falls in HPV vaccine coverage due to the infodemic of anti-vaccine information taking place online and offline. For instance, in the case of Denmark, the HPV vaccine was well received by the Danish population and during the first years, vaccine uptake was more than 90% for at least 1 vaccine dose in the childhood vaccination program and 75–85% in the catch-up birth cohorts. However, in 2013, after a series of HPV anti-vaccination media coverage and social media messaging, the vaccination uptake dramatically decreased. Denmark rebuilt confidence among the population through extraordinary efforts, such as establishing the Danish Cancer Society telephone hotline, where parents could call with questions regarding HPV vaccination, and an information campaign ''*Stop HPV - stop cervical cancer*''. In addition, an effort was made to communicate the scientific results

related to the effect of HPV vaccination, where Denmark was one of the first countries to report a decreased risk of high-grade cervical lesions among vaccinated women.[6]

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore: • Urge Member States to formally endorse and express shared support for the EU Code of Practice on Disinformation and commit together to long term support of its application, including funding for impact related research. • Recommend EU Member States to keep working in close cooperation with online platforms to encourage them to promote authoritative sources, demote content that is fact-checked as false or misleading, and take down illegal content or content that could cause physical harm. • Gather good practices at the EU Member States level, including activities and communications campaign to counter fight anti-vaccine infodemics taking place in the countries.

6) Supporting a stable supply environment for HPV and HBV vaccines across Europe.

Whilst there is a stable supply environment for HPV and HBV vaccines in the context of both the achievement of elimination goals and the forthcoming amendments to the EU Pharmaceutical Legislation, there is the need for vigilance to maintain a stable supply chain environment. This should include providing clear signals of European demand, such as through the new EU Council Recommendation on vaccines-preventable cancers.

The European Cancer Organisation therefore encourages the European Commission to support Member States' vaccines forecasting and to consider any necessary improvements in respect to supply chain transparency, especially in case of vaccine shortages.

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore: • Acknowledge the need to maintain a stable environment for vaccine supply in Europe. • Support EU Member States in conveying clear signals of European demand.

[6] HPV World, *HPV vaccination crisis and recovery: the Danish case*, Available at: https://www.hpvworld.com/articles/hpv-vaccination-crisis-and-recovery-the-danish-case/

7) **Creating synergies between the European Commission and the World Health Organisation in implementing policies and strategies for the elimination of all cancers and diseases caused by HPV and HBV.**

The 2020 World Health Organization (WHO) strategy for the global elimination of cervical cancer as a public health problem, together with the forthcoming Europe's Beating Cancer Plan, the EU Cancer Mission and the EU4Health Programme, create a unique opportunity for Europe to be an international regional leader in replicating what has already been achieved for another once-endemic virus, smallpox – the elimination of all the cancers and diseases caused by HPV. This goal is achievable through evidence-based steps in four key areas: vaccination, screening, treatment, and public awareness.

The European Cancer Organisation suggests that the European Union and the wider WHO European region should create synergies and commit to the core goal of matching and exceeding the WHO Global Strategy for Cervical Cancer Elimination and implement policies and strategies for the elimination of all the cancers and diseases caused by HPV including through the implementation of gender-neutral HPV vaccination programmes with a 90% uptake target for all genders.

Moreover, in May 2022 the 75th World Health Assembly noted a new set of integrated global health sector strategies on viral hepatitis for the period of 2022–2030. Based on the new strategy, a broad range of Member States have developed comprehensive national hepatitis programmes and elimination strategies guided by the global health sector strategy.

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore:

- State an explicit connection with WHO commitments in respect to vaccine-preventable cancers and a commitment to joint work with WHO on the topics.
- Express commitment by EU Member States to provide support to neighbouring countries and developing countries in achieving shared goals in HPV and HBV cancer elimination.

8) **Urging Member States to adopt public health strategies that include multi-stakeholders educational campaigns.**

Education and effective delivery of vaccination are key to increase vaccine coverage across Europe.

Yet some recent surveys of key stakeholders indicate a sense that not enough is currently being enacted to promote HPV vaccination.

The ECO HPV Action Network considers that a greater effort is needed to engage young people and parents in vaccination promotion. This can be supported by educational trainings and targeted campaigns across Member States. Moreover, the European Cancer Organisation suggests implementation of workforce training focusing on improving communications skills to communicate on the topic of vaccination with patients. The European Commission 2022 State of Vaccine Confidence

in the EU reveals that vaccine confidence among the public and healthcare professionals is high across most populations, with some exceptions and caveats. However, perceptions towards the HPV vaccine have become markedly more negative since 2020.

As doctors and healthcare professionals are considered one of the most trusted sources of information when talking about vaccination, effective communication is an excellent way to address vaccine hesitancy and doubts expressed by patients.

As an example, the EU co-funded PROTECT-EUROPE project coordinated by ECO aims to provide information and training on optimising one-to-one communication with young people and their parents/carers for the wide range of healthcare professionals involved in HPV vaccination. The training programmes will be delivered online and will be cascaded into Member States via a training-the-trainers approach.

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore:

- Express long-term support for pan-European awareness campaigns and projects to benefit all countries in the implementation of cancer prevention via vaccination.
- Commit all EU countries to improve training and education of relevant healthcare professionals and education stakeholders about the importance and nature of HPV vaccination.

9) Committing Member States to further facilitate access to vaccination and to implement coordinated vaccination catch-up programmes among the population.

Catch-up vaccination programmes are crucial to reduce the incidence of HPV and HBV cancers.

The European Cancer Organisation recommends countries to be provided with additional guidance on effective delivery systems to achieve improved uptake of HPV and HBV vaccination across Europe. This would include a focus on effective planning and data management as well as close collaboration between commissioners, service providers and vaccinators and data system managers. It is particularly important for service providers and vaccinators to be able to take a pro-active approach, especially to engaging 'hard-to-reach' groups, and to have the information and confidence to respond to concerns about vaccine safety and other issues.

Generally, the highest take-up is reached by school-based systems, although Portugal has achieved over 90% with a clinic-based system with HPV vaccination. Also, it is important to consider the lessons-learnt from the COVID-19 pandemic in respect to COVID-19 vaccination coverage in Europe which have included the development of innovative delivery systems including pharmacist-led vaccination or mobile clinics.

Pharmacists could play an important role in increasing vaccination coverage in Europe. Therefore, the European Cancer Organisation urges the European Commission to encourage Member States to implement suitable policies and legislation that permits and enhances pharmacists' active involvement in pharmacy-based immunisation programs across Europe.

Moreover, it is crucial to invest in catch-up programmes for everyone up to age 26. This is particularly important post-COVID when so many people missed out. It is also important that catch-up includes boys/men who were not eligible at the routine vaccination age – this will help to protect the large number of males affected by the delayed extension of vaccination programmes to boys.

For instance, in December 2022, the Irish Minister for Health Stephen Donnelly announced the opening of the *Laura Brennan HPV Vaccination Catch-Up Programme*. The programme provided eligible people with the possibility to schedule an appointment for a free vaccine which will be administered through vaccination clinics and schools. Moreover, the programme offers free HPV vaccination to all boys and girls in second-level education who were previously eligible to receive the vaccine and who have not yet received it, and it is also open to young women up to the age of 25 who have left secondary school and did not previously receive the vaccine.

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore:

- Urge EU Member States to consider different options of vaccination sites for HPV and HBV and consider non-physician health professionals as vaccinators (e.g., pharmacists).
- Invite EU Member States to implement catch-up HPV vaccination programmes for all the population up to the age of 26. This will help protect the large number of population affected by the delayed extension of vaccination programmes to boys, and due to the disruption caused by the COVID-19 pandemic.

10) Securing long-term commitment by the European Union to the funding of vaccine-preventable cancers research.

The European Cancer Organisation notes recent research developments in respect to the application of vaccination technology and approaches to other areas of cancer prevention and treatment.

We also note ongoing discussions within the European Commission about the most appropriate financing mechanisms to support such vaccine research.

The forthcoming proposal for a new EU Council Recommendation on Vaccine-Preventable Cancers should therefore:

- Express commitment by the EU and its Member States to support the research environment for the potential application of vaccine technology and approaches to other areas of cancer prevention and treatment.
- Indicate the specific EU funding mechanisms to be purposed towards vaccine-preventable cancers research.

Appended to our response is the recent report on "*Improving HPV Vaccine Uptake in Children, Adolescents, and Young Adults*" outlining ECO's views on effectiveness of interventions designed to improve uptake of HPV vaccination.

The report has been produced by the European Cancer Organisation's HPV Action Network and approved according to its policy decision-making process. The Network comprises representatives drawn from the European Cancer Organisation's Member Societies, Patient Advisory Committee members, Community 365 and other invited stakeholders.

european cancer ORGANISATION

Improving HPV Vaccine Uptake in Children, Adolescents, and Young Adults

An Umbrella Review of Interventions

HPV Action Network

The HPV Action Network is one of the European Cancer Organisation's Focused Topic Networks, established as part of our Strategy for 2020-2023. The HPV Action Network was launched in December 2019, following a resolution passed at the 2019 European Cancer Summit in September. This called for effective strategies to eliminate the cancers caused by HPV as a public health problem to be implemented in all European countries by 2030.

The HPV Action Network helped to influence the development of Europe's Beating Cancer Plan. This contains a key strategic commitment to gender-neutral vaccination across the European Union and the Network hopes to see a similar goal for the whole European region.

Co-chaired by Professor Daniel Kelly and Professor Rui Medeiros, the HPV Action Network convenes Member Societies and Patient Advocacy Groups of the European Cancer Organisation, as well as our Community 365 and other interested stakeholders. The Network currently comprises about 45 organisations.

An up-to-date list of Network participants is available on the Network website europeancancer.org/topic-networks and acknowledged on the inside back cover of this report. The website also contains a range of other information about the Network, including publications and reports.

If you would like to find out more about the HPV Action Network, please contact us at: info@europeancancer.org.

FOREWORD

HPV causes about 5% of all cancers worldwide. The most common of these cancers is cervical but the virus is also implicated in cancers of the vagina, vulva, anus, penis, head and neck. A significant proportion of the cancers caused by HPV in Europe are in men.

The World Health Organization now has a global strategy for the elimination of cervical cancer. Europe's Beating Cancer Plan, published by the European Commission in 2021, contains a 'flagship' commitment to HPV vaccination. Both strategies share the goal of a 90% vaccination uptake for girls and the Beating Cancer Plan also wants to see an increasing number of boys vaccinated through gender-neutral programmes in every member state.

But vaccination rates in Europe, and elsewhere, currently vary widely. Data for the European region shows that only two countries achieved a 90% uptake of girls receiving all their vaccine doses. While several managed over 70% uptake, other countries had coverage rates of below 50% and at least two currently vaccinate fewer than 10% of girls.

An important part of the explanation for sub-optimal vaccination rates is low vaccine confidence among parents and carers as well as young people themselves. This can be caused by insufficient information, a lack of trust in health authorities and vaccine manufacturers, and concerns about vaccine safety. But we know that vaccine confidence can be improved, and vaccine uptake increased if the right policies and programmes are put in place. That is why the European Cancer Organisation's HPV Action Network commissioned this important review of published evidence. Our expert research team took a detailed look at the existing evidence base, by means of an umbrella review (essentially a systematic review of systematic reviews) and identified a range of interventions that have been shown to make a difference in terms of intention to be vaccinated, and uptake rates for HPV vaccination.

Compared to many other cancer prevention strategies – such as tobacco control, reducing alcohol consumption, increasing physical activity or tackling obesity – HPV vaccination is easy-to-deliver, has an immediate positive health impact and is highly efficacious. In fact, it is probably the single most effective means of cancer prevention in the medical arsenal.

We will therefore share these findings widely and encourage HPV vaccination programmes in Europe and beyond to make the best possible use of this evidence. If we can achieve a 90% vaccination rate across Europe, we know we will succeed in eliminating HPV cancers as a public health problem in the region.

Professor Daniel Kelly & Professor Rui Medeiros
Co-Chairs, HPV Action Network

Contents

Acknowledgements

This report has been produced by the European Cancer Organisation's HPV Action Network and approved according to its policy decision-making process. The Network comprises representatives drawn from the European Cancer Organisation's Member Societies, Patient Advisory Committee members, Community 365[1] and other invited stakeholders.

The HPV Action Network is very grateful to the international and multi-disciplinary research team that conducted this research, led by Deborah Edwards at Cardiff University.

Thanks are due to all those members of the HPV Action Network who took the time to comment on this research.

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1 Community 365 is a group of charity, philanthropy and industry contributors to the Focused Topic Networks of the European Cancer Organisation. Community 365 provide ideas, guidance, practical support and resources for our work in convening stakeholders and building consensus in the European cancer community. Community 365 contributors do not have a decision-making role in our policy work. Rather, policies of the European Cancer Organisation, such as those represented in this document, are agreed by our Board after consultation with our Member Societies and Patient Advisory Committee, via our Policy Pathway process. In particular, for this report, we appreciate the support of MSD, BD, Roche and NOMAN is an Island: Race to End HPV who contributed to the cost of this independent research completed by Edwards D, Bennett C, Sherman S, et al.
More information here: europeancancer.org/community-365

Executive Summary

An umbrella review (a systematic review of systematic reviews) was conducted to explore the effectiveness of interventions designed to improve uptake of HPV vaccination and HPV vaccination intention.

Ten systematic reviews met the selection criteria and reported interventions focused on change at individual-, community-, and organisational-levels, with some interventions using a mix of approaches. The effectiveness of interventions for HPV vaccination intention and HPV vaccination uptake (reported separately for initiation and completion where available) is presented for children and adolescents, parents, and young adults.

Inconsistencies and gaps in the reporting in the underpinning systematic reviews and poor geographical representation among the included studies mean that the findings need to be interpreted with some caution. In this executive summary, we present those interventions which appeared to be effective.

HPV vaccination intention

Systematic reviews that explored vaccination intention (Figure 1) included a wide range of educational interventions that focused on change at an individual level. Influencing factors were varying timings, duration and delivery methods or sources.

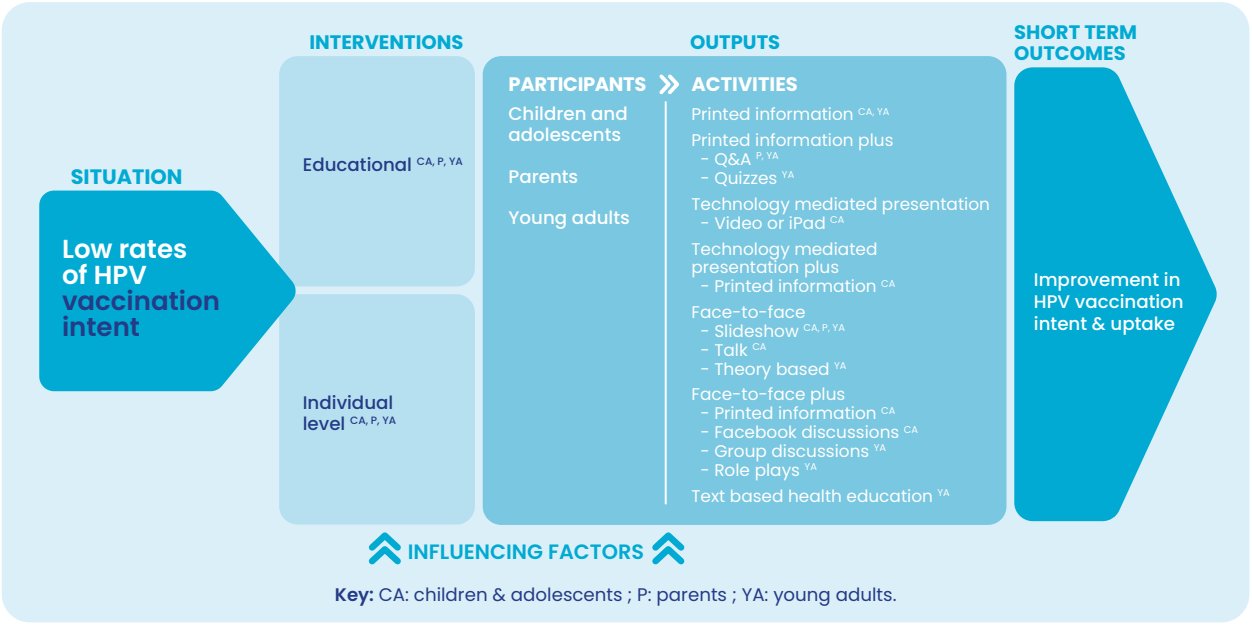
Face-to-face presentations with or without additional interventions such as printed information, Facebook discussions, theory-based slideshows, group discussions and role play (depending on the target group) and printed information were effective at increasing HPV vaccination intention in children and adolescents, parents, and young adults.

Printed information with or without additional interventions such as Q&A sessions and quizzes (depending on the target group) were effective at increasing HPV vaccination intention in children and adolescents, parents, and young adults.

Technology mediated presentations using videos or iPads with or without additional interventions such as printed information were effective at increasing HPV vaccination intention in children, adolescents and parents.

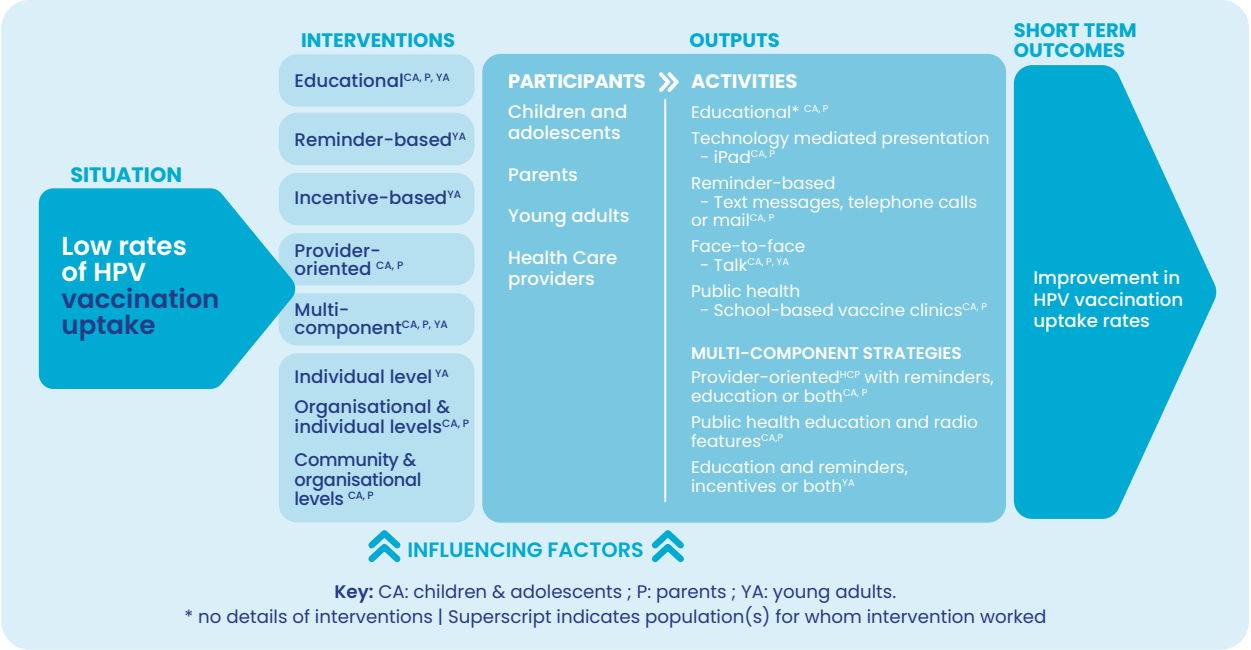
Text-based health education was effective at increasing HPV vaccination intention in young adults.

Figure 1. Logic model for HPV vaccination intention interventions



Key: CA: children & adolescents ; P: parents ; YA: young adults.

Figure 2. Logic model for HPV vaccination uptake interventions



HPV vaccination uptake

Systematic reviews that explored vaccination uptake (Figure 2) included a wide range of educational interventions, technology mediated presentations, reminder-based strategies and incentive-based strategies that focused on change at an individual level.

For the educational interventions, influencing factors were timings, duration and delivery methods or sources. Multi-component interventions included provider-based strategies, public health components and radio features that focused on change at an organisational and/or community as well as at the individual level. Influencing factors were demographic factors such as age, gender, race and insurance coverage.

Some reviews provided details of HPV vaccination initiation (Figure 3) and completion (Figure 4), and this information is detailed below where available.

Technology mediated presentations delivered using an iPad appeared to be effective at increasing HPV vaccination uptake rates for children and adolescents.

The stand-alone reminder-based strategies included text messages, telephone calls, pre-recorded voice messages, letters or postcards, email and Facebook messages. Text based reminder-based strategies appeared to be effective at increasing HPV vaccination initiation for young adults and completion for children, adolescents and young adults. Telephone calls or voice messages, letters or postcards also appeared to be effective for increasing HPV vaccination completion and/or uptake for all population groups and additionally email and Facebook messages were effective for young adults. Where evaluated, text messages were more effective than other methods.

Incentive-based strategies (e.g., free of charge vaccine, gift vouchers) appeared to be effective at increasing HPV vaccination initiation and completion rates for young adults.

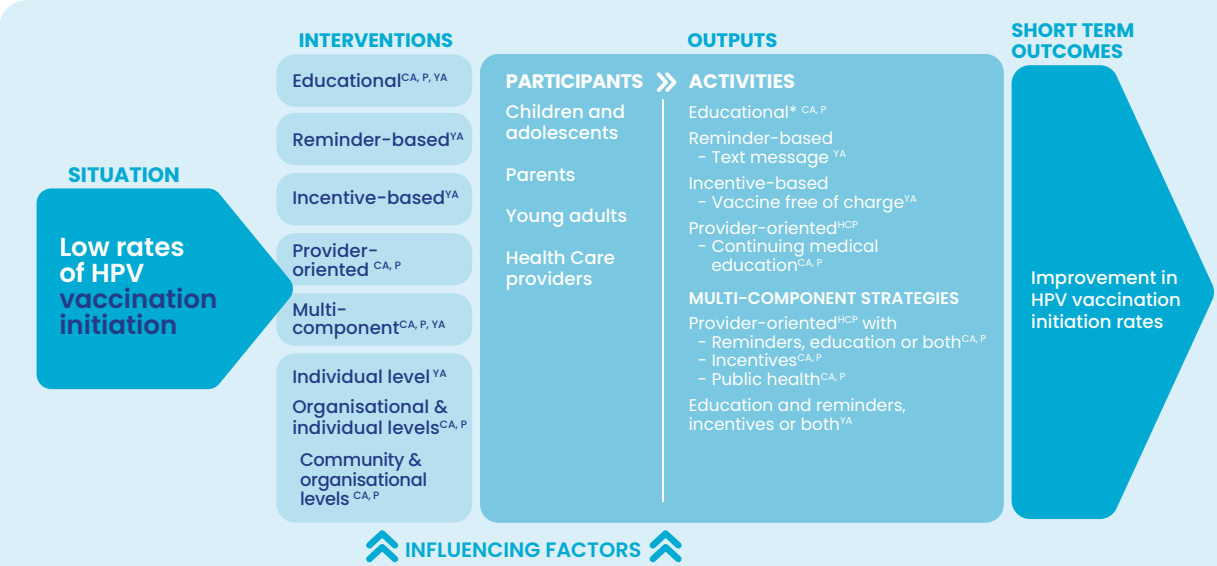
A public health intervention which involved school-based vaccination clinics in the US appeared to be effective at increasing HPV vaccination uptake for children and adolescents.

Multi-component interventions that involved only reminders and incentives appeared to be effective at increasing HPV vaccination completion for children and adolescents only.

Multi-component interventions that involved an educational component alongside reminder or incentive-based strategies appeared to be effective at increasing HPV vaccination initiation for young adults. Whereas multi-component interventions that involved just reminders and incentives appeared to only be effective at increasing HPV vaccination completion for children and adolescents.

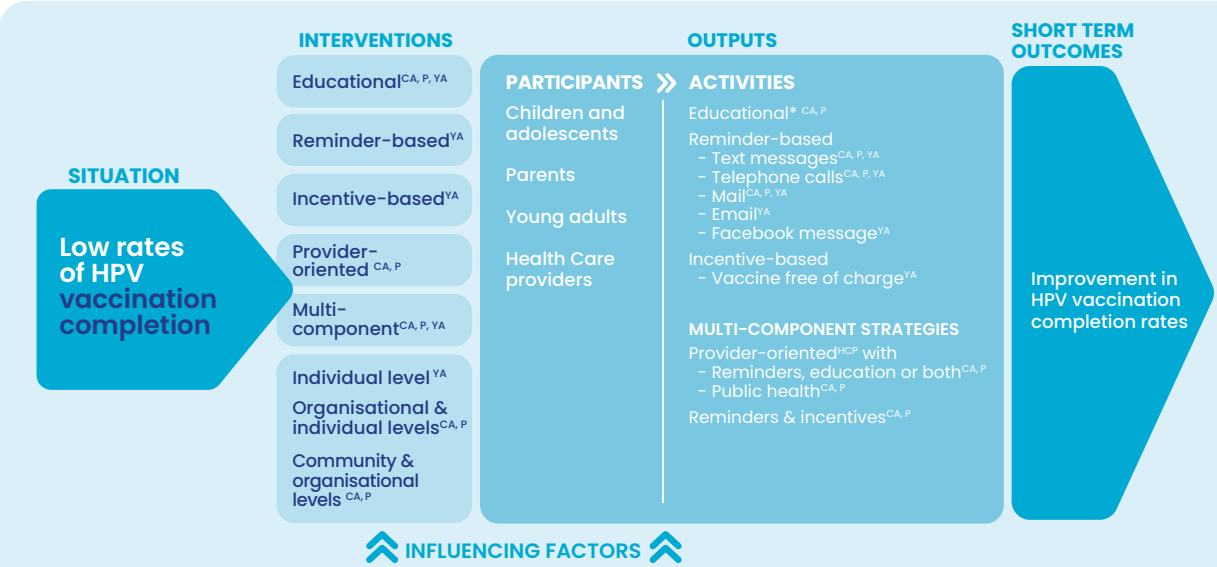
Multi-component interventions that involved

Figure 3. Logic model for HPV vaccination initiation interventions



Key: CA: children & adolescents ; P: parents ; YA: young adults.
* no details of interventions | Superscript indicates population(s) for whom intervention worked

Figure 4. Logic model for HPV vaccination completion interventions



Key: CA: children & adolescents ; P: parents ; YA: young adults.
* no details of interventions | Superscript indicates population(s) for whom intervention worked

provider-oriented strategies alongside incentives, reminders and/or education appeared to be effective at increasing HPV vaccination initiation, completion and uptake for children and adolescents. In contrast, provider-oriented strategies with just incentives appeared to only be effective at increasing HPV vaccination initiation for children and adolescents.

Multi-component interventions that involved provider-oriented strategies alongside public health components appeared to be effective at increasing HPV vaccination initiation and completion for children, adolescents. Additionally public health components, education and radio features appeared to be effective at increasing HPV vaccination uptake for children and adolescents.

Educational interventions, where specified, involved face-to-face presentations which appeared to be effective at increasing HPV vaccination initiation for children and adolescents and uptake rates for children, adolescents and young adults.

From the summary above, we can extract some key points:

1. There is no single magic bullet solution to increasing vaccination uptake or intention:
   a. Interventions that work to increase initiation do not always work to increase completion, for example.
   b. Different approaches may be more suited to some populations than others.
2. Face-to-face presentations, printed information and supplementing both strategies with additional components appear to be effective at increasing vaccination intention.
3. Reminders and multi-component strategies, especially ones that include some intervention aimed at provider level (professional education, electronic health record alerts, a vaccination coordinator post, home visits, health information technology systems, nurse standing orders and pre-typed consents) appear to be effective at increasing vaccination uptake.

Introduction

The Human Papilloma Virus (HPV) is implicated in the causation of several cancers including those arising in cervical, oropharyngeal, anal, vulval and penile tissue.[1,2] It is possible to reduce the rates of these cancers using HPV vaccination, and the level of protection offered has recently been confirmed by evidence of significant reductions in cervical intraepithelial neoplasia and cervical cancer rates in the cohort of girls in England who have been offered the vaccine since 2008.[3] Given this level of benefit it is important to understand the factors that help promote the uptake of HPV vaccination in girls, and in boys, as they will also benefit from a gender-neutral strategy.[4]

One of the major challenges to be addressed is vaccine hesitancy in **young adults**. These are the groups most likely to benefit from HPV vaccination, and they may be amenable to interventions that improve motivation and vaccine uptake.

Importantly, there is a need to identify effectiveness of evidence-based interventions aimed at addressing vaccine hesitancy, and to highlight constituent elements of successful interventions that can be recommended, or indeed strengthened, for different target populations. One of the major challenges to be addressed is vaccine hesitancy in young adults. These are the groups most likely to benefit from HPV vaccination, and they may be amenable to interventions that improve motivation and vaccine uptake. This project aimed to identify interventions by drawing on existing systematic reviews that have collated the available published evidence, and to use this information to highlight the approaches that might be most successful in addressing HPV vaccine hesitancy. It will also be possible to show what approaches may be worth adopting to strengthen the available evidence base on HPV vaccine uptake as well as reduce rates of hesitancy and vaccine refusal.

The initial intention had been to conduct a systematic review of the effectiveness of interventions to improve HPV vaccination coverage among children, adolescents and young adults. However, following a preliminary search of the literature it quickly became apparent that many systematic reviews had already been conducted in this area. It was therefore decided to conduct a systematic review of reviews known as an umbrella review to provide an overview of the best available evidence from multiple systematic reviews to answer the research question.[5–9] To date, no other umbrella reviews have been conducted in this area. Previous umbrella reviews in the field of HPV vaccinations have explored the safety, efficacy, and effectiveness of human papillomavirus vaccines,[10] HPV and cancer prevention in Europe[11] and factors associated with HPV vaccination in the US.[12] The purpose of this umbrella review was therefore to answer the question "What is the evidence for interventions used to improve HPV vaccination uptake in children, adolescents and young adults?".

Methods

This umbrella review was conducted in accordance with the JBI methodology for umbrella reviews,[9] following the study protocol which was registered in the PROSPERO (Prospective Register of Systematic Reviews) database (CRD42021273894). The manuscript was prepared using the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.[13]

Aims and objectives

The aim was to provide an overview of interventions used to improve HPV vaccine uptake in children, adolescents and young adults and to summarise the quantitative evidence of their efficacy.

The specific objectives were to:

1. Determine what interventions exist
2. Determine the effectiveness of different interventions

Inclusion criteria

The inclusion criteria were developed using PICO as follows:

Types of participants

This umbrella review considered both male and female children, adolescents and young adults, aged 9 to 26 years, or their parents/guardians.

The following exclusion criteria were applied:

- Children under 9 years of age
- Adults over 26 years of age

Interventions

This umbrella review considered systematic reviews that had evaluated routine or catch-up interventions aimed at increasing HPV vaccination coverage in any setting where the HPV vaccine is delivered such as schools, youth facilities, primary care and sexual health facilities.

Comparators

This umbrella review considered all comparisons within the systematic reviews that compared the intervention to usual care or a control group.

Outcomes

This umbrella review considered the uptake of the HPV vaccine (initiation, completion, receipt of any dose) as the primary outcome. The secondary outcomes that were considered were willingness, intent, and adverse events.

Types of Research Synthesis

This umbrella review considered systematic reviews and meta-analyses of quantitative studies (randomised controlled trials (RCTs), quasi-experimental, and pre-post design). An eligible systematic review was considered one where a clearly focused question was provided, where the review authors used a comprehensive literature search strategy (at least two databases, provided keyword/search strategy/ justified publication restrictions) and had conducted a risk of bias assessment.

Search strategy

The search strategies aimed to locate published research syntheses for the past 10 years (January 2011 to July 2021) published in the English language. An initial limited search of MEDLINE was undertaken to identify articles on the topic. The searches and preliminary keywords used were HPV or papilloma or papillomavirus AND vaccin* or immunis* or inject* AND intervention or effect* or strateg* or program* AND complet* or uptake or engag* or hesitancy AND uptake or complet* or engag* or adher* or complic* or hesitan*or coverage AND adolescent* or youth* or "young adult* or teenager* or teen* or juvenile* AND review or meta-analysis or synthesis or overview.

To identify published resources that had not yet been catalogued in the electronic databases, recent editions of the journals *Vaccines, Preventive Medicine* and *Preventive Medicine Reports* were hand-searched. Reference lists of included studies were scanned and forward citation tracking was performed using ISI Web of Science searches.

Comprehensive searches (Appendix 1) were conducted across five databases:

- On the Ovid Platform: MEDLINE, Embase, Global Health
- On the Ebsco Platform: CINAHL
- Web of Science

Study screening and selection

Following the search, all citations retrieved were imported into the reference management software EndNote X20, where duplicate references were removed. All remaining citations were imported into the software programme Covidence where titles and abstracts were reviewed by two members of the research team and considered against the topic inclusion criteria. All potentially relevant papers were retrieved in full and assessed in detail against the inclusion criteria by two independent reviewers using a purposely designed screening tool. Reasons for exclusion of full text articles that did not meet the inclusion criteria were recorded and reported in the umbrella review (Appendix 2). Any disagreements that arose between the reviewers at each stage of the selection process were resolved through discussion, or with a third reviewer.

Assessment of methodological quality

Eligible syntheses were critically appraised by two independent reviewers for methodological quality using the standardised critical appraisal instrument from the JBI.[5] Any disagreements that arose between the reviewers were resolved through discussion, or with a third reviewer. All syntheses, regardless of the results of their methodological quality, underwent data extraction and synthesis.

Data collection

Data were extracted directly into tables following the format recommended by the Centre for Research and Dissemination. One reviewer extracted the data, and a second reviewer independently checked the data extraction forms for accuracy and completeness. The data extracted included:

1) type of review;

2) countries where the primary studies were conducted;

3) databases used;

4) search timeframes;

5) number of studies included in the review;

6) participants (number and comorbidities);

7) type(s) of intervention(s) and comparison conditions (including duration and level of personal contact);

8) outcomes of significance (types and characteristics);

9) outcome measures;

10) assessment and follow up timeframes;

11) critical appraisal tools and ratings;

12) methods of analysis and heterogeneity;

13) effect size and confidence intervals;

14) findings;

15) conclusions.

Any disagreements between the reviewers were resolved through discussion or with a third reviewer.

Data summary

To determine the degree of overlap of primary studies included in multiple systematic reviews, the corrected covered area (i.e., one primary study covered by multiple systematic reviews) was calculated.[14] Using this approach for the corrected covered area, less than 5% overlap is a slight overlap, 6-10% is a moderate overlap, 11-15% is a high overlap and >15% is a very high overlap. Thirty one primary studies were duplicated across the systematic reviews (see Appendix 3). The corrected covered score was found to be 4% (i.e., a slight overlap with systematic reviews mostly considering different primary studies). A total of 110 primary studies were cited by the included systematic reviews including 79 (72%) that were cited only once. All systematic reviews were included in this umbrella review regardless of the degree of overlap and percentage corrected covered area.

The data extracted from selected reviews were tabulated and accompanied by a narrative synthesis, structured around the type of intervention, target population characteristics, type of outcome and intervention content. The number of studies that informed the outcome, the number of participants (from included studies) and the heterogeneity of the results of included reviews were also reported.

For the first objective an adapted version[15,16] of the social ecological model[17] was used to examine and organise the interventions. The model was also used to identify the levels at which HPV vaccination interventions have been targeted: the individual, community, organisational and policy/society.

For the second objective the findings from the systematic reviews were presented in tables and

as a series of thematic summaries by participant group (i.e., children and adolescents, parents or young adults) and by the effectiveness of interventions across the different outcomes (vaccine uptake, intention and adverse events). The results of the systematic reviews from the individual studies included in the umbrella review have been presented in a "summary of evidence" table that includes the intervention and a simple visual indicator of the effectiveness of the intervention for each outcome using a colour coded system. In this system, green represents an intervention that leads to improvement, blue represents an intervention that does not lead to an improvement and orange represents an intervention that does not consistently lead to an improvement with some studies showing improvement and others showing none.[9] It is important to note that data from the meta-analyses within the included systematic reviews could not be used in this review as the original systematic reviews had combined interventions that were heterogenous or had combined data across adolescents and young adults.

Results

Study inclusion

The database searches identified 1046 records as being potentially relevant to the review. After the duplicates had been removed, the titles and abstracts of 95 were reviewed. 42 full text publications were selected for retrieval and 32 were excluded (see Appendix 2). One additional record was retrieved from forward citation tracking. All full text publications that met the inclusion criteria went forward to critical appraisal (n=10) and at the end of this process all 10 were considered suitable for inclusion. The PRISMA checklist was followed for the reporting of this review and the flow of studies through the review is presented in a PRISMA flow diagram (Figure 5).[13]

Methodological quality

The results of the critical appraisal are presented in Table 1. All included systematic reviews had clear questions (Q1), appropriate inclusion criteria (Q2), used appropriate search strategies (Q3), used adequate sources (Q4) and used appropriate criteria for appraising (Q5). With regards to critical appraisal (Q6) and data extraction (Q7), one systematic review did not provide clear information but inferred that these processes were conducted by one person.[18] Four systematic reviews did not mention how many people undertook critical appraisal.[19–22] For two systematic reviews, although the methods used to combine studies was appropriate (Q8), one did not present any data or significance levels and only reported the findings as a narrative that stated where level of intent or uptake had increased[23] and in the other, although a meta-analysis was conducted the results were not presented in a forest plot.[20] One systematic review conducted a meta-analysis despite heterogeneity in the interventions.[24] None of the systematic reviews conducted a funnel plot for publication bias. One systematic review stated that publication bias wasn't feasible because the number of included studies for each meta-analysis was less than the recommended 10 studies[25] and the remaining systematic reviews did not mention publication bias (Q9). Four systematic reviews did not report any recommendations (Q10),[21,22,24,26] one did not explicitly state recommendations, but they could be inferred within the discussion.[18] One systematic review did not provide recommendations that were appropriate due to poor reporting of the findings.[27] Directives for research were provided in all systematic reviews (Q11).

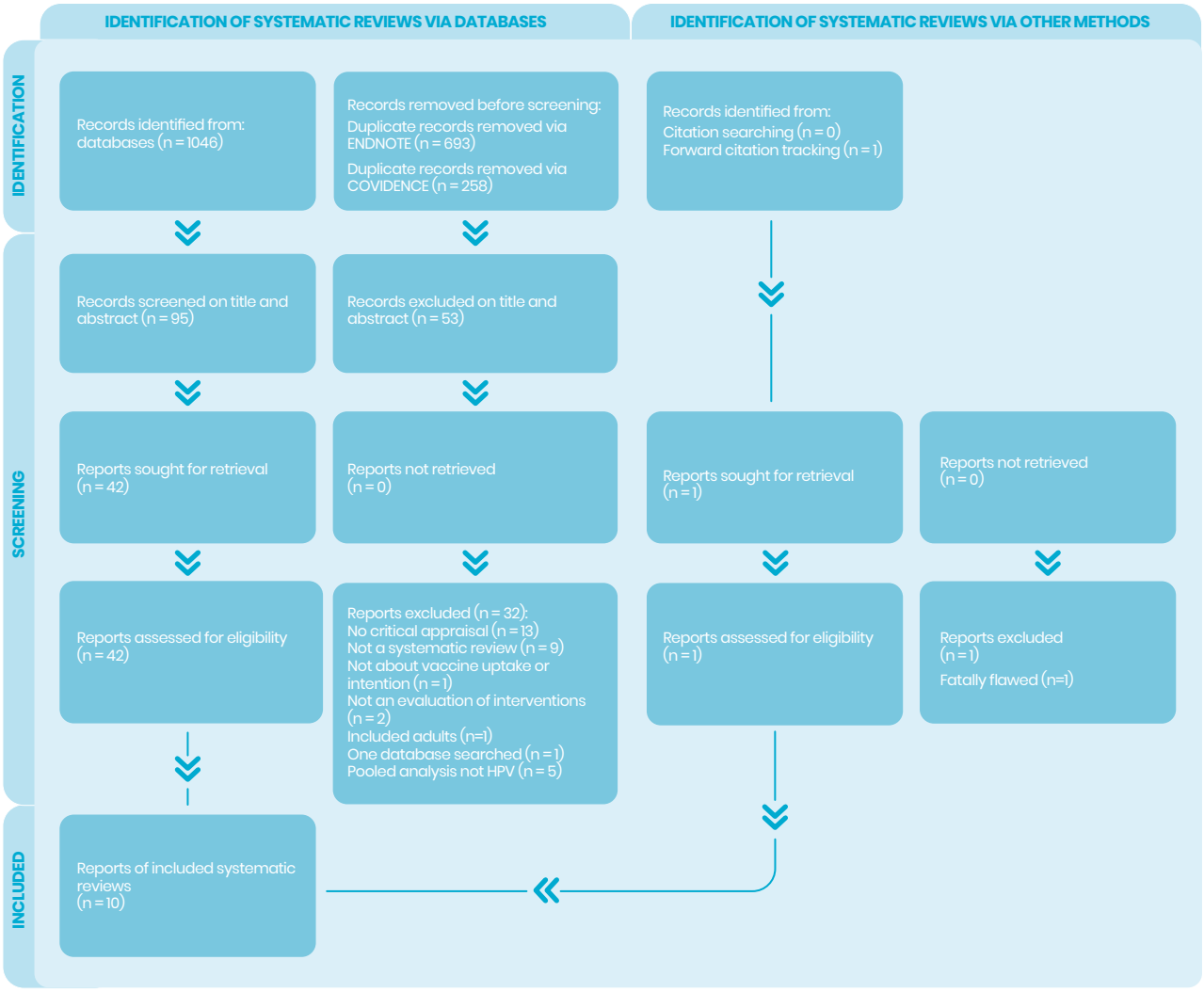
Table 1. Critical appraisal scores

CITATIONS	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Abdullahi et al. 2020[25]	Y	Y	Y	Y	Y	Y	Y	N	UC	N/A	Y
Barnard et al. 2019[19]	Y	Y	Y	Y	Y	N	UC	Y	UC	UC	Y
Eisenhauer et al. 2021[20]	Y	Y	Y	Y	Y	UC	Y	N	UC	Y	Y
Flood et al. 2020[23]	Y	Y	Y	Y	Y	Y	Y	UC	UC	Y	Y
Fu et al. 2014[27]	Y	Y	Y	Y	Y	UC	Y	Y	UC	Y	Y
Ilozumba et al.2021[22]	Y	Y	Y	Y	Y	Y	Y	Y	UC	N/A	Y
Lott et al. 2020[26]	Y	Y	Y	Y	Y	UC	Y	Y	UC	N/A	Y
Mogaka et al. 2021[21]	Y	Y	Y	Y	Y	Y	Y	y	UC	N/A	Y
Priest and Knowlden 2015[18]	Y	Y	Y	Y	Y	UC	Y	Y	UC	N/A	Y
Rodriguez et al. 2019[24]	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y

Key: N/A: not applicable ; N: No ; UC: unclear ; Y: Yes

Q1 Is the review question clearly and explicitly stated?
Q2 Were the inclusion criteria appropriate for the review question?
Q3 Was the search strategy appropriate?
Q4 Were the sources and resources used to search for studies adequate?
Q5 Were the criteria for appraising studies appropriate?
Q6 Was critical appraisal conducted by two or more reviewers independently?
Q7 Were there methods to minimie errors in data extraction?
Q8 Were the methods used to combine studies appropriate?
Q9 Was the likelihood of publication bias assessed?
Q10 Were recommendations for policy and/or practice supported by the reported data?
Q11 Were the specific directives for new research appropriate?

Figure 5. Flow of studies through the review



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

The characteristics of the included reviews are displayed in Tables 2 and 3. The 10 systematic reviews included a total of 95 RCTs, 28 quasi experimental studies, 14 cohort studies, six non-randomised pre-test/post-test studies with control groups, five single group pre-test/post-test studies, one single group post-test study and one randomised longitudinal study. The primary studies were published between 2004 and 2020.

Five systematic reviews did not use any date restrictions and conducted their searches in August 2013,[27] December 2017,[19] October 2018,[25] November 2018,[26] and November 2019.[22] The five other systematic reviews conducted their searches from January 2000 to January 2014,[18] January 2000 to December 2018,[21] January 2006 to January 2017,[24] 2007 to the end of 2019[23] and[20] 2014 to 2019.[20] Seven systematic reviews restricted their searches to English[18–21,23,24,27] and three did not use any language restriction.[22,25,26]

The instruments used for bias appraisal were the Cochrane Risk of Bias Tool (n=5),[19,22,25–27] Revised Cochrane Risk of Bias Tool (n=1),[20] Risk of Bias in Non-Randomised Studies of Interventions Tool (n=1),[20] Quality Assessment Tool for Quantitative Studies (n=1),[23] JBI Appraisal Tool for Cross-Sectional Studies (n=1),[22] Critical Skills Appraisal Programme Tools (n=1),[21] Downs and Black Modified Methodological Quality checklist (n=1),[18] Strengthening the Reporting of Observational Studies in Epidemiology checklist (n=1)[24] and the Consolidated Standards of Reporting Trials checklist (n=1).[24]

The total number of participants across all ten systematic reviews was 451,132 and the number of participants in each systematic review ranged from 2625[19] to 276,205[20] However, a number of studies within two of the systematic reviews did not provide details of their participant numbers.[19,25] All the reviews except one[20] included studies with small sample sizes of less than 200 participants.

With regards to gender, the systematic reviews included studies of mixed samples of heterosexual males and females (n=9)[18–25,27] gay or bisexual males and females (n=1):[26] females only (n=8),[18,19,21,22,24–27] heterosexual males only (n=4)[18,24,25,27] or gay or bisexual males only (n=1).[26] In five of the systematic reviews, details of gender were not provided for all of the included studies.[19,21,22,25,27]

Five of the systematic reviews did not report the ethnicity of participants[18,19,21,23,25] and in one further systematic review of the 30 included studies, 28 did not report on ethnicity.[24] For the remaining systematic reviews, populations were either predominately white (n=2)[20,27] or included a broad range of ethnicities.[22,26]

The terminology used across the systematic reviews to describe participants' ages varied widely, with one describing 9-26 years olds as adolescents and young adults,[26] whereas others described the same age group as children and adolescents[20] or children, adolescents and young adults.[24,27] Three systematic reviews included participants between the ages of 18 to 26 years[18,19,21] and two of these were specific to college students.[18,19] One included 10 to 19 year olds[25] and another included adolescents aged 12 to 19 years.[23] Ilozumba et al.[22] used the terms 'adolescents' and 'young adults' and did not state the precise ages of participants.

The included primary studies were conducted across a diverse range of countries which included USA (n=10),[18–27] Australia (n=5),[18,19,22,23,27] the UK, (n=3)[23,25,27] Sweden (n=3),[23,25,27] India (n=2),[21,27] Canada (n=1),[18] China (n=1),[21] Hong Kong (n=2),[23,27] Hungary (n=1),[23] Ireland (n=1),[27] Singapore (n=1),[23] Tanzania (n=1),[25] and Taiwan (n=1).[23] Two reviews only included studies from the USA.[20,24]

The number of databases searched within the systematic reviews ranged from two[27] to eight.[25] These included: PubMed,[19,21,22,26,27] MEDLINE,[18,20,23–25] CINAHL,[18–20,22–25] CENTRAL/Cochrane Library,[18–20,23,25] EMBASE,[20,23,25,26] Scopus,[23,25] Global Health,[25] Web of Science,[21,22,24–27] Africa-Wide information,[25] PsycINFO,[19,22,23] EBSCO,[19] PsycArticles,[23] AMED,[23] Science Direct,[21] Academic Search Premier,[18] ERIC[18] and SportDiscus.[18] Two systematic reviews also searched Google Scholar.[21,26]

Table 2. Characteristics of included systematic reviews (n=10)

STUDY CITATION REVIEW OBJECTIVES	PARTICIPANTS	SEARCH DETAILS	CHARACTERISTICS OF INCLUDED PRIMARY STUDIES
Abdullahi et al. 2020[25] To evaluate the effects of interventions to improve vaccine uptake among adolescents	**Participants** Parents (3 studies, n=541[a]) Adolescents (5 studies, n=13812) Healthcare providers (2 studies, n=227[c]) Adolescents and HCPs (1 study n=13118[a]) Parents and HCPs (2 studies, n=2620 Parents, n=3119 HCPs) N=33437[a] participants across all included studies **Gender** Females only (2 studies) Males and females (4 studies) Parents of males only (1 study) Parents of females only (1 study) Parents of males and females (1 study) Mother of females only (1 study) Parents of adolescent[c] (1 study) HCPs working with adolescents[b] (2 studies) **Age (years)** 10 to 19 **Ethnicity** Not reported	**Databases** N=8 CENTRAL, MEDLINE, EMBASE, CINAHL, Africa-Wide Information, Global Health, Scopus, WoS (Science Citation Index Expanded, Social Sciences Citation Index, Web of Science Core Collection) **Date restrictions** No date restrictions Searched in October 2018 **Language restrictions** No language restrictions	**Number of relevant studies** N=13 **Study designs** RCTs (n=11) Quasi-experimental (n=1) Controlled before and after study (n=1) **Countries of interventions** USA (n=10) Sweden (n=1) UK (n=1) Tanzania (n=1) **Recruitment** Schools (n=3) Community settings (n=2) Health care settings (n=6) Not clear (n=2)
Barnard et al. 2019[19] To summarise the best available evidence on interventions that could be implemented in the college environment to increase HPV vaccination uptake in college students who were not previously vaccinated	**Participants** College students (9 studies, n=2625[a]) **Gender** Females only (n=7) Males and females (n=1) Not specified (n=1) **Age (years)** 18 to 26 (n= 6) Under the age of 27 (n=1) Not specified (n=1) Mean age 19.03 (n=1) **Ethnicity** Not reported, however included one study where all the students were Chinese	**Databases** N=5 PubMed, CINAHL, PsycINFO, Cochrane Library, EBSCO **Date restrictions** No date restrictions Searched in December 2017 **Language restrictions** English	**Number of relevant included studies** N=9 **Study designs** RCTs (n=8) Single group post-test study (n=1) **Countries of interventions** USA (n=8) Australia (n=1) **Recruitment** Colleges / universities (n=9)
Eisenhauer et al. 2021[20] What targeted interventions improve HPV vaccination rates among adolescents in family practice recruitment?	**Participants** Children, adolescents (11 studies, n=276,205) **Gender** Males and females No further details provided **Age (years)** 9 to 26 **Ethnicity across all papers combined** White (Hispanic and non-Hispanic) (30.6%) African American/Black (16.0%) Native American (1.6%) Asian (1.3%) Pacific Islander (0.1%) Other/not reported (50.4%) To summarise the best available evidence on interventions that could be implemented in the college environment to increase HPV vaccination uptake in college students who were not previously vaccinated	**Databases** N=4 MEDLINE; CINAHL; EMBASE; Cochrane Library **Date restrictions** Last 5 years (2014-2019) **Language restrictions** English	**Number of relevant included studies** N=11 **Study designs** RCTs (n=7) Quasi experimental studies (n=4) **Countries of interventions** USA (n=11) **Recruitment** Family and paediatric primary care offices (n=11)

STUDY CITATION REVIEW OBJECTIVES	PARTICIPANTS	SEARCH DETAILS	CHARACTERISTICS OF INCLUDED PRIMARY STUDIES
Flood et al. 2020[23] To assess the impact of school-based education interventions on HPV uptake and perceptions/ knowledge of HPV and its associated cancers in 15–17 year old adolescents	**Participants** Adolescents (9 studies, n=10681) **Gender** Males and females (n=4) Females (n=5) **Age (years)** 11 to 19 **Ethnicity** Not reported	**Databases** N=8 MEDLINE, EMBASE, Scopus, CINAHL, PsycINFO, PsycArticles, AMED and Cochrane Reviews **Date restrictions** 2007 until end 2019 **Language restrictions** English	**Number of relevant included studies** N=9 **Study designs** RCT (n=2) Quasi experimental studies (n=7) **Countries of interventions** Australia (n=1); Singapore (n=1), USA (n=2), Sweden (n=1), Taiwan (n=1), Hungary (n=1), Hong Kong (n=1), UK (n=1) **Recruitment** Schools (n=9)
Flood et al. 2020[23] To assess the impact of school-based education interventions on HPV uptake and perceptions/ knowledge of HPV and its associated cancers in 15–17 year old adolescents	**Participants** Adolescents (9 studies, n=10681) **Gender** Males and females (n=4) Females (n=5) **Age (years)** 11 to 19 **Ethnicity** Not reported	**Databases** N=8 MEDLINE, EMBASE, Scopus, CINAHL, PsycINFO, PsycArticles, AMED and Cochrane Reviews **Date restrictions** 2007 until end 2019 **Language restrictions** English	**Number of relevant included studies** N=9 **Study designs** RCT (n=2) Quasi experimental studies (n=7) **Countries of interventions** Australia (n=1); Singapore (n=1), USA (n=2), Sweden (n=1), Taiwan (n=1), Hungary (n=1), Hong Kong (n=1), UK (n=1) **Recruitment** Schools (n=9)
Fu et al. 2014[27] To summarise and evaluate the evidence for educational interventions to increase HPV vaccination acceptance	**Participants** Parent and guardians of children, adolescents and young adults (7 studies, n=2538) Mothers of children and adolescents (4 studies, n=863) Adolescents (4 studies, n=1946) College students (16 studies, n=3280) Young adults (2 studies, n=979) N=9606 participants across all included studies **Gender** Females only (n=9) Males and females (n=7) Mothers of females only (n=5) Males only (n=3) Gender not specified (n= 9) **Age (years)** 12 to 18 (n = 2) / 18 to 26 (n=16) Under the age of 27 (n=1) Parents of children aged 9 to 26 (n=6) Mothers of children aged 8 to 18 (n=4) Not specified (n=4) **Ethnicity** Not stated (n=11) Over 70% White (n=13) Mixed ethnicities (n=8) Hispanics only (n=1)	**Databases** N=2 PubMed; Web of Science **Date restrictions** No date restrictions Searched in August 2013 **Language restrictions** English	**Number of relevant included studies** N=33 **Study designs** RCTs (n=28)c Quasi experimental studies (n= 5) **Countries of interventions** Australia (n=2) Hong Kong (n= 2) India (n=1) Ireland (n=1) Sweden (n=1) USA (n=18) UK (n=2) Not specified (n=6) **Recruitment** Health care clinics (n=4) Schools or Universities (n=19) Community settings (n=9) All of the above (n=1)

STUDY CITATION REVIEW OBJECTIVES	PARTICIPANTS	SEARCH DETAILS	CHARACTERISTICS OF INCLUDED PRIMARY STUDIES
Ilozumba et al. 2021[22] To synthesise existing evidence on mobile health (mHealth) interventions geared at improving HPV related knowledge, HPV vaccination intent and HPV vaccination uptake	**Participants** Adolescents, young adults or parents (19 studies, n=27,412) **Gender** Males and females (n=10) Females (n=2) Not specified (n=7) **Age (years)** Adolescents (n=6)[d] Young adults (n=4)[d] Adolescents and young adults (n=1)[d] Not specified (n=8)[d] **Ethnicity** Not stated (n=7) Mixed ethnicities (n=6) Over 70% Black (n=2) Over 70% Hispanic (n=1) Over 70% African American (n=1) Mexican only (n=1) Korean-American (n=1)	**Databases** N=4 PubMed, CINAHL, PsycINFO, Web of Science (Social Science Citation Index) **Date restrictions** No date restrictions Searched in November 2019 **Language restrictions** No language restrictions	**Number of relevant included studies** N=19 **Study designs** RCTs (n=10) Randomised longitudinal study (n=1) Quasi experimental studies (n=2) Prospective cohort study (n=1) Single group pre-test / post-test study (n=1) Non-randomised pre-post designs with control groups (n=4) **Countries of interventions** USA (n=18) Australia (n=1) **Recruitment** Clinical settings including paediatric clinics, planned parenthood centres and outpatient clinics (n=14) School (n=1) College (n=1) Not reported (n=3)
Lott et al. 2020[26] To assess the effectiveness of interventions to increase HPV vaccine uptake, measured as vaccine series initiation and series completion, among adolescents and young adults, aged 9–26 years old, identifying as a racial and ethnic minority or sexual and gender minority group in high-income countries	**Participants** Adolescent/young adults (5 studies, n=9034) Parent –child dyad approach (3 studies, n=488) Parents of adolescents alone (1 studies, n=200) N=9722 participants across all included studies **Gender**: Females only (n=7) Gay or bisexual males (n=1) Homosexual/bisexual females and males (n=1) **Age (years)** 9 to 26 **Ethnicity** Black (n=2) / African American (n=2) Haitian American (n=1) /Hispanic (n=2) Latinx (n=2) / Asian (n=1) American Indian (Hopi) (n=1) / Alaskan Native (n=1) Korean-American (n=1) / Khmer American (n=1) Other race (n=1)	**Databases** N=3 PubMed, EMBASE, Web of Science Google Scholar engine search first 50 results **Date restrictions** No date restrictions Searched in November 2018 **Language restrictions** No language restrictions	**Number of relevant included studies** N=9 **Study designs** RCT (n=8) Non-randomised pre-post designs with control groups (n=1) **Countries of interventions** USA (n=9) **Recruitment** Health care settings (n=3) Universities (n=1) Community settings (n=5)
Mogaka et al. 2019[21] To evaluate and elaborate on the possible effects of an educational intervention containing information about HPV infection and vaccination on parents' decisions in allowing vaccination of their children against HPV infection, consequently impacting the risk of future cervical cancer.	**Participants** Parents (8 studies, n=1751) Adolescent and young adults (3 studies, n=1074) **Gender** Females only (n=1) Males and females (n=2) Parents of females (n=3) Parents of adolescents[b] (n=5) **Age (years)** 18-26 years (n=3) Parents of adolescents[d] (n=8) **Ethnicity** Not reported	**Databases** N=3 PubMed, Science Direct, and Web of Science Google Scholar **Date restrictions** January 2000 to December 2018 **Language restrictions** English	**Number of relevant included studies** N=11 **Study designs** RCTs (n=4) Quasi-experimental (n=7) **Countries of interventions** USA (n=8) China (n=2) India (n=1) **Recruitment** Not reported

STUDY CITATION REVIEW OBJECTIVES	PARTICIPANTS	SEARCH DETAILS	CHARACTERISTICS OF INCLUDED PRIMARY STUDIES
Priest and Knowlden 2015[18] To systematically analyse primary prevention HPV interventions in college students and to develop recommendations to enhance their effectiveness	**Participants** College students (6 studies) N=3029, participants across all included studies **Gender** Females only (n=4) Males only (n=1) Males and Females (n=1) **Age (years)** 18-26 (n=6) **Ethnicity** Not reported	**Databases** N = 6 Academic Search Premier, CENTRAL, CINAHL, ERIC, MEDLINE, SPORTDiscus **Date restrictions** January 2000 to January 2014 **Language restrictions** English	**Number of relevant included studies** N=6 **Study designs** RCT (n=3) Single group pre-test / post-test study (n=3) **Countries of interventions** USA (n=4); Australia (n=1), Canada (n=1) **Recruitment** Colleges/Universities (n=6)
Rodriguez et al. 2019[24] To identify what interventions have successfully increased HPV vaccine initiation or completion in males and females aged 9-26 years	**Participants** Children, adolescents, young adults (30 studies, n=75,117) **Gender** Males only (n=2) Females only (n=19) Males and females (n=9) **Age (years)** All ages 9 to 26 (n=4) Children 9-12 (n=1) Adolescents 13-17 (n=2) Children and adolescents 9-17 (n=10) Young adults 18-26 (n=13) **Ethnicity** Not reported (n=27) Mixed ethnicities (n=1) Korean American (n=1) Haitian American (n=1)	**Databases** N=3 CINAHL, MEDLINE, and Web of Science **Date restrictions** 2006 to 2017 **Language restrictions** English only	**Number of relevant included studies** N=30 **Study designs** RCT (n=14) Quasi-experimental (n=3) Cohort (n=13) **Countries of interventions** USA (n=30) Excluded studies conducted outside the USA **Recruitment** Health care clinics (n=17) University/college (n=7) Schools (n=6) Other (n=4) (postpartum unit, managed care, community setting)

a One study did not specify the number of participants
b Gender of participants not specified
c Unclear if two of the RCTS were randomised
d Age not reported
Key: HCP: healthcare professionals

Table 3. Characteristics of included systematic reviews continued (n=10)

APPRAISAL INSTRUMENTS AND RATINGS	OUTCOME, OUTCOME MEASURES, METHODS OF ANALYSIS	MAIN RESULTS AND FINDINGS OF SYSTEMATIC REVIEWS AS REPORTED BY REVIEW AUTHORS	KEY FEATURES OF SUCCESSFUL INTERVENTIONS	COMMENTS
Abdullahi et al. 2020[25] (10-19 years)				
Cochrane RoB Low, high or unclear risk Low RoB (n=3) Unclear RoB (n=7) High RoB (n=3)	**Outcomes** HPV vaccination uptake rates **Outcome measures** HPV vaccination uptake rates (n=13) **Methods of analysis** Meta-analysis - using the random-effects model if there was no significant statistical heterogeneity, methodological difference, or high risk of bias Mixed-effect logistic regression model	**Recipient-oriented interventions** Health education (adolescents) improves HPV vaccine uptake compared to usual practice Financial incentives may improve HPV vaccine uptake compared to usual practice **Provider-oriented interventions** Provider prompts probably make little or no difference compared to usual practice Provider education with performance feedback may increase the proportion of adolescents who are offered and accept HPV vaccination by clinicians, compared to usual practice **Health system interventions** A class-based school vaccination strategy probably leads to slightly higher HPV vaccine uptake than an age-based school vaccination strategy **Multi-component interventions** A multi-component provider intervention involving adolescents and parents probably improves uptake of HPV vaccine compared to usual practice A multi-component intervention targeting providers and parents involving social marketing and health education may improve HPV vaccine uptake compared to usual practice	**Recipient-oriented interventions** Health education - importance of vaccinations Financial incentives **Health system interventions** School vaccination strategy - class-based rather than age-based approaches **Multi-component interventions** Multi-component provider and parent interventions - vaccination education telephone calls - radio messages **Multi-component provider interventions** - staff education - repeated contacts individualised feedback - incentives	A variety of settings 76% of the included studies were conducted in the USA Interventions too heterogenous to conduct an overall pooled analysis I2 reported inappropriately for analysis conducted with single studies Meta-analysis combined initiation and completion data to report an overall vaccine uptake. Also combined heterogenous interventions of two school-based interventions and one educational intervention conducted with mother and daughter dyads dinner events featuring educational presentations on HPV Most of the evidence is of low to moderate certainty, the exception was health education with high certainty. This implies that while this research provides some indication of the likely effect of these interventions, the likelihood that the effects will be substantially different is high Self-reported vaccine uptake Data on HPV uptake from two of the included studies were not reported within the review The percentage change in HPV vaccine initiation and/or completion across the studies was not reported The review did not provide details of any theoretical models The sample size for one of the studies (8%, 1/13) was less than 200 participants The duration of the interventions where reported varied from a 12 minute interactive presentation to 30-40 minutes, 1 to 2 hour structured educational sessions or 2-3 day curriculum or 6-8 educational visits over 12 months 54% (6/11) of the studies reported the time frame for measuring the outcomes post-intervention which ranged from 3 months to 12 months
Barnard et al. 2019[19] (College students)				
Cochrane RoB Performance bias (n=9) Detection bias (n=9) Selection bias (n=5) Attrition bias (n=1) Reporting bias (n=4)	**Outcomes** HPV vaccination uptake rates **Outcome measures** Uptake of at least one dose (n=6) Overall vaccination rate (n=1) Completion of any dose (n=1) 2nd or 3rd dose of HPV vaccination (n=1) **Methods of analysis** Not reported but findings presented narratively	**Recipient-oriented interventions** While there are many studies demonstrating improvement in vaccination intention, very few interventions targeting college students have demonstrated effectiveness at increasing actual HPV vaccine uptake All but one of the studies had a non-significant treatment effect The studies that achieved at least a 20% uptake of at least the first dose utilised interventions that would be relatively easy to implement as they are relatively inexpensive and easy to disseminate widely	**Health education** - combined peer and medical provider message The interventions that achieved the highest vaccination rates appear to be relatively easy to implement, such as videos, leaflets, and monthly reminders	None of the studies used the same intervention 77% (10/13) of studies were conducted in the USA Authors noted that few studies have examined the impact of intervention vaccine uptake by male students Poor reporting of significance and data from primary studies Ethnicity wasn't reported but one study was conducted with Chinese students Theoretical models were briefly mentioned in the narrative but details from individual studies were not reported Evidence often based on single studies with small sample sizes (33% (3/9) less than 200 participants Duration of the interventions which included videos or direct education was not reported 89% (8/9) of the studies reported the time frame for measuring the outcomes post-intervention which ranged from 4 weeks to 10 months The percentage change in HPV vaccine initiation and/or completion rates were not reported. The vaccine uptake rates ranged from 5% to 53%

APPRAISAL INSTRUMENTS AND RATINGS	OUTCOME, OUTCOME MEASURES, METHODS OF ANALYSIS	MAIN RESULTS AND FINDINGS OF SYSTEMATIC REVIEWS AS REPORTED BY REVIEW AUTHORS	KEY FEATURES OF SUCCESSFUL INTERVENTIONS	COMMENTS
Eisenhauer et al. 2021[20] (9–26 years)				
Revised Cochrane RoB High, low, some concerns Low RoB (n=2) Some concerns (n=4) ROBINS-I High, moderate, low Low RoB (n=4) Moderate RoB (n=1)	**Outcomes** HPV vaccination uptake rates **Outcome measures** HPV vaccine series initiation rates (n=10) HPV vaccine series completion (n=8) **Methods of analysis** Meta analysis: For RCTs, odds ratios and relative risk were calculated using the Mantel–Haenszel method Narrative: Conclusions were drawn based on aggregate comparisons and commonalities of the findings for non-randomised controlled studies	**Multi-component interventions** Pooled analysis of five randomised controlled trials demonstrated a significant increase in the primary outcome of interest, increased vaccination rates, in favour of reminders to promote vaccinations Across all interventions, mixed findings were reported for the effectiveness of interventions on improving HPV vaccine series initiation rates in family practice settings Across all interventions, mixed findings were reported for the effectiveness of interventions on improving HPV vaccine series completion rates in family practice settings	**Multi-component interventions** Multi-component provider and patient intervention occurring at every stage of patient contact (pre-visits, during visit and post visit) - staff education - nurses standing orders - pre-typed consents - patient education - sensory incentives - provider reminders - extended office hours - online educational resources - reminder systems University of Pittsburgh School of Medicine's 4 Pillars Practice Transformation Program - (1) determine the practice's current vaccination rate - (2) select and implement evidence-based strategies from the 4 Pillars - (3) evaluate for an improvement in the vaccination rate	Participants were recorded as being adolescents although in reality interventions would have been completed by parents and providers based on data reported for same studies in other reviews All of the included studies were conducted in the USA One study included data for other vaccines Tdap, MCV as well as HPV Data analysis not stratified by age group and included those added 9 to 26 years Meta-analysis was not appropriate as the authors combined studies where the interventions were different (reminders sent to the patient or system-based reminders for providers) Interventions focusing on reminders (although variations within the interventions which included phone calls; mail; text messages; tailored reminders via iPad in office or provider reminders Details of statistical analysis, including p values, were not consistently reported in the systematic review Poor reporting across primary studies with rates not always reported for intervention and control groups Evidence often based on single studies with small sample sizes (33%, 3/9) of less than 200 participants The review was framed around the health belief model but did not report details of theoretical models from individual studies There was wide variation across the studies for the timing and frequency of reminder messages The time frame for measuring the outcomes post-intervention was not reported Where reported, the percentage change in HPV vaccine initiation rates ranged from 1% to 23.5% and the completion rates from 2% to 20.7%
Fu et al. 2014[27] (Parents, adolescents, young adults or college students)				
Cochrane RoB High, moderate, low Low RoB (n=7) Medium RoB (n=15) High RoB (n=11)	**Outcomes** HPV vaccination uptake rates HPV vaccination intention **Outcome measures** HPV vaccination intention (n=28) HPV vaccination uptake (n=5) **Methods of analysis** Calculated the relative risk and 95% confidence whenever sufficient data were provided, and outcomes involved a comparison of event probabilities If studies reported both between- and within-group comparisons, the authors stated that they preferentially reported between-group comparisons	**Educational interventions** Four studies explored educational interventions that included printed materials, videos or educational sessions, designed to detect change in vaccine uptake in adolescents, college students or young adults. All but one of the studies had a non-significant treatment effect The 6 interventions which included printed materials, videos, a combination of both online materials, or slide presentations involving adolescents or college students which examined effect on vaccination intention found significant improvement as assessed immediately post-intervention regardless of the format and content of the education All except one of the 8 studies targeting parents where the interventions were either printed material, videos or radio advertisements did not show any improvements in vaccination intention.	The review did not identify any clearly superior interventions meriting strong recommendation for wide-spread implementation **Message framing** Some studies did find that gain/loss framing affected HPV vaccination intention under particular circumstances (as demonstrated by significant interactions with other variables including aspects of sexual history; number of vaccinations required for immunity; among persons printed in red versus grey colour; among persons characterised as present-versus future-minded; and among persons characterised as avoidance- versus approach-oriented	None of the studies used the same intervention 54% of studies were conducted in the USA Poor reporting of significance and data from primary studies Well-designed studies adequately powered to detect change in vaccine uptake were rare The majority of studies did not involve any follow-up assessment beyond the period immediately following the intervention. Only one study reported a 6 month follow up period which was conducted using medical record review The duration of interventions varied from HPV educational videos ranging in length from 3 to 10 min to one hour-long live presentations delivered at school The review did not provide details of any theoretical models Evidence often based on single studies with small sample sizes (51%, 17/31) of less than 200 participants The percentage change in HPV vaccine initiation and/or completion across the studies was not reported. The rate of HPV vaccine initiation and/or completion was only reported for 5 studies which ranged from 5.5% to 43.3%

APPRAISAL INSTRUMENTS AND RATINGS	OUTCOME, OUTCOME MEASURES, METHODS OF ANALYSIS	MAIN RESULTS AND FINDINGS OF SYSTEMATIC REVIEWS AS REPORTED BY REVIEW AUTHORS	KEY FEATURES OF SUCCESSFUL INTERVENTIONS	COMMENTS
		The one study (educational video) included a follow-up assessment and although higher intention to be vaccinated was seen immediately post-intervention this was extinguished after 1 month **Message framing** The most common message-framing dichotomy tested in studies that were identified as part of the review was gain- versus loss-framing through printed or online material. None of the ten studies showed significant main effects of gain-/loss-framing Another common framing theme among the identified studies was varying the specifics of HPV disease prevention messages provided to participants, most often between cervical cancer and genital warts prevention messages. None of these 5 studies found any difference in vaccination intention between treatment conditions		
Ilozumba et al. 2021[22] (adolescents, young adults, college students or parents in the USA)				
Cochrane RoB Low, high, some concerns Low RoB (n=3 Some concerns (n=5) High RoB (n=3) JBI appraisal tool for cross sectional studies 100% of bias was attributed to selection bias	**Outcomes** HPV vaccination uptake rates HPV vaccination intention **Outcome measures** HPV vaccination intention (n=2) HPV vaccination series initiation (n=1) HPV vaccination series initiation completion (n=10) 2nd or 3rd dose of HPV vaccination (n=4) HPV vaccination uptake rates (n=3) **Methods of analysis** Not reported but findings presented narratively	**Reminder-based interventions** Despite the variation in mhealth intervention designs, all but four studies reported increases in intent to vaccinate or vaccination uptake Within the context of the United States, mHealth interventions have shown great potential for improving rates of vaccination In communities and countries where vaccination rates are related to issues around scheduling and remembering to vaccinate, simple text messages or appointment phone call reminders might be sufficient to see an increase in uptake However, in contexts where there is active vaccine denial due to lack of knowledge, prevailing attitudes or misinformation, more targeted or tailored health interventions with clear theoretical underpinnings are needed	**Reminder-based interventions** mHealth interventions seem to have a positive impact on uptake although the authors commented that the success of interventions cannot be linked to any specific format of mHealth intervention or any theoretical underpinnings However, four studies indicated that text reminders were more effective than other mHealth reminder methods	Poor reporting of significance and data from primary studies None of the studies used the same intervention 95% (18/19) of studies were conducted in the USA Only three interventions attempted to utilise culturally developed or tailored messages to deliver health education information We found errors in the counting of effective studies when reporting within the text when compared to the data extraction in the tables Two studies included data for other vaccines Tdap, MCV as well as HPV The authors reported in the included studies table that the participants were adolescents whereas the majority of the interventions were delivered to parents. One study was conducted with HIV infected 16-26 year olds but the authors did not report this The authors' narrative summary did not differentiate between studies that were conducted across different participant groups (i.e. adolescents, young adults, college students and parents) or between different outcomes measures (i.e. vaccine initiation or completion, 2nd or 3rd dose of the vaccine) Included two studies with small sample sizes (10%, 2/19) with less than 200 participants (n=23 and n=69) Overall, the majority of the included studies did not elucidate on their theoretical understanding of health education, health communication, mHealth intervention development or adoption There was wide variation across the studies for the timing and frequency of reminder messages The time frame for measuring the outcomes post-intervention was not reported The rate of HPV vaccine initiation and/or completion across the studies was not reported

APPRAISAL INSTRUMENTS AND RATINGS	OUTCOME, OUTCOME MEASURES, METHODS OF ANALYSIS	MAIN RESULTS AND FINDINGS OF SYSTEMATIC REVIEWS AS REPORTED BY REVIEW AUTHORS	KEY FEATURES OF SUCCESSFUL INTERVENTIONS	COMMENTS
Flood et al. 2020[23] (11–19 years)				
QATQS Strong >10 Moderate 6–10 Weak ≤ 5 Strong (n=3) Moderate (n=5) Weak (n=1)	**Outcomes** HPV vaccination uptake rates HPV vaccination intention **Outcome measures** HPV vaccination uptake rates (n=3) HPV vaccination intention (n=6) **Methods of analysis** Not reported but findings presented narratively	**School based educational interventions** There were mixed findings for the effect of the interventions on HPV vaccine uptake for adolescents. Although the authors commented that the combined findings from two large high-quality studies and one smaller study, demonstrate the potential to increase HPV vaccination uptake rates in middle adolescent populations through school-based interventions All of the school based educational interventions improved adolescents' intention to receive the HPV vaccine	School-based educational interventions with few resources can have a significant impact on HPV vaccination uptake especially in countries where the initial uptake of vaccination is quite low The three studies that focused on uptake all encouraged open dialogue around the important issues relating to sexual behaviour and HPV risk	Poor reporting of significance and data from primary studies 55% (5/9) of the studies were conducted with females only 66% (6/9) of studies investigated intention and the authors comment that intention is an unreliable predictor of actual vaccine uptake 80% (4/5) of the studies provided details of theoretical models that they used to guide them in the planning and development of their educational intervention One study had a sample size of less than 200 participants (n=26) The duration of all HPV interventions ranged from 10 minutes to 120 minutes 55% (5/9) of the studies reported the time frame for measuring the outcomes post-intervention at various timepoints up to 6 months post intervention The rate of HPV vaccine initiation and/or completion across the studies was not reported
Lott et al. 2020[28] (9 to 26 years, parents and adolescents) from minority groups				
Cochrane RoB No overall study ratings provided but appraisal provided for different questions Some risk of bias was found for all studies Selection bias: unsatisfactory (n=4), Attrition bias: serious risk (n=4) Non RCT (n=1) Serious risk of bias due to confounding and bias in the measurement of outcomes. Low risk of bias for all other domains	**Outcomes** HPV vaccination uptake rates HPV vaccination intention **Outcome measures** HPV vaccine series initiation rates (n=7) HPV vaccine series completion (n=7) HPV vaccination intent (n=2) **Methods of analysis** Not reported but findings presented narratively	**Multi-component interventions** The authors reported a wide range of minority groups and intervention types, so their ability to compare across the studies was limited. Conflicting results existed across population groups for HPV vaccination initiation and completion The authors also reported that they found limited evidence to suggest educational and reminder interventions may be effective for improving HPV vaccine series initiation and completion in minority populations	**Multi-component interventions** Educational and appointment reminder interventions may improve HPV vaccine series initiation and completion in minority youth in the U.S. The interventions that were associated with significant improvements in series initiation were an educational intervention for Hopi mother-daughter dyads delivered during community dinner events (but only for those with no previous HPV vaccine dose) and an educational intervention with tailored content for 18–25 year old gay and bisexual males delivered alongside monthly vaccination reminders Interventions that aimed to increase contact between patients and providers, may have been more effective than those aimed at providing educational information or addressing vaccine-related attitudes, without any regard for the actual medical appointment or provision of HPV vaccine	All of the included studies were conducted with minority groups in the USA Given the lack of high quality, adequately powered studies, further research is warranted to identify effective strategies for improving HPV vaccine uptake for minority populations Broad "catch-all" type interventions that are not specifically designed to meet the needs of any one participant group may not be as effective for some groups and may exacerbate vaccination inequities This review underscores the need for better tailoring of interventions to specific minority populations in order to maximise effect and use of healthcare resources The review did not provide details of any theoretical models Evidence often based on single studies with small sample sizes (66%, 5/8) less than 200 participants We found errors in the counting of effective studies when comparing the narrative summary to the data extraction in the tables and in the interpretation of odds ratios The percentage change in HPV vaccine initiation and/or completion across the studies was not reported. Series initiation rates ranged from 11.1 to 84% and series completion rates ranged from 5.6% to 74.2%. Studies with a reminder component were associated with an increase of 0–19% in vaccine initiation and an increase of 3.7–37.4% in series completion The duration of interventions was not reported All of the studies reported the time frame for measuring the outcomes post-intervention which ranged from 1 month to 12 months

APPRAISAL INSTRUMENTS AND RATINGS	OUTCOME, OUTCOME MEASURES, METHODS OF ANALYSIS	MAIN RESULTS AND FINDINGS OF SYSTEMATIC REVIEWS AS REPORTED BY REVIEW AUTHORS	KEY FEATURES OF SUCCESSFUL INTERVENTIONS	COMMENTS
Mogaka et al. 2019[21] (18-26; parents of adolescents)				
CASP tools No overall study ratings provided but appraisal provided for different questions The studies evaluated did not report whether participants or researchers were blinded. The authors reported that many studies also did not include standard-treatment or no-treatment control groups	**Outcomes** HPV vaccination uptake rates HPV vaccination intention **Outcome measures** HPV vaccination intention (parental) (n=8) HPV vaccination intention (adolescent) (n=2) HPV vaccine series completion (n=1) **Methods of analysis** Results are reported in percentages and comparison made among the different results In select cases odds ratio with a 95% confidence interval is reported The analysis includes pre- and post-intervention percentages as reported by the authors in their respective articles for a quasi-experimental design study Results from randomised controlled trials comparing vaccination intent between intervention and control groups were reported as percentages	**Educational interventions** The parents that were exposed to the educational intervention had a percentage increase in their intent to vaccinate their children compared to parents that were not exposed. These results were also similar to that of the groups of adolescent and young adults	**Health education** - The presence of a trained social worker who also participated in a question and answer session with the participants after giving out the leaflets	75% of studies were from the USA Poor reporting of significance and data from primary studies and a number of errors detected within the tables when cross checked with the primary sources No within groups statistical analysis presented Intention to vaccinate was treated as equivalent to actual vaccination for the purposes of this systematic review The percentage change in HPV intent across the studies ranged from 7 to 50%. Follow up assessment was only reported for one study which was 9 months after the intervention using medical record review The duration of interventions varied from a 5-minute radio broadcast, HPV educational videos ranging in length from 10 min to 13 min to one hour-long educational slide show presentations The review was framed around the theory of planned behaviour but did not report details of theoretical models from individual studies Evidence often based on single studies with small sample sizes (54%, 6/11) less than 200 participants
Priest and Knowlden, 2015[18] (College students)				
Downs and Black 1998 Low, moderate and high Data not presented for the subset of studies that we extracted that were relevant to this umbrella review	**Outcomes** HPV vaccination uptake rates HPV vaccination intention **Outcome measures** Uptake of at least one dose (n=3) HPV vaccination intention (college students) (n=3) **Methods of analysis** Not reported but findings presented narratively	**Educational interventions** All educational interventions improved college students' intention to receive the HPV vaccine However, there is insufficient evidence to determine if brief, single-session educational interventions are of an appropriate duration to increase HPV vaccine uptake or HPV vaccine series completion. All but one of the studies had a non-significant treatment effect[a]	**HPV vaccination intention** Health education - tailoring materials - HPV specific information - operationalizing theories **HPV vaccination uptake** Health education - combined peer and medical provider message - HPV specific information - use of reminders	None of the studies used the same intervention 66% (4/6) of studies were conducted in the USA Poor reporting of significance and data from primary studies All of the studies mentioned one or more theoretical frameworks when designing the intervention Evidence often based on single studies with small sample sizes (83%, 5/6) of less than 200 participants Authors commented that only one study included men Authors suggest considering booster sessions between doses to improve series completion The duration of all HPV interventions ranged from 5 minutes to 2 hours. All but one study delivered the intervention in a single session Interventions in this review conducted follow up data from 1 month to 6 months. The rate of HPV vaccine initiation and/or completion across the studies was not reported

APPRAISAL INSTRUMENTS AND RATINGS	OUTCOME, OUTCOME MEASURES, METHODS OF ANALYSIS	MAIN RESULTS AND FINDINGS OF SYSTEMATIC REVIEWS AS REPORTED BY REVIEW AUTHORS	KEY FEATURES OF SUCCESSFUL INTERVENTIONS	COMMENTS
Rodriguez et al. 2019[24] (9 to 26 years)				
Cochrane RoB Low, high, unclear No overall study ratings provided but appraisal provided for different question RoB linked to adequacy of the generation of the randomisation sequence: low (n=22), unclear (n=10), high (n=2) RoB resulting from the adequacy of allocation concealment: low (n=5), unclear (n=14), high (n=15) RoB linked to the adequacy of blinding of participants and research personnel: low (n=13), unclear (n=13), high (n=8) RoB related to the blinding of outcome assessors: low (n=4), unclear (n=26), high (n=4) Risk of bias linked to the completeness of outcome data: low (n=25), unclear (n=3), high (n=6)	**Outcome** HPV vaccination uptake rates **Outcome measures** HPV vaccine series initiation rates (n=22) HPV vaccine series completion (n=19) Receipt of any HPV vaccine dose (n=4) **Methods of analysis** Random effects model and the pooled relative incidence estimates, and the corresponding 95% CIs were calculated. Across 17 studies. Heterogeneity was assessed using I2 and the Cochran Q statistic. Statistical tests for asymmetry were determined using funnel plots and accompanied by the Egger test	**Multi-component interventions** Behavioural and informational interventions doubled HPV vaccine initiation Evidence supports behavioural interventions for increasing HPV vaccine initiation and completion Interventions that improved the initiation of the HPV vaccine series were narrative education, reminders, outreach plus reminders, education plus reminders, financial incentives plus reminders, and brief motivational behavioural interventions Tailored education, outreach and education, and brief health messaging were recipient-oriented interventions that had no effect on the initiation of the HPV vaccine series	Recipient-oriented interventions that improved the completion of the HPV vaccine series were tailored education, outreach and education, education plus reminders, reminders in general, financial incentives plus reminders, and brief motivational behavioural interventions The provider-oriented interventions that improved the initiation of the HPV vaccine series were prompts, training, training plus assessment and feedback, consultation, funding, and multi-component interventions Prompts, funding and multi-component features were also found to be provider-oriented interventions that improved the completion of HPV vaccine series	All of studies were conducted in the USA Several subgroup meta-analyses were conducted that did not take the type of interventions into account 30 were included in the review and 17 of these were presented in a meta-analysis. The narrative synthesis does not cover all of the remaining 13 articles and only summarises some of the 17 included in the meta-analysis so complete data extraction was not possible Duration of the interventions which included videos or direct education was not reported The sample size for 20% (6/30) of the studies was less than 200 participants The time frame for measuring the outcomes post-intervention was not reported The review did not provide details of any theoretical models The rate of HPV vaccine initiation and/or completion across the studies was not reported

Key: CASP: critical appraisal skills programme; CI: confidence intervals; mHealth: mobile health; QATQS: quality assessment tool for quantitative studies; RoB: risk of bias

Theoretical underpinnings

Reporting on the use of theoretical models was mixed across the systematic reviews with only two of the systematic reviews providing details of any theoretical models.[18,27] Four did not provide any details of theoretical models[24–27] and in another they were mentioned briefly but details from individual studies were not reported.[19] Two systematic reviews framed the review on either the health belief model[20] or the theory of planned behaviour[21] but did not report details of theoretical models from individual studies. In another systematic review, the majority of included studies did not elucidate on their theoretical understanding of health education, health communication, mobile health intervention development, or adoption.[22]

Across all the included systematic reviews participants across the primary studies were recruited through schools,[18,22,23,25,27] colleges or universities (e.g. via university health clinics or health fairs),[18,19,26,27] community settings[24–27] or health care / clinical settings (e.g. health care clinics, paediatric clinics, planned parenthood centres, outpatient clinics, postpartum units, managed care),[24–27] family and paediatric primary care offices[20] and one further systematic review did not report the location of recruitment.[21]

A variety of methods of analysis were conducted which included a narrative synthesis (n=6),[18,19,21–23,26] meta-analysis using a random effects model.[20,24,25] or conducted relative risk or odds ratios at 95% confidence intervals (n=1).[27]

All those that used meta-analysis had calculated heterogeneity using I^2 (n=3).[20,24,25]

Across all systematic reviews, studies reported varying timeframes in measuring outcomes following interventions: 4 weeks to 10 months,[19] 1-12 months,[26] 3-12 months,[25] 1-6 months,[18], up to 6 months,[23], 6 months[27] and 9 months.[21] However, only one of these systematic reviews reported the time frames for all of their included studies.[26] Additionally, three systematic reviews did not report any time frames used by studies for measuring the outcomes post-interventions.[20,22,24]

Findings of the review

Numerous and varied types of interventions were reported across the included systematic reviews. To organise the various interventions in a meaningful way an adapted version[15,16] of the social ecological model[17] was employed to identify the levels at which HPV vaccination interventions have targeted change at: the individual, community and organisational levels. The nature of the interventions is outlined in the first part of this section. The effectiveness of interventions for HPV vaccination intention and HPV vaccination uptake is presented in the final part of this section in relation to children and adolescents, parents, and young adults. The findings reported for young adults are based on some studies that recruited from college settings and some that recruited from community settings.

Details of interventions

Individual level

Interventions that focused on change at the level of the individual included a range of educational, promotional nudge based, reminder-based and incentive-based strategies as detailed below.

Educational strategies

There were a wide variety of different educational strategies used across interventions which included:

- Face-to-face presentations delivered as talks or slideshows[18,21,23,27] (one study reported across several of the included reviews used a theoretical framework to inform the presentation[18,24,26])
- Face-to-face presentations plus additional components which included printed information, Facebook discussions, role plays, discussion, other unspecified activities[18,23]
- Brief negotiated interviewing[24,26]
- Technology mediated presentations using videos (with or without message framing), iPads, photographic short stories, online storytelling[18,21–23,25,26]
- Technology mediated presentations plus additional components which included printed information[27]
- Printed information such as leaflets, brochures, folders, postcards[18,20,21,23,24,27]
- Printed information plus additional components which included Q&A sessions, quizzes, a range of other community activities[21,25,27]
- Printed information with or without message framing[21,27]
- Online information with or without message framing[27]
- Text message based health education information[22]

Eight of the reviews[18,19,21,22,24–27] provided detailed descriptions of the content of the printed materials given to participants which included:

- Information on aspects of HPV epidemiology and the potential morbidity associated with HPV infection
- Information for parents regarding the current or future availability of an HPV vaccine to protect children against infection
- The connection between HPV, cervical cancer and genital warts (but with little if any discussion around oropharyngeal cancer)
- HPV vaccine as a means of primary prevention including vaccine recommendations, vaccine schedules, vaccine efficacy and vaccine safety
- Other issues were sometimes incorporated into educational literature which included types of sexually transmitted infections and modes of transmission, long-term complications, prevention of sexually transmitted infections and condom use.

There was wide variation across the timing, duration and nature of educational interventions. For example ranging from shorter presentations (3–13 minutes,[21,25,27] a 5 minute radio broadcast,[21] 30–40 minutes[25] or 1–2 hours presentations) to longer 2-3 day curriculum sessions[25] or 6-8 educational visits over 12 months.[25] Some systematic reviews did not report the duration of interventions that included videos or direct education.[19,24,26] Others only reported that the timing and frequency of reminder messages varied widely.[20,22]

Educational components were delivered by a variety of role holders, including professionals with a nursing, healthcare or medical background, school health and social care teachers, science teachers, community health workers, social workers, peers, members of research teams and a combination of peer and healthcare providers.

Promotional nudge based strategies

A nudge using promotional material such as a keychain was described in two systematic reviews.[25,26]

Reminder-based strategies

Reminders delivered via text messages, letters, postcards, telephone calls, pre-recorded voice messages, emails or Facebook messages were described in four systematic reviews.[20,22,24,26]

Incentive-based strategies

Incentives to complete the vaccine series included financial, non-financial and non-sensory rewards. Financial incentives included: reimbursement of expenses, gift vouchers and free of charge vaccines. Non-financial incentives included t-shirts, food (pizza, evening dinner events) and prizes.[24–26] Sensory incentives, included opportunities to hit a special 'HPV gong' or a pet known as an 'HPV Prevention Pup'.[20]

Community level

Two different types of interventions focused on change at the level of the community and included radio features and public health strategies. Radio features included advertisements or announcements,[21,27] in some instances also with message framing.[27] Public health strategies included school-based vaccination programmes, a practice based "vaccine blitz", vaccine walk-in clinics and express clinics.[20,24]

Organisational level

There were several different types of provider-oriented interventions that focused on change at the organisational level. These included continuing professional education, electronic health record alerts, a vaccination coordinator post, home visits, health information technology systems, nurse standing orders and pre-typed consents.[20,24]

Multi-component strategies

A number of systematic reviews also reported multiple-component strategies, some of which were targeted at just one level or across multiple levels. These included:

- Educational interventions and promotional nudge
- Educational and reminder-based and/or incentive-based strategies
- Reminders and incentives
- Provider-oriented interventions and reminder-based and/or incentive-based strategies
- Provider-oriented interventions and incentives
- Provider-oriented interventions and public health interventions
- Public health interventions, education and radio features

Effectiveness of interventions for HPV vaccination intention

Table 4 provides an overall summary of evidence for the effectiveness of interventions for HPV vaccination **intention**. The accompanying logic model of effective interventions is displayed in Figure 6.

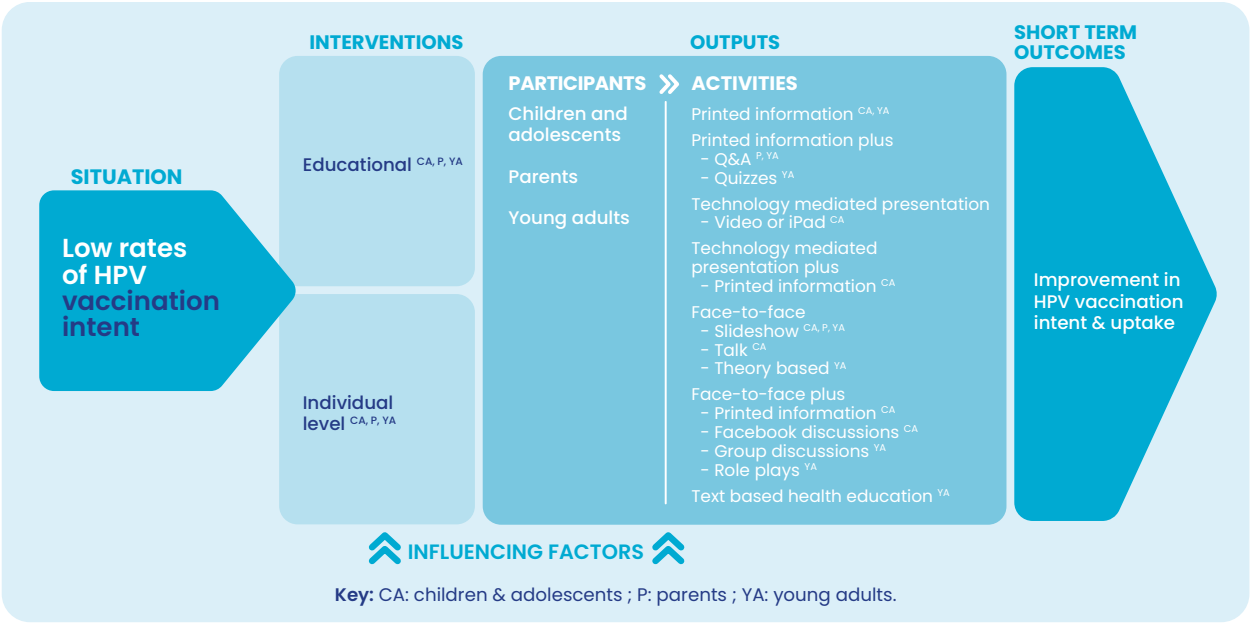
Table 4. Summary of evidence for the effectiveness of educational interventions for HPV vaccination intention

	INTENTION		
INTERVENTIONS	CHILDREN OR ADOLESCENTS	PARENTS	YOUNG ADULTS
Printed Information			
Printed information with message framing			
Printed information plus			
Technology mediated presentation - IPad or Video			
Technology mediated presentation - Stories			
Technology mediated presentation plus			
Face-to-face presentation			
Face-to-face presentation plus			
Text based information			
Online information with message framing			
Radio features			
Radio features with message framing			

Key: 'Plus' refers to a range of additional components

- Intervention leads to improvement in HPV vaccination intention
- Intervention does not lead to an improvement in HPV vaccination intention
- Intervention does not consistently lead to an improvement in HPV vaccination intention (some studies showing improvement and others not)
- Not reported

Figure 6. Logic model for HPV vaccination intention interventions



Key: CA: children & adolescents ; P: parents ; YA: young adults.

Interventions aimed at children and adolescents

Interventions from nine studies reported across three systematic reviews[21,23,27] investigated children and adolescents' HPV vaccination intention. They all used a variety of educational strategies targeted at the individual level (see below and Appendix 4). All but one of the nine studies showed a significant positive effect of the intervention on HPV vaccination intention. Interventions that appeared to be effective included educational strategies that used face-to-face presentations (talks or slideshows), face-to-face presentations plus (printed information or Facebook discussions), printed information, technology mediated presentations (videos or iPads) and technology-mediated presentations (videos and printed information). An educational strategy that used technology mediated presentations (to deliver a photographic short story) did not appear to improve HPV vaccination intention.

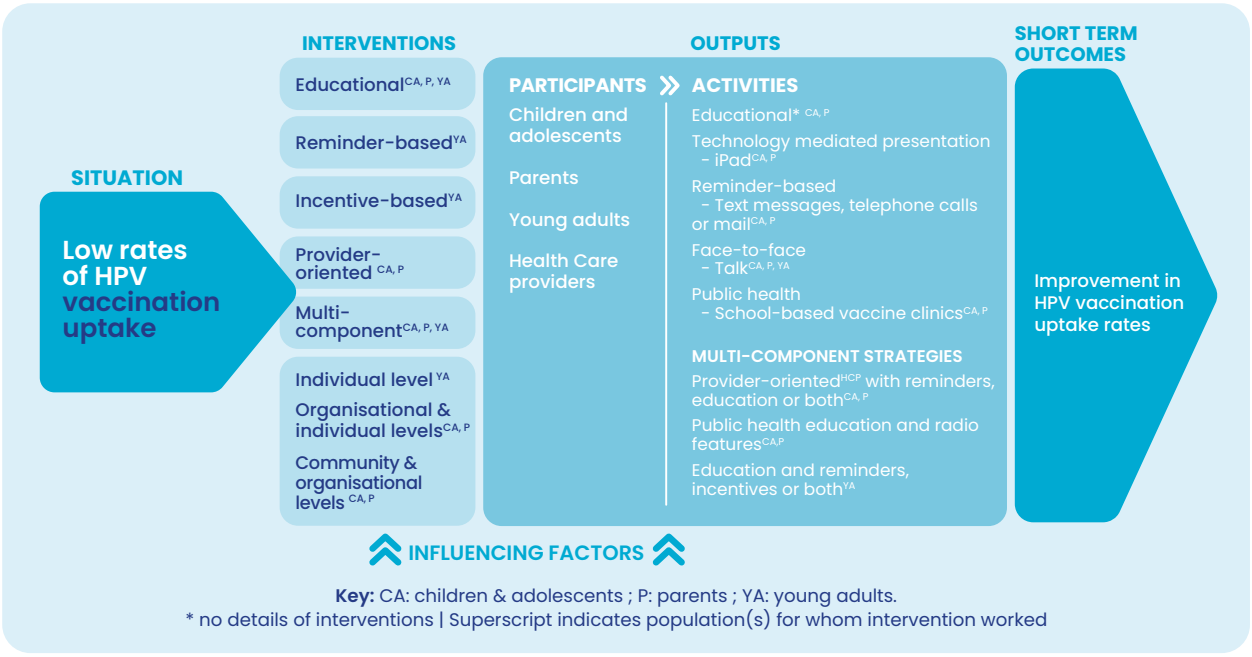
Interventions aimed at parents

Interventions from 15 studies across four systematic reviews[21,22,26,27] investigated parental HPV vaccination intention. These were all delivered in community settings and used a variety of educational strategies (see Appendix 5). Interventions that appeared to be effective included educational strategies that used face-to-face presentations (slideshows), printed information plus (Q&A sessions). There were mixed findings in relation to technology mediated presentations (videos or iPads) and printed information (with or without message framing). Educational strategies that used radio features and online information (with message framing) did not appear to improve HPV vaccination intention.

Interventions aimed at young adults

Interventions from 15 studies across four systematic reviews[18,22,26,27] investigated parental HPV vaccination intention. These were all delivered in community settings and used a variety of educational strategies (see Appendix 6). Interventions that appeared to be effective included educational strategies that used face-to-face presentations (slideshows), face-to-face plus (theory-based slideshow, discussion and role plays), printed information plus (Q&A sessions and quizzes) and text-based health education. There were mixed findings regarding technology mediated presentations (videos or iPads), printed information (with or without message framing) and online information (with message framing). Educational strategies that used radio features, and technology mediated presentations (to deliver culturally appropriate storytelling to specific ethnic groups) did not appear to improve HPV vaccination intention.

Figure 7. Logic model for HPV vaccination uptake interventions

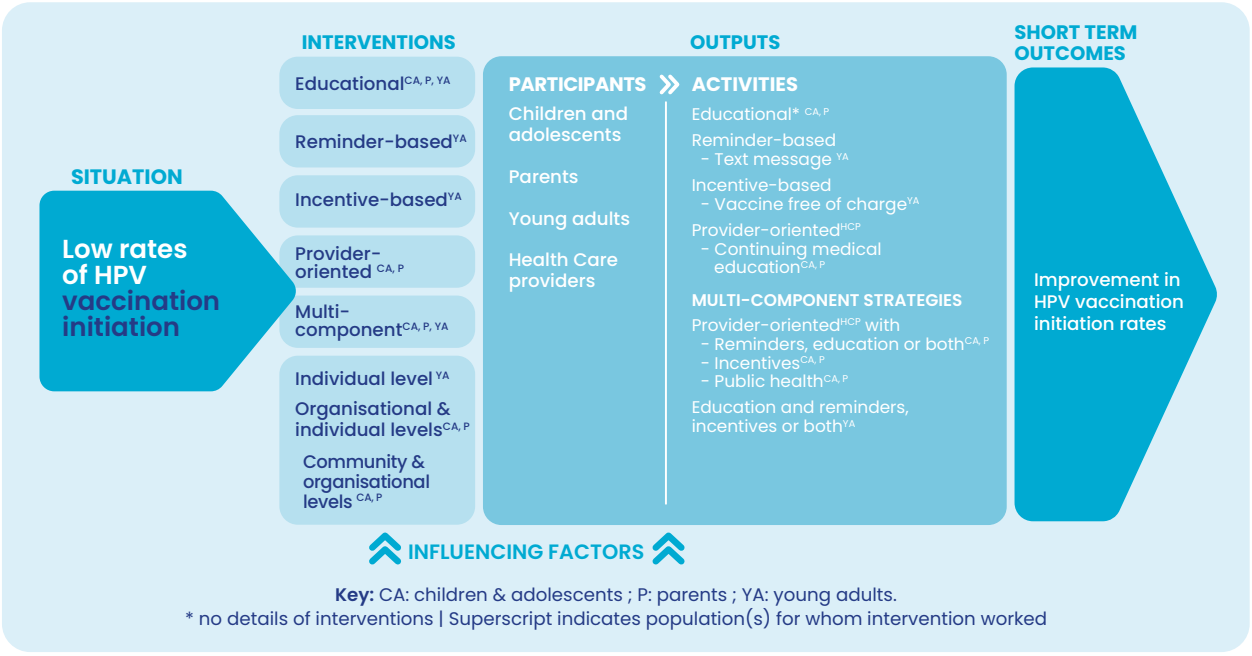


Key: CA: children & adolescents ; P: parents ; YA: young adults.
* no details of interventions | Superscript indicates population(s) for whom intervention worked

Effectiveness of interventions for HPV vaccination uptake

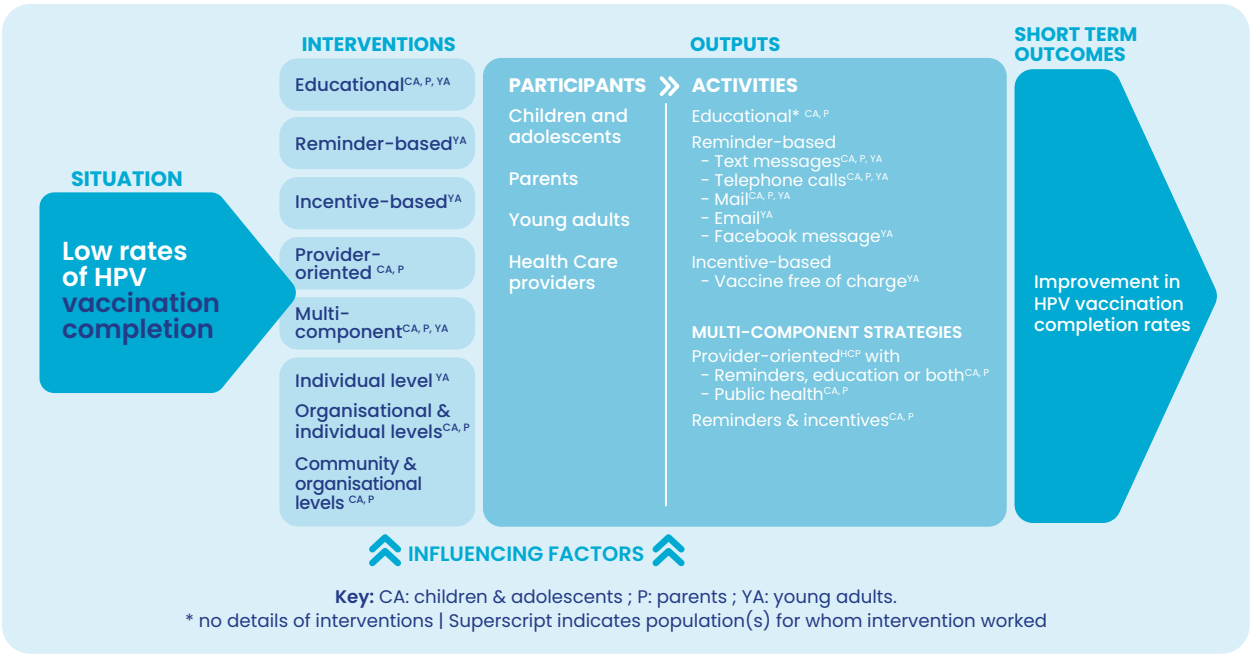
Table 5 gives an overall summary of evidence for the effectiveness of interventions for HPV vaccination uptake and the accompanying logic model of effective interventions are displayed in Figures 7 to 9. Where provided, the data for this outcome was reported as presented within the included reviews (vaccine initiation (dose 1), vaccine completion (dose 3) or overall vaccine uptake) and presented for each population group separately. For overall vaccine uptake the reviews used varying terminology and reported on 'completion of dose 2 or 3', 'completion of at least one dose', 'HPV vaccination', 'completion' or only referred to 'vaccine uptake' without any further explanation. For the purposes of this review these are all termed 'vaccine uptake'.

Figure 8. Logic model for HPV vaccination initiation interventions



Key: CA: children & adolescents ; P: parents ; YA: young adults.
* no details of interventions | Superscript indicates population(s) for whom intervention worked

Figure 9. Logic model for HPV vaccination completion interventions



Key: CA: children & adolescents ; P: parents ; YA: young adults.
* no details of interventions | Superscript indicates population(s) for whom intervention worked

Interventions aimed at children, adolescents and parents

Interventions conducted with children, adolescents and parents from 17 studies reported across four systematic reviews[20,22,24–27] investigated HPV vaccination initiation rates and used educational (one study), reminder (three studies) or multi-component strategies (13 studies). These were targeted at the individual level (eight studies), both the organisational and individual levels (five studies) or both the community and organisational level (one study) (see Appendix 7). Ten studies showed a significant positive effect of the intervention on HPV vaccination initiation rates. Interventions that appeared to be effective included educational strategies (but no further details were provided) and multi-component interventions that involved provider-oriented strategies. Multi-component interventions that involved an educational component alongside reminder or incentive strategies and stand-alone reminder strategies had mixed results. Multi-component interventions involving education, reminders and/or incentives conducted with mothers or mother/daughter dyads and a multi-component intervention with a promotional nudge (keychain) did not appear to improve HPV vaccination initiation rates.

Interventions from 22 studies reported across six reviews[20,22–26] investigated HPV vaccination completion rates and used educational (one study), reminder-based (five studies) or multi-component strategies (16 studies) targeted at either the individual level (four studies) or both the organisational and individual levels (14 studies (see Appendix 7). 18 studies showed a significant positive effect of the intervention on HPV vaccination completion rates. Interventions that appeared to be effective included reminder-based strategies, educational strategies (but no further details were provided) and multi-component interventions that involved provider-oriented strategies. The stand-alone reminder-based strategies included text messages, telephone calls, pre-recorded voice messages or postcards. Where evaluated, text messages were more effective than other methods. Multi-component interventions that involved an educational component alongside reminder or incentive strategies had mixed results.

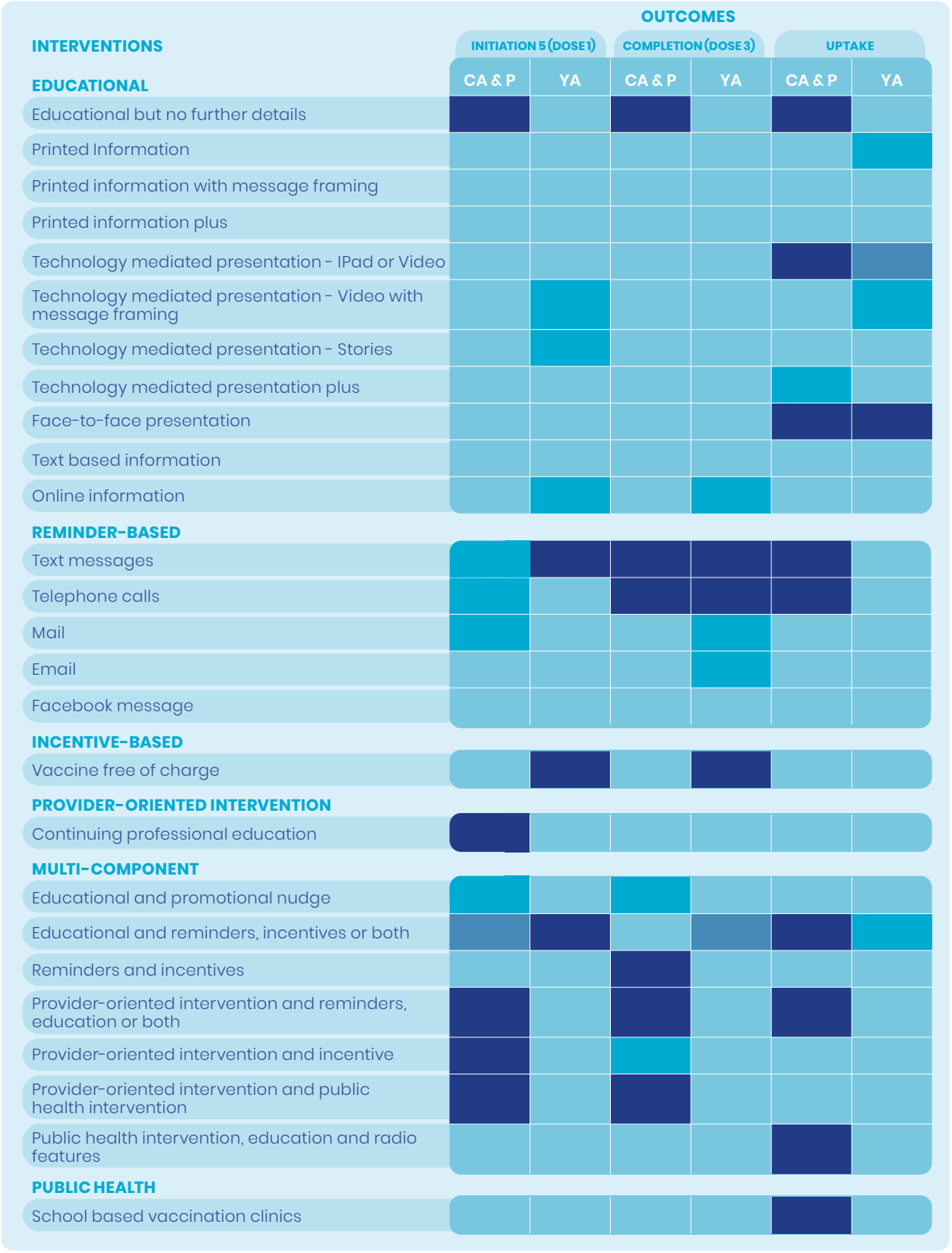
Interventions from 13 studies reported across four systematic reviews[22–25] investigated HPV vaccination uptake rates and used educational (four studies), organisational (one study), public health (one study), reminder-based (three studies) or multi-component strategies (three studies), targeted at either the individual level (three studies), organisational (two studies) level, organisational and individual levels (two studies) or community and individual levels (one study) (see Appendix 7). Five studies did not clarify how they were defining uptake, with the remaining studies defining uptake as HPV vaccination initiation or completion, change in HPV vaccination status or uptake of at least one dose. All studies except one showed a significant positive effect of the intervention on HPV vaccination uptake rates. Interventions that appeared to be effective included educational strategies (but no further details were provided), educational strategies involving face-to-face presentations (a talk), technology mediated presentations (iPad), reminder-based strategies, public health strategies (a school-based vaccination clinic) and multi-component interventions strategies (public health, education and radio features; education, reminders, incentives or both; provider-oriented and reminders, education or both). The stand-alone reminder-based strategies included text messages, telephone calls or mailed reminders. Where evaluated, text messages were more effective than other methods. Face-to face presentations plus a range of classroom-based activities did not appear to be effective in improving HPV vaccination uptake rates.

Interventions conducted with young adults

Interventions from 10 studies reported across four systematic reviews[19,22,24,26] investigated HPV vaccination initiation rates and used educational (three studies), public incentive-based (five studies), reminder-based (one study) or multi-component strategies (one study) which were all targeted at the individual level (see Appendix 8). Nine studies showed a significant positive effect of the intervention on HPV vaccination initiation rates. Interventions that appeared to be effective included reminder-based strategies (text messages), incentive-based strategies (where the vaccine was provided free of charge (USA) or included a $25 gift voucher) and multi-component interventions that involved an educational component alongside a reminder-based strategy. Educational interventions that involved online information, technology mediated presentations (video with or without message framing with online story telling) did not appear to improve HPV vaccination initiation rates.

Interventions from nine studies reported across six systematic reviews[19,21,22,24,26,27] investigated HPV vaccination completion rates and used educational (one study), reminder-based (three studies),

Table 5. Summary of evidence for the effectiveness of interventions for HPV uptake



Key: CA: children and adolescents, P: parents; plus refers to a range of different additional components; YA: young adults

- Intervention leads to improvement in HPV vaccination uptake
- No Intervention does not lead to an improvement in HPV vaccination uptake
- Intervention does not consistently lead to an improvement in HPV vaccination uptake (some studies showing improvement and others not)
- Not reported

incentive-based studies (three studies) or multi-component strategies (two studies) which were all targeted at the individual level (see Appendix 8). Seven studies showed a significant positive effect of the intervention on HPV vaccination completion rates. Interventions that appeared to be effective included reminder-based strategies (using texts, telephone messages, mail, email, Facebook messages) and incentive-based strategies (where the vaccine was provided of free of charge in the USA). Educational strategies (online information) did not appear to improve HPV vaccination initiation rates.

Interventions from seven studies reported across six systematic reviews[19,21,22,24,26,27] investigated HPV vaccination uptake rates and used educational (one study), reminder-based (three studies), incentive-based studies (three studies) or multi-component strategies (two studies) which were all targeted at the individual level (see Appendix 8). Only two studies showed a significant positive effect of the intervention on HPV vaccination initiation rates. Interventions that appeared to be effective were educational strategies (language-specific peer-to-peer education to Chinese students at a USA university). Multi-component interventions that involved an educational component alongside a reminder or incentive-based strategy did not appear to improve HPV vaccination initiation rates. Educational interventions that involved technology mediated presentations with or without message framing had mixed results. However, when the narratives with the video were led by peers and medical experts' vaccination uptake significantly improved.

Adverse effects

Only one systematic review[25] reported on adverse effects as a secondary outcome of the interventions, noting that only one included study considered this. This study reported that health education did not have any adverse effects in relation to usual practice.

Quality of the evidence

An overall assessment of the quality of the evidence for each comparison using GRADE (Grading of Recommendations, Assessment, Development and Evaluation) was not possible. This was because of all the systematic reviews included in this umbrella review only one completed GRADE[25] and the quality of the evidence for all outcomes of relevance are presented in Appendix 7 and ranged from low to moderate certainty.

Discussion

This umbrella review (a systematic review of systematic reviews) was conducted to explore the effectiveness of interventions designed to improve uptake of HPV vaccination and HPV vaccination intention. Importantly, these systematic reviews were undertaken before the Covid-19 pandemic which raised specific concerns regarding vaccine hesitancy alongside public health measures, such as social distancing, to prevent viral spread. Inconsistencies and gaps in the reporting of the underpinning systematic reviews and poor geographical representation among the included studies means that the findings need to be interpreted with some caution.

The HPV vaccine can protect against the types of HPV that can lead to cervical cancer, other anogenital cancers, oropharyngeal cancer, and genital warts for both males and females.[29] In order to reach national vaccination goals and to reduce HPV-related cancer disparities, effective interventions are needed to increase HPV vaccination uptake.[29] It is important, therefore, that vaccination intent is translated into vaccination behaviour and effective interventions identified.

The long-term impact of HPV vaccination programmes on HPV-related disease is clearly demonstrable. Data from over a 10 year period from the National HPV Vaccination Programme in Australia showed substantial declines in high-grade cervical disease and genital warts for both women and men.[30] Recent data from a large observational study for the National Vaccination Programme in England showed substantial reductions in cervical cancer and cervical carcinoma in situ among young women after the introduction of the HPV vaccination programme, especially in individuals who were offered the vaccine at age 12–13 years.[3] It has also been postulated that there will be a decrease in the number of colposcopies and detected high-grade cervical intraepithelial lesions (CIN2+)[31] leading to a reduction in colposcopy workload and associated clinical activity.[32]

HPV vaccination intention

It has previously been reported that personal intentions to receive the HPV vaccine vary substantially; from 48% to 96%.[33] In this umbrella review intentions were reported to be from as low as 24% pre-intervention to as high as 90%

post-intervention depending on whether the target was parental intent for their child to have the vaccine or whether it was intent to have the vaccine oneself. This umbrella review found that systematic reviews that explored vaccination intentions included a wide range of educational interventions that focused on change at an individual level. Factors related to the intervention design that increased intention were timings, duration and delivery methods or sources. It does appear however, that educational interventions targeted at children and adolescents as well as parents have more success than those targeted solely at parents.

HPV vaccination uptake

It is important to note that the impact interventions have is context specific, in other words, what works in one setting may not work in another. The baseline vaccination coverage rates reported within the individual studies within this umbrella review varied greatly and, where reported, ranged from 1% to 53%. Additionally, the percentage change in HPV vaccination initiation and/or completion across the studies was often not reported. A recent survey in the WHO European region demonstrated that only ten countries have a defined target vaccine coverage rate for HPV vaccination. In addition, only four of these ten countries report target vaccination coverage rates that are in line with the WHO elimination goals.[34] This is of relevance since baseline coverage determines the potential impact of an intervention. For example, an intervention that increases coverage from 30% to 60% in a particular context may not work to raise coverage from 60% to 90% elsewhere or even within the same population because the needs of populations and sub-populations differ. Indeed, it has been reported that many countries that start with suboptimal HPV vaccination coverage during the first two years of implementation are unable to reach high coverages during subsequent years.[35] Although specific interventions can be helpful, their impact may be limited especially if overall trust in vaccines is low.[36]

Influencing factors

Eisenhauer et al. (2021) suggested that certain demographic factors which they called "unmodifiable demographic variables" could contribute to a person's decision to vaccinate.[20] These include age, sex, race, setting and insurance coverage. However, only one of their included systematic reviews explored the influence of race/ethnicity on uptake and two further systematic reviews presented findings separately for gender.[24,25] As with educational interventions aimed at improving vaccination intention, influencing factors for interventions aimed at improving uptake were related to the intervention design with regard to timings, duration and delivery methods or sources.

Multi-component strategies

This umbrella review found that provider-oriented interventions (such as professional education, electronic health record alerts, a vaccination coordinator post, home visits, health information technology systems, nurse standing orders and pre-typed consents) with the additional components of reminder-based strategies and/or incentive-based strategies and/or education strategies appeared to be effective. Also, public health interventions with the additional components of education strategies and radio features and educational strategies with the additional components of reminder-based strategies and/or incentive-based strategies appeared to be effective. These findings concur with the work of Fernandez et al. (2010) who suggested that multi-component strategies that impact across all levels of the social-ecological model are likely to be most effective in increasing HPV vaccination uptake.[33]

Limitations of the evidence base

The generalisability of the findings from this umbrella review is limited by the high prevalence of studies from the USA. For all but one of the systematic reviews, more than half of included studies were from the USA (range 54% to 100%),[23] with three reviews exclusively including studies from the USA.[20,24,26]

There were a range of methodological concerns in the included systematic reviews including small sample sizes, poor and/or incorrect reporting of statistical analyses in the primary studies and inappropriate combining of studies in a meta-analysis. Many studies utilised just one intervention group with a pre-test, post-test design or two intervention groups without a control condition for comparison.

The primary outcome across most of the studies was self-reported vaccination behaviour as opposed to actual vaccination behaviour and vaccine intent was often used as a proxy for vaccination receipt.

In addition, very few studies have examined the impact of interventions on vaccine uptake among male students or across different ethnic groups.

It is worth noting that very few studies within the included systematic reviews provided any details of theoretical models that they used to guide them in the planning and development of their interventions.

Conclusion

Our umbrella review reveals that that there is no single magic bullet solution to increasing HPV vaccination uptake or intention. Interventions that work to increase initiation do not always work to increase completion for example and different approaches may be more suited to some populations and contexts than others. What has emerged is that face-to-face presentations, printed information and supplementing both strategies with additional components appear to be effective at increasing vaccination intention. Furthermore, reminders and multi-component strategies, especially those that include some intervention aimed at provider level services appear to be effective at increasing vaccination uptake. More needs to be done to improve vaccine delivery systems across the European region and ensure HPV vaccine uptake is maximised. This umbrella review provides a comprehensive evidence base to build upon.

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Appendices

Appendix 1. Search strategies

Cinahl – Conducted 29th July 2021

S1	(MH "Child")	487,449
S2	(MH "Adolescence+")	558,393
S3	MH "Young Adult") OR (MH "Students, College") or (MM "Students")	294,808
S4	TI (adolescen* or teen* or child* or "young adult*" or "young person" or "young people" or youth or juvenile* or girl* or boy* or "young wom?n" or "young m?n" student* or college* or universit*) or AB(adolescen* or teen* or child* or "young adult*" or "young person" or "young people" or youth or juvenile* or girl or boy or "young wom?n" or "young m?n" or student* or college* or universit*)	983,959
S5	(MM "Adolescent Health Services")	2,037
S6	S1 OR S2 OR S3 OR S4 OR S5	1,462,640
S7	(MH "Vaccines")	9,156
S8	(MH "Vaccination Coverage")	628
S9	TI (Gardasil or Cervarix or Vaccin* or Immunis* or Immuniz* or Inoculat* or Jab* or Shot* or Injection*) or AB (Gardasil or Cervarix or Vaccin* or Immunis* or Immuniz* or Inoculat* or Jab* or Shot* or Injection*)	134,324
S10	(MM "Papillomavirus Vaccine")	3,685
S11	(MH "Immunization+")	29,600
S12	S7 OR S8 OR S9 OR S10 OR S11	144,478
S13	(MH "Papillomavirus Infections+")	11,808
S14	(MH "Papillomaviruses")	5,459
S15	TX (HPV or papillomavirus or papilloma or papillomaviridae)	25,815
S16	S13 OR S14 OR S15	27,116
S17	TI (uptake or coverage or complet*or accept* or intention* or hesitan*or refus* or engag* or adher* or rate* or concordan*or adher* or nonadher* or non-adher* complian* or comply* or noncomplian* or non-complian* or noncomply* or non-comply* complier* or noncomplier* or non-complier* accept* or nonaccept* or non-accept* or abandon* or co-operat* or cooperat* or unco-operative* or uncooperative* or nonco-operat* or noncooperat* or non-cooperat* or willing* or confidence) or AB (uptake or coverage or complet*or accept* or intention* or hesitan*or refus* or engag* or adher* or rate* or concordan*or adher* or nonadher* or non-adher* complian* or comply* or noncomplian* or non-complian* or noncomply* or non-comply* complier* or noncomplier* or non-complier* accept* or nonaccept* or non-accept* or abandon* or co-operat* or cooperat* or unco-operative* or uncooperative* or nonco-operat* or noncooperat* or non-cooperat* or willing* or confidence or awareness)	1,030,749
S18	TI (trial or intervention* or effect* or impact* or initiative* or strategy or strategies or program* or practice* or efficacy or efficiency or implement* or evaluat* or assess* or address* or campaign* or approach* or improv* or increas*) or AB (trial or intervention* or effect* or impact* or Initiative* or strategy or strategies or program* or practice* or efficacy or efficiency or implement* or evaluat* or assess* or address* or campaign* or approach* or improv* or increas*)	3,607,894
S19	Ti (review* or meta*) or AB (review* or meta*)	899,820
S20	(MM "Meta Analysis")	1,863

S21	(MM "Systematic Review")	1,503
S22	S19 OR S20 OR S21	900,245
S23	S6 AND S12 AND S16 AND S17 AND S18 AND S22	214
S24	S6 AND S12 AND S16 AND S17 AND S18 AND S22 - English language	214
S25	S6 AND S12 AND S16 AND S17 AND S18 AND S22 - 2011-2021	186

Ovid MEDLINE(R) ALL – Conducted 28th July 2021

1	exp Papillomavirus Infections/ (37122)
2	exp papillomaviridae/ (34511)
3	exp papillomavirus vaccines/ (8694)
4	HPV.mp. (45632)
5	papillomavirus.mp. (51921)
6	papilloma.mp. (23650)
7	papillomaviridae.mp. (26101)
8	1 or 2 or 3 or 4 or 5 or 6 or 7 (83903)
9	exp Vaccination/ or exp vaccination coverage/ (91316)
10	exp Immunization/ or exp immunization programs/ (191417)
11	exp Vaccination Refusal/ (575)
12	exp Vaccines/ (242235)
13	(Gardasil or Cervarix or Vaccin* or Immunis* or Immuniz* or Inoculat* or Jab* or Shot* or Injection*).ti,ab. (1128225)
14	9 or 10 or 11 or 12 or 13 (1222710)
15	exp Adolescent/ (2109979)
16	exp Child/ (1991198)
17	exp Young Adult/ or exp youth/ or exp Students/ (2631978)
18	(Adolescen* or Teen* or Child* or "young person*" or "young adult*" or "young people" or Youth* or Juvenile* or boy* or girl* or "young wom?en" or "young m?n" or college* or universit* or student*).tw. (2583476)
19	exp Adolescent Health Services/ (5744)
20	15 or 16 or 17 or 18 or 19 (4742777)
21	(uptake or coverage or complet*or accept* or intention* or hesitan*or refus* or engag* or adher* or rate* or concordan*or adher* or nonadher* or non-adher* complian* or comply* or noncomplian* or non-complian* or noncomply* or non-comply* complier* or noncomplier* or non-complier* accept* or nonaccept* or non-accept* or abandon* or co-operat* or cooperat* or unco-operative* or uncooperative* or nonco-operat* or noncooperat* or non-cooperat* or willing* or confidence or awareness).ti,ab. (4562006)
22	(trial* or intervention* or effect* or impact* or Initiative* or strateg* or program* or practice* or efficac* or efficienc* or implement* or evaluat* or assess* or address* or campaign* or approach* or improv* or increas*).ti,ab. (16891772)
23	exp Meta-Analysis/ or "systematic review"/ (231446)
24	(review* or meta*).ti,ab. (4659391)
25	23 and 24 (222127)

26 8 and 14 and 20 and 21 and 22 and 25 (104)

27 limit 26 to english language (102)

28 limit 27 to yr="2011 -Current" (94)

Embase – Conducted 28th July 2021

1 exp Papillomavirus Infections/ (30552)

2 exp papillomaviridae/ (48981)

3 exp papillomavirus vaccines/ (14958)

4 HPV.mp. (58252)

5 papillomavirus.mp. (55610)

6 papilloma.mp. (27158)

7 papillomaviridae.mp. (2203)

8 1 or 2 or 3 or 4 or 5 or 6 or 7 (100708)

9 exp Vaccination/ or exp vaccination coverage/ (156267)

10 exp Immunization/ or exp immunization programs/ (266626)

11 exp Vaccination Refusal/ (645)

12 exp Vaccines/ (290302)

13 (Gardasil or Cervarix or Vaccin* or Immunis* or Immuniz* or Inoculat* or Jab* or Shot* or Injection*).ti,ab. (1086642)

14 9 or 10 or 11 or 12 or 13 (1199295)

15 exp Adolescent/ (1264780)

16 exp Child/ (2066154)

17 exp Young Adult/ or exp youth/ or exp Students/ (3189330)

18 (Adolescen* or Teen* or Child* or "young person*" or "young adult*" or "young people" or Youth* or Juvenile* or boy* or girl* or "young wom?en" or "young m?n" or college* or universit* or student*).tw. (2963367)

19 exp Adolescent Health Services/ (80934)

20 15 or 16 or 17 or 18 or 19 (4437945)

21 (uptake or coverage or complet*or accept* or intention* or hesitan*or refus* or engag* or adher* or rate* or concordan*or adher* or nonadher* or non-adher* complian* or comply* or noncomplian* or non-complian* or noncomply* or non-comply* complier* or noncomplier* or non-complier* accept* or nonaccept* or non-accept* or abandon* or co-operat* or cooperat* or unco-operative* or uncooperative* or nonco-operat* or noncooperat* or non-cooperat* or willing* or confidence or awareness).ti,ab. (5286731)

22 (trial* or intervention* or effect* or impact* or Initiative* or strateg* or program* or practice* or efficac* or efficienc* or implement* or evaluat* or assess* or address* or campaign* or approach* or improv* or increas*).ti,ab. (18170552)

23 exp Meta-Analysis/ or "systematic review"/ (409307)

24 (review* or meta*).ti,ab. (5111415)

25 23 and 24 (368778)

26 8 and 14 and 20 and 21 and 22 and 25 (144)

27 limit 26 to english language (140)

28 limit 27 to yr="2011 -Current" (131)

Global Health – Conducted 29th July 2021

1 exp papillomaviridae/ (20605)

2 HPV.mp. (18308)

3 papillomavirus.mp. (18124)

4 papilloma.mp. (3076)

5 papillomaviridae.mp. (20607)

6 1 or 2 or 3 or 4 or 5 (22753)

7 exp Vaccination/ or exp vaccination coverage/ (73920)

8 exp Immunization/ or exp immunization programs/ (90912)

9 exp Vaccines/ (79769)

10 (Gardasil or Cervarix or Vaccin* or Immunis* or Immuniz* or Inoculat* or Jab* or Shot* or Injection*).ti,ab. (245158)

11 7 or 8 or 9 or 10 (251144)

12 exp Adolescent/ or exp Children/ (324640)

13 exp Young Adult/ or exp youth/ or exp students/ or exp college students/ (62182)

14 (Adolescen* or Teen* or Child* or "young person*" or "young adult*" or "young people" or Youth* or Juvenile* or boy* or girl* or "young wom?en" or "young m?n" or college* or universit* or student*).tw. (563312)

15 12 or 13 or 14 (563317)

16 (uptake or coverage or complet*or accept* or intention* or hesitan*or refus* or engag* or adher* or rate* or concordan*or adher* or nonadher* or non-adher* complian* or comply* or noncomplian* or non-complian* or noncomply* or non-comply* complier* or noncomplier* or non-complier* accept* or nonaccept* or non-accept* or abandon* or co-operat* or cooperat* or unco-operative* or uncooperative* or nonco-operat* or noncooperat* or non-cooperat* or willing* or confidence or awareness).ti,ab. (805779)

17 (trial* or intervention* or effect* or impact* or Initiative* or strateg* or program* or practice* or efficac* or efficienc* or implement* or evaluat* or assess* or address* or campaign* or approach* or improv* or increas*).ti,ab. (2635342)

18 exp Meta-Analysis/ or "systematic review"/ (55348)

19 (review* or meta*).ti,ab. (643467)

20 18 or 19 (644349)

21 6 and 11 and 15 and 16 and 17 and 20 (240)

22 limit 21 to english language (232)

23 limit 22 to yr="2011 -Current" (207)

Web of Science (Science Citation Index Expanded and Social Sciences Citation Index) – Conducted 28th July 2021

(HPV or papillomavirus or papilloma or papillomaviridae) TOPIC

(Adolescen* or Teen* or Child* or "young person*" or "young adult*" or "young people" or Youth* or Juvenile* or boy* or girl* or "young wom?en" or "young m?n") TOPIC

(uptake or coverage or complet*or accept* or intention* or hesitan*or refus* or engag* or adher* or rate* or concordan*or adher* or nonadher* or non-adher* complian* or comply* or noncomplian* or non-complian* or noncomply* or non-comply* complier* or noncomplier* or non-complier* accept* or nonaccept* or non-accept* or abandon* or co-operat* or cooperat* or unco-operative* or uncooperative* or nonco-operat* or noncooperat* or non-cooperat* or willing* or confidence or awareness) TOPIC

(trial* or intervention* or effect* or impact* or Initiative* or strateg* or program* or practice* or efficac* or efficienc* or implement* or evaluat* or assess* or address* or campaign* or approach* or improv* or increas*) TOPIC

(review* or meta*) TOPIC

428 results

Appendix 2. Studies excluded from the review with reasons

	Author	Reason for exclusion
1.	Acampora et al. 2020	No critical appraisal conducted
2.	Blasi et al. 2015	No critical appraisal conducted
3.	Brandt et al. 2021	No critical appraisal conducted
4.	Crocker-Buque et al. 2017	No critical appraisal conducted
5.	Francis et al. 2017	No critical appraisal conducted
6.	Gilkey and McRee 2016	No critical appraisal conducted
7.	Niccolai and Hansen 2015	No critical appraisal conducted
8.	Ortiz et al. 2019	No critical appraisal conducted
9.	Paul and Fabio 2014	No critical appraisal conducted
10.	Ryan et al. 2018	No critical appraisal conducted
11.	Smulian et al. 2016	No critical appraisal conducted
12.	Vollrath et al. 2018	No critical appraisal conducted
13.	Walling et al. 2016	No critical appraisal conducted
14.	Acampora et al. 2019	Not a systematic review: Poster presentation
15.	Cataldi et al. 2020	Not a systematic review: Narrative literature review
16.	Dempsey and Zimet 2015	Not a systematic review: Narrative literature review
17.	Foss et al. 2019	Not a systematic review: A scoping review of reviews
18.	Garland et al. 2011	Not a systematic review: Narrative literature review
19.	Holloway 2019	Not a systematic review: Narrative literature review
20.	Lehmann et al. 2016	Not a systematic review: Narrative literature review
21.	Miller et al. 2018	Not a systematic review: Narrative literature review
22.	Oliver et al. 2016	Not a systematic review: Narrative literature review
23.	Balcezak et al. 2021	Not about vaccine uptake or intention
24.	Lopez et al. 2020	Not an evaluation of interventions
25.	Vu et al. 2020	Not an evaluation of interventions
26.	Rani et al. 2020	Only one database searched
27.	Kaufman et al. 2018	Pooled analysis across reported for a variety of vaccinations including but not limited to HPV
28.	Baroy et al. 2016	Pooled analysis reported for a variety of vaccinations including but not limited to HPV

29.	Das et al. 2016	Pooled analysis reported for a variety of vaccinations including but not limited to HPV
30.	Jarrett et al. 2015	Pooled analysis reported for variety of vaccinations including but not limited to HPV
31.	Sadaf et al. 2013	Pooled analysis reported for variety of vaccinations including but not limited to HPV
32.	Ou and Youngstedt 2021	Studies of adults ages 27+ were included
33.	Mavundza et al. 2021	Fatally flawed – many reporting errors between the text and the tables and a number of the meta-analyses incorrectly interpreted. On checking data extraction with several of the primary studies the authors have incorrectly extracted the original data for a number of studies

Appendix 3. List of relevant primary studies included in systematic reviews

PRIMARY STUDIES (N=110) INCLUDED IN SYSTEMATIC REVIEWS	BARNARD ET AL. 2019[19]	ILOZUMBA ET AL. 2021[22]	LOTT ET AL. 2020[26]	RODRIGUEZ ET AL. 2019[24]	MOGAKA ET AL. 2019[21]	PRIEST AND KNOWLDEN 2015[18]	EISENHAUER ET AL. 2021[20]	FLOOD ET AL. 2020[23]	FU ET AL. 2014[27]	ABDULLAHI ET AL. 2020[25]
1. Aragones et al. 2015		X								
2. Bar-Shain et al. 2015		X					X			
3. Basu and Mittal 2007					X				X	
4. Bennett et al. 2015	X			X						
5. Berenson et al. 2016				X						
6. Brabin et al. 2010									X	
7. Brewer et al. 2011				X						
8. Casey et al. 2013				X						
9. Cassidy et al. 2014		X		X						
10. Cates et al. 2014										X
11. Cates et al. 2018							X			
12. Chan et al. 2007					X				X	
13. Chan et al. 2015					X					
14. Chao et al. 2015			X	X						
15. Chung et al. 2015				X						
16. Cox et al. 2010									X	
17. Crosby et al. 2011				X						
18. Daley et al. 2014				X						
19. Davies et al. 2017								X		
20. Davis et al. 2004					X				X	
21. Dempsey et al. 2006									X	
22. Dempsey et al. 2019		X					X			
23. DiClemente et al. 2011									X	

INCLUDED SYSTEMATIC REVIEWS (N=10)

PRIMARY STUDIES (N=110) INCLUDED IN SYSTEMATIC REVIEWS	BARNARD ET AL. 2019[19]	ILOZUMBA ET AL. 2021[22]	LOTT ET AL. 2020[26]	RODRIGUEZ ET AL. 2019[24]	MOGAKA ET AL. 2019[21]	PRIEST AND KNOWLDEN 2015[18]	EISENHAUER ET AL. 2021[20]	FLOOD ET AL. 2020[23]	FU ET AL. 2014[27]	ABDULLAHI ET AL. 2020[25]
24. Diclemente et al. 2015			X							X
25. Dixon et al. 2019		X								
26. Doherty and Low 2008									X	
27. Dunlop et al. 2010									X	
28. Eldred et al. 2015				X						
29. Fahy et al. 2010									X	
30. Fiks et al. 2016										X
31. Fiks et al. 2013				X						
32. Gainforth et al. 2012 (J Health Psychol)									X	
33. Gainforth et al. 2012 (Public Health Nurs)									X	
34. Gargano et al. 2014								X		
35. Gargano et al. 2015										X
36. Gerend and Barley 2009									X	
37. Gerend and Shepherd 2007									X	
38. Gerend and Shepherd 2012	X									
39. Gerend and Sias 2009									X	
40. Gerend et al. 2008									X	
41. Gerend et al. 2013						X				
42. Gottvall et al. 2010									X	
43. Grandahl et al. 2016								X		X
44. Henrikson et al. 2018		X					X			
45. Hopfer 2012	X			X		X			X	
46. Joseph et al. 2016			X	X						
47. Juraskova et al. 2011	X					X			X	
48. Keeshin and Feinberg 2017		X								
49. Kempe et al. 2016		X								
50. Kennedy et al. 2011					X				X	
51. Kepka et al. 2011					X				X	
52. Kester et al. 2014					X					
53. Kharbanda et al. 2011[a/b] (Vaccine) / J Adolesc Health)[a]		X		X[b]						
54. Kim et al. 2018			X							
55. Krawczyk et al. 2012						X			X	
56. Krieger et al. 2013									X	
57. Kwan et al. 2011					X			X	X	
58. Lai et al. 2015								X		

INCLUDED SYSTEMATIC REVIEWS (N=10)

PRIMARY STUDIES (N=110) INCLUDED IN SYSTEMATIC REVIEWS	BARNARD ET AL. 2019[19]	ILOZUMBA ET AL. 2021[22]	LOTT ET AL. 2020[26]	RODRIGUEZ ET AL. 2019[24]	MOGAKA ET AL. 2019[21]	PRIEST AND KNOWLDEN 2015[18]	EISENHAUER ET AL. 2021[20]	FLOOD ET AL. 2020[23]	FU ET AL. 2014[27]	ABDULLAHI ET AL. 2020[25]
59. Leader et al. 2009									X	
60. Lechuga et al. 2011									X	
61. Lee et al. 2016		X	X	X						
62. Lim et al. 2017								X		
63. Lin et al. 2014				X						
64. Lloyd et al. 2009								X	X	
65. Long et al. 2017	X									
66. Mantzari et al. 2015										X
67. Marek et al. 2012								X		
68. Matheson et al. 2014		X								
69. McGaffey et al. 2019							X			
70. McLean et al. 2017							X			
71. Mehta et al. 2013/2014						X				
72 Moore et al. 2010				X						
73 Morris et al. 2015		X								
74 Nan and Madden 2012									X	
75 Nan et al. 2012 (Hum Commun Res)									X	
76 Nan et al. 2012 (Hum Commun Res)									X	
77 Parra Medina et al. 2015			X							
78 Paskett et al. 2016										X
79. Patel et al. 2012	X			X		X			X	
80. Patel et al. 2014		X		X						
81. Perez et al. 2016	X									
82 Perkins et al. 2015				X						X
83 Perkins et al. 2020							X			
84 Pierre Joseph et al. 2014				X						
85 Rand et al. 2017		X					X			
86 Rand et al. 2015		X								
87 Reiter et al. 2018			X							
88. Richman et al. 2016	X	X	X	X						
89. Richman et al. 2019		X								
90. Rickert et al. 2015										X
91. Rickert et al. 2014				X						
92. Spleen et al. 2012					X				X	
93. Staras et al. 2015				X						X

INCLUDED SYSTEMATIC REVIEWS (N=10)

PRIMARY STUDIES (N=110) INCLUDED IN SYSTEMATIC REVIEWS	BARNARD ET AL. 2019[19]	ILOZUMBA ET AL. 2021[22]	LOTT ET AL. 2020[26]	RODRIGUEZ ET AL. 2019[24]	MOGAKA ET AL. 2019[21]	PRIEST AND KNOWLDEN 2015[18]	EISENHAUER ET AL. 2021[20]	FLOOD ET AL. 2020[23]	FU ET AL. 2014[27]	ABDULLAHI ET AL. 2020[25]
94. Stubbs et al. 2014				X						
95. Suarez Mora et al. 2018					X					
96. Szilagyi et al. 2015							X			X
97. Szilagyi et al. 2020							X			
98. Szilagyi et al. 2011				X						
99. Szilagyi et al. 2013		X								
100. Tull et al. 2019		X								
101. Underwood et al. 2015				X						
102. Vanderpool et al. 2013					X				X	
103. Vanderpool et al. 2011				X						
104.Vanderpool et al. 2015				X						
105.Venkatesan 2011	X									
106. Watson-Jones et al. 2012										X
107. Winer et al. 2016			X							X
108. Wright et al. 2012				X						
109.Yoost et al. 2017								X		
110. Zimmerman et al. 2017							X			
	INCLUDED SYSTEMATIC REVIEWS (N=10)									

a The authors reported this as one study across two publications

b Kharbanda et al. 2011a was the duplicate study

The shaded rows represent where the primary studies were duplicated across the systematic reviews

Appendix 4. Educational interventions conducted with children and adolescents to increase HPV vaccination intention as assessed by the included systematic reviews

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Individual level Face-to-face presentation and printed information vs printed information 3 groups I1: Approx. 120 min over 2–3 days with a variety of interactive activities and a parent directed brochure I2: Parent directed brochure only C: No intervention	Flood et al. 2020[23]	1068 (1 study)	Both intervention groups showed an increase in interest in receiving HPV vaccine post-intervention[a]
Individual level Face-to-face presentation and printed information 2 groups: one school was the control and the other school the intervention I: A trained health educator delivered the intervention. Education in 8 classes (25–33 students in each class). 45 min didactic presentation followed by Q&A and handouts. C: No education provided	Flood et al. 2020[23]	1068 (1 study)	Both genders in the intervention group demonstrated significant improvement in intention to be vaccinated despite financial barriers in comparison to the control group[a]
Individual level Face-to-face presentation and/or Facebook discussions 2 groups: both had a 50 min lecture with brief discussion delivered by a nursing teacher I: Over the next 2 weeks the students then had the option of entering Facebook discussions. C: Over the next 2 weeks then had the option of entering face to- face discussions	Flood et al. 2020[23]	1068 (1 study)	An increase in intention in the intervention arm though improvements were noted in both arms from baseline[a]
Individual level Technology mediated presentation: IPad Individual level 1 group I: A presentation on individual tablets with no evidence of any discussion with the team members after the presentation	Flood et al. 2020[23]	150 (1 study)	An increased intention to be vaccinated after the intervention[a]
Individual level Face-to-face: slideshow 1 group I: Didactic slide presentation	Flood et al. 2020[23]	953 (1 study)	More students indicated a positive intention to accept the vaccine after the intervention[a]
Individual level Printed information 3 groups I: Fact sheet about HPV prevalence, detection, prevention, treatment and symptoms C1: Fact sheet about chlamydia C2: Fact sheet about the environment	Fu et al. 2014[27] Flood et al. 2020[23]	174 (1 study)	From Fu et al. 2014[27] I: Mean 3.36 ±0.74; C1: Mean 3.09±0.8 No significance differences[a] I: Mean 3.36 ±0.74; C2: Mean 3.00 ±0.89; p=0.02 From Flood et al. 2020[23] One study showed that intention to accept HPV vaccination were highest in intervention group[a]
Individual level Face-to-face presentation: talk 2 groups I: Group introduced to a 10-minute educational information session about HPV and vaccination C: No information	Mogaka et al. 2019	131 (1 study)	Post Intervention intent: I: 86%; C:I 67% OR 3.09 (95% CI 1.02, 9.3) Those in the intervention group have a 3.09 times higher likelihood of having the HPV vaccine
Individual level Technology mediated presentation: photographic short story 2 groups I: Evidence-guided photographic short story about HPV infection and vaccine C: No information	Mogaka et al. 2019	41 (1 study)	Pre intervention intent: I: 24%; Post-intervention intent: I: 34% Authors reported an intent to vaccinate (+18.4%, p=0.06)[b]
Individual level Technology mediated presentation (video) and printed information vs printed information 2 groups I:10-min educational video about HPV and the HPV vaccine including personal stories for adolescents and a fact sheet about the HPV vaccine for their parents C: Fact sheet about the HPV vaccine for parents	Fu et al. 2014[27]	533 (1 study)	RR 1.08 (95% CI 1.0, 1.16) Those in the intervention group have an 8% increased likelihood of having the HPV vaccine Authors reported results as 90% of the intervention group and 83% of the control group "want the vaccine" p=0.015

Key: C: control group; CI: confidence interval; I: intervention group; OR: odds ratio; RR: relative risk

a further details of statistical analysis including p values were not reported in the systematic review

b data incorrectly interpreted as being significant

Appendix 5. Educational interventions conducted with parents to increase HPV vaccination intention as assessed by the included systematic reviews

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Individual level Technology mediated presentation: IPad 2 groups I: Tailored educational material using an iPad C: No detail provided	Ilozumba et al. 2021[22]	294 (1 study)	There were no differences between intervention and control arms in vaccination intention at baseline or post-intervention[a]
Individual level Face-to-face presentation: slideshow 1 group I: One educational slide presentation followed by a question/answer session conducted by a gynaecologist oncologist	Fu et al. 2014[27] Mogaka et al. 2019[21] (Parents and adolescents)	943 (1 study)	From Fu et al. 2014[27] RR 1.15 (95% CI 1.10, 1.20) From Mogaka et al. 2019[21] Pre intervention: 41.6% Post intervention: 58.9%[a]
Individual level Technology mediated presentation: video 2 groups I: Theory-guided, culturally grounded storytelling narrative video intervention, in English and Khmer delivered to mothers and daughters C: no details provided	Lott et al. 2020[26] (Mother and daughter dyads)	19 (1 study)	Intent to receive vaccine within one month 44.4% (4/9) I vs. 11.1% (1/9) C[a]
Individual level Printed information 2 groups I: Fact sheet about epidemiology and morbidity associated with HPV infection based on CDC vaccine fact sheet and a baseline paragraph about HPV and the vaccine C: Baseline paragraph about HPV and the vaccine	Fu et al. 2014[27]	840 (1 study)	I: RR 6.56 (95% CI 6.28, 6.84) C: RR 6.28 (95% CI 5.99, 6.57) Between-group p=0.17
Individual level Printed information 2 groups I: Two-page fact sheet adapted from the CDC mailed to participants C: No information sheet	Fu et al. 2014[27] Mogaka et al. 2019[21]	205 (1 study)	From Fu et al. 2014[27] I: Mean 5.9±3.1 C: Mean 5.7 ± 2.7 No significant differences[a] From Mogaka et al. 2019[21] Pre intervention intent: Not provided Post intervention intent: 43%[a]
Individual level Printed information with message framing 5 groups with 4 groups who were all given a 1-page fact sheet about HPV infection and vaccine of varying presentations of HPV risk statistics. Some were also asked rhetorical questions to gain commitment to cancer prevention and thus, HPV vaccination I1: Graphic risk presentation I2: Graphic risk presentation + rhetorical questions I3. Non-graphic risk presentation I4. Non-graphic risk presentation + rhetorical questions C: 2 groups both given 1-page fact sheet about HPV infection and vaccine plus: C1: Rhetorical questions C2: No additional information	Fu et al. 2014[27]	471 (1 study)	Graphic (I1 + I2): Mean 12.96 Non-graphic (I3 + I4): Mean 11.89 Control (C1 + C2): Mean 11.88 p=0.004 Rhetorical questions (I2 + I4 + C1): Mean 12.60 No rhetorical questions (I1 + I3 + C2): Mean 11.9 p=0.033
Individual level Printed information 1 group I: Fact sheet about HPV prevalence, seriousness and route of transmission, as well as diagnosis, treatment and brief details about the HPV vaccine	Fu et al. 2014[27] Mogaka et al. 2019[21]	506 (1 study)	From Fu et al. 2014 RR 1.37 (95% CI 1.25, 1.51) Authors reported change in agreement to vaccinate as: yes: +20%, no: -3%, no response: 17%. From Mogaka et al. 2019[21] Pre intervention: 9% Post intervention: 37%[a]
Individual level Printed information and Q&A session 1 group I: Fact sheet about cervical cancer and HPV vaccine. Afterwards a trained social worker was available to answer questions	Fu et al. 2014[27] Mogaka et al. 2019[21]	522 (1 study)	From Fu et al. 2014[27] RR 2.88 (95% CI 2.47, 3.36) From Mogaka et al. 2019[21] Pre intervention: 27% (Female) / 24% (Male)[a] Post intervention: 74% (Female) / 74% (Male)[a]

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Individual level Printed information 1 group I: Fact sheet that detailed the effectiveness of the HPV vaccine on reducing HPV infection and by implication cervical cancer	Fu et al. 2014[27] Mogaka et al. 2019[21]	170 (1 study)	From Fu et al. 2014[27] RR 1.60 (95% CI 1.23 to 2.08) Authors reported change in agreement to vaccinate as: agree: +20%, disagree: -8%, undecided: -25% p<0.001 From Mogaka et al. 2019[21] Pre intervention: 32% / Post intervention: 52%[a]
Individual level Face-to-face presentation: slideshow 1 group I: One-hour educational slide presentation about HPV infection, disease and vaccine which included time for discussion lead by health educators	Fu et al. 2014[27] Mogaka et al. 2019[21]	38 (1 study)	From Fu et al. 2014[27] 1 month - Pre-intervention: 0.72; Post-intervention:1.38 (p=0.002) 6 months - Pre-intervention: 1.46; Post-intervention:1.84; (p=0.07) 31% of the sampled parents had daughters who had already started the HPV vaccination series at the time of the intervention From Mogaka et al. 2019[21] Pre intervention: 32.5% / Post intervention: 44.4% p=0.002 (1 month)
Community level Radio features 2 groups I:5 min radio novel announcement about cervical cancer, HPV infection, HPV vaccine, concerns about the HPV vaccine and decision-making activities related to vaccine uptake C: Prostate cancer radio announcement	Fu et al. 2014[27] Mogaka et al. 2019[21]	60 (1 study)	From Fu et al. 2014[27] RR 0.86 (95% CI 0.65, 1.13) Authors reported results as 61% of intervention vs. 67% of control group answered very probable p=0.58 From Mogaka et al. 2019[21] Pre intervention intent: Intervention 53%[a] Post intervention intent: Intervention 61%[a] p=0.26
Individual level Printed information with message framing 2 groups both given 1-page fact sheet about HPV infection and vaccine of varying message frame I1: Gain / I2: Loss	Fu et al. 2014[27]	72 (1 study)	I1: Mean 5.9 ±1.3 I2: Mean 5.62±1.4 p=0.397
Individual level Printed information with message framing 2 groups and both groups given gain and loss-framed brochures about HPV virus and the vaccine in varying order I1: Gain before loss / I2: Loss before gain	Fu et al. 2014[27]	150 (1 study)	No results reported for comparison of the two message framing orders (I1 vs. I2) I1: Pre-intervention Mean 5.13 ± 1.63; Post-intervention Mean 6.51 ± 1.13; p<0.05 I2: Pre-Intervention: Mean 5.13 ±1.63; Post-intervention Mean 6.22 ± 1.28; p< 0.01
Individual level Online content with message framing 6 groups presented with an online message based on the Ontario government's about HPV vaccine for parents of varying gain, loss or mixed frame I1: Gain for parents of girls I2: Loss for parents of girls I3: Mixed for parents of girl I4: Gain for parents of boys I5: Loss for parents I6: Mixed for parents of boys	Fu et al. 2014[27]	367 (1 study)	No significant main effect of message frame on intention[a]
Individual level Technology mediated presentation: video 1 group I: Group introduced to educational video about HPV	Mogaka et al. 2019[21]	104 (1 study)	Pre intervention intent: 30.8% Post intervention intent: 71.2%[a]

Key: C: control group; CI: confidence interval; I: intervention group; RR: relative risk

a further details of statistical analysis including p values were not reported in the systematic review

Appendix 6. Educational interventions conducted with young adults for HPV vaccination intent as assessed by the included systematic reviews

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Community level Radio features with message framing 4 groups: 3 groups all listened to radio advertisement of varying formats, and some given 5-min discussion time afterwards I1: Narrative advert (woman describes her cervical cancer treatment) + discussion I2: Informational advert (facts about HPV and cervical cancer) + discussion I3: Narrative advert only (no discussion) C: Informational advert only (no discussion)	Fu et al. 2014[27]	69 (1 study)	No significant main effects of message format and discussion condition[a] I1: Mean 4.83 ±0.93 I2: Mean 5.62± 1.16 I3: Mean 5.8 ±0.73 C: Mean 5.02± 1.31
Individual level Face-to-face presentation: slideshow 3 groups: All groups viewed HPV vaccine slide presentation of varying focus I1: Cervical cancer prevention for women I2: Genital warts prevention for men I3: Head and neck cancer protection for men	Fu et al. 2014[27]	150 (1 study)	Comparison of post-test scores for the 3 groups (p=0.56) Pre-intervention (I1 + I2 + I3): Mean 3.19 ± 1.33 (p=0.0001 Post-intervention (I1 + I2 + I3): Mean 3.91 ± 1.34 (p=0.0001)
Individual level Printed information, Q&A session and quiz 2 groups I: Online HPV fact sheet including question/answer section, personal story and self-quiz C: No online fact sheet	Fu et al. 2014[27]	119 (1 study)	Immediately post-intervention: I: Mean 2.7 ± 2.8; C: Mean 1.2±1.9; p=0.036 1 month post-intervention: No significant difference Average scores 1 month post-intervention depicted graphically only (no numerical results reported)
Individual level Printed information vs technology mediated presentation (video) 3 groups I1: HPV pamphlet I2: HPV video C: general cancer prevention strategies	Priest and Knowlden 2015[18] Fu et al. 2014[27]	200 (1 study)	From Priest and Knowlden 2015[18] Increased vaccination intention from baseline to post intervention for both intervention groups (p<0.05) Control group reported no differences in vaccination intention from baseline to post intervention.[a] Both intervention groups reported higher vaccination intention than the control group (p <0. 05) No significant difference in vaccination intention between the two intervention groups[a] From Fu et al. 2014 I1 Mean 4.39 ± 1.86; C: Mean 3.88 ± 1.77; p<0.05 I2 Mean 4.57 ± 1.90; C: 3.88 ± 1.77; p<0.05 I1 vs. I2: no significant difference[a]
Individual level Printed information 1 group I: Binder with basic HPV facts and information tailored to participants' perceived barriers versus active control (basic information binder)	Priest and Knowlden 2015[18]	94 (1 study)	Within group comparisons Both groups increased intent to receive the HPV vaccine from baseline to postintervention (p <0.001) Those receiving specific and tailored information experienced larger increases in HPV vaccination intention from baseline to postintervention compared with the active control group (p=0.048)
Individual level Face-to-Face: Slideshow, discussion role plays 2 groups I: Theory-based educational intervention C: Knowledge-based educational intervention (no further details provided)	Priest and Knowlden 2015[18]	16 (1 study)	Intervention group had higher intent to vaccinate at post-test than did the control group (p=0.002)
Individual level Technology mediated presentation: online story telling 1 group I: A culturally-appropriate online educational story-telling intervention	Lott et al. 2020[26]	87 (1 study) (Korean American)	Intent to receive the vaccine at two-month follow-up among those not vaccinated (n=77) • No statistically significant difference between I and C[a], 49.4% said they intended to receive vaccine, 28.6% said "I don't know"
Individual level Online content with message framing 4 groups presented with an online message of varying gain/loss and risk frames I1: Gain, high-risk I2: Gain, low-risk I3: Loss, high-risk I4: Loss, low-risk	Fu et al. 2014[27]	286 (1 study)	Main effects: High-risk (I1 + I3): Mean 20.00 ± 11.23 Low risk message (I2 +I4): Mean 22.27±11.37 p=0.04–0.05* (text and table report different p values) Gain (I1 + I2): Mean: 21.40 ± 11.59 Loss (I3 + I4): Mean: 20.81 ± 11.03 p=0.81

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Individual level Printed information with message framing 2 groups both given 2-page fact sheet about HPV vaccine of varying message frame I1: Gain I2: Loss	Fu et al. 2014[27]	121 (1 study)	No significant main effect of message frame on intention[a]
Individual level Printed information with message framing 4 groups all given 2-page fact sheet of varying message frame and hypothetical number of HPV shots I1: Gain, 6-shot series I2: Loss, 6-shot series I3: Gain, single shot I4: Loss, single shot	Fu et al. 2014[27]	243 (1 study)	I1: Mean 3.96 ± 1.54 I2: Mean 3.74 ± 1.72 p=0.45 I3: Mean 3.60 ± 1.55 I4: Mean 4.65 ± 1.32 p< 0.001
Individual level Printed information with message framing 4 groups all given 2-page fact sheet about HPV infection and vaccine of varying message frame and colour-threat priming I1: Gain, red text box I2: Loss, red text box I3: Gain, grey text box I4: Loss, grey text box	Fu et al. 2014[27]	126 (1 study)	I1: Mean 3.62 ±0.259 I2: Mean 4.41 ±0.237 p<0.05 I3: Mean 3.86±0.251 I4: Mean 3.67 ±0.250 p>0.5
Individual level Printed information with message framing 2 groups: both given 2-page fact sheet about HPV infection and vaccine with varying additional content about I1: Consequences for men I2: Consequences for men+women	Fu et al. 2014[27]	356 (1 study)	I1: Mean: 3.93 ± 1.40 I2: Mean: 3.78± 1.52 p>0.15
Individual level Printed information with message framing 2 groups, both viewed online informational pamphlet about HPV infection and a section about HPV vaccine with varying message frame I1: Gain I2: Loss	Fu et al. 2014[27]	229 (1 study)	No main effect of message framing on intention[a] p=0.65
Individual level Online content with message framing 2 groups, both viewed online information pamphlet about HPV infection and a section about HPV vaccine with varying message frame I1: Gain I2: Loss	Fu et al. 2014[27]	282 (1 study)	No significant main effect of message intention[a]
Individual level Printed information with message framing 2 groups both given 1-page HPV vaccine fact sheet of varying focus: I1: Genital warts prevention I2: Cervical cancer prevention	Fu et al. 2014[27]	188 (1 study)	No significant direct effect of message focus on daughters' or mothers' intention[a]
Individual level Online content with message framing 2 groups, both viewed online blog with varying levels of support for HPV vaccine I1: Positive blog (vaccine is "effective and safe") I2: Negative blog (vaccine is "not effective and potentially dangerous")	Fu et al. 2014[27]	176 (1 study)	I1: Mean 4.872 ± 0.0205 (standard error) I2: Mean 3.97 ±0.242 (standard error) p<0.05 I1: Mean 4.872 ± 0.0205 (standard error) C: Mean 4.781 ±0.214 (standard error) p< 0.05 I2 vs C (p≥ 0.05)
Individual level Text based health education 1 group I: Text messages to deliver health education	Ilozumba et al. 2021[22]	30 (1 study)	Increase intent to receive HPV vaccination (p<0.01)[a]

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Individual level Online content with message framing 3 groups all viewed online paragraph about HPV disease and vaccine with framing paragraphs of varying focus I1. Cervical cancer prevention I2. Cervical cancer + sexually transmitted illness prevention I3. Cervical cancer + sexually transmitted illness prevention + suggestion that HPV vaccination may lead to sexual promiscuity	Fu et al. 2014[27]	70 (1 study)	I1: Mean 3.77 ± 1.45 I2: Mean 3.21 ± 1.47 I3: Mean 3.40 ± 1.23 p=0.360
Individual level Technology mediated presentation: IPad 2 groups I: Tailored educational material using an iPad C: No detail provided	Ilozumba et al. 2021[22]	1294 (1 study)	There were no differences between intervention and control arms in vaccination intention at baseline or post-intervention for either parents or young adults[a]

Key: C: control group; CI: confidence interval; I: intervention group

a further details of statistical analysis including p values were not reported in the systematic review

Appendix 7. Interventions conducted with children, adolescents and parents for HPV vaccination uptake as assessed by the included systematic reviews

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Provider-oriented intervention Organisational level Multi-component performance improvement continuing medical education intervention 2 groups I: 6–8 education visits over 12 months by an HPV physician-educator; focused education sessions on HPV-related topics, individualised feedback and quality improvement incentives where physicians were eligible to receive MOC credits, which fulfilled requirements for maintaining board certification in paediatrics C: Usual care	Abdullahi et al. 2020[25]	15,849 (1 study) Healthcare providers and their adolescent patients (boys and girls aged 11–21 years)	Girls in the intervention group are probably more likely to receive their next HPV vaccine dose than those in the comparison group OR 1.6 (95% CI 1.1 to 2.2) The effects are probably larger for boys and the authors note that this may be because publicly funded HPV vaccination for boys became available during the study OR 25.00 (95% CI 15.00 to 40.00) Moderate certainty
Multi-component intervention Individual and organisational levels Provider-oriented: continuing medical education training and 1-page tip sheet Education: online information, printed information Radio features 2 groups I: Social marketing intervention C: Usual care	Abdullahi et al. 2020[25]	28,869 (1 study) Health providers and parents of 9-13 year old boys	RR 1.41 (95% CI 1.25 to 1.59) Low certainty
Public health intervention Organisational level School based vaccination clinic 2 groups I: School located vaccinations (includes other vaccines) C: No school located vaccination clinics	Rodriguez et al. 2019[24] At least one dose	2000 (1 study) (Females only)	Dose 1: (16.3%) Initiation (females only): OR 2.56 (1.34, 4.88) At school-located vaccination clinics (intervention), more females received at least one dose (than controls (no school located vaccination clinics)
Educational intervention Individual level Face-to-face presentation: talk 1 group I: A 1h after school telehealth session detailing types of STDs and modes of transmission, long-term complications, prevention of STDs, condom use, and HPV vaccination	Flood et al. 2020[23] HPV vaccination initiation or completion	26 (1 study)	HPV vaccine initiation or completion was 38% (10/26) at the time of the intervention session. This report increased to 71.4%, 15/21 at 6 months among those who attended that session[a]
Educational intervention Individual level Strategy not specified 3 groups with educational interventions (no further details provided) I1: Delivered to parents only I2: Delivered to parents and adolescents C: Control group (no further details provided)	Rodriguez et al. 2019[24] HPV vaccination initiation HPV vaccination completion	686 (1 study)	Dose 1: AOR 3.0 (95% CI 2.1, 4.3) 3 times higher likelihood of having the HPV vaccine compared to the control group Dose 3: AOR 2.1 (95% CI 1.3, 3.4) 2.1 times higher likelihood of having the HPV vaccine compared to the control group

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Multi-component intervention Individual level Education: printed information Reminders: telephone calls Incentives: Non-financial 1 group I: Nurses created back-to-school packets. Used "one call" reminder system to return consent forms and provide reminders for doses 2–3. Used informational booth at school orientation, classrooms, newspaper articles, school website, and special events. Provided incentives to increase participation t-shirts, pizza and sub sandwich parties, and prizes	Rodriguez et al. 2019[24] Percentage uptake	511 (1 study)	Dose 1 (70%) Dose 3 (62%)[a]
Multi-component intervention Organisational and individual levels Provider-oriented – education; EHR alerts Reminders – telephone calls 4 groups that involved a 3-part clinician focused intervention (education, electronic health record-based alerts, and audit and feedback), family-focused (reminder calls and decision support) or combination I1: Clinician only I2: Family only I3: Combination C: Control group (no further details provided)	Rodriguez et al. 2019[24] Uptake of all three doses	22,486 (1 study) (Females only)	Dose 1 (16%) C; (25%) [Ia] Dose 2: (65%) C; (73%) [Ia] Dose 3: (63%) C; 76%) [Ia]
Multi-component intervention Organisational and individual level Provider-oriented: immunisation navigators Reminders: telephone calls, letter, home visits 2 groups I: Immunisation navigators at each practice implemented a tiered protocol: immunisation tracking, telephone or mail reminder/recall, and home visits if participants remained unimmunised or behind on preventive care visits C: Control group (no further details provided)	Rodriguez et al. 2019[24] Uptake of all three doses	7546 (1 study)	Dose 1 (43%) C; (59%) [Ia] Dose 2 (36%) C; (52%) [Ia] Dose 3:(24%) C; (37%) [Ia]
Multi-component intervention Individual level Face -to-face presentation (talk) and printed information Incentives: not specified 3 groups I: One-hour lesson about HPV and preventive methods focusing on vaccination and condom use, folder about HPV and prevention and incentives to view project's website about HPV and other STIs C1: No educational materials, completed baseline survey C2: No educational materials and did not complete baseline survey	Fu et al. 2014[27] HPV vaccination initiation	276 (1 study)	RR 1.36 (95% CI 0.72, 2.56)
Multi-component intervention Individual level Technology mediated presentation: Video Nudge: promotional keychain 1 group I: Multi-component, computer delivered intervention including a culturally appropriate video and promotional keychain as appointment reminder	Lott et al. 2020[26] Abdullahi et al. 2020[25] HPV vaccination initiation HPV vaccination completion	216 (1 study)	From Lott et al. 2020[26] Series initiation within seven months 11.1% I vs. 11.1% C Series completion within seven months; 5.6% I vs. 1.9% (p=0.12) From Abdullahi et al. 2020[25] RR 1.00 (95% CI 0.47 to 2.13)
Multi-component intervention Organisational level Provider-oriented: education Public health: "vaccine blitz" 1 group I: educational exercise and vaccine blitz of all recommended vaccines	Rodriguez et al. 2019[24] HPV vaccination completion	173 (1 study)	Completion rate: Females (43.9%), Males (34%)
Multi-component Intervention Individual level Reminders: letters Incentives: financial 2 groups I: No out of pocket costs and Vaccine reminder letter, in English and Spanish, mailed every three months C: Control no further details	Lott et al. 2020[26] Rodriguez et al. 2019[24] HPV vaccination completion	8436 (1 study) Lott et al. 202026 Sub sample – minority groups 12,205 (1 study) Rodriguez et al. 2019[24] Total sample	From Lott et al. 202026 Series completion within 12 months • Black participants: I: 51.9%. C: 37.6% (p < 0.01) • Hispanic participants: I: 56.9%; C: 45.9% (p<0.01) • Asian participants: I: 63.2%; C: 53.3% (p < 0.01) From Rodriguez et al. 2019[24] I: 56.4% C: 46.6%[a]

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Educational intervention Individual level Face-to-face: variety of activities 2 groups I: Delivered by mainly Health and Social teachers with small groups structure. Average 60 min though range of resources used and time taken including activities, magazines, DVD and numerous other options C: No education	Flood et al. 2020[23] HPV vaccination uptake	6995 (1 study)	One study showed no change in HPV vaccination uptake[a]
Educational intervention Individual level Face-to-face presentation: talk 1 group I: School nurses delivered a face-to-face 30 min individual structured and consistent interview C: No structured teaching	Flood et al. 2020[23] Abdullahi et al. 2020[25] HPV vaccination uptake	741 (1 study)	From Flood et al. 2020 HPV vaccination rates increased to a higher degree compared to the control group (p=0.02)[a] From Abdullahi et al. 2020[25] RR 1.44 (95% CI 1.15,1.79)
Multi-component intervention Organisational and individual level Education: printed information (postcard) Provider-oriented: HIT system 4 groups The postcard campaign contained healthcare information about vaccine benefits, costs, adverse effects, and safety and was designed to prompt parents and adolescents to discuss the vaccine with their doctor. The HIT system contained health risk questions for adolescents to verify vaccination history and indicate interest in learning about the vaccine. The HIT system summarised adolescent responses for providers in real time via colour-coded system I1: Postcard campaign I2: in-clinic health information technology I3: Combined postcard and health information technology C: Usual practice	Abdullahi et al. 2020[25] Rodriguez et al. 2019[24] HPV vaccination uptake	2822 (1 study)	From Adbullahi et al. 2021 RR 1.84 (95% CI 1.32 to 2.54) Low certainty evidence From Rodriguez et al. 201924 Postcards= 68/1,234 girls, 91/1,605 boys Controls for postcards= 44/1,236 girls, 85/1,588 boysa Health information technology= 44/728 girls, 73/1,046 boys Controls for HIT= 68/1,742 girls, 103/2,147 boysa Combined HIT and postcards= 27/361 girls, 38/525 boys Controls for combined= 27/869 girls, 50/1067 boys[a]
Multi-component intervention Individual level Educational: printed information Incentives: financial on completion of series Reminders: text messages 2 groups I: In addition to the invitation letters, all participants were sent a standard leaflet containing information about HPV and the HPV vaccine. Participants in the intervention groups received an invitation letter with an enclosed offer of Love2Shop vouchers worth GBP 45 upon completion of 3 HPV vaccination doses. Reminders: text messages C: Standard practice with no incentives and no reminder system	Abdullahi et al. 2020[25] HPV vaccination uptake	500 (1study)	RR 1.45 (95% CI 1.05 to 1.99) Moderate certainty evidence
Multi-component intervention Organisational and individual level Public health: school-based vaccination clinic Education: printed information and other community activities Radio features 2 groups: teachers, parents, and girls in the target vaccination group were provided with verbal and written information about HPV vaccination through school, parent, and community meetings; leaflets and posters; radio messages; and through community drama troupes I: Provision of HPV vaccine through a class-based strategy (targeting girls in school class 6) C: Provision of HPV vaccine through an age-based strategy (targeting girls born in 1998)	Abdullahi et al. 2020[25] HPV vaccination uptake	5537 (1 study)	RR 1.45 (95% CI 1.05 to 1.99) Moderate certainty evidence RR 1.09 (95% CI 1.06 to 1.13) Showed that a class-based delivery tactic probably leads to slightly higher HPV vaccine uptake than an age-based delivery strategy Low certainty
Educational intervention Individual level Educational: strategy not specified 1 group No further information provided	Rodriguez et al. 2019[24] 2nd or 3rd dose	650 (1 study)	Prior dose (12%) Received vaccine by follow-up (26%) Received three doses by follow-up (58%)[a]

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Reminder-based intervention Individual level Reminders: text, pre-recorded voice message or postcard No further details provided	Eisenbauer et al. 2021[20] Ilozumba et al. 2021[22] HPV vaccination initiation HPV vaccination completion	3,933 (1 study)	From Ilozumba et al. 2021[22] Receiving one message was associated with a greater likelihood of vaccination compared to receiving two (19.4%) or three messages (p <0.0001) Overall, when assessing telephone reminders in comparison to other reminder systems, vaccination completion rates did not differ[a] Parents receiving a single text (38.8%) and postcards (40.1%) were more likely to get their child vaccinated than those receiving a phone call[a] From Eisenbauer et al. 2021[20] Significant difference reported in the percentage change in vaccination initiation rates for those in the intervention group (22.9%) compared to the control group (p<0.005)[a] Percentage change in vaccination completion rate 31%[a]
Multi-component intervention Organisational and individual level Provider-oriented: education Reminders: letters 2 groups I and C but no further details provided	Eisenbauer et al. 2021[20] HPV vaccination initiation HPV completion rates	24,658 (1 study)	Significant difference reported in the percentage change in vaccination initiation rates between the intervention (11.3) and control group (p<0.001)[a] Significant difference reported in the percentage change in vaccination completion rates between the intervention (12.5) and control group (p<0.002)[a]
Multi-component intervention Organisational and individual level Provider-oriented: education Incentives: sensory (HPV gong or HPV pup) Reminders: not specified 2 groups I and C but no further details provided	Eisenbauer et al. 2021[20] HPV vaccination initiation HPV vaccination completion	857 (1 study)	Significant difference reported in the vaccination initiation rates between the intervention (31.9 to 44.5) and control group (40.6 to 59.3) for those aged 11 to 12 (p<0.001) No significant difference reported in the vaccination initiation rates between the intervention (48.4 to 55.4) and control group (53 to 61.7) for those aged 13 to 17 (p<0.340) No significant difference reported in the vaccination completion rates between the intervention (31.6 to 52.3) and control group (32 to 52.7) for those aged 11 to 12 (p<1.001) No significant difference reported in the vaccination completion rates between the intervention (59.5 to 71.9) and control group (55.6 to 66) for those aged 13 to 17 (p<0.080)
Multi-component intervention Organisational and individual level Provider-oriented: education; EHR alerts, nurse standing orders Reminders: Voice mails and text messages Education: Printed information (posters) 2 groups I and C but no further details provided	Eisenbauer et al. 2021[20] HPV vaccination initiation HPV vaccination completion	16,136 (1 study)	Significant difference reported in vaccination initiation rates between the intervention (75-90) and control group (p<0.001)[a] Significant difference reported in the vaccination completion rates between the intervention (60 to 69) and control group (p<0.001)[a]
Multi-component intervention Organisational and individual level Provider-oriented: education; nurse standing orders, pre-typed consents Printed information: posters Public Health: vaccine walk-in clinics and express walk-in clinics 2 groups I and C but no further details provided	Eisenbauer et al. 2021[20] HPV vaccination initiation	10,681 (1 study)	Significant difference reported in vaccination initiation rates between the intervention (61.6 to 69.1) and control group (52.5 to 62.7) (p<0.001) Significant difference reported in the vaccination completion rates between the intervention (0-50) and control group (31.3 to 44.1) (p<0.001)
Reminder-based intervention Individual level Reminders: letter vs telephone calls / text messages No further details provided	Ilozumba et al. 2021[22] HPV vaccination initiation HPV vaccination completion	1805 (1 study)	No significant differences in receipts of the first vaccination for those in the intervention group (mailed reminders and telephone/text reminders)[a] Those in the intervention group (mailed reminders and telephone/text reminders) were more likely to have their child complete the series (10.3%) compared with usual care (6.8%) p=0.035
Reminder-based intervention Individual level Reminders: text messages No further details provided	Ilozumba et al. 2021[22] HPV vaccination initiation	3812 (1 study)	No statistically significant increase in first dose vaccination for the intervention group (text message reminders)[a]

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Multi-component intervention Individual level Reminders: telephone calls Education: printed information 2 groups I: Brochure based on predictors of parental acceptance and HBM and telephone reminders for dose completion C: Historic controls	Ilozumba et al. 2021[22] Rodriguez et al. 2019[24] HPV vaccination initiation HPV vaccination completion	23 (1 study)	From Ilozumba et al. 2021[22] Parents who received the intervention were 9.4 times more likely to have their child have the HPV vaccine compared with the historical control groupa Parents who received the intervention (educational brochure and telephone reminder) were 22.5 times more likely to have their child complete the three-dose series compared with the historical control group. 62.5% who received reminder phone calls had their child complete the vaccination series, compared to 6.9% in the control group From Rodriguez et al. 2019[24] I: (62.5%); C: (6.9%) OR 22.5 (95% CI 4.3, 118.0) I:1 (75%); C: 7/29 (24.1%) OR 9.4 (95% CI 2.7, 33.1)
Multi-component intervention Individual level Education: Face-to-face presentation (talk) Incentive: dinner event 1 group: Mother-daughter dinner events featuring educational presentations on HPV	Lott et al. 2020[26] Abdullahi et al. 2020[25] HPV vaccination initiation	97 (1 study) (Mother and daughter dyads)	From Lott et al. 2020[26] Series initiation within 11 months • Among those with no previous HPV vaccine dose: 50% (11/22) I vs. 27.3% (6/22) C RR 1.8 (95% CI 0.8 to 4.4) Series completion within 11 months • Among those previously unvaccinated: I vs C RR 3.0 (95% CI: 0.8 to 10.8) • Among all girls (any dose of previous HPV vaccine): 32% (8/25) I vs 27.6% (8/29) C RR 1.2 (95% CI: 0.6 to 2.3) From Abdullahi et al. 2020[25] RR 2.3 (95% CI 0.93 to 5.72)
Multi-component intervention Individual level Reminders: text messages Education: strategy not specified No further details provided	Ilozumba et al. 2021[22] HPV vaccination completion	69 (1 study)	Those in the text message group were 15.5 times more likely to have their child complete vaccination than those in the education-only group (p< 0.001). Vaccination was also associated with parents' age and awareness of the vaccine before study participation
Reminder-based intervention Individual level Reminders: text messages 2 groups I and C but no further details provided	Ilozumba et al. 2021[22] HPV vaccination completion	312 (1 study)	Those in the text group performed significantly better on all 4 outcomes (included vaccine completion) than the control group (p<0.05)[a]
Reminder-based intervention Individual level Reminders: telephone, text messages 3 groups I and C but no further details provided	Ilozumba et al. 2021[22] HPV vaccination completion	749 (1 study)	In the text group, parents in the intervention were more likely to have their child complete the series (49% vs 31% with 3 doses (p< 0.001). Significantly less participants with telephone reminders completed the vaccination series[a] In the phone arm, there was no significant difference in rates of HPV doses 1–3 between intervention and control groups.
Reminder-based intervention Individual level Reminders: not specified No further details provided	Ilozumba et al. 2021[22] HPV vaccination completion	1422 (1 study)	In one study adolescents in the intervention group were more likely to receive vaccines within the recommended dosing intervals for all doses (p>0.01) The intervention was more effective for younger adolescents (p <0.01) and reminding the parent and adolescent did not increase effectiveness[a]
Reminder-based intervention Individual level Reminders: email, telephone calls, text messages No further details provided	Ilozumba et al. 2021[22] HPV vaccination completion	5050 (1 study)	Participants who received a repeated reminder were more likely to be up to date (complete HPV vaccine series) than those in the enrolment phone call only group (24.6% vs 12.4%) (p< 0.001) Text messages were the most effective reminder method[a]
Multi-component Intervention Individual level Education: Face-to-face (brief negotiated interviewing) Incentives: financial (vaccine free of charge) 2 groups with brief negotiated interviewing with mothers to address beliefs, attitudes, and readiness for behaviour change, and to identify next steps for vaccination 1: Negotiated Interviewing, vaccine free of charge C: control no further details	Lott et al. 2020[26] Rodriguez et al. 2019[24] (Mothers) HPV vaccination initiation HPV vaccination completion	200 (1 study)	From Lott et al. 2020[26] Series initiation within one month • 56% (55/96) I vs. 51% (52/97) C (p=0.47) Series completion within 12 months • 10% (10/100) I vs. 6% (7/97) C (p=0.39) From Rodriguez et al. 2019[24] I:Dose 1: (56%); Dose 2: (21%); Dose 3: (10%)a C: Dose 1: (51%); Dose 2: (16%); Dose 3: (6%)a

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Multi-component intervention Individual level Education: strategy not specified Reminders: follow up phone calls 1 group: Mother/daughter educational intervention and referral, navigation, and follow-up phone call services delivered by community health workers and undergraduate peer educators, in English and Spanish	Lott et al. 2020[26] (Mother and daughter dyads) HPV vaccination initiation HPV vaccination completion	372 (1 study)	Series initiation within six months 84% I vs 84% C[a] Series completion within six months 72.2% I vs. 42.5% C (p <0.001; adjusted OR 2.24, 95% CI 1.25–4.02)
Reminder-based intervention Individual level Reminders: text messages 3 Groups I: Three weekly text message reminders for next vaccine dose C1: Offered card but did not sign up C2: Historic control	Ilozumba et al. 2021[22] Rodriguez et al. 2019[24] Dose 2 or 3	1512 (1 study)	From Ilozumba et al. 2021[22] Receipt of the second and third vaccine doses. Parents in the intervention group (text message reminders) were more likely to have their child receive their next HPV vaccine dose on time–within one month of its due date (p=0.001) From Rodriguez et al. 2019[24] On-time receipt of the next vaccine dose within month of due date I: 51.6% C1: 35.0% C2: 38.1% C2: Historic control: OR: 1.83 (95% CI1.23, 2.71)
Reminder-based intervention Individual level Reminders: not specified No further details provided	Ilozumba et al. 2021[22] HPV vaccination completion	262 (1 study)	No significant difference in completion rates between males and females (evaluated the effectiveness of different messaging types)[a]
Educational intervention Individual level Technology mediated presentations: iPad No further details provided	Ilozumba et al. 2021[22] HPV vaccination uptake	1596 (1 study) (parents)	HPV vaccination uptake (change in HPV dose status) adolescents at the intervention clinic had nearly double the odds of receiving a dose of the HPV vaccine (OR:1.82. p<0.001) Comparing HPV uptake between those adolescents whose parents received the tablet and watched the video and those who did not had 3 times greater odds of received a dose for the HPV vaccine (OR 3.07; p=0.003).78%) compared to the control group (52.8%)
Reminder-based intervention Individual level Reminders: motivational or self-regulatory messages text messages No further details provided	Ilozumba et al. 2021[22] HPV vaccination uptake	4386 (1 study)	Parents in the intervention group (motivational or self-regulatory text messages) led to higher vaccination rates for their child at the third school visit than the control condition (p=0.10) Both forms of text messages, motivational and self-regulatory, resulted in an increase in HPV vaccine receipt with a slightly high point increase in the motivational group (3.29% vs 2.64%) There was no significant difference in vaccination rates at the third school visit between the motivation and self-regulatory messages
Reminder-based intervention Individual level Reminders: telephone calls, text messages, letter No further details provided	Ilozumba et al. 2021[22] HPV vaccination uptake	4115 (1 study)	Increased vaccination rates in the telephone reminder group, compared to a group that received mailed reminders[a] For children who were behind on a given vaccine, there was a significant increase in vaccination in both the mailed and telephone interventions (p< 0.05)
Multi-component intervention Organisational and individual levels Provider-oriented: financial incentive 2 groups I: Practice-based interventions ($1 per reminder sent, maximum $1,000 per practice) (two telephone messages 4 months apart) C: "comparison county" (no further details provided)	Rodriguez et al. 2019[24] Dose 2 or 3	NRb (1 study)	Initiation in those aged 11–12 years: Boys: 14.2%– 32.1%, Girls: 27.4%–43.4%[a] Initiation in those aged 13–18 years: Boys: 1.6%–4.2%[a]

Key: AOR: adjusted odds ratio; C: control; CI: confidence interval; HBM: health belief model; HIT: health information technology; I: intervention;
OR: odds ratio; RR: relative risk; SMD: standardised mean difference; STDs: sexually transmitted diseases; STIs: sexually transmitted infections

a further details of statistical analysis including p values were not reported in the systematic review

b All Dublin County medical practices providing immunisations to adolescents aged 11–18 years and using North Carolina Immunization Registry

c No comparisons conducted over time

Appendix 8. Interventions conducted with young adults or college students for HPV vaccination uptake as assessed by the included systematic reviews

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Incentive-based intervention Individual level 1 intervention but 3 population groups 3 groups all given a voucher for vaccine after completing questionnaire I1: Rural clinics I2: Rural community college I3: Urban university health clinic (reference category)	Rodriguez et al. 2019[24] HPV vaccination initiation HPV vaccination completion	706 (1 study) (Females only) Young adults & College students	Rural clinic: Dose 1 (45.1%), Dose 2: (13.8%), Dose 3: (4.5%) Rural college: Dose 1 (6.8%), Dose 2 (2.8%), Dose 3 (1.6%) Urban clinic: Dose 1 (50.7%), Dose 2: 83 (39.7%), Dose 3 (28.2%) Uptake of the next dose was also greatest for women recruited from clinics than colleges[a]
Incentive-based intervention Individual level 2 groups I: Vaccine free of charge alternate dosing schedule (0, 2, 12 months) C: Vaccine free of charge using standard dosing schedule (0, 6, 12 months)	Rodriguez et al. 2019[24] HPV vaccination initiation HPV vaccination completion	220 (1 study) (Males only) Young adults & College students	I: Dose 1 (96.4%), Dose 2 (95.5%), Dose 3 (94.6%) C: Dose 1 (89.0%), Dose 2:(88.1%) Dose 3 (79.8%) A college setting was effective in vaccinating young adult males, with completion higher using an alternative dosing schedule than standard dosing schedule (0, 2, 12 months vs 0, 6, 12 months)[a]
Incentive-based intervention Individual level 3 groups that all had the vaccine free of charge I1: No doses prior I2: One dose prior I3: Two doses prior	Rodriguez et al. 2019[24] HPV vaccination initiation HPV vaccination completion	873 (1 study) Young adults	I1: Dose 1 (75%); Dose 2 (67%); Dose 3 (57%) I2: Dose 2 (77%) Dose 2 (64%) I3: Dose 3 (90%)[a]
Incentive-based intervention Individual level 1 group I: $25 gift card for questionnaire and voucher for all three doses free of charge	Rodriguez et al. 2019[24] HPV vaccination initiation	495 (1 study) (Females only) Young adults	Dose 1 (25.9%)[a]
Incentive-based intervention Individual level 1 group I: Voucher for Gardasil 3-dose regimen after completion of questionnaire (via structured interview). Compensated $25 gift card	Rodriguez et al. 201924 HPV vaccination initiation	247 (1 study) Young adults	Dose 1 (44.9%)[a]
Reminder-based intervention Individual level 1 group I: Dose 1 administered after delivery of baby before discharge. Reminder call or letter 2 weeks prior to doses 2 and 3. Dose 2 administered at 6-week postpartum visit (within 42–70 days after dose 1). Dose 3 administered in outpatient setting (within 120–160 days after dose 2). Patients receiving dose 3 >160 days removed	Rodriguez et al. 2019[24] HPV vaccination completion	150 (1 study) (post-partum females) Young adults	% females Dose 1 41.3% (95% CI 33.4, 49.7%) Dose 2: 23.3% (95% CI 16.8, 30.9%) Dose 3: 30.7% (95% CI 23.4, 38.7%)
Multi-component intervention Individual level Educational: Technology mediated presentation (video) and printed information Incentives (T-Shirt) 2 groups I:13-min educational video about HPV and vaccination, plus CDC HPV vaccine information sheet and a free t-shirt C: CDC HPV vaccine fact sheet and a free t-shirt	Fu et al. 2014[27] Mogaka et al. 201921 HPV vaccination completion	344 (1 study) Young adults	From Fu et al. 2014 RR 1.36 (95% CI 1.03, 1.79) 43.3% of intervention group and 31.9% of control group completed the 3-dose series (p=0.03) From Mogaka et al. 2019[21] Intervention 43.3%; Control 31.9% (p=0.03)
Reminder-based intervention Individual level Reminders: text message, email No further details provided	Ilozumba et al. 2021[22] HPV vaccination completion	255 (1 study) Young adults	More young adults completed the 3-dose HPV series in the intervention group (who were sent a monthly text or e-mail message) than those in the control group (p< 0.05
Reminder-based intervention Individual level Reminders: telephone, text message, email, letter, Facebook message 2 groups I: Automated reminder messages for doses 2–3 (text, e-mail, phone, private Facebook message, or standard mail) versus C: routine follow-up - further details provided	Ilozumba et al. 2021[22] Rodriguez et al. 2019[24] HPV vaccination completion	365 (1 study) Young adults	From Ilozumba et al. 2021[22] No significant difference in completion rates between intervention and (text, email, phone call, private Facebook message, standard mail control groups) for young adults[a] From Rodriguez et al. 2019 I: Dose 3: 31 (17.2%) C: Dose 3: 35 (18.9%) OR 0.92 (95% CI 0.59, 1.44)

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Reminder-based intervention Individual level Reminders: test message 1 group I: Text messages to deliver health education over 7 days	Ilozumba et al. 2021[22] Lott et al. 2020[26] Rodriguez et al. 2019[24] HPV vaccination initiation	30 (1 study) (Korean-American) Young adults	From Ilozumba et al. 2021[22] Increase receipt of the HPV vaccine (p<0.01)[a] From Lott et al. 2020 Increase receipt of the HPV vaccine[a] From Rodriguez et al. 2021 9 (30.0%) received HPV dose 1
Multi-component intervention Individual level Education: population-targeted, individually-tailored content about HPV and HPV vaccine delivered online Reminders: monthly email or text message No further details provided	Lott et al. 2020[26] HPV vaccination initiation HPV vaccination completion	150 (1 study) (Gay and bisexual males) Young adults	Series initiation within seven months • 44.7% I vs. 25.7% C (p=0.02) OR 2.34 (95% CI: 1.18–4.67) Series completion within seven months • 10.5% I vs. 2.7% C (p=0.07) OR 4.24 (95% CI: 0.87–20.66)[f]
Education based intervention Individual level Education: online information - tailored education versus active control (CDC vaccine website) 2 groups I: Educational website tailored to baseline survey responses (MeFirst) C: Standard CDC information HPV factsheet	Barnard et al. 2019[19] Rodriguez et al. 2019[24] Completing one dose (%) Completing two doses (%) Completing three doses (%)	661 (1 study) College students	Between group comparison No significant differences in HPV vaccine uptake[a] Completing one dose I: (7.83%) / C: (8.73%) Completing two doses I: (3.31%) / C: (3.61%) Completing three doses I: (0.60%) / C: (1.2%) From Rodriguez et al. 2019[24] I: Dose 1; n=26; Dose 2 n=11 C: Dose 1 n=29, Dose 2 n=12
Education based intervention Individual level Technology mediated presentations: HPV specific educational videos with and without message framing 3 groups I: HPV specific educational videos (vaccination benefits) C1: HPV specific educational videos costs of not getting vaccinated C2: General video with no message framing	Barnard et al. 2019[19] HPV vaccination initiation	739 (1 study) College students	Between group comparison No significant difference in HPV vaccine uptake[a] Vaccination benefits (5%) Costs of not getting vaccinated (6%) No message framing (7%)
Education based intervention Individual level Technology mediated presentations: HPV specific educational videos (narratives led by peer and medical experts; peers alone, by medical experts alone) versus active control (no narrative) 6 groups I1: Video of HPV vaccine decision narratives delivered by peers I2: Video of HPV vaccine decision narratives delivered by medical experts I3: Video of HPV vaccine decision narratives delivered by peers and experts C1: Informational video without narratives C2: CampusWeb site providing information about HPV and the vaccine C3: No message	Barnard et al. 2019[19] Priest and Knowlden 2015[18] Fu et al. 2014[27] Rodriguez et al. 2019[24] HPV vaccine uptake of at least one dose (%)	404 (1 study) College students	From Barnard et al. 2019[19] The peer and medical expert-led vaccination video was associated with increases in receiving at least one HPV vaccine dosea I1:17.8% vaccinated / I2: 6.0% vaccinated I3: 21.8% vaccinated / C: 11.8% vaccinated From Priest and Knowlden 2015[18] I3 was twice as likely to vaccinate at 2-month follow-up compared with C (all controls collapsed; p=0.036) I1 did not increase the odds of vaccinating compared with C (p=0.185) I2 decreased the odds of vaccinating compared with C (p=0.25) I3 was nearly twice as likely (22%) as Cnt (12%) to get vaccinated (p=0.035) I3 significantly increased vaccination at 2-month follow-up (p<0.001) Vaccine uptake in I1 (p=0.207) and I2 (p=0.444) did not change from postintervention to 2-month follow-up From Fu et al. 201427 and Rodriguez et al. 2019[24] I1:17.8% vaccinated / I2: 6.0% vaccinated I3: 21.8% vaccinated / C: 11.8% vaccinated From Fu et al. 2014 I1 vs. control (C1 + C2 + C3): RR 1.61 (95% CI 0.80,3.28) I2 vs. control (C1 +C2 + C3): RR 0.48 (95% CI 0.13,1.69) I3 vs. control (C1 +C2 + C3): RR 2.07 (95% CI 1.05, 4.10)
Education based intervention Individual level Printed information: information leaflet about cervical cancer versus information leaflet about cervical cancer and genital warts 4 groups I: 2 groups both given fact sheet about HPV disease and vaccine with framing paragraphs of varying focus I1. Cervical cancer prevention I2. Cervical cancer + genital warts prevention C: No control condition	Barnard et al. 2019[19] Priest and Knowlden 2015[18] Fu et al. 2014[27] HPV vaccine uptake of at least one dose (%)	159 (1 study) College students	From Barnard et al. 2019[19] No significant difference in HPV vaccine uptake[a] Leaflet about cervical cancer (32%) Leaflet about cervical cancer plus genital warts (44%) From Priest and Knowlden 2015[18] 32% of I1 and 44% of I2 participants had received one or more doses of the HPV vaccine at 2-month follow-up; difference between groups was not significant (p=0.291) From Fu et al. 2014 I1:33.3% vaccinated / I2: 41.7% vaccinated (p=0.61) RR 0.2 (95% CI -0.44, 0.56)

SOCIAL-ECOLOGICAL MODEL LEVEL INTERVENTION DETAILS	SYSTEMATIC REVIEWS	NUMBER OF PARTICIPANTS (STUDIES)	EFFECT
Education based intervention Individual level Face-to-face: language-specific peer-to-peer education to Chinese students at a USA university No further details provided	Barnard et al. 2019[19] Overall HPV vaccination rate	nr (1 study) College students	HPV vaccinations increased by 41% compared with the same period the year before (331 vs 235 HPV vaccine doses) and 83.7% (277) of the doses were administered to Chinese students[a]
Multi-component intervention Individual level Education: printed information Reminders: letter I: Fact sheet about HPV and vaccination given and contents reviewed with the study coordinator. Two weeks later, mailed copy of the fact sheet and reminder letter including how to schedule vaccination C: HPV vaccine briefly mentioned, different HPV vaccination fact sheet given and information on how to schedule vaccination given fact sheet with message framing	Barnard et al. 2019[19] Priest and Knowlden 2015[18] Fu et al. 2014[27] Rodriguez et al. 2019[24] HPV vaccine uptake of at least one dose (%)	256 (1 study) College students	From Barnard et al. 2019[19] No significant difference in HPV vaccine uptake[a] 5.5% of participants received at least 1 HPV vaccine dose[b] From Priest and Knowlden 2015[18] Intervention and control groups reported no difference in HPV vaccine uptake 6 months postintervention. The intervention was not significantly associated with HPV vaccine uptake (RR 0.84) From Fu et al. 2014 Rate of receipt of the first dose of HPV vaccine in the intervention group was low (5.5%) and did not differ significantly from that of the control group. RR 0.84 (95% CI 0.31, 2.28)
Education based intervention Individual level Technology mediated presentations: videos 2 groups I: HPV education and practical advice C: Women's health topics	Barnard et al. 2019[19] HPV vaccine uptake of at least one dose (%)	70 (1 study) College students	Between group comparison No significant differences in HPV vaccine uptake[a,b]
Multi-component intervention Individual level Education: text-based health education messages Reminders: text messages 2 groups I: 7 electronic messages once per month over 7 months (4 health education messages about HPV and HPV vaccine, 2 appointment reminders, 1 message for follow-up survey) C: Received standard care (paper card with next appointment date)	Barnard et al. 2019[19] Ilozumba et al. 2021[22] Lott et al. 2020[26] 2nd or 3rd dose of the HPV vaccine (Voluntarily initiating first dose of vaccine)	264 (1 study) College students	From Barnard et al. 2019 and Ilozumba et al. 2021[22] Between group comparison No significant differences in HPV vaccine completion rates for intervention (educational and reminder strategy) and control group[a] From Barnard et al. 2019 and Rodriguez et al. 2019[24] Completing two doses HPV education (53%) Standard care (52%) Completing three doses HPV education (34%) Standard care (32%) From Lott et al. 2020[26] Series completion within seven months Black participants: I: 74.2%; C: 36.8%[a] "Other" race participants: I: 37.9%; C: 50%[a] Homosexual/bisexual participants: I: 38.9%; C: 20%[a]
Education based intervention Individual level Technology mediated presentations: videos and message framing 2 groups I: HPV specific educational videos (high threat communication) C: HPV specific educational videos (low threat communication)	Barnard et al. 2019[19] HPV vaccine uptake of at least one dose (%)	72 (1 study) College students	3 participants (6.25%) obtained the vaccine[b]
Education based intervention Individual level Technology mediated presentation: online story telling 1 group I: A culturally-appropriate online educational story-telling intervention	Lott et al. 202026 HPV vaccine series initiation	87 (1 study) (Korean American) College students	Series initiation or scheduled appointment to receive vaccine within two months 15.6% vs 7.1% C (p=0.317)

Key: AOR: adjusted odds ratio; C: control; CI: confidence interval; HBM: health belief model; HIT: health information technology; I: intervention;
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b All Dublin County medical practices providing immuniations to adolescents aged 11–18 years and using North Carolina Immunization Registry

HPV Action Network Participants

Member Organisations Part of this Network

European Association of Urology

European Federation for Colposcopy

European Head & Neck Society

European Oncology Nursing Society

esdo

ESGO European Society of Gynaecological Oncology

ESOP

European Society of Pathology

European Society for Sexual Medicine

ESTRO

IPOS International Psycho-Oncology Society

ipvs International Papillomavirus Society

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