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**Vaccine acceptability, uptake and completion amongst men who have sex with men: A
systematic review, meta-analysis and theoretical framework**

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Abstract

Background: Due to an increased risk of sexually transmitted infections (STIs), gay, bisexual and other men who have sex with men (MSM) have been recommended to receive vaccinations against human papillomavirus, meningitis C and hepatitis A/B. This review aimed to compare the rates of vaccine acceptability, uptake and completion, and to identify determinants of vaccine outcomes specific to MSM to inform a theoretical framework.

Methods: In January 2020 four databases were explored to identify vaccination behaviours and associated factors among MSM. A narrative systematic review and meta-analysis were performed. Data were synthesised for theoretical modelling. **Results:** Seventy-eight studies, mostly from the USA, were included. The average vaccine acceptability was 63% (median=72%, range: 30%-97%), vaccine uptake 45% (median=42%, range: 5%-100%) and vaccine completion 47% (median=45%, range: 12%-89%). Six categories of factors associated with vaccination acceptability, uptake and completion were conceptualised: Individual (e.g., demographic and psychosocial); Interpersonal (e.g., peer education); Healthcare provider (e.g., vaccine recommendation); Organisational and practice setting (e.g., routine collection of patient sexual orientation information that is integrated into a clinical decision support system); Community environment (e.g., targeted health promotion campaigns); and National, state and local policy environment (e.g., public health guidelines targeting MSM). **Conclusion:** Despite overall high levels of acceptability, uptake and completion rates were below targets predicted by cost-effectiveness modelling across all recommended vaccines. These parameters may need to be adjusted for more precise estimations of cost-effectiveness. Addressing the multiple levels of determinants, as outlined in our theoretical framework, will help guide interventions to increase vaccine completion among MSM.

Keywords: Gay, Bisexual, MSM, HPV, Meningitis, HAV, HBV, vaccination

INTRODUCTION

Gay, bisexual and other men who have sex with men (MSM) are at an increased risk of sexually transmitted infections (STIs) associated with substantial physical and mental ill-health.[1-2] Marginalisation, stigmatisation, homophobia and social attitudes towards homosexuality have had a negative impact on access to healthcare and preventative treatments for MSM, contributing to health disparities due to sexual orientation.[3] The MSM population globally is estimated to be between 0.3% to 6.5%, but MSM carry a substantial burden of all STIs.[4] There is evidence of syndemicity, where mental health issues, substance abuse, and/or the experience of violence co-occur with higher rates of STIs.[5] Specific psycho-social factors also influence the susceptibility to STIs, such as the lack of disclosure of same-sex sexual practices to health professionals (HCPs) resulting in reduced access to relevant healthcare services, notably screening and vaccinations.[6]

The MSM community are at greater risk of hepatitis A (HAV) and B (HBV) viruses, human papillomavirus (HPV) and meningitis C (MenC); infections that are all preventable with effective vaccinations. Although gender-neutral and universal vaccination programmes in childhood are the most effective strategies against communicable diseases, many countries, including Australia, Brazil, Canada, Germany, Ireland, Mexico, the Netherlands, Thailand, Taiwan, UK and USA, have at some point adopted a selective approach to vaccination targeting only high-risk individuals, including MSM. This approach is guided by cost-effectiveness modelling comparing the speculated financial benefits of selective vaccination programmes over universal immunisation, when the benefits of the universal approach are expected to be marginal. Predicted vaccination uptake rates inform cost-effectiveness modelling, with some using the above 80% uptake as a parameter for the estimation.[7] Thus, uptake rates below the 80% mark would be deemed as suboptimal and less cost-effective.

In the past 30 years, vaccination programmes targeting MSMs' higher risk of HPV, HAV, HBV or MenC have been included in the national guidelines of many countries. Unfortunately, selective vaccination policies have not realised any benefit for MSM, but rather maintained the gap in sexual health inequity between MSM and men who have sex with women (MSW). For example, the UK NHS vaccination programme in 2008 offered the HPV vaccination to all girls aged twelve to thirteen to protect against HPV-induced cervical cancer. This female-only strategy achieved 'herd protection' for young women and unvaccinated men of corresponding age. There was a dramatic decline in HPV amongst young unvaccinated heterosexual men, but the rates of HPV infection in MSM remained stable, illustrating how a selective strategy can widen health inequalities.[8] Taking this into account, along with additional evidence that HPV is associated with genital warts and non-cervical cancers, an MSM-selective HPV vaccination program was piloted in England from 2016 for gay and bisexual men aged up to 45 years attending sexual health clinics. However, only half of MSM initiated the vaccine within the first 12 months [9], indicating a need for parallel public health investments, community engagement and individual-level behaviour change interventions to improve awareness and vaccine initiation among MSM. In 2018, the economic modelling was revised taking into account the costs of HPV-related cancers, such as oral cancers in heterosexual men.[9] As a result, since 2019 all adolescent boys have been offered HPV vaccine, regardless of their sexual orientation.

In the future selective vaccination programmes may be considered for other diseases impacting the MSM community; these include the potential HIV vaccination and the partially-effective meningitis B vaccination against gonorrhoea [10-11]. If selective vaccination strategies are used, it is essential to understand how these should be developed to achieve the best possible uptake and clinical outcomes. Understanding barriers and

facilitators to vaccine initiation in MSM would help inform the development of effective public health interventions and modelling studies on which vaccination policies are based.

Vaccine acceptability and behaviour

Vaccine acceptability (or ‘acceptance’) is a heterogeneous construct referring to the degree to which an individual is willing to undergo the recommended course of vaccination. The concept of acceptability has been focused on understanding the demand for vaccination and resultant adherence. Active demand represents intentional seeking of vaccination by an informed individual who perceives benefits and need of a particular vaccination. In contrast, passive acceptability reflects compliance with recommendations from healthcare professionals and community leaders in line with recommended public health programmes. Although acceptability of health interventions has been conceptualised [12], there is no single construct of ‘vaccine acceptability’ and historically it has been most commonly operationalised as ‘agreement’, ‘acceptance’, ‘willingness’, ‘perceived likelihood’ or ‘intention’ to be vaccinated.[13] Other terms such as ‘vaccine hesitancy’ have been used as an indicator of delay, deferral or vaccination refusal and observed as a continuum between vaccination receipt and rejection.[14] In general, acceptability is closely related to motivation and decision-making processes and studies of acceptability aim to identify individuals that have negative attitudes towards vaccines, resulting in a lack of vaccination adherence. Previous reviews examining vaccination behaviours in MSM have focussed on existing vaccines, notably HPV [15], HBV [16-17] and the hypothetical acceptability of a vaccine for HIV [11], indicating moderate-to-high levels of acceptability.

Vaccine uptake and completion describe actual vaccine behaviours and go beyond motivation. The term ‘uptake’ refers to the initiation or administration of the first vaccination dose, but sometimes multiple doses are needed within a given time to achieve sufficient

immunological response. Thus, incomplete vaccination compromises effectiveness, making vaccine completion the most important indicator of the success of a vaccination regimen.

To date, no review has synthesised data on vaccination acceptability and behaviour (i.e. uptake and completion) among MSM. Furthermore, there has been no systematic synthesis of the correlates of acceptability and behaviour related to vaccinations against STIs in MSM. To inform the development of vaccination programmes for future vaccine-preventable STIs in MSM this review aimed: i) to estimate the pooled rates of vaccine acceptability, uptake and completion in MSM; and ii) to identify the positive and negative correlates of vaccine behaviours in MSM.

METHODS

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[18]

Search strategy

Pubmed, Web of Science, Embase and Scopus were explored to identify relevant articles published before 30st of January 2020 (Figure 1). There were no time or geographical restrictions for the published articles. Specific MeSH terms were individually adjusted to each database using the following words: (human papillomavirus, HPV) or (hepatitis, HAV, HBV) or (meningitis, meningococcal) and (vaccin*, immuni*, jab, inoculat*) and (gay, MSM, homosexual*, bisexual*).

Eligibility

The specific inclusion for study selection were:

- i) Peer-reviewed original studies written in English. Editorials, reviews, modelling analyses and conference proceedings were excluded.

- ii) Studies on vaccination acceptability, uptake and completion for preventative vaccines against HPV, HAV, HBV and MenC. Hypothetical vaccines, such as HIV or hepatitis C, or those not specifically aimed at MSM (e.g. ‘flu vaccine) were excluded. Articles reporting vaccine knowledge or similar cognitions without detailing vaccination behaviours or correlates were excluded.
- iii) Studies about gay, bisexual and other men who have sex with men (MSM) of various sexual and gender identities, including cis men as well as transgender men and women. Studies not focussing entirely on MSM population and reporting insufficient cases (<5% or <50 cases) to draw meaningful conclusions were excluded.
- iv) Quantitative or mixed-methods studies. Purely qualitative studies were excluded.

Selection process

Database searches were conducted by three reviewers (TN, MF, DM). Records from each database were transferred to EndNote, a bibliographical management tool, to remove all duplicates. The articles were screened for relevance against the inclusion/exclusion criteria, first reviewing titles and abstracts, and then the full-text articles for all those appearing to meet the eligibility criteria. The reviewers worked independently and then achieved consensus in group discussion. The reviewers also hand-searched the reference sections of relevant systematic reviews and articles meeting the inclusion criteria for additional studies. If a study reported on male vaccination in general, but with a substantial proportion of MSM, the authors were asked clarification about the MSM-specific data if necessary. Key authors of relevant articles were also contacted to identify additional publications for inclusion.

Data extraction, synthesis and meta-analysis

The data extracted included authors, publication year, country, number of MSM participants, vaccine type, study design, sample characteristics, the rates of vaccine

acceptability, uptake and completion as well as their statistically significant correlates, both positive and negative. The data was collated in a spreadsheet; data from multiple publications but relating to one study were merged to avoid bias. Data synthesis was undertaken to create a narrative outline comparing rates of vaccine acceptability, initiation and completion across the four vaccine types and explored the similarities and differences in identified correlates.

The data synthesis informed the construction of a theoretical framework by TN and CW to explain and predict MSM's vaccination behaviours. A mapping exercise was used to construct a basic model of barriers and facilitators for vaccinations in MSM. This subsequently informed charting of demographic, behavioural and psychological factors that were then grouped thematically to construct levels of various influences on vaccine acceptability and behaviours, such as individual and community-level factors. The mapping of identified correlates used a socio-ecological approach [19] to organise them into distinct levels of influence on individual behaviour. The face validity of the framework was confirmed in discussions with co-authors.

Multilevel mixed-effects meta-regression models (Supplementary file A) were estimated to account for effect size dependency, using log-odds as the outcome measures, with random slopes for each dependent variable (acceptability, uptake, completion) nested within studies. A compound symmetric structure for the random effects was used, estimating a single random effects variance and correlation for all three dependent variables. The amount of heterogeneity (i.e., τ) was estimated using the restricted maximum-likelihood estimator. Cook's distances were used to examine whether studies were overly influential in the context of the model. Studies with a Cook's distance larger than the median plus six times the interquartile range of the Cook's distances were considered to be overly influential. Confidence intervals and prediction intervals were computed using the Knapp and Hartung *t*-distribution method. Models were estimated using R and the metafor packages.

Quality and relevance assessment

Appraisal Tool for Cross-Sectional Studies (AXIS tool) was used to assess the overall quality and risk of bias in cross-sectional studies.[20] The AXIS tool does not generate a global quality assessment score but rather evaluates individual characteristics. In this review, AXIS enabled the identification of methodologically weaker studies and those with higher and lower relevance for an MSM-selective vaccination programme. Thus, studies were categorised to be of either 'higher', 'medium' or 'lower' quality and relevance.

RESULTS

Search results & quality assessment

In total, 3706 records were identified through database searches, 1143 titles and abstracts were screened after removing duplicates, and 327 papers reviewed in full. Seventy-eight studies were included in this review (Table 1).

The methodological quality of the studies and their relevance for an MSM-selective vaccination approach varied: Lower (9), Medium (32) and Higher (37). Most studies of medium or lower quality had either not justified their sample size, stated their response rate, funding source or commented on conflicts of interest.

Study characteristics

Vaccination acceptability and behaviours were explored for HPV (33 studies), HBV (24), HBV & HAV (9), HAV (5), MenC (4) and HPV & HBV & HAV (3). Studies were published from 1990 to 2020 and originated from USA (43), Netherlands (7), United Kingdom (7), Australia (6), Canada (3), China (3), Taiwan (2), Hong Kong (1), Italy (1), Germany (1), Mexico (1), Ireland (1), Brazil (1) and Thailand (1). Studies were predominantly cross-sectional with 64 studies, 5 service evaluation, 9 cohort studies and 3 experimental. Convenience sampling was the most common recruitment strategy within the

following locations: healthcare settings, e.g. sexual health clinics (24), internet-based panels and online LGBT networks (20), LGBT community settings such as pride events, gay bars and gyms (16), large clinical datasets (9), university/college settings (1) and a combination of various community and healthcare settings (7). Nineteen studies were grounded in theoretical frameworks: Health Belief Model (12), Theory of Planned Behaviour (8), Social Cognition Theory (3), Diffusion of Innovation (1), Model of Persuasion (1), Syndemic Conceptual Theory (1), Protection Motivation Theory (1), Reasoned Action Approach (1), and Integrative Model of Behavioural Prediction (1).

This review reports on vaccine acceptability and behaviours among 134,038 MSM. The synthesis reflects studies of mostly men of white ethnicity, university educated with access to healthcare. While most of the HPV vaccination studies focussed on younger MSM (<26 years), the studies of HBV, HAV and MenC vaccinations surveyed men in their 30s.

Vaccine acceptability

Studies predominantly focussed on HPV vaccine acceptability (18), with fewer examining HBV (3) or combined HBV&HAV (1). Across all studies, the average vaccine acceptability was 63% (median=72%, range: 30%-97%) in MSM, or if reported on Likert-type scales acceptability was within the third and fourth quartiles. The lowest acceptability (30%) was reported in an Australian study of 16-20 years old MSM who were asked about the hypothetical purchasing of the HPV vaccine for \$450.[22] In contrast, the highest acceptability of 97% was reported among MSM in China recruited through a non-governmental organization and an outpatient HIV clinic.[48] In this study, acceptability of a free HPV vaccine was even higher in MSM living with HIV (99%), decreasing to 80% should payment be needed. Free vaccination yielded higher acceptability and direct payment lower acceptability in four other studies.[26,31,39,48] There was an upward trend in HPV vaccine acceptability over time, reflecting changes in policies and guidelines recommending

MSM-selective vaccination programmes. In general, higher rates of acceptability were found amongst MSM attending sexual health clinics compared to those in the community.

Fifty-eight distinct correlates of vaccine acceptability (39 positive and 18 negative) were identified (Table 2). Within demographic correlates, older MSM, those who identified as an ethnic minority within predominantly White populations, as well as those who lived in less urbanised areas reported lower vaccine acceptability. MSM in full-time employment, had higher educational levels or household incomes, were more likely to accept vaccination. Men who disclosed their sexual orientation to an HCP, accessed sexual health services, notably STI/HIV screening or had received vaccines in the past reported higher vaccine acceptability. Personal risk indicators associated with greater vaccination acceptability were MSM who identified as 'homosexual/gay', had a greater number of sexual partners, had been diagnosed with an STI/HIV or engaged in anal intercourse. Conversely, MSM who had never visited an LGBT-community venue nor used any gay dating apps to meet other men reported lower acceptability. Awareness and knowledge about viral infections and the preventative vaccines, as well as being exposed to promotional material about vaccinations, were associated with higher acceptability. Several psychological variables, including higher perceived severity and susceptibility of infection, concerns, worry and anxiety about virus-induced diseases were associated with higher acceptability. Positive attitudes and perceptions of the vaccines concerning the benefits, effectiveness and their protective properties as well as higher self-efficacy, perceived behavioural control, social norms and anticipated regret correlated with higher acceptability. Lower vaccine acceptability was associated with higher perceived practical and clinical barriers such as vaccine cost, side effects, lack of time and a fear of needles. Stigma, embarrassment and the belief that vaccination was a sign of promiscuity or that it was aimed at women only, correlated with lower acceptability.

Vaccine uptake

Studies of vaccine initiation or uptake of a single dose of a vaccine predominantly focussed on those against HBV (17), HPV (17), HAV (5) and MenC (4), or a combination of HBV, HAV and HPV vaccines (11). The average vaccine uptake in MSM across all studies was 45% (median=42%, range: 5%-100%). For HPV vaccine it was 37% (median=26%, range: 5%-100%). The average uptake for HBV and HAV vaccines was 50% (median=49%, range: 9%-88%) and 49% (median=53%, range: 17%-89%), respectively. The average uptake for the MenC vaccination was 42% (median=38%, range: 23%-67%). The lowest reported rate of vaccine uptake of 5% was reported in 2011 for HPV vaccination of younger MSM (18-26 years old) across 20 USA cities, 1 year after the MSM-selective recommendation by the U.S. Center for Disease Control and Prevention.[27] Subsequent cohort analyses demonstrated an increase in HPV vaccine to 41% by 2014 within those geographical locations.[40] One hundred percent vaccine uptake was reported in Rhode Island (USA) where the vaccination program was accompanied by a package of MSM-relevant healthcare services including specialist risk assessment, HIV testing, behavioural risk reduction counselling and a \$20 incentive for each visit.[28]

There was an association between time since vaccine availability and uptake rates (Figure 2). In 2015, the average uptake of HPV vaccine was only 32%, with a large amount of heterogeneity across studies [95% prediction interval (PI) 5%, 81%]. Uptake was estimated to be higher for Hepatitis A (2015 mean = 69% [95% PI 19%, 95%]) and Hepatitis B vaccinations (2015 mean = 74% [95% PI 23%, 96%]), but still heterogeneous. Few studies reported results for Meningitis C, but uptake rates appeared to be similar to HPV vaccination, (2015 mean = 40% [95% PI 5%, 89%]). Based primarily on data from the longer-established Hepatitis B vaccine, uptake rates appeared to increase over time (e.g, HBV

2000 mean = 46% [95% PI 8%, 89%], HBV 2008 mean = 62% [95% PI 15%, 94%], HBV 2015 mean = 74% [95% PI 23%, 96%]).

Seventy-five distinct correlates of vaccine uptake (60 positive and 15 negative) were identified. Amongst demographic correlates, age was highly correlated with uptake in a curvilinear fashion; MSM below the age of 25 years or above the age of 40 were less likely to initiate vaccinations. Similar to vaccine acceptability, studies of vaccine uptake reported positive associations with higher level of education, income and employment, living in urban areas and being from a White ethnic background. Healthcare utilisation, such as frequent STI screening, disclosure to HCP of sexual orientation, receipt of HCPs' recommendations to vaccinate, previous vaccinations, using PrEP or receiving HIV care, were all positively correlated with uptake. Behavioural indicators of higher risk of getting an STI such as the number of sexual partners, previous STI diagnosis, HIV positive status, engaging in unprotected anal intercourse, having sex in bathhouses and using recreational drugs were correlated with uptake. Several indicators of lower STI risk were positively correlated with uptake, such as being in a relationship, taking daily multivitamins or receiving travel-related vaccinations. Awareness and knowledge about the virus and vaccinations as well as accessing information about available vaccines (e.g. local gay newspapers or peer education) or counselling from an HCP were associated with uptake. Perceived risk of infection, vaccination effectiveness and benefits, self-efficacy, social norms, motivation, positive attitudes and implementing intentions positively correlated with uptake. Perceptions of multiple barriers to vaccination and concern about sexual orientation disclosure were negatively associated with uptake.

Vaccine completion

Studies of vaccine completion, of two or three doses as per guidelines, mainly focussed on those against HBV (10), HPV (9), MenC (1) or a combination of HBV, HAV

and HPV (3) vaccines. The average vaccine completion across all studies was 47% (median=45%, range: 12%-89%). The average completion for HBV vaccine was 57% (median=59%), HPV (average=28%, median=40%), HAV (27% and 28% in two studies) and 50% for MenC in HIV-positive MSM. The lowest vaccine completion (12%) was reported in Scotland after one year of an MSM HPV immunisation programme provided by sexual health services.[54] In contrast, the highest vaccine completion rate of 89% was achieved in Thailand among MSM recruited through the internet and community-based outreach programmes.[76]

Twenty-eight distinct correlates of vaccine completion (23 positive and 5 negative) were identified. Vaccine completion was positively correlated with the demographic characteristics of older age, higher income, higher education level, employment and living in an urban area. Generally, the regular utilisation of sexual health services and being reminded to complete vaccination directly by an HCP or through text messages were associated with completion. As seen with vaccine acceptability and uptake, men of higher risk of acquiring an STI (i.e. higher number of sexual partners, previous STI diagnosis, HIV positive status, exclusively homosexual identity, alcohol use before/during sex) were more likely to complete the vaccination course. Being in a stable relationship or travelling to a hepatitis-endemic country also correlated with completion. One study reported that exchanging goods, money or drugs for sex were negatively associated with vaccination completion. While the perceived severity of infection, self-efficacy and perceived benefits of vaccination were positively associated with completion, perceived personal barriers correlated negatively.

Moderators of vaccine behaviours (meta-analysis)

The effects of moderator variables (i.e. vaccine type, year of data collection, recruitment setting, sampling method, participant age, sexuality, ethnicity, education, HIV status and health insurance) were generally small, and in most cases, confidence intervals

overlapped substantially, even for moderator values at opposite extremes (e.g., estimated values for samples with 0% and 100% higher education) (Supplementary File A). Some moderators appeared to have substantial effects (e.g., population-based samples showed lower rates than convenience samples; those with higher HIV prevalence showed higher rates), but wide confidence intervals preclude definitive conclusions. An exception to this pattern was that rates were higher outside the US (e.g., for 2015 HPV uptake, US mean = 24% [95% PI 5%, 65%], non-US mean = 46% [95% PI 7%, 90%]). Similarly, samples recruited in healthcare settings showed higher uptake rates than other recruitment approaches. Unexpectedly, rates were estimated to be lower when the sample had greater access to healthcare/health insurance (e.g., for 2015 HPV uptake, mean at 50% insured = 25% [95% PI 8%, 56%], mean at 100% insured = 9% [95% PI 2%, 27%]).

DISCUSSION

This review synthesises the literature on acceptability, uptake and completion of each of four different vaccines with current recommendations specific to MSM. Our findings demonstrate generally positive views on vaccinations against STIs with over half of MSM motivated to undergo vaccination. However, the multiple barriers faced by MSM appear to generate an ‘intention-behaviour gap’, with over a quarter of MSM not initiating vaccination, and approximately half of those who receive the first dose not completing the recommended course. This review indicates that vaccination programmes aimed at MSM may achieve high levels of vaccine acceptability, but uptake and completion may not reach levels as predicted in cost-effectiveness modelling.[7] As such, to improve vaccination rates in MSM to an adequate level may require additional support and investment for public health programmes as well as a consideration of universal vaccination approaches.

The analysis identified nearly 100 distinct correlates of vaccination acceptability and behaviour in MSM. There was a substantial overlap of associated factors across vaccine acceptability, uptake and completion, suggesting a specific set of determinants that represent components from across social cognition models. At the individual level, studies have shown that younger or much older MSM, from lower socio-economic backgrounds, with less education and lower social mobility, are less likely to accept, initiate, and complete vaccinations (see Table 2 for demographic factors). There are also significant differences by race and ethnicity, with minority subgroups exhibiting lower acceptability and uptake of vaccines. Attitudes and beliefs about perceived low susceptibility and severity of infection, perceived lower vaccine effectiveness or limited benefits are associated with suboptimal uptake and completion. MSM who perceived multiple barriers were less likely to engage with vaccination services and studies consistently outlined that personal financial cost of vaccination decreased acceptability. MSM-selective vaccination approaches are unlikely to reach 'seldom heard' or hard-to-reach MSM outside of large urban areas with limited access to MSM-specific healthcare services.[42-44,48,59,69,70,73]

At the interpersonal level, perceived norms were positively associated with vaccine acceptability and uptake, however, the influence of family and peers in vaccine decisions appears less important among MSM than in other vaccine eligible populations (e.g. adolescents, young adult women).[105-106] Identifying the most influential or credible referent group for MSM is critical; the peer influencers or other popular opinion leaders may vary depending on the level of connectedness to the LGBT community.[107-108]

Individual and interpersonal factors interrelate with restricted access and utilisation of healthcare, notably specialist sexual health and vaccination services for MSM and other sexual minorities. Men with restricted access to sexual networks and LGBT community resources, those living in less urbanised geographical locations, of a lower behavioural risk

profile, who do not identify as 'gay' or are unable to disclose their same-sex sexual practices to HCPs may be less motivated to initiate and complete vaccination. Expecting stigmatisation and discrimination in healthcare environments deters vaccination uptake among MSM, especially for vaccinations against STIs.[30, 109] Therefore, the opportunity to disclose sexual orientation or same-sex sexual practices to healthcare providers that are sensitive and receptive to MSMs' needs is essential to the success of selective vaccination programmes. These findings highlight the importance of intervening at a structural level (e.g. among healthcare providers, organisations serving MSM) as well as with individuals, to facilitate activities within and across communities such as vaccination outreach or peer education.[30,109] Unlike heterosexual men, younger MSM face multiples barriers related to the formation of sexual identity, hence support and education around working with sexual and gender minority groups is essential.

Our findings are consistent with the three previous reviews on HPV and HBV vaccinations and the utilisation of sexual health services in MSM [12-14] demonstrating barriers to acceptability and uptake. However, the present review offers a more comprehensive outline of the vaccination behaviour spectrum from acceptability to completion. A meta-analysis of 29 studies on HPV vaccine acceptability in men, regardless of their sexual orientation, reported that only a half were motivated to receive it, similar to the rate identified in the present review.[109] It showed that receiving an HCP recommendation to vaccinate as well as perceptions of vaccine benefits and barriers were associated with acceptability. Another systematic review of HPV vaccine acceptability in women demonstrated similar findings, highlighting the role of healthcare professionals in promoting vaccination and influencing perceptions, beliefs and attitudes towards the vaccine.[110] Also, previous reviews identified similar barriers to HIV testing in MSM [111-113], indicating that demographic characteristics such as age, ethnicity, sexual identity, education, income as well

as perceived stigma, poor healthcare utilisation and the lack of active encouragement from healthcare professionals were associated with screening uptake. A meta-analysis of 29 studies on a hypothetical HIV vaccine acceptability also reported that over a half of participants (65%) would be willing to receive it, suggesting that vaccines are seen as positive interventions in MSM [17]. Although HIV vaccination was not included in this review, as it is not yet available, the meta-analysis identified the same predictors as the present review across all vaccines, in particular risk perceptions, attitudes towards the vaccine and perceived barriers. Consequently, MSM experience additional challenges in accessing and utilising specialist healthcare services which compromises vaccine acceptability, uptake and completion when compared with universal vaccination programmes. Hence, in the absence of gender-neutral vaccination programmes, strategies that target MSM should adopt an integrated approach that would serve their unique healthcare needs.[114] Such an approach must deliver culturally sensitive healthcare programmes recognising physical, social and mental health issues faced by sexual and gender minorities that contribute to health inequalities. Access to vaccination services should be extended beyond typical healthcare settings with adequate support from the community and public policies. As such, countries that cannot provide specialist MSM-inclusive services should consider universal vaccination, as they may not achieve optimal vaccine coverage for the selective programme in line with cost-effectiveness modelling.

Theoretical framework

To guide the development of vaccination programmes for MSM, we developed a social-ecological framework that situates vaccine-related behaviours within an interrelated system (Figure 3). The framework conceptualises vaccination behaviours through motivation for vaccines, their initiation and completion, and proposes six levels of factors facilitating vaccine acceptability and behaviours needed for optimal rates to be achieved. The framework

also outlines specific obstacles within the context of public and community health as well as healthcare services. It acknowledges environmental factors associated with vaccination behaviour, such as the role of referent groups as well as location, international policies and vaccination guidelines.

Barriers and facilitators are influenced by specific structural and socio-cultural contexts, which differ between countries and the structure of their healthcare services. Each may need to develop a unique strategy for targeting MSM concerning age, settings in which the vaccine is available or whether it is given for free, or paid by the patient or their insurer. For example, considering the differences in health services between the US and the UK, which would influence the provision and delivery of vaccination programmes having an impact on the experience of barriers and facilitation for uptake and completion. MSM in the UK may refuse vaccination for different reasons to MSM in the US. Thus, our framework considers that the socio-cultural context should determine appropriate and effective vaccine promotion interventions.

Strengths and limitations

Our systematic review provides a comprehensive summary of research on vaccination acceptability and behaviour in MSM across all available vaccines against STIs. Our theoretical framework identifies constructs relevant for MSM-selective vaccination strategy, which were also recognised in similar socio-ecological models.[115-116] The results of the meta-analysis need to be treated with caution, especially when considering potential moderators due to the heterogeneity of measures used. Previous reviews have highlighted the need to standardise vaccine acceptability and uptake measures, proposing a validated scale and harmonising monitoring and evaluation outcomes.[10] The present review synthesised literature about vaccine uptake and completion looking at convenience samples of MSM, mostly accessing healthcare settings, over-representing populations with easier access to

vaccination services. There is a possibility that the pooled rates may be overestimated, as MSM recruited from non-clinical settings showed lower acceptability and uptake. The findings may be skewed towards MSM residing in high-income countries and urbanised areas, who are comfortable participating in LGBT-communities; the views of those on the community margins, such as MSM who do not identify as 'gay', 'bisexual', or of ethnic minority, may be underrepresented.[80] No qualitative studies were included in this review, hence the understanding of contexts in which the vaccination behaviours occurred is limited and warrant further research.

This review comprehensively collates factors associated with vaccination behaviours across multiple vaccines recommended for MSM and a specific overlap of correlates across studies was found. However, there might be other unexplored factors that could be associated with vaccination behaviours in MSM such as marital status, personality traits, internalised homophobia, participation in LGBT activism, sexual health anxiety, depression and medical mistrust. One systematic review identified the role of parental attitudes towards vaccination for their children, but little is known about parental uptake in the context of MSM vaccination.[117] These factors should be explored in future studies on vaccination behaviours in MSM. Previous systematic reviews identified interventions to increase vaccination [118-119] but data specific to MSM were not synthesised. Most studies in our review were cross-sectional in design with only a few examining specific interventions such as awareness campaigns, a reminder system or a mobile phone application. Future research need to identify the most effective intervention to increase vaccination uptake and completion in MSM.

Conclusion

This review indicates that vaccination rates in MSM are sub-optimal when compared with the assumptions of cost-effectiveness modelling. While selective vaccination

approaches, in the absence of universal strategies, could directly protect those utilising specialist healthcare services, MSM with limited access to vaccines remain unprotected. Cost-effectiveness modelling of vaccinations for MSM need to adjust their parameters to reflect barriers to vaccine motivation, initiation and completion evidenced from the literature. When developing effective vaccination programmes for MSM policy-makers and public health intervention developers need to consider multi-level factors that influence vaccination behaviours. Our proposed theoretical framework can inform policies, guidelines and educational training of HCPs to maximise clinical and cost-effectiveness of MSM-selective vaccination programmes. Future research needs to explore the effectiveness of interventions aimed at increasing vaccination rates in MSM and other sexual and gender minority groups at risk of STIs.

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References

1. Ong, J. J., Baggaley, R. C., Wi, T. E., Tucker, J. D., Fu, H., Smith, M. K., ... & Terris-Prestholt, F. (2019). Global Epidemiologic Characteristics of Sexually Transmitted Infections Among Individuals Using Preexposure Prophylaxis for the Prevention of HIV Infection: A Systematic Review and Meta-analysis. *JAMA Network Open*, *2*(12), e1917134-e1917134.
2. Hafeez, H., Zeshan, M., Tahir, M. A., Jahan, N., & Naveed, S. (2017). Health care disparities among lesbian, gay, bisexual, and transgender youth: A literature review. *Cureus*, *9*(4).
3. Zeeman, L., Sherriff, N., Browne, K., McGlynn, N., Mirandola, M., Gios, L., ... & Farinella, F. (2019). A review of lesbian, gay, bisexual, trans and intersex (LGBTI) health and healthcare inequalities. *European journal of public health*, *29*(5), 974-980.
4. Mauck, D. E., Gebrezgi, M. T., Sheehan, D. M., Fennie, K. P., Ibañez, G. E., Fenkl, E. A., & Trepka, M. J. (2019). Population-based methods for estimating the number of men who have sex with men: a systematic review. *Sexual health*, *16*(6), 527-538.
5. Mustanski, B., Garofalo, R., Herrick, A., & Donenberg, G. (2007). Psychosocial health problems increase risk for HIV among urban young men who have sex with men: preliminary evidence of a syndemic in need of attention. *Annals of Behavioral Medicine*, *34*(1), 37-45.
6. Brooks, H., Llewellyn, C. D., Nadarzynski, T., Pelloso, F. C., Guilherme, F. D. S., Pollard, A., & Jones, C. J. (2018). Sexual orientation disclosure in health care: a systematic review. *Br J Gen Pract*, *68*(668), e187-e196.
7. Lin, A., Ong, K. J., Hobbelen, P., King, E., Mesher, D., Edmunds, W. J., ... & Jit, M. (2017). Impact and cost-effectiveness of selective human papillomavirus vaccination of men who have sex with men. *Clinical infectious diseases*, *64*(5), 580-588.

8. Chow, E. P., Read, T. R., Wigan, R., Donovan, B., Chen, M. Y., Bradshaw, C. S., & Fairley, C. K. (2015). Ongoing decline in genital warts among young heterosexuals 7 years after the Australian human papillomavirus (HPV) vaccination programme. *Sexually transmitted infections*, *91*(3), 214-219.
9. Datta, S., Pink, J., Medley, G. F., Petrou, S., Staniszewska, S., Underwood, M., ... & Keeling, M. J. (2019). Assessing the cost-effectiveness of HPV vaccination strategies for adolescent girls and boys in the UK. *BMC infectious diseases*, *19*(1), 1-16.
10. Whelan, J., Kløvstad, H., Haugen, I. L., & van Beest, M. R. D. R. (2016). Ecologic study of meningococcal B vaccine and Neisseria gonorrhoeae infection, Norway. *Emerging infectious diseases*, *22*(6), 1137.
11. Newman, P. A., & Logie, C. (2010). HIV vaccine acceptability: a systematic review and meta-analysis. *Aids*, *24*(11), 1749-1756.
12. Sekhon, M., Cartwright, M., & Francis, J. J. (2017). Acceptability of healthcare interventions: an overview of reviews and development of a theoretical framework. *BMC health services research*, *17*(1), 1-13.
13. Allen, J. D., Coronado, G. D., Williams, R. S., Glenn, B., Escoffery, C., Fernandez, M., ... & Mullen, P. D. (2010). A systematic review of measures used in studies of human papillomavirus (HPV) vaccine acceptability. *Vaccine*, *28*(24), 4027-4037.
14. Dubé, E., Laberge, C., Guay, M., Bramadat, P., Roy, R., & Bettinger, J. A. (2013). Vaccine hesitancy: an overview. *Human vaccines & immunotherapeutics*, *9*(8), 1763-1773.
15. Nadarzynski, T., Smith, H., Richardson, D., Jones, C. J., & Llewellyn, C. D. (2014). Human papillomavirus and vaccine-related perceptions among men who have sex with men: a systematic review. *Sex Transm Infect*, *90*(7), 515-523.

16. Yee, L. J., & Rhodes, S. D. (2002). Understanding correlates of hepatitis B virus vaccination in men who have sex with men: what have we learned?. *Sexually transmitted infections*, 78(5), 374-377.
17. Vet, R., de Wit, J. B., & Das, E. (2017). Factors associated with hepatitis B vaccination among men who have sex with men: a systematic review of published research. *International journal of STD & AIDS*, 28(6), 534-542.
18. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS med*, 6(7), e1000097.
19. Kumar, S., Quinn, S. C., Kim, K. H., Musa, D., Hilyard, K. M., & Freimuth, V. S. (2012). The social ecological model as a framework for determinants of 2009 H1N1 influenza vaccine uptake in the United States. *Health Education & Behavior*, 39(2), 229-243.
20. Downes, M. J., Brennan, M. L., Williams, H. C., & Dean, R. S. (2016). Development of a critical appraisal tool to assess the quality of cross-sectional studies (AXIS). *BMJ open*, 6(12), e011458.
21. Reiter, P. L., Brewer, N. T., McRee, A. L., Gilbert, P., & Smith, J. S. (2010). Acceptability of HPV vaccine among a national sample of gay and bisexual men. *Sexually transmitted diseases*, 37(3), 197.
22. Simatherai, D., Bradshaw, C. S., Fairley, C. K., Bush, M., Heley, S., & Chen, M. Y. (2009). What men who have sex with men think about the human papillomavirus vaccine. *Sexually transmitted infections*, 85(2), 148-149.
23. Thomas, E. A., & Goldstone, S. E. (2011). Should I or shouldn't I: decision making, knowledge and behavioral effects of quadrivalent HPV vaccination in men who have sex with men. *Vaccine*, 29(3), 570-576.

24. Wheldon, C. W., Daley, E. M., Buhi, E. R., Nyitray, A. G., & Giuliano, A. R. (2011). Health beliefs and attitudes associated with HPV vaccine intention among young gay and bisexual men in the southeastern United States. *Vaccine*, *29*(45), 8060-8065.
25. Rank, C., Gilbert, M., Ogilvie, G., Jayaraman, G. C., Marchand, R., Trussler, T., ... & ManCount Study Team. (2012). Acceptability of human papillomavirus vaccination and sexual experience prior to disclosure to health care providers among men who have sex with men in Vancouver, Canada: implications for targeted vaccination programs. *Vaccine*, *30*(39), 5755-5760.
26. Lau, J. T., Wang, Z., Kim, J. H., Lau, M., Lai, C. H., & Mo, P. K. (2013). Acceptability of HPV vaccines and associations with perceptions related to HPV and HPV vaccines among men who have sex with men in Hong Kong. *PloS one*, *8*(2), e57204.
27. Meites, E., Markowitz, L. E., Paz-Bailey, G., Oster, A. M., & NHBS Study Group. (2014). HPV vaccine coverage among men who have sex with men—National HIV Behavioral Surveillance System, United States, 2011. *Vaccine*, *32*(48), 6356-6359.
28. van den Berg, J. J., Larson, H. E., Zimet, G. D., & Lally, M. A. (2014). Bundling human papillomavirus vaccination and rapid human immunodeficiency virus testing for young gay and bisexual men. *LGBT health*, *1*(3), 233-237.
29. Zou, H., Meng, X., Jia, T., Zhu, C., Chen, X., Li, X., ... & Zhang, X. (2016). Awareness and acceptance of human papillomavirus (HPV) vaccination among males attending a major sexual health clinic in Wuxi, China: A cross-sectional study. *Human vaccines & immunotherapeutics*, *12*(6), 1551-1559.
30. Cummings, T., Kasting, M. L., Rosenberger, J. G., Rosenthal, S. L., Zimet, G. D., & Stupiansky, N. W. (2015). Catching up or missing out? Human papillomavirus

- vaccine acceptability among 18-to 26-year-old men who have sex with men in a US national sample. *Sexually transmitted diseases*, 42(11), 601-606.
31. Reiter, P. L., McRee, A. L., Katz, M. L., & Paskett, E. D. (2015). Human papillomavirus vaccination among young adult gay and bisexual men in the United States. *American journal of public health*, 105(1), 96-102.
 32. Zou, H., Grulich, A. E., Cornall, A. M., Tabrizi, S. N., Garland, S. M., Prestage, G., ... & Chen, M. Y. (2014). How very young men who have sex with men view vaccination against human papillomavirus. *Vaccine*, 32(31), 3936-3941.
 33. Fisher, K. A., Cahill, L., Tseng, T. S., & Robinson, W. T. (2016). HPV vaccination coverage and disparities among three populations at increased risk for HIV. *Translational Cancer Research*, 5, S1000-S1006.
 34. Gerend, M. A., Madkins, K., Gregory Phillips, I. I., & Mustanski, B. (2016). Predictors of human papillomavirus vaccination among young men who have sex with men. *Sexually transmitted diseases*, 43(3), 185.
 35. Giuliani, M., Vescio, M. F., Donà, M. G., Latini, A., Frasca, M., Colafigli, M., ... & Cristaudo, A. (2016). Perceptions of Human Papillomavirus (HPV) infection and acceptability of HPV vaccine among men attending a sexual health clinic differ according to sexual orientation. *Human vaccines & immunotherapeutics*, 12(6), 1542-1550.
 36. Gorbach, P. M., Cook, R., Gratz, B., Collins, T., Parrish, A., Moore, J., ... & Meites, E. (2017). Human papillomavirus vaccination among young men who have sex with men and transgender women in 2 US cities, 2012–2014. *Sexually transmitted diseases*, 44(7), 436.

37. Jones, J., Parrish, A., Collins, T., & Chang, P. (2016). HPV vaccine acceptance among a sample of Southern men who have sex with men: A comparison of younger and older men. *Journal of Gay & Lesbian Social Services, 28*(3), 245-254.
38. Marra, E., Alberts, C. J., Zimet, G. D., Paulussen, T. G., Heijman, T., Hogewoning, A. A., ... & van der Loeff, M. S. (2016). HPV vaccination intention among male clients of a large STI outpatient clinic in Amsterdam, the Netherlands. *Papillomavirus Research, 2*, 178-184.
39. Sadlier, C., Lynam, A., O'Dea, S., Delamere, S., Quinlan, M., Clarke, S., ... & Bergin, C. (2016). HPV vaccine acceptability in HIV-infected and HIV negative men who have sex with men (MSM) in Ireland. *Human vaccines & immunotherapeutics, 12*(6), 1536-1541.
40. Thompson, E. L., Vamos, C. A., Vázquez-Otero, C., Logan, R., Griner, S., & Daley, E. M. (2016). Trends and predictors of HPV vaccination among US College women and men. *Preventive medicine, 86*, 92-98.
41. Wheldon, C. W., Daley, E. M., Walsh-Buhi, E. R., Baldwin, J. A., Nyitray, A. G., & Giuliano, A. R. (2018). An integrative theoretical framework for HPV vaccine promotion among male sexual minorities. *American journal of men's health, 12*(5), 1409-1420.
42. Loretan, C., Chamberlain, A. T., Sanchez, T., Zlotorzynska, M., & Jones, J. (2019). Trends and Characteristics Associated with HPV Vaccination Uptake Among Men Who Have Sex with Men in the United States, 2014–2017. *Sexually transmitted diseases, 46*(7), 465.
43. Kahle, E. M., Meites, E., Sineath, R. C., Nasrullah, M., Bowles, K. E., DiNenno, E., ... & Sanchez, T. (2017). Sexually transmitted disease testing and uptake of human

- papillomavirus vaccine in a large online survey of US men who have sex with men at risk for HIV infection, 2012. *Sexually transmitted diseases*, 44(1), 62-67.
44. Oliver, S. E., Hoots, B. E., Paz-Bailey, G., Markowitz, L. E., Meites, E., & NHBS Study Group (2017). Increasing Human Papillomavirus Vaccine Coverage Among Men Who Have Sex With Men-National HIV Behavioral Surveillance, United States, 2014. *Journal of acquired immune deficiency syndromes (1999)*, 75 Suppl 3(Suppl 3), S370–S374.
45. Knapper, C., Birley, H., & Parker, I. (2018). Audit of a human papillomavirus vaccine programme for men who have sex with men delivered through an Integrated Sexual Reproductive Health service. *International journal of STD & AIDS*, 29(11), 1106-1109.
46. McRee, A. L., Shoben, A., Bauermeister, J. A., Katz, M. L., Paskett, E. D., & Reiter, P. L. (2018). Outsmart HPV: Acceptability and short-term effects of a web-based HPV vaccination intervention for young adult gay and bisexual men. *Vaccine*, 36(52), 8158-8164.
47. Halkitis, P. N., Valera, P., LoSchiavo, C. E., Goldstone, S. E., Kantzanos, M., Maioratesi, A. J., ... & Kapadia, F. (2019). Human papillomavirus vaccination and infection in young sexual minority men: the P18 cohort study. *AIDS patient care and STDs*, 33(4), 149-156.
48. Tian, T., Wang, D., Papamichael, C., Yan, Z., Guoyao, S., Zhanlin, Z., ... & Jianghong, D. (2019). HPV vaccination acceptability among men who have sex with men in Urumqi, China. *Human vaccines & immunotherapeutics*, 15(4), 1005-1012.
49. Allen-Leigh, B., Rivera-Rivera, L., Yunes-Díaz, E., Portillo-Romero, A. J., Brown, B., León-Maldonado, L., ... & Lazcano-Ponce, E. C. (2020). Uptake of the HPV vaccine among people with and without HIV, cisgender and transgender women and

- men who have sex with men and with women at two sexual health clinics in Mexico City. *Human vaccines & immunotherapeutics*, 16(4), 981-990.
50. Checchi, M., Mesher, D., McCall, M., Coukan, F., Chau, C., Mohammed, H., ... & Soldan, K. (2019). HPV vaccination of gay, bisexual and other men who have sex with men in sexual health and HIV clinics in England: vaccination uptake and attendances during the pilot phase. *Sexually transmitted infections*, 95(8), 608-613.
51. Edelstein, M., Iyanger, N., Hennessy, N., Mesher, D., Checchi, M., Soldan, K., ... & Yarwood, J. (2019). Implementation and evaluation of the human papillomavirus (HPV) vaccination pilot for men who have sex with men (MSM), England, April 2016 to March 2017. *Eurosurveillance*, 24(8), 1800055.
52. Li, X., Cao, X., Li, Z., Yang, Y., Li, M., Feng, B., ... & Gao, L. (2019). Human Papillomavirus awareness and vaccine acceptability among men who have sex with men from mainland China. *Scientific reports*, 9(1), 1-8.
53. McGrath, L., Fairley, C. K., Cleere, E. F., Bradshaw, C. S., Chen, M. Y., & Chow, E. P. (2019). Human papillomavirus vaccine uptake among young gay and bisexual men who have sex with men with a time-limited targeted vaccination programme through sexual health clinics in Melbourne in 2017. *Sexually transmitted infections*, 95(3), 181-186.
54. Pollock, K. G., Wallace, L. A., Wrigglesworth, S., McMaster, D., & Steedman, N. (2019). HPV vaccine uptake in men who have sex with men in Scotland. *Vaccine*, 37(37), 5513-5514.
55. McCusker, J., Hill, E. M., & Mayer, K. H. (1990). Awareness and use of hepatitis B vaccine among homosexual male clients of a Boston community health center. *Public health reports*, 105(1), 59-64.

56. Dufour, A., Remis, R. S., Alary, M., Otis, J., Mâsse, B., Turmel, B., ... & Omega Study Group. (1999). Factors associated with hepatitis B vaccination among men having sexual relations with men in Montreal, Quebec, Canada. *Sexually transmitted diseases*, 26(6), 317-324.
57. Neighbors, K., Oraka, C., Shih, L., & Lurie, P. (1999). Awareness and utilization of the hepatitis B vaccine among young men in the Ann Arbor area who have sex with men. *Journal of American College Health*, 47(4), 173-178.
58. Rhodes, S. D., Diclemente, R. J., Yee, L. J., & Hergenrather, K. C. (2000). Hepatitis B vaccination in a high risk MSM population: the need for vaccine education. *Sexually transmitted infections*, 76(5), 408-409.
59. MacKellar, D. A., Valleroy, L. A., Secura, G. M., McFarland, W., Shehan, D., Ford, W., LaLota, M., Celentano, D. D., Koblin, B. A., Torian, L. V., Thiede, H., Janssen, R. S., & Young Men's Survey Study Group (2001). Two decades after vaccine license: hepatitis B immunization and infection among young men who have sex with men. *American journal of public health*, 91(6), 965-971.
60. Rhodes, S. D., DiClemente, R. J., Yee, L. J., & Hergenrather, K. C. (2001). Correlates of hepatitis B vaccination in a high-risk population: an Internet sample. *The American journal of medicine*, 110(8), 628-632.
61. Williamson, L. M., Hart, G. J., Flowers, P., Frankis, J. S., & Der, G. J. (2001). The Gay Men's Task Force: the impact of peer education on the sexual health behaviour of homosexual men in Glasgow. *Sexually Transmitted Infections*, 77(6), 427-432.
62. Rhodes, S. D., & Diclemente, R. J. (2003). Psychosocial predictors of hepatitis B vaccination among young African-American gay men in the deep south. *Sexually transmitted diseases*, 30(5), 449-454.

63. de Wit, J. B., Vet, R., Schutten, M., & van Steenbergen, J. (2005). Social-cognitive determinants of vaccination behavior against hepatitis B: an assessment among men who have sex with men. *Preventive medicine, 40*(6), 795-802.
64. Schutten, M., De Wit, J. B. F., & Van Steenbergen, J. E. (2002). Why do gay men want to be vaccinated against hepatitis B? An assessment of psychosocial determinants of vaccination intention. *International journal of STD & AIDS, 13*(2), 86-90.
65. Gunn, R. A., Lee, M. A., Murray, P. J., Gilchick, R. A., & Margolis, H. S. (2007). Hepatitis B vaccination of men who have sex with men attending an urban STD clinic: impact of an ongoing vaccination program, 1998–2003. *Sexually transmitted diseases, 34*(9), 663-668.
66. Warwick, Z., Dean, G., & Carter, P. (2007). B safe, B sorted: results of a hepatitis B vaccination outreach programme. *International journal of STD & AIDS, 18*(5), 335-337.
67. Das, E., De Wit, J. B., Vet, R., & Frijns, T. (2008). 'Feeling'risk and seeing solutions: Predicting vaccination intention against Hepatitis B infection among men who have sex with men. *Journal of Health Psychology, 13*(6), 728-732.
68. De Wit, J. B., Das, E., & Vet, R. (2008). What works best: objective statistics or a personal testimonial? An assessment of the persuasive effects of different types of message evidence on risk perception. *Health Psychology, 27*(1), 110.
69. Weinbaum, C. M., Lyerla, R., MacKellar, D. A., Valleroy, L. A., Secura, G. M., Behel, S. K., ... & Torian, L. V. (2008). The Young Men's Survey phase II: hepatitis B immunization and infection among young men who have sex with men. *American journal of public health, 98*(5), 839-845.

70. Baars, J. E., Boon, B. J., Garretsen, H. F., & van de Mheen, D. (2011). The reach of a hepatitis B vaccination programme among men who have sex with men. *The European Journal of Public Health, 21*(3), 333-337.
71. Storholm, E. D., Fisher, D. G., Reynolds, G. L., Napper, L. E., Morrissey, T. A., & Kochems, L. M. (2010). Hepatitis vaccination of men who have sex with men at gay pride events. *Prevention Science, 11*(2), 219-227.
72. Reiter, P. L., & Brewer, N. T. (2011). Hepatitis B vaccination among a national sample of gay and bisexual men. *Sexually transmitted diseases, 38*(3), 235.
73. Matthews, J. E., Stephenson, R., & Sullivan, P. S. (2012). Factors associated with self-reported HBV vaccination among HIV-negative MSM participating in an online sexual health survey: a cross-sectional study. *PLoS One, 7*(2), e30609.
74. Pitasi, M. A., Bingham, T. A., Sey, E. K., Smith, A. J., & Teshale, E. H. (2014). Hepatitis B virus (HBV) infection, immunity and susceptibility among men who have sex with men (MSM), Los Angeles County, USA. *AIDS and Behavior, 18*(3), 248-255.
75. Vet, R., Wit, J. B. D., & Das, E. (2014). The role of implementation intention formation in promoting hepatitis B vaccination uptake among men who have sex with men. *International journal of STD & AIDS, 25*(2), 122-129.
76. Chonwattana, W., Raengsakulrach, B., Holtz, T. H., Wasinrapee, P., Tongtoyai, J., Chaikummao, S., ... & Curlin, M. E. (2016). Hepatitis B vaccination uptake and correlates of serologic response among HIV-infected and uninfected men who have sex with men (MSM) in Bangkok, Thailand. *Vaccine, 34*(17), 2044-2050.
77. Queiroz, A. A. F. L. N., de Sousa, Á. F. L., Matos, M. C. B., de Araújo, T. M. E., Brignol, S., Reis, R. K., ... & Moura, M. E. B. (2019). Factors associated with self-

- reported non-F of the hepatitis B vaccine series in men who have sex with men in Brazil. *BMC infectious diseases*, 19(1), 1-8.
78. Wiending, S., Ma, A. H., & Clutterbuck, D. J. (2016). An audit of hepatitis B vaccination for men who have sex with men before and after sexual health service integration. *International journal of STD & AIDS*, 27(10), 898-900.
79. Truong, H. H. M., Fatch, R., Do, T. D., & McFarland, W. (2018). Hepatitis B vaccination and infection prevalence among men who have sex with men who travel internationally. *Sexually transmitted diseases*, 45(5), e25.
80. Ross, M. W., Månsson, S. A., Daneback, K., & Tikkanen, R. (2005). Characteristics of men who have sex with men on the Internet but identify as heterosexual, compared with heterosexually identified men who have sex with women. *CyberPsychology & Behavior*, 8(2), 131-139.
81. Sansom, S., Rudy, E., Strine, T., & Douglas, W. (2003). Hepatitis A and B vaccination in a sexually transmitted disease clinic for men who have sex with men. *Sexually transmitted diseases*, 30(9), 685-688.
82. Rudy, E. T., Detels, R., Douglas, W., & Greenland, S. (2003). Factors affecting hepatitis vaccination refusal at a sexually transmitted disease clinic among men who have sex with men. *Sexually transmitted diseases*, 30(5), 411-418.
83. Jin, F., Prestage, G. P., Pell, C. M., Donovan, B., Van de Ven, P. G., Kippax, S. C., ... & Grulich, A. E. (2005). Hepatitis A and B infection and vaccination in a cohort of homosexual men in Sydney. *Sexual Health*, 1(4), 227-237.
84. Siconolfi, D. E., Halkitis, P. N., & Rogers, M. E. (2009). Hepatitis vaccination and infection among gay, bisexual, and other men who have sex with men who attend gyms in New York City. *American journal of men's health*, 3(2), 141-149.

85. Gilbert, L. K., Levandowski, B. A., Scanlon, K. E., & Peterson, R. S. (2010). A comparison of hepatitis A and hepatitis B measures among vaccinated and susceptible online men who have sex with men. *International journal of STD & AIDS, 21*(6), 400-405.
86. Hoover, K. W., Butler, M., Workowski, K. A., Follansbee, S., Gratzner, B., Hare, C. B., ... & Kent, C. K. (2012). Low rates of hepatitis screening and vaccination of HIV-infected MSM in HIV clinics. *Sexually transmitted diseases, 39*(5), 349-353.
87. Ng, B. E., Moore, D., Michelow, W., Hogg, R., Gustafson, R., Robert, W., ... & Gilbert, M. (2014). Relationship between disclosure of same-sex sexual activity to providers, HIV diagnosis and sexual health services for men who have sex with men in Vancouver, Canada. *Canadian Journal of Public Health, 105*(3), e186-e191.
88. Metheny, N., & Stephenson, R. (2016). Disclosure of sexual orientation and uptake of HIV testing and hepatitis vaccination for rural men who have sex with men. *The Annals of Family Medicine, 14*(2), 155-158.
89. Rhodes, S. D., Grimley, D. M., & Hergenrather, K. C. (2003). Integrating behavioral theory to understand hepatitis B vaccination among men who have sex with men. *American journal of health behavior, 27*(4), 291-300.
90. Rhodes, S. D., & Hergenrather, K. C. (2003). Using an integrated approach to understand vaccination behavior among young men who have sex with men: stages of change, the health belief model, and self-efficacy. *Journal of Community Health, 28*(5), 347-362.
91. Rhodes, S. D., & Arceo, R. (2004). Developing and testing measures predictive of hepatitis A vaccination in a sample of men who have sex with men. *Health Education Research, 19*(3), 272-283.

92. Rhodes, S. D., & Hergenrather, K. C. (2008). Attitudes and beliefs about hepatitis B vaccination among gay men: the Birmingham Measurement Study. *Journal of Homosexuality*, 55(1), 124-149.
93. Friedman, M. S., Blake, P. A., Koehler, J. E., Hutwagner, L. C., & Toomey, K. E. (2000). Factors influencing a communitywide campaign to administer hepatitis A vaccine to men who have sex with men. *American Journal of Public Health*, 90(12), 1942.
94. Alberts, C. J., Boyd, A., Bruisten, S. M., Heijman, T., Hogewoning, A., Van Rooijen, M., ... & Sonder, G. J. (2019). Hepatitis A incidence, seroprevalence, and vaccination decision among MSM in Amsterdam, the Netherlands. *Vaccine*, 37(21), 2849-2856.
95. Chen, G. J., Lin, K. Y., Sun, H. Y., Sheng, W. H., Hsieh, S. M., Huang, Y. C., ... & Chang, S. C. (2018). Incidence of acute hepatitis A among HIV-positive patients during an outbreak among MSM in Taiwan: Impact of HAV vaccination. *Liver International*, 38(4), 594-601.
96. Burrell, S., Vodstrcil, L. A., Fairley, C. K., Kilner, A., Bradshaw, C. S., Chen, M. Y., & Chow, E. P. (2020). Hepatitis A vaccine uptake among men who have sex with men from a time-limited vaccination programme in Melbourne in 2018. *Sexually transmitted infections*, 96(2), 110-114.
97. Lin, K. Y., Hsieh, S. M., Sun, H. Y., Lo, Y. C., Sheng, W. H., Chuang, Y. C., ... & Chang, S. C. (2018). Serologic responses and effectiveness of hepatitis A vaccination among human immunodeficiency virus-positive individuals during the outbreak of acute hepatitis A. *Hepatology*, 68(1), 22-31.
98. Singh, V., Crosby, R. A., Gratz, B., Gorbach, P. M., Markowitz, L. E., & Meites, E. (2018). Disclosure of sexual behavior is significantly associated with receiving a

- panel of health care services recommended for men who have sex with men. *Sexually transmitted diseases*, 45(12), 803-807.
99. Srivastav, A., O'Halloran, A., Lu, P. J., Williams, W. W., & Hutchins, S. S. (2019). Vaccination differences among US adults by their self-identified sexual orientation, National Health Interview Survey, 2013–2015. *PloS one*, 14(3), e0213431.
100. Nadarzynski, T., Smith, H., Richardson, D., Bremner, S., & Llewellyn, C. (2018). Men who have sex with men who do not access sexual health clinics nor disclose sexual orientation are unlikely to receive the HPV vaccine in the UK. *Vaccine*, 36(33), 5065-5070.
101. Koch, J., Hellenbrand, W., Schink, S., Wichmann, O., Carganico, A., Drewes, J., ... & Marcus, U. (2016). Evaluation of a temporary vaccination recommendation in response to an outbreak of invasive meningococcal serogroup C disease in men who have sex with men in Berlin, 2013–2014. *Eurosurveillance*, 21(5), 30122.
102. Holloway, I. W., Wu, E. S., Gildner, J., Fenimore, V. L., Tan, D., Randall, L., & Frew, P. M. (2018). Quadrivalent meningococcal vaccine uptake among men who have sex with men during a meningococcal outbreak in Los Angeles County, California, 2016-2017. *Public Health Reports*, 133(5), 559-569.
103. Phillips, G., Johnson, A. K., Adames, C. N., & Mustanski, B. (2018). Meningitis vaccination, knowledge, and awareness among YMSM in Chicago. *Health Education & Behavior*, 45(4), 607-615.
104. Martín-Sánchez, M., Fairley, C. K., Bradshaw, C. S., Chen, M. Y., & Chow, E. P. (2020). Meningococcal vaccine uptake among men who have sex with men in response to an invasive meningococcal C disease outbreak in Melbourne, Australia. *Sexually transmitted infections*, 96(4), 246-250.

105. de Visser, R., Waites, L., Parikh, C., & Lawrie, A. (2011). The importance of social norms for uptake of catch-up human papillomavirus vaccination in young women. *Sexual health*, 8(3), 330-337.
106. Xiao, X., & Borah, P. (2020). Do Norms Matter? Examining Norm-Based Messages in HPV Vaccination Promotion. *Health Communication*, 1-9.
107. Ko, N. Y., Hsieh, C. H., Wang, M. C., Lee, C., Chen, C. L., Chung, A. C., & Hsu, S. T. (2013). Effects of Internet popular opinion leaders (iPOL) among Internet-using men who have sex with men. *Journal of medical Internet research*, 15(2), e40.
108. Petruzzella, A., Feinstein, B. A., Davila, J., & Lavner, J. A. (2019). Moderators of the association between community connectedness and internalizing symptoms among gay men. *Archives of sexual behavior*, 48(5), 1519-1528.
109. Newman, P. A., Logie, C. H., Doukas, N., & Asakura, K. (2013). HPV vaccine acceptability among men: a systematic review and meta-analysis. *Sex Transm Infect*, 89(7), 568-574.
110. Brewer, N. T., & Fazekas, K. I. (2007). Predictors of HPV vaccine acceptability: a theory-informed, systematic review. *Preventive medicine*, 45(2-3), 107-114.
111. Lorenc, T., Marrero-Guillamón, I., Llewellyn, A., Aggleton, P., Cooper, C., Lehmann, A., & Lindsay, C. (2011). HIV testing among men who have sex with men (MSM): systematic review of qualitative evidence. *Health education research*, 26(5), 834-846.
112. Deblonde, J., De Koker, P., Hamers, F. F., Fontaine, J., Luchters, S., & Temmerman, M. (2010). Barriers to HIV testing in Europe: a systematic review. *European journal of public health*, 20(4), 422-432.

113. Noble, M., Jones, A. M., Bowles, K., DiNenno, E. A., & Tregear, S. J. (2017). HIV testing among internet-using MSM in the United States: systematic review. *AIDS and Behavior*, *21*(2), 561-575.
114. Mayer, K.H., Bekker, L.G., Stall, R., Grulich, A.E., Colfax, G. and Lama, J.R., 2012. Comprehensive clinical care for men who have sex with men: an integrated approach. *The Lancet*, *380*(9839), pp.378-387.
115. Ryan, G., Avdic, L., Daly, E., Askelson, N., Farris, P. E., Shannon, J., ... & Seegmiller, L. (2020). Influences on HPV vaccination across levels of the social ecological model: perspectives from state level stakeholders. *Human Vaccines & Immunotherapeutics*, 1-8.
116. Bednarczyk, R. A., Chamberlain, A., Mathewson, K., Salmon, D. A., & Omer, S. B. (2018). Practice-, provider-, and patient-level interventions to improve preventive care: development of the P3 model. *Preventive medicine reports*, *11*, 131-138.
117. Newman, P. A., Logie, C. H., Lacombe-Duncan, A., Baiden, P., Tepjan, S., Rubincam, C., ... & Asey, F. (2018). Parents' uptake of human papillomavirus vaccines for their children: a systematic review and meta-analysis of observational studies. *BMJ open*, *8*(4), e019206.
118. Das, J. K., Salam, R. A., Arshad, A., Lassi, Z. S., & Bhutta, Z. A. (2016). Systematic review and meta-analysis of interventions to improve access and coverage of adolescent immunizations. *Journal of Adolescent Health*, *59*(4), S40-S48.
119. Crocker-Buque, T., Edelstein, M., & Mounier-Jack, S. (2017). Interventions to reduce inequalities in vaccine uptake in children and adolescents aged < 19 years: a systematic review. *J Epidemiol Community Health*, *71*(1), 87-97.