THE LANCET Public Health

Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Brisson M, Bénard E, Drolet M, et al. Population-level impact, herd immunity, and elimination after human papillomavirus vaccination: a systematic review and meta-analysis of predictions from transmission-dynamic models. *Lancet Public Health* 2016; published online Sept 27. http://dx.doi.org/10.1016/S2468-2667(16)30001-9.

Table S1. Search strategy

Pubmed Search :

("models, theoretical"[mesh] OR "theoretical models"[tiab] OR "mathematical model"[tiab] OR "models, statistical" [mesh] OR "cost-benefit analysis"[mesh] OR "cost-effectiveness"[tiab] OR "risk-benefit analysis"[tiab]) AND ("papillomavirus vaccines"[mesh] OR "papillomavirus vaccination"[tiab] OR "human papillomavirus vaccine"[tiab] OR "HPV vaccine"[tiab] OR "HPV vaccination"[tiab]) NOT ("developing countries"[mesh] OR "Poverty"[Mesh] OR "HIV infections"[mesh] OR "HIV infections"[tiab] OR "HIV"[mesh] OR "Models, Animal"[mesh] OR "Patient Acceptance of Health Care"[Mesh] OR "health education"[mesh] OR "Clinical Trial" [Publication Type])

Embase Search :

'wart virus vaccine'/exp OR 'hpv vaccine':ti OR 'hpv vaccination':ti OR 'papillomavirus vaccine':ti OR 'papillomavirus vaccination':ti AND ('theoretical model'/exp OR 'computer simulation'/exp OR 'risk benefit analysis'/exp OR 'mathematical model'/exp OR 'cost effectiveness analysis'/exp OR 'cost benefit analysis'/exp) NOT ('parent counseling'/exp OR 'parent consent'/exp OR 'parent'/exp OR 'parental attitude'/exp OR 'human immunodeficiency virus infection'/exp OR 'health education'/exp OR 'attitude to health'/exp OR 'developing country'/exp OR 'low income country'/exp OR 'lowest income group'/exp OR 'nonhuman'/exp OR 'clinical study'/exp)

Table S2. Description of the 19 pre-determined HPV vaccination scenarios

	Vaccination coverage					
	0%	20%	40%	60%	80%	100%
NO VACCINATION	x					
BASE CASE *(vaccine efficacy=100% ; duration of vaccine protection=Life)*						
Girls-Only		x	x	x	x	x
Girls&Boys		x	x	x	x	x
SENSITIVITY ANALYSIS 1 *(vaccine efficacy=100% ; duration of vaccine protection=20 years)*						
Girls-Only			x		x	
Girls&Boys			x		x	
SENSITIVITY ANALYSIS 2 *(vaccine efficacy=90% ; duration of vaccine protection=Life)*						
Girls-Only			x		x	
Girls&Boys			x		x	

Table S3. Characteristics of the models included in the systematic review and meta-analysis

Corresponding Author (Country)	Model type	Model stratification (risk groups)	HPV types included	Partnership formation & dissolution	Transmission probability	Proportion that develop natural immunity & duration of natural immunity	Baseline HPV16 prevalence (15-24 yrs)	Model with cervical cancer	Vaccine efficacy (VE) parameters*†	Outcomes used for Model calibration
Baussano[1,2] (Italy)	Deterministic	Age, gender, sexual activity	Individual: 16, 18, 31, 33, 45, 52, 58, 35, 39, 51, 56, 59, 68	Instantaneous	Per partnership	Proportion: 24% (HPV16) 44% (HPV18) Duration: lifelong	W : 5·5% M : 5·4%	No	- Take - Waning of VE (function of age and time since vaccination)	- HPV prevalence
Bogaards[3-7] (Netherlands)	Deterministic transmission, otherwise individual-based	Age, gender, sexual activity	Individual: 16, 18, 31, 33, 45, 52, 58 and 7 other types	Instantaneous	Per partnership	Proportion: 100% Duration, mean : 24 yrs (HPV16) 34 yrs (HPV18)	W : 5·2% M : 2·0%	Yes	- Take - Waning of VE (protection for x yrs & abrupt end or constant rate)	- Sexual activity - HPV prevalence
Brisson[8-14] (Canada)	Stochastic and individual-based	Age, gender, sexual activity	Individual: 6, 11, 16, 18, 31, 33, 45, 52, 58, 35, 39, 51, 56, 59, 66, 68, 73, 82	Duration of partnership	Per act	Proportion: 14-84% (women) 0–64% (men) Duration: lifelong	W : 5·6% M : 5·2%	Yes	- Take - Degree - Waning of VE (normal distribution)	- Sexual activity - HPV prevalence
Burger[15-19] (Norway)	Deterministic	Age, gender, sexual activity	Individual: 16, 18	Instantaneous	Per partnership	Proportion: Women 88% (HPV16) 87% (HPV18) Men 11% (HPV16, 18) Duration: lifelong	W : 9·7% M : 4·5%	Yes	- Degree - Waning of VE (protection for x yrs then % lost each year)	- HPV prevalence
Canfell[20-22,23] (Australia)	Deterministic	Age, gender, sexual activity	Individual: 16,18 Grouped: other HR types	Instantaneous	Per partnership	Proportion: 100% Duration, mean: 5-100 yrs	W : 7·9% M : 5·5%	Yes	- Take - Degree - Waning of VE (protection for x yrs then % lost each year)	- Sexual activity - HPV prevalence
Chesson[24,25] (USA)	Deterministic	Age, gender	Individual: 16,18 Grouped: 6/11	NA	Age, and HPV-type-specific probability of HPV acquisition	Proportion: 100% Duration: lifelong	W : 6·2% M : 6·2%	No	- Degree - No waning	- NA. Direct parameters in the model
De Blasio[26] (Norway)	Deterministic	Age, gender, sexual activity	Individual: 6, 11, 16, 18 Grouped: 10 other HR types	Instantaneous	Per partnership	Proportion: 100% Duration, mean: 15 years	W : 8·7% M : 8·2%	Yes	- Take - Waning of VE (constant rate)	- Sexual activity - HPV prevalence
Elbasha[27,28] (USA)	Deterministic	Age, gender, sexual activity	Individual: 16, 18, 6, 11, 31, 33 45, 52, 58	Instantaneous	Per partnership	Proportion: 60% Duration: lifelong	W : 3·9% M : 3·0%	Yes	- Degree - Waning of VE (constant rate)	- Indirectly from cervical cancer and AGW consultations
Guzzetta[29] (Italy)	Deterministic	Age, gender, sexual activity	Grouped: 16/18	Instantaneous	Per partnership	Proportion: 47% Duration: lifelong	W : 3·0% M : 3·4%	Yes	- Take - Waning of VE (constant	- Sexual activity - HPV prevalence

Corresponding Author (Country)	Model type	Model stratification (risk groups)	HPV types included	Partnership formation & dissolution	Transmission probability	Proportion that develop natural immunity & duration of natural immunity	Baseline HPV16 prevalence (15-24 yrs)	Model with cervical cancer	Vaccine efficacy (VE) parameters*†	Outcomes used for Model calibration
									rate)	
Jepsen[30,31] (Ireland)	Stochastic and individual-based	Age, gender	Individual: 16, 18	Duration of partnership	Per act	No natural immunity	W : NA†† M : NA	Yes	- Take - Waning of VE (protection for x yrs & abrupt end or constant rate)	- Sexual activity - HPV prevalence - HPV incidence
Jit[32-34] (United Kingdom)	Deterministic	Age, gender, sexual activity	Individual: 16, 18 Grouped: 31/33/39/45/51/52/56/58/59/68	Instantaneous	Per partnership	Proportion: 96% Duration, mean: 20 yrs	W : 7·2% M : 5·9%	Yes	- Take - Waning of VE (protection for x yrs & abrupt end or constant rate)	- Sexual activity - HPV prevalence
Matthijsse[35] (Netherlands)	Stochastic and individual-based	Age, gender, sexual activity	Individual: 16, 18	Duration of partnership	Per act	Proportion: 100% Duration, mean: 112 yrs (HPV16) 43 yrs (HPV18)	W : 4·2% M : 5·3%	No	- Degree - No waning	- Sexual activity - HPV prevalence
Mikolajczyk[36] (Germany)	Deterministic	Age, gender, sexual activity	Individual: 16, 18 Grouped: 6/11¥, Other HR cross-protective, Other HR not cross-protective	Instantaneous	Per act	Proportion: 18% Duration, mean: 10 yrs	W : 6·9% M : 6·4%	Yes	- Take - Waning of VE (protection for x yrs then % lost each year)	- HPV prevalence
Tully[37] (Canada)	Deterministic	Age, gender	Grouped: 16/18	Instantaneous	Per partnership	Proportion: 100% Duration, mean: 2.5 yrs	W : 7·0% M : 5·3%	Yes	- Take - Waning of VE (constant rate)	- HPV prevalence - HPV incidence
Turner[38] (United Kingdom)	Deterministic	Age, gender, sexual activity	Individual: 16, 18 Grouped: 10 other HR types	Duration of partnership	Per partnership	Proportion: 25, 50, 75, 100% Duration, mean: 2, 10, 20 yrs, lifelong	W : 8·1% M : 10·2%	Yes	- Take - Waning of VE (constant rate)	- Sexual activity - HPV prevalence
Vänskä[39] (Finland)	Deterministic	Age, gender, sexual activity	Individual: 16, 18, 31, 33, 45, 52, 58, 39, 51, 56, 59, 66, 68	Instantaneous	Per partnership	Proportion: 100% Duration, mean: 27 yrs	W : 8·5% M : 7·7%	No	- Take - Waning of VE (protection for x yrs then % lost each year)	- Sexual activity - HPV prevalence

HR: High-risk; LR: Low-risk; VE: Vaccine efficacy; W: women; M: Men; NA: Not provided by the authors.

* Take: probability that a vaccinated individual develops immunity; Degree: degree of protection against infection per act or partnership;

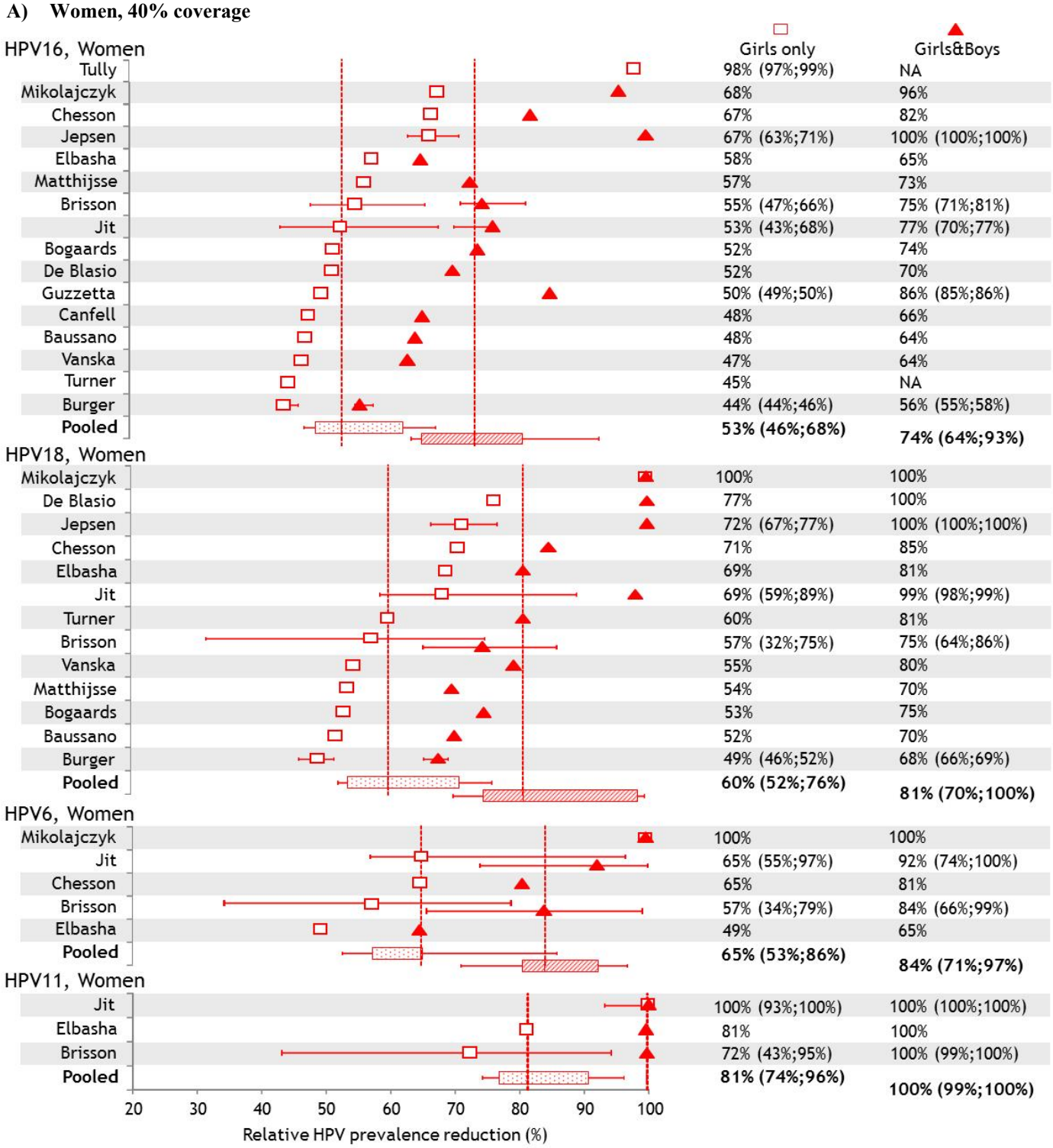
† Waning: some models can reproduce different waning functions. We present all of the model's waning functions.

†† Jepsen provided prevalence for all age groups, but not for 15-24 year olds.

¥ Mikolajczyk model the impact of HPV6 and HPV11 separately but use the same parameters for both types

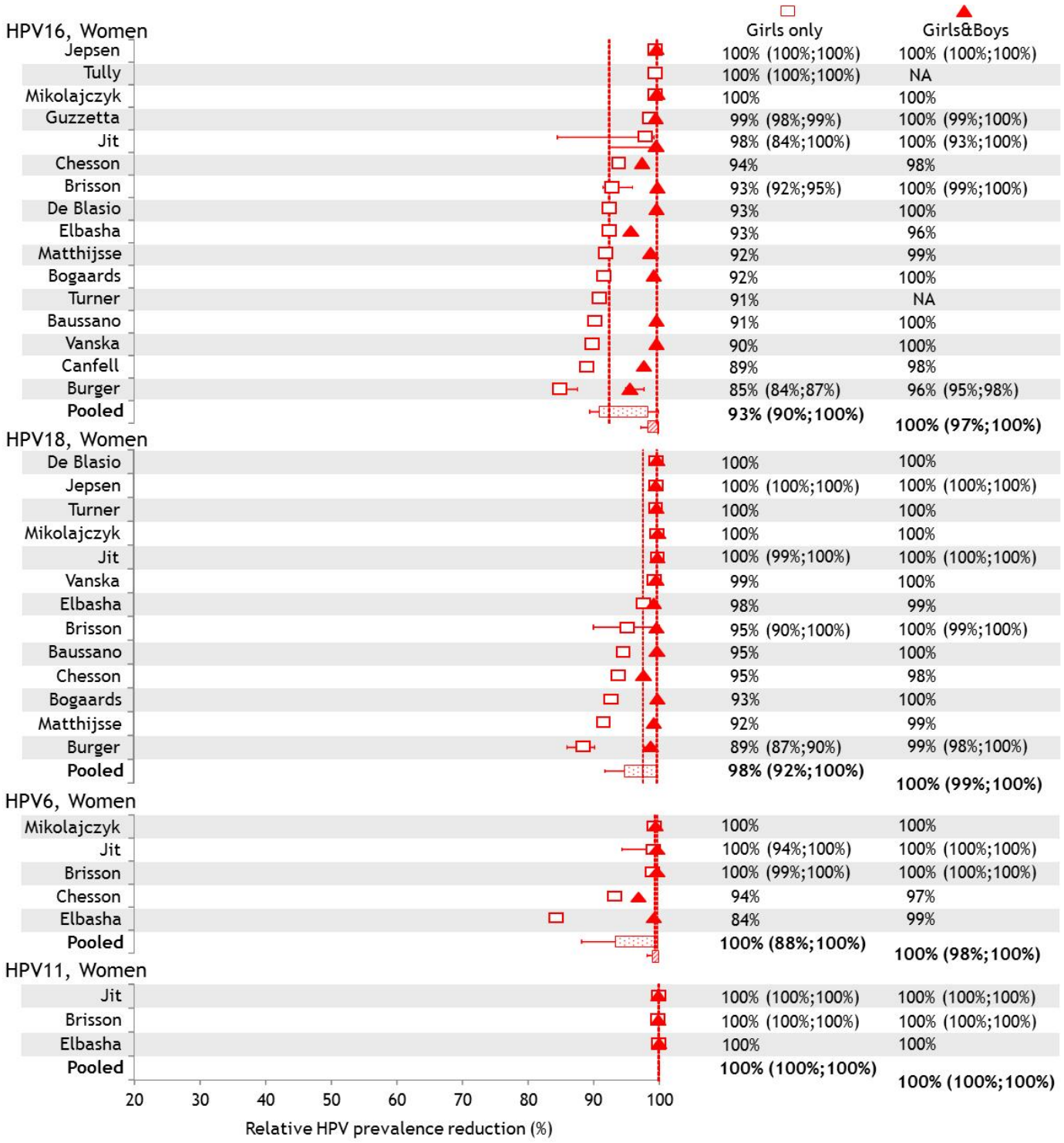
Figure S1. Predicted Relative reductions in the prevalence of HPV16, HPV18, HPV6, and HPV11 infections among women and men, after 70 years of Girls-Only or Girls&Boys vaccination.

A) Women, 40% coverage



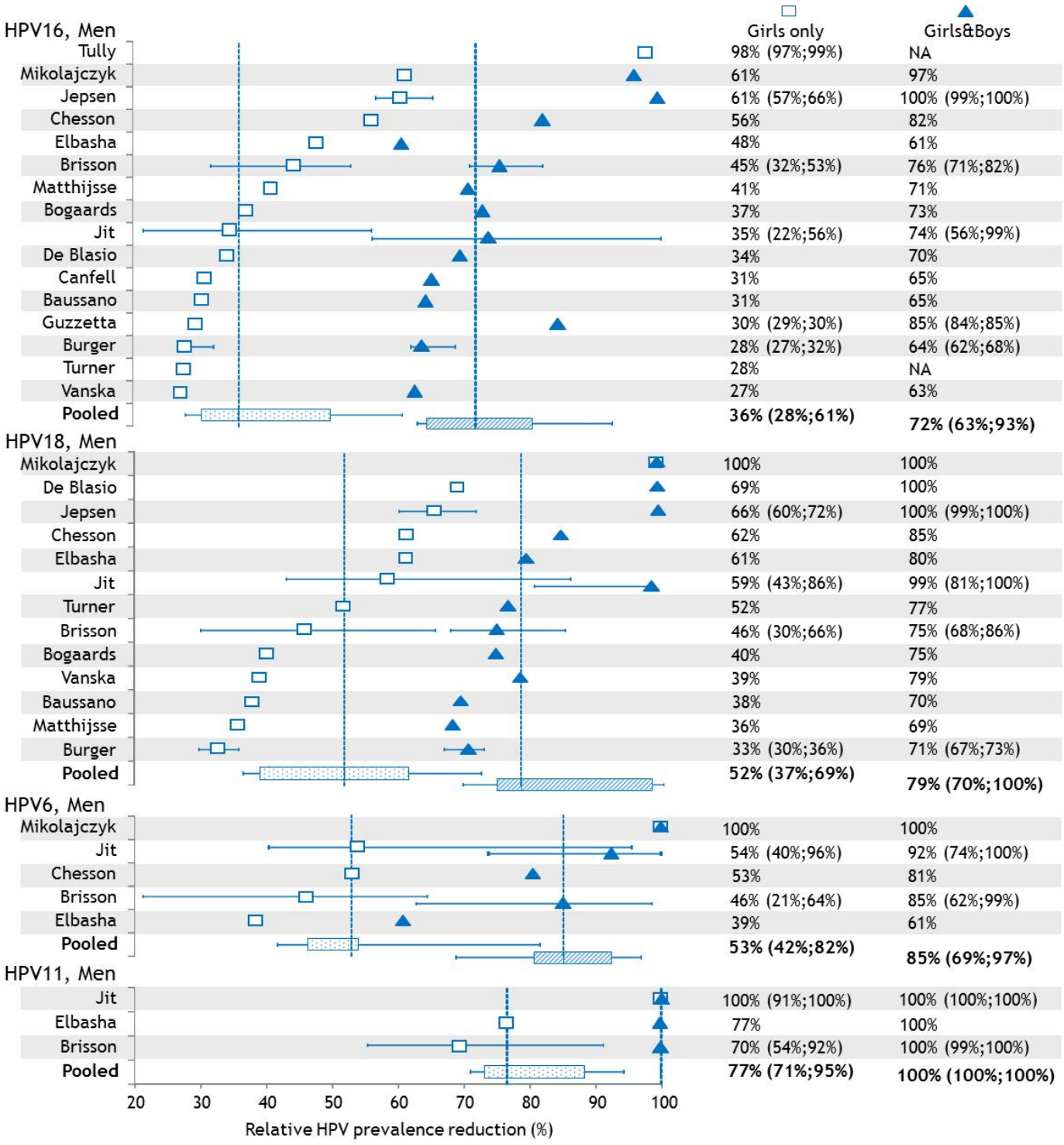
NA: Not available; Girls-Only: Vaccination of pre-adolescent girls only; Girls&Boys: Vaccination of pre-adolescent girls and boys. The models are identified by their corresponding author. For illustrative purposes, the models are ranked according to their predicted reduction of HPV16, HPV18, HPV6, or HPV11. The pooled estimates represent the median and the uncertainty interval (10%; 90% percentiles) of predictions. Predictions were performed for the base-case vaccine characteristics: Vaccine efficacy=100% and Duration of vaccine protection=Lifelong. Models with error bars provided uncertainty intervals (10%; 90% percentile) around their median model predictions. Mikolajczyk model the impact of HPV6 and HPV11 separately but use the same parameters for both types.

B) Women, 80% coverage



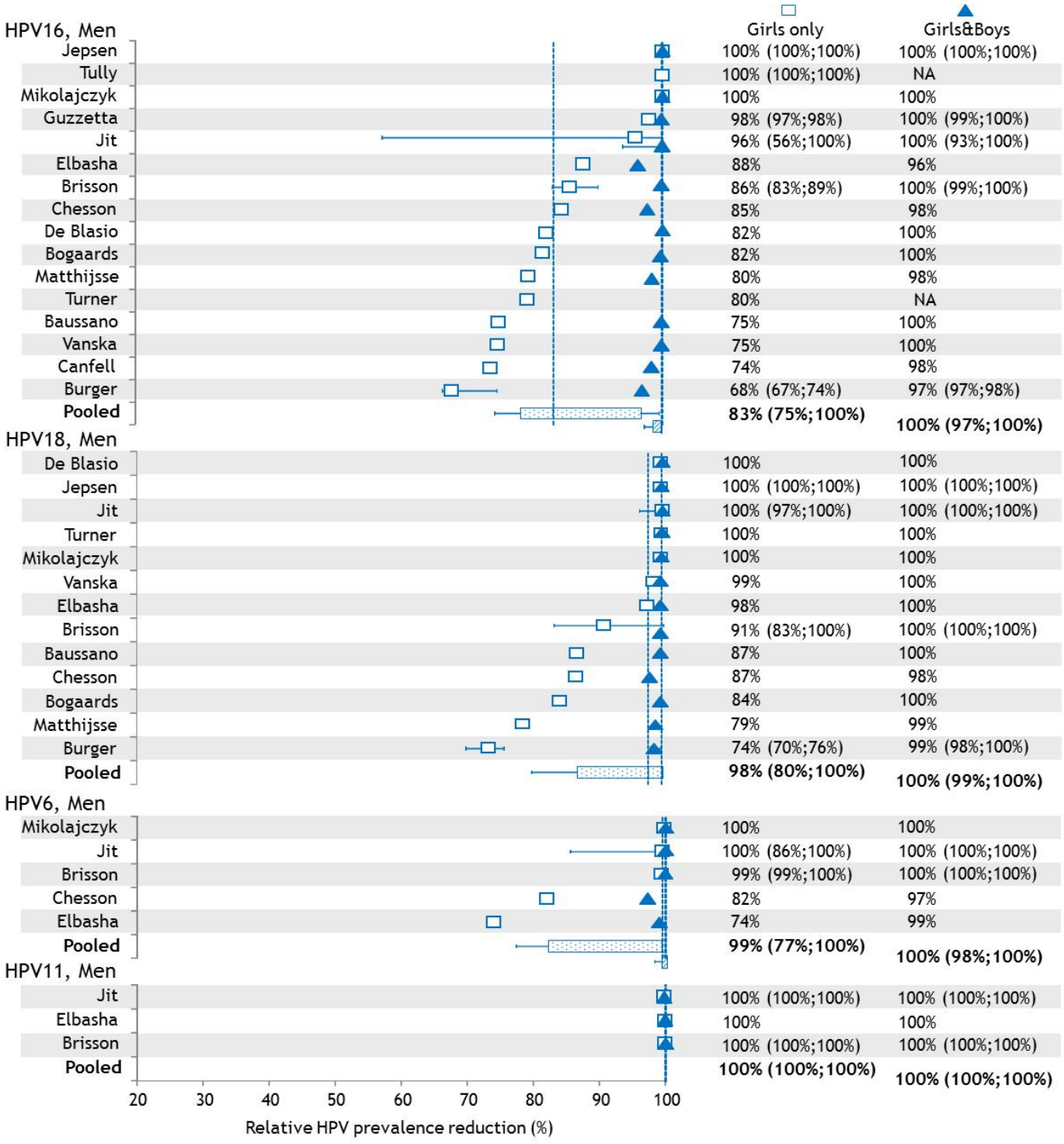
NA: Not available; Girls-Only: Vaccination of pre-adolescent girls only; Girls&Boys: Vaccination of pre-adolescent girls and boys. The models are identified by their corresponding author. For illustrative purposes, the models are ranked according to their predicted reduction of HPV16, HPV18, HPV6, or HPV11. The pooled estimates represent the median and the uncertainty interval (10%; 90% percentiles) of predictions. Predictions were performed for the base-case vaccine characteristics: Vaccine efficacy=100% and Duration of vaccine protection=Lifelong. Models with error bars provided uncertainty intervals (10%; 90% percentile) around their median model predictions. Mikolajczyk model the impact of HPV6 and HPV11 separately but use the same parameters for both types.

C) Men, 40% coverage



NA: Not available; Girls-Only: Vaccination of pre-adolescent girls only; Girls&Boys: Vaccination of pre-adolescent girls and boys. The models are identified by their corresponding author. For illustrative purposes, the models are ranked according to their predicted reduction of HPV16, HPV18, HPV6, or HPV11. The pooled estimates represent the median and the uncertainty interval (10%; 90% percentiles) of predictions. Predictions were performed for the base-case vaccine characteristics: Vaccine efficacy=100% and Duration of vaccine protection=Lifelong. Models with error bars provided uncertainty intervals (10%; 90% percentile) around their median model predictions. Mikolajczyk model the impact of HPV6 and HPV11 separately but use the same parameters for both types.

D) Men, 80% coverage



NA: Not available; Girls-Only: Vaccination of pre-adolescent girls only; Girls&Boys: Vaccination of pre-adolescent girls and boys. The models are identified by their corresponding author. For illustrative purposes, the models are ranked according to their predicted reduction of HPV16, HPV18, HPV6, or HPV11. The pooled estimates represent the median and the uncertainty interval (10%; 90% percentiles) of predictions. Predictions were performed for the base-case vaccine characteristics: Vaccine efficacy=100% and Duration of vaccine protection=Lifelong. Models with error bars provided uncertainty intervals (10%; 90% percentile) around their median model predictions. Mikolajczyk model the impact of HPV6 and HPV11 separately but use the same parameters for both types.

Table S4. Pooled model predictions of relative reduction in HPV prevalence (RRprev) for different strategies after 70 years of vaccination

A) HPV16 and 18, among women

	HPV16 RR_{prev} (n=16)* Median (80% Uncertainty Interval†)			**HPV16 RR_{prev}** (n=14) Median (80% Uncertainty Interval)			**HPV18 RR_{prev}** (n=13) Median (80% Uncertainty Interval)		
Coverage	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only
Base Case *(vaccine efficacy=100% ; duration of vaccine protection=Life)*									
20%	27% (23%;39%)	40% (34%;58%)	13% (9%;19%)	27% (23%;37%)	41% (34%;58%)	13% (8%;20%)	32% (27%;44%)	45% (38%;65%)	14% (11%;25%)
40%	53% (46%;68%)	74% (64%;93%)	18% (13%;32%)	53% (45%;67%)	73% (64%;93%)	18% (13%;27%)	60% (52%;76%)	81% (70%;100%)	19% (12%;28%)
60%	77% (70%;96%)	92% (86%;100%)	15% (7%;19%)	76% (69%;90%)	91% (85%;100%)	14% (7%;19%)	86% (75%;100%)	96% (91%;100%)	9% (0%;19%)
80%	93% (90%;100%)	100% (97%;100%)	7% (0%;10%)	92% (89%;99%)	100% (96%;100%)	7% (0%;10%)	98% (92%;100%)	100% (99%;100%)	1% (0%;8%)
100%	100% (100%;100%)	100% (100%;100%)	0% (0%;0%)	100% (100%;100%)	100% (100%;100%)	0% (0%;0%)	100% (100%;100%)	100% (100%;100%)	0% (0%;0%)
Sensitivity analysis 1 *(vaccine efficacy=100% ; duration of vaccine protection=20 years)*									
40%	38% (16%;65%)	45% (17%;74%)	11% (2%;24%)	38% (30%;51%)	48% (39%;75%)	11% (4%;24%)	42% (36%;74%)	60% (46%;100%)	15% (5%;29%)
80%	62% (27%;98%)	70% (21%;100%)	5% (0%;13%)	62% (56%;97%)	70% (61%;100%)	6% (0%;14%)	76% (59%;100%)	91% (58%;100%)	0% (0%;19%)
Sensitivity analysis 2 *(vaccine efficacy=90% ; duration of vaccine protection=Life)*									
40%	47% (33%;66%)	63% (46%;91%)	19% (13%;31%)	47% (31%;62%)	60% (44%;93%)	18% (13%;27%)	60% (37%;69%)	73% (56%;100%)	20% (13%;32%)
80%	86% (63%;100%)	97% (84%;100%)	12% (0%;24%)	85% (61%;98%)	96% (83%;100%)	13% (1%;24%)	94% (71%;100%)	100% (95%;100%)	5% (0%;25%)

* 2 models with grouped HPV16/18 were included and 14 models provided predictions for the Girls&Boys Scenario. † 10^{th} and 90^{th} percentile of predictions.

B) HPV16 and 18, among men (Table S3 – continued)

	HPV16 RR_{prev} (n=16)* Median (80% Uncertainty Interval†)			**HPV16 RR_{prev}** (n=14) Median (80% Uncertainty Interval)			**HPV18 RR_{prev}** (n=13) Median (80% Uncertainty Interval)		
Coverage	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only
Base Case *(vaccine efficacy=100% ; duration of vaccine protection=Life)*									
20%	17% (13%;33%)	40% (34%;58%)	23% (21%;26%)	17% (13%;31%)	40% (34%;58%)	23% (21%;26%)	25% (17%;37%)	46% (40%;65%)	24% (13%;32%)
40%	36% (28%;61%)	72% (63%;93%)	35% (27%;39%)	36% (28%;59%)	71% (63%;94%)	35% (27%;39%)	52% (37%;69%)	79% (70%;100%)	32% (19%;39%)
60%	60% (49%;94%)	92% (85%;100%)	31% (11%;40%)	59% (48%;85%)	91% (84%;100%)	32% (11%;40%)	77% (56%;100%)	96% (90%;100%)	17% (0%;36%)
80%	83% (75%;100%)	100% (97%;100%)	16% (1%;25%)	82% (74%;99%)	100% (97%;100%)	18% (1%;25%)	98% (80%;100%)	100% (99%;100%)	2% (0%;19%)
100%	100% (98%;100%)	100% (100%;100%)	0% (0%;2%)	100% (98%;100%)	100% (100%;100%)	0% (0%;2%)	100% (100%;100%)	100% (100%;100%)	0% (0%;0%)
Sensitivity analysis 1 *(vaccine efficacy=100% ; duration of vaccine protection=20 years)*									
40%	25% (6%;57%)	47% (12%;72%)	23% (6%;35%)	25% (13%;40%)	51% (23%;72%)	23% 6%;35%	30% (25%;66%)	57% (43%;100%)	26% (8%;35%)
80%	49% (12%;98%)	70% (17%;100%)	14% (4%;25%)	49% (29%;94%)	73% (44%;100%)	14% (6%;25%)	59% (48%;100%)	91% (53%;100%)	8% (0%;28%)
Sensitivity analysis 2 *(vaccine efficacy=90% ; duration of vaccine protection=Life)*									
40%	27% (20%;58%)	62% (51%;91%)	34% (26%;45%)	27% (18%;54%)	60% (51%;93%)	33% (25%;42%)	50% (25%;61%)	71% (56%;100%)	31% (18%;41%)
80%	71% (43%;100%)	97% (86%;100%)	30% (1%;46%)	64% (41%;97%)	96% (86%;100%)	31% (3%;46%)	88% (53%;100%)	99% (94%;100%)	12% (0%;40%)

* 2 models with grouped HPV16/18 were included and 14 models provided predictions for the Girls&Boys Scenario. † 10^{th} and 90^{th} percentile of predictions.

C) HPV6 and 11, among women (Table S3 – continued)

	HPV6 RR_{prev} (n=5) * Median (80% Uncertainty Interval†)			**HPV6 RR_{prev}** (n=3) Median (80% Uncertainty Interval)			**HPV11 RR_{prev}** (n=3) Median (80% Uncertainty Interval)		
Coverage	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only
Base Case *(vaccine efficacy=100% ; duration of vaccine protection=Life)*									
20%	35% (29%;71%)	54% (39%;82%)	11% (8%;18%)	32% (27%;34%)	43% (37%;52%)	11% (10%;18%)	43% (35%;82%)	65% (57%;93%)	22% (11%;22%)
40%	65% (53%;86%)	84% (71%;97%)	16% (6%;27%)	57% (51%;63%)	84% (69%;91%)	27% (18%;27%)	81% (74%;96%)	100% (99%;100%)	19% (4%;26%)
60%	83% (75%;96%)	100% (89%;100%)	10% (4%;17%)	83% (72%;88%)	100% (89%;100%)	17% (12%;17%)	100% (99%;100%)	100% (99%;100%)	0% (0%;1%)
80%	100% (88%;100%)	100% (98%;100%)	0% (0%;10%)	100% (88%;100%)	100% (99%;100%)	0% (0%;12%)	100% (100%;100%)	100% (100%;100%)	0% (0%;0%)
100%	100% (99%;100%)	100% (100%;100%)	0% (0%;1%)	100% (98%;100%)	100% (100%;100%)	0% (0%;2%)	100% (100%;100%)	100% (100%;100%)	0% (0%;0%)
Sensitivity analysis 1 *(vaccine efficacy=100% ; duration of vaccine protection=20 years)*									
40%	48% (28%;86%)	69% (38%;97%)	10% (4%;25%)	37% (27%;55%)	49% (36%;81%)	11% (10%;27%)	46% (40%;89%)	80% (62%;96%)	18% (4%;31%)
80%	89% (55%;100%)	99% (71%;100%)	7% (0%;19%)	78% (52%;96%)	98% (68%;100%)	15% (3%;20%)	95% (76%;99%)	100% (99%;100%)	5% (1%;23%)
Sensitivity analysis 2 *(vaccine efficacy=90% ; duration of vaccine protection=Life)*									
40%	59% (36%;84%)	77% (52%;94%)	17% (6%;23%)	42% (34%;56%)	56% (51%;80%)	18% (15%;25%)	72% (52%;94%)	99% (91%;100%)	27% (5%;39%)
80%	90% (68%;100%)	100% (94%;100%)	6% (0%;30%)	75% (65%;94%)	100% (95%;100%)	19% (4%;33%)	100% (98%;100%)	100% (100%;100%)	0% (0%;2%)

† 2 models with grouped HPV6/11 were included in these analyses. † 10^{th} and 90^{th} percentile of predictions.

D) HPV6 and 11, among men (Table S3 – continued)

	HPV6 RR_{prev} (n=5)* Median (80% Uncertainty Interval†)			**HPV6 RR_{prev}** (n=3) Median (80% Uncertainty Interval)			**HPV11 RR_{prev}** (n=3) Median (80% Uncertainty Interval)		
Coverage	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only	Girls-Only	Girls&Boys	Incremental Girls&Boys vs Girls-Only
Base Case *(vaccine efficacy=100% ; duration of vaccine protection=Life)*									
20%	26% (21%;67%)	54% (37%;82%)	24% (7%;27%)	23% (20%;25%)	44% (35%;52%)	24% (10%;27%)	37% (30%;80%)	64% (60%;93%)	27% (12%;30%)
40%	53% (42%;82%)	85% (69%;97%)	28% (3%;43%)	46% (40%;52%)	85% (66%;91%)	38% (13%;45%)	77% (71%;95%)	100% (100%;100%)	23% (5%;29%)
60%	76% (62%;93%)	100% (87%;100%)	17% (0%;35%)	70% (59%;81%)	100% (87%;100%)	17% (3%;38%)	100% (99%;100%)	100% (99%;100%)	0% (0%;1%)
80%	99% (77%;100%)	100% (98%;100%)	0% (0%;22%)	87% (77%;97%)	100% (99%;100%)	0% (0%;21%)	100% (100%;100%)	100% (100%;100%)	0% (0%;0%)
100%	100% (92%;100%)	100% (100%;100%)	0% (0%;8%)	100% (96%;100%)	100% (100%;100%)	0% (0%;4%)	100% (100%;100%)	100% (100%;100%)	0% (0%;0%)
Sensitivity analysis 1 *(vaccine efficacy=100% ; duration of vaccine protection=20 years)*									
40%	40% (22%;84%)	72% (38%;97%)	18% (5%;35%)	35% (22%;48%)	53% (36%;83%)	24% (15%;36%)	44% (36%;89%)	84% (61%;97%)	22% (4%;36%)
80%	88% (49%;100%)	99% (70%;100%)	10% (0%;22%)	68% (43%;94%)	99% (66%;100%)	20% (4%;23%)	95% (71%;99%)	100% (99%;100%)	5% (1%;28%)
Sensitivity analysis 2 *(vaccine efficacy=90% ; duration of vaccine protection=Life)*									
40%	48% (27%;80%)	77% (52%;94%)	28% (8%;34%)	32% (26%;45%)	52% (52%;79%)	28% (22%;36%)	65% (48%;93%)	99% (93%;100%)	33% (7%;45%)
80%	78% (57%;100%)	100% (93%;100%)	18% (0%;40%)	61% (56%;92%)	100% (93%;100%)	31% (6%;42%)	100% (98%;100%)	100% (100%;100%)	0% (0%;2%)

† 2 models with grouped HPV6/11 were included in these analyses. † 10^{th} and 90^{th} percentile of predictions.

Table S5: Percentage and number of models predicting similar or greater vaccination impact for HPV18, HPV6 and HPV11 than HPV16*

	Women				Men			
	Girls only % (n)		Girls&Boys % (n)		Girls only % (n)		Girls&Boys % (n)	
	40% Coverage	80% Coverage	40% Coverage	80% Coverage	40% Coverage	80% Coverage	40% Coverage	80% Coverage
HPV18	92% (12/13)	100% (13/13)	92% (11/12)	100% (12/12)	92% (12/13)	92% (12/13)	83% (10/12)	100% (12/12)
HPV6	67% (2/3)	67% (2/3)	100% (3/3)	100% (3/3)	67% (2/3)	67% (2/3)	100% (3/3)	100% (3/3)
HPV11	100% (3/3)	100% (3/3)	100% (3/3)	100% (3/3)	100% (3/3)	100% (3/3)	100% (3/3)	100% (3/3)

* We did not include models that merged types HPV16 and HPV18 or HPV6 and HPV 11.

Table S6. Percentage and number of models predicting HPV elimination†

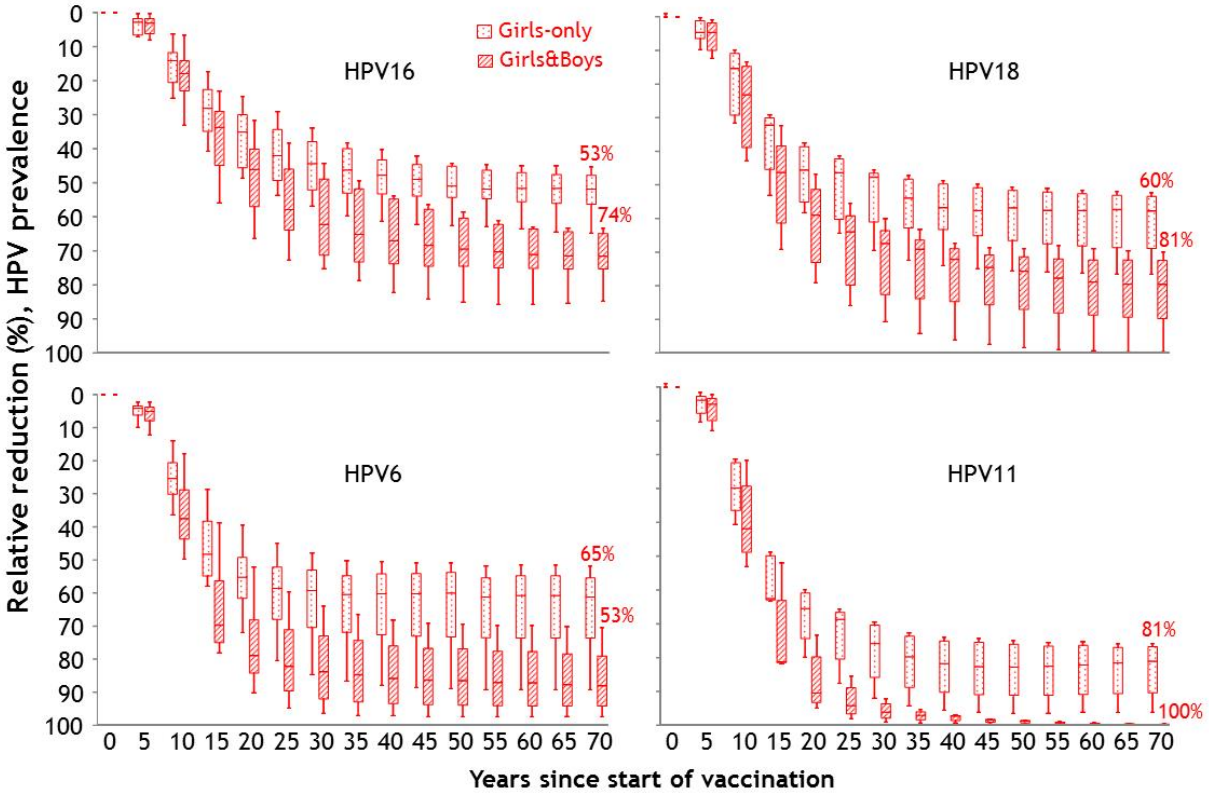
	HPV16 % (n)		**HPV18** % (n)		**HPV6** % (n)		**HPV11** % (n)	
Coverage	Girls-Only (N=16)	Girls&Boys (N=14)*	Girls-Only (N=13)	Girls&Boys (N=13)	Girls-Only (N=5)	Girls&Boys (N=5)	Girls-Only (N=3)	Girls&Boys (N=3)
20%	0% (0)	0% (0)	0% (0)	8% (1)	0% (0)	20% (1)	0% (0)	33% (1)
40%	0% (0)	7% (1)	8% (1)	31% (4)	20% (1)	20% (1)	33% (1)	100% (3)
60%	13% (2)	29% (4)	23% (3)	38% (5)	20% (1)	60% (3)	100% (3)	100% (3)
80%	19% (3)	64% (9)	46% (6)	92% (12)	60% (3)	80% (4)	100% (3)	100% (3)
100%	88% (14)	100% (14)	92% (12)	100% (13)	60% (3)	100% (5)	100% (3)	100% (3)

† Elimination: RRprev ≥ 99% for both women and men after 70 years of vaccination

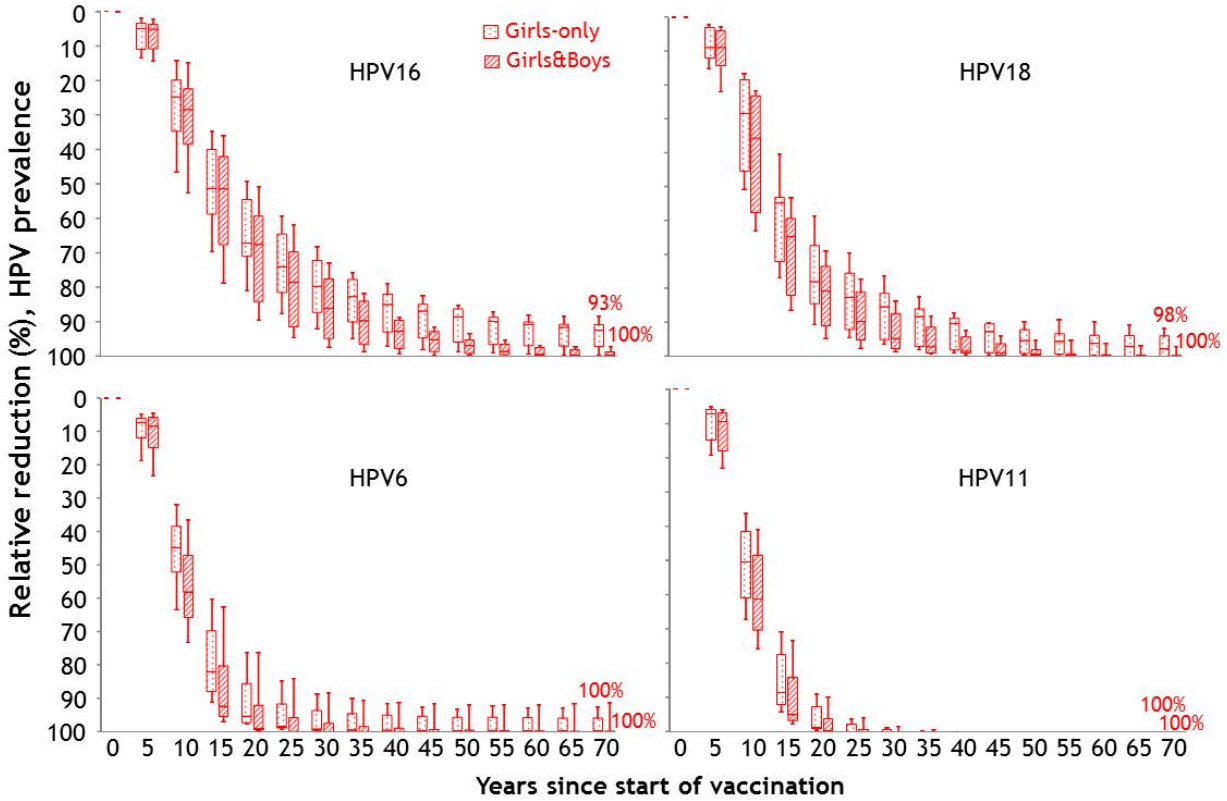
* 14 models provided predictions for the Girls&Boys Scenario.

Figure S2. Post-vaccination dynamics: pooled predictions of the relative reduction in HPV16, 18, 6, and 11 infections among women and men after the introduction of Girls-Only or Girls&Boys vaccination.

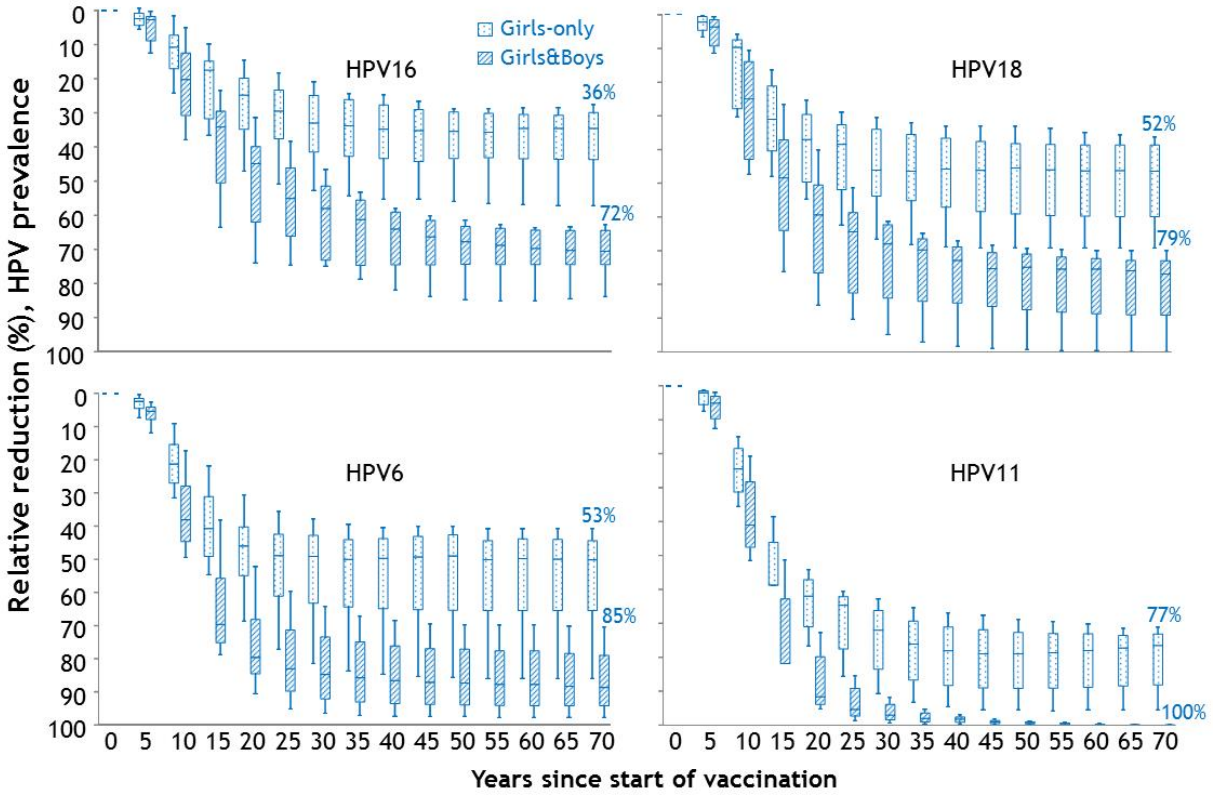
A) Women, 40% coverage



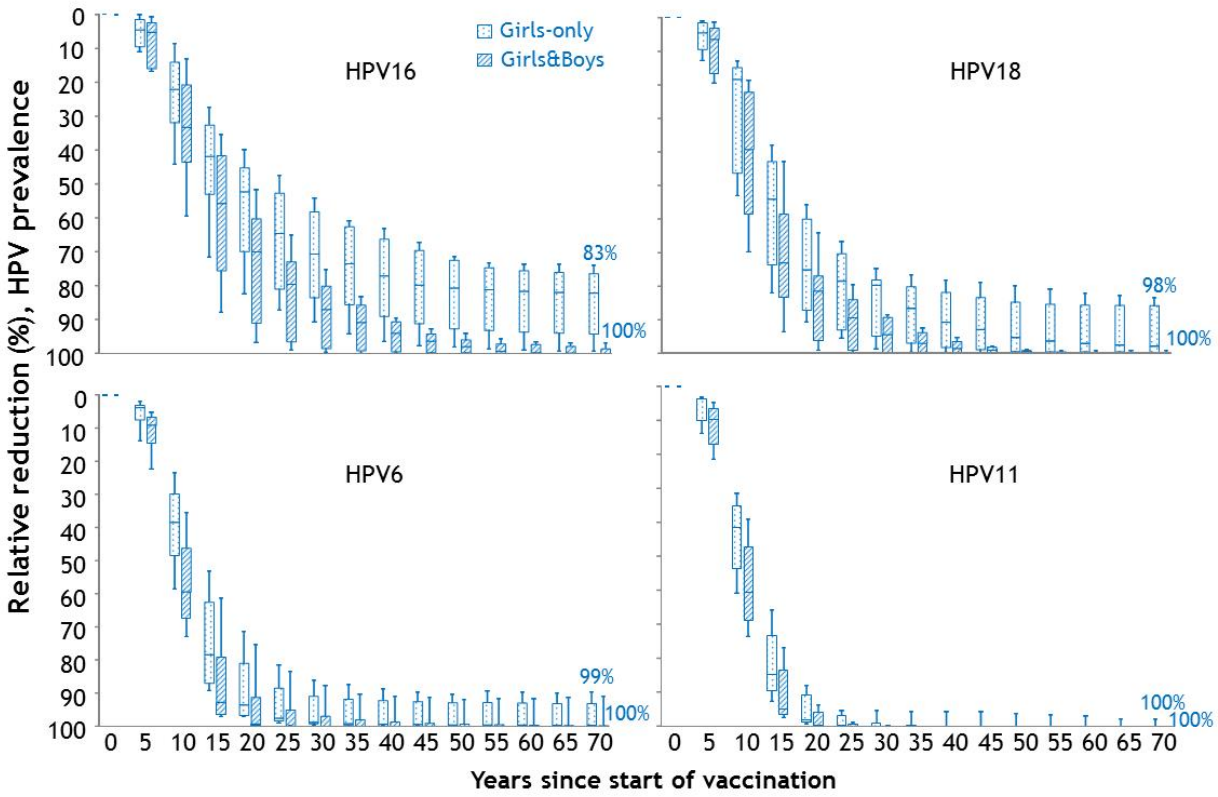
B) Women, 80% coverage



C) Men, 40% coverage

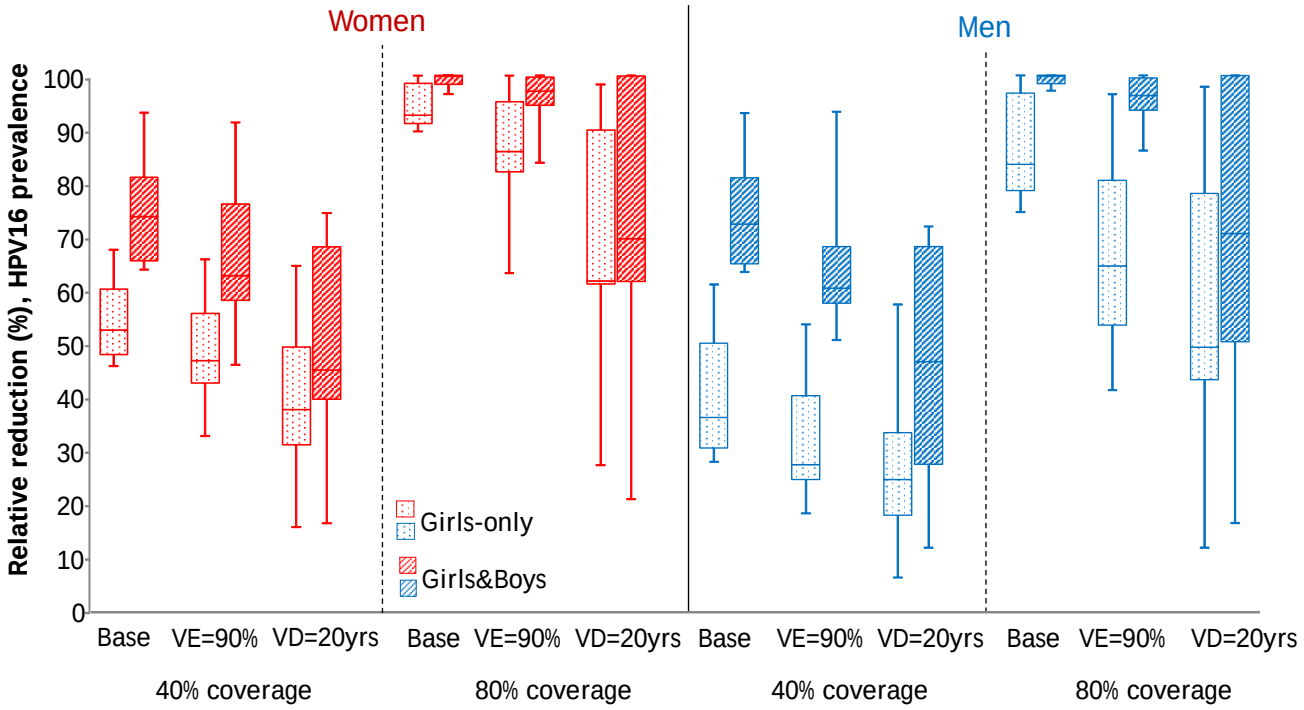


D) Men, 80% coverage



Girls-Only: Vaccination of pre-adolescent girls only; Girls&Boys: Vaccination of pre-adolescent girls and boys.
The pooled estimates represent the median and the uncertainty interval (10%; 90% percentiles) of predictions. Predictions were performed for the base-case vaccine characteristics: Vaccine efficacy=100% and Duration of vaccine protection=Lifelong.

Figure S3. Sensitivity Analysis – Vaccine efficacy and duration on vaccine protection.



Girls-Only: Vaccination of girls only; Girls&Boys: Vaccination of girls and boys. The pooled estimates represent median and 10th, 25th, 75th, and 90th percentiles of the predictions of the models at 70 years after the introduction of vaccination. Base-case vaccine characteristics: Vaccine efficacy (VE)=100% and Duration of vaccine protection (VD)=Lifelong. See appendix table S4 for values of pooled estimates and uncertainty intervals.

Table S7. Potential sources of heterogeneity between the different models' predictions of relative reduction in HPV16 prevalence: univariate meta-regressions.

A) Girls-Only vaccination

	Base				20 years			
	40%		80%		40%		80%	
	Mean HPV16 RR_{prev}, % (95% CI) *p-value*		Mean HPV16 RR_{prev}, % (95% CI) *p-value*		Mean HPV16 RR_{prev}, % (95% CI) *p-value*		Mean HPV16 RR_{prev}, % (95% CI) *p-value*	
	Women	Men	Women	Men	Women	Men	Women	Men
Model characteristics								
Deterministic/Compartmental[1,2,4-9,11,13-16]	56 (49;63)	42 (32;52)	93 (91;96)	85 (79;90)	37 (27;48)	27 (15;38)	64 (49;79)	52 (35;69)
Stochastic/Individual-based[3,10,12]	60 (45;74)	49 (29;69)	95 (90;100)	89 (77;100)	54 (30;78)	47 (20;74)	83 (48;100)	80 (40;100)
	p=0·67	*p=0·55*	*p=0·55*	*p=0·57*	*p=0·23*	*p=0·19*	*p=0·33*	*p=0·23*
Model stratified by sexual activity group								
Yes[1-5,7-9,11-13,15,16]	52 (47;57)	37 (30;43)	93 (91;95)	83 (78;88)	34 (27;41)	22 (16;29)	61 (48;74)	49 (34;63)
No[6,10,14]	78 (68;87)	72 (58;85)	98 (94;100)	95 (85;100)	74 (58;90)	71 (56;86)	99 (69;100)	100 (66;100)
	p=0·0002	*p=0·0002*	*p=0·04*	*p=0·06*	*p=0·0005*	*p<0·0001*	*p=0·04*	*p=0·02*
Probability of transmission								
Per partnership[1,2,4,5,7-9,11,14-16]	54 (47;61)	39 (29;49)	93 (90;95)	84 (78;89)	37 (26;48)	26 (14;37)	62 (47;78)	50 (32;67)
Per act[3,10,12,13]	62 (50;74)	52 (35;69)	96 (92;100)	91 (82;100)	50 (30;70)	45 (23;66)	82 (54;100)	78 (47;100)
Other[6]	67 (43;91)	56 (23;89)	94 (86;100)	85 (66;100)	NA	NA	NA	NA
	p=0·41	*p=0·33*	*p=0·36*	*p=0·39*	*p=0·26*	*p=0·15*	*p=0·25*	*p=0·14*
Natural immunity among women								
Low: ≤35% or ≤10yrs[1,10,13,14]	70 (60;81)	63 (49;77)	98 (94;100)	94 (85;100)	50 (33;67)	47 (30;64)	73 (48;98)	71 (42;99)
High: >35% and >10yrs[2-9,11,12,15,16]	52 (46;58)	37 (29;45)	92 (90;95)	83 (78;88)	35 (24;47)	22 (11;34)	64 (47;81)	50 (31;69)
	p=0·008	*p=0·005*	*p=0·03*	*p=0·05*	*p=0·16*	*p=0·03*	*p=0·55*	*p=0·26*
Natural history of cervical cancer included								
Yes[2-5,7-11,13-15]	58 (50;65)	45 (35;55)	94 (92;97)	88 (83;93)	43 (33;53)	34 (23;45)	72 (59;86)	63 (48;79)
No[1,6,12,16]	55 (42;67)	39 (21;57)	92 (88;96)	77 (69;88)	21 (0;44)	9 (0;35)	36 (5;67)	19 (0;55)
	p=0·70	*p=0·58*	*p=0·28*	*p=0·10*	*p=0·10*	*p=0·10*	*p=0·05*	*p=0·04*
Potential conflict of interests								
≥ 1 author from industry[8,14]	78 (64;92)	73 (55;91)	96 (91;100)	94 (81;100)	57 (35;79)	52 (28;75)	80 (46;100)	72 (32;100)
Declare potential conflict[¥ 2,3,10,13,16]	58 (49;67)	46 (35;58)	95 (91;99)	89 (81;97)	44 (30;58)	34 (19;49)	73 (51;94)	63 (37;88)
No declared potential conflict[1,4-7,9,11,12,15]	52 (45;58)	35 (26;44)	93 (89;95)	82 (76;88)	31 (18;44)	19 (5;33)	58 (38;77)	46 (23;69)
	p=0·01	*p=0·006*	*p=0·37*	*p=0·20*	*p=0·15*	*p=0·08*	*p=0·44*	*p=0·47*
Impact factor[±]								
IF > 5[2-6,8,11]	54 (44;63)	40 (27;53)	92 (89;95)	83 (75;90)	37 (23;52)	25 (9;42)	68 (47;89)	57 (32;81)
IF ≤ 5[1,7,9,10,12-16]	60 (51;67)	46 (34;57)	95 (92;98)	88 (81;94)	42 (28;56)	34 (19;49)	66 (46;85)	56 (34;79)
	p=0·43	*p=0·53*	*p=0·15*	*p=0·31*	p=0·65	*p=0·46*	*p=0·86*	*p=0·99*
HPV16 prevalence young women (continuous variable)[all, except 10,13]	-1·1 (-3·6;1·4)	-1·4 (-4·8;2·1)	-0·6 (-1·3;0·2)	-1·3 (-3·1;0·4)	3·1 (-1·7;7·9)	2·3 (-3·3;7·8)	6·5 (0·0;12·9)	6·3 (-1·5;14·1)
	p=0·40	*p=0·44*	*p=0·16*	*p=0·15*	*p=0·22*	*p=0·43*	*p=0·07*	*p=0·13*

NA : not applicable; *1 : Baussano, 2 : Bogaards, 3 : Brisson, 4 : Burger, 5 :Canfell, 6 : Chesson, 7 : De Blasio, 8 : Elbasha, 9 : Guzzetta, 10 : Jepsen, 11 : Jit, 12 : Matthijsse, 13 : Mikolajczyk, 14 : Tully, 15 : Turner, 16 : Vänskä. [¥]At least one author declared a potential conflict of interest (e.g., funding from industry); [±]Highest impact factor.

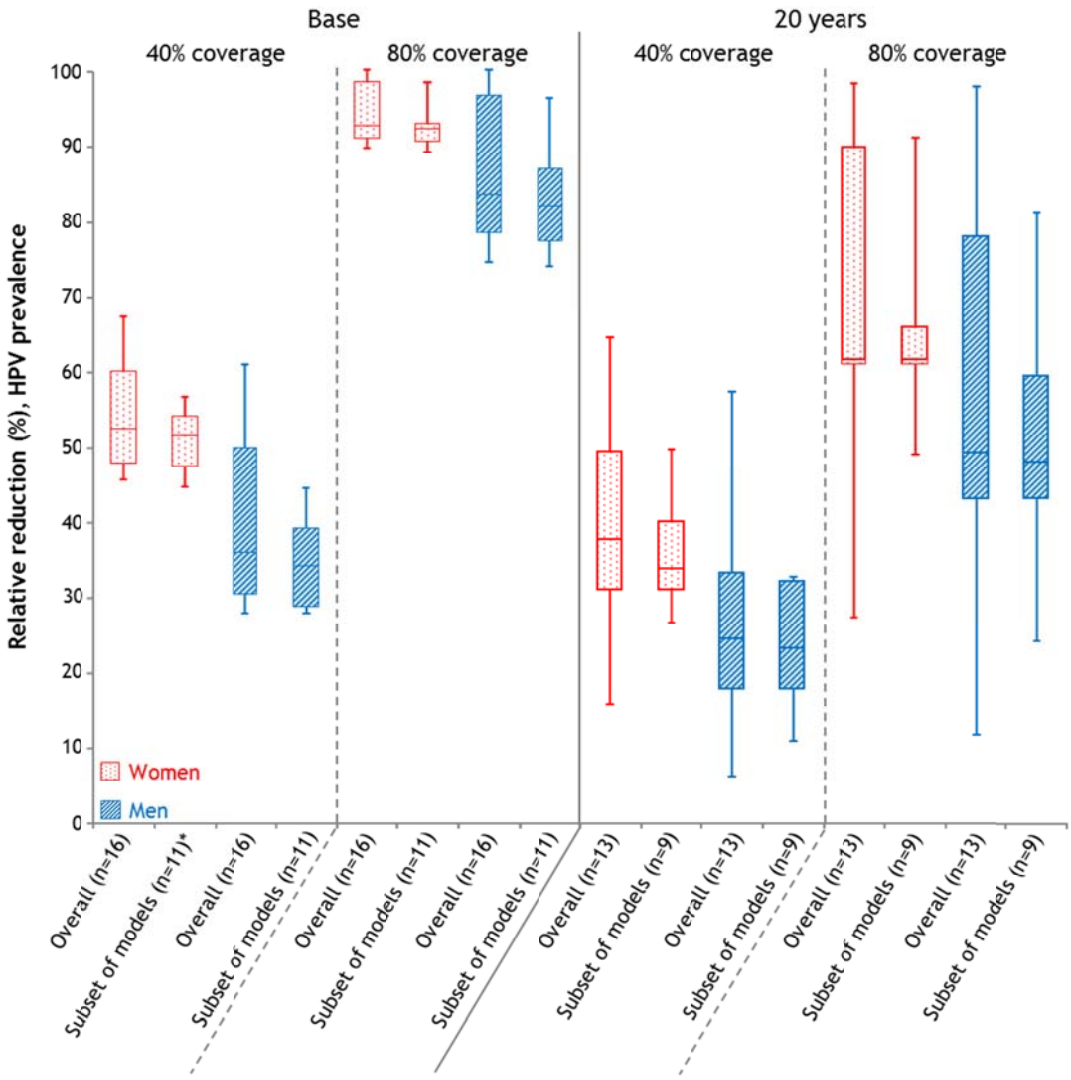
B) Girls&Boys vaccination

	Base				20 years			
	40%		80%		40%		80%	
	Mean HPV16 RR_{prev}, % (95% CI) *p-value*		Mean HPV16 RR_{prev}, % (95% CI) *p-value*		Mean HPV16 RR_{prev}, % (95% CI) *p-value*		Mean HPV16 RRprev, % (95% CI) *p-value*	
	Women	Men	Women	Men	Women	Men	Women	Men
Model characteristics								
Deterministic / Compartmental[1,2,4-9,11,13,14]	73 (66;80)	73 (66;79)	99 (98;100)	98 (98;100)	45 (32;58)	42 (28;55)	66 (49;84)	63 (44;81)
Stochastic / Individual-based[3,10,12]	83 (70;96)	82 (70;95)	100 (98;100)	100 (98;100)	76 (47;100)	78 (47;100)	84 (46;100)	87 (45;100)
	p=0·20	*p=0·19*	*p=0·33*	*p=0·53*	*p=0·07*	*p=0·05*	*p=0·41*	*p=0·31*
Model stratified by sexual activity group								
Yes[1-5,7-9,11-13,14]	72 (67;78)	72 (67;78)	99 (98;100)	99 (98;100)	45 (34;56)	43 (31;55)	67 (50;83)	64 (46;81)
No[6,10]	91 (77;100)	91 (78;100)	99 (97;100)	99 (97;100)	100 (63;100)	100 (60;100)	100 (47;100)	100 (42;100)
	p=0·02	*p=0·02*	*p=0·87*	*p=0·76*	*p=0·01*	*p=0·02*	*p=0·25*	*p=0·25*
Probability of transmission								
Per partnership[1,2,4,5,7-9,11,14]	69 (63;75)	69 (63;75)	99 (98;100)	99 (98;100)	42 (29;55)	39 (25;52)	63 (45;80)	58 (40;77)
Per act[3,10,12,13]	86 (77;95)	86 (77;95)	100 (99;100)	100 (99;100)	73 (51;96)	75 (52;98)	90 (60;100)	91 (60;100)
Other[6]	83 (64;100)	83 (65;100)	98 (95;100)	98 (95;100)	*NA	NA	NA	NA
	p=0·02	*p=0·02*	*p=0·30*	*p=0·33*	*p=0·03*	*p=0·02*	*p=0·14*	*p=0·10*
Natural immunity among women								
Low: ≤35% or ≤10yrs[1,10,13]	87 (75;99)	87 (76;98)	100 (98;100)	100 (99;100)	60 (33;86)	60 (32;88)	71 (38;100)	71 (36;100)
High: >35% and >10yrs[2-9,11,12,14]	72 (66;78)	71 (66;77)	99 (98;100)	99 (98;100)	47 (31;62)	44 (27;60)	69 (50;88)	65 (45;85)
	p=0·04	*p=0·03*	*p=0·18*	*p=0·17*	*p=0·42*	*p=0·33*	*p=0·93*	*p=0·77*
Natural history of cervical cancer included								
Yes[2-5,7-13]	77 (69;84)	77 (69;84)	99 (98;100)	99 (98;100)	55 (41;68)	53 (39;67)	76 (60;91)	74 (58;90)
No[1,6,14]	71 (59;83)	70 (59;81)	99 (98;100)	99 (98;100)	25 (0;55)	20 (0;51)	37 (2;71)	29 (0;66)
	p=0·43	*p=0·37*	*p=0·82*	*p=0·85*	*p=0·09*	*p=0·08*	*p=0·06*	*p=0·04*
Potential conflict of interests								
≥ 1 author from industry[8]	65 (44;87)	61 (41;81)	96 (94;98)	96 (95;98)	39 (0;82)	23 (0;70)	68 (13;100)	57 (0;100)
Declared potential conflict[¥ 2,3,10,13,14]	82 (72;91)	82 (73;91)	100 (99;100)	100 (99;100)	62 (42;81)	59 (38;80)	78 (54;100)	74 (47;100)
No declared potential conflict[1,4-7,9,11,12]	72 (64;79)	72 (65;79)	99 (98;100)	99 (98;100)	42 (24;60)	42 (23;61)	62 (40;84)	62 (37;86)
	p=0·22	*p=0·13*	*p=0·01*	*p=0·004*	*p=0·33*	*p=0·31*	*p=0·64*	*p=0·77*
Impact factor [±]								
IF > 5[2-6,8,11]	71 (62;79)	71 (63;79)	98 (97;99)	99 (98;99)	50 (30;69)	48 (27;68)	74 (51;97)	72 (47;97)
IF ≤ 5[1,7,9,10,12,13,14]	79 (71;88)	79 (70;87)	100 (99;100)	100 (99;100)	50 (31;69)	48 (27;69)	65 (42;88)	61 (36;86)
	p=0·19	*P=0·21*	*p=0·02*	*p=0·04*	*p=0·97*	*p=0·99*	*p=0·60*	*p=0·54*
HPV16 prevalence young women (continuous variable)[all, except 10,13]	-2·0 (-4·7;0·7)	-1·2 (-3·8;1·5)	-0·1 (-0·5;0·3)	0·0 (-0·3;0·4)	4·7 (-0·5;9·8)	6·1 (0·8;11·3)	8·2 (1·3;15·1)	9·3 (2·0;16·6)
	p=0·16	*p=0·39*	*p=0·78*	*p=0·90*	*p=0·10*	*p=0·04*	*p=0·04*	*p=0·03*

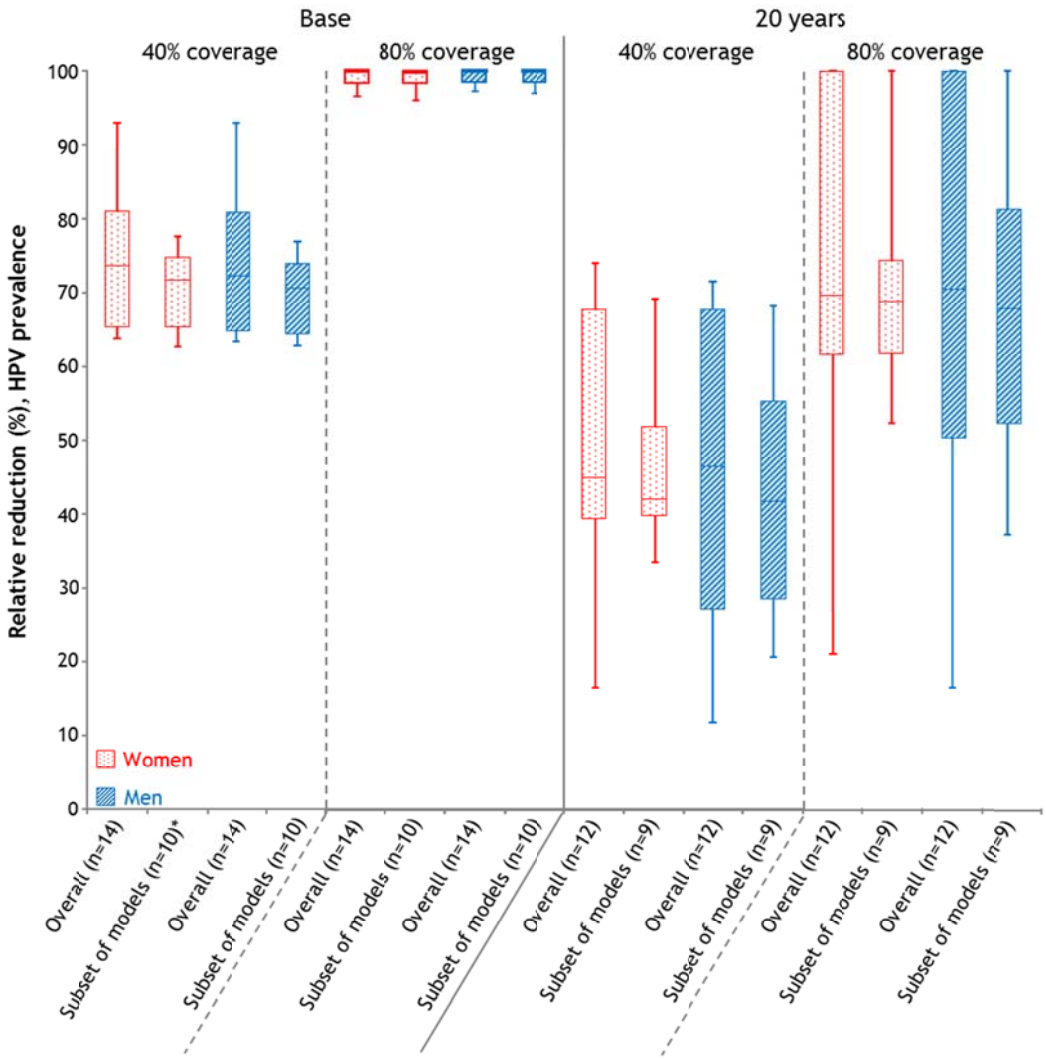
NA : not applicable; *1 : Baussano, 2 : Bogaards, 3 : Brisson, 4 : Burger, 5 :Canfell, 6 : Chesson, 7 : De Blasio, 8 : Elbasha, 9 : Guzzetta, 10 : Jepsen, 11 : Jit, 12 : Matthijsse, 13 : Mikolajczyk, 14 : Vänskä. [¥]At least one author declared a potential conflict of interest (e.g., funding from industry); [±]Highest impact factor.

Figure S4. Pooled predictions of the relative reduction in HPV16 prevalence using 1) all models and 2) a subset of models that include sexual activity risk groups and assume natural immunity is moderate to high among women (≥35% acquire natural immunity and immunity last more than 10 years) (main sources of heterogeneity identified in the meta-regression analysis – see table 2 in the main manuscript).

A) Girls-Only



B) Girls&Boys



Girls-Only: Vaccination of girls only; Girls&Boys: Vaccination of girls and boys. The pooled estimates represent median and 10th, 25th, 75th, and 90th percentiles of the predictions of the models at 70 years after the introduction of vaccination. Base-case vaccine characteristics: Vaccine efficacy (VE)=100% and Duration of vaccine protection (VD)=Lifelong.

* Subset of models that include sexual activity risk groups and assume natural immunity is moderate to high among women (≥35% acquire natural immunity and immunity last more than 10 years)

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