Title:

Factors associated with human papillomavirus, hepatitis A, hepatitis B and mpox vaccination uptake among gay, bisexual and other men who have sex with men in the UK– findings from the large community-based RiiSH-Mpox survey

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DP, RW, KF, CHM, JS, HM reviewed and updated the survey instrument. Survey implementation, data collection and data management were carried out by RW and DO. GB, CM, DO, HM curated secondary analysis plan with review and contributions from KF, MC, JS, RS, SM. GB conducted analysis and completed the first manuscript draft. All authors contributed to successive drafts and reviewed and approved the final manuscript.

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Ethical approval of this study was provided by the UKHSA Research and Ethics Governance Group (REGG; ref: R&D 524). Online informed consent was received from all participants and all methods were performed in accordance with guidelines and regulations set by the UKHSA REGG.

Competing interests:

Authors have no competing interests to declare.

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The data that support the findings of this study are available upon reasonable request from the UK Health Security Agency (UKHSA). Requests can be directed to Dr Hamish Mohammed (hamish.mohammed@ukhsa.gov.uk).

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Abstract (250/250)

Background: Gay, bisexual, and other men who have sex with men (GBMSM) face a disproportionate burden of sexually transmitted infections and are eligible for targeted vaccinations for hepatitis A (HAV), hepatitis B (HBV), human papilloma virus (HPV) and mpox. This study examines the sociodemographic characteristics, sexual behaviours, and sexual healthcare service (SHS) use associated with vaccination uptake.

Methods: We undertook analyses of RiiSH-Mpox - an online, community-based survey with GBMSM recruited via social media and dating apps. We calculated vaccination uptake (≥1 dose) among eligible GBMSM. Bivariate and multivariable logistic regression was performed to identify factors independently associated with vaccination uptake among eligible participants.

Results: Reported uptake in eligible GBMSM was around two-thirds for each of the vaccinations considered: mpox 69% (95% confidence interval (CI): 66%-72%), HAV 68% (CI:65%-70%), HBV 72% (CI:69%-74%) and HPV 65% (CI:61%-68%). Vaccination course completion (receiving all recommended doses) ranged from 75% (HBV) to 89% (HAV) among eligible GBMSM. Individuals who represented missed opportunities for vaccination ranged from 22-30% of eligible SHS attendees. Younger participants, individuals identifying as bisexual, reporting lower educational qualifications, or being unemployed reported lower uptake across multiple GBMSM-selective vaccinations. Individuals who reported greater levels of sexual behaviour and recent SHS use were more likely to report vaccinations.

Conclusion: Eligible participants reported high uptake of vaccinations; however, uptake was lower amongst young GBMSM and self-identifying bisexual men. Awareness of groups with lower vaccination uptake will help inform practice, delivery strategies and health promotion, to improve the reach and impact of vaccinations amongst GBMSM.

Introduction

Gay, bisexual, and other men who have sex with men (GBMSM) continue to be disproportionately affected by sexually transmitted infections (STIs) and viral hepatitides (VHs) both globally[1] and in the UK[2]. To reduce individual and public health impacts of these infections in the UK, several vaccines are recommended for GBMSM[3–6], this includes HPV (human papilloma virus), Hepatitis A (HAV) and Hepatitis B (HBV), which can be spread through sexual contact amongst other means[7].

UK immunisation policy and clinical advice is outlined in The Green Book: Immunisation against Infectious Disease, a compilation of immunisation evidence, procedures, and guidance for vaccine preventable diseases[8]. The UK currently recommends opportunistic immunisation against HAV and HBV to all GBMSM, particularly those who change sexual partners frequently[3,7]. HPV vaccination in the UK was initially introduced for girls aged 12-13 to prevent cervical cancer[9], but was recommended for GBMSM up to and including age 45 from 2016 and for adolescent boys from 2019[5]. Most recently, GBMSM-selective vaccination programmes have been brought into focus through the rapid introduction of vaccination for mpox in response to the 2022 mpox outbreak which particularly affected this group[10].

There is limited literature examining STI/VH vaccination uptake and acceptability among GBMSM. While a pilot study among UK GBMSM found that 89% would willingly receive the HPV vaccine upon recommendation[11], reported uptake of the HPV vaccine is only 34% among GBMSM attending sexual health services (SHS) in England (uptake has also likely decreased due to the impact of COVID-19 on SHS in-person service delivery)[12]. Data on HAV/HBV vaccination uptake among GBMSM in England is also very limited.

To understand STI/VH vaccination uptake inequalities, we investigated the factors associated with uptake of recommended STI/VH vaccines in the UK among a community-sample of GBMSM.

Methods

Study design and Data collection

This study used data collected by the 2022 round of the 'Reducing inequalities in Sexual Health during the mpox outbreak' (RiiSH-mpox) survey, part of a series of cross-sectional community-based surveys first run in 2017[13]. The RiiSH surveys focus on health and wellbeing, sexual risk behaviours, and use of SHS amongst GBMSM, and have been used to improve understanding of the factors underlying STI trends among GBMSM in the UK[14,15]. RiiSH-Mpox included questions on these core topics as well as mpox vaccine uptake during the 2022 mpox outbreak. Details of the RiiSH-Mpox methodology have been previously reported[15].

The RiiSH-Mpox survey was deployed from 24 November-19 December 2022 and included participants that were aged ≥16 years, a UK resident, individuals self-identifying as men (cisgender/transgender), transgender women, or gender-diverse individuals assigned male at birth (gender was overlooked in this analysis, 99% self-identified as a cis-male), and individuals who self-reported having had sex with a man in the last year. Participants were recruited through advertisements on social media (Facebook, Instagram, Twitter [now X]) and through the geospatial networking application ('dating app') Grindr. Online consent was provided by all participants. Lookback periods for healthcare-related factors and sexual risk behaviours varied from reporting since August 2022 (i.e. last 3-4 months), to ever.

Due to relatively low numbers of participants who did not self-report being white or gay/homosexual these variables were dichotomised as white or any other ethnic group, and either gay/homosexual or bisexual, respectively.

Data analysis

Vaccination uptake

To measure uptake and completion levels of vaccination, percentages and 95% confidence intervals (CI) (Clopper-Pearson) were calculated. Uptake was defined as receiving at least one dose of a vaccine and completion as receiving all recommended doses as outlined by the most recent UK vaccination guidance. at the time of the survey (2 doses of HAV, HPV or mpox vaccine and 3 HBV vaccine doses).

Uptake amongst all participants and eligible GBMSM for each vaccine was calculated. Reflecting UK vaccination guidance [3], we considered all GBMSM as eligible for HAV and HBV vaccination. HPV vaccination eligibility was considered in GBMSM reporting SHS attendance who were up to and including age 45, given opportunistic vaccination recommendations across SHS. In line with mpox vaccination guidance[6,10], mpox vaccination eligibility was considered in those reporting: ≥10 physical male sex partners, meeting partners in public sex environments (Sex on premise venues (SOP), cruising grounds or sex parties), having a positive STI test, report of HIV-PrEP or use of chemsex-associated recreational drugs (crystal methamphetamine, mephedrone or gamma-hydroxybutyrate/gamma-butyrolactone). SHS attendance was not considered as part of eligibility for HAV, HBV and mpox vaccination given vaccination availability outside of SHS (e.g. mpox vaccination

outreach, general practice and travel clinic availability for VH vaccination [vaccination setting was not recorded in this survey]).

To measure the association between uptake of different vaccine types, logistic regression was used to generate the unadjusted (uOR) and adjusted odds ratio (aOR) of receiving at least one dose of a respective vaccine versus also receiving at least one dose of another vaccine (vaccines were compared sequentially, in a pairwise manner). For adjusted analyses, age-group and sexual orientation were considered a priori, and additional factors were added in a forwards stepwise manner based on significant bivariate association and evidence from previous literature[11,16–19]. Analyses were adjusted for age, sexuality, ethnicity, educational qualifications, employment, and financial situation.

Missed vaccination opportunities in those attending sexual health services

GBMSM who reported ever having attended an SHS and who met respective proxy vaccination eligibility were considered missed opportunities for vaccination if no vaccination history was reported.

Factors associated with vaccination uptake

Among all participants irrespective of previous SHS attendance (except those over age 45/ those who had not previously attended SHS for HPV vaccination), Pearson's chi-squared test and bivariate logistic regression was used to examine association between sociodemographic, sexual behaviour and health-related factors with vaccination uptake for the HAV, HBV and HPV vaccines, respectively. Analysis of factors associated with vaccination for mpox uptake has been previously reported[15] so was not examined

in this analysis. Multivariable adjustment for significant sociodemographic, sexual behaviour and health-related factors, as per methods described above, was applied.

All analysis was completed using Stata V17.0 (College Station, TX, USA) and all p values below 5% were deemed statistically significant.

Results

Altogether, 1435 individuals engaged with RiiSH-Mpox survey, of whom 1333 met the inclusion criteria. Of these, half were aged over 45 years, 37% were 30-44 and the remaining 13% were 16-29. Almost all self-identified as gay/homosexual (89%) and were of white ethnicity (92%). Most lived in England (86%), 81% were employed, 37% reported at least degree level education, with 48% responding that they were financially comfortable. See Appendix A for sample characteristics.

Vaccination Uptake

Among all participants, 97% self-reported receiving at least one dose of any STI/VH vaccination. HAV vaccination uptake was 68% (CI:65%-70%, 903/1333) and HBV vaccination was 72% (CI:69%-74, 954/1333). Mpox vaccination uptake among eligible participants was 69% (CI:66%-72%, 601/875), or 52% (CI:49%-55%, 692/1,333) among all GBMSM. In those under age 45 who had ever attended a SHS, HPV vaccination was 73% (CI:69%-76%, 417/574), or 42% (CI:39%-45%, 562/1333) among all participants. See table 1.

Receiving one vaccine type was uniformly associated with receiving at least one other (Appendix B). The highest association was found between the HAV and HBV vaccines, individuals who had received one were 12 times more likely to have received at least one dose of the other (aOR:11.98, CI: 9.01-15.92).

Vaccine Completion

HAV vaccination had the highest completion level amongst participants with 89% (CI:87%-91%, 807/903) of those that had received at least one dose completing the course. Among individuals that initiated HBV vaccination, 75% completed the course (CI:72%-77%, 712/954). Of those that had initiated HPV vaccination 84% (CI:80%-88%, 350/ 417) had completed the course and 42% (CI:38%-45%, 288/692) of those that had initiated vaccination for mpox completed the course.

Missed vaccination opportunities in those attending sexual health services

Missed vaccination opportunities among GBMSM who ever reported SHS attendance history were considered 27% (CI:24-29%) for HAV vaccination, 22% (CI:20-25%) for HBV vaccination, 27% (CI: 26-33%) for HPV vaccination, and 30% (CI: 26-33%) for mpox vaccination.

Factors associated with vaccination uptake

Hepatitis A Vaccination uptake

There was a bivariate association between HAV uptake and sexual orientation, educational level, and employment status, see Table 2. There were significantly lower odds of HAV vaccination amongst those self-reporting as bisexual (aOR:0.56, (CI:0.4-0.8) vs gay/homosexual), having an education that was below degree-level (aOR:0.7, (CI:0.55-0.9)) and being unemployed (aOR:0.69, (CI:0.52-0.92)). There was no evidence of an independent association existing between HAV vaccination uptake and age, however uptake was lower in both the 16-29 age group (aOR:0.54, (CI:0.37-0.78)) and the over 45 age group (aOR:0.74, (CI:0.57-0.97)).

Sexual behaviours associated with HAV vaccination uptake included self-reported usage of chemsex-related recreational drugs in the previous year (aOR:1.87, (CI:1.16-3.02)), reporting ten or more male physical sex partners (aOR:1.85, (CI:1.4-2.44)), reporting attendance at SOP venues (aOR:1.58, (CI:1.22-2.05)), self-reporting ≥10 condomless anal sex (CAS) partners (aOR:1.44, (CI:1.12-1.86)) (all since Aug 2022). Health related factors associated with HAV vaccination uptake included self-reporting being a person living with HIV (aOR:2, (CI:1.38-2.88)), receiving a positive STI test in the past year (aOR:1.95, (CI:1.29-2.96)), visiting a SHS in the past year, (aOR:4.31, (CI:3.36-5.54)), STI test in the past year (aOR:3.25, (CI:2.53-4.18)) and reporting usage of HIV-PrEP since December 2021 (aOR:3.15, (CI:2.43-4.07)).

Hepatitis B Vaccination uptake.

There was a bivariate association between HBV uptake and sexual orientation, educational qualifications, and employment status, see Table 3. There were lower odds of HBV vaccination uptake in those self-reporting as bisexual (aOR:0.57, (CI:0.39-0.82) vs gay/homosexual), having an education that was below degree-level (aOR:0.59, (CI:0.46-0.76)) and being unemployed (aOR:0.71, (CI:0.53-0.96)). There was no

evidence of an independent association existing between HBV vaccination uptake and age however uptake was lower in both the 16-29 age group (aOR:0.44, (CI:0.3-0.65)) and the over 45 age group (aOR:0.53, (CI:0.4-0.7)).

Sexual behaviours associated with uptake included reported usage of chemsex-related recreational drugs in the previous year (aOR:1.75, (CI:1.06-2.88)), reporting ten or more physical male sex partners (aOR:1.89, (CI:1.41-2.53)) reporting attendance at SOP venues (aOR:1.51, (CI:1.15-1.99)), self-reporting ≥10 CAS partners (aOR:1.77, (CI:1.37-2.29)) (all since Aug 2022). There were associations with reporting being a person living with HIV (aOR:1.84, (CI:1.26-2.68)), receiving a positive STI test in the past year (aOR:3.17, (CI:1.9-5.29)), visiting a SHS in the past year, (aOR:5.33, (CI:4.1-6.93)), having an STI test in the past year (aOR:4.29, (CI:3.31-5.58)) and reporting usage of HIV-PrEP since Dec 2021 (aOR:4.68, (CI:3.51-6.26)).

HPV vaccination uptake

Among eligible individuals the only sociodemographic factors found to have an association with HPV vaccination uptake were being in the 16-29 (younger) age-category (aOR:0.62, (CI:0.43-0.89 vs those aged 30-44)) and having an education below degree-level (aOR:0.55, (CI:0.39-0.78)), see Table 4.

The sexual behaviours that were associated with HPV vaccination uptake include usage of chemsex-related drugs in the previous year (aOR:1.92, (CI:1.01-3.63)), reporting ten or more physical male sex partners (aOR:3.85, (CI:1.77-8.37)) reporting attendance at SOP venues (aOR:1.84, (CI:1.26-2.67)), self-reporting ≥10 CAS partners (aOR:4.27, (CI:2.38-7.65)) (all since August 2022). There were increased

odds of HPV vaccination in a multivariable model amongst those reporting being a person living with HIV (aOR:3.3, (CI:1.7-6.39)), receiving a positive STI test in the past year (aOR:7.77, (CI:3.5-17.28)), visiting a SHS in the past year (aOR:14.3, (CI:9.51-21.51)), STI test in the past year (aOR:7.74, (CI:5.14-11.65)) and reporting usage of HIV-PrEP since December 2021 (aOR:4.12, (aOR:8.99, (CI:5.97-13.53)).

Discussion

Analyses of a large, community-based survey of GBMSM in the UK show that vaccination uptake was high but far from universal for all targeted vaccinations, with uptake at around two-thirds across each of the STI/VH vaccinations considered. In GBMSM attending SHS, approximately a quarter were considered potential missed opportunities for vaccination across each vaccine type. There was highly correlated uptake between different vaccines and similar sociodemographic, behavioural and SHS use factors were associated with uptake of each STI/VH vaccine. This provides an important insight into HAV, HBV and HPV vaccination uptake amongst GBMSM for which there is limited uptake data in the UK[21].

The sociodemographic factors identified in this study found to commonly be associated with lower vaccination uptake were younger age, self-identifying as bisexual, and markers of lower financial or social capital such as an education below degree-level or being unemployed. Vaccination uptake was higher amongst those reporting sexual behaviour which increases risk of STI transmission, and relatedly, in those reporting recent SHS use (greater sexual behaviour is often associated with SHS utilisation[20]); indicating that those who are most at need of vaccines are receiving them. This mirrors findings of a previous analysis of mpox vaccination uptake[15]. Vaccine completion ranged from 42% for mpox to 89% for HAV. The lower completion rate for the mpox vaccination is likely due to the recency of

implementation of the vaccination in response to the outbreak in 2022, as well as the fact that the offer of second doses only commenced 2-3 months prior to the survey[10].

The lower odds of vaccination amongst younger age groups has previously been reported in other studies assessing HBV and HPV vaccination[16,19,21]. Gay self-identification, higher levels of education and employment were also consistently found to be linked with higher vaccination uptake amongst GBMSM, including both HBV and HPV vaccinations[16,18,21]. Young people and bisexual/straight-identifying GBMSM have been identified as groups that have a higher sexual risk and a lower SHS engagement[22–24]. Promotion focused on bisexual men is important to reduce the burden of these vaccine preventable STI/VHs amongst GBMSM, but also potentially amongst women[25].

There is also a consistent association between higher vaccination uptake and SHS usage (although HAV/HBV vaccines are also administered outside of SHS). Previous research has found that GBMSM are not actively seeking out vaccines such as the HPV vaccine[11,17] and that vaccination for HPV is reliant on recommendation by clinicians[26,27]. It follows that to become aware of, and to be identified as a candidate for vaccination, they must be attending SHSs, (HPV vaccination is targeted to GBMSM attending SHS only). This association has been identified previously with one study finding that 90.9% of GBMSM reporting HPV vaccination had attended a SHS in the previous year[28] (86% in this sample).

Those with markers of lower financial or social capital reported lower vaccination uptake, indicating that health inequalities faced by GBMSM are exacerbated amongst those who already experience inequity. The effects of marginalisation may be compounded, and this requires an intersectional approach to understanding these groups and how to target them effectively. Understanding their behaviour and whether they require changes in policy and tailored interventions to increase their engagement with SHS,

and subsequently uptake of STI/VH vaccinations, is needed. This could be through health-promotion messaging such as community outreach programmes and media-based advertisements to reach those who may not normally access SHS. One means may be through encouraging online SHS[29] to identify potential vaccination candidates, but this does require online services that are well-integrated with physical SHS and have good signposting for GBMSM, as vaccination requires attendance at a physical venue.

Vaccine completion is also incredibly important to confer the maximum protection against infection, amongst this sample many of those that initiated vaccination completed the course of vaccination. One previous study assessing incomplete vaccination amongst GBMSM in England found that the most common reason for not receiving additional vaccine doses was because they were unaware when their next dose was due[26]. This indicates that vaccine completion requires additional or alternative promotion to encourage that those who receive their initial dose will continue to receive additional vaccine doses.

This study has limitations due to the cross-sectional methodology used. For example, there may have been recall error as vaccination was self-reported. Also, participants' behaviours may have changed, and chronology of vaccination relative to behaviour cannot be ascertained (except vaccination for mpox which only became established June 2022[10]). There may also be a degree of misclassification bias by retrospectively applying eligibility criteria to participants as their behaviours may have changed over time. It is also possible that respondents may have self-identified differently in this survey than they would when presenting at a SHS, this may affect whether they were offered a vaccine or affect their eligibility within this study.

Due to the questions regarding vaccination which fell into the 'ever' lookback period, it is impossible to know when vaccination occurred, which could explain high association between HAV and HBV

vaccination due to combined packaging of the HAV and HBV vaccination or administration of the combined (HAV/HBV) Twinrix vaccine.

There are also limitations based on the participants' demographics with lower response numbers from young people and people who did not self-describe as white. This necessitated dichotomising variables, limiting the quality of these findings for minority groups who also have an increased burden of STIs[2,30,31], using dichotomised measures limits this study's ability to assess inequalities in vaccine access by ethnicity or gender identity. To preserve the anonymity of respondents, geographical data about participants was limited to whether they were living in England, Scotland, Wales, or Northern Ireland. As SHS and vaccine access may be affected by location this lack of detail prevents us from evaluating inequities in vaccine delivery further.

There is also potential participation bias, for example the sample appears to be more health conscious than the general GBMSM population. For instance, HPV vaccine uptake within the eligible sample was 65% compared to 34% of GBMSM nationally[12]. This survey did not include questions regarding willingness to receive HAV, HBV or HPV vaccines, however respondents showed a high willingness to receive the mpox vaccine (75% of those that had not been offered the mpox vaccine)[15]. This sample also excludes GBMSM not using the applications that this survey was advertised on. However, unlike previous studies[28,32] which often focus on those attending SHS, the target population for this study was the GBMSM community more broadly.

Improving uptake is dependent on understanding barriers faced by GBMSM which limit vaccination uptake. Within the UK, awareness of factors affecting uptake (especially as the JCVI has advised routine implementation of opportunistic vaccination for mpox[33] and gonorrhoea [the latter using 4CMenB

vaccination[34]]), will help inform practice and health promotion that aligns with NHS[35] and UKHSA[36] health equity goals. In an international context, these results could raise awareness of potential limitations in vaccination uptake due to service provision differences and sociodemographic factors in equivalent and future GBMSM-selective vaccination programmes.

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Table 1, the self-reported uptake and completion levels of the Mpox, HAV, HBV and HPV vaccine amongst RiiSH-Mpox participants

	Whole sample *			Eligible Population †			Completion ‡			Missed Opportunity ††		
	n ¶	%	95% confidence interval	n ¶	%	95% confidence interval	n §	%	95% confidence interval	n ††	%	95% confidence interval
Mpox	692	52	49%-55%	601	69	66%-72%	288	42**	38%-45%	249	30	26-33%
HAV	903	68	65%-70%	903	68	65%-70%	807	89	87%-91%	318	27	24-29%
HBV	954	72	69%-74%	954	72	69%-74%	712	75	72%-77%	267	22	20-25%
HPV	562	42	39%-45	417	73	69%-76%	367	65	61%-69%;	157	27	24-31%

*Uses all 1333 RiiSH-Mpox participants as a denominator † uses all eligible RiiSH-MPOX participants as a denominator, we considered all GBMSM as eligible for HAV and HBV vaccination. HPV vaccination eligibility was GBMSM reporting SHS attendance under the age of 45, mpox vaccination eligibility was considered in those reporting: ≥10 physical male sex partners, meeting partners in public sex environments (Sex on premise venues (SOP), cruising grounds or sex parties), having a positive STI test, report of PrEP or use of chemsex-associated recreational drugs (crystal methamphetamine, mephedrone or gamma-hydroxybutyrate/gamma-butyrolactone). ‡ Completion is reported as the percentage of those that received the first dose that self-reported completing the vaccine course ¶ Participants with self-reported uptake of ≥1 vaccine dose(s) § Participants with self-reported completion of that respective vaccine course, 2 doses of HAV or Mpox and 3 doses of HBV or HPV ** Low completion in vaccination for Mpox may be due to recency of vaccine programme implementation ††N is all individuals who have previously attended SHS and are eligible for that particular vaccine, Mpox - 875, HAV/HBV - 1333 and HPV - 574. †† number of individuals who have not been vaccinated despite eligibility and SHS attendance. Note, for HAV and HBV vaccination uptake, the whole sample and eligible populations are the same.

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Table 2. Sociodemographic characteristics and Health-related and sexual behaviour factors associated with self-reported HAV vaccination uptake among RiiSH-Mpox participants

	n total	% of RiiSH-Mpox participants	n of HAV vaccinated participants *	% of group vaccinated	% of HAV vaccinated people	uOR **	95% confidence interval		P	aOR §	95% confidence interval		P
Sociodemographic Characteristics													
Age-group													
16-29	176	13	101	57	11	0.48	0.34	0.69		0.54	0.37	0.78	0.570
30-44	486	36	358	74	40	1.00				1.00			
45+	671	50	444	66	49	0.70	0.54	0.90	0.570	0.74	0.57	0.97	
Sexual orientation													
Gay/ homosexual	1187	89	823	69	91	1.00				1.00			
Bisexual †	146	11	80	55	9	0.54	0.38	0.76	<0.001	0.56	0.40	0.80	0.001
Ethnicity													
White	1223	92	832	68	92	1.00				1.00			
Other	110	8	71	65	8	0.86	0.57	1.29	0.454	0.90	0.59	1.37	0.610
Country of Birth													
UK	1113	83	756	68	84	1.00				1.00			
Other	220	17	147	67	16	0.95	0.70	1.29	0.748	0.91	0.66	1.26	0.586
Country of Residence													
England	1148	86	779	68	86	1.00				1.00			
Rest of UK	185	14	124	67	14	0.96	0.69	1.34	0.823	0.98	0.70	1.37	0.904
Educational level													
Degree level or higher	495	37	594	71	66	1.00				1.00			
Below degree level	838	63	309	62	34	0.68	0.54	0.86	0.001	0.70	0.55	0.90	0.050
Employment													
Currently Employed	1074	19	749	70	83	1.00				1.00			
Not Employed	259	81	154	59	17	0.64	0.48	0.84	0.002	0.69	0.52	0.92	0.012
Household Composition													
Alone	506	38	552	67	61	1.00				1.00			
With Others	827	62	351	69	39	0.87	0.70	1.12	0.321	0.88	0.69	1.12	0.307
Relationship Status													
Relationship	591	44	510	86	56	1.00				1.00			
Single	742	56	393	53	44	1.11	0.88	1.40	0.870	1.08	0.85	1.37	0.540
Comfortable Financial Status													
Yes ††	693	52	453	65	50	1.00				1.00			
No	640	48	450	70	50	0.80	0.63	1.00	0.054	0.93	0.73	1.18	0.551
Health-related factors													
HIV Status													
Negative/ Unknown	1131	85	744	66	82	1.00				1.00			
PLWHIV	202	15	159	79	18	1.92	1.34	2.75	<0.001	2.00	1.38	2.88	<0.001
MPOX-related behaviour modification ¶													
No	626	47	412	66	46	1.00				1.00			
Yes	707	53	491	69	54	1.18	0.94	1.49	0.157	1.11	0.88	1.42	0.355
STI Positive Test													
No	1177	70	778	66	86	1.00				1.00			
Yes	156	30	125	80	14	3.38	2.63	4.35	<0.001	1.95	1.29	2.96	0.002
Visited SHC in past year													
No	478	36	221	46	24	1.00				1.00			
Yes	855	64	682	80	76	4.58	3.59	5.86	<0.001	4.31	3.36	5.54	<0.001
STI test in past year													
No	405	30	196	48	22	3.41				1.00			
Yes	928	70	707	76	78	1.00	2.67	4.37	<0.001	3.25	2.53	4.18	<0.001
PrEP Use in Past Year													
No	734	55	415	57	46	1.00				1.00			
Yes	599	45	488	81	54	3.38	2.63	4.35	<0.001	3.15	2.43	4.07	<0.001
Sexual behaviours													
Usage of chemsex-related drugs in the previous year													
No	1222	92	815	67	90	1.00				1.00			
Yes	111	8	88	79	10	1.91	1.19	3.07	0.007	1.87	1.16	3.02	0.010
Number of Male Physical Sex Partners													
none	100	8	64	64	7	1.00				1.00			
1	180	14	93	52	10	0.60	0.36	0.99		0.59	0.35	0.98	<0.001
2 to 4	389	29	256	66	28	1.08	0.68	1.71		1.05	0.66	1.68	
5 to 9	280	21	192	69	21	1.23	0.76	1.98		1.17	0.72	1.90	
10+	384	29	298	78	33	1.95	1.21	3.13	0.006	1.78	1.10	2.88	
reported use of SOP venues in the lookback period													
No	888	67	568	64	63	1.00				1.00			
Yes	445	33	335	75	37	1.72	1.33	2.21	<0.001	1.58	1.22	2.05	<0.001
Number of CAS partners in the lookback period (since Dec 2021)													
none	401	30	245	61	27	1.00				1.00			
1	263	20	159	60	18	0.97	0.71	1.34		0.94	0.68	1.29	<0.001
2 to 4	315	24	219	70	24	1.45	1.06	1.99		1.42	1.03	1.95	
5 to 9	146	11	118	81	13	2.68	1.70	4.24		2.42	1.52	3.85	
10+	208	16	162	78	18	2.24	1.53	3.29	<0.001	2.1	1.42	3.10	

* Participants with self-reported uptake of ≥1 HAV vaccine dose(s).† Includes those identifying as bisexual, straight, or another way. †† Top two quartiles ("I am comfortable"/"I am very comfortable" from the question, "How would you best describe your current financial situation". ¶ Behaviour modification includes self-report of any of the following from May 2022: fewer sexual partners, reduced visits to sex on premises venues or PSE (i.e. cruising grounds), and avoiding: all sex, condomless anal sex, skin-to-skin contact, or visiting clubs or crowds. § Adjusted for age-group, ethnicity, sexual orientation, educational qualifications, employment, and financial situation. ** uOR=Unadjusted odds ratio. aOR=adjusted odds ratio.

Table 3. Sociodemographic characteristics and Health-related and sexual behaviour factors associated with self-reported HBV vaccination uptake among RiiSH-Mpox participants

	n total	% of RiiSH-Mpox participants	n of HBV vaccinated participants *	% of group vaccinated	% of HBV vaccinated people	uOR **	95% confidence interval		P	aOR §	95% confidence interval		P
Sociodemographic Characteristics													
Age-group													
16-29	176	13	110	63	12	0.40	0.27	0.58		0.44	0.30	0.65	0.343
30-44	486	36	392	81	41	1.00				1.00			
45+	671	50	452	67	47	0.49	0.38	0.65	0.343	0.53	0.40	0.70	
Sexual orientation													
Gay/ homosexual	1187	89	866	73	91	1.00				1.00			
Bisexual †	146	11	88	60	9	0.56	0.39	0.80	0.002	0.57	0.39	0.82	0.002
Ethnicity													
White	1223	92	872	71	91	1.00				1.00			
Other	110	8	82	75	9	1.12	0.75	1.84	0.720	1.17	0.74	1.86	0.501
Country of Birth													
UK	1113	83	796	72	83	1.00				1.00			
Other	220	17	158	72	17	1.01	0.74	1.40	0.928	0.88	0.63	1.24	0.469
Country of Residence													
England	1148	86	824	72	86	1.00				1.00			
Rest of UK	185	14	130	70	14	1.01	0.74	1.40	0.928	0.95	0.67	1.35	0.770
Educational level													
Degree level or higher	495	37	638	76	67	1.00				1.00			
Below degree level	838	63	316	64	33	0.55	0.43	0.71	<0.001	0.59	0.46	0.76	<0.001
Employment													
Currently Employed	1074	19	790	74	83	1.00				1.00			
Not Employed	259	81	164	63	17	0.55	0.43	0.71	<0.001	0.71	0.53	0.96	0.026
Household Composition													
Alone	506	38	370	73	39	1.00				1.00			
With Others	827	62	584	71	61	0.88	0.69	1.13	0.325	0.85	0.66	1.09	0.195
Relationship Status													
Relationship	591	44	539	91	56	1.00				1.00			
Single	742	56	415	56	44	1.13	0.89	1.43	0.330	1.12	0.88	1.44	0.360
Comfortable Financial Status													
Yes ††	693	52	482	70	51	1.00				1.00			
No	640	48	472	74	49	0.70	0.55	0.89	0.004	0.82	0.64	1.06	0.122
Health-related factors													
HIV Status													
Negative/ Unknown	1131	85	793	70	83	1.00				1.00			
PLWHIV	202	15	161	80	17	1.67	1.16	2.41	0.006	1.84	1.26	2.68	0.001
MPOX-related behaviour modification ¶													
No	626	47	434	69	45	1.00				1.00			
Yes	707	53	520	74	55	1.23	0.97	1.56	0.088	1.14	0.90	1.46	0.281
STI Positive Test													
No	1177	70	816	69	86	1.00				1.00			
Yes	156	30	138	88	14	3.39	2.04	5.63	<0.001	3.17	1.90	5.29	<0.001
Visited SHC in past year													
No	478	36	232	49	24	1.00				1.00			
Yes	855	64	722	84	76	5.76	4.45	7.45	<0.001	5.33	4.10	6.93	<0.001
STI test in past year													
No	405	30	198	49	21	1.00				1.00			
Yes	928	70	756	81	79	4.60	3.56	5.93	<0.001	4.29	3.31	5.58	<0.001
PrEP Use in Past Year													
No	734	55	428	58	45	1.00				1.00			
Yes	599	45	526	88	55	5.15	3.87	0.69	<0.001	4.68	3.51	6.26	<0.001
Sexual behaviours													
Usage of chemsex-related drugs in the previous year													
No	1222	92	864	71	91	1.00				1.00			
Yes	111	8	90	81	9	1.78	1.09	2.90	0.022	1.75	1.06	2.88	0.028
Number of Male Physical Sex Partners													
none	100	8	64	64	7	1.00				1.00			
1	180	14	103	57	11	0.75	0.45	1.25		0.71	0.43	1.19	<0.001
2 to 4	389	29	268	69	28	1.25	0.79	1.98		1.16	0.72	1.86	
5 to 9	280	21	208	74	22	1.63	1.00	2.65		2.51	0.92	2.48	
10+	384	29	311	81	33	2.40	1.48	3.88	<0.001	2.10	1.28	3.44	
reported use of SOP venues in the lookback period													
No	888	67	606	68	64	1.00				1.00			
Yes	445	33	348	78	36	1.67	1.28	2.18	<0.001	1.51	1.15	1.99	0.003
Number of CAS partners in the lookback period (since Dec 2021)													
none	401	30	82	20	9	1.00				1.00			
1	263	20	177	67	19	1.23	0.89	1.71		1.19	0.85	1.67	0.000
2 to 4	315	24	237	75	25	1.82	1.31	2.52		1.83	1.31	2.56	
5 to 9	146	11	115	79	12	2.22	1.42	3.46		2.02	1.28	3.18	
10+	208	16	174	84	18	3.06	2.01	4.65	0.000	2.91	1.89	4.47	

* Participants with self-reported uptake of ≥1 HBV vaccine dose(s).† Includes those identifying as bisexual, straight, or another way. †† Top two quartiles ("I am comfortable"/"I am very comfortable" from the question, "How would you best describe your current financial situation". ¶ Behaviour modification includes self-report of any of the following from May 2022: fewer sexual partners, reduced visits to sex on premises venues or PSE (i.e. cruising grounds), and avoiding: all sex, condomless anal sex, skin-to-skin contact, or visiting clubs or crowds. § Adjusted for age-group, ethnicity, sexual orientation, educational qualifications, employment, and financial situation. ** uOR=Unadjusted odds ratio. aOR=adjusted odds ratio.

Table 4. Sociodemographic characteristics and Health-related and sexual behaviour factors associated with self-reported HPV vaccination uptake among RiiSH-Mpox participants below 45

	n total	% of RiiSH-Mpox participants 45+	n of HPV vaccinated participants *	% of group vaccinated	% of HPV vaccinated people	uOR **	95% confidence interval		P	aOR §	95% confidence interval		P
Sociodemographic Characteristics													
Age-group													
16-29	176	27	95	54	22	0.53	0.38	0.760	<0.001	0.62	0.43	0.89	0.011
30-44	486	73	334	69	78	1.00				1.00			
Sexual orientation													
Gay/ homosexual	579	87	385	66	90	1.00				1.00			
Bisexual †	83	13	44	53	10	0.57	0.36	0.900	0.017	0.67	0.41	1.08	0.100
Ethnicity													
White	589	89	42	7	10	1.00				1.00			
Other	73	11	387	530	90	0.71	0.43	1.160	0.169	0.80	0.47	1.35	0.399
Country of Birth													
UK	589	89	93	16	22	1				1.00			
Other	132	20	336	255	78	1.38	0.91	2.080	0.130	1.32	0.85	2.05	0.223
Country of Residence													
England	565	85	367	65	86	1.00				1.00			
Rest of UK	97	15	62	64	14	0.96	0.61	1.500	0.130	0.99	0.62	1.58	0.966
Educational level													
Degree level or higher	437	66	124	28	29	1.00				1.00			
Below degree level	225	34	305	136	71	0.53	0.38	0.740	<0.001	0.55	0.39	0.78	0.001
Employment													
Currently Employed	572	86	385	67	90	1.00				1.00			
Not Employed	90	14	44	49	10	0.47	0.30	0.730	0.001	0.62	0.38	1.00	0.051
Household Composition													
Alone	221	33	156	71	36	1.00				1.00			
With Others	443	67	273	62	64	0.47	0.30	0.730	0.028	0.70	0.99	1.00	0.051
Relationship Status													
Single	343	52	213	62	50	1.00				1.00			
Relationship	319	48	216	68	50	0.85	0.62	1.170	0.307	1.39	0.98	1.95	0.059
Comfortable Financial Status													
Yes ††	353	53	217	61	51	1.00				1.00			
No	309	47	212	69	49	0.73	0.53	1.010	0.055	0.91	0.65	1.29	0.603
Health-related factors													
HIV Status													
Negative/ Unknown	584	88	363	62	85	1.00				1.00			
PLWHIV	78	12	66	85	15	3.35	1.77	6.330	<0.001	3.30	1.70	6.39	0.059
MPOX-related behaviour modification ¶													
No	329	50	203	62	47	1.00				1.00			
Yes	333	50	226	68	53	1.31	0.95	1.810	0.097	1.17	0.83	1.64	0.368
STI Positive Test													
No	568	86	342	60	80	1.00				1.00			
Yes	94	14	87	93	20	8.21	3.73	18.060	<0.001	7.77	3.50	17.28	<0.001
Visited SHC in past year													
No	227	34	62	27	14	1.00				1.00			
Yes	435	66	367	84	86	14.36	9.72	21.220	<0.001	14.30	9.51	21.51	<0.001
STI test in past year													
No	165	25	47	28	11	1.00				1.00			
Yes	497	75	382	77	89	8.34	9.72	21.220	<0.001	7.74	5.14	11.65	<0.001
PrEP Use in Past Year													
No	341	52	148	43	34	1.00				1.00			
Yes	321	48	281	88	66	9.16	6.18	13.590	<0.001	8.99	5.97	13.53	<0.001
Sexual behaviours													
Usage of chemsex-related drugs in the previous year													
No	601	91	382	64	89	1.00				1.00			
Yes	61	9	47	77	11	1.93	1.04	3.580	0.038	1.92	1.01	3.63	0.047
Number of Male Physical Sex Partners													
None	34	5	16	47	4	1.00				1.00			
1	88	13	39	44	9	0.90	0.41	1.98		0.85	0.38	1.92	<0.001
2 to 4	200	30	120	60	28	1.69	0.81	3.50		1.63	0.77	3.46	
5 to 9	135	20	90	67	21	2.25	1.05	4.82		2.12	0.97	4.63	
10+	205	31	164	80	38	4.50	2.11	9.58		3.85	1.77	8.37	
reported use of SOP venues in the lookback period													
No	442	67	262	59	61	1.00				1.00			
Yes	220	33	167	76	39	2.17	1.51	3.11	<0.001	1.84	1.26	2.67	0.001
Number of CAS partners in the lookback period (since Dec 2021)													
None	172	26	87	51	20	1.00				1.00			
1	138	21	74	54	17	1.13	0.72	1.77		1.03	0.65	1.64	<0.001
2 to 4	157	24	110	70	26	2.29	1.45	3.60		2.19	1.37	3.50	
5 to 9	74	11	57	77	13	2.28	1.77	6.08		2.74	1.45	5.16	
10+	121	18	101	83	24	4.93	2.80	8.68	<0.001	4.27	2.38	7.65	

* Participants with self-reported uptake of ≥1 HPV vaccine dose(s) in those under 45 years.† Includes those identifying as bisexual, straight, or another way. †† Top two quartiles ("I am comfortable"/"I am very comfortable" from the question, "How would you best describe your current financial situation". ¶ Behaviour modification includes self-report of any of the following from May 2022: fewer sexual partners, reduced visits to sex on premises venues or PSE (i.e. cruising grounds), and avoiding: all sex, condomless anal sex, skin-to-skin contact, or visiting clubs or crowds. § Adjusted for age-group, ethnicity, sexual orientation, educational qualifications, employment, and financial situation. ** uOR=Unadjusted odds ratio. aOR=adjusted odds ratio.

Appendix A. Sociodemographic, Health-related and sexual behaviour characteristics of those who self-reported ≥1 dose of the Mpox, HAV, HBV and HPV vaccines amongst RiiSH-Mpox participant

	n total	% of RiiSH-Mpox participants	n of mpox vaccinated participants	% of MPOX vaccinated people	n of HAV vaccinated participants	% of HAV vaccinated people	n of HBV vaccinated participants	% of HBV vaccinated people	n of HPV vaccinated participants	% of HPV vaccinated people
Sociodemographic Characteristics										
Age-group										
16-29	176	13	78	11	101	11	110	12	95	17
30-44	486	36	263	38	358	40	392	41	334	59
45+	671	50	351	51	444	49	452	47	133	24
Sexual orientation										
Gay/ homosexual	1187	89	645	93	823	91	866	91	509	91
Bisexual *	146	11	47	7	80	9	88	9	53	9
Ethnicity										
White	1223	92	635	92	832	92	872	91	512	91
Other	110	8	57	8	71	8	82	9	50	9
Country of Birth										
UK	1113	83	566	82	756	84	796	83	446	79
Other	220	17	126	18	147	16	158	17	116	21
Country of Residence										
England	1148	86	613	89	779	86	824	86	479	85
Rest of UK	185	14	79	11	124	14	130	14	83	15
Educational level										
Degree level or higher	838	63	199	29	594	66	638	67	394	70
Below degree level	495	37	493	71	309	34	316	33	169	30
Employment										
Currently Employed	1074	19	595	86	749	83	790	83	497	88
Not employed	259	81	97	14	154	17	164	17	65	12
Household Composition										
With others	827	38	515	74	351	39	584	61	342	61
Alone	506	62	278	40	552	61	370	39	220	39
Relationship Status										
In relationship	591	44	320	46	510	56	539	56	291	52
Single	742	56	372	54	393	44	415	44	271	48
Comfortable Financial Status										
Yes	693	52	331	48	453	50	482	51	282	50
No	640	48	361	52	450	50	472	49	280	50
Sexual behaviours										
Usage of chemsex-related drugs in the previous year										
No	1222	92	617	89	815	90	864	91	500	89
Yes	111	8	75	11	88	10	90	9	62	11
Number of Male Physical Sex Partners										
None	100	8	31	4	64	7	64	7	28	5
1	180	14	41	6	93	10	103	11	47	8
2 to 4	389	29	170	25	256	28	268	28	159	28
5 to 9	280	21	180	26	192	21	208	22	119	21
10+	384	29	270	39	298	33	311	33	209	37
reported use of SOP venues in the lookback period										
No	888	67	382	55	568	63	606	64	346	62
Yes	445	33	310	45	335	37	348	36	216	38
Number of CAS partners in the lookback period										
None	401	30	57	8	245	27	82	9	119	21
1	263	20	99	14	159	18	177	19	96	17
2 to 4	315	24	185	27	219	24	237	25	143	25
5 to 9	146	11	109	16	118	13	115	12	78	14
10+	208	16	143	21	162	18	174	18	126	22
Health-related factors										
HIV Status										
Negative/ Unknown	1131	85	575	83	744	82	793	83	461	82
PLWHIV	202	15	117	17	159	18	161	17	101	18
**MPOX-related behaviour modification †† **										
No	626	47	247	36	412	46	434	45	264	47
Yes	707	53	445	64	491	54	520	55	298	53
STI Positive Test										
No	1177	70	568	82	778	86	816	86	457	81
Yes	156	30	124	18	125	14	138	14	105	19
Visited SHC in past year										
No	478	36	82	12	221	24	232	24	60	11
Yes	855	64	610	88	682	76	722	76	484	86
STI test in past year										
No	405	30	81	12	196	22	198	21	60	11
Yes	928	70	611	88	707	78	756	79	502	89
PrEP Use in Past Year										
No	734	55	228	33	415	46	428	45	201	36
Yes	599	45	464	67	488	54	526	55	361	64

* also includes those identifying straight, or another way. . † Top two quartiles ("I am comfortable"/"I am very comfortable" from the question, "How would you best describe your current financial situation". †† Behaviour modification includes self-report of any of the following: fewer sexual partners, reduced visits to sex on premises venues or PSE and avoiding: all sex, condomless anal sex, skin-to-skin contact, or visiting clubs or crowds from May 2022.

Appendix B Vaccine uptake and association between uptake of different STI vaccine types amongst RiiSH-Mpox participants

	n	n receiving both vaccines *	% receiving both vaccines	uOR †	95% confidence interval			P	aOR ††	95% confidence interval			P
Any Vaccine Uptake	1135		97										
Mpox Vaccine uptake													
Mpox	692												
HAV	903	558	62	3.57	2.80	-	4.56	<0.001	3.30	2.57	-	4.25	<0.001
HBV	954	581	61	3.76	2.91	-	4.86	<0.001	3.40	2.61	-	4.42	<0.001
HPV	562	387	69	3.38	2.69	-	4.25	<0.001	4.14	3.16	-	5.42	<0.001
HAV Vaccine Uptake	903		68										
Mpox	692	558	81	3.57	2.80	-	4.56	<0.001	3.30	2.57	-	4.25	<0.001
HAV	903												
HBV	954	794	83	12.29	9.29	-	16.26	<0.001	11.98	9.01	-	15.92	<0.001
HPV	562	490	87	5.90	4.44	-	7.84	<0.001	8.04	5.82	-	11.11	<0.001
HBV Vaccine uptake	954		72										
Mpox	692	581	84	3.76	2.91	-	4.86	<0.001	3.40	2.61	-	4.42	<0.001
HAV	903	794	88	12.29	9.29	-	16.26	<0.001	11.98	9.01	-	15.92	<0.001
HBV	954												
HPV	562	512	91	7.62	5.15	-	10.53	<0.001	9.27	6.51	-	13.21	<0.001
HPV Vaccine Uptake			42										
Mpox	692	387	56	3.38	2.69	-	4.25	<0.001	3.30	2.57	-	4.25	<0.001
HAV	903	490	54	5.90	4.44	-	7.84	<0.001	8.04	5.82	-	11.11	<0.001
HBV	954	512	54	7.62	5.52	-	10.53	<0.001	9.27	6.51	-	13.21	<0.001
HPV	562												

* Participants with self-reported uptake of ≥1 vaccine dose of both vaccine types.† uOR=Unadjusted odds ratio. aOR=adjusted odds ratio. †† Adjusted for age-group, sexual orientation, educational level, employment, ethnicity and financial situation.