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Supplementary appendix

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Supplementary appendix:

Impact of HPV vaccination and cervical screening on cervical cancer elimination: a comparative modelling analysis in 78 low-income and lower-middle-income countries

The Lancet (2020)

CONTENTS

Table S1: Cumulative cases averted from girls-only HPV vaccination and cervical screening, and incremental cases averted from screening in addition to vaccination

		Cumulative cases (million)		Cumulative cases averted (million)						Incremental cases prevented [vs vaccination alone]			
		Status quo		Vaccination only		Vaccination & 1 lifetime screen		Vaccination & 2 lifetime screens		Vaccination & 1 lifetime screen		Vaccination & 2 lifetime screens	
Regions	**Year**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**
ALL LMICs (N=78)													
	2030	3·86	[3·69-3·86]	0·01	[0·00-0·01]	0·01	[-0·06-0·05]	-0·02	[-0·17-0·09]	0·01	[-0·07-0·04]	-0·02	[-0·17-0·09]
	2045	11·19	[10·73-11·19]	0·44	[0·36-0·47]	1·14	[1·02-1·27]	1·62	[1·54-2·18]	0·78	[0·58-0·80]	1·26	[1·10-1·70]
	2060	21·34	[20·68-21·34]	3·18	[3·03-3·64]	5·72	[5·00-5·86]	7·61	[7·05-8·41]	2·22	[1·82-2·69]	4·58	[3·86-4·78]
	2075	34·66	[34·04-34·66]	10·68	[10·61-11·93]	15·23	[13·35-15·35]	18·29	[16·54-19·12]	3·42	[2·67-4·62]	7·19	[5·85-7·69]
	2090	51·27	[51·04-51·28]	23·88	[23·70-25·54]	30·00	[26·96-30·02]	33·58	[30·83-34·40]	4·46	[3·26-6·14]	8·86	[7·14-9·69]
	2105	70·99	[70·99-71·55]	40·95	[40·87-42·91]	48·47	[44·66-48·59]	52·45	[49·14-53·35]	5·56	[3·79-7·64]	10·43	[8·27-11·50]
	2120	93·50	[93·50-95·25]	60·99	[60·45-62·95]	69·72	[65·31-69·82]	74·12	[70·44-75·09]	6·77	[4·32-9·37]	12·14	[9·45-13·67]
World Bank income levels													
LIC (n=34)	2030	0·90	[0·90-0·97]	0·00	[0·00-0·00]	0·00	[-0·02-0·01]	-0·01	[-0·05-0·02]	0·00	[-0·02-0·01]	-0·01	[-0·05-0·02]
	2045	2·83	[2·83-3·10]	0·18	[0·16-0·20]	0·38	[0·38-0·42]	0·52	[0·49-0·65]	0·22	[0·19-0·24]	0·33	[0·33-0·47]
	2060	5·95	[5·95-6·55]	1·28	[1·17-1·31]	1·99	[1·92-2·01]	2·52	[2·49-2·71]	0·73	[0·61-0·82]	1·32	[1·21-1·43]
	2075	10·61	[10·61-11·75]	4·30	[4·05-4·39]	5·49	[5·32-5·53]	6·39	[6·29-6·58]	1·19	[0·93-1·48]	2·27	[1·90-2·34]
	2090	17·04	[17·04-18·93]	9·62	[9·27-9·92]	11·22	[11·11-11·33]	12·35	[12·35-12·54]	1·60	[1·19-2·06]	2·92	[2·43-3·09]
	2105	25·22	[25·22-28·09]	16·87	[16·35-17·52]	18·96	[18·91-19·04]	20·42	[20·19-20·46]	2·04	[1·44-2·69]	3·55	[2·94-3·83]
	2120	35·02	[35·02-39·07]	25·68	[24·85-26·77]	28·30	[28·20-28·46]	29·91	[29·62-30·26]	2·52	[1·69-3·45]	4·23	[3·50-4·78]
Lower MIC (n=44)	2030	2·96	[2·73-2·96]	0·00	[0·00-0·00]	0·01	[-0·05-0·03]	-0·02	[-0·12-0·07]	0·01	[-0·05-0·03]	-0·01	[-0·13-0·07]
	2045	8·36	[7·63-8·36]	0·25	[0·20-0·29]	0·76	[0·64-0·85]	1·13	[1·01-1·53]	0·56	[0·39-0·56]	0·93	[0·77-1·24]
	2060	15·40	[14·13-15·40]	1·87	[1·85-2·36]	3·72	[3·08-3·85]	5·11	[4·53-5·71]	1·49	[1·20-1·87]	3·26	[2·65-3·35]
	2075	24·05	[22·29-24·05]	6·56	[6·30-7·62]	9·70	[8·04-9·86]	11·91	[10·24-12·54]	2·24	[1·74-3·14]	4·92	[3·95-5·35]
	2090	34·24	[32·11-34·24]	14·62	[13·78-15·92]	18·69	[15·85-18·77]	21·22	[18·49-21·86]	2·85	[2·07-4·08]	5·94	[4·71-6·61]
	2105	45·77	[43·47-45·77]	24·59	[23·35-26·05]	29·54	[25·70-29·56]	32·26	[28·68-32·93]	3·51	[2·35-4·95]	6·89	[5·33-7·67]
	2120	58·48	[56·18-58·48]	35·60	[34·23-37·27]	41·51	[36·85-41·53]	44·50	[40·18-45·19]	4·24	[2·63-5·92]	7·92	[5·95-8·90]
World Bank regions													
East Asia & Pacific (n=12)	2030	0·71	[0·64-0·71]	0·00	[0·00-0·00]	0·01	[-0·01-0·01]	0·00	[-0·03-0·02]	0·00	[-0·01-0·01]	-0·01	[-0·03-0·02]
	2045	1·93	[1·71-1·93]	0·05	[0·04-0·06]	0·16	[0·14-0·19]	0·24	[0·23-0·35]	0·12	[0·08-0·13]	0·20	[0·18-0·28]
	2060	3·37	[2·96-3·37]	0·37	[0·36-0·47]	0·76	[0·61-0·81]	1·05	[0·93-1·20]	0·34	[0·26-0·38]	0·67	[0·57-0·73]
	2075	4·95	[4·34-4·95]	1·22	[1·10-1·41]	1·84	[1·45-1·90]	2·29	[1·90-2·44]	0·50	[0·36-0·62]	1·03	[0·81-1·07]
	2090	6·59	[5·77-6·59]	2·49	[2·18-2·72]	3·28	[2·59-3·33]	3·79	[3·10-3·93]	0·61	[0·41-0·79]	1·21	[1·92-1·29]
	2105	8·23	[7·21-8·23]	3·92	[3·41-4·15]	4·83	[3·85-4·86]	5·36	[4·41-5·51]	0·71	[0·44-0·91]	1·35	[1·00-1·44]
	2120	9·86	[8·62-9·86]	5·34	[4·64-5·58]	6·37	[5·12-6·39]	6·93	[5·71-7·07]	0·80	[0·47-1·02]	1·49	[1·06-1·59]

		Cumulative cases (million)		Cumulative cases averted (million)						Incremental cases prevented [vs vaccination alone]			
		Status quo		Vaccination only		Vaccination & 1 lifetime screen		Vaccination & 2 lifetime screens		Vaccination & 1 lifetime screen		Vaccination & 2 lifetime screens	
Regions	**Year**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**
Europe & Central Asia (n=6)	2030	0·10	[0·10-0·10]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]
	2045	0·25	[0·24-0·25]	0·01	[0·01-0·01]	0·02	[0·02-0·03]	0·03	[0·03-0·04]	0·01	[0·01-0·02]	0·02	[0·02-0·03]
	2060	0·39	[0·37-0·39]	0·05	[0·05-0·06]	0·09	[0·08-0·10]	0·12	[0·11-0·13]	0·03	[0·03-0·04]	0·07	[0·06-0·07]
	2075	0·53	[0·50-0·53]	0·14	[0·13-0·16]	0·19	[0·16-0·20]	0·23	[0·21-0·25]	0·04	[0·04-0·06]	0·09	[0·08-0·09]
	2090	0·66	[0·62-0·66]	0·25	[0·23-0·28]	0·31	[0·27-0·32]	0·35	[0·31-0·37]	0·04	[0·04-0·07]	0·09	[0·09-0·11]
	2105	0·79	[0·74-0·79]	0·36	[0·33-0·39]	0·43	[0·37-0·44]	0·48	[0·42-0·49]	0·05	[0·04-0·07]	0·10	[0·09-0·12]
	2120	0·91	[0·85-0·91]	0·47	[0·43-0·50]	0·55	[0·47-0·56]	0·59	[0·53-0·61]	0·05	[0·04-0·08]	0·11	[0·10-0·13]
Latin America & Caribbean (n=5)	2030	0·07	[0·06-0·07]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]
	2045	0·18	[0·16-0·18]	0·01	[0·01-0·01]	0·02	[0·02-0·03]	0·03	[0·02-0·04]	0·01	[0·01-0·01]	0·02	[0·01-0·03]
	2060	0·34	[0·29-0·34]	0·05	[0·05-0·06]	0·09	[0·07-0·10]	0·12	[0·09-0·13]	0·04	[0·02-0·04]	0·07	[0·05-0·07]
	2075	0·51	[0·44-0·51]	0·14	[0·12-0·16]	0·21	[0·15-0·22]	0·26	[0·19-0·26]	0·05	[0·03-0·07]	0·09	[0·07-0·11]
	2090	0·69	[0·60-0·69]	0·29	[0·23-0·31]	0·37	[0·27-0·38]	0·42	[0·30-0·43]	0·06	[0·04-0·09]	0·11	[0·08-0·14]
	2105	0·87	[0·75-0·87]	0·44	[0·35-0·47]	0·53	[0·39-0·55]	0·59	[0·44-0·60]	0·07	[0·04-0·11]	0·12	[0·09-0·16]
	2120	1·04	[0·90-1·04]	0·59	[0·48-0·62]	0·70	[0·52-0·71]	0·75	[0·57-0·77]	0·07	[0·05-0·12]	0·13	[0·09-0·17]
Middle East & North Africa (n=7)	2030	0·07	[0·06-0·07]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]	0·00	[0·00-0·00]
	2045	0·20	[0·17-0·20]	0·00	[0·00-0·01]	0·01	[0·01-0·02]	0·02	[0·02-0·03]	0·01	[0·01-0·01]	0·02	[0·01-0·03]
	2060	0·37	[0·31-0·37]	0·03	[0·03-0·05]	0·07	[0·05-0·07]	0·10	[0·08-0·11]	0·03	[0·02-0·04]	0·07	[0·05-0·07]
	2075	0·57	[0·48-0·57]	0·12	[0·10-0·15]	0·19	[0·12-0·19]	0·25	[0·17-0·25]	0·04	[0·03-0·07]	0·10	[0·07-0·13]
	2090	0·78	[0·66-0·78]	0·28	[0·22-0·33]	0·37	[0·25-0·37]	0·44	[0·30-0·44]	0·04	[0·03-0·09]	0·11	[0·09-0·16]
	2105	1·02	[0·85-1·02]	0·48	[0·37-0·54]	0·59	[0·41-0·59]	0·66	[0·47-0·66]	0·05	[0·04-0·11]	0·12	[0·09-0·18]
	2120	1·25	[1·05-1·25]	0·68	[0·54-0·76]	0·81	[0·58-0·81]	0·89	[0·64-0·89]	0·05	[0·04-0·12]	0·13	[0·10-0·20]
South Asia (n=7)	2030	1·52	[1·31-1·52]	0·00	[0·00-0·0]	0·00	[-0·03-0·02]	-0·01	[-0·07-0·04]	0·01	[-0·03-0·01]	-0·01	[-0·07-0·06]
	2045	4·22	[3·55-4·22]	0·11	[0·08-0·14]	0·38	[0·28-0·41]	0·56	[0·44-0·75]	0·27	[0·18-0·29]	0·48	[0·34-0·68]
	2060	7·54	[6·31-7·54]	0·82	[0·77-1·11]	1·70	[1·28-1·74]	2·36	[1·93-2·64]	0·62	[0·51-0·88]	1·53	[1·15-1·54]
	2075	11·22	[9·35-11·22]	2·74	[2·34-3·33]	4·09	[3·04-4·16]	5·11	[4·01-5·44]	0·84	[0·69-1·34]	2·12	[1·67-2·37]
	2090	15·00	[12·48-15·00]	5·72	[4·66-6·44]	7·35	[5·45-7·41]	8·50	[6·59-8·83]	0·97	[0·79-1·63]	2·40	[1·92-2·78]
	2105	18·70	[15·55-18·70]	8·99	[7·29-9·83]	10·82	[8·14-10·91]	12·04	[9·37-12·40]	1·08	[0·85-1·83]	2·57	[2·07-3·05]
	2120	22·25	[18·49-22·25]	12·17	[9·89-13·13]	14·19	[10·79-14·31]	15·47	[12·08-15·85]	1·18	[0·90-2·02]	2·72	[2·19-3·30]

		Cumulative cases (million)		Cumulative cases averted (million)						Incremental cases prevented [vs vaccination alone]			
		Status quo		Vaccination only		Vaccination & 1 lifetime screen		Vaccination & 2 lifetime screens		Vaccination & 1 lifetime screen		Vaccination & 2 lifetime screens	
Regions	**Year**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**	**Median**	**[min-max]**
Sub-Saharan Africa (n=41)	2030	1·39	[1·39-1·52]	0·00	[0·00-0·00]	0·00	[-0·03-0·02]	-0·01	[-0·07-0·03]	0·00	[-0·03-0·02]	-0·01	[-0·07-0·03]
	2045	4·40	[4·40-4·90]	0·24	[0·21-0·26]	0·56	[0·55-0·60]	0·79	[0·73-0·97]	0·34	[0·30-0·36]	0·53	[0·52-0·73]
	2060	9·33	[9·33-10·44]	1·89	[1·69-1·93]	3·01	[2·92-3·05]	3·92	[3·86-4·20]	1·16	[0·99-1·31]	2·16	[1·99-2·31]
	2075	16·89	[16·89-18·93]	6·72	[6·25-6·90]	8·68	[8·43-8·70]	10·16	[10·06-10·49]	1·96	[1·52-2·46]	3·77	[3·16-3·91]
	2090	27·55	[27·55-30·91]	15·48	[14·86-16·19]	18·21	[18·14-18·34]	20·23	[20·07-20·41]	2·73	[1·95-3·48]	4·94	[4·04-5·22]
	2105	41·39	[41·39-46·46]	27·54	[26·76-29·12]	31·37	[31·14-31·49]	33·71	[33·31-34·04]	3·60	[2·38-4·61]	6·17	[4·93-6·56]
	2120	58·18	[58·18-65·34]	42·35	[41·20-45·01]	47·20	[46·95-47·84]	49·92	[49·48-50·92]	4·60	[2·82-6·00]	7·57	[5·91-8·28]

LIC: Low Income Countries

Lower MIC: Lower Middle Income Countries

Median prediction from the 3 models. Range=minimum and maximum estimates from the 3 models. Vaccination coverage=90% at age 9 years (and at ages 10-14 years in 2020), Vaccine efficacy=100% against HPV16/18/31/33/45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake=45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen and Treat efficacy=100%, Lost to follow-up=10%.

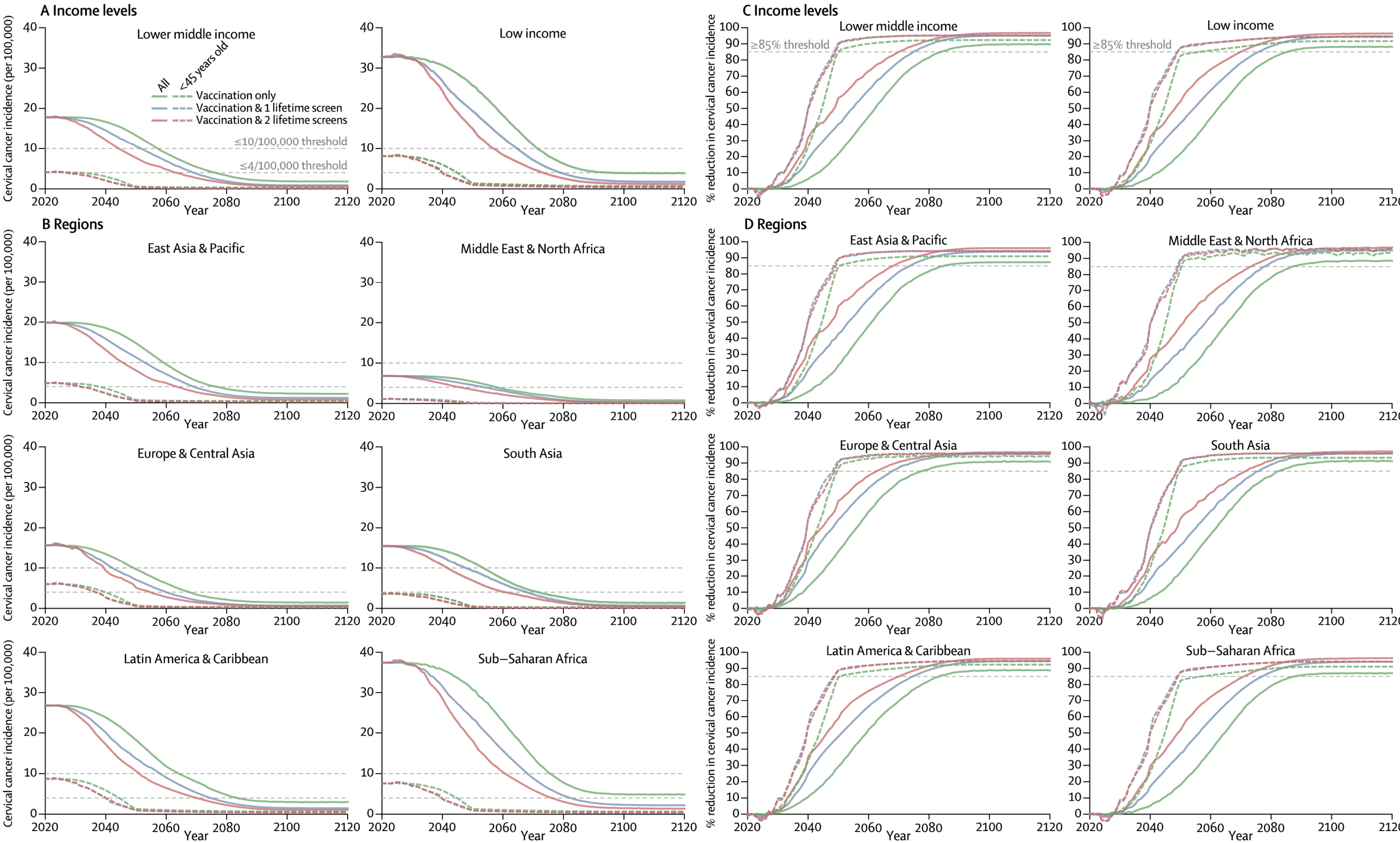

Figure S1: Dynamics of elimination, by income level, region and age (ALL vs ≤45 years). The average age-standardised cervical cancer incidence per 100,000 women-years, by (A) World Bank income level and (B) region, and the relative reduction in incidence after HPV vaccination and screening ramp-up, by (C) World Bank income level and (D) region. Median prediction from the 3 models. Vaccination coverage=90% at age 9 years (and at ages 10-14 years in 2020), Vaccine efficacy=100% against HPV16/18/31/33/45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake= 45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen & Treat efficacy =100%, Lost to follow-up=10%.

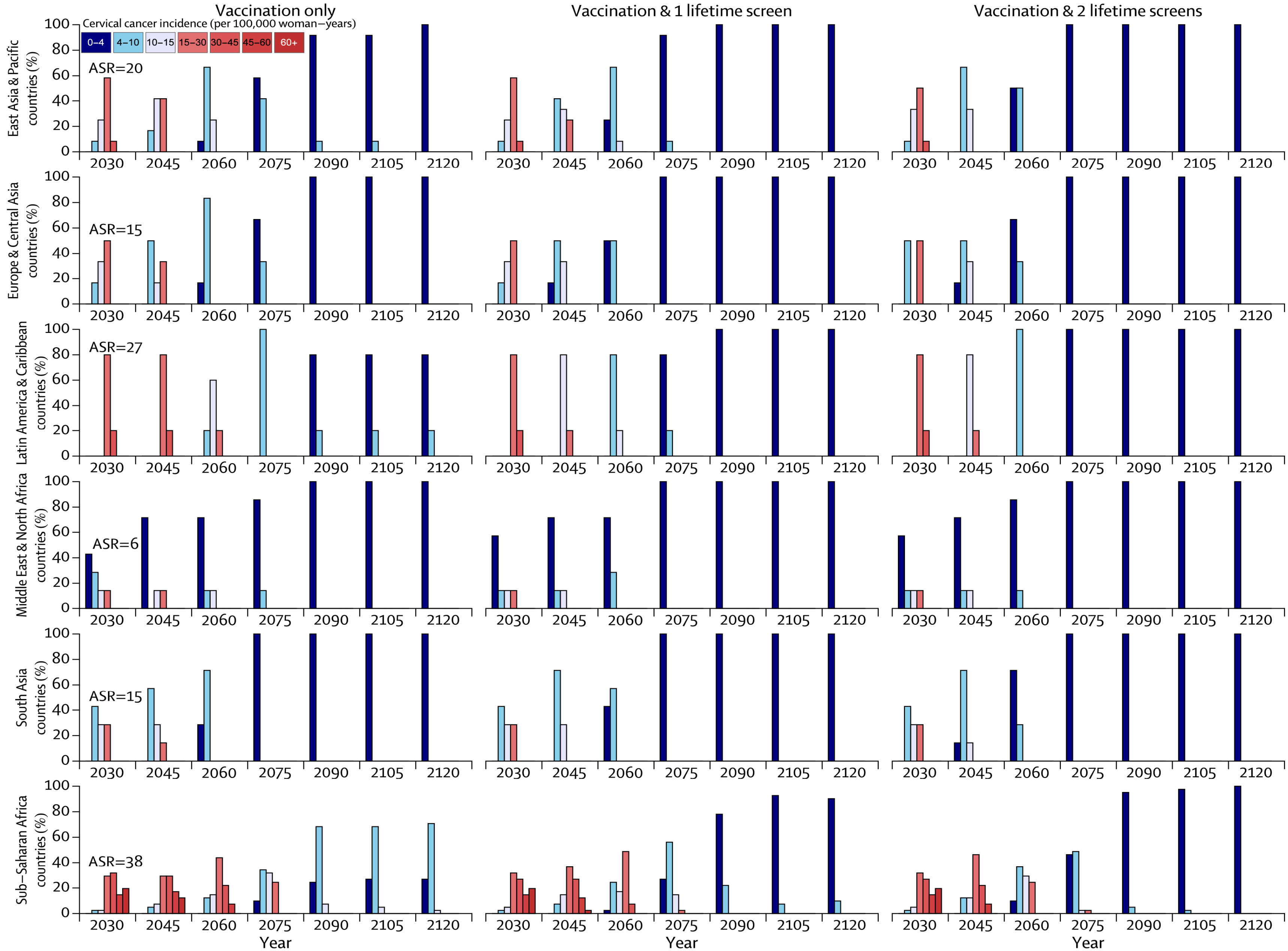

Figure S2: Change in the distribution of the country-specific age-standardised cervical cancer incidence over time, by region. Median prediction from the 3 models: Vaccination coverage=90% at age 9 years (and at ages 10-14 years in 2020), Vaccine efficacy=100% against HPV16/18/31/33/45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake= 45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen & Treat efficacy efficacy=100%, Lost to follow-up=10%. ASR= Age-Standardised incidence Rate of cervical cancer.

East Asia & Pacific	HPV–ADVISE S0	HPV–ADVISE S1	HPV–ADVISE S2	HPV–ADVISE S3	HARVARD S0	HARVARD S1	HARVARD S2	HARVARD S3	POLICY1 S0	POLICY1 S1	POLICY1 S2	POLICY1 S3	MEDIAN OF MODELS S0	MEDIAN OF MODELS S1	MEDIAN OF MODELS S2	MEDIAN OF MODELS S3
Cambodia	15.57	1.43	0.68	0.45	15.57	1.09	0.59	0.40	13.58	1.72	1.34	1.02	15.57	1.43	0.68	0.45
Indonesia	26.46	3.21	1.34	0.92	26.46	3.99	1.88	1.15	23.09	2.93	2.24	1.70	26.46	3.21	1.88	1.15
Korea Democratic People's Republic	12.44	0.95	0.47	0.36	12.43	0.73	0.46	0.33	10.85	1.42	1.08	0.92	12.43	0.95	0.47	0.36
Lao People's Democratic Republic	12.74	1.13	0.53	0.37	12.74	0.90	0.48	0.34	11.12	1.42	1.09	0.85	12.74	1.13	0.53	0.37
Mongolia	26.13	2.23	1.07	0.74	26.13	3.81	1.83	1.16	22.33	2.86	2.20	1.72	26.13	2.86	1.83	1.16
Myanmar	24.15	2.45	1.05	0.82	24.15	3.37	1.66	1.14	21.07	2.76	2.11	1.76	24.15	2.76	1.66	1.14
Papua New Guinea	32.94	3.62	1.67	1.32	32.94	4.41	2.30	1.66	28.75	3.92	3.13	2.69	32.94	3.92	2.30	1.66
Philippines	17.00	1.48	0.71	0.49	17.00	1.20	0.64	0.45	14.84	1.90	1.46	1.14	17.00	1.48	0.71	0.49
Solomon Islands	23.48	2.04	0.98	0.79	23.48	3.23	1.67	1.21	20.49	2.79	2.22	1.91	23.48	2.79	1.67	1.21
Timor–Leste	12.95	1.08	0.50	0.34	12.95	1.94	0.88	0.55	11.30	1.41	1.01	0.77	12.95	1.41	0.88	0.55
Vanuatu	16.92	1.19	0.59	0.47	16.92	0.93	0.58	0.42	14.76	1.96	1.38	1.19	16.92	1.19	0.59	0.47
Vietnam	8.00	0.72	0.35	0.25	8.00	0.57	0.31	0.22	6.98	0.92	0.71	0.56	8.00	0.72	0.35	0.25

Europe & Central Asia	HPV–ADVISE S0	HPV–ADVISE S1	HPV–ADVISE S2	HPV–ADVISE S3	HARVARD S0	HARVARD S1	HARVARD S2	HARVARD S3	POLICY1 S0	POLICY1 S1	POLICY1 S2	POLICY1 S3	MEDIAN OF MODELS S0	MEDIAN OF MODELS S1	MEDIAN OF MODELS S2	MEDIAN OF MODELS S3
Georgia	10.75	0.87	0.42	0.30	10.75	0.67	0.43	0.29	9.18	1.01	0.77	0.62	10.75	0.87	0.43	0.30
Kyrgyz Republic	22.09	1.75	0.87	0.64	22.09	3.09	1.55	1.06	19.28	2.19	1.71	1.42	22.09	2.19	1.55	1.06
Moldova	23.64	2.68	1.21	0.97	23.64	3.21	1.69	1.23	22.44	2.65	2.13	1.82	23.64	2.72	1.69	1.23
Tajikistan	6.14	0.46	0.22	0.17	6.14	0.35	0.22	0.16	5.36	0.60	0.45	0.38	6.14	0.46	0.23	0.17
Ukraine	18.85	1.68	0.79	0.65	18.85	1.12	0.75	0.56	18.75	2.24	1.76	1.53	18.85	1.68	0.79	0.65
Uzbekistan	11.02	0.92	0.43	0.31	11.02	0.78	0.41	0.29	9.62	1.05	0.77	0.60	11.02	0.92	0.43	0.31

Latin America & Caribbean	HPV–ADVISE S0	HPV–ADVISE S1	HPV–ADVISE S2	HPV–ADVISE S3	HARVARD S0	HARVARD S1	HARVARD S2	HARVARD S3	POLICY1 S0	POLICY1 S1	POLICY1 S2	POLICY1 S3	MEDIAN OF MODELS S0	MEDIAN OF MODELS S1	MEDIAN OF MODELS S2	MEDIAN OF MODELS S3
Bolivia	42.59	4.61	1.91	1.49	42.59	4.03	2.10	1.54	36.78	5.69	4.42	3.71	42.59	4.61	2.10	1.54
El Salvador	21.92	2.33	1.06	0.78	21.92	1.48	1.07	0.82	18.93	3.13	2.70	2.37	21.92	2.33	1.07	0.82
Haiti	20.15	2.36	1.03	0.76	20.15	1.41	1.00	0.74	17.40	2.87	2.48	2.15	20.15	2.36	1.03	0.77
Honduras	22.15	2.39	1.07	0.77	22.15	3.09	1.55	1.05	19.13	3.02	2.44	2.07	22.15	3.02	1.55	1.05
Nicaragua	24.07	3.00	1.28	0.97	24.07	3.31	1.72	1.19	20.78	3.34	2.78	2.40	24.07	3.31	1.72	1.19

Middle East & North Africa	HPV–ADVISE S0	HPV–ADVISE S1	HPV–ADVISE S2	HPV–ADVISE S3	HARVARD S0	HARVARD S1	HARVARD S2	HARVARD S3	POLICY1 S0	POLICY1 S1	POLICY1 S2	POLICY1 S3	MEDIAN OF MODELS S0	MEDIAN OF MODELS S1	MEDIAN OF MODELS S2	MEDIAN OF MODELS S3
Arab Rebuplic of Egypt	2.68	0.27	0.13	0.09	2.68	0.21	0.14	0.10	2.24	0.36	0.31	0.25	2.68	0.27	0.14	0.10
Djibouti	13.77	1.57	0.63	0.44	13.77	0.98	0.51	0.34	11.52	1.68	1.35	1.05	13.77	1.57	0.63	0.44
Morocco	19.71	2.42	1.01	0.66	19.71	1.38	0.74	0.49	16.48	2.43	1.98	1.55	19.71	2.41	1.01	0.66
Republic of Yemen	1.96	0.18	0.10	0.08	1.96	0.13	0.09	0.06	1.64	0.29	0.24	0.21	1.96	0.18	0.10	0.08
Syrian Arab Rebuplic	4.06	0.36	0.18	0.12	4.06	0.27	0.18	0.13	3.40	0.51	0.42	0.35	4.06	0.36	0.18	0.13
Tunisia	4.46	0.42	0.20	0.13	4.46	0.32	0.17	0.11	3.73	0.56	0.46	0.36	4.46	0.42	0.20	0.13
West Bank and Gaza	2.80	0.35	0.15	0.1	2.80	0.19	0.13	0.10	2.34	0.35	0.29	0.25	2.80	0.35	0.15	0.10

South Asia	HPV–ADVISE S0	HPV–ADVISE S1	HPV–ADVISE S2	HPV–ADVISE S3	HARVARD S0	HARVARD S1	HARVARD S2	HARVARD S3	POLICY1 S0	POLICY1 S1	POLICY1 S2	POLICY1 S3	MEDIAN OF MODELS S0	MEDIAN OF MODELS S1	MEDIAN OF MODELS S2	MEDIAN OF MODELS S3
Afghanistan	7.31	0.58	0.28	0.20	7.31	0.46	0.29	0.19	6.38	0.76	0.59	0.47	7.31	0.58	0.29	0.20
Bangladesh	11.89	1.00	0.47	0.33	11.89	0.84	0.44	0.31	10.37	1.22	0.95	0.73	11.89	1.00	0.47	0.33
Bhutan	14.65	1.19	0.55	0.37	14.65	1.05	0.54	0.37	12.79	1.49	1.11	0.83	14.65	1.19	0.55	0.37
India	16.84	1.48	0.71	0.48	16.84	1.18	0.63	0.44	13.79	1.62	1.28	0.99	16.84	1.48	0.71	0.48
Nepal	23.56	1.79	0.83	0.60	23.56	3.46	1.60	1.03	20.56	2.42	1.80	1.41	23.56	2.42	1.60	1.03
Pakistan	8.18	0.69	0.33	0.22	8.19	0.58	0.30	0.21	7.14	0.83	0.64	0.48	8.18	0.69	0.33	0.22
Sri Lanka	8.98	0.84	0.40	0.26	8.98	0.63	0.33	0.22	7.67	0.88	0.69	0.51	8.98	0.84	0.40	0.26

Sub–Saharan Africa	HPV–ADVISE S0	HPV–ADVISE S1	HPV–ADVISE S2	HPV–ADVISE S3	HARVARD S0	HARVARD S1	HARVARD S2	HARVARD S3	POLICY1 S0	POLICY1 S1	POLICY1 S2	POLICY1 S3	MEDIAN OF MODELS S0	MEDIAN OF MODELS S1	MEDIAN OF MODELS S2	MEDIAN OF MODELS S3
Angola	41.94	5.72	2.34	1.54	41.94	6.17	3.01	1.82	47.23	7.46	6.25	5.00	41.94	6.17	3.01	1.82
Benin	28.40	4.43	1.69	1.15	28.40	1.95	1.12	0.71	31.99	5.09	4.42	3.42	28.40	4.43	1.69	1.15
Burkina Faso	51.06	6.71	2.78	1.91	51.06	4.92	2.48	1.59	57.50	9.17	7.48	5.99	51.06	6.71	2.78	1.91
Burundi	65.10	8.00	3.46	2.45	65.10	6.23	3.24	2.17	73.31	11.92	9.79	8.02	65.10	8.00	3.46	2.45
Cabo Verde	20.88	2.29	0.98	0.73	20.88	1.36	0.91	0.62	23.52	3.80	3.17	2.68	20.88	2.29	0.98	0.73
Cameroon	34.91	4.36	1.76	1.30	34.91	5.10	2.44	1.56	39.31	6.32	5.01	4.12	34.91	5.10	2.44	1.56
Central African Republic	21.27	2.84	1.09	0.76	21.27	3.20	1.51	0.92	23.95	3.80	3.05	2.43	21.27	3.20	1.51	0.92
Chad	21.30	2.88	1.13	0.80	21.30	3.24	1.52	0.92	23.99	3.81	3.04	2.42	21.30	3.24	1.52	0.92
Comoros	55.65	6.16	2.76	1.99	55.65	5.36	2.76	1.86	62.68	10.14	8.23	6.74	55.65	6.16	2.77	1.99
Côte d'Ivoire	32.88	5.07	1.91	1.23	32.88	5.13	2.41	1.34	37.03	5.72	4.73	3.61	32.88	5.13	2.41	1.34
Democratic Republic of the Congo	28.21	3.42	1.36	0.93	28.21	4.30	2.03	1.19	31.77	5.00	4.07	3.19	28.21	4.30	2.03	1.19
Eritrea	15.07	1.71	0.69	0.49	15.07	1.07	0.56	0.38	16.98	2.69	2.14	1.71	15.07	1.71	0.69	0.49
Ethiopia	21.23	2.42	1.01	0.69	21.23	3.21	1.49	0.91	23.91	3.79	2.97	2.36	21.23	3.21	1.49	0.91
Ghana	37.32	5.61	2.10	1.35	37.32	5.92	2.73	1.51	42.03	6.50	5.27	3.98	37.32	5.92	2.73	1.51
Guinea	52.15	7.00	2.89	1.95	52.15	4.96	2.50	1.58	58.73	9.33	7.69	6.15	52.15	7.00	2.89	1.95
Guinea–Bissau	35.69	5.12	2.00	1.36	35.69	5.38	2.57	1.53	40.19	6.33	5.17	4.11	35.69	5.38	2.57	1.53
Kenya	38.31	4.98	2.04	1.41	38.31	3.66	1.81	1.16	43.15	6.87	5.51	4.41	38.31	4.98	2.04	1.41
Lesotho	62.38	7.39	3.28	2.41	62.38	5.55	3.10	2.16	70.26	11.52	9.91	8.42	62.38	7.39	3.28	2.41
Liberia	42.15	6.01	2.32	1.58	42.15	4.05	2.01	1.22	47.47	7.48	6.15	4.84	42.15	6.01	2.32	1.58
Madagascar	58.92	6.95	3.02	2.19	58.92	5.64	2.95	1.97	66.35	10.80	8.92	7.32	58.92	6.95	3.02	2.19
Malawi	80.53	9.20	4.09	3.09	80.53	7.78	4.05	2.88	90.69	14.92	11.94	9.97	80.53	9.20	4.10	3.09
Mali	48.83	6.03	2.53	1.75	48.83	4.77	2.36	1.50	55.00	8.74	7.01	5.57	48.83	6.03	2.53	1.75
Mauritania	37.84	5.56	2.18	1.48	37.84	5.56	2.71	1.63	42.62	6.75	5.63	4.49	37.84	5.58	2.71	1.63
Mozambique	49.36	5.92	2.72	2.04	49.36	4.63	2.56	1.85	55.58	9.25	7.73	6.59	49.36	5.92	2.72	2.04
Niger	10.52	1.29	0.54	0.37	10.52	0.75	0.40	0.27	11.85	1.90	1.55	1.24	10.52	1.29	0.54	0.37
Nigeria	30.35	4.56	1.75	1.14	30.35	4.82	2.20	1.25	34.18	5.33	4.27	3.27	30.35	4.82	2.20	1.25
Republic of the Congo	19.80	2.95	1.09	0.70	19.80	1.39	0.74	0.45	22.30	3.44	2.82	2.11	19.80	2.95	1.09	0.70
Rwanda	35.80	4.98	1.97	1.37	35.80	5.40	2.57	1.56	40.32	6.41	5.21	4.16	35.80	5.40	2.57	1.56
São Tomé and Príncipe	16.93	1.27	0.64	0.51	16.93	0.84	0.54	0.42	14.16	2.32	1.80	1.74	16.93	1.27	0.64	0.51
Senegal	42.88	6.18	2.39	1.61	42.88	4.15	2.04	1.24	48.30	7.59	6.18	4.84	42.88	6.18	2.39	1.61
Sierra Leone	15.26	1.74	0.73	0.50	15.26	1.07	0.57	0.39	17.19	2.71	2.22	1.76	15.26	1.74	0.73	0.50
Somalia	26.81	3.48	1.37	0.98	26.81	3.98	1.89	1.17	30.19	4.82	3.84	3.09	26.81	3.98	1.89	1.17
South Sudan	30.46	4.13	1.66	1.18	30.46	4.48	2.18	1.37	34.31	5.54	4.52	3.69	30.46	4.48	2.18	1.37
Sudan	9.12	0.84	0.39	0.25	9.12	0.64	0.33	0.22	7.63	1.19	0.95	0.73	9.12	0.84	0.39	0.25
Swaziland	90.23	11.28	5.04	3.62	90.22	7.96	4.47	3.10	101.61	16.64	14.37	12.21	90.23	11.28	5.04	3.62
Tanzania	67.17	8.57	3.52	2.36	67.17	6.51	3.19	1.95	75.65	12.01	9.72	7.63	67.17	8.57	3.52	2.36
The Gambia	32.00	4.13	1.75	1.32	31.99	4.41	2.23	1.50	36.04	5.94	4.94	4.19	32.00	4.41	2.23	1.50
Togo	27.42	3.92	1.53	1.04	27.42	4.04	1.96	1.18	30.88	4.88	4.06	3.23	27.42	4.04	1.96	1.18
Uganda	62.48	6.84	3.19	2.37	62.48	5.88	3.16	2.23	70.36	11.58	9.62	8.10	62.48	6.84	3.20	2.37
Zambia	76.61	9.93	4.16	2.79	76.61	7.29	3.68	2.29	86.28	13.62	11.37	9.08	76.61	9.93	4.16	2.79
Zimbabwe	72.49	9.28	3.95	2.70	72.49	6.79	3.50	2.25	81.64	13.01	10.90	8.87	72.49	9.28	3.95	2.70

Incidence at equilibrium (per 100,000) (≤ 4/100,000): S0: Status quo; S1: Vaccination only; S2: Vaccination & 1 lifetime screen; S3: Vaccination & 2 lifetime screens

Figure S3: Predicted age-standardised incidence of cervical cancer at equilibrium (2110-2120), by country for the three CCEMC models. No highlighted color denotes the country does not achieve elimination (≤4/100,000 threshold). Vaccination coverage=90% at age 9 years (and at ages 10-14 years in 2020), Vaccine efficacy=100% against HPV16/18/31/33/ 45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake= 45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen & Treat efficacy=100%, Lost to follow-up=10%. ASR= Age-Standardised incidence Rate of cervical cancer.

East Asia & Pacific	HPV–ADVISE				HARVARD				POLICY1				MEDIAN OF MODELS			
	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
Cambodia	X	2077	2070	2064	X	2073	2070	2064	X	2076	2072	2065	X	2076	2070	2064
Indonesia	X	2087	2075	2069	X	2101	2075	2069	X	2085	2079	2074	X	2087	2075	2069
Korea Democratic People's Republic	X	2063	2057	2053	X	2060	2056	2051	X	2062	2057	2050	X	2062	2057	2051
Lao People's Democratic Republic	X	2071	2065	2059	X	2068	2065	2057	X	2070	2066	2056	X	2070	2065	2057
Mongolia	X	2082	2075	2070	X	2092	2075	2068	X	2085	2079	2073	X	2085	2075	2070
Myanmar	X	2079	2067	2062	X	2082	2070	2063	X	2080	2074	2068	X	2080	2070	2063
Papua New Guinea	X	2087	2074	2069	X	X	2079	2071	X	2102	2091	2085	X	2102	2079	2071
Philippines	X	2075	2069	2063	X	2072	2068	2062	X	2075	2071	2064	X	2075	2069	2063
Solomon Islands	X	2074	2065	2060	X	2076	2066	2059	X	2075	2070	2064	X	2075	2066	2060
Timor–Leste	X	2068	2062	2056	X	2068	2061	2053	X	2067	2062	2052	X	2068	2062	2053
Vanuatu	X	2067	2059	2054	X	2061	2058	2052	X	2067	2060	2050	X	2067	2059	2052
Vietnam	X	2062	2055	2049	X	2059	2055	2047	X	2059	2053	2044	X	2059	2055	2047

Europe & Central Asia	HPV–ADVISE				HARVARD				POLICY1				MEDIAN OF MODELS			
	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
Georgia	X	2064	2058	2052	X	2060	2056	2050	X	2061	2056	2050	X	2061	2056	2050
Kyrgyz Republic	X	2077	2070	2065	X	2079	2069	2063	X	2077	2072	2066	X	2077	2070	2065
Moldova	X	2078	2068	2061	X	2080	2069	2063	X	2080	2075	2069	X	2080	2069	2063
Tajikistan	X	2051	2043	2041	X	2049	2042	2039	X	2047	2040	2038	X	2049	2042	2039
Ukraine	X	2069	2061	2056	X	2064	2061	2055	X	2071	2066	2059	X	2069	2061	2056
Uzbekistan	X	2065	2059	2053	X	2062	2059	2052	X	2063	2058	2050	X	2063	2059	2052

Latin America & Caribbean	HPV–ADVISE				HARVARD				POLICY1				MEDIAN OF MODELS			
	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
Bolivia	X	X	2074	2068	X	X	2079	2073	X	X	X	2089	X	X	2079	2073
El Salvador	X	2082	2074	2069	X	2077	2075	2073	X	2092	2088	2085	X	2082	2075	2073
Haiti	X	2082	2074	2066	X	2076	2074	2071	X	2088	2084	2082	X	2082	2074	2071
Honduras	X	2079	2071	2065	X	2082	2072	2065	X	2085	2079	2074	X	2082	2072	2065
Nicaragua	X	2083	2072	2065	X	2086	2075	2069	X	2090	2084	2080	X	2086	2075	2069

Middle East & North Africa	HPV–ADVISE				HARVARD				POLICY1				MEDIAN OF MODELS			
	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
Arab Rebuplic of Egypt	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020
Djibouti	X	2072	2064	2058	X	2068	2065	2058	X	2070	2068	2061	X	2070	2065	2058
Morocco	X	2081	2073	2068	X	2076	2073	2068	X	2081	2078	2074	X	2081	2073	2068
Republic of Yemen	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020
Syrian Arab Rebuplic	X	2035	2027	2030	X	2035	2028	2028	2020	2020	2020	2020	X	2035	2027	2028
Tunisia	X	2048	2040	2035	X	2046	2039	2033	2023	2024	2025	2026	X	2046	2039	2033
West Bank and Gaza	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020	2020

South Asia	HPV–ADVISE				HARVARD				POLICY1				MEDIAN OF MODELS			
	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
Afghanistan	X	2057	2049	2045	X	2054	2048	2042	X	2053	2047	2040	X	2054	2048	2042
Bangladesh	X	2068	2062	2055	X	2064	2061	2054	X	2066	2062	2051	X	2066	2062	2054
Bhutan	X	2068	2063	2058	X	2066	2062	2055	X	2067	2063	2054	X	2067	2063	2055
India	X	2076	2070	2065	X	2072	2069	2063	X	2074	2071	2063	X	2074	2070	2063
Nepal	X	2072	2066	2062	X	2077	2066	2059	X	2072	2068	2062	X	2072	2066	2062
Pakistan	X	2062	2055	2049	X	2059	2055	2047	X	2059	2053	2046	X	2059	2055	2047
Sri Lanka	X	2068	2061	2054	X	2064	2061	2053	X	2064	2060	2050	X	2064	2061	2053

Sub–Saharan Africa	HPV–ADVISE				HARVARD				POLICY1				MEDIAN OF MODELS			
	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3	S0	S1	S2	S3
Angola	X	X	2084	2080	X	X	2088	2081	X	X	X	X	X	X	2088	2081
Benin	X	X	2080	2074	X	2086	2083	2080	X	X	X	2095	X	X	2083	2080
Burkina Faso	X	X	2086	2081	X	X	2088	2081	X	X	X	X	X	X	2088	2081
Burundi	X	X	2091	2085	X	X	2094	2085	X	X	X	X	X	X	2094	2085
Cabo Verde	X	2079	2070	2064	X	2072	2070	2066	X	2091	2083	2079	X	2079	2070	2066
Cameroon	X	X	2076	2070	X	X	2078	2071	X	X	X	X	X	X	2078	2071
Central African Republic	X	2082	2071	2065	X	2081	2072	2065	X	2096	2084	2079	X	2082	2072	2065
Chad	X	2081	2070	2064	X	2080	2071	2064	X	2092	2081	2076	X	2081	2071	2064
Comoros	X	X	2086	2082	X	X	2087	2081	X	X	X	X	X	X	2087	2082
Côte d'Ivoire	X	X	2080	2076	X	X	2082	2076	X	X	X	2093	X	X	2082	2076
Democratic Republic of the Congo	X	2088	2076	2071	X	X	2078	2072	X	X	X	2087	X	X	2078	2072
Eritrea	X	2074	2065	2059	X	2069	2067	2060	X	2079	2075	2070	X	2074	2067	2060
Ethiopia	X	2079	2071	2066	X	2080	2070	2064	X	2096	2082	2076	X	2080	2071	2066
Ghana	X	X	2081	2076	X	X	2083	2076	X	X	X	2106	X	X	2083	2076
Guinea	X	X	2086	2082	X	X	2090	2083	X	X	X	X	X	X	2090	2083
Guinea–Bissau	X	X	2080	2075	X	X	2082	2076	X	X	X	X	X	X	2082	2076
Kenya	X	X	2080	2076	X	2100	2083	2077	X	X	X	X	X	X	2083	2077
Lesotho	X	X	2091	2086	X	X	2097	2092	X	X	X	X	X	X	2097	2092
Liberia	X	X	2082	2077	X	X	2085	2080	X	X	X	X	X	X	2085	2080
Madagascar	X	X	2088	2083	X	X	2092	2085	X	X	X	X	X	X	2092	2085
Malawi	X	X	X	2088	X	X	X	2084	X	X	X	X	X	X	X	2088
Mali	X	X	2084	2079	X	X	2084	2078	X	X	X	X	X	X	2084	2079
Mauritania	X	X	2082	2077	X	X	2086	2080	X	X	X	X	X	X	2086	2080
Mozambique	X	X	2085	2081	X	X	2090	2084	X	X	X	X	X	X	2090	2084
Niger	X	2069	2061	2054	X	2065	2062	2053	X	2071	2068	2063	X	2069	2062	2054
Nigeria	X	X	2077	2072	X	X	2077	2070	X	X	X	2084	X	X	2077	2072
Republic of the Congo	X	2084	2073	2067	X	2077	2074	2069	X	2092	2086	2080	X	2084	2074	2069
Rwanda	X	X	2079	2074	X	X	2080	2074	X	X	X	X	X	X	2080	2074
São Tomé and Príncipe	X	2070	2063	2056	X	2065	2060	2055	X	2080	2069	2066	X	2070	2063	2056
Senegal	X	X	2082	2077	X	X	2084	2079	X	X	X	X	X	X	2084	2079
Sierra Leone	X	2077	2069	2062	X	2072	2070	2063	X	2083	2079	2075	X	2077	2070	2063
Somalia	X	2087	2073	2067	X	2100	2074	2068	X	X	2097	2084	X	2100	2074	2068
South Sudan	X	X	2076	2071	X	X	2078	2072	X	X	X	2094	X	X	2078	2072
Sudan	X	2067	2061	2054	X	2064	2060	2052	X	2064	2060	2050	X	2064	2060	2052
Swaziland	X	X	X	2098	X	X	X	2097	X	X	X	X	X	X	X	2098
Tanzania	X	X	2091	2086	X	X	2094	2085	X	X	X	X	X	X	2094	2086
The Gambia	X	X	2076	2070	X	X	2081	2074	X	X	X	X	X	X	2081	2074
Togo	X	2095	2077	2071	X	X	2080	2075	X	X	X	2091	X	X	2080	2075
Uganda	X	X	2089	2084	X	X	2094	2086	X	X	X	X	X	X	2094	2086
Zambia	X	X	X	2090	X	X	2102	2089	X	X	X	X	X	X	X	2090
Zimbabwe	X	X	2101	2088	X	X	2099	2089	X	X	X	X	X	X	2101	2089

Year of elimination (≤ 4/100,000) — S0: Status quo; S1: Vaccination only; S2: Vaccination & 1 lifetime screen; S3: Vaccination & 2 lifetime screens

Figure S4: Predicted year of elimination using the ≤4/100,000 women-years threshold, by country for the three CCEMC models. An X denotes the country is not predicted to achieve elimination. Vaccination coverage=90% at age 9 years (and at ages 10-14 years in 2020), Vaccine efficacy=100% against HPV16/18/31/33/45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake= 45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen & Treat efficacy=100%, Lost to follow-up=10%.

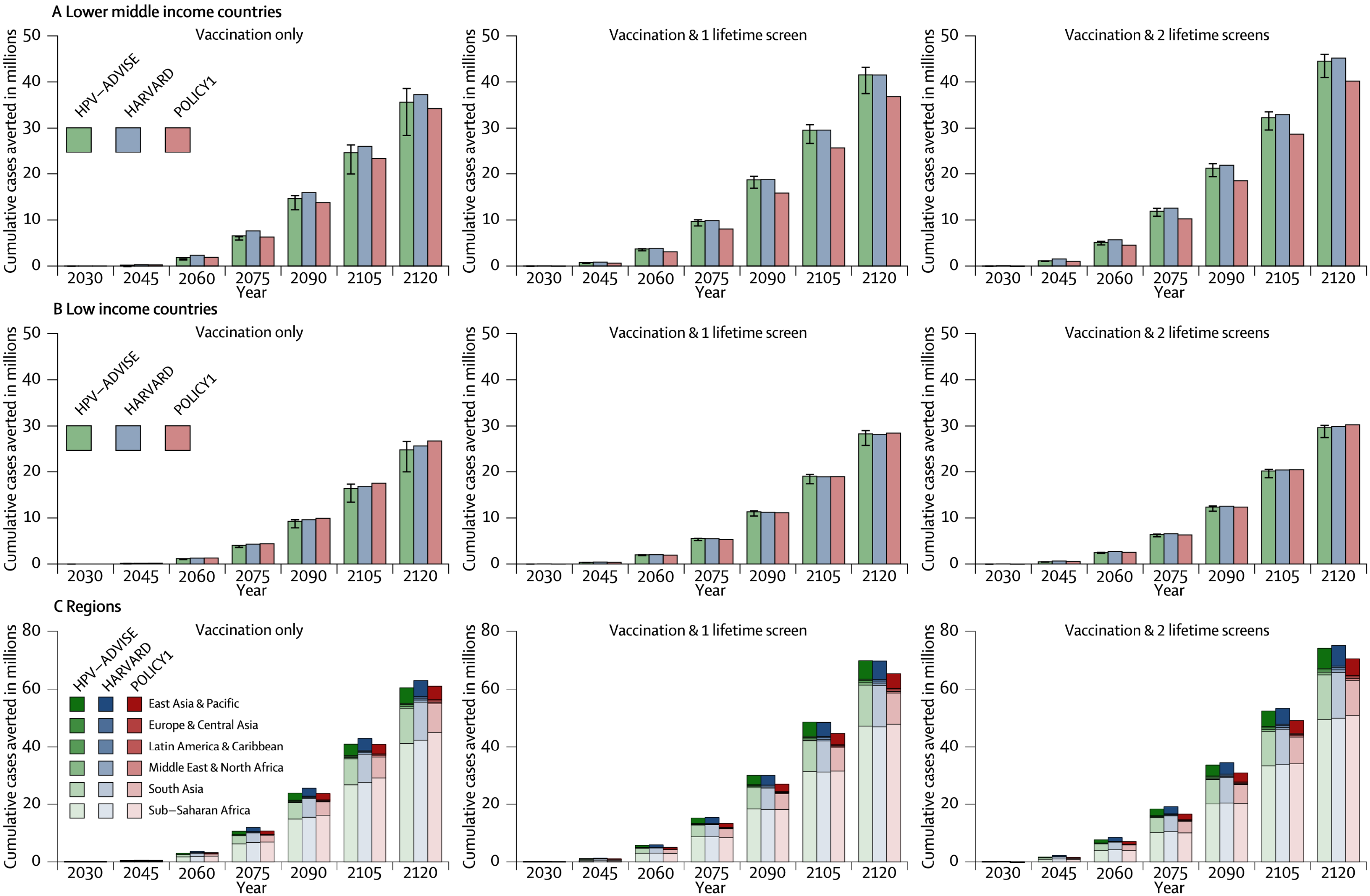

Figure S5: Variability in model predictions of cervical cancer cases averted. Cumulative cases averted by girls-only vaccination or girls-only vaccination and screening, by World Bank income level and region. Predictions from each model: Error bars represent the minimum and maximum from HPV-ADVISE (within model variability). Vaccination coverage=90%, Vaccine efficacy=100% against HPV16/18/31/33/45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake= 45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen & Treat efficacy=100%, Lost to follow-up=10%.

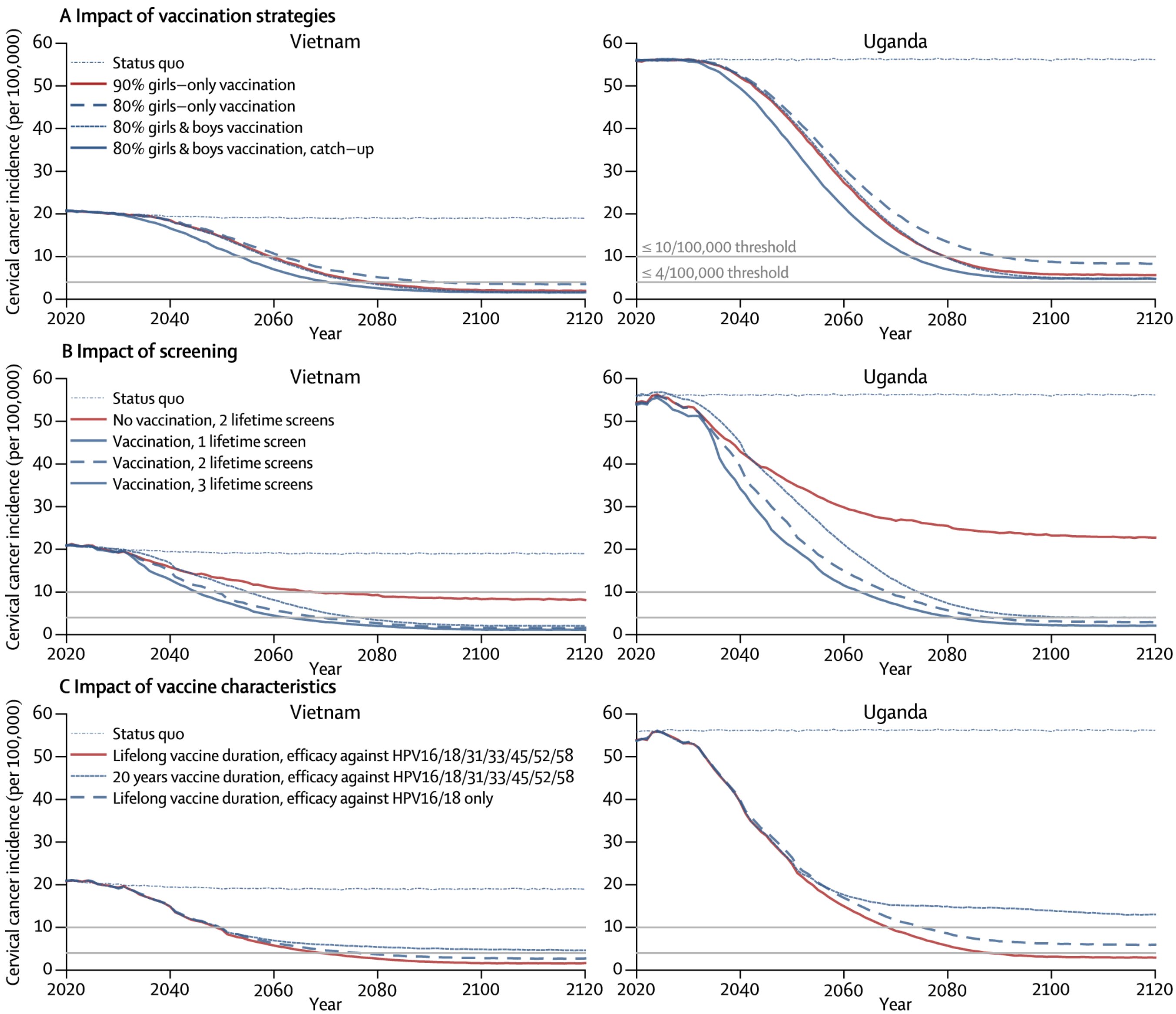

Figure S6: Sensitivity analysis of the impact of vaccination strategies, number of lifetime screens and vaccine characteristics. Average age-standardised cervical cancer incidence per 100,000 women-years in Vietnam and Uganda over time for different (A) vaccination strategies, (B) cervical cancer screening strategies, and (C) vaccine characteristics. Median prediction from the models. BASE CASE: Vaccination coverage=80% at age 9 (and at ages 10-14 years in 2020 only), Vaccine efficacy=100% against HPV16/18/31/33/45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake= 45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen & Treat efficacy=100%, Lost to follow-up=10%. Catch-up: vaccination of females aged 15-25 years in 2020 only; 3 lifetime screens were assumed to occur at ages 30, 40 and 50 years.

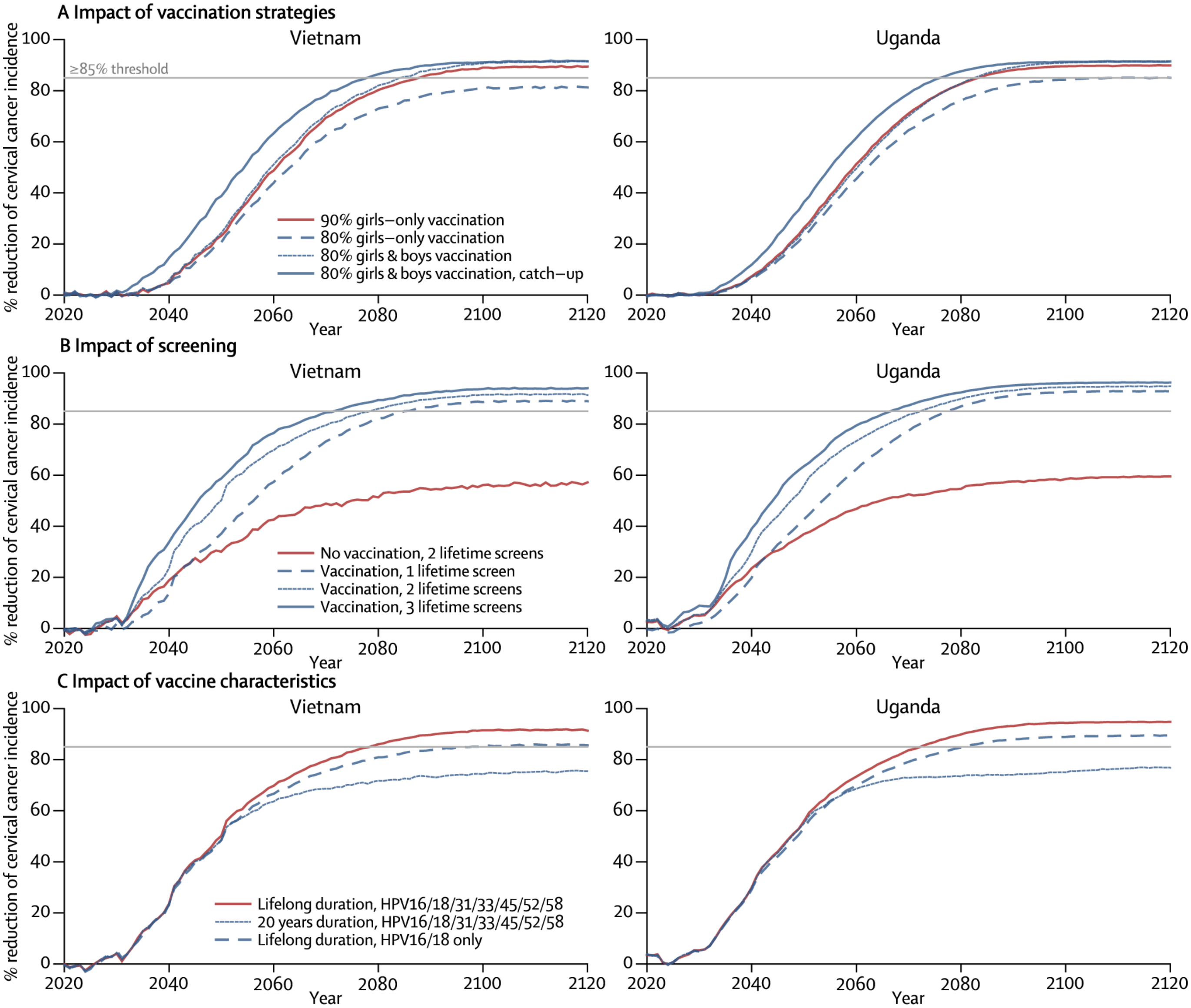

Figure S7: Sensitivity analysis of the impact of vaccination strategies, number of lifetime screens and vaccine characteristics. Percentage reduction of the average age-standardised cervical cancer incidence per 100,000 women-years in Vietnam and Uganda over time for different (A) vaccination strategies, (B) cervical cancer screening strategies, and (C) vaccine characteristics. Median prediction from the models. BASE CASE: Vaccination coverage=80% at age 9 (and at ages 10-14 years in 2020 only), Vaccine efficacy=100% against HPV16/18/31/33/45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake= 45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen & Treat efficacy=100%, Lost to follow-up=10%. Catch-up: vaccination of females aged 15-25 years in 2020 only; 3 lifetime screens were assumed to occur at ages 30, 40 and 50 years.

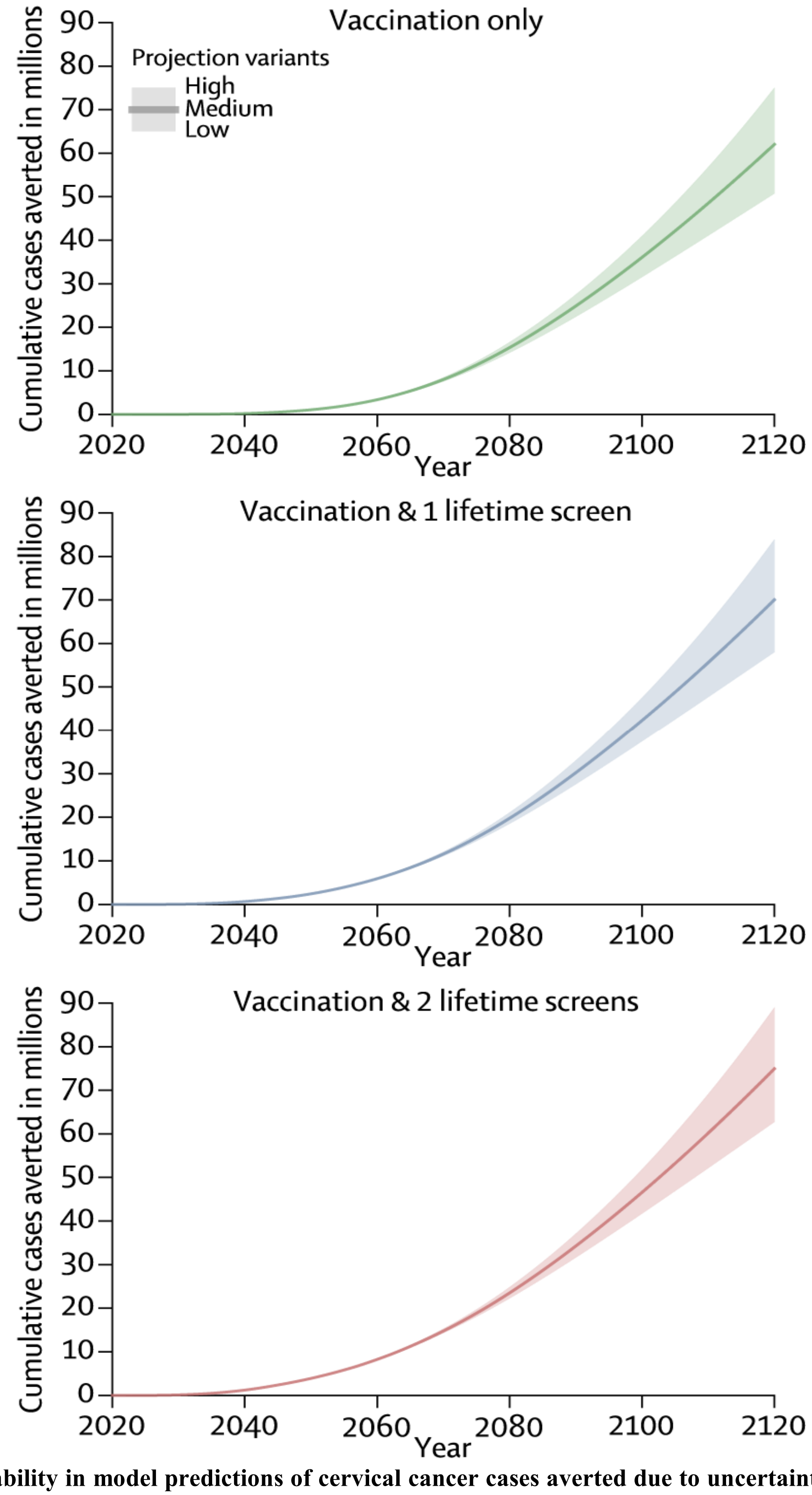

Figure S8: Variability in model predictions of cervical cancer cases averted due to uncertainty in the United Nations (UN) population projections. Solid line represents the median prediction of the models using the Medium UN population projections and shaded area the predictions using the Low and High UN population projections. Vaccination coverage=90%, Vaccine efficacy=100% against HPV16/18/31/33/45/52/58, Vaccine duration=Lifetime; Screening=HPV testing, Screening uptake= 45% (2023-2029), 70% (2030-2044), 90% (2045+); Screen & Treat efficacy=100%, Lost to follow-up=10%.

Technical appendix:

Impact of HPV vaccination and cervical screening on cervical cancer elimination: a comparative modelling analysis in 78 low-income and lower-middle-income countries

The Lancet (2020)

GLOBAL MODELING OF CERVICAL CANCER ELIMINATION

CONTENTS

Modeled scenarios in step 2

Table T1: Description of the scenarios modeled in step 2 of model comparison

	Scenarios description									Models														
	Vaccination					Screening				Harvard		HPV-ADVISE					Policy1-cervix					Spectrum		
	Age (yrs)	Sex	Cov (%)	Catch-up	Vaccine	Nb of screens	Age (yrs)	Ramp-up	Screening uptake (%) (2023/2030/ 2045/2060)	NI	UG	BN	IN	NG	UG	VN	G	CN	MY	PG	VN	PE	UG	VN
S0	-	-	0	-	-	-	-	-	0		x	x	x	x		x	x							x
S1		-	0	-	-	1	35	No	40		x	x	x	x		x	x							x
S2	-	-	0	-	-	1	35	No	90		x	x	x	x		x	x							x
S3	9	F	40	10-14	HPV9	-	-	-	0		x	x	x	x		x	x							x
S4	9	F	40	10-14	HPV9	-	-	-	0		x	x	x	x		x	x							x
S5	9	F	80	10-14	HPV9	-	-	-	0		x	x	x	x		x	x							x
S6	9	F	90	10-14	HPV9	-	-	-	0		x	x	x	x		x	x							x
S7	9	F+M	40	10-14	HPV9	-	-	-	0		x	x	x	x		x	x							x
S8	9	F+M	80	10-14	HPV9	-	-	-	0		x	x	x	x		x	x							x
S9	9	F+M	90	10-14	HPV9	-	-	-	0		x	x	x	x		x	x							x
S10	9	F	80	10-45	HPV9	-	-	-	0		x	x	x	x		x	x							x
S11	9	F	40	10-14	HPV9	1	35	No	40		x	x	x	x		x	x							x
S12	9	F	40	10-14	HPV9	1	35	No	80		x	x	x	x		x	x							x
S13	9	F	40	10-14	HPV9	1	35	No	90		x	x	x	x		x	x							x
S14	9	F	90	10-45	HPV9	1	35	No	90		x	x	x	x		x	x							x
S15	9	F	80	10-14	HPV9	2	35/45	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S16	9	F	80	10-25	HPV9	2	35/45	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S17	9	F	80	10-25	HPV9	2	35/45	Low	25/35/60/80	x	x		x	x	x	x		x	x	x	x	x	x	x
S18	9	F	80	10-14	HPV9 (20 yrs)	2	35/45	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S19	9	F	80	10-14	HPV4	2	35/45	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S20	9	F	80	10-14	HPV9	0	-	No	-	x	x		x	x	x	x		x	x	x	x	x	x	x
S21	9	F	90	10-14	HPV9	2	35/45	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S22	9	F	90	10-14	HPV9	3	30/40/50	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S23	9	F	90	10-25	HPV9	3	30/40/50	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S24	9	F	90	10-14	HPV9	3	30/40/50	Low	25/35/60/80	x	x		x	x	x	x		x	x	x	x	x	x	x
S25	9	F	90	10-25	HPV9	3	30/40/50	Low	25/35/60/80	x	x		x	x	x	x		x	x	x	x	x	x	x
S26	9	F	90	10-14	HPV9	1	35	Low	25/35/60/80	x	x		x	x	x	x		x	x	x	x	x	x	x
S27	9	F	90	10-14	HPV9	0	-	No	-	x	x		x	x	x	x		x	x	x	x	x	x	x
S28	9	F	90	10-25	HPV9	0	-	No	-	x	x		x	x	x	x		x	x	x	x	x	x	x
S29	9	F+M	80	10-14	HPV9	2	35/45	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S30	9	F+M	80	10-25	HPV9	2	35/45	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S31	9	F+M	80	10-14	HPV9	2	35/45	Low	25/35/60/80	x	x		x	x	x	x		x	x	x	x	x	x	x
S32	9	F+M	80	10-25	HPV9	2	35/45	Low	25/35/60/80	x	x		x	x	x	x		x	x	x	x	x	x	x
S33	9	F+M	80	10-25	HPV9	3	30/40/50	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S34	9	F+M	80	10-14	HPV9	1	35	Low	25/35/60/80	x	x		x	x	x	x		x	x	x	x	x	x	x
S35	9	F+M	80	10-14	HPV9	0	-	No	-	x	x		x	x	x	x		x	x	x	x	x	x	x
S36	9	F+M	80	10-25	HPV9	0	-	No	-	x	x		x	x	x	x		x	x	x	x	x	x	x
S37	9	F+M	90	10-14	HPV9	0	-	No	-	x	x		x	x	x	x		x	x	x	x	x	x	x
S38	9	F+M	90	10-25	HPV9	3	30/40/50	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x

	Scenarios description									Models														
	Vaccination					Screening				Harvard		HPV-ADVISE					Policy1-cervix					Spectrum		
	Age (yrs)	**Sex**	**Cov (%)**	**Catch-up**	**Vaccine**	**Nb of screens**	**Age (yrs)**	**Ramp-up**	**Screening uptake (%) (2023/2030/ 2045/2060)**	**NI**	**UG**	**BN**	**IN**	**NG**	**UG**	**VN**	**G**	**CN**	**MY**	**PG**	**VN**	**PE**	**UG**	**VN**
S39	9	F+M	90	10-25	HPV4	3	30/40/50	High	45/70/90/90	x	x		x	x	x	x		x	x	x	**x**	x	x	x
S40	9	F+M	70	10-14	HPV9	3	30/40/50	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S41	9	F	80	10-14	HPV9	3	30/40/50	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S42	9	F	80	10-14	HPV9	1	35	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x
S43	9	-	0	-	-	2	35/45	High	45/70/90/90	x	x		x	x	x	x		x	x	x	x	x	x	x

F: female; F+M: female and male.

Cov: Coverage

Nb: Number

HPV9: nonavalent vaccine (HPV6/11/16/18/31/33/45/52); HPV4: quadrivalent vaccine (HPV6/11/16/18)

Harvard: NI: Nicaragua, UG: Uganda.

HPV-ADVISE: BN: Benin, IN: India, NG: Nigeria, UG: Uganda, VN: Vietnam.

Policy1-Cervix: G: generic, CN: China, MY: Malaysia, PG: Papua New Guinea, VN: Vietnam.

Spectrum: PE: Peru, UG: Uganda, VN: Vietnam.

Three standardised base-case HPV vaccination and cervical screening scenarios examined

Table T2: Detailed description of the base-case scenarios

Scenario	Vaccination					Screening			Treatment *
	Vaccine efficacy	Duration of protection	Age at vaccination	Coverage	Gender	Coverage	Frequency in lifetime	Ages of screening	Detected precancer
Status quo **(S0)** Comparator: no scale-up of vaccination, screening or treatment	N/A	N/A	N/A	N/A	N/A	No ramp up	N/A	N/A	N/A
Vaccination only (S1)[†] Girls-only vaccination	100% against HPV 16,18,31,33, 45,52,58	Lifetime	Routine 9 yrs old & 1-year MAC catch-up to age 14 yrs	90%	Female	No ramp up	N/A	N/A	N/A
Vaccination & once lifetime screening (S2)[†] Girls-only vaccination & once lifetime screening (with clinically detected cancer treatment scale-up[*])	100% against HPV 16,18,31,33, 45,52,58	Lifetime	Routine 9 yrs old & 1-year MAC catch-up to age 14 yrs	90%	Female	45% (2023), 70% (2030), 90% (2045)	once	35 years	Scales up with screening scale-up; of screen-detected precancer, 90% successfully treated
Vaccination & twice lifetime screening (S3)[†] Girls-only vaccination & twice lifetime screening (with clinically detected cancer treatment scale-up[*])	100% against HPV 16,18,31,33, 45,52,58	Lifetime	Routine 9 yrs old & 1-year MAC catch-up to age 14 yrs	90%	Female	45% (2023), 70% (2030), 90% (2045)	twice	35 years, 45 years	Scales up with screening scale-up; of screen-detected precancer, 90% successfully treated

MAC: multi-age cohort

[*] Although modeled in the accompanying paper published in *The Lancet* (Canfell, Kim, Brisson et al., Lancet (2020)) examining the impact of HPV vaccination, screening and treatment scale-up on cervical cancer mortality, cancer treatments have no impact on the results of this paper as we focus on cancer incidence (cervical cancer incidence is not affected by treatment)

[†] Because treatment is not modeled in the current paper, strategies S1, S2, and S3 are equivalent to strategies S1A, S2A, and S3A in the accompanying Mortality paper (see Appendix in Canfell, Kim, Brisson et al., Lancet (2020))

Description of the 78 LMIC

Table T3: Countries by geographic region

Geographic region	Countries
East Asia & Pacific	Cambodia, Indonesia, Korea Democratic People's Republic, Lao People's Democratic Republic, Mongolia, Myanmar, Papua New Guinea, Philippines, Solomon Islands, Timor-Leste, Vanuatu, Vietnam
Europe & Central Asia	Georgia, Kyrgyz Republic, Moldova, Tajikistan, Ukraine, Uzbekistan
Latin America & Caribbean	Bolivia, El Salvador, Haiti, Honduras, Nicaragua
Middle East & North Africa	Arab Republic of Egypt, Djibouti, Morocco, Syrian Arab Republic, Tunisia, West Bank and Gaza, Yemen Republic
South Asia	Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka
Sub-Saharan Africa	Angola, Benin, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Republic of the Congo, Rwanda, São Tomé and Principe, Senegal, Sierra Leone, Somalia, South Sudan, Sudan, Swaziland, Tanzania, The Gambia, Togo, Uganda, Zambia, Zimbabwe

Source: Group definitions are based on the regions used by The World Bank. (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups - https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries)

Table T4: Countries by income group

Income group	Countries
Low income	Afghanistan, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Democratic People's Republic of Korea, Democratic Republic of the Congo, Eritrea, Ethiopia, Guinea, Guinea-Bissau, Haiti, Liberia, Madagascar, Malawi, Mali, Mozambique, Nepal, Niger, Republic of Yemen, Rwanda, Senegal, Sierra Leone, Somalia, South Sudan, Syrian Arab Republic, Tajikistan, Tanzania, The Gambia, Togo, Uganda, Zimbabwe
Lower middle income	Angola, Arab Republic of Egypt, Bangladesh, Bhutan, Bolivia, Cabo Verde, Cambodia, Cameroon, Côte d'Ivoire, Djibouti, El Salvador, Georgia, Ghana, Honduras, India, Indonesia, Kenya, Kyrgyz Republic, Lao People's Democratic Republic, Lesotho, Mauritania, Moldova, Mongolia, Morocco, Myanmar, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Philippines, Republic of the Congo, São Tomé and Principe, Solomon Islands, Sri Lanka, Sudan, Swaziland, Timor-Leste, Tunisia, Ukraine, Uzbekistan, Vanuatu, Vietnam, West Bank and Gaza, Zambia

Source: The World Bank (income groups are based on gross national income per capita; https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups - https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries

Global modeling approach

A) HPV-ADVISE (Agent-based Dynamic model for VaccInation & Screening Evaluation)

HPV-ADVISE GLOBAL was used to predict the population-level effectiveness of different cervical cancer elimination scenarios over time. The overall approach was to generalize the predictions from 5 core transmission dynamic models of HPV infection and natural history of cervical cancer (5 Core HPV-ADVISE LMIC models) to 78 LMICs, based on country-specific sexual behavior, HPV prevalence, and cervical cancer incidence (see Figure T1 and the "Technical Appendix HPV-ADVISE LMIC" for a detailed description of methods (http://www.marc-brisson.net/HPVadvise-LMIC.pdf).

HPV-ADVISE GLOBAL is based on 5 Core HPV-ADVISE LMIC models calibrated to highly stratified data from India, Vietnam, Uganda, Nigeria, and Benin to reproduce country-specific: 1) demography; 2) sexual behavior; 3) HPV transmission & natural history of disease and; 4) screening and treatment. Briefly, HPV-ADVISE LMIC models are individual-based, transmission-dynamic models of multi-type HPV infection and diseases. The models simulate HPV transmission through sexual activity. Sexual partnership formation and dissolution are explicitly modeled, and based on different risk groups (including female sex workers) and sexual mixing. A total of 18 different genotypes are modeled individually. HPV-ADVISE LMIC reproduces genotype-specific natural history of cervical cancer from HPV infection to cervical cancer via precancerous cervical lesions (grade I, II and III). The models also reproduce complex cervical screening and treatment algorithms at the individual level, by tracking and simulating each woman's screening history.

For the global modeling analysis, country-specific predictions of the impact of vaccination and screening on cervical cancer incidence and mortality were performed using a 5-step approach:

1. Each of the 78 LMICs was mapped to the 5 core HPV-ADVISE LMIC models through a ranking process based on similarity in terms of sexual behavior, HPV prevalence, HPV type distribution and cervical cancer incidence. The sexual behavior and epidemiological outcomes used to determine the ranking were: 1) Female mean lifetime number of sexual partners (obtained from USAID's DHS Program[1] for the majority of countries or from specific studies[2-9]), 2) Adjusted HPV prevalence by world region[10], 3) Percentage of cervical cancer positive for HPV16/18/31/33/45/52/58 by world region[11], 4) Age-standardised cervical cancer incidence rate[12,13]. For each country, overall ranking scores were computed by 1) estimating the absolute difference between its outcomes and those from the 5 countries represented by the core models (India, Vietnam, Uganda, Nigeria, and Benin), 2) for each outcome, ranking the countries' similarity to each core model country from 1 (most similar) to 5 (least similar), and 3) using the average ranking over the 4 outcomes as a global score. For example, for Côte d'Ivoire, the average rankings over the 4 outcomes associated with the Benin, Nigeria, Uganda, India, and Vietnam models were 1.5, 1.8, 3.0, 3.8, and 4.2, respectively.
2. Each of the 78 LMICs was assigned to the 2 most similar core HPV-ADVISE LMIC models based on the average ranking score. For Côte d'Ivoire, the 2 core models were those calibrated to Benin and Nigeria.
3. For each vaccination and screening scenario, we estimated the age- and stage-specific percentage reductions in the incidence of cervical cancer over time using the 5 core HPV-ADVISE LMIC models. Of note, each core model has 50 parameter sets representing uncertainty in sexual behavior and natural history parameters as well as variability in epidemiology within countries. Hence, there were 50 predictions per scenario per core model.
4. For each of the 78 LMICs, we estimated the percentage reductions in age- and stage-specific cervical cancer incidence over time using the weighted average of the predictions of the 2 core HPV-ADVISE LMIC models selected in Step 2. The percentage reductions were based on 60% of the results from the core model with the most similar ranking and 40% from the other model.
5. To estimate the impact of vaccination and screening on cervical cancer incidence rates over time, we applied the relative reductions over time estimated in Step 4 to the country-, age- and stage-specific cervical cancer incidence and mortality estimated from GLOBOCAN 2018[12,13].

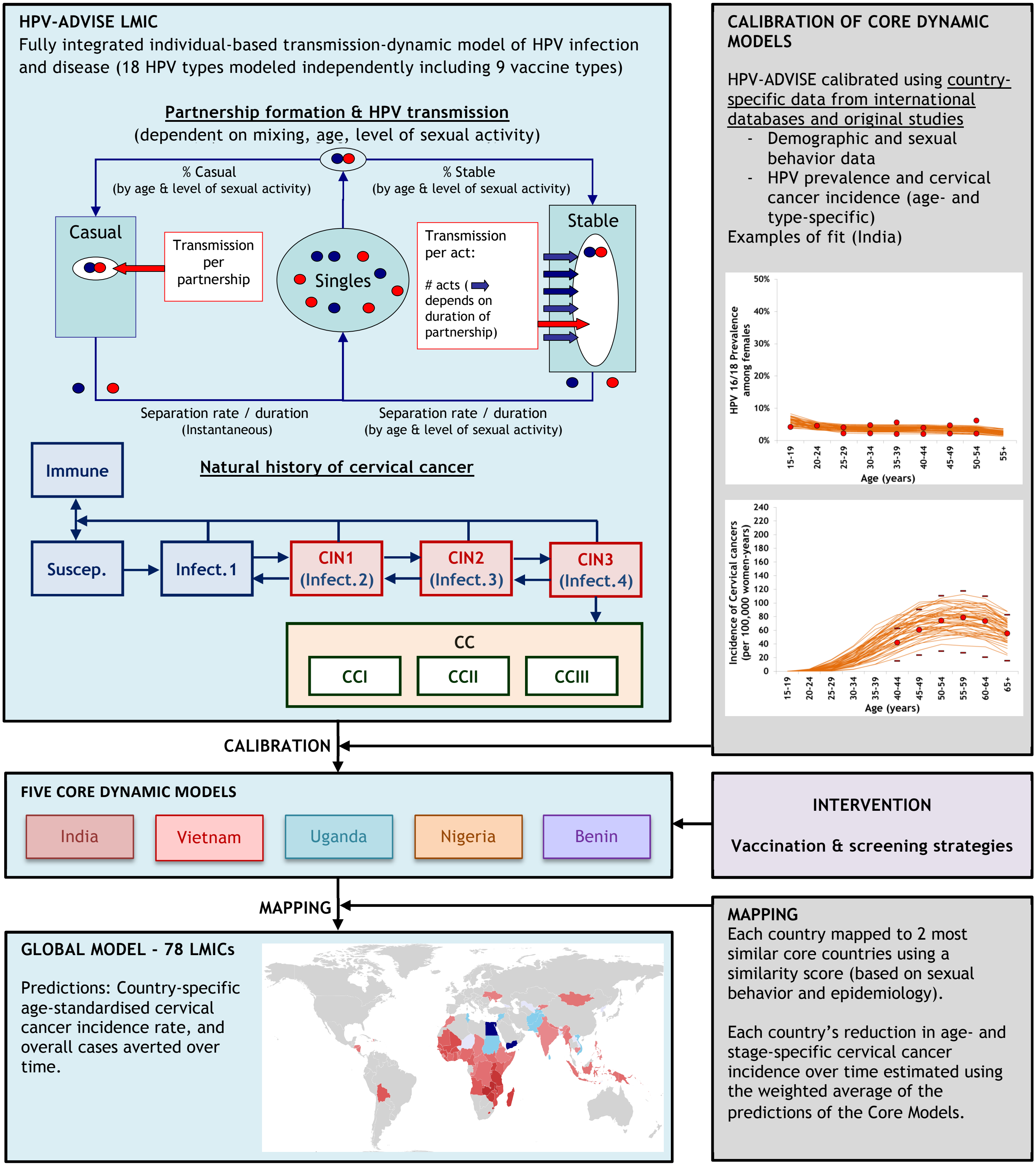

Figure T1: HPV-ADVISE

B) Harvard

As previously described[14], we used a multi-modeling approach to project the population health and economic consequences for alternative cervical cancer elimination scenarios over time. Our multi-modeling framework involves a dynamic transmission model of HPV transmission (“Harvard-HPV”), an individual-based model of cervical carcinogenesis (“Harvard-CC”), and a companion multi-country population model (“Harvard-Scale Up”) (Figure T2).

Briefly, Harvard-HPV is an individual (i.e., agent-based) dynamic model that simulates heterosexual partnership acquisition and dissolution, and independent transmission of seven HPV genotypes (HPV-16, -18, -31, -33, -45, -52, -58). Individuals are stratified by sex, age, and sexual activity category (SAC; four categories: none (0), low (1), medium (2), high (3)), which govern initial sexual mixing in the population. Harvard-CC is an individual-based stochastic model that simulates HPV-induced cervical carcinogenesis associated with all HPV types[15]. Health states in the model, descriptive of each patient’s underlying true health, include infection status, grade of cervical intraepithelial neoplasia (CIN), and stage of cancer. HPV types are stratified as HPV-16; -18; -31; -33; -45; -52; -58; pooled other high-risk infections; and pooled low-risk infections. The probabilities governing the model transitions depend on age; HPV type; duration of HPV infection; type-specific natural immunity; as well as a woman’s history of prior infection; and previously treated CIN. Harvard-Scale Up is a multi-cohort companion model that captures important country- and region-specific variations (e.g., population size, cervical cancer burden) in each of the individual LMICs.

Harvard-HPV was used to project reductions in HPV incidence by genotype and age over time associated with each of the elimination scenarios; these reductions served as inputs into Harvard-CC. Harvard-CC was then used to project reductions in cervical cancer incidence by genotype and age over time for each of the elimination scenarios; these reductions served as inputs into Harvard-Scale Up. Finally, Harvard-Scale Up was used to estimate country-specific changes in cervical cancer incidence, taking into consideration demographic changes over time.

Both the Harvard-HPV and Harvard-CC models require highly-detailed data on sexual behavior and cervical cancer epidemiology that are limited in most LMICs. We therefore employed two calibrated Harvard-HPV models and four calibrated Harvard-CC models adapted to settings where data permitted calibration (El Salvador, India, Nicaragua, Uganda) to capture variation in sexual behavior and cervical cancer epidemiological profiles across settings.

To project country-specific changes in cervical cancer incidence under alternative elimination scenarios in each of the 78 LMICs, we took a three-step approach:

1. For each vaccination and screening scenario, we estimated the age- and genotype-specific percentage changes in the incidence of HPV infection over time using Harvard-HPV.
2. We relied on a mapping process (Figure T2) to link the Harvard-HPV model to the Harvard-CC model based on trends in age- and genotype-specific HPV prevalence. The outputs from Step 1 were applied to the corresponding HPV incidence inputs in Harvard-CC to estimate reductions in cervical cancer incidence by age and stage over time.

We then mapped Harvard-CC to each individual LMIC in Harvard-Scale Up using the minimum sum of square difference of country-specific cervical cancer incidence among women ages 40-59 from GLOBOCAN 2018 versus the four Harvard-CC settings. To estimate the impact of vaccination and screening on cervical cancer incidence rates over time, we applied the relative reductions over time estimated in Step 2 to the country-, age- and stage-specific cervical cancer incidence from GLOBOCAN 2018.

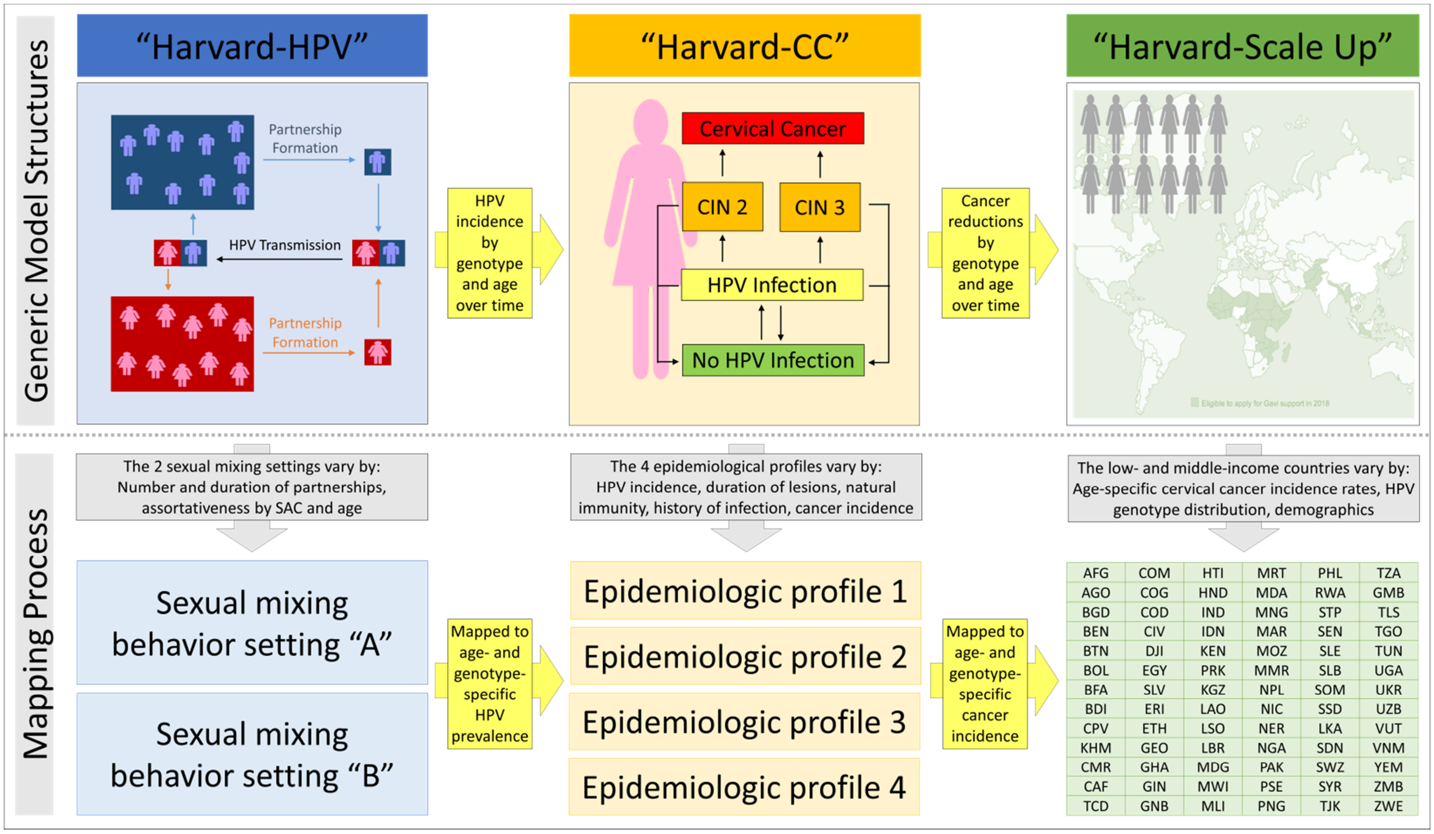

Figure T2: Harvard

C) Policy1-Cervix

Policy1-Cervix is a dynamic multicohort model with multiple components: HPV transmission, HPV vaccination, cervical precancer, cancer survival, screening, diagnosis and treatment. For the global model, additional country-specific trends and incidence data are used (Figure T3). A similar approach has been described and used globally [16], and the model has also been used in a range of other settings (see 'policy1.org' for a list of publications).

Briefly, the natural history component of the model simulates HPV infection which can persist and/or progress to cervical intraepithelial neoplasia grades I, II and III (CIN1, CIN2, CIN3); CIN 3 can then progress to invasive cervical cancer. Progression and regression rates between states are modelled separately for types HPV 16, HPV 18, other high-risk nonavalent-included types (31/33/45/52/58), and other non-nonavalent-included high risk types (Figure T3). It captures the increased risk of CIN2+ recurrence in successfully treated women (compared to the baseline risk of CIN2+ in the population), as previously described [17].

To capture the impact of HPV vaccination, we used a general dynamic transmission model. The dynamic transmission model stratified the population by sex, 5-year age group, and four sexual behavior classes, each with varying levels of activity, defined by the annual number of new sexual partners; this is described in more detail in a previous publication[18]. This generalized sexual behavior model was explicitly used to account for the additional effects of herd immunity through vaccination.

For this analysis, we took a four-step approach:

1. The pattern of age-specific model-predicted cervical cancer incidence rates in the absence of screening was calibrated to each region based on GLOBOCAN 2018[19] taking into account regional differences in the attributable HPV types in cervical cancer, based on an international meta-analysis of HPV types in cancer by region[11]. The regions we calibrated to were Europe and Central Asia, Middle East and North Africa, Latin America and Caribbean, South Asia, East Asia and Pacific, and Sub-Saharan Africa.
2. We then simulated vaccination and screening scenarios through our generalized transmission model to obtain reductions in incident HPV rates by type after vaccination (and additional impacts due to herd effects) (these two separate model components are illustrated in Figure T3).
3. In the trends analysis, we captured changing trends in cervical cancer diagnosis, which indirectly reflects changes due to a range of factors including sexual behavior and exposure to the established co-factors in HPV progression to cervical cancer. The trends analysis was based on high quality cancer registry data from IARC's Cancer Incidence in Five Continents (CI5)[20], using data from Volumes VIII-XI covering the period 1993-2012 and is described in detail in previous publications[16]. Please note that for the accompanying mortality manuscript, we did not incorporate trends in mortality rates over time.
4. To obtain country-specific outputs, we applied the age- and year-specific cancer incidence reductions (due to vaccination and screening) obtained from the model and year-specific changes due to trends for the region the country is within to age-specific cancer rates for each country as estimated in GLOBOCAN 2018. Country-specific outputs estimates were then grouped to provide regional-specific outputs. These steps are further described graphically in Figure T3.

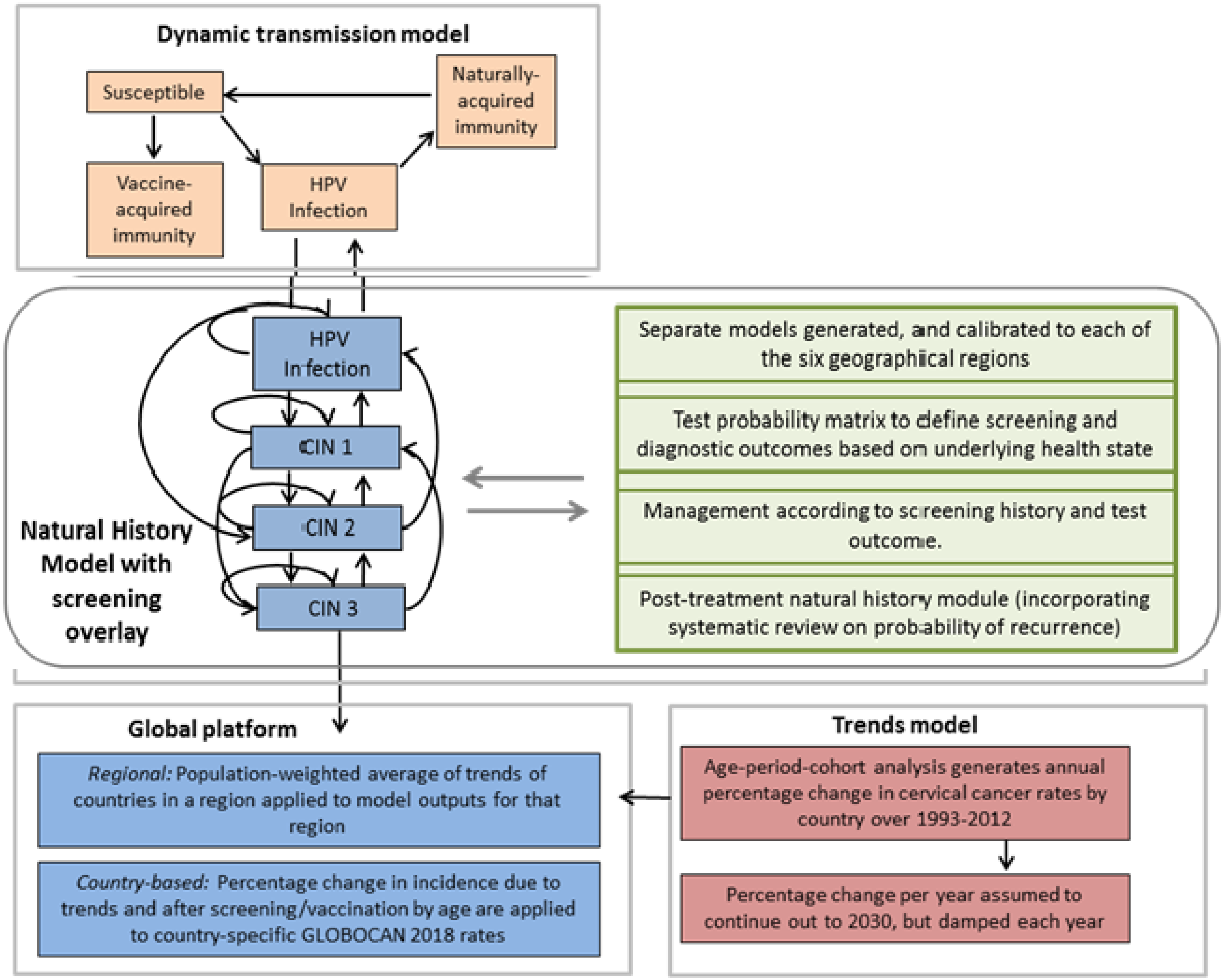

Figure T3. Policy1-Cervix

Estimation of country-specific population size between 2100-2120

The age-stratified population for all countries between 2020 and 2100 were taken from United Nations World Population Prospects: The 2017 Revision (using the medium variant projections; medium-fertility assumption, normal mortality and normal international migration). Because the CCEMC model projections of cervical cancer cases averted were for 101 years (to 2120) and population data were only available up to 2100, we extrapolated the United Nations World Population from 2100 to 2120.

To do this, first, we defined a population matrix ($P_{a,y}$) representing the number of people of age group "a" (five-year age groups) at year "y" (between 2000-2100). Second, we defined the effective survival rates (($S_{a,y}$)= ($P_{a+1,y}$)/ ($P_{a,y-5}$)) as the ratio of the population of the subsequent age group over the population of the age group five years before. The effective birth rate (($B_{0-4,y}$)=($P_{0-4,y}$)) was defined as the 0-4 years old population. As survival and birth rates oscillate over time with different periods, we used Fourier analysis in the extrapolation process. The extrapolation of survival and birth rates after 2100 were performed in three steps: 1) for each age group, we removed the secular trend using a least-squares linear fit; 2) we performed a fast Fourier transform (FFT) and find local maxima in the power spectrum (dominant oscillatory components that have particular frequencies) that allowed us to define a least-squares fit (which is the sum of cosine functions representing each particular dominant frequency); and 3) we re-added the secular trend that was previously removed to these oscillatory components to get the full extrapolation results. Using this method, we estimated the effective survival rates and the birth rate for years 2100 onwards for all age groups and countries. To get the projections for the population for years 2101 to 2120, we used the birth rates and the effective survival rates (($P_{5-9,y}$)=($B_{0-4,y-5}$)·($S_{0-4,y}$)). Then, subsequent age group populations were obtained iteratively as (($P_{a+1,y}$)=($P_{a,y-5}$)·($S_{a,y}$)).

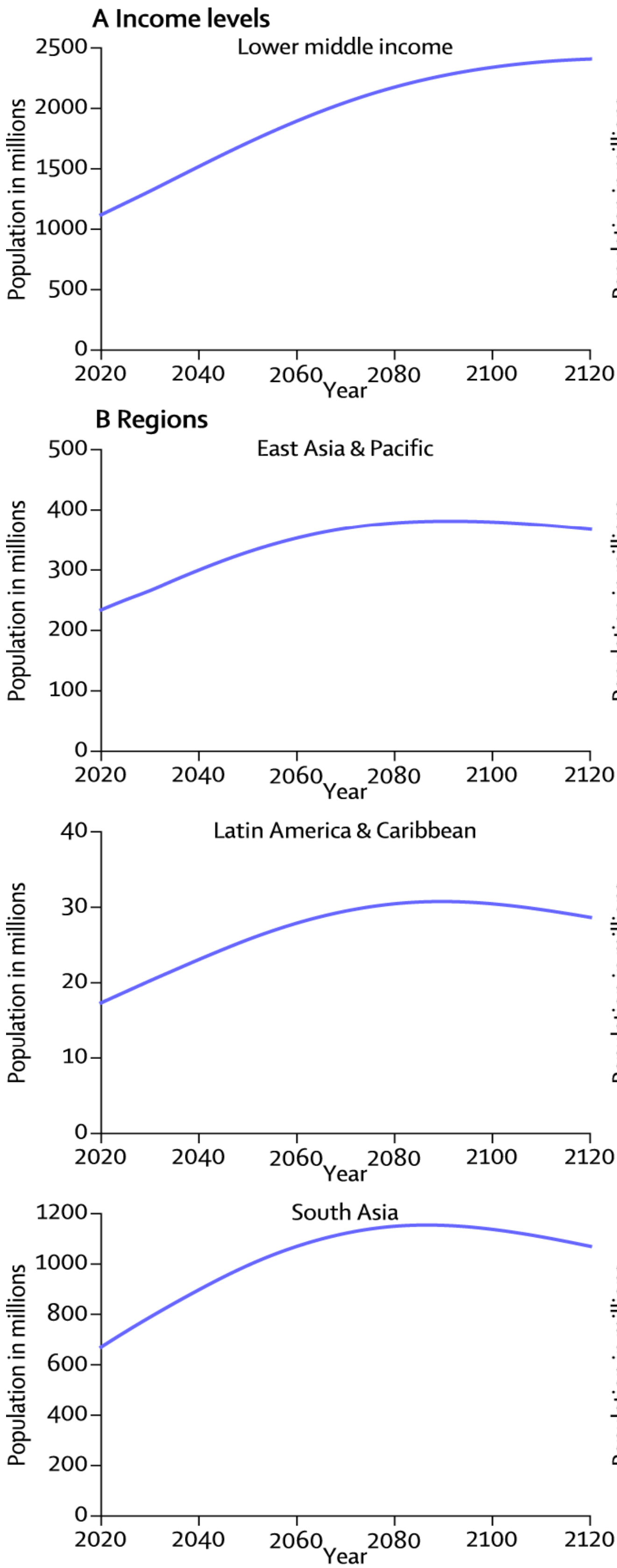

Figure T4. Population predictions by income level & region

HPV-FRAME reporting standard checklist

Table T5. HPV-Frame reporting standard checklist. The checklist below includes the core reporting standard from HPV-FRAME, according to Canfell et al, 2019 [21].

a) Inputs	Reported? (Y/N)	Reported by age? (Y/N)	Report by sex (F-only, M-only or both)?	Comments
Core reporting standard				
Target population for intervention	Y	Y	F-only	Vaccination: females aged 9 years; single year of catch-up ages 10-14 years or 10-25 years. Screening: at age 35 years +/- age 45 years. Cancer treatment: all ages.
Sexual behaviour	Y	Y (for dynamic models)	Y	The transmission model/ sexual behaviour parameters were used to inform the expected reduction in the HPV incidence rates due to HPV vaccination (see Technical Appendix).
Cohort examined for evaluation/ time horizon	Y	N	F-only	101 year time horizon (2020-2120) Impact was examined for all ages Results reported for 2020, 2030, 2045, 2060, 2075, 2095, 2105, 2120 (see Main paper and Appendix).
Quality of life assumptions	Not applicable	Not applicable	Not applicable	This paper focuses on the impacts on health outcomes only.
Calibration	Y	Y	F-only	All models reproduce Globocan 2018 incidence at a country level (see Technical Appendix). The CCEMC models were calibrated to sexual behaviour, HPV prevalence and Cervical cancer incidence (see Technical appendix for references to CCEMC calibration methods).
Validation (where possible)	Y	Y (implicitly)	F-only	The individual CCEMC models previously have been used to various HPV vaccination and cervical screening strategies for many countries, including high- resource countries, low-resource settings and globally (see Technical Appendix).
Costs	Not applicable	Not applicable	Not applicable	This paper focuses on the impacts on health outcomes only.
Reporting standard for HPV vaccination in adolescent individuals				
Vaccine uptake	Y	Y	Y	Main scenarios assumed 90% of girls aged 9 years would be vaccine with broad-spectrum HPV vaccine, plus single year of catch-up ages 10-14 years (see methods).
Vaccine efficacy	Y (implicitly)	Y (implicitly)	Y (implicitly)	We assumed 100% vaccine efficacy, independent of age and sex.
Vaccine cross-protection	Y (implicitly)	Y (implicitly)	Y (implicitly)	NA. We assumed that vaccine efficacy is 100% for HPV16, 18, 31, 33, 45, 51 and 58.
Reporting standard for model of cervical screening				
Routine screening behaviour (routine and follow-up and test of cure)	Y	Y	F-only	We assumed 70% of women were screened at once-lifetime screening at age 35 years or twice-lifetime screening at age 35 and 45 years (See methods).
Screening test (s) and colposcopy accuracies	Y	Y (implicitly)	F-only	Sensitivity of HPV test was assumed 90% for CIN2 and 94% for CIN3+ across three models, and assumed to be independent of age. We did not model or assumed a specific test to confirm cancer diagnosis. However, we assumed that 90% of women detected HPV positive and diagnosed with a lesion will be treated. We also assumed that 90% of women with detected cancer are treated (see methods).
Abnormal test management (primary and triage)	Y	Y (implicitly)	F-only	Assumed to be independent of age. We assumed that 90% of women detected HPV positive and diagnosed with a lesion will be treated. Similarly, we also assumed 90% of women detected HPV positive and diagnosed with cancer would be treated (see methods).
Diagnostic follow-up of abnormal tests	N	N	F-only	Diagnostic confirmation was not modeled; we assumed 90% of women detected HPV positive and diagnosed with cancer would be treated (see methods).

a) Inputs	Reported? (Y/N)	Reported by age? (Y/N)	Report by sex (F-only, M-only or both)?	Comments
Management by disease grade (confirmed disease)	N	N	F-only	We assumed that 90% of detected lesions are treated. Hence, management of disease was not specifically modeled.
Sources of information for screening structure and parameterization		Y	F-only	The screening pathway follows WHO recommendations for LMICs. It was simplified for the Global modelling exercise.
Reporting standard for integrated models of HPV vaccination and cervical screening				
HPV type incidence, clearance and progression rates	Y (implicitly)	Y (implicitly)	Y (implicitly)	Type-specific HPV incidence, clearance, and progression were modeled separately for HPV types 16, 18, other oncogenic nonavalent-included types (31, 33, 45, 52, and 58) and other oncogenic nonavalent-non-included types (see Technical Appendix).
Herd effect	Y (implicitly)	Y (implicitly)	Y (implicitly)	Herd effect of HPV vaccination were captured by the dynamic transmission component of all three models (see Technical Appendix).
Association between vaccination and screening uptake	Y	Y	F-only (N/A for males)	Vaccine and screening uptake were assumed to be independent of one another.
Reporting standard for models of HPV prevention in LMIC				
HIV prevalence rates, if endemic in country	N	N	N	We did not explicitly take into account HIV prevalence in this study. This is currently being addressed in another CCEMC study.
Description of any opportunistic or pilot/demonstration screening project ongoing	N	N	N	As this study models the impact of HPV vaccination and cervical screening strategies in 78 LMICs, this is not relevant.

b) Outputs	Reported? (Y/N)	Reported by age? (Y/N)	Report by sex (F-only, M-only or both)?	Report as calibration or validation target? (Y/N)
Core reporting standard				
Cancer incidence, mortality, life years, QALYs/DALYs (as appropriate)	Y	Y	F-only	Age-standardised and age-specific incidence were reported. We also reported number of cases averted as the impacts of HPV vaccination and screening strategies for women aged 0-99 years and 0-44 years (see Results and Appendix). Not reported for LYs, QALYs, DALYs as this paper focuses on the impacts on cancer incidence only.
HPV prevalence, pre-intervention	N	N	N	This level of detail is not reported. This paper focuses on the impact on cancer incidence and results were also not sensitive to herd immunity effects. HPV prevalence is thus not a driver of our conclusions.
CIN2 detected	N	N	N	This level of detail is not reported. This paper focuses on the impact on cancer incidence. Impact of interventions on CIN2 was thus not a focus of the paper.
Sensitivity analysis on key inputs	Y (implicitly)	Y (implicitly)	F-only	This was a comparative analysis using three models with different structural and parameterisation assumptions. As such sensitivity analysis is built into the reported ranges of results between models. Also we did a number of additional exploratory/explanatory scenarios to understand the sensitivity of the model results to underlying aspects of the impact modelling (see Appendix).
Incremental cost-effectiveness ratios and costs saved		N	N	This paper focuses on the impacts on cancer incidence only.

b) Outputs	Reported? (Y/N)	Reported by age? (Y/N)	Report by sex (F-only, M-only or both)?	Report as calibration or validation target? (Y/N)
Reporting standard for HPV vaccination in adolescent individuals				
Absolute reductions in HPV infections, cervical, and other HPV-related cancers and/or warts post vaccination	N	N	F-only	This paper only focuses on the reduction of cervical cancer incidence post vaccination.
Absolute reduction in CIN2+ post vaccination	N	N	F-only	This paper only focuses on the reduction of cervical cancer incidence post vaccination.
Absolute reduction in invasive cancer post-vaccination		N	F-only	Outputs considered the absolute reduction in age-standardised rates of cervical cancer incidence.

QALYs: quality-adjusted life-years

REFERENCES

1. United States Agency of International Development (USAID). The Demographic and Health Surveys (DHS) Program. Available at: https://dhsprogram.com/. Accessed December 7 2019.
2. Nahar Q, Sultana F, Alam A, et al. Genital human papillomavirus infection among women in Bangladesh: findings from a population-based survey. *PLoS One* 2014; 9(10): e107675.
3. Tshomo U, Franceschi S, Dorji D, et al. Human papillomavirus infection in Bhutan at the moment of implementation of a national HPV vaccination programme. *BMC Infect Dis* 2014; 14: 408.
4. Alfaro KM, Gage JC, Rosenbaum AJ, et al. Factors affecting attendance to cervical cancer screening among women in the Paracentral Region of El Salvador: a nested study within the CAPE HPV screening program. *BMC Public Health* 2015; 15: 1058.
5. Maza M, Melendez M, Masch R, et al. Acceptability of self-sampling and human papillomavirus testing among non-attenders of cervical cancer screening programs in El Salvador. *Prev Med* 2018; 114: 149-55.
6. Kouyoumjian SP, Mumtaz GR, Hilmi N, et al. The epidemiology of HIV infection in Morocco: systematic review and data synthesis. *Int J STD AIDS* 2013; 24(7): 507-16.
7. Chaouki N, Bosch FX, Munoz N, et al. The viral origin of cervical cancer in Rabat, Morocco. *Int J Cancer* 1998; 75(4): 546-54.
8. Ardhaoui M, Ennaifer E, Letaief H, et al. Prevalence, Genotype Distribution and Risk Factors for Cervical Human Papillomavirus Infection in the Grand Tunis Region, Tunisia. *PLoS One* 2016; 11(6): e0157432.
9. Aruhuri B, Tarivonda L, Tenet V, et al. Prevalence of cervical human papillomavirus (HPV) infection in Vanuatu. *Cancer Prev Res (Phila)* 2012; 5(5): 746-53.
10. Bruni L, Diaz M, Castellsague X, Ferrer E, Bosch FX, de Sanjose S. Cervical human papillomavirus prevalence in 5 continents: meta-analysis of 1 million women with normal cytological findings. *J Infect Dis* 2010; 202(12): 1789-99.
11. Serrano B, Alemany L, Tous S, et al. Potential impact of a nine-valent vaccine in human papillomavirus related cervical disease. *Infect Agent Cancer* 2012; 7(1): 38.
12. International Agency for Research on Cancer. Global cancer observatory. Available at https://gco.iarc.fr/. Accessed October 24 2019.
13. United Nations, Department of Economic and Social Affairs, Division P. World Population Prospects: The 2017 Revision, custom data acquired via website. 2017. Available at https://esa.un.org/unpd/wpp/dataquery/. Accessed October 17 2018.
14. Burger EA, Campos NG, Sy S, Regan C, Kim JJ. Health and economic benefits of single-dose HPV vaccination in a Gavi-eligible country. *Vaccine* 2018; 36(32 Pt A): 4823-9.
15. Campos NG, Burger EA, Sy S, et al. An updated natural history model of cervical cancer: derivation of model parameters. *Am J Epidemiol* 2014; 180(5): 545-55.
16. Simms KT, Steinberg J, Caruana M, et al. Impact of scaled up human papillomavirus vaccination and cervical screening and the potential for global elimination of cervical cancer in 181 countries, 2020-99: a modelling study. *Lancet Oncol* 2019; 20(3): 394-407.
17. Lew JB, Simms KT, Smith MA, et al. Primary HPV testing versus cytology-based cervical screening in women in Australia vaccinated for HPV and unvaccinated: effectiveness and economic assessment for the National Cervical Screening Program. *Lancet Public Health* 2017; 2(2): e96-e107.
18. Smith MA, Canfell K, Brotherton JM, Lew JB, Barnabas RV. The predicted impact of vaccination on human papillomavirus infections in Australia. *Int J Cancer* 2008; 123(8): 1854-63.
19. Bray F, Colombet M, Mery L, et al. Cancer Incidence in Five Continents, Vol. XI (electronic version). Lyon: International Agency for Research on Cancer. Available from: http://ci5.iarc.fr, Accessed November 11 2019; 2017.
20. Parkin DM, Whelan SL, Ferlay J, Teppo L, Thomas DB, Editors. Cancer Incidence in Five Continents Vol. VIII, 2002.
21. Canfell K, Kim JJ, Kulasingam S, et al. HPV-FRAME: A consensus statement and quality framework for modelled evaluations of HPV-related cancer control. *Papillomavirus research (Amsterdam, Netherlands)* 2019; 8: 100184.