Supplementary File

Variations in the Natural History of High-Risk HPV Types Following HPV-16/18 Bivalent Vaccination in Females Aged 18-45 Years

Supplementary Appendix

Supplementary Method 1. The methods of HPV DNA testing

The HPV DNA enzyme immunoassay method (SPF10-PCR-DEIA, Labo Biomedical Products, Netherlands) was used to qualitatively detect HPV DNA in cervical exfoliated cells and tissue samples. Samples with positive or probably-positive DEIA results were further genotyped for 25 HPV types, including 13 high-risk types (16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, and 68) and 12 intermediate/low-risk types (6, 11, 34, 40, 42, 43, 44, 53, 54, 66, 70, and 74), using a reverse hybridization line probe assay (SPF10-PCR-LiPA25, Labo Biomedical Products, Netherlands) and type-specific DEIA for HPV-16 and HPV-18 (TS16/18, Labo Biomedical Products, Netherlands).

Supplementary Method 2. Multiple testing adjustment

To control for multiple comparisons, we applied a stratified Benjamini-Hochberg false discovery rate (FDR) procedure. Because the analyses included both individual HPV types (HPV-16, -18, -31, -33, -35, -39, -45, -51, -52, -56, -58, -59, and -68) and grouped HPV categories (HPV-16/18, HPV-31/33/45, and HR-HPV), FDR adjustment was performed within each stratum. This approach ensured balanced error control, while avoiding potential dilution of signals from single-type analyses, which may occur because grouped comparisons generally involve larger sample sizes and yield smaller p values.

For each original p value within a stratum, the following steps were performed:

1. **Handling very small p values**: For calculation purposes, any p value reported as <0.0001 was set to 0.0001.

2. **Ranking:** The valid p values were ranked in ascending order. Tied p values were assigned the same average rank. Comparisons without estimable hazard ratios (e.g., when the numerator was zero) were excluded from the ranking and subsequent adjustment.

3. **Adjustment formula**: For a total of m valid comparisons, the FDR-adjusted q value for the i-th ordered p value was calculated as:

$$q_{(i)} = \min_{j \geq i} \left(\frac{p_{(j)} \times m}{j} \right), \quad q_{(i)} \leq 1$$

Where $p_{(j)}$ is the j-th smallest p value and j is its rank. A monotone step-down correction was applied to ensure that the sequence of adjusted q values is non-decreasing.

Supplementary Table 1. Incidences of HR-HPV persistent infections (over 12 months) in the participants who were negative for the corresponding HPV type at baseline

	Vaccine group			Control group			HR (95%CI)	Original p value	FDR-adjusted q value
	n/N*	Person-years at risk	Incidence (95%CI), per 1000 person-years	n/N*	Person-years at risk	Incidence (95%CI), per 1000 person-years			
HPV type									
HPV-16	8/3403	21574.6	0.4 (0.2, 0.7)	48/3392	21269.4	2.3 (1.7, 3.0)	0.17 (0.08, 0.35)	**<0.0001**	**0.0013**
HPV-18	4/3447	21867.3	0.2 (0.1, 0.5)	24/3434	21720.0	1.1 (0.7, 1.6)	0.17 (0.06, 0.48)	**0.0009**	**0.0059**
HPV-31	12/3453	21897.3	0.5 (0.3, 1.0)	21/3451	21800.6	1.0 (0.6, 1.5)	0.57 (0.28, 1.15)	0.1176	0.3058
HPV-33	12/3449	21854.2	0.5 (0.3, 1.0)	24/3438	21747.2	1.1 (0.7, 1.6)	0.49 (0.25, 0.99)	**0.0457**	0.1485
HPV-35	18/3459	21907.7	0.8 (0.5, 1.3)	15/3453	21876.4	0.7 (0.4, 1.1)	1.20 (0.60, 2.37)	0.6095	0.7203
HPV-39	41/3438	21652.7	1.9 (1.4, 2.6)	42/3417	21551.6	1.9 (1.4, 2.6)	0.98 (0.64, 1.50)	0.9120	0.9120
HPV-45	1/3465	22011.7	0 (0, 0.3)	2/3456	21950.9	0.1 (0, 0.4)	0.50 (0.05, 5.51)	0.5713	0.7203
HPV-51	54/3413	21419.4	2.5 (1.9, 3.3)	45/3403	21376.0	2.1 (1.6, 2.8)	1.20 (0.81, 1. 79)	0.3574	0.7203
HPV-52	129/3293	20389.3	6.3 (5.3, 7.5)	90/3311	20640.0	4.4 (3.5, 5.4)	1.45 (1.11, 1.90)	**0.0065**	**0.0282**
HPV-56	32/3448	21734.5	1.5 (1.0, 2.1)	29/3423	21585.1	1.3 (0.9, 1.9)	1.10 (0.67, 1.82)	0.7085	0.7675
HPV-58	45/3435	21645.2	2.1 (1.6, 2.8)	40/3420	21542.0	1.9 (1.4, 2.5)	1.12 (0.73, 1.72)	0.5923	0.7203
HPV-59	11/3460	21932.8	0.5 (0.3, 0.9)	8/3450	21894.0	0.4 (0.2, 0.7)	1.37 (0.55, 3.41)	0.4957	0.7203
HPV-68	27/3442	21720.5	1.2 (0.9, 1.8)	31/3431	21702.1	1.4 (1.0, 2.0)	0.87 (0.52, 1.46)	0.6002	0.7203
HPV group									
HPV-16/18	12/3475	22080.5	0.5 (0.3, 1.0)	72/3463	21983.5	3.3 (2.6, 4.1)	0.17 (0.09, 0.31)	**<0.0001**	**0.0003**
HPV-31/33/45	25/3476	22096.2	1.1 (0.8, 1.7)	47/3465	22025.0	2.1 (1.6, 2.8)	0.53 (0.32, 0.86)	**0.0105**	**0.0158**
HR-HPV	394/3477	22096.8	17.8 (16.2, 19.7)	419/3465	22025.0	19.0 (17.3, 20.9)	0.94 (0.81, 1.10)	0.4386	0.4386

HR-HPV, high-risk human papillomavirus; HR, hazard ratio; 95%CI, 95% confidence interval; FDR, false discovery rate.
For type-specific analyses, the standard Cox proportional hazards model was used. For HPV-16/18, HPV-31/33/45, and HR-HPV groups, the Wei-Lin-Weissfeld (WLW) Cox model was applied. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
* n, the number of events; N, the number of participants in the analysis set.

Supplementary Table 2. Incidences of HR-HPV-associated CIN2+ among participants who were negative for the corresponding HPV type at baseline and did not have multiple HR-HPV infections during follow-up (sensitivity analysis)

	Vaccine group			Control group			HR (95%CI)	Original p value	FDR-adjusted q value
	n/N*	Person-years at risk	Incidence (95%CI), per 1000 person-years	n/N*	Person-years at risk	Incidence (95%CI), per 1000 person-years			
HPV type									
HPV-16	1/3467	21472.5	0 (0, 0.3)	9/3404	21090.8	0.4 (0.2, 0.8)	0.11 (0.01, 0.88)	**0.0373**	0.0933
HPV-18	0/3541	21859.9	0	1/3473	21508.9	0 (0, 0.3)	NE	NE	NE
HPV-31	0/3534	21795.7	0	1/3488	21572.9	0 (0, 0.3)	NE	NE	NE
HPV-33	1/3532	21787.1	0 (0, 0.3)	3/3494	21622.1	0.1 (0, 0.4)	0.38 (0.04, 3.63)	0.3970	0.6617
HPV-35	0/3544	21846.8	0	3/3514	21762.1	0.1 (0, 0.4)	NE	NE	NE
HPV-39	0/3490	21559.8	0	0/3438	21353.5	0	NE	NE	NE
HPV-45	0/3568	22002.6	0	0/3533	21861.1	0	NE	NE	NE
HPV-51	0/3444	21267.3	0	2/3418	21139.7	0.1 (0, 0.4)	NE	NE	NE
HPV-52	9/3285	20361.5	0.4 (0.2, 0.9)	1/3286	20431.2	0 (0, 0.3)	9.17 (1.16, 72.44)	**0.0356**	0.0933
HPV-56	0/3498	21571.7	0	1/3452	21369.3	0 (0, 0.3)	NE	NE	NE
HPV-58	5/3503	21627.9	0.2 (0.1, 0.6)	5/3459	21439.1	0.2 (0.1, 0.6)	1.08 (0.31, 3.74)	0.9083	0.9950
HPV-59	0/3544	21871.3	0	3/3512	21756.1	0.1 (0, 0.4)	NE	NE	NE
HPV-68	1/3504	21633.9	0 (0, 0.3)	1/3462	21448.7	0 (0, 0.3)	1.01 (0.06, 16.13)	0.9950	0.9950
HPV group									
HPV-16/18	1/3571	22038.2	0 (0, 0.3)	10/3528	21830.1	0.5 (0.2, 0.9)	0.10 (0.01, 0.77)	**0.0268**	0.0804
HPV-31/33/45	1/3585	22109.7	0 (0, 0.3)	4/3558	22018.3	0.2 (0.1, 0.5)	0.29 (0.03, 2.61)	0.2698	0.2698
HR-HPV	17/3585	22109.7	0.8 (0.5, 1.2)	30/3558	22018.3	1.4 (1.0, 1.9)	0.58 (0.32, 1.06)	0.0757	0.1136

HR-HPV, high-risk human papillomavirus; HR, hazard ratio; 95%CI, 95% confidence interval; NE, not estimated; FDR, false discovery rate.
For type-specific analyses, the standard Cox proportional hazards model was used. For HPV-16/18, HPV-31/33/45, and HR-HPV groups, the Wei-Lin-Weissfeld (WLW) Cox model was applied. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
* n, the number of events; N, the number of participants in the analysis set.

Supplementary Table 3. The persistence of incident HR-HPV infections in the vaccine group and the control group

	Vaccine group			Control group			Original p value	FDR-adjusted q value
	N*	n*	Proportion (95%CI)	N*	n*	Proportion (95%CI)		
HPV type								
HPV-16	92	10	10.9 (5.3, 19.1)	176	75	42.6 (35.2, 50.3)	**<0.0001**	**0.0013**
HPV-18	38	4	10.5 (2.9, 24.8)	114	41	36.0 (27.2, 45.5)	**0.0029**	**0.0189**
HPV-31	56	17	30.4 (18.8, 44.1)	101	32	31.7 (22.8, 41. 7)	0.8636	0.9615
HPV-33	51	21	41.2 (27.6, 55.8)	74	31	41.9 (30.5, 53.9)	0.9364	0.9615
HPV-35	47	26	55.3 (40.1, 69.8)	66	27	40.9 (29.0, 53.7)	0.1303	0.4235
HPV-39	182	73	40.1 (32.9, 47.6)	145	61	42.1 (33.9, 50.5)	0.7204	0.9615
HPV-45	14	6	42.9 (17.7, 71.1)	32	11	34.4 (18.6, 53.2)	0.5834	0.9615
HPV-51	225	86	38.2 (31.8, 44.9)	200	78	39.0 (32.2, 46.1)	0.8694	0.9615
HPV-52	299	160	53.5 (47.7, 59.3)	277	116	41.9 (36.0, 47.9)	**0.0052**	**0.0225**
HPV-56	135	61	45.2 (36.6, 54.0)	121	50	41.3 (32.4, 50.6)	0.5335	0.9615
HPV-58	108	57	52.8 (42.9, 62.5)	122	64	52.5 (43.2, 61.6)	0.9615	0.9615
HPV-59	75	25	33.3 (22.9, 45.2)	77	22	28.6 (18.8, 40.0)	0.5254	0.9615
HPV-68	124	50	40.3 (31.6, 49.5)	140	52	37.1 (29.1, 45.7)	0.5964	0.9615
HPV group								
HPV-16/18	130	14	10.8 (6.0, 17.4)	290	116	40.0 (34.3, 45.9)	**<0.0001**	**0.0003**
HPV-31/33/45	121	44	36.4 (27.8, 45.6)	207	76	35.7 (29.2, 42. 7)	0.9109	0.9109
HR-HPV	1446	601	41.2 (38.7, 43.8)	1645	666	40.1 (37.7, 42.5)	0.5361	0.8042

HR-HPV, high-risk human papillomavirus; 95%CI, 95% confidence interval; FDR, false discovery rate.
p values were determined using the chi-squared test or Fisher's exact test. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
*N, the number of infection events; n, the number of persistent infection events.

Supplementary Table 4. The clearance of incident HR-HPV infections in the vaccine group and the control group

	Vaccine group					Control group					HR (95%CI)	Original p value	FDR-adjusted q value
	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years			
HPV type													
HPV-16	92	91	98.9 (94.1, 100.0)	96.6	94.2 (76.7, 115.7)	176	155	88.1 (82.3, 92.5)	278.4	55.7 (47.6, 65.2)	1.78 (1.36, 2.31)	**<0.0001**	**0.0013**
HPV-18	38	38	100 (90.7, 100.0)	45.3	83.9 (61.1, 115.3)	114	101	88.6 (81.3, 93.8)	137.9	73.2 (60.3, 89.0)	1.32 (0.90, 1.93)	0.1496	0.4524
HPV-31	56	53	94.6 (85.1, 98.9)	70.1	75.6 (57.7, 98.9)	101	91	90.1 (82.5, 95.1)	131.7	69.1 (56.2, 84.8)	0.99 (0.70, 1.39)	0.9366	0.9366
HPV-33	51	42	82.4 (69.1, 91.6)	59.3	70.9 (52.4, 95.9)	74	65	87.8 (78.2, 94.3)	103.5	62.8 (49.3, 80.1)	1.25 (0.84, 1.85)	0.2747	0.5822
HPV-35	47	40	85.1 (71.7, 93.8)	70.3	56.9 (41.8, 77.6)	66	60	90.9 (81.3, 96.6)	91.5	65.6 (50.9, 84.5)	0.88 (0.59, 1.32)	0.5427	0.7094
HPV-39	182	170	93.4 (88.8, 96.5)	243.4	69.8 (60.1, 81.2)	145	131	90.3 (84.3, 94.6)	198.6	66.0 (55.6, 78.3)	1.08 (0.86, 1.36)	0.4977	0.7094
HPV-45	14	13	92.9 (66.1, 99.8)	11.1	117.6 (68.3, 202.6)	32	32	100.0 (89.1, 100.0)	35.4	90.3 (63.9, 127.7)	2.39 (1.15, 4.99)	**0.0203**	0.1320
HPV-51	225	201	89.3 (84.5, 93.0)	284.3	70.7 (61.6, 81.2)	200	183	91.5 (86.7, 95.0)	266.0	68.8 (59.5, 79.5)	1.05 (0.86, 1.28)	0.6463	0.7638
HPV-52	299	239	79.9 (74.9, 84.3)	531.5	45.0 (39.6, 51.0)	277	238	85.9 (81.3, 89.8)	438.4	54.3 (47.8, 61.6)	0.83 (0.70, 1.00)	**0.0488**	0.2115
HPV-56	135	127	94.1 (88.7, 97.4)	180.7	70.3 (59.1, 83.6)	121	110	90.9 (84.3, 95.4)	167.9	65.5 (54.3, 79.0)	1.08 (0.84, 1.40)	0.5457	0.7094
HPV-58	108	91	84.3 (76.0, 90.6)	176.4	51.6 (42.0, 63.4)	122	101	82.8 (74.9, 89.0)	168.1	60.1 (49.4, 73.0)	0.82 (0.62, 1.09)	0.1740	0.4524
HPV-59	75	72	96.0 (88.8, 99.2)	90.0	80.0 (63.5, 100.7)	77	72	93.5 (85.5, 97.9)	91.7	78.5 (62.3, 98.9)	0.97 (0.70, 1.35)	0.8571	0.9285
HPV-68	124	114	91.9 (85.7, 96.1)	154.7	73.7 (61.3, 88.6)	140	127	90.7 (84.6, 95.0)	187.3	67.8 (57, 80.7)	1.14 (0.88, 1.48)	0.3135	0.5822
HPV group													

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	Vaccine group					Control group					HR (95%CI)	Original p value	FDR-adjusted q value
	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years			
HPV-16/18	130	129	99.2 (95.8, 100.0)	141.9	90.9 (76.5, 108.1)	290	256	88.3 (84.0, 91.7)	416.3	61.5 (54.4, 69.5)	1.61 (1.30, 1.99)	**<0.0001**	**0.0003**
HPV-31/33/45	121	108	89.3 (82.3, 94.2)	140.5	76.9 (63.7, 92.9)	207	188	90.8 (86.0, 94.4)	270.7	69.5 (60.2, 80.1)	1.17 (0.92, 1.49)	0.1956	0.2209
HR-HPV	1446	1291	89.3 (87.6, 90.8)	2013.7	64.1 (60.7, 67.7)	1645	1466	89.1 (87.5, 90.6)	2296.5	63.8 (60.7, 67.2)	1.05 (0.97, 1.14)	0.2209	0.2209

HR-HPV, high-risk human papillomavirus; HR, hazard ratio; 95%CI, 95% confidence interval; FDR, false discovery rate.
For type-specific analyses, the standard Cox proportional hazards model was used. For HPV-16/18, HPV-31/33/45, and HR-HPV groups, the Wei-Lin-Weissfeld (WLW) Cox model was applied. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
*N, the number of infection events; n, the number of cleared infection events.

Supplementary Table 5. Persistence duration of incident HR-HPV infections in the vaccine group and the control group

	Vaccine group			Control group			Original p value	FDR-adjusted q value
	N*	Mean times (SD), months#	Median times (IQR), months	N*	Mean times (SD), months#	Median times (IQR), months		
HPV type								
HPV-16	92	2.4 (8.6)	0 (0, 0)	176	7.8 (14.5)	0 (0, 11.1)	**<0.0001**	**0.0013**
HPV-18	38	3.7 (15.4)	0 (0, 0)	114	4.9 (10.7)	0 (0, 6.1)	**0.0073**	**0.0316**
HPV-31	56	4.3 (9.2)	0 (0, 5.6)	101	6.1 (15.7)	0 (0, 5.5)	0.8601	0.8601
HPV-33	51	4.6 (6.8)	0 (0, 9.3)	74	6.9 (10.6)	0 (0, 12.1)	0.5059	0.7328
HPV-35	47	7.3 (9.4)	5.0 (0, 13.3)	66	5.7 (10.3)	0 (0, 6.9)	0.1393	0.4527
HPV-39	182	4.9 (8.6)	0 (0, 6.3)	145	5.6 (9.1)	0 (0, 9.1)	0.5252	0.7328
HPV-45	14	3.0 (3.9)	0 (0, 5.8)	32	2.5 (4.4)	0 (0, 5.2)	0.6691	0.7908
HPV-51	225	5.2 (9.2)	0 (0, 6.9)	200	4.6 (8.2)	0 (0, 6.8)	0.7744	0.8389
HPV-52	299	11.8 (16.7)	5.2 (0, 17.2)	277	7.7 (12.7)	0 (0, 11.6)	**0.0014**	**0.0091**
HPV-56	135	5.5 (8.6)	0 (0, 9.1)	121	5.7 (10.9)	0 (0, 6.8)	0.5604	0.7328
HPV-58	108	9.3 (11.9)	5.4 (0, 16.6)	122	6.9 (10.1)	4.4 (0, 10.9)	0.2353	0.6118
HPV-59	75	3.6 (6.9)	0 (0, 5.7)	77	2.9 (6.3)	0 (0, 4.5)	0.4577	0.7328
HPV-68	124	4.5 (7.7)	0 (0, 6.8)	140	4.4 (8.0)	0 (0, 6.5)	0.5637	0.7328
HPV group								
HPV-16/18	130	2.8 (11.0)	0 (0, 0)	290	6.6 (13.2)	0 (0, 8.5)	**<0.0001**	**0.0003**
HPV-31/33/45	121	4.3 (7.7)	0 (0, 5.9)	207	5.8 (12.8)	0 (0, 6.1)	0.8495	0.8495
HR-HPV	1446	6.5 (11.5)	0 (0, 10.5)	1645	5.9 (11.1)	0 (0, 8.0)	0.2290	0.3435

HR-HPV, high-risk human papillomavirus; FDR, false discovery rate; SD, standard deviation; IQR, interquartile range.
p values were determined using the Wilcoxon rank sum test. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
*N, the number of infection events;
#The persistence duration of infection exhibited a left-skewed distribution. Due to persistence events occurring in fewer than 50% for certain HPV types, the median times and lower quartile were 0 months. Therefore, we also presented the mean times for each HPV type.

Supplementary Table 6. The clearance time of HR-HPV infections in the vaccine group and the control group

	Vaccine group		Control group		Original p value	FDR-adjusted q value
	N*	Median times (IQR), months	N*	Median times (IQR), months		
HPV type						
HPV-16	92	7.6 (5.7, 13.7)	176	13.1 (6.6, 24.5)	**0.0007**	**0.0091**
HPV-18	38	8.3 (5.7, 13.5)	114	11.8 (6.2, 17.0)	0.1148	0.3731
HPV-31	56	13.0 (6.7, 18.2)	101	12.3 (6.2, 17.0)	0.4851	0.7883
HPV-33	51	12.8 (6.1, 17.2)	74	13.2 (6.7, 23.2)	0.2479	0.4604
HPV-35	47	13.1 (7.0, 25.1)	66	13.8 (6.9, 20.8)	0.9281	0.9281
HPV-39	182	12.6 (7.8, 18.4)	145	12.6 (7.1, 18.7)	0.7586	0.8218
HPV-45	14	11.0 (6.1, 11.7)	32	12.7 (6.9, 14.3)	0.0660	0.2860
HPV-51	225	12.1 (6.9, 17.9)	200	12.6 (7.7, 22.6)	0.2355	0.4604
HPV-52	299	14.2 (10.2, 28.5)	277	13.2 (8.7, 26.7)	0.2018	0.4604
HPV-56	135	12.9 (10.5, 19.1)	121	13.2 (10.2, 21.6)	0.5740	0.8218
HPV-58	108	14.7 (10.9, 27.1)	122	12.8 (7.3, 22.5)	0.0518	0.2860
HPV-59	75	12.4 (6.2, 16.6)	77	12.0 (6.7, 15.1)	0.7166	0.8218
HPV-68	124	12.8 (6.9, 18.6)	140	12.6 (10.3, 22.8)	0.6378	0.8218
HPV group						
HPV-16/18	130	7.8 (5.7, 13.5)	290	12.9 (6.2, 22.5)	**0.0005**	**0.0015**
HPV-31/33/45	121	12.8 (6.7, 15.7)	207	12.9 (6.4, 18.6)	0.4821	0.6682
HR-HPV	1446	13.0 (6.9, 23.0)	1645	12.9 (6.9, 22.7)	0.6682	0.6682

HR-HPV, high-risk human papillomavirus; FDR, false discovery rate; IQR, interquartile range.
p values were determined using the Wilcoxon rank sum test. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
* N, the number of infection events;

Supplementary Table 7. The persistence of incident single-type HR-HPV infections in the vaccine group and the control group

	Vaccine group			Control group			Original p value	FDR-adjusted q value
	N*	n*	Proportion (95%CI)	N*	n*	Proportion (95%CI)		
HPV type								
HPV-16	52	2	3.9 (0.5, 13.2)	95	38	40.0 (30.1, 50.6)	**<0.0001**	**0.0013**
HPV-18	23	3	13.0 (2.8, 33.6)	60	19	31.7 (20.3, 45.0)	0.0853	0.3696
HPV-31	30	9	30.0 (14.7, 49.4)	45	13	28.9 (16.4, 44.3)	0.9175	0.9411
HPV-33	26	11	42.3 (23.4, 63.1)	37	16	43.2 (27.1, 60.5)	0.9411	0.9411
HPV-35	24	12	50.0 (29.1, 70.9)	35	12	34.3 (19.1, 52.2)	0.2274	0.5912
HPV-39	128	46	35.9 (27.7, 44.9)	78	30	38.5 (27.7, 50.2)	0.7157	0.9411
HPV-45	8	4	50.0 (15.7, 84.3)	16	4	25.0 (7.3, 52.4)	0.2207	0.5912
HPV-51	149	54	36.2 (28.5, 44.5)	125	41	32.8 (24.7, 41.8)	0.5510	0.8954
HPV-52	189	99	52.4 (45.0, 59.7)	166	60	36.1 (28.8, 44.0)	**0.0021**	**0.0137**
HPV-56	77	29	37.7 (26.9, 49.4)	59	26	44.1 (31.2, 57.6)	0.4506	0.8368
HPV-58	70	34	48.6 (36.4, 60.8)	69	32	46.4 (34.3, 58.8)	0.7956	0.9411
HPV-59	51	16	31.4 (19.1, 45.9)	49	16	32.7 (20.0, 47.5)	0.8909	0.9411
HPV-68	77	32	41.6 (30.4, 53.4)	81	27	33.3 (23.2, 44.7)	0.2854	0.6184
HPV group								
HPV-16/18	75	5	6.7 (2.2, 14.9)	155	57	36.8 (29.2, 44.9)	**<0.0001**	**0.0003**
HPV-31/33/45	64	24	37.5 (25.7, 50.5)	98	33	33.7 (24.4, 43.9)	0.6181	0.6181
HR-HPV	904	351	38.8 (35.6, 42.1)	915	334	36.5 (33.4, 39.7)	0.3063	0.4595

HR-HPV, high-risk human papillomavirus; 95%CI, 95% confidence interval; FDR, false discovery rate.
p values were determined using the chi-squared test or Fisher's exact test. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
*N, the number of infection events; n, the number of persistent infection events.

Supplementary Table 8. The clearance of incident single-type HR-HPV infections in the vaccine group and the control group (sensitivity analysis)

	Vaccine group					Control group					HR (95%CI)	Original p value	FDR-adjusted q value
	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years			
HPV type													
HPV-16	52	52	100.0 (93.2, 100.0)	49.9	104.3 (79.5, 136.9)	95	85	89.5 (81.5, 94.8)	141.4	60.1 (48.6, 74.4)	1.83 (1.28, 2.62)	**0.0009**	**0.0117**
HPV-18	23	23	100.0 (85.2, 100.0)	33.6	68.4 (45.4, 102.9)	60	53	88.3 (77.4, 95.2)	64.6	82.1 (62.7, 107.5)	0.96 (0.56, 1.66)	0.8960	0.9998
HPV-31	30	28	93.3 (77.9, 99.2)	36.8	76.2 (52.6, 110.3)	45	40	88.9 (76.0, 96.3)	66.8	59.8 (43.9, 81.6)	1.07 (0.65, 1.76)	0.7928	0.9998
HPV-33	26	19	73.1 (52.2, 88.4)	31.0	61.4 (39.1, 96.2)	37	32	86.5 (71.2, 95.5)	49.6	64.5 (45.6, 91.3)	1.12 (0.62, 2.01)	0.7131	0.9998
HPV-35	24	19	79.2 (57.9, 92.9)	30.8	61.6 (39.3, 96.6)	35	33	94.3 (80.8, 99.3)	46.5	71.0 (50.5, 99.9)	0.89 (0.50, 1.61)	0.7083	0.9998
HPV-39	128	121	94.5 (89.1, 97.8)	172.0	70.3 (58.9, 84.1)	78	71	91.0 (82.4, 96.3)	99.6	71.3 (56.5, 90.0)	0.95 (0.70, 1.27)	0.7090	0.9998
HPV-45	8	7	87.5 (47.4, 99.7)	5.7	122.7 (58.5, 257.3)	16	16	100.0 (79.4, 100.0)	17.3	92.6 (56.8, 151.2)	3.24 (1.06, 9.85)	**0.0387**	0.1677
HPV-51	149	133	89.3 (83.2, 93.7)	179.7	74.0 (62.4, 87.7)	125	114	91.2 (84.8, 95.5)	156.2	73.0 (60.7, 87.7)	1.00 (0.78, 1.29)	0.9998	0.9998
HPV-52	189	148	78.3 (71.7, 84.0)	348.7	42.4 (36.1, 49.9)	166	145	87.4 (81.3, 92.0)	244.9	59.2 (50.3, 69.7)	0.70 (0.56, 0.89)	**0.0030**	**0.0195**
HPV-56	77	72	93.5 (85.5, 97.9)	93.9	76.7 (60.8, 96.6)	59	54	91.5 (81.3, 97.2)	80.1	67.4 (51.6, 88.0)	1.22 (0.84, 1.75)	0.2945	0.7657
HPV-58	70	58	82.9 (72.0, 90.8)	111.2	52.2 (40.3, 67.5)	69	57	82.6 (71.6, 90.7)	90.5	63.0 (48.6, 81.7)	0.77 (0.53, 1.11)	0.1646	0.5350
HPV-59	51	49	96.1 (86.5, 99.5)	64.5	75.9 (57.4, 100.5)	49	46	93.9 (83.1, 98.7)	56.4	81.6 (61.1, 109.0)	0.87 (0.58, 1.31)	0.5123	0.9998
HPV-68	77	70	90.9 (82.2, 96.3)	109.1	64.2 (50.8, 81.1)	81	75	92.6 (84.6, 97.2)	115.3	65.1 (51.9, 81.6)	1.01 (0.72, 1.41)	0.9689	0.9998
HPV group													

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	Vaccine group					Control group					HR (95%CI)	Original p value	FDR-adjusted q value
	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years			
HPV-16/18	75	75	100.0 (95.2, 100.0)	83.5	89.8 (71.6, 112.6)	155	138	89.0 (83.0, 93.5)	206.0	67.0 (56.7, 79.2)	1.44 (1.08, 1.92)	**0.0125**	**0.0375**
HPV-31/33/45	64	54	84.4 (73.1, 92.2)	73.4	73.5 (56.3, 96.0)	98	88	89.8 (82.0, 95.0)	133.7	65.8 (53.4, 81.1)	1.10 (0.78, 1.55)	0.5826	0.5826
HR-HPV	904	799	88.4 (86.1, 90.4)	1267.0	63.1 (58.8, 67.6)	915	821	89.7 (87.6, 91.6)	1229.0	66.8 (62.4, 71.5)	0.93 (0.85, 1.03)	0.1681	0.2522

HR-HPV, high-risk human papillomavirus; HR, hazard ratio; 95%CI, 95% confidence interval; FDR, false discovery rate.
For type-specific analyses, the standard Cox proportional hazards model was used. For HPV-16/18, HPV-31/33/45, and HR-HPV groups, the Wei-Lin-Weissfeld (WLW) Cox model was applied. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
*N, the number of infection events; n, the number of cleared infection events.

Supplementary Table 9. Persistence duration of incident single-type HR-HPV infections in the vaccine group and the control group (sensitivity analysis)

	Vaccine group			Control group			Original p value	FDR-adjusted q value
	N*	Mean times (SD), months#	Median times (IQR), months	N*	Mean times (SD), months#	Median times (IQR), months		
HPV type								
HPV-16	52	0.6 (3.4)	0 (0, 0)	95	6.7 (14.2)	0 (0, 9.1)	**<0.0001**	**0.0013**
HPV-18	23	5.7 (19.5)	0 (0, 0)	60	3.8 (6.8)	0 (0, 5.7)	0.1571	0.5408
HPV-31	30	4.2 (9.4)	0 (0, 5.9)	45	7.5 (19.9)	0 (0, 5.0)	0.9786	0.9786
HPV-33	26	4.9 (7.2)	0 (0, 11.0)	37	6.1 (9.0)	0 (0, 12.1)	0.7276	0.8599
HPV-35	24	6.9 (10.3)	2.5 (0, 11.7)	35	3.9 (6.6)	0 (0, 5.8)	0.2348	0.5408
HPV-39	128	4.2 (7.8)	0 (0, 5.8)	78	5.0 (9.3)	0 (0, 6.7)	0.6619	0.8599
HPV-45	8	3.4 (4.2)	2.3 (0, 5.4)	16	1.2 (2.5)	0 (0, 0.4)	0.2285	0.5408
HPV-51	149	4.5 (8.0)	0 (0, 6.6)	125	4.0 (8.2)	0 (0, 5.3)	0.5270	0.7612
HPV-52	189	11.8 (16.8)	5.1 (0, 17.2)	166	6.4 (12.2)	0 (0, 7.6)	**0.0004**	**0.0026**
HPV-56	77	4.1 (6.1)	0 (0, 6.8)	59	5.5 (9.3)	0 (0, 10.6)	0.5172	0.7612
HPV-58	70	8.6 (10.8)	0 (0, 17.5)	69	5.9 (8.6)	0 (0, 8.5)	0.2500	0.5408
HPV-59	51	3.3 (6.9)	0 (0, 5.4)	49	3.2 (5.7)	0 (0, 5.1)	0.8448	0.9152
HPV-68	77	5.3 (9.0)	0 (0, 10.7)	81	4.5 (8.8)	0 (0, 6.7)	0.2912	0.5408
HPV group								
HPV-16/18	75	2.1 (11.3)	0 (0, 0)	155	5.6 (11.9)	0 (0, 8.0)	**<0.0001**	**0.0003**
HPV-31/33/45	64	4.4 (8.0)	0 (0, 5.9)	98	6.0 (14.7)	0 (0, 5.6)	0.7925	0.7925
HR-HPV	904	6.1 (11.3)	0 (0, 9.4)	915	5.2 (10.6)	0 (0, 6.7)	0.1229	0.1844

HR-HPV, high-risk human papillomavirus; FDR, false discovery rate; SD, standard deviation; IQR, interquartile range.
p values were determined using the Wilcoxon rank sum test. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
*N, the number of infection events;
#The persistence duration of infection exhibited a left-skewed distribution. Due to persistence events occurring in fewer than 50% for certain HPV types, the median times and lower quartile were 0 months. Therefore, we also presented the mean times for each HPV type.

Supplementary Table 10. The clearance time of single-type HR-HPV infections in the vaccine group and the control group (sensitivity analysis)

	Vaccine group		Control group		Original p value	FDR-adjusted q value
	N*	Median times (IQR), months	N*	Median times (IQR), months		
HPV type						
HPV-16	52	7.2 (5.7, 13.2)	95	13.0 (5.9, 24.5)	**0.0196**	0.2158
HPV-18	23	9.7 (5.6, 18.2)	60	11.7 (6.0, 13.8)	0.5619	0.8175
HPV-31	30	13.0 (6.8, 18.0)	45	12.3 (6.2, 22.1)	0.9139	0.9384
HPV-33	26	12.9 (6.9, 17.9)	37	13.1 (6.9, 22.7)	0.6804	0.8175
HPV-35	24	13.0 (7.7, 19.7)	35	14.3 (7.0, 24.4)	0.6545	0.8175
HPV-39	128	13.2 (8.2, 17.9)	78	12.2 (7.0, 17.0)	0.4802	0.8175
HPV-45	8	9.1 (5.4, 11.3)	16	13.4 (6.0, 14.3)	**0.0498**	0.2158
HPV-51	149	12.0 (7.1, 17.0)	125	12.1 (6.9, 19.3)	0.9384	0.9384
HPV-52	189	16.0 (10.6, 28.7)	166	13.1 (8.0, 25.4)	**0.0428**	0.2158
HPV-56	77	12.5 (10.5, 18.2)	59	13.1 (6.9, 23.5)	0.3704	0.8175
HPV-58	70	14.8 (11.3, 25.7)	69	12.9 (7.0, 22.5)	0.0779	0.2532
HPV-59	51	12.6 (7.3, 18.0)	49	12.3 (6.7, 17.2)	0.6147	0.8175
HPV-68	77	14.0 (11.4, 22.8)	81	12.9 (10.0, 23.9)	0.6917	0.8175
HPV group						
HPV-16/18	75	7.9 (5.6, 13.9)	155	12.2 (5.9, 18.6)	**0.0382**	0.1146
HPV-31/33/45	64	12.5 (6.7, 16.5)	98	12.9 (6.2, 20.1)	0.4448	0.4448
HR-HPV	904	13.0 (7.3, 23.4)	915	12.7 (6.9, 22.5)	0.3424	0.4448

HR-HPV, high-risk human papillomavirus; FDR, false discovery rate; IQR, interquartile range.
p values were determined using the Wilcoxon rank sum test. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
* N, the number of infection events;

Supplementary Table 11. The clearance of incident HR-HPV infections in the vaccine group and the control group, defined by two consecutive negative results (sensitivity analysis)

	Vaccine group					Control group					HR (95%CI)	Original p value	FDR-adjusted q value
	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years			
HPV type													
HPV-16	80	76	95.0 (87.7, 98.6)	85.0	89.4 (71.4, 112)	144	112	77.8 (70.1, 84.3)	212.9	52.6 (43.7, 63.3)	1.60 (1.20, 2.12)	**0.0013**	**0.0169**
HPV-18	35	33	94.3 (80.8, 99.3)	35.5	92.9 (66.1, 130.7)	94	77	81.9 (72.6, 89.1)	117.1	65.8 (52.6, 82.2)	1.41 (0.95, 2.09)	0.0927	0.4017
HPV-31	50	41	82.0 (68.6, 91.4)	66.6	61.5 (45.3, 83.6)	86	73	84.9 (75.5, 91.7)	124.0	58.9 (46.8, 74.0)	1.03 (0.72, 1.49)	0.8583	0.9241
HPV-33	40	34	85.0 (70.2, 94.3)	47.2	72.1 (51.5, 100.9)	61	50	82.0 (70.0, 90.6)	80.1	62.4 (47.3, 82.3)	1.27 (0.83, 1.93)	0.2758	0.7171
HPV-35	40	30	75.0 (58.8, 87.3)	59.3	50.6 (35.4, 72.4)	53	48	90.6 (79.3, 96.9)	68.4	70.2 (52.9, 93.2)	0.92 (0.60, 1.42)	0.7067	0.9241
HPV-39	142	116	81.7 (74.3, 87.7)	210.1	55.2 (46.0, 66.3)	120	102	85.0 (77.3, 90.9)	186.7	54.6 (45.0, 66.3)	1.08 (0.84, 1.38)	0.5457	0.9241
HPV-45	12	12	100.0 (73.5, 100.0)	12.5	96.0 (54.5, 169)	29	27	93.1 (77.2, 99.2)	31.0	87.1 (59.8, 127.0)	0.97 (0.47, 1.97)	0.9241	0.9241
HPV-51	183	160	87.4 (81.7, 91.9)	241.8	66.2 (56.7, 77.3)	158	135	85.4 (79.0, 90.5)	209.7	64.4 (54.4, 76.2)	0.99 (0.79, 1.23)	0.9230	0.9241
HPV-52	246	171	69.5 (63.4, 75.2)	466.0	36.7 (31.6, 42.6)	214	168	78.5 (72.4, 83.8)	349.1	48.1 (41.4, 56.0)	0.82 (0.67, 1.00)	**0.0446**	0.2899
HPV-56	111	96	86.5 (78.7, 92.2)	136.1	70.5 (57.7, 86.1)	98	86	87.8 (79.6, 93.5)	131.8	65.2 (52.8, 80.6)	1.21 (0.92, 1.61)	0.1765	0.5736
HPV-58	86	66	76.7 (66.4, 85.2)	155.3	42.5 (33.4, 54.1)	100	73	73.0 (63.2, 81.4)	160.8	45.4 (36.1, 57.1)	0.94 (0.69, 1.29)	0.7172	0.9241
HPV-59	66	61	92.4 (83.2, 97.5)	78.1	78.1 (60.8, 100.4)	62	57	91.9 (82.2, 97.3)	71.7	79.5 (61.3, 103.0)	0.95 (0.66, 1.35)	0.7620	0.9241
HPV-68	97	88	90.7 (83.1, 95.7)	122.8	71.7 (58.1, 88.3)	109	92	84.4 (76.2, 90.6)	142.6	64.5 (52.6, 79.1)	1.09 (0.82, 1.45)	0.5606	0.9241
HPV group													

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	Vaccine group					Control group					HR (95%CI)	Original p value	FDR-adjusted q value
	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years	N*	n*	Proportion (95%CI)	Person -years at risk	Clearance (95%CI), per 100 person-years			
HPV-16/18	115	109	94.8 (89.0, 98.1)	120.5	90.5 (75.0, 109.1)	238	189	79.4 (73.7, 84.4)	330.0	57.3 (49.7, 66.1)	1.62 (1.27, 2.07)	**0.0001**	**0.0003**
HPV-31/33/45	102	87	85.3 (76.9, 91.5)	126.3	68.9 (55.8, 85.0)	176	150	85.2 (79.1, 90.1)	235.1	63.8 (54.4, 74.9)	1.03 (0.79, 1.34)	0.8434	0.8434
HR-HPV	1188	981	82.6 (80.3, 84.7)	1716.3	57.2 (53.7, 60.9)	1328	1103	83.1 (80.9, 85.0)	1886.0	58.5 (55.1, 62.0)	1.01 (0.92, 1.11)	0.8389	0.8434

HR-HPV, high-risk human papillomavirus; HR, hazard ratio; 95%CI, 95% confidence interval; FDR, false discovery rate.

For type-specific analyses, the standard Cox proportional hazards model was used. For HPV-16/18, HPV-31/33/45, and HR-HPV groups, the Wei-Lin-Weissfeld (WLW) Cox model was applied. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

*N, the number of infection events; n, the number of cleared infection events.

Supplementary Table 12. The clearance time of HR-HPV infections in the vaccine group and the control group, defined by two consecutive negative results (sensitivity analysis)

	Vaccine group		Control group		Original p value	FDR-adjusted q value
	N*	Median times (IQR), months	N*	Median times (IQR), months		
HPV type						
HPV-16	80	6.9 (5.6, 13.0)	144	12.9 (5.9, 24.3)	**0.0196**	0.2158
HPV-18	35	7.7 (5.6, 13.2)	94	11.4 (6.0, 18.6)	0.5619	0.8175
HPV-31	50	13.0 (6.7, 18.9)	86	11.1 (6.1, 22.3)	0.9139	0.9384
HPV-33	40	12.4 (6.1, 17.6)	61	13.1 (6.8, 18.8)	0.6804	0.8175
HPV-35	40	12.9 (6.7, 22.2)	53	12.3 (6.0, 17.8)	0.6545	0.8175
HPV-39	142	12.9 (9.1, 22.8)	120	13.3 (10.4, 23.7)	0.4802	0.8175
HPV-45	12	11.0 (5.8, 13.1)	29	12.3 (6.0, 14.1)	**0.0498**	0.2158
HPV-51	183	12.1 (6.8, 19.0)	158	12.3 (7.1, 22.6)	0.9384	0.9384
HPV-52	246	16.5 (9.8, 30.8)	214	13.1 (8.9, 28.5)	**0.0428**	0.2158
HPV-56	111	12.5 (6.8, 17.7)	98	13.0 (9.7, 17.9)	0.3704	0.8175
HPV-58	86	18.1 (11.3, 28.9)	100	13.8 (10.4, 23.8)	0.0779	0.2532
HPV-59	66	12.6 (7.0, 16.8)	62	12.1 (6.1, 17.2)	0.6147	0.8175
HPV-68	97	12.7 (6.8, 18.6)	109	12.6 (7.0, 18.6)	0.6917	0.8175
HPV group						
HPV-16/18	115	7.1 (5.6, 13.0)	238	12.1 (5.9, 23.1)	**0.0382**	0.1146
HPV-31/33/45	102	12.5 (6.1, 17.5)	176	12.4 (6.2, 18.5)	0.4448	0.4448
HR-HPV	1188	12.9 (6.8, 23.1)	1328	12.8 (6.8, 23.1)	0.3424	0.4448

HR-HPV, high-risk human papillomavirus; FDR, false discovery rate; IQR, interquartile range.
p values were determined using the Wilcoxon rank sum test. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
* N, the number of infection events;

Supplementary Table 13. The persistence and clearance of HPV-52 single infection and multiple infection in the control group

	n*	N*	Proportion (95%CI)	P value	Person-years at risk	Incidence (95%CI), per 100 person-years	HR (95%CI)	P value^	Mean times (SD), months#	Median times (IQR), months	P value&
Persistence											
HPV 52 single infection	60	166	36.1 (28.8, 44.0)	-	-	-	-	-	6.4 (12.2)	0 (0, 7.6)	-
HPV 52 multiple infection~	18	49	36.7 (23.4, 51.7)	0.9398	-	-	-	-	5.4 (9.2)	0 (0, 6.2)	0.9915
HPV-16/18/31/33/45	6	20	30.0 (11.9, 54.3)	0.5874	-	-	-	-	4.0 (7.7)	0 (0, 4.4)	0.5205
HPV-35/39/51/56/58/59/68	12	29	41.4 (23.5, 61.1)	0.5899	-	-	-	-	6.4 (10.1)	0 (0, 11.2)	0.5965
Clearance											
HPV 52 single infection	145	166	87.4 (81.3, 92.0)	-	244.9	49.3 (41.9, 58.1)	-	-	-	13.1 (8.0, 25.4)	-
HPV 52 multiple infection~	42	49	85.7 (72.8, 94.1)	0.7651	68.2	51.3 (37.9, 69.5)	1.02 (0.72, 1.44)	0.9110	-	13.1 (6.9, 25.3)	0.9385
HPV-16/18/31/33/45	17	20	85.0 (62.1, 96.8)	0.7672	24.3	58.3 (36.2, 93.8)	1.24 (0.75, 2.07)	0.3999	-	13.0 (6.3, 22.3)	0.4135
HPV-35/39/51/56/58/59/68	25	29	86.2 (68.3, 96.1)	0.8652	43.9	47.5 (32.1, 70.3)	0.90 (0.59, 1.38)	0.6432	-	13.8 (11.1, 27.2)	0.5768

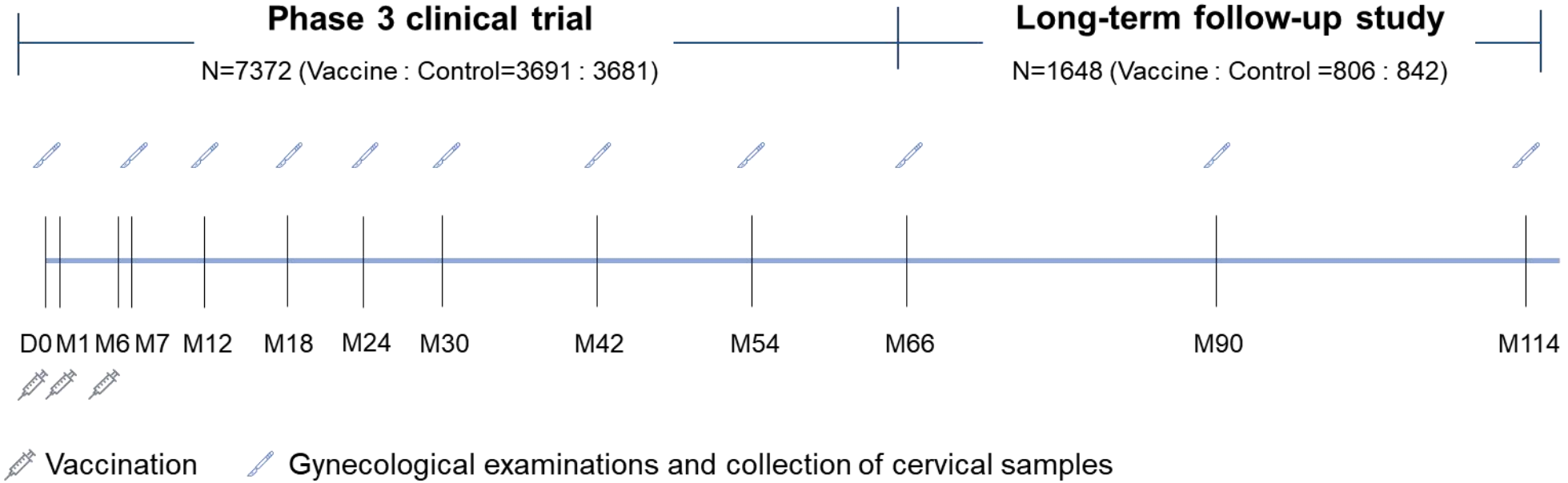
HPV, human papillomavirus; HR, hazard ratio; 95%CI, 95% confidence interval; SD, standard deviation; IQR, interquartile range.
All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
*N, the number of infection events; n, the number of persistent or cleared infection events.
#The persistence duration of infection exhibited a left-skewed distribution. Due to persistence events occurring in fewer than 50% for certain groups, the median times and lower quartile were 0 months. Therefore, we also presented the mean times for each HPV type.
&P values were determined using the Wilcoxon rank sum test.
^P values were determined using the Cox regression model.
~Recognizing that prolonged HPV-52 infection duration inherently increases multiple infection risk due to expanded temporal exposure (key source of collinearity), we operationally defined HPV-52 multiple infections as only those episodes with strictly simultaneous onset of both HPV-52 and another HR-HPV type.

Supplementary Table 14. The persistence and clearance of HPV-52 infection in the non-surgical and postoperatively censored participants in the vaccine group and the control group

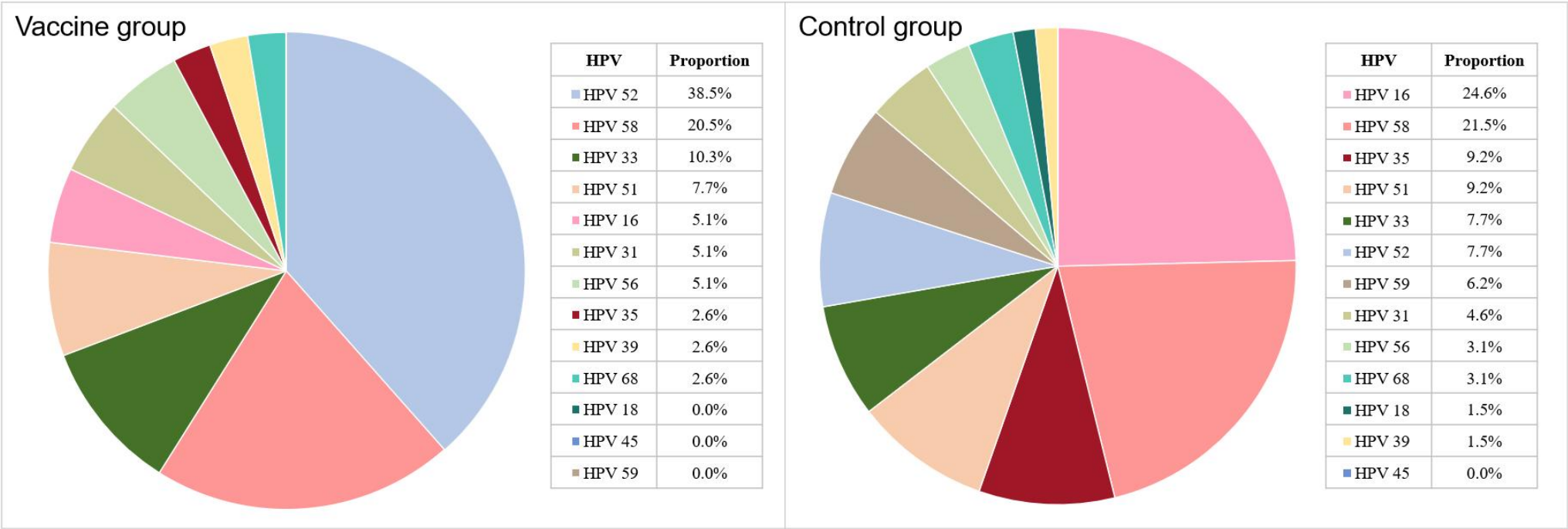
	n*	N*	Proportion (95%CI)	P value	Person-years at risk	Incidence (95%CI), per 100 person-years	HR (95%CI)	P value^	Mean times (SD), months#	Median times (IQR), months	P value&
Persistence											
Vaccine group	160	297	53.9 (48.0, 59.7)	**0.0039**	-	-	-	-	11.8 (16.7)	5.2 (0, 17.2)	**0.0009**
Control group	115	275	41.8 (35.9, 47.9)	-	-	-	-	-	7.5 (12.4)	0 (0, 11.6)	-
Clearance											
Vaccine group	232	297	78.1 (73.0, 82.7)	**0.0427**	522.0	44.4 (39.1, 50.6)	0.82 (0.69, 0.99)	**0.0382**	-	14.2 (10.2, 27.9)	0.1569
Control group	233	275	84.7 (79.9, 88.8)	-	427.0	54.6 (48.0, 62.0)	-	-	-	13.1 (8.0, 26.5)	-

HPV, human papillomavirus; HR, hazard ratio; 95%CI, 95% confidence interval; SD, standard deviation; IQR, interquartile range.
All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.
*N, the number of infection events; n, the number of persistent or cleared infection events.
#The persistence duration of infection exhibited a left-skewed distribution. Due to persistence events occurring in fewer than 50% for certain groups, the median times and lower quartile were 0 months. Therefore, we also presented the mean times for each HPV type.
&P values were determined using the Wilcoxon rank sum test.
^P values were determined using the Cox regression model.

Supplementary Figure 1. The study design



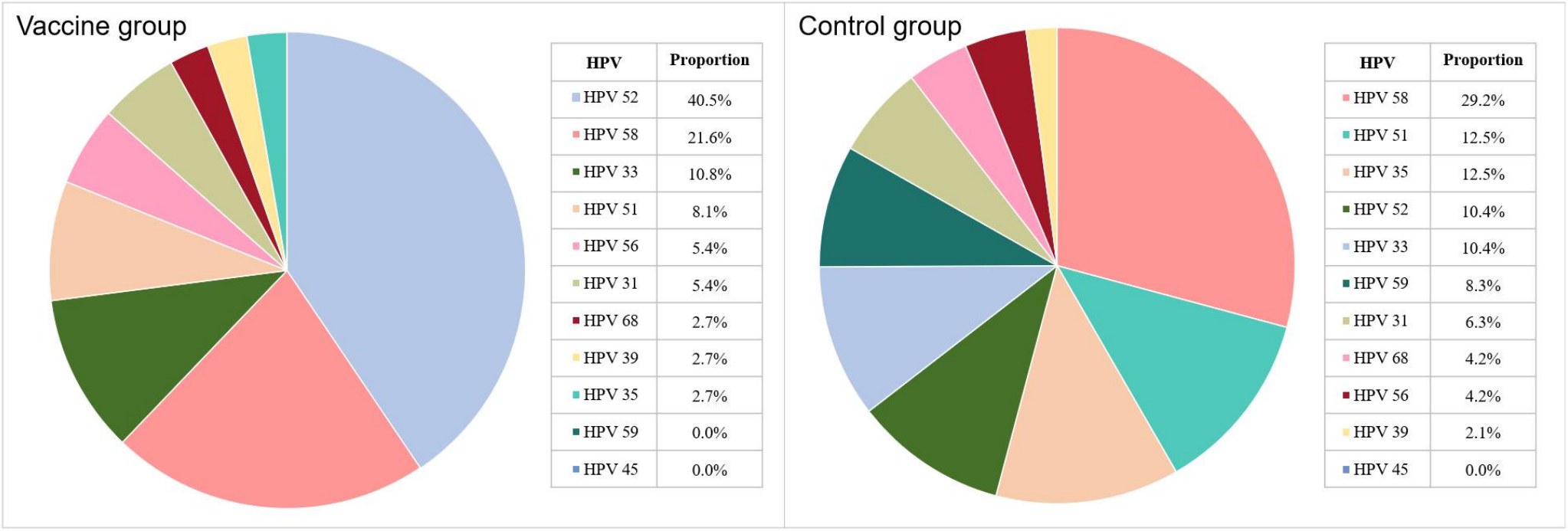
Supplementary Figure 2. Constituent ratio of HR-HPV associated cervical intraepithelial neoplasia grade 2 or greater in the vaccine group and the control group



HPV	Proportion
HPV 52	38.5%
HPV 58	20.5%
HPV 33	10.3%
HPV 51	7.7%
HPV 16	5.1%
HPV 31	5.1%
HPV 56	5.1%
HPV 35	2.6%
HPV 39	2.6%
HPV 68	2.6%
HPV 18	0.0%
HPV 45	0.0%
HPV 59	0.0%

HPV	Proportion
HPV 16	24.6%
HPV 58	21.5%
HPV 35	9.2%
HPV 51	9.2%
HPV 33	7.7%
HPV 52	7.7%
HPV 59	6.2%
HPV 31	4.6%
HPV 56	3.1%
HPV 68	3.1%
HPV 18	1.5%
HPV 39	1.5%
HPV 45	0.0%

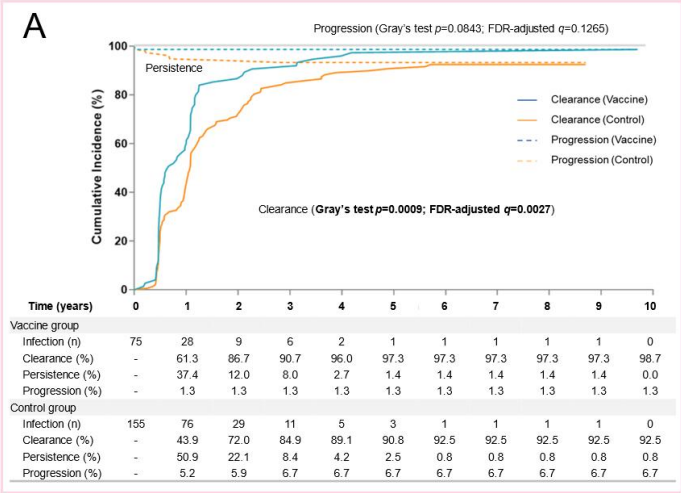
Supplementary Figure 3. Constituent ratio of HR-HPV associated cervical intraepithelial neoplasia grade 2 or greater in the vaccine group and the control group (excluding HPV-16/18 related cases)



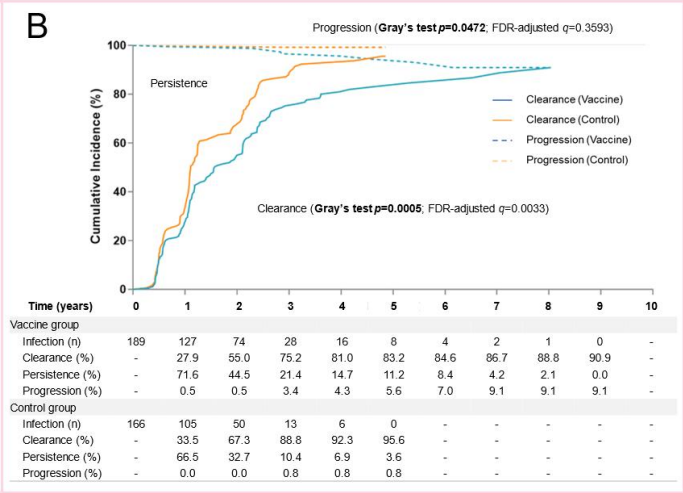
HPV	Proportion
HPV 52	40.5%
HPV 58	21.6%
HPV 33	10.8%
HPV 51	8.1%
HPV 56	5.4%
HPV 31	5.4%
HPV 68	2.7%
HPV 39	2.7%
HPV 35	2.7%
HPV 59	0.0%
HPV 45	0.0%

HPV	Proportion
HPV 58	29.2%
HPV 51	12.5%
HPV 35	12.5%
HPV 52	10.4%
HPV 33	10.4%
HPV 59	8.3%
HPV 31	6.3%
HPV 68	4.2%
HPV 56	4.2%
HPV 39	2.1%
HPV 45	0.0%

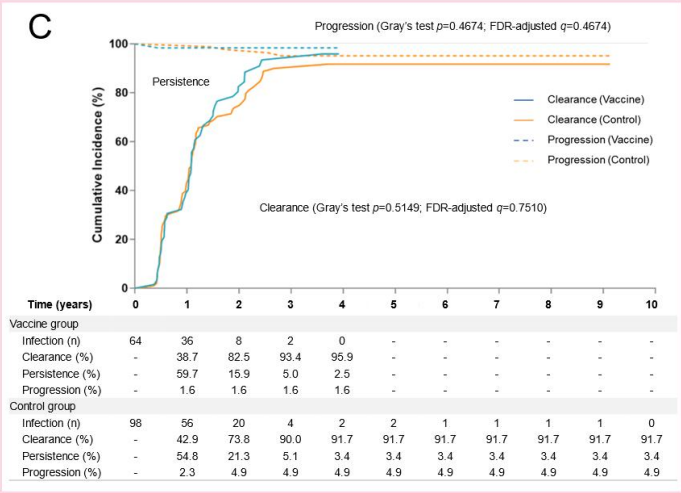
Supplementary Figure 4. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-16/18, HPV-52 and HPV-31/33/45 single infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	75	28	9	6	2	1	1	1	1	1	0
Clearance (%)	-	61.3	86.7	90.7	96.0	97.3	97.3	97.3	97.3	97.3	98.7
Persistence (%)	-	37.4	12.0	8.0	2.7	1.4	1.4	1.4	1.4	1.4	0.0
Progression (%)	-	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Control group											
Infection (n)	155	76	29	11	5	3	1	1	1	1	0
Clearance (%)	-	43.9	72.0	84.9	89.1	90.8	92.5	92.5	92.5	92.5	92.5
Persistence (%)	-	50.9	22.1	8.4	4.2	2.5	0.8	0.8	0.8	0.8	0.8
Progression (%)	-	5.2	5.9	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	189	127	74	28	16	8	4	2	1	0	-
Clearance (%)	-	27.9	55.0	75.2	81.0	83.2	84.6	86.7	88.8	90.9	-
Persistence (%)	-	71.6	44.5	21.4	14.7	11.2	8.4	4.2	2.1	0.0	-
Progression (%)	-	0.5	0.5	3.4	4.3	5.6	7.0	9.1	9.1	9.1	-
Control group											
Infection (n)	166	105	50	13	6	0	-	-	-	-	-
Clearance (%)	-	33.5	67.3	88.8	92.3	95.6	-	-	-	-	-
Persistence (%)	-	66.5	32.7	10.4	6.9	3.6	-	-	-	-	-
Progression (%)	-	0.0	0.0	0.8	0.8	0.8	-	-	-	-	-



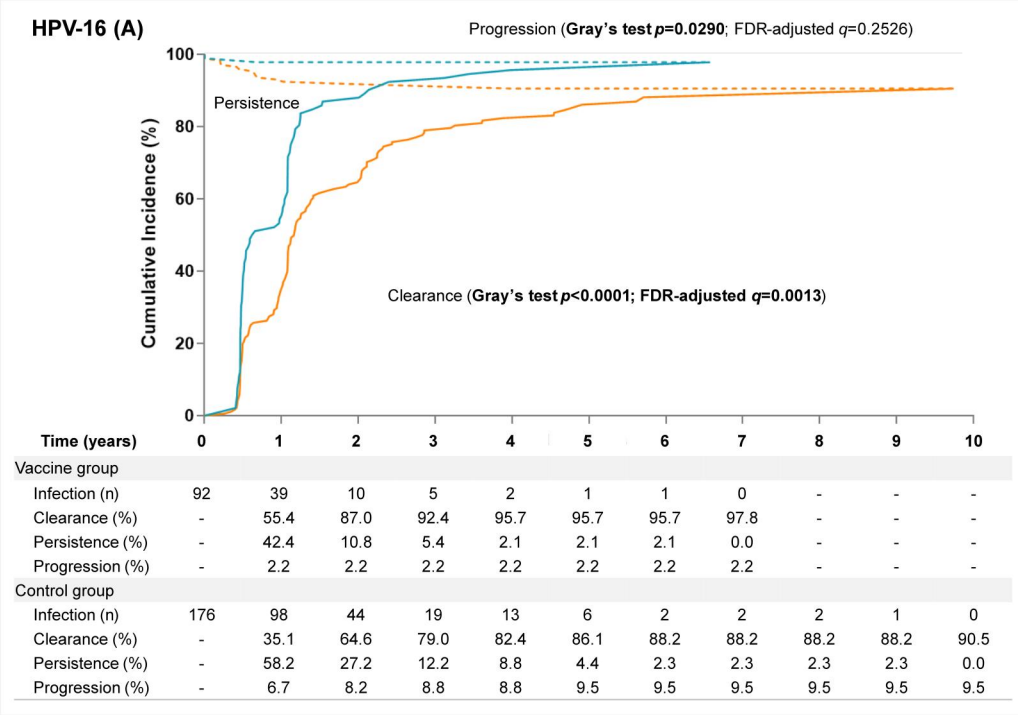
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	64	36	8	2	0	-	-	-	-	-	-
Clearance (%)	-	38.7	82.5	93.4	95.9	-	-	-	-	-	-
Persistence (%)	-	59.7	15.9	5.0	2.5	-	-	-	-	-	-
Progression (%)	-	1.6	1.6	1.6	1.6	-	-	-	-	-	-
Control group											
Infection (n)	98	56	20	4	2	2	1	1	1	1	0
Clearance (%)	-	42.9	73.8	90.0	91.7	91.7	91.7	91.7	91.7	91.7	91.7
Persistence (%)	-	54.8	21.3	5.1	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Progression (%)	-	2.3	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

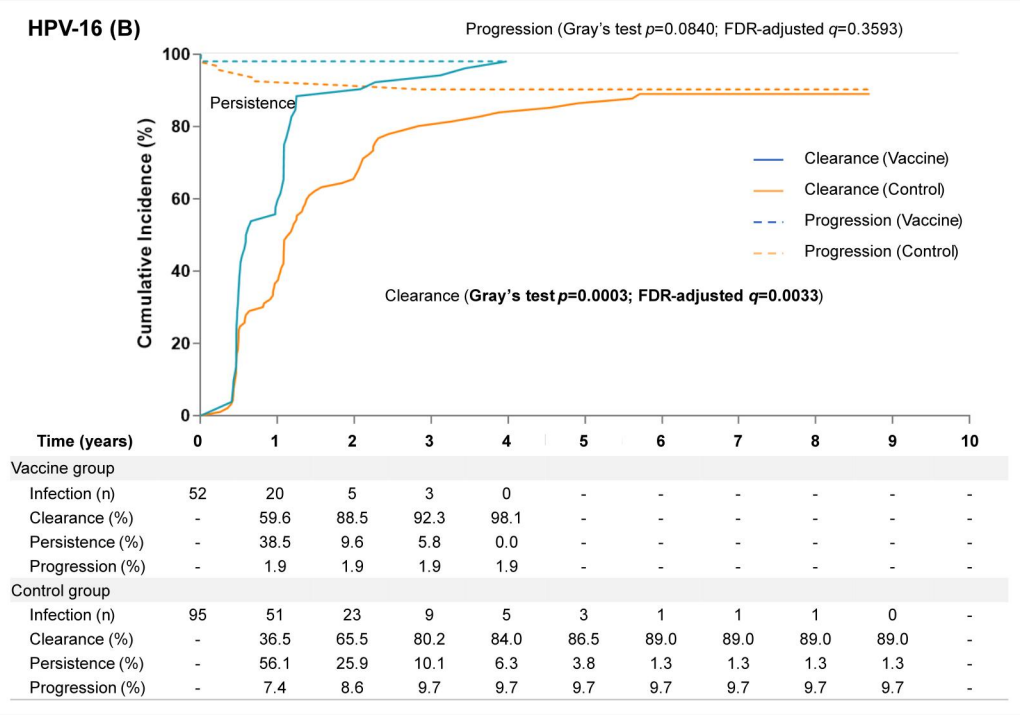
A HPV-16/18; **B** HPV-52; **C** HPV-31/33/45;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 5. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-16 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	92	39	10	5	2	1	1	0	-	-	-
Clearance (%)	-	55.4	87.0	92.4	95.7	95.7	95.7	97.8	-	-	-
Persistence (%)	-	42.4	10.8	5.4	2.1	2.1	2.1	0.0	-	-	-
Progression (%)	-	2.2	2.2	2.2	2.2	2.2	2.2	2.2	-	-	-
Control group											
Infection (n)	176	98	44	19	13	6	2	2	2	1	0
Clearance (%)	-	35.1	64.6	79.0	82.4	86.1	88.2	88.2	88.2	88.2	90.5
Persistence (%)	-	58.2	27.2	12.2	8.8	4.4	2.3	2.3	2.3	2.3	0.0
Progression (%)	-	6.7	8.2	8.8	8.8	9.5	9.5	9.5	9.5	9.5	9.5



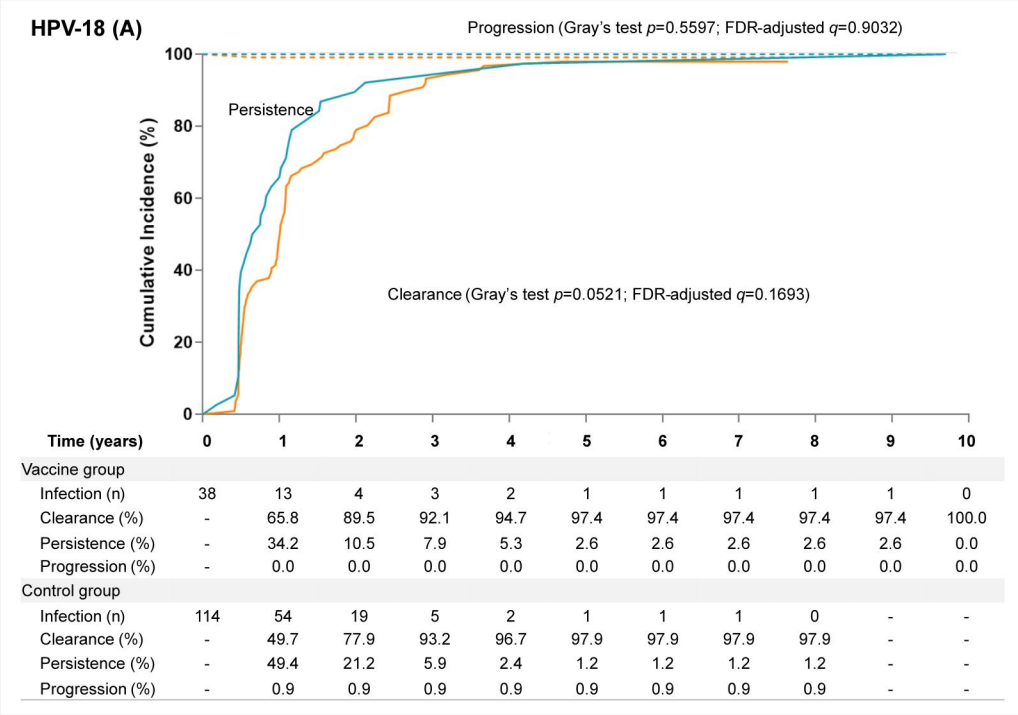
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	52	20	5	3	0	-	-	-	-	-	-
Clearance (%)	-	59.6	88.5	92.3	98.1	-	-	-	-	-	-
Persistence (%)	-	38.5	9.6	5.8	0.0	-	-	-	-	-	-
Progression (%)	-	1.9	1.9	1.9	1.9	-	-	-	-	-	-
Control group											
Infection (n)	95	51	23	9	5	3	1	1	1	0	-
Clearance (%)	-	36.5	65.5	80.2	84.0	86.5	89.0	89.0	89.0	89.0	-
Persistence (%)	-	56.1	25.9	10.1	6.3	3.8	1.3	1.3	1.3	1.3	-
Progression (%)	-	7.4	8.6	9.7	9.7	9.7	9.7	9.7	9.7	9.7	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

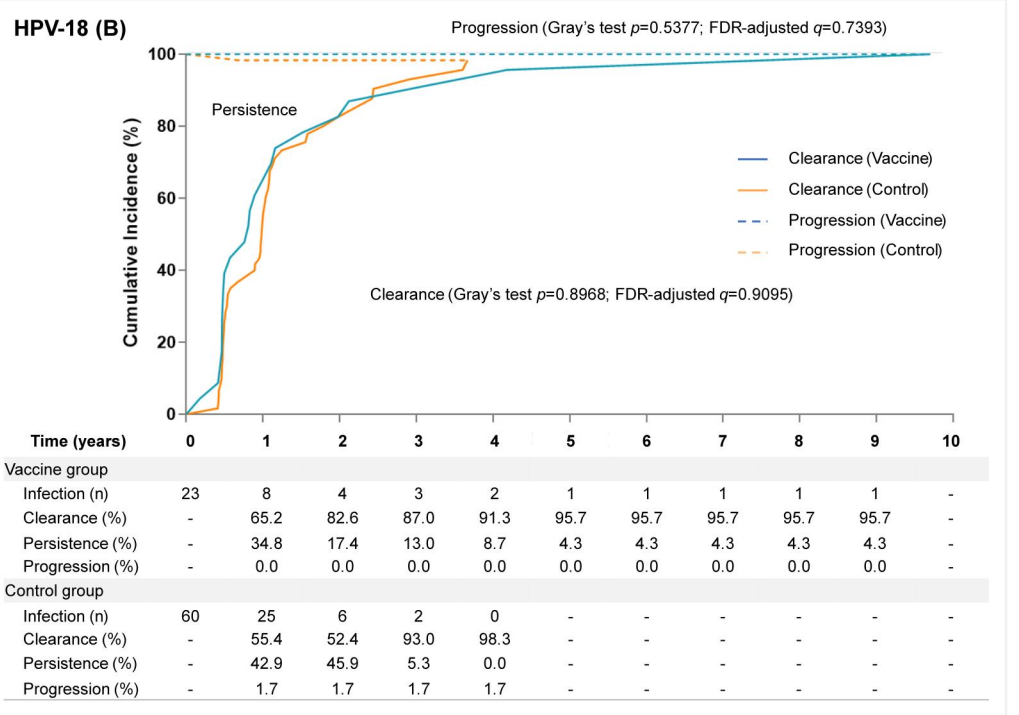
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 6. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-18 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	38	13	4	3	2	1	1	1	1	1	0
Clearance (%)	-	65.8	89.5	92.1	94.7	97.4	97.4	97.4	97.4	97.4	100.0
Persistence (%)	-	34.2	10.5	7.9	5.3	2.6	2.6	2.6	2.6	2.6	0.0
Progression (%)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Control group											
Infection (n)	114	54	19	5	2	1	1	1	0	-	-
Clearance (%)	-	49.7	77.9	93.2	96.7	97.9	97.9	97.9	97.9	-	-
Persistence (%)	-	49.4	21.2	5.9	2.4	1.2	1.2	1.2	1.2	-	-
Progression (%)	-	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	-	-



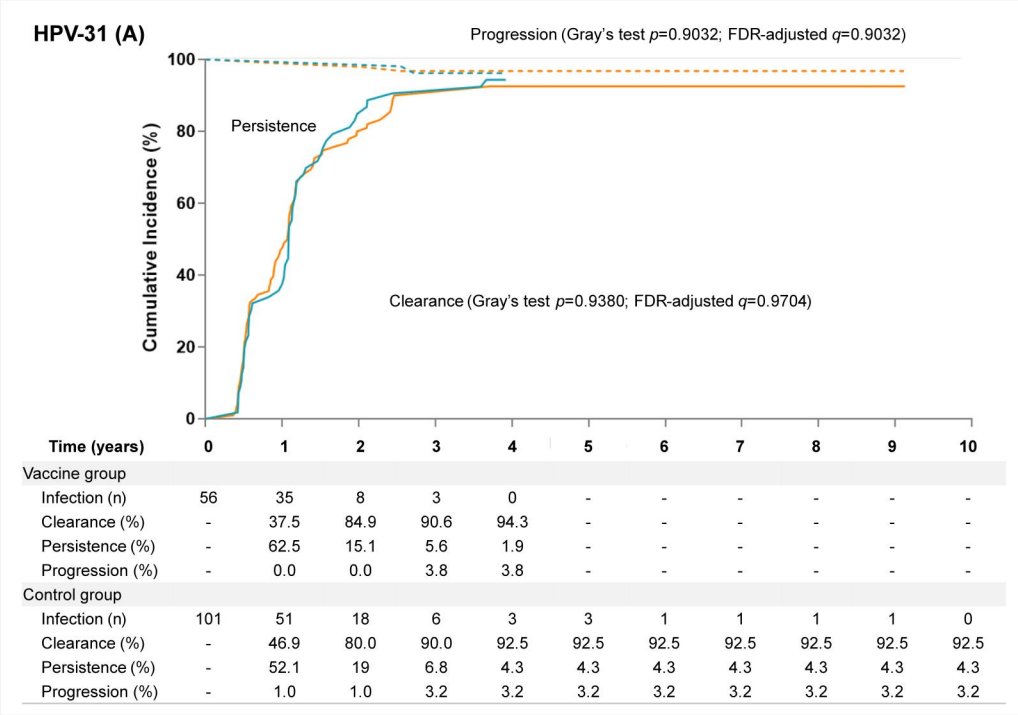
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	23	8	4	3	2	1	1	1	1	1	-
Clearance (%)	-	65.2	82.6	87.0	91.3	95.7	95.7	95.7	95.7	95.7	-
Persistence (%)	-	34.8	17.4	13.0	8.7	4.3	4.3	4.3	4.3	4.3	-
Progression (%)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Control group											
Infection (n)	60	25	6	2	0	-	-	-	-	-	-
Clearance (%)	-	55.4	52.4	93.0	98.3	-	-	-	-	-	-
Persistence (%)	-	42.9	45.9	5.3	0.0	-	-	-	-	-	-
Progression (%)	-	1.7	1.7	1.7	1.7	-	-	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

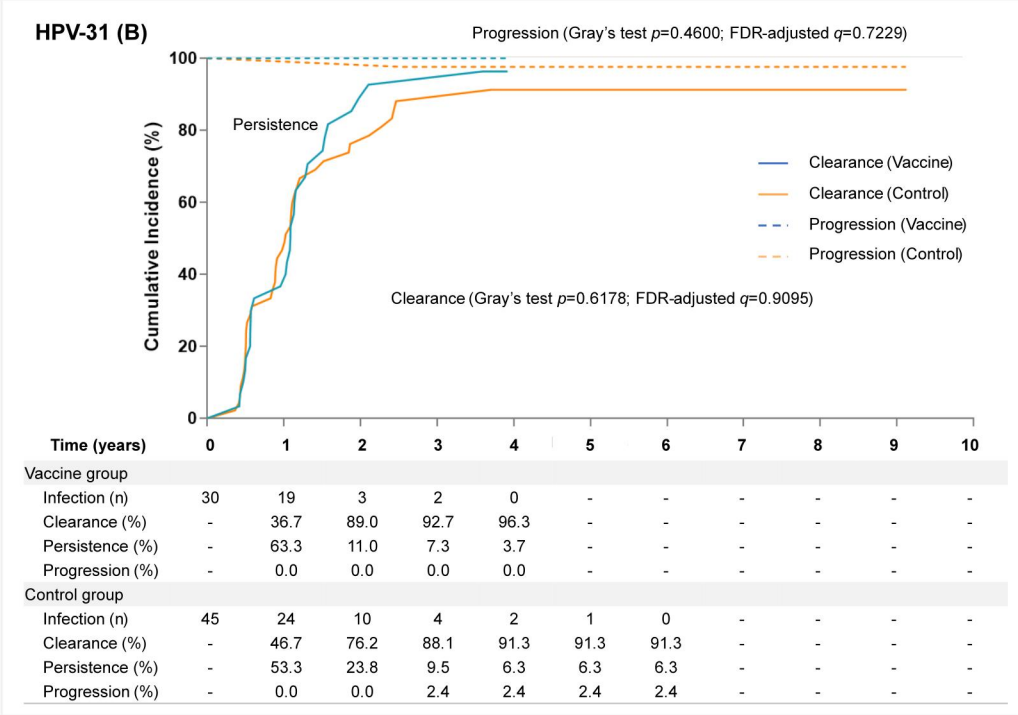
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 7. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-31 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	56	35	8	3	0	-	-	-	-	-	-
Clearance (%)	-	37.5	84.9	90.6	94.3	-	-	-	-	-	-
Persistence (%)	-	62.5	15.1	5.6	1.9	-	-	-	-	-	-
Progression (%)	-	0.0	0.0	3.8	3.8	-	-	-	-	-	-
Control group											
Infection (n)	101	51	18	6	3	3	1	1	1	1	0
Clearance (%)	-	46.9	80.0	90.0	92.5	92.5	92.5	92.5	92.5	92.5	92.5
Persistence (%)	-	52.1	19	6.8	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Progression (%)	-	1.0	1.0	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2



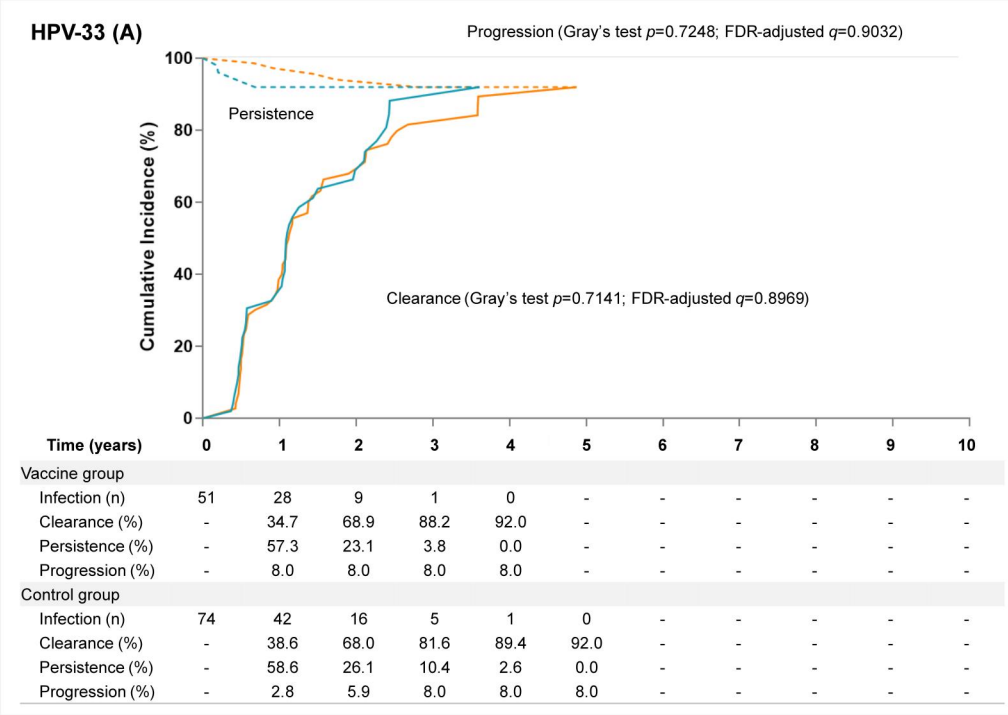
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	30	19	3	2	0	-	-	-	-	-	-
Clearance (%)	-	36.7	89.0	92.7	96.3	-	-	-	-	-	-
Persistence (%)	-	63.3	11.0	7.3	3.7	-	-	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Control group											
Infection (n)	45	24	10	4	2	1	0	-	-	-	-
Clearance (%)	-	46.7	76.2	88.1	91.3	91.3	91.3	-	-	-	-
Persistence (%)	-	53.3	23.8	9.5	6.3	6.3	6.3	-	-	-	-
Progression (%)	-	0.0	0.0	2.4	2.4	2.4	2.4	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

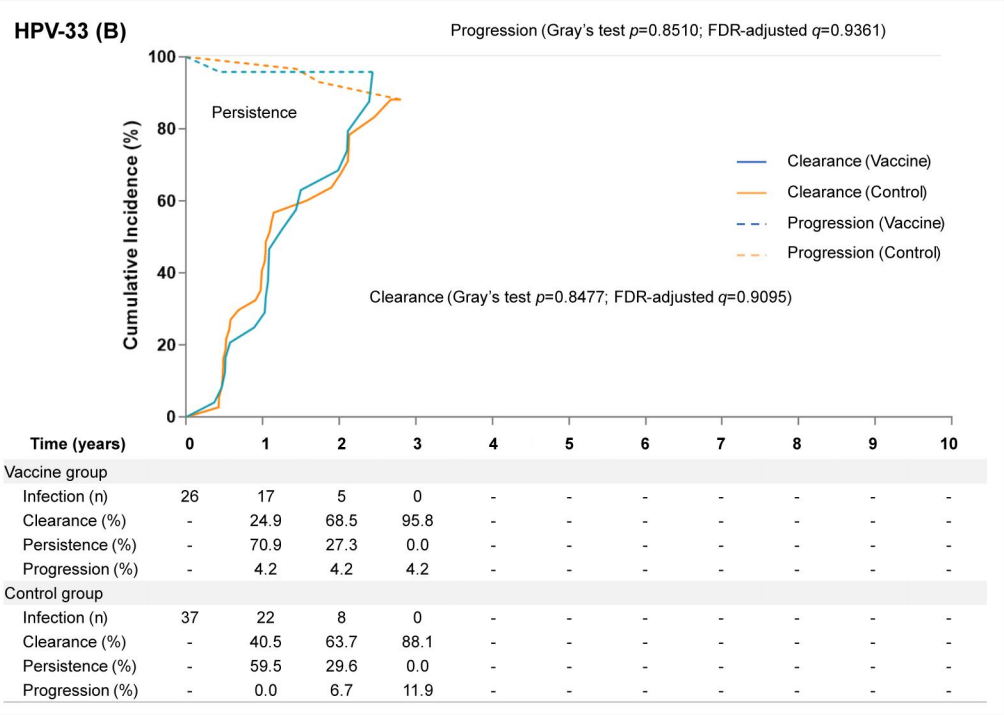
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 8. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-33 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	51	28	9	1	0	-	-	-	-	-	-
Clearance (%)	-	34.7	68.9	88.2	92.0	-	-	-	-	-	-
Persistence (%)	-	57.3	23.1	3.8	0.0	-	-	-	-	-	-
Progression (%)	-	8.0	8.0	8.0	8.0	-	-	-	-	-	-
Control group											
Infection (n)	74	42	16	5	1	0	-	-	-	-	-
Clearance (%)	-	38.6	68.0	81.6	89.4	92.0	-	-	-	-	-
Persistence (%)	-	58.6	26.1	10.4	2.6	0.0	-	-	-	-	-
Progression (%)	-	2.8	5.9	8.0	8.0	8.0	-	-	-	-	-



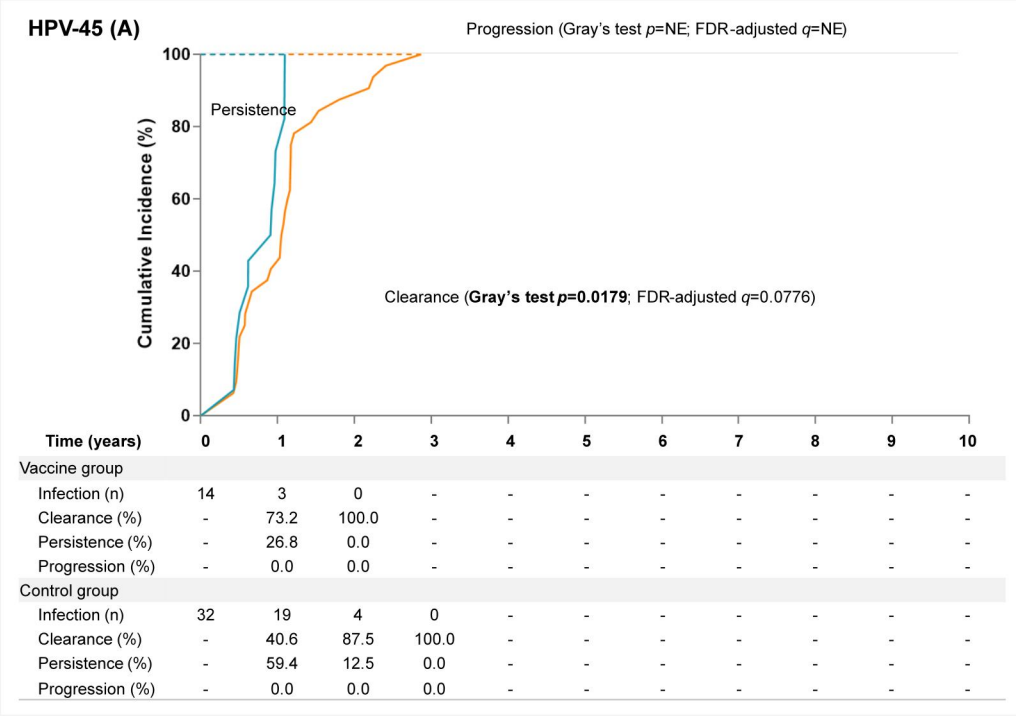
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	26	17	5	0	-	-	-	-	-	-	-
Clearance (%)	-	24.9	68.5	95.8	-	-	-	-	-	-	-
Persistence (%)	-	70.9	27.3	0.0	-	-	-	-	-	-	-
Progression (%)	-	4.2	4.2	4.2	-	-	-	-	-	-	-
Control group											
Infection (n)	37	22	8	0	-	-	-	-	-	-	-
Clearance (%)	-	40.5	63.7	88.1	-	-	-	-	-	-	-
Persistence (%)	-	59.5	29.6	0.0	-	-	-	-	-	-	-
Progression (%)	-	0.0	6.7	11.9	-	-	-	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

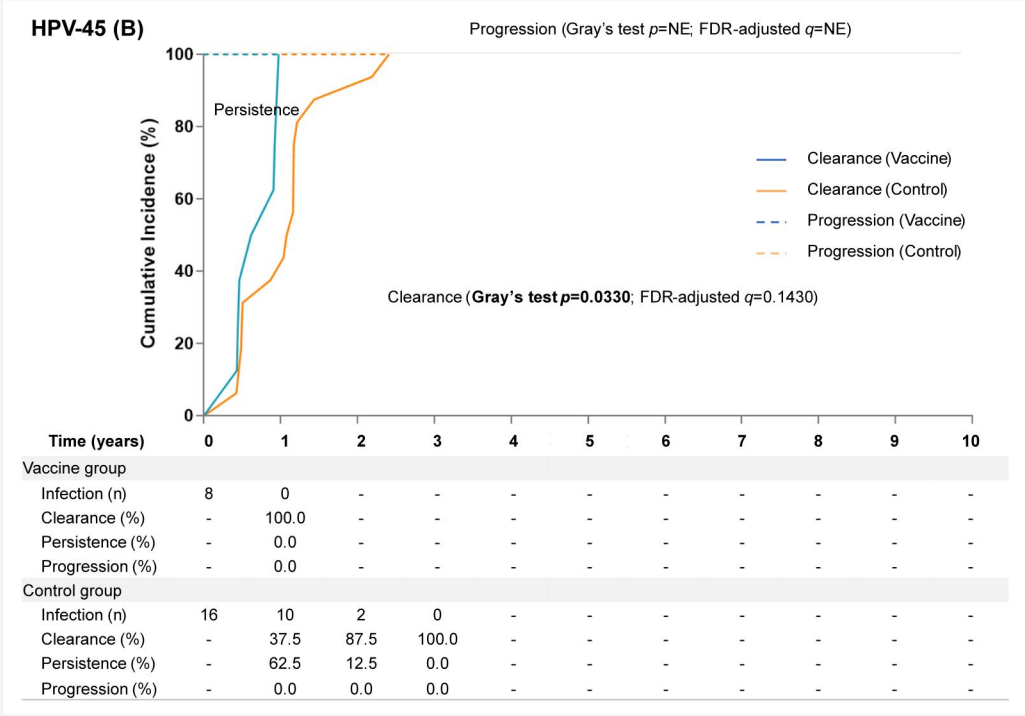
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 9. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-45 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	14	3	0	-	-	-	-	-	-	-	-
Clearance (%)	-	73.2	100.0	-	-	-	-	-	-	-	-
Persistence (%)	-	26.8	0.0	-	-	-	-	-	-	-	-
Progression (%)	-	0.0	0.0	-	-	-	-	-	-	-	-
Control group											
Infection (n)	32	19	4	0	-	-	-	-	-	-	-
Clearance (%)	-	40.6	87.5	100.0	-	-	-	-	-	-	-
Persistence (%)	-	59.4	12.5	0.0	-	-	-	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	-	-	-	-	-	-	-



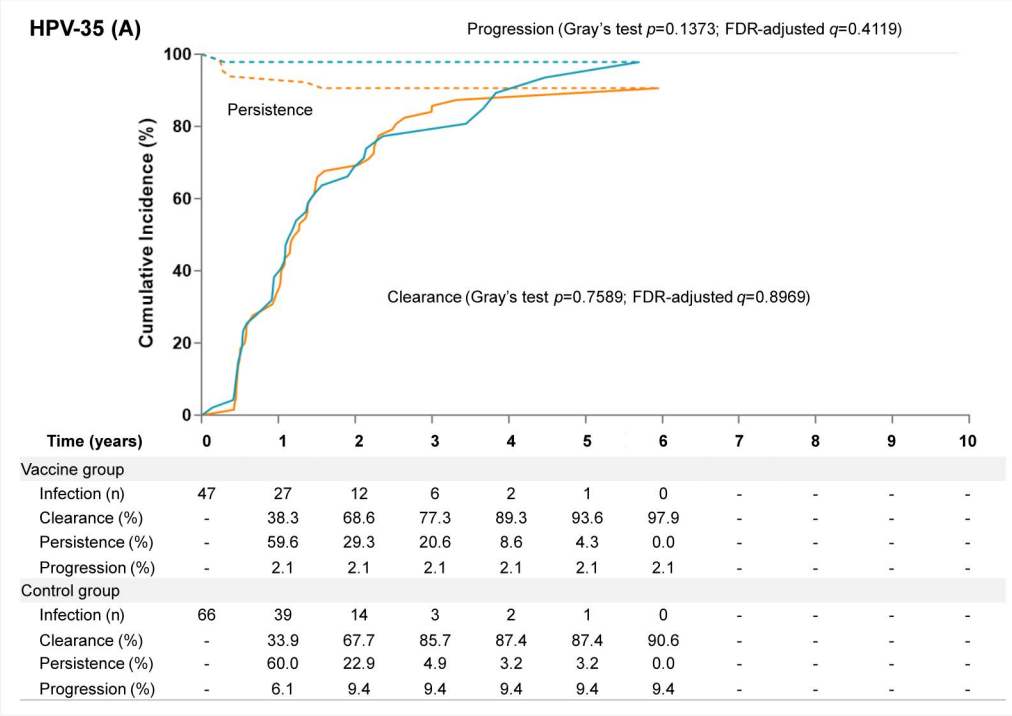
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	8	0	-	-	-	-	-	-	-	-	-
Clearance (%)	-	100.0	-	-	-	-	-	-	-	-	-
Persistence (%)	-	0.0	-	-	-	-	-	-	-	-	-
Progression (%)	-	0.0	-	-	-	-	-	-	-	-	-
Control group											
Infection (n)	16	10	2	0	-	-	-	-	-	-	-
Clearance (%)	-	37.5	87.5	100.0	-	-	-	-	-	-	-
Persistence (%)	-	62.5	12.5	0.0	-	-	-	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	-	-	-	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

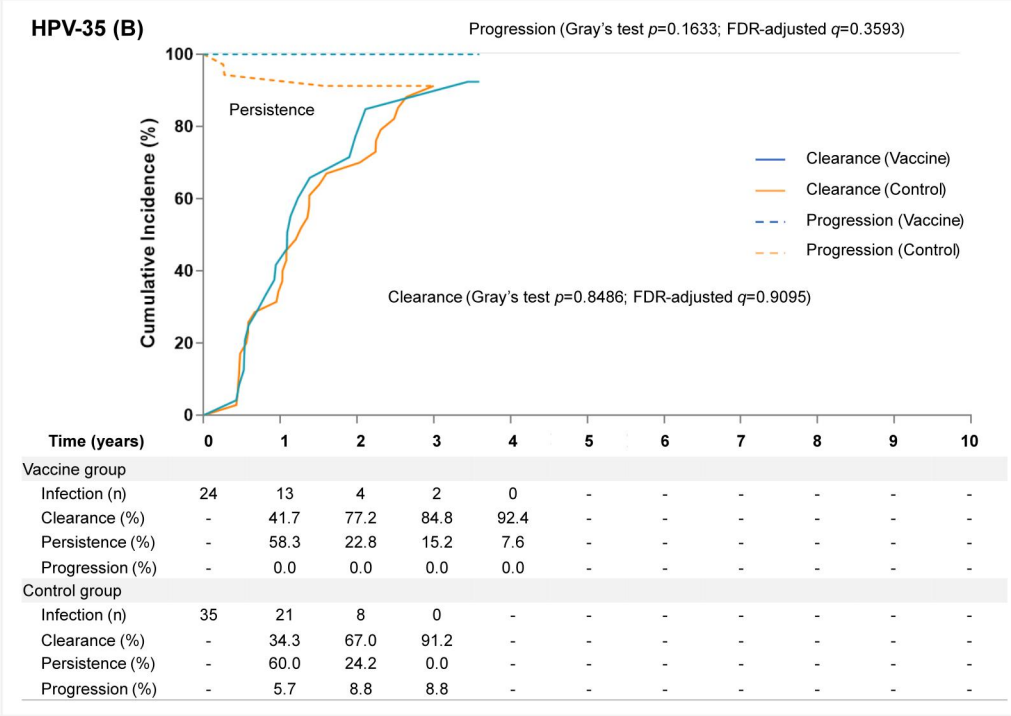
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 10. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-35 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	47	27	12	6	2	1	0	-	-	-	-
Clearance (%)	-	38.3	68.6	77.3	89.3	93.6	97.9	-	-	-	-
Persistence (%)	-	59.6	29.3	20.6	8.6	4.3	0.0	-	-	-	-
Progression (%)	-	2.1	2.1	2.1	2.1	2.1	2.1	-	-	-	-
Control group											
Infection (n)	66	39	14	3	2	1	0	-	-	-	-
Clearance (%)	-	33.9	67.7	85.7	87.4	87.4	90.6	-	-	-	-
Persistence (%)	-	60.0	22.9	4.9	3.2	3.2	0.0	-	-	-	-
Progression (%)	-	6.1	9.4	9.4	9.4	9.4	9.4	-	-	-	-



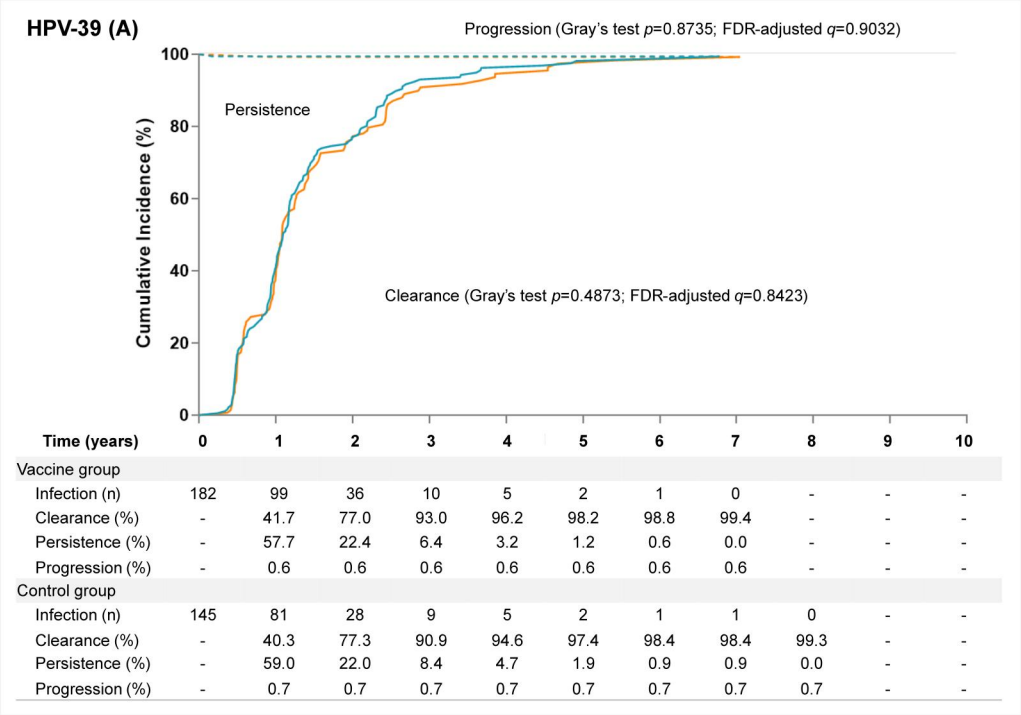
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	24	13	4	2	0	-	-	-	-	-	-
Clearance (%)	-	41.7	77.2	84.8	92.4	-	-	-	-	-	-
Persistence (%)	-	58.3	22.8	15.2	7.6	-	-	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Control group											
Infection (n)	35	21	8	0	-	-	-	-	-	-	-
Clearance (%)	-	34.3	67.0	91.2	-	-	-	-	-	-	-
Persistence (%)	-	60.0	24.2	0.0	-	-	-	-	-	-	-
Progression (%)	-	5.7	8.8	8.8	-	-	-	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

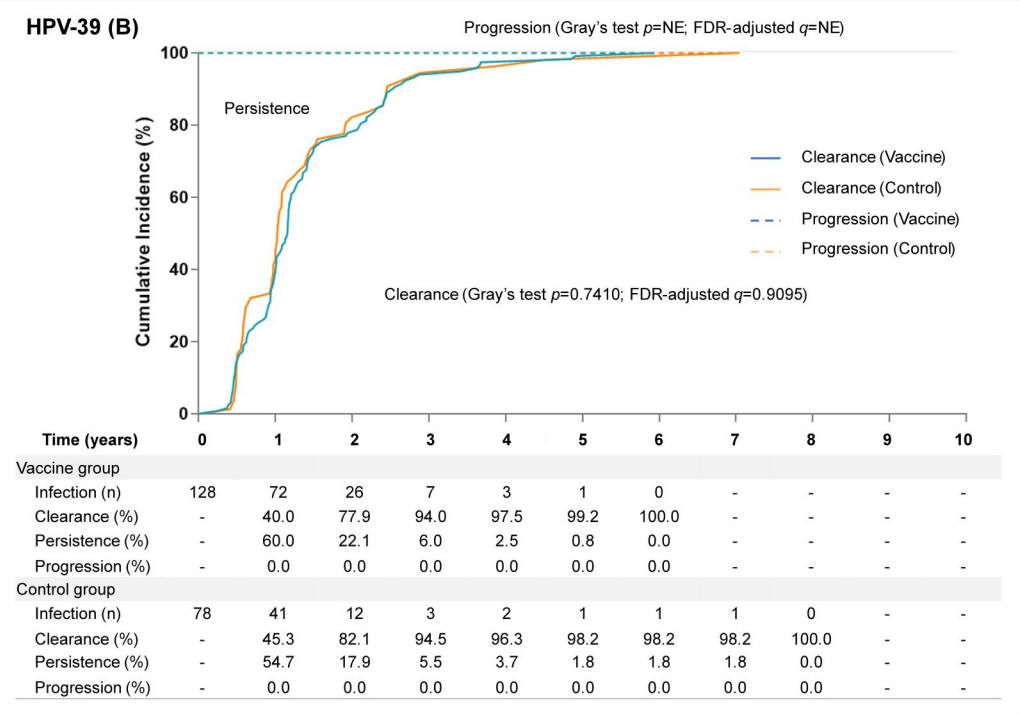
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 11. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-39 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	182	99	36	10	5	2	1	0	-	-	-
Clearance (%)	-	41.7	77.0	93.0	96.2	98.2	98.8	99.4	-	-	-
Persistence (%)	-	57.7	22.4	6.4	3.2	1.2	0.6	0.0	-	-	-
Progression (%)	-	0.6	0.6	0.6	0.6	0.6	0.6	0.6	-	-	-
Control group											
Infection (n)	145	81	28	9	5	2	1	1	0	-	-
Clearance (%)	-	40.3	77.3	90.9	94.6	97.4	98.4	98.4	99.3	-	-
Persistence (%)	-	59.0	22.0	8.4	4.7	1.9	0.9	0.9	0.0	-	-
Progression (%)	-	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	-	-



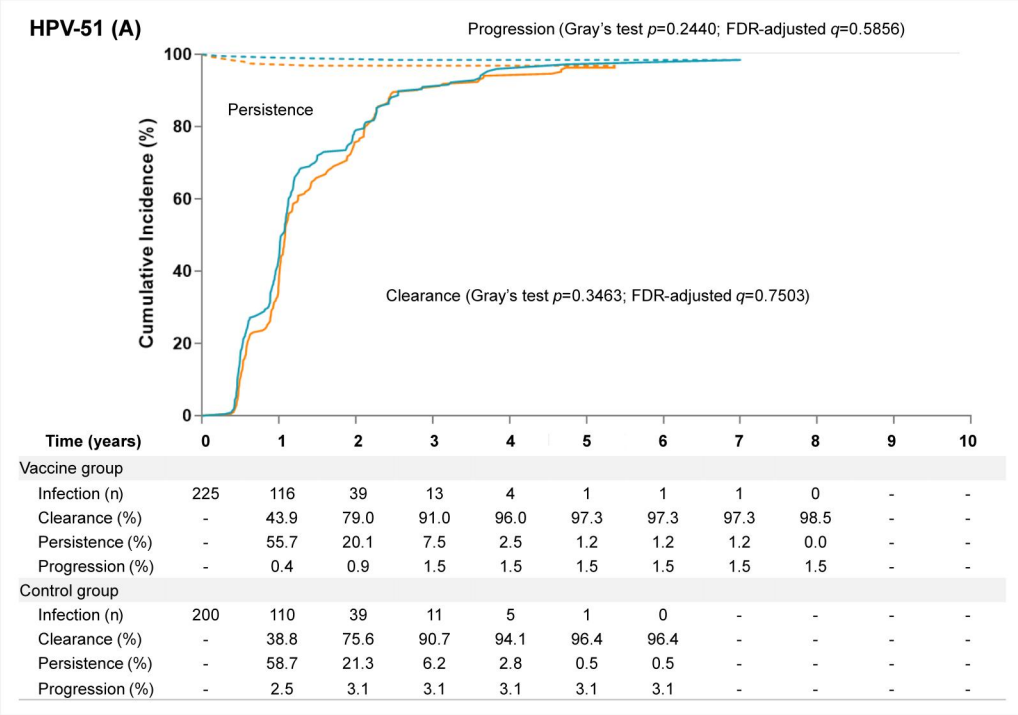
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	128	72	26	7	3	1	0	-	-	-	-
Clearance (%)	-	40.0	77.9	94.0	97.5	99.2	100.0	-	-	-	-
Persistence (%)	-	60.0	22.1	6.0	2.5	0.8	0.0	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-
Control group											
Infection (n)	78	41	12	3	2	1	1	1	0	-	-
Clearance (%)	-	45.3	82.1	94.5	96.3	98.2	98.2	98.2	100.0	-	-
Persistence (%)	-	54.7	17.9	5.5	3.7	1.8	1.8	1.8	0.0	-	-
Progression (%)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

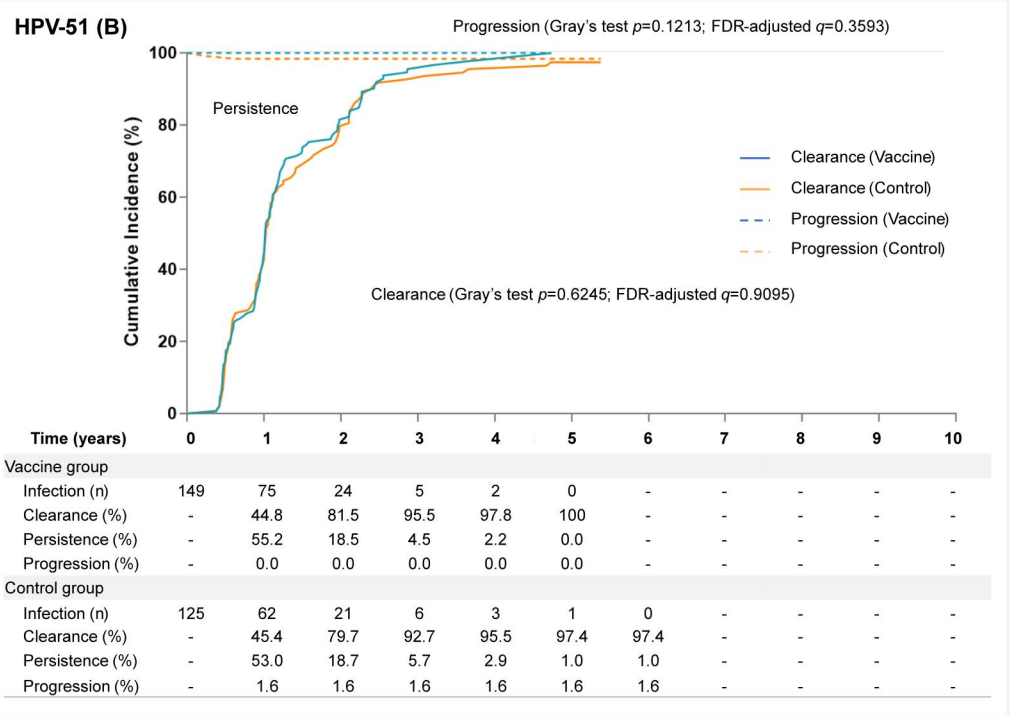
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 12. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-51 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	225	116	39	13	4	1	1	1	0	-	-
Clearance (%)	-	43.9	79.0	91.0	96.0	97.3	97.3	97.3	98.5	-	-
Persistence (%)	-	55.7	20.1	7.5	2.5	1.2	1.2	1.2	0.0	-	-
Progression (%)	-	0.4	0.9	1.5	1.5	1.5	1.5	1.5	1.5	-	-
Control group											
Infection (n)	200	110	39	11	5	1	0	-	-	-	-
Clearance (%)	-	38.8	75.6	90.7	94.1	96.4	96.4	-	-	-	-
Persistence (%)	-	58.7	21.3	6.2	2.8	0.5	0.5	-	-	-	-
Progression (%)	-	2.5	3.1	3.1	3.1	3.1	3.1	-	-	-	-



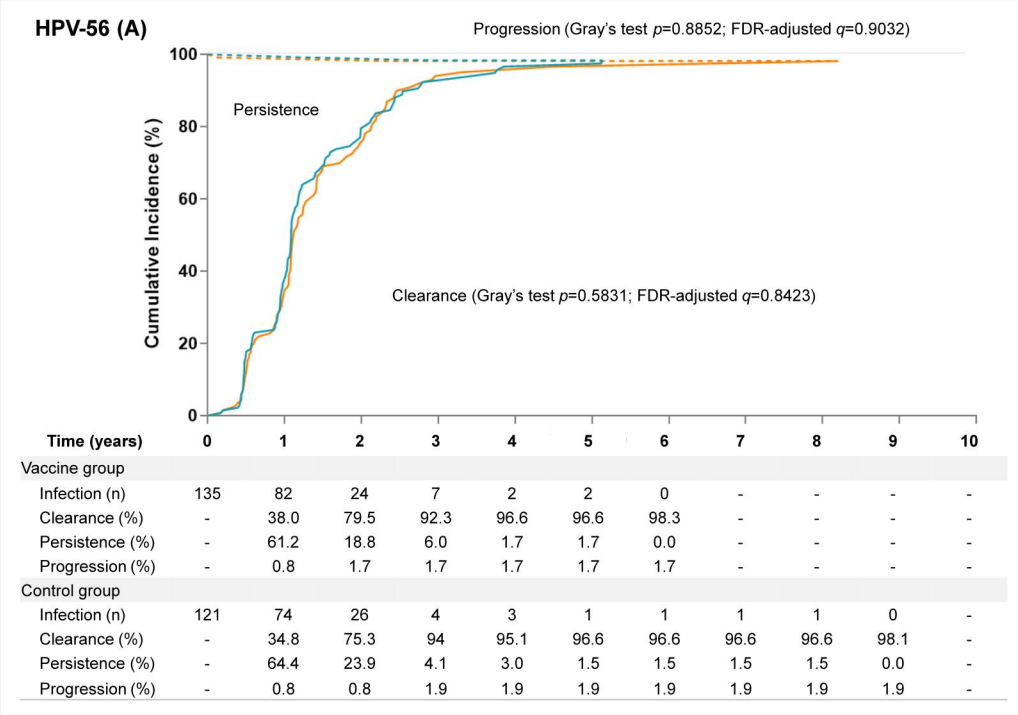
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	149	75	24	5	2	0	-	-	-	-	-
Clearance (%)	-	44.8	81.5	95.5	97.8	100	-	-	-	-	-
Persistence (%)	-	55.2	18.5	4.5	2.2	0.0	-	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-
Control group											
Infection (n)	125	62	21	6	3	1	0	-	-	-	-
Clearance (%)	-	45.4	79.7	92.7	95.5	97.4	97.4	-	-	-	-
Persistence (%)	-	53.0	18.7	5.7	2.9	1.0	1.0	-	-	-	-
Progression (%)	-	1.6	1.6	1.6	1.6	1.6	1.6	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

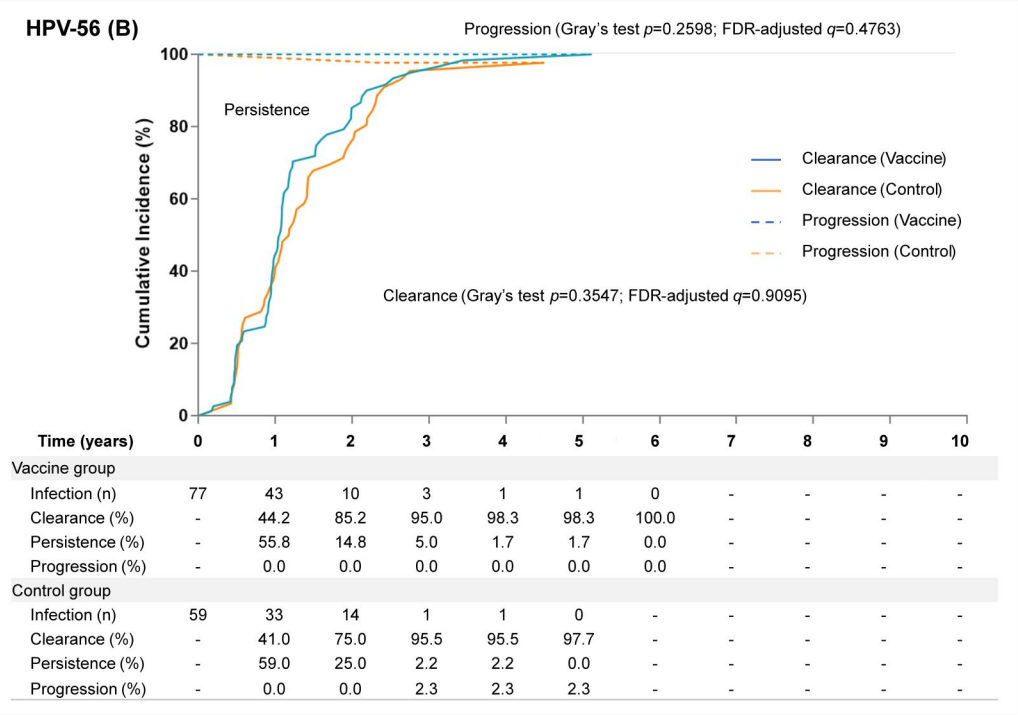
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 13. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-56 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	135	82	24	7	2	2	0	-	-	-	-
Clearance (%)	-	38.0	79.5	92.3	96.6	96.6	98.3	-	-	-	-
Persistence (%)	-	61.2	18.8	6.0	1.7	1.7	0.0	-	-	-	-
Progression (%)	-	0.8	1.7	1.7	1.7	1.7	1.7	-	-	-	-
Control group											
Infection (n)	121	74	26	4	3	1	1	1	1	0	-
Clearance (%)	-	34.8	75.3	94	95.1	96.6	96.6	96.6	96.6	98.1	-
Persistence (%)	-	64.4	23.9	4.1	3.0	1.5	1.5	1.5	1.5	0.0	-
Progression (%)	-	0.8	0.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	-



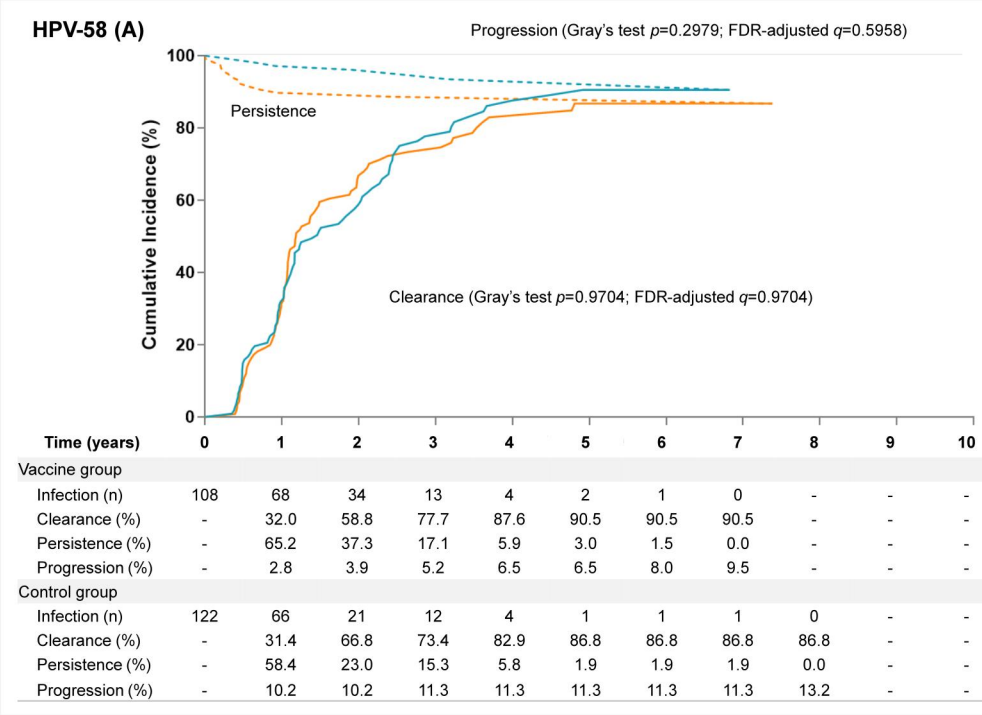
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	77	43	10	3	1	1	0	-	-	-	-
Clearance (%)	-	44.2	85.2	95.0	98.3	98.3	100.0	-	-	-	-
Persistence (%)	-	55.8	14.8	5.0	1.7	1.7	0.0	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-
Control group											
Infection (n)	59	33	14	1	1	0	-	-	-	-	-
Clearance (%)	-	41.0	75.0	95.5	95.5	97.7	-	-	-	-	-
Persistence (%)	-	59.0	25.0	2.2	2.2	0.0	-	-	-	-	-
Progression (%)	-	0.0	0.0	2.3	2.3	2.3	-	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

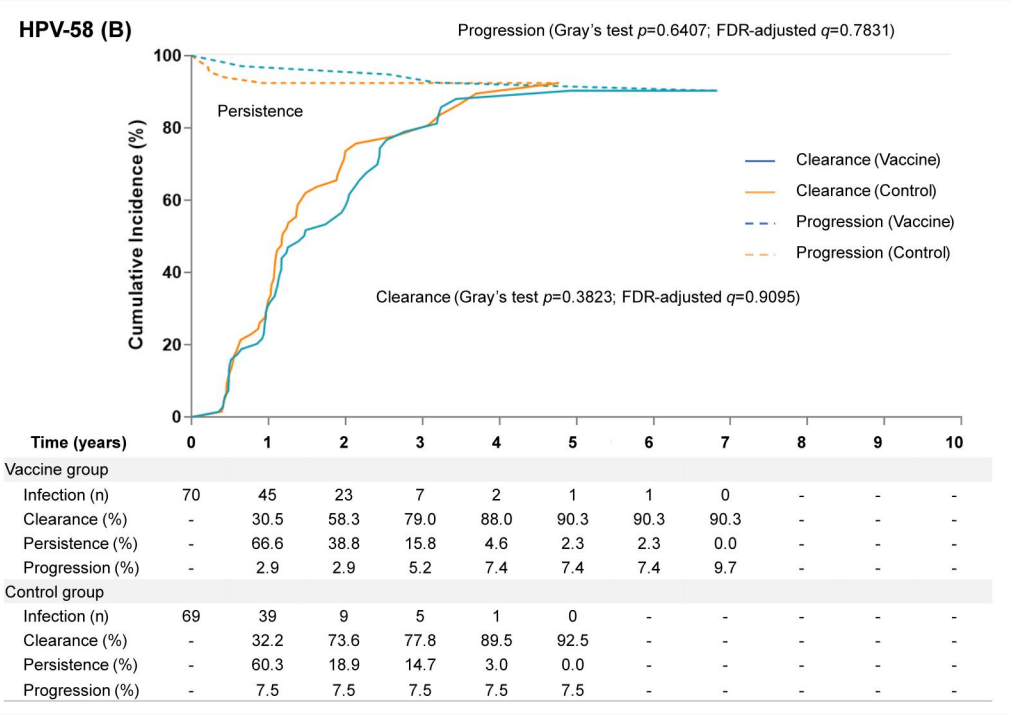
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 14. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-58 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	108	68	34	13	4	2	1	0	-	-	-
Clearance (%)	-	32.0	58.8	77.7	87.6	90.5	90.5	90.5	-	-	-
Persistence (%)	-	65.2	37.3	17.1	5.9	3.0	1.5	0.0	-	-	-
Progression (%)	-	2.8	3.9	5.2	6.5	6.5	8.0	9.5	-	-	-
Control group											
Infection (n)	122	66	21	12	4	1	1	1	0	-	-
Clearance (%)	-	31.4	66.8	73.4	82.9	86.8	86.8	86.8	86.8	-	-
Persistence (%)	-	58.4	23.0	15.3	5.8	1.9	1.9	1.9	0.0	-	-
Progression (%)	-	10.2	10.2	11.3	11.3	11.3	11.3	11.3	13.2	-	-



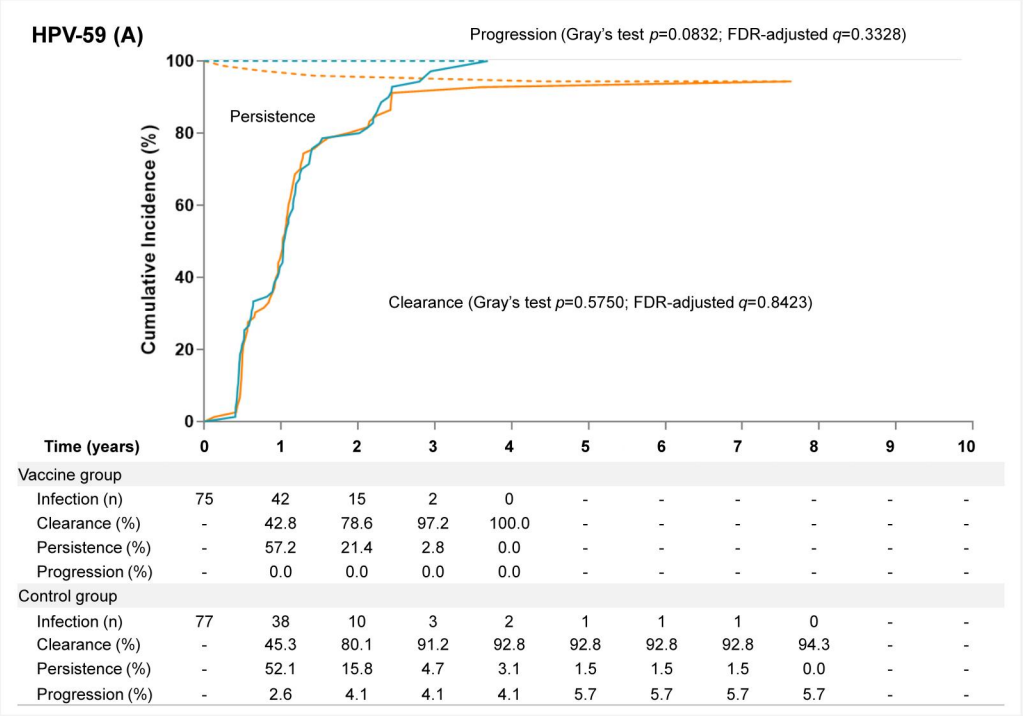
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	70	45	23	7	2	1	1	0	-	-	-
Clearance (%)	-	30.5	58.3	79.0	88.0	90.3	90.3	90.3	-	-	-
Persistence (%)	-	66.6	38.8	15.8	4.6	2.3	2.3	0.0	-	-	-
Progression (%)	-	2.9	2.9	5.2	7.4	7.4	7.4	9.7	-	-	-
Control group											
Infection (n)	69	39	9	5	1	0	-	-	-	-	-
Clearance (%)	-	32.2	73.6	77.8	89.5	92.5	-	-	-	-	-
Persistence (%)	-	60.3	18.9	14.7	3.0	0.0	-	-	-	-	-
Progression (%)	-	7.5	7.5	7.5	7.5	7.5	-	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

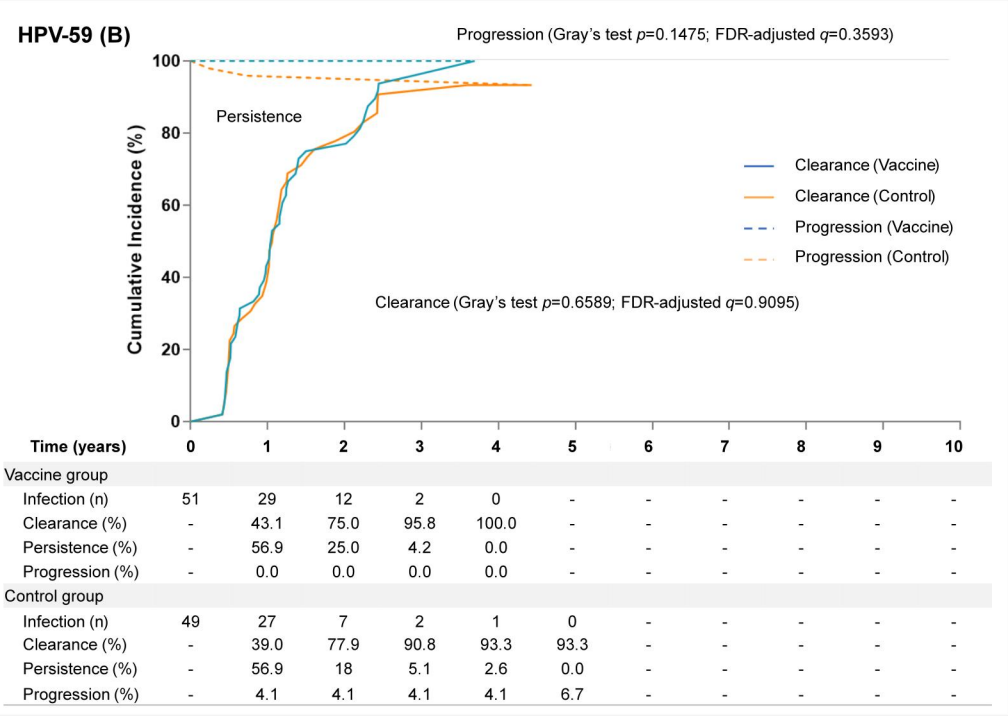
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 15. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-59 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	75	42	15	2	0	-	-	-	-	-	-
Clearance (%)	-	42.8	78.6	97.2	100.0	-	-	-	-	-	-
Persistence (%)	-	57.2	21.4	2.8	0.0	-	-	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Control group											
Infection (n)	77	38	10	3	2	1	1	1	0	-	-
Clearance (%)	-	45.3	80.1	91.2	92.8	92.8	92.8	92.8	94.3	-	-
Persistence (%)	-	52.1	15.8	4.7	3.1	1.5	1.5	1.5	0.0	-	-
Progression (%)	-	2.6	4.1	4.1	4.1	5.7	5.7	5.7	5.7	-	-



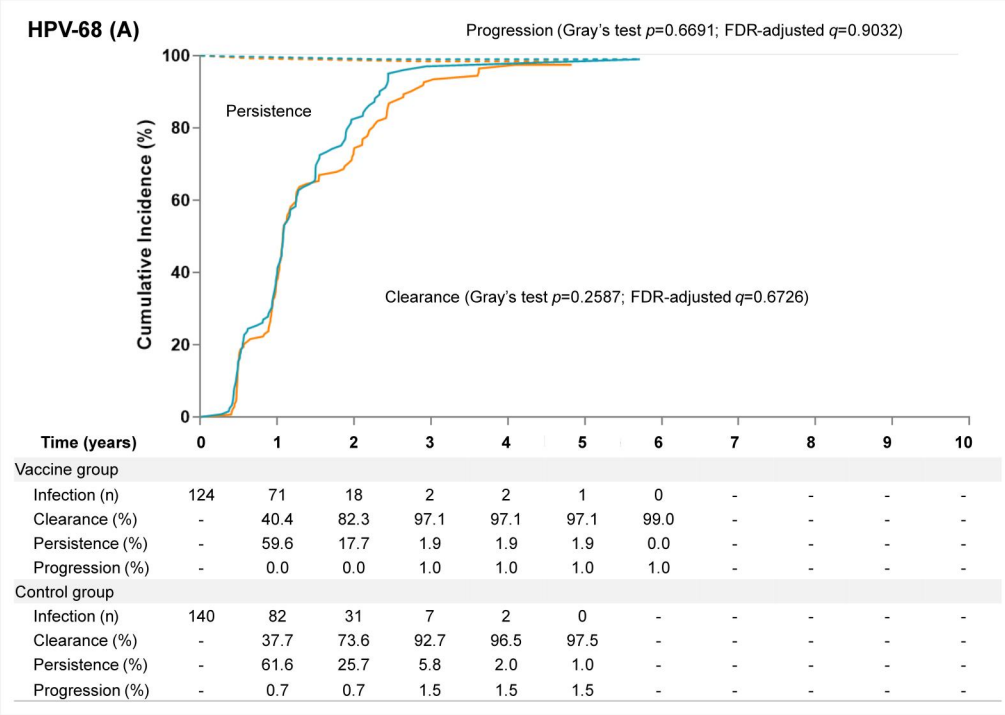
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	51	29	12	2	0	-	-	-	-	-	-
Clearance (%)	-	43.1	75.0	95.8	100.0	-	-	-	-	-	-
Persistence (%)	-	56.9	25.0	4.2	0.0	-	-	-	-	-	-
Progression (%)	-	0.0	0.0	0.0	0.0	-	-	-	-	-	-
Control group											
Infection (n)	49	27	7	2	1	0	-	-	-	-	-
Clearance (%)	-	39.0	77.9	90.8	93.3	93.3	-	-	-	-	-
Persistence (%)	-	56.9	18	5.1	2.6	0.0	-	-	-	-	-
Progression (%)	-	4.1	4.1	4.1	4.1	6.7	-	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

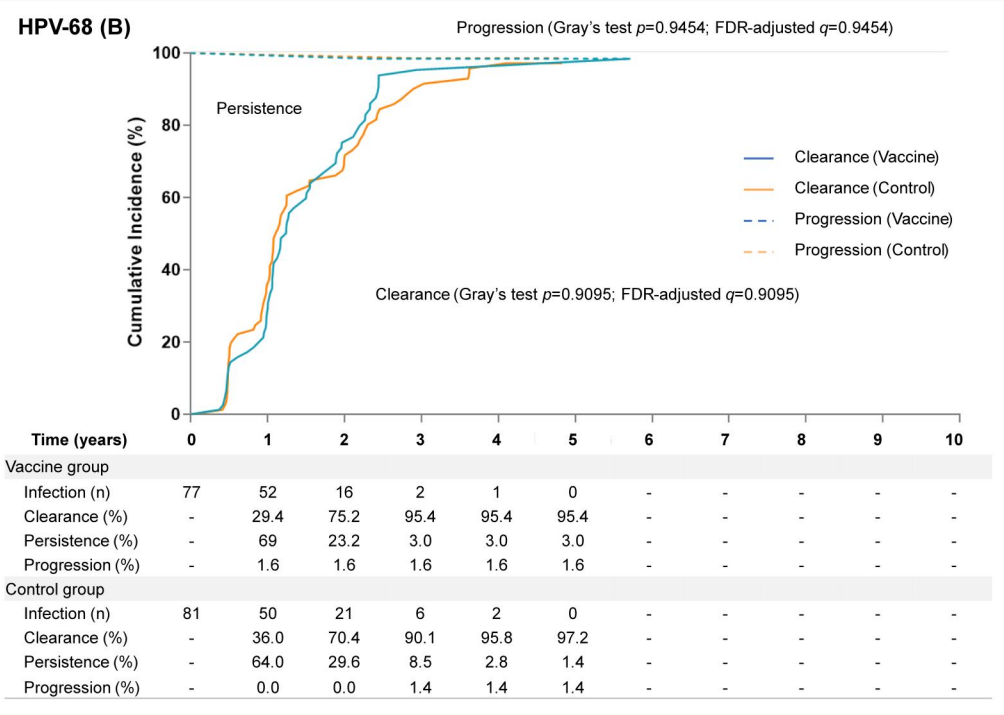
A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 16. Competing cumulative risks of clearance, progression (to CIN2+), and persistence of HPV-68 infections in the vaccine group and the control group



Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	124	71	18	2	2	1	0	-	-	-	-
Clearance (%)	-	40.4	82.3	97.1	97.1	97.1	99.0	-	-	-	-
Persistence (%)	-	59.6	17.7	1.9	1.9	1.9	0.0	-	-	-	-
Progression (%)	-	0.0	0.0	1.0	1.0	1.0	1.0	-	-	-	-
Control group											
Infection (n)	140	82	31	7	2	0	-	-	-	-	-
Clearance (%)	-	37.7	73.6	92.7	96.5	97.5	-	-	-	-	-
Persistence (%)	-	61.6	25.7	5.8	2.0	1.0	-	-	-	-	-
Progression (%)	-	0.7	0.7	1.5	1.5	1.5	-	-	-	-	-



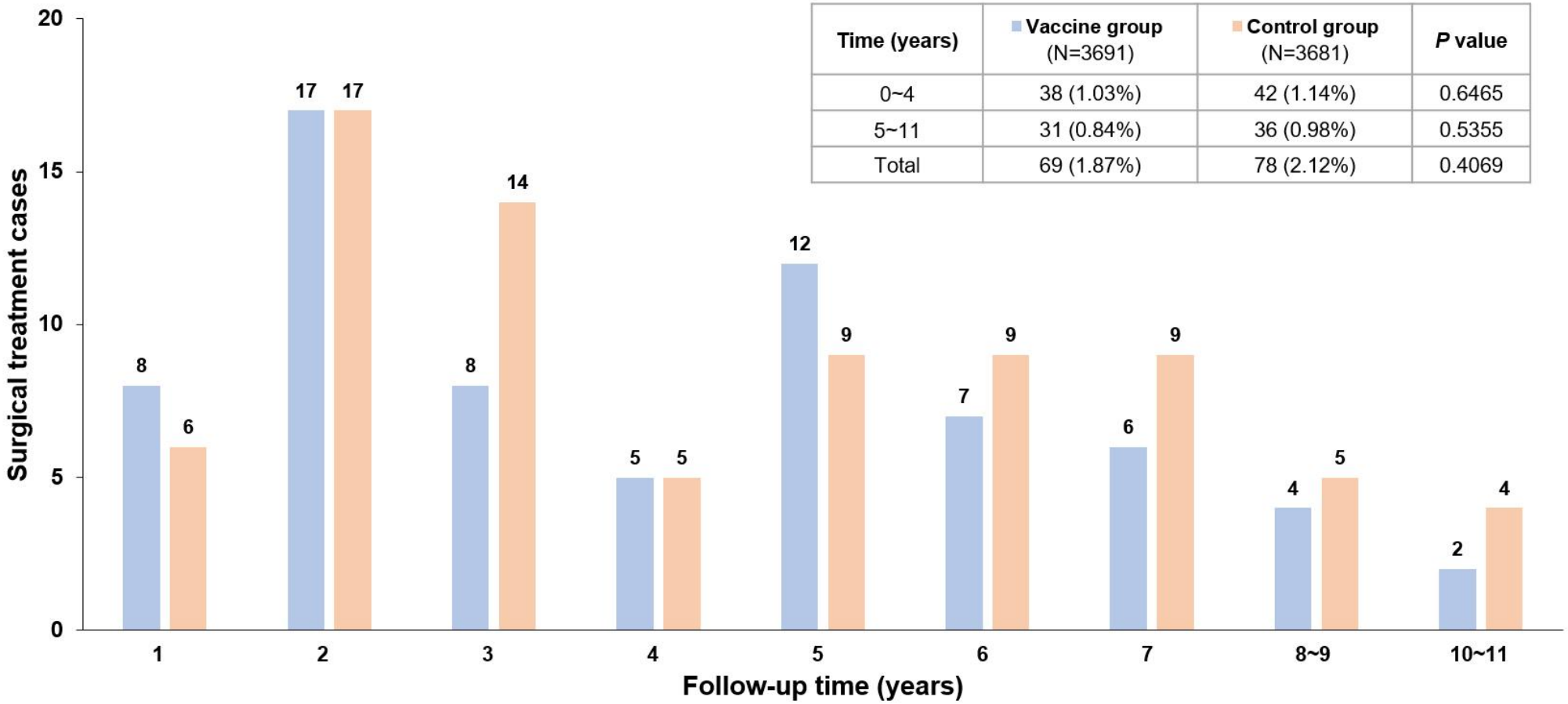
Time (years)	0	1	2	3	4	5	6	7	8	9	10
Vaccine group											
Infection (n)	77	52	16	2	1	0	-	-	-	-	-
Clearance (%)	-	29.4	75.2	95.4	95.4	95.4	-	-	-	-	-
Persistence (%)	-	69	23.2	3.0	3.0	3.0	-	-	-	-	-
Progression (%)	-	1.6	1.6	1.6	1.6	1.6	-	-	-	-	-
Control group											
Infection (n)	81	50	21	6	2	0	-	-	-	-	-
Clearance (%)	-	36.0	70.4	90.1	95.8	97.2	-	-	-	-	-
Persistence (%)	-	64.0	29.6	8.5	2.8	1.4	-	-	-	-	-
Progression (%)	-	0.0	0.0	1.4	1.4	1.4	-	-	-	-	-

CIN2+, cervical intraepithelial neoplasia grade 2 or greater; HR-HPV, high-risk human papillomavirus; FDR, false discovery rate.

A Overall population; **B** Participants without multiple HR-HPV infections;

In competing risk analyses, the estimates for progression (to CIN2+), clearance, and persistence add up to 100% at each time point. A stratified Benjamini-Hochberg FDR procedure was used to adjust for multiple comparisons. All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.

Supplementary Figure 17. Temporal distributions of surgical treatment in the vaccine group and the control group



Time (years)	Vaccine group (N=3691)	Control group (N=3681)	*P* value
0~4	38 (1.03%)	42 (1.14%)	0.6465
5~11	31 (0.84%)	36 (0.98%)	0.5355
Total	69 (1.87%)	78 (2.12%)	0.4069

p values were determined using the chi-squared test or Fisher's exact test.
All statistical tests were two-sided, with a significance level of $\alpha = 0.05$.