SUMMARY 2

Global Cervical Cancer Prevention

HPV Vaccination of Pre-Adolescent Girls Analyses

Summary of Prior Work

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Submitted: November 26, 2013

This summary document provides an overview of the projected impact and cost-effectiveness of HPV adolescent vaccination. Several prior publications listed in the reference section provide greater detail. However, since we provided extracted estimates for the *Lancet* Commission on Investing in Health we provide this summary as brief documentation for the model used to assess benefits in 72 GAVI-eligible countries and 33 Latin American and Caribbean countries.

TABLE OF CONTENTS

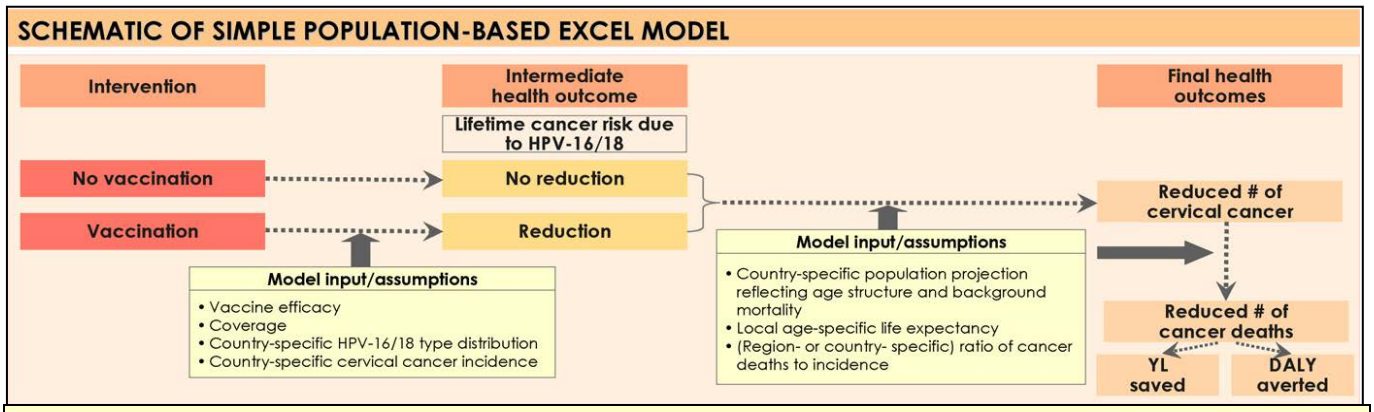
I. POPULATION-BASED COMPANION MODEL

Overview

The companion population-based model is a flexible tool that has been developed to reflect the main features of HPV vaccines, and to project the potential impact (health and economic consequences) of HPV vaccination at the population level in settings where data are very limited. The model is constructed as a static cohort simulation model based on a structure similar to a simple decision tree, and is programmed using Microsoft® Excel and Visual Basic for Applications, 6.3 (Microsoft Corporation, Redmond, WA). The model tracks a cohort of girls at a target age (e.g., 9 years) through their lifetimes, comparing health and cost outcomes with and without HPV vaccination programs. Unlike our more complex empirically-calibrated micro-simulation models (Goldie 2007, Kim 2007a, Diaz 2008, Kim 2008, Diaz 2010, Sharma 2011, Campos 2011), the companion model does not fully simulate the natural history of HPV infection and cervical carcinogenesis. Instead, based on simplifying assumptions (i.e.,

duration and stage distribution of, and mortality from, cervical cancer), which rely on insights from analyses performed with the micro-simulation model, and using the best available data on local age-specific incidence of cervical cancer and HPV 16,18 type distribution, and assumed vaccine efficacy and coverage, the model estimates reduction in cervical cancer risk at different ages. By applying this reduction to country-specific, age-structured population prospects incorporating background mortality (UN 2009), the model calculates averted cervical cancer cases and deaths, and transforms them into aggregated population health outcomes, years of life saved (YLS) and disability-adjusted life years (DALYs) averted. DALYs are calculated using the standard approach by the Global Burden of Disease (GBD) study (Murray 1996) although they are not age-weighted. The model also combines vaccination program costs and direct medical treatment costs associated with cervical cancer over the course of the simulation, and generates short-term financial costs, long-term economic outcomes (e.g., lifetime costs), and incremental costs (expressed in 2005 international dollars) per DALY averted.

Figure 1. Schematic Model



The Excel-based companion model is a static cohort simulation model that tracks a birth cohort of girls for their lifetimes, comparing health and cost outcomes with and without HPV vaccination programs. The model uses data on age-specific incidence of cervical cancer and HPV-16/18 type distribution in cancer, assumptions about vaccine efficacy and coverage, and population-based data, to generate estimates of averted cases of cervical cancer and cancer deaths, years of life saved (YLS) and disability-adjusted life years (DALYs) averted. The model tracks program costs and direct medical treatment costs over the course of the simulation. The main final outcome measure is incremental costs (expressed in 2005 I$) per DALY averted. (Goldie 2008a)

The companion model captures the burden of HPV infection by estimating the number of cervical cancer cases caused by HPV infection based on epidemiological data obtained from various sources. In the absence of vaccination, women may develop HPV infections and cervical cancer based on the epidemiologic estimates specific to each country. We assume that age-specific cervical cancer incidence, average age of sexual debut, and the level of other risk factors remain constant over the time horizon of the model. We assume that girls are fully immunized with 3 doses. We assume that girls effectively immunized against HPV16/18 can be infected with non-16/18 type HPV (e.g., no cross-protection is assumed), and vaccine-induced immunity is lifelong. All assumptions are varied in sensitivity analyses.

This report focuses solely on the 72 countries identified as GAVI-eligible or formerly GAVI-eligible, listed in Table 1 below.

Table 1. Categorization of GAVI countries in current Excel model

Country	GAVI-eligibility	Cancer Incidence (Globocan 2008)	WHO GBD Region	Economic classification (World Bank)
Afghanistan	GAVI	6.6	EMR D	Low income
Angola	(formerly) GAVI	30	AFR D	Lower middle income
Armenia	(formerly) GAVI	17.3	EUR B	Lower middle income
Azerbaijan	(formerly) GAVI	10	EUR B	Upper middle income
Bangladesh	GAVI	29.8	SEAR D	Low income
Benin	GAVI	35	AFR D	Low income
Bhutan	(formerly) GAVI	20.4	SEAR D	Lower middle income
Bolivia	(formerly) GAVI	36.4	AMR D	Lower middle income
Burkina Faso	GAVI	28.6	AFR D	Low income
Burundi	GAVI	49.1	AFR E	Low income
Cambodia	GAVI	27.4	WPR B	Low income
Cameroon	GAVI	24	AFR D	Lower middle income
Central African Republic	GAVI	19.4	AFR E	Low income
Chad	GAVI	19.9	AFR D	Low income
Comoros	GAVI	51.7	AFR D	Low income
Congo, Democratic Republic	GAVI	21.3	AFR E	Low income
Congo, Republic of (Brazzaville)	(formerly) GAVI	27.2	AFR E	Lower middle income
Cote d'Ivoire	GAVI	26.9	AFR E	Lower middle income
Cuba	(formerly) GAVI	23.1	AMR A	Upper middle income
Djibouti	GAVI	12.7	EMR D	Lower middle income
Eritrea	GAVI	12.9	AFR E	Low income
Ethiopia	GAVI	18.8	AFR E	Low income
Georgia	(formerly) GAVI	9.4	EUR B	Lower middle income
Ghana	GAVI	39.5	AFR D	Lower middle income
Guinea	GAVI	56.3	AFR D	Low income
Guinea-Bissau	GAVI	35.1	AFR D	Low income
Guyana	GAVI	44.7	AMR B	Lower middle income
Haiti	GAVI	16	AMR D	Low income

Table 1. Categorization of GAVI countries in current Excel model (cont.)

Country	GAVI-eligibility	Cancer Incidence (Globocan 2008)	WHO GBD Region	Economic classification (World Bank)
Honduras	(formerly) GAVI	37.8	AMR B	Lower middle income
India	GAVI	27	SEAR D	Lower middle income
Indonesia	(formerly) GAVI	12.7	SEAR B	Lower middle income
Kenya	GAVI	23.4	AFR E	Low income
Kiribati	(formerly) GAVI	9.5 (Micronesia)	WPR B	Lower middle income
Korea, Democratic Republic	GAVI	6.6	SEAR	Low income
Kyrgyzstan	GAVI	26.5	EUR B	Low income
Lao People Democratic Republic	GAVI	22.1	WPR B	Lower middle income
Lesotho	GAVI	35	AFR E	Lower middle income
Liberia	GAVI	41.8	AFR D	Low income
Madagascar	GAVI	27.2	AFR D	Low income
Malawi	GAVI	50.8	AFR E	Low income
Mali	GAVI	37.7	AFR D	Low income
Mauritania	GAVI	35.1	AFR D	Lower middle income
Moldova	(formerly) GAVI	17.1	EUR C	Lower middle income
Mongolia	(formerly) GAVI	28.4	WPR B	Lower middle income
Mozambique	GAVI	50.6	AFR E	Low income
Myanmar	GAVI	26.4	SEAR D	Low income
Nepal	GAVI	32.4	SEAR D	Low income
Nicaragua	GAVI	39.9	AMR D	Lower middle income
Niger	GAVI	15.6	AFR D	Low income
Nigeria	GAVI	33	AFR D	Lower middle income
Pakistan	GAVI	19.5	EMR D	Lower middle income
Papua New Guinea	GAVI	23.2	WPR B	Lower middle income
Rwanda	GAVI	34.5	AFR E	Low income
Sao Thome and Principe	GAVI	23.0 (Middle Africa)	AFR D	Lower middle income

Table 1. Categorization of GAVI countries in current Excel model (cont.)

Country	GAVI-eligibility	Cancer Incidence (Globocan 2008)	WHO GBD Region	Economic classification (World Bank)
Senegal	GAVI	34.7	AFR D	Lower middle income
Sierra Leone	GAVI	41.9	AFR D	Low income
Solomon Islands	GAVI	17.6	WPR B	Lower middle income
Somalia	GAVI	20.3	EMR D	Low income
Sri Lanka	(formerly) GAVI	11.8	SEAR B	Lower middle income
Sudan	GAVI	7	EMR D	Lower middle income
Tajikistan	GAVI	8.7	EUR B	Low income
Tanzania	GAVI	50.9	AFR E	Low income
The Gambia	GAVI	32.4	AFR D	Low income
Timor Leste	(formerly) GAVI	11.4	SEAR B	Lower middle income
Togo	GAVI	30	AFR D	Low income
Uganda	GAVI	47.5	AFR E	Low income
Ukraine	(formerly) GAVI	16.1	EUR C	Lower middle income
Uzbekistan	GAVI	10.8	EUR B	Lower middle income
Viet Nam	GAVI	11.5	WPR B	Lower middle income
Yemen	GAVI	3	EMR D	Lower middle income
Zambia	GAVI	52.8	AFR E	Lower middle income
Zimbabwe	GAVI	47.4	AFR E	Low income

SELECTED ASSUMPTIONS FOR THE BASE CASE

Assumptions include: 1) the average mean duration of time between detection of invasive cancer and death is 4-6 years for GAVI-eligible countries – with no effective cervical cancer screening (varied from 2–10 years in Goldie 2008a, 2008c); 2) ratio of mortality to incidence approximates 80% for GAVI-eligible countries (range 50%–90%, in Goldie 2008c); and (3) in the absence of screening programs we assume that asymptomatic local noninvasive cancer would not be detected, and thus, cancers detected on the basis of symptoms are all at regional and distant stages – this assumption is restricted to GAVI-eligible countries and countries with no population screening (of note, in analyses in which we included non-GAVI eligible and GAVI-eligible countries, published elsewhere, different assumptions are used for countries as they drastically differ in screening services, health services capacity and socioeconomic profile – e.g., this necessitates different assumptions for Haiti and Argentina in terms of cancer stage at detection). Please note that these assumptions were informed by the stochastic micro-simulation model which explicitly models the natural history of HPV and cervical carcinogenesis, stage progression conditional on several variables, etc. As we have explained in detail elsewhere, and in separate documents, we used this more detailed model to ensure the simplifying assumptions of the "average" at the population level used in the excel model are reasonable. Assessment of concordance and validity between models, when restricted to the straightforward question of vaccine benefit projections, showed close alignment. We include a sample of these results later in this document. Alternatives to these assumptions were examined in sensitivity analysis.

Input Requirement	**Assumptions**	**Variability**
Average age of HPV death by country	Country-specific	Model output
Average age onset of vaccine preventable cancer case	Country-specific	Model output
Number of preventable cancer cases (by country & year)	Country-specific	Model output
Number of averted HPV deaths (by country and year)	Country-specific	Model output

DALY Assumptions

DALY (Disability-Adjusted Life Years)	Baseline Parameters Used in Analyses Estimating Vaccine Benefits	Baseline Parameters Used in Analyses Estimating Vaccine Costs Relative to Benefits
Discount rate, r	0	0.03
Age weight modulating factor, K	0	0
Constant, C	0.1658	0.1658
Age weight parameter, beta	0.04	0.04
r+beta	0.07	0.07
Duration of disability, L	6	6
Disability weight, D	0.075	0.075

Vaccination strategies assume three doses are required, and are distinguished by age of vaccination, coverage level (defined as completion of a three-dose course) and vaccine efficacy. The base case assumes 70% coverage at 100% efficacy to estimate the potential avertable burden without making assumptions about the differential operational capacity to deliver the vaccine. Alternative coverage rates are evaluated in sensitivity analyses. The model may be run as a single cohort for one-time vaccination of a group of girls (e.g., 12-year-old girls in 2011), or for multiple cohorts (e.g., 9-year-olds girls each year for 10 years). As the age of vaccination is a user-defined input, the model may also consider catch-up vaccination of older girls. The model's "base year" is the year in which the program is initiated or the implementation decision is made (e.g., 2011 would be present time); all future costs and benefits are discounted to this year. The "intervention year" cannot be earlier than the base year.

We assume vaccination is prior to sexual debut and in the past have used 9-12 years of age. The age is user-defined and the model can accommodate any age. Of note, there is very little difference from analyses that vaccinate 10, 11 and 12 year old girls given our simplifying assumptions. While this may seem counter-intuitive, the reasons are as follows: (1) we assume sexual debut is older than age 12 and thus vaccine efficacy does not differ based on prior exposure to HPV 16 and 18 in these cohorts; (2) the population size change between 10, 11 and 12 is not nearly as substantial and influential as the year to year difference in the first years of life. The "real-world" difference in age groups between 9 and 12 (e.g., vaccinating at age 10 versus 11 versus 12) is the obtainable coverage in each country based on local circumstances – for example, coverage can vary depending on programmatic strategy

for vaccinating girls, location of primary services, whether school-based vaccination is employed, etc.) Since in this analysis, coverage is "imposed" by the analyst, the differences between vaccinating 10 and 11 are small. All that being said, the model can accommodate any age specified by the user.

Proportion of cervical cancer cases attributable to HPV 16,18

We used estimates of the proportion of HPV 16,18 in women with cervical cancer from a large retrospective, cross-sectional study of HPV genotypes among patients with invasive cervical cancer during 1949-2009 (de Sanjose 2010; personal communication M. Diaz). More than 10,000 cases of invasive cervical cancer were included and a common protocol was used for collection of specimens, histological confirmation and classification, and HPV testing was centralized in two laboratories with common protocols and parameters for quality control. Highly sensitive assays were used for HPV detection, therefore, it was not necessary to correct for multiple types.

We ran sensitivity analyses on these estimates, assuming a flat rate of 70% of cancers attributable to HPV 16 and 18, as well as utilizing country-specific estimates as opposed to regional estimates. In general, the country-specific estimates may be considered less reliable than the regional estimates due to limited sample size, variation in sensitivity of assays used to detect HPV DNA, and variation in the defined population being considered (e.g., all women with cancer versus all women with HPV-positive cancer). Finally, some "country-specific" estimates were derived from regional estimates when country-specific data were unavailable.

For analyses conducted with the Excel-based model, screening is not considered. We have conducted analyses using our microsimulation model that incorporate both screening and vaccination in approximately 24 countries to date, and have documented and distributed those findings widely. Publication list and results available on request.

Of note, to conduct a cost-effectiveness analysis in poor countries and assume the cost of treatment is zero (based on the fact it is not available to all women) is not appropriate from an ethical and equity perspective, because it imposes a double jeopardy (i.e., if a cervical cancer death is associated with

zero costs, it will always be more cost-effective to not prevent and treat disease – an unacceptable assumption – global equity mandates inclusion of consequences of disease- expressed in health and economic metrics - albeit adjusted to reflect country-specific valuation and currency). The cost estimates assume that while some treatment for cervical cancer is available, treatment for CIN1 or CIN2/3 is not available. Costs for cervical cancer treatment represent an average treatment cost per case (e.g., an average number of visits for treatment of cervical cancer) and are assumed to be realized at around median survival time after cancer onset. In the base case, every cancer case is assumed to incur cancer treatment costs although limited access to care may also be considered.

Cost-effectiveness analyses assume a modified societal perspective (meaning that direct non-medical costs are not considered in the ratio), although the model may consider alternative perspectives (e.g., health care provider, payor). Future costs and health outcomes (years of life) are discounted by 3% annually (DCPP, WHO CHOICE, Drummond 2005, Gold 1996), although the discount rate may be adjusted by the user. The model allows for one-way and multi-way (deterministic) sensitivity analyses of key variables (e.g., year of intervention, age at vaccination, coverage, program cost for 3 doses of vaccine, etc.).

DATA AND SOURCES

Demographic Data

Demographic estimates for age-specific population size (in 1-year intervals) and age-specific life expectancy (in five-year intervals) were from United Nations World Population Prospects 2010 data (UN 2011) and 2009 World Health Organization (WHO) life tables (WHO Life Tables), respectively. In years when no data were available (e.g., years 2051-2100) we used a growth factor calculated as a function of a country's population in 2049 and 2050. Because population estimates extend to 2110, the model can vaccinate 9-year-olds only through year 2029. Exceptions to the use of these data included three countries, Antigua and Barbuda, Dominica, and St. Kitts and Nevis, for which United Nations World Population Prospects 2010 data were not available; instead the latest estimates available were used (UN 2005). Similarly, estimates were not available for Kosovo, Marshall Islands, Seychelles and

Tuvalu, in which case, we distributed total population by age structure evenly among all ages within a band, and applied the growth rate to project for future years (World Facts).

Cancer Incidence (Globocan 2008)

While previous versions of the model utilized a hierarchical ranking of cervical cancer incidence data (e.g., country-specific incidence rates from Cancer Incidence in Five Continents (CI5C) (volumes 1-9) (Parkin 2005, Curado 2007); estimates from Cancer Incidence in Africa (Parkin 2003) (where applicable); or estimates from Globocan 2008 (Ferlay 2010)), for this version of the model we elected to use one source (Globocan 2008) for all countries. This decision reflects that fact that, according to the International Agency for Research on Cancer, (1) incidence data derive from population-based cancer registries, the most important source being Cancer Incidence in Five Continents (Parkin 2005, Curado 2007); (2) population-based cancer registries may cover entire national populations but more often cover smaller, subnational areas, and, particularly in developing countries, only major cities; (3) Globocan 2008 prioritizes incidence data in the following manner: national incidence data; local incidence data and national mortality data with regional models built in the absence of (or low quality) country-specific national or local incidence data; local incidence data and no mortality data; frequency data; and no data, in which case Globocan 2008 presents the country-specific rates of neighboring countries in the same region.

The Globocan 2008 database presents estimates of cancer incidence and mortality by age group, sex, cancer, and country for the year 2008. It should be emphasized that:

- Incidence data are generally associated with some delay as they require time to be compiled and published, but recent information can often be found in routine reports from the registries themselves, commonly available via their websites.
- While the quality of information from most of the developing countries might not be of sufficient quality, this information is still of unique importance as it often remains the only relatively unbiaised source of information available on the profile of cancer.

- Population-based cancer registries can also produce survival statistics by following up their vital status of cancer patients. Survival probabilities can be used to estimate mortality from incidence in the absence of mortality data.
- Mortality statistics are collected and made available by the WHO. While not all datasets are of the same quality, their advantages are national coverage and long-term availability. For some countries, coverage of the population is incomplete, so that the mortality rates produced are implausibly low, and in others, the quality of cause of death information is poor. While almost all the European and American countries have comprehensive death registration systems, most African and Asian countries (including the populous countries of Nigeria, India and Indonesia) do not. The Globocan 2008 estimates utilize the provisional estimates of the age- and sex-specific deaths from cancer (of all types) for 2008 in each country of the world.
- National population estimates for 2008 were extracted from the United Nation (UN) population division, the 2008 revision (UN 2009). These estimates may differ slightly (especially for older age groups) from those prepared by national authorities
- The ASR is calculated using 5 age-groups 0-14, 15-44, 45-54, 55-64, 65+. The result may be slightly different from that computed using the same data categorized using traditional 5-year age bands.

Instead of using constant rates for age groups 15- to 39-year-olds, as in previous versions of the model, we calculated a linear regression. Therefore, rates from 10- to 14-year-olds to 35- to 39-year-olds are increasing. We assumed the rate reported for the age group 0- to 14-year-olds represented only the group of 10- to 14-year-olds, with zero cases for 0- to 4-year-olds and 5- to 9-year-olds.

Table 2. Summary of model inputs of age-specific cervical cancer incidence for the companion model. Globocan 2008 (Ferlay 2010)

Country	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-99
Afghanistan	0.0	0.0	0.0	0.4	0.9	1.3	1.8	2.2	9.3	19.7	23.3	21.7	20.6	14.0	17.6	22.3	22.3	22.3
Albania	0.0	0.0	0.0	4.5	6.6	8.7	10.8	12.9	15.0	18.0	19.4	21.4	20.1	17.0	11.5	3.0	3.0	3.0
Angola	0.0	0.0	0.3	1.8	3.3	4.8	6.3	7.8	54.1	62.8	84.1	109.3	116.5	106.1	115.0	63.3	63.30	63.30
Armenia	0.0	0.0	0.0	1.3	2.7	4.0	5.4	6.7	29.8	56.7	53.1	23.3	47.5	50.6	98.9	30.9	30.88	30.88
Azerbaijan	0.0	0.0	0.0	0.7	1.4	2.0	2.7	3.4	14.0	20.4	37.2	28.7	46.6	20.5	35.5	24.0	23.96	23.96
Bangladesh	0.0	0.0	0.0	1.4	2.9	4.3	5.8	7.2	54.4	79.5	100.4	104.8	84.5	122.4	91.8	51.2	51.15	51.15
Benin	0.0	0.0	0.0	1.7	3.5	5.2	7.0	8.7	53.7	102.4	92.3	122.4	130.6	120.1	132.7	70.5	70.48	70.48
Bhutan	0.0	0.0	0.0	1.4	2.8	4.1	5.5	6.9	37.7	60.2	67.7	67.4	70.9	50.1	42.2	36.3	36.28	36.28
Bolivia	0.0	0.0	0.0	3.4	6.8	10.2	13.6	17.0	73.2	106.2	91.0	97.6	78.5	90.0	128.3	122.7	122.73	122.73
Bosnia & Herzegovina	0.0	0.0	0.0	5.9	8.7	11.6	14.4	17.3	20.1	23.8	23.2	24.7	23.5	20.4	17.6	14.4	14.4	14.4
Burkina Faso	0.0	0.0	0.2	2.0	3.8	5.7	7.5	9.3	58.4	84.4	82.3	112.3	89.4	51.6	108.7	33.0	33.04	33.04
Burundi	0.0	0.0	0.3	2.8	5.3	7.7	10.2	12.7	90.8	107.7	153.7	162.4	216.5	143.6	179.7	83.1	83.07	83.07
Cambodia	0.0	0.0	0.0	1.2	2.5	3.7	5.0	6.2	52.1	63.1	84.8	103.4	73.8	92.6	114.0	89.3	89.26	89.26
Cameroon	0.0	0.0	1.0	2.2	3.4	4.6	5.8	7.0	37.7	59.8	77.2	99.7	78.6	62.0	53.2	64.9	64.87	64.87
Cape Verde	0.0	0.0	0.0	2.2	4.4	6.7	8.9	11.1	62.4	90.7	94.4	111.1	134.2	111.3	129.1	59.3	59.30	59.30
Central African Rep.	0.0	0.0	0.3	1.1	2.0	2.8	3.7	4.5	25.1	48.1	63.7	87.4	66.6	53.3	55.5	57.7	57.71	57.71
Chad	0.0	0.0	0.3	1.1	1.9	2.7	3.5	4.3	28.4	55.3	57.7	73.8	73.3	69.5	62.4	53.0	53.03	53.03
China	0.0	0.0	0.1	1.6	3.2	4.7	6.3	7.8	27.5	18.9	23.6	25.2	17.2	14.3	13.3	15.9	15.90	15.90
Comoros	0.0	0.0	0.0	3.4	6.8	10.3	13.7	17.1	94.2	105.1	148.2	143.1	225.9	178.7	184.3	111.1	111.08	111.08
Congo, Dem Rep	0.0	0.0	0.7	1.7	2.7	3.8	4.8	5.8	32.1	53.9	69.4	91.0	71.6	55.4	48.1	57.1	57.1	57.1
Congo, Republic of	0.0	0.0	0.0	1.1	2.1	3.2	4.2	5.3	31.7	74.0	93.6	130.6	103.5	72.3	65.8	68.2	68.2	68.2
Cote d'Ivoire	0.0	0.0	0.0	0.8	1.6	2.5	3.3	4.1	30.3	48.5	56.5	102.1	154.9	109.9	167.0	47.2	47.20	47.20
Cuba	0.0	0.0	0.0	5.0	9.9	14.9	19.8	24.8	33.5	42.7	46.7	48.7	43.6	54.1	48.4	36.5	36.5	36.5
Djibouti	0.0	0.0	0.0	0.7	1.3	2.0	2.6	3.3	18.6	22.8	35.6	43.8	43.4	45.6	69.6	49.5	49.48	49.48
Egypt	0.0	0.0	0.1	0.2	0.2	0.3	0.3	0.4	3.3	2.0	5.0	3.1	8.3	6.5	4.4	5.4	5.40	5.40
El Salvador	0.0	0.0	0.0	5.3	10.6	16.0	21.3	26.6	73.8	89.5	89.2	77.8	80.2	97.0	92.4	101.0	100.99	100.99
Eritrea	0.0	0.0	0.4	1.0	1.6	2.3	2.9	3.5	18.1	20.9	33.6	43.6	47.0	42.9	70.2	56.5	56.47	56.47
Ethiopia	0.0	0.0	0.9	1.8	2.7	3.7	4.6	5.5	29.9	31.7	47.3	57.2	74.3	61.2	92.0	73.5	73.50	73.50
Fiji	0.0	0.0	0.0	10.3	22.3	34.3	46.2	58.2	70.2	78.6	96.8	66.5	128.6	84.3	95.3	80.2	80.2	80.2
Georgia	0.0	0.0	0.0	0.9	1.9	2.8	3.8	4.7	18.6	25.7	25.6	28.9	17.2	26.8	28.0	28.1	28.13	28.13
Ghana	0.0	0.0	0.1	2.3	4.4	6.6	8.7	10.9	63.6	116.1	104.6	146.6	134.9	117.3	155.5	77.3	77.27	77.27
Guatemala	0.0	0.0	0.0	3.6	7.2	10.8	14.4	18.0	65.4	85.8	81.8	78.2	56.7	71.1	66.4	90.4	90.37	90.37
Guinea	0.0	0.0	0.0	3.3	6.6	9.8	13.1	16.4	90.6	156.4	143.5	202.9	194.8	172.3	246.8	111.7	111.7	111.7
Guinea-Bissau	0.0	0.0	0.0	2.4	4.9	7.3	9.8	12.2	59.3	92.5	90.8	108.6	136.4	102.6	132.3	68.7	68.7	68.7

Table 2. Summary of model inputs of age-specific cervical cancer incidence (cont.) Globocan 2008 (Ferlay 2010)

Country	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-99
Guyana	0.0	0.0	0.0	3.8	7.5	11.3	15.0	18.8	65.5	114.8	126.2	181.9	96.2	129.1	159.6	120.3	120.35	120.35
Haiti	0.0	0.0	0.0	0.6	1.2	1.7	2.3	2.9	8.9	36.0	22.7	32.9	66.8	0.0	131.0	226.7	226.72	226.72
Honduras	0.0	0.0	0.0	4.0	8.0	12.1	16.1	20.1	69.6	96.4	91.7	106.8	91.2	118.6	105.2	111.9	111.85	111.85
India	0.0	0.0	0.0	2.2	4.3	6.5	8.6	10.8	48.6	64.1	77.9	88.0	91.5	85.5	66.6	60.2	60.2	60.2
Indonesia	0.0	0.0	0.0	0.9	1.9	2.8	3.8	4.7	22.7	28.4	34.4	36.9	49.6	42.3	37.6	32.8	32.75	32.75
Iraq	0.0	0.0	0.0	0.3	0.6	1.0	1.3	1.6	6.0	6.4	7.7	9.9	8.3	9.5	8.9	8.1	8.10	8.10
Kenya	0.0	0.0	0.0	1.2	2.4	3.5	4.7	5.9	47.0	37.6	61.5	66.2	136.1	49.8	116.8	55.6	55.6	55.6
Kiribati	0.0	0.0	0.0	1.1	2.3	3.4	4.6	5.7	16.7	20.3	40.2	0.0	0.0	42.3	51.5	41.3	41.3	41.3
Korea, Dem Rep	0.0	0.0	0.0	1.0	2.1	3.1	4.2	5.2	20.2	18.2	16.8	12.9	8.2	8.8	11.0	11.9	11.91	11.91
Kosovo	0.0	0.0	0.0	5.7	7.9	10.1	12.3	14.5	16.7	20.3	40.2	40.9	41.6	42.3	51.5	41.3	41.3	41.3
Kyrgyzstan	0.0	0.0	0.0	2.0	4.1	6.1	8.2	10.2	39.5	73.6	58.7	45.6	54.6	47.5	50.5	74.0	74.0	74.0
Lao People Dem Rep	0.0	0.0	0.0	1.7	3.4	5.0	6.7	8.4	56.7	57.0	61.0	70.2	64.0	58.6	60.5	40.5	40.46	40.46
Lesotho	0.0	0.0	0.0	2.4	4.9	7.3	9.8	12.2	68.4	84.7	100.2	82.3	142.5	98.2	98.9	116.9	116.93	116.93
Liberia	0.0	0.0	0.0	2.0	4.1	6.1	8.2	10.2	60.6	102.4	100.6	152.2	175.5	142.3	208.5	81.5	81.46	81.46
Madagascar	0.0	0.0	0.1	1.7	3.3	4.8	6.4	8.0	48.8	58.5	74.0	76.5	96.3	104.7	119.8	80.5	80.54	80.54
Malawi	0.0	0.0	0.0	4.8	9.7	14.5	19.4	24.2	112.3	99.7	166.5	136.9	237.5	94.1	112.1	36.2	36.2	36.2
Mali	0.0	0.0	0.0	3.4	6.9	10.3	13.8	17.2	86.5	105.5	91.6	89.7	135.4	113.5	109.4	30.1	30.1	30.1
Marshall Island	0.0	0.0	0.0	5.7	7.9	10.1	12.3	14.5	16.7	20.3	40.2	40.9	41.6	42.3	51.5	41.3	41.3	41.3
Mauritania	0.0	0.0	0.0	2.4	4.8	7.1	9.5	11.9	60.6	90.7	90.3	110.2	136.3	104.1	137.9	67.7	67.73	67.73
Micronesia	0.0	0.0	0.0	5.7	7.9	10.1	12.3	14.5	16.7	20.3	40.2	40.9	41.6	42.3	51.5	41.3	41.3	41.3
Moldova	0.0	0.0	0.0	2.5	5.0	7.5	10.0	12.5	41.5	46.5	46.9	42.8	36.2	26.9	21.2	24.3	24.31	24.31
Mongolia	0.0	0.0	0.0	2.2	4.3	6.5	8.6	10.8	76.0	88.5	80.7	78.0	81.6	68.3	49.2	52.3	52.30	52.30
Morocco	0.0	0.0	0.0	0.5	0.9	1.4	1.8	2.3	19.3	39.1	59.4	56.5	41.2	47.2	31.3	39.7	39.70	39.70
Mozambique	0.0	0.0	0.1	3.8	7.4	11.1	14.7	18.4	98.1	101.0	145.4	144.9	222.3	159.6	159.1	95.4	95.4	95.4
Myanmar	0.0	0.0	0.1	2.4	4.6	6.9	9.1	11.4	54.8	68.8	70.5	81.8	76.2	69.1	79.6	61.4	61.38	61.38
Nepal	0.0	0.0	0.0	1.9	3.8	5.7	7.6	9.5	75.2	84.3	104.0	102.9	107.6	109.3	81.3	39.8	39.79	39.79
Nicaragua	0.0	0.0	0.0	4.3	8.6	13.0	17.3	21.6	74.3	104.6	72.7	108.2	124.8	125.2	119.7	103.5	103.50	103.50
Niger	0.0	0.0	0.0	0.8	1.6	2.3	3.1	3.9	28.3	43.9	45.1	38.9	75.9	61.6	39.2	15.3	15.3	15.3
Nigeria	0.0	0.0	0.0	1.1	2.2	3.3	4.4	5.5	41.9	107.3	87.9	125.1	120.1	128.0	110.4	86.4	86.4	86.4
Pakistan	0.0	0.0	0.0	1.2	2.3	3.5	4.6	5.8	43.6	50.2	64.2	65.4	59.6	64.9	47.6	27.9	27.9	27.9
Palestinian Territory	0.0	0.0	0.0	5.7	7.9	10.1	12.3	14.5	16.7	20.3	40.2	40.9	41.6	42.3	51.5	41.3	41.3	41.3
Papua New Guinea	0.0	0.0	0.0	2.5	5.1	7.6	10.2	12.7	56.8	57.1	61.8	59.1	91.1	10.9	27.7	86.1	86.05	86.05
Paraguay	0.0	0.0	0.0	2.7	5.4	8.1	10.8	13.5	50.4	79.1	95.1	99.0	125.2	127.4	113.6	119.5	119.5	119.5
Philippines	0.0	0.0	0.0	6.2	13.2	20.2	27.1	34.1	41.1	24.6	39.9	40.9	16.0	16.0	19.4	17.6	17.6	17.6
Rwanda	0.0	0.0	0.0	1.6	3.2	4.7	6.3	7.9	68.7	74.0	119.7	146.1	148.3	108.3	61.5	35.6	35.61	35.61

Table 2. Summary of model inputs of age-specific cervical cancer incidence (cont.) Globocan 2008 (Ferlay 2010)

Country	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-99
Samoa	0.0	0.0	0.0	3.2	24.6	45.9	67.3	88.6	110.0	49.9	70.5	45.1	55.6	61.7	61.7	61.7	61.7	61.7
Sao Thome (Middle Africa)	0.0	0.0	0.6	1.7	2.8	3.9	5.0	6.1	35.9	56.9	72.6	94.8	79.9	65.1	60.1	59.9	59.9	59.9
Senegal	0.0	0.0	0.0	2.2	4.5	6.7	9.0	11.2	60.8	91.3	90.0	109.9	135.7	103.1	137.9	63.5	63.5	63.5
Sierra Leone	0.0	0.0	0.0	2.2	4.4	6.6	8.8	11.0	60.5	102.6	100.5	152.8	175.4	141.1	204.0	78.4	78.37	78.37
Solomon Islands	0.0	0.0	0.0	1.2	2.3	3.5	4.6	5.8	34.2	52.4	40.6	70.9	45.0	30.1	92.3	43.5	43.50	43.50
Somalia	0.0	0.0	0.7	1.8	2.9	4.0	5.1	6.2	35.1	33.8	51.8	60.0	91.4	58.1	99.1	66.5	66.49	66.49
Sri Lanka	0.0	0.0	0.0	0.3	0.7	1.0	1.4	1.7	13.6	24.7	38.6	38.5	46.9	62.7	45.1	37.5	37.5	37.5
Sudan	0.0	0.0	0.0	0.3	0.5	0.8	1.0	1.3	6.3	9.7	19.2	30.7	19.0	26.7	48.4	44.1	44.10	44.10
Swaziland	0.0	0.0	0.0	3.9	7.8	11.6	15.5	19.4	101.2	130.2	134.3	112.5	189.5	124.7	138.1	181.3	181.3	181.3
Syria	0.0	0.0	0.0	0.2	0.4	0.5	0.7	0.9	3.8	3.9	6.2	7.4	5.3	6.6	8.5	4.0	4.0	4.0
Tajikistan	0.0	0.0	0.0	0.6	1.2	1.8	2.4	3.0	12.6	30.9	36.1	30.1	24.7	11.8	17.7	16.1	16.08	16.08
Tanzania	0.0	0.0	0.4	3.0	5.5	8.1	10.6	13.2	88.9	104.2	153.6	148.9	222.1	183.1	201.6	111.4	111.43	111.43
The Gambia	0.0	0.0	0.0	3.8	7.6	11.5	15.3	19.1	83.1	71.2	101.3	91.1	93.8	7.9	91.4	80.6	80.6	80.6
Timor Leste (South-Eastern Asia)	0.0	0.0	0.0	1.3	2.6	3.8	5.1	6.4	34.7	36.8	46.2	50.2	49.5	42.5	43.2	36.5	36.5	36.5
Togo	0.0	0.0	0.0	1.0	2.0	2.9	3.9	4.9	36.1	78.2	72.1	114.1	137.0	119.3	139.0	66.0	65.96	65.96
Tonga	0.0	0.0	0.0	5.7	7.9	10.1	12.3	14.5	16.7	20.3	40.2	40.9	41.6	42.3	51.5	41.3	41.3	41.3
Turkmenistan	0.0	0.0	0.0	1.1	1.6	2.2	2.7	3.3	3.8	12.0	22.5	12.8	32.3	35.4	22.6	47.2	47.2	47.2
Tuvalu	0.0	0.0	0.0	5.7	7.9	10.1	12.3	14.5	16.7	20.3	40.2	40.9	41.6	42.3	51.5	41.3	41.3	41.3
Uganda	0.0	0.0	0.1	2.6	5.2	7.7	10.3	12.8	92.5	111.7	154.1	176.0	209.7	104.3	157.1	54.0	54.0	54.0
Ukraine	0.0	0.0	0.0	2.4	4.8	7.2	9.6	12.0	33.3	39.7	32.7	32.7	25.4	27.0	25.2	17.8	17.80	17.80
Uzbekistan	0.0	0.0	0.0	0.7	1.5	2.2	3.0	3.7	14.3	25.9	35.5	41.2	34.5	32.4	38.7	24.4	24.4	24.4
Vanuatu	0.0	0.0	0.0	8.5	13.5	18.4	23.4	28.3	33.3	62.5	84.6	106.6	135.4	164.3	193.1	193.1	193.1	193.1
Viet Nam	0.0	0.0	0.0	1.1	2.2	3.2	4.3	5.4	34.1	21.7	36.4	41.4	27.9	20.8	26.9	16.7	16.7	16.7
Yemen	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.4	2.9	4.8	7.3	9.6	7.6	28.1	13.4	12.8	12.82	12.82
Zambia	0.0	0.0	0.2	2.9	5.6	8.2	10.9	13.6	103.2	97.0	139.5	185.3	224.5	210.6	239.9	60.1	60.09	60.09
Zimbabwe	0.0	0.0	0.0	2.0	4.0	5.9	7.9	9.9	93.5	99.1	116.4	149.0	207.3	201.6	164.3	137.8	137.8	137.8

Proportion of cervical cancer cases attributable to HPV 16,18

We used estimates of the proportion of HPV 16,18 in women with cervical cancer from a large retrospective, cross-sectional study of HPV genotypes among patients with invasive cervical cancer during 1949-2009 (de Sanjose 2010; personal communication M. Diaz). More than 10,000 cases of invasive cervical cancer were included and a common protocol was used for collection of specimens, histological confirmation and classification, and HPV testing was centralized in two laboratories with common protocols and parameters for quality control. Highly sensitive assays were used for HPV detection, therefore, it was not necessary to correct for multiple types.

We ran sensitivity analyses on these estimates, assuming a flat rate of 70% of cancers attributable to HPV 16 and 18, as well as utilizing country-specific estimates as opposed to regional estimates. In general, the country-specific estimates may be considered less reliable than the regional estimates due to limited sample size, variation in sensitivity of assays used to detect HPV DNA, and variation in the defined population being considered (e.g., all women with cancer versus all women with HPV-positive cancer). Finally, some “country-specific” estimates were derived from regional estimates when country-specific data were unavailable.

Table 3. Proportion of HPV 16,18 in cervical cancer used as model parameter estimate

Country	Regional estimate	Region	Flat estimate	Country-specific estimate
Afghanistan	84%	Asia, South	70%	73%
Angola	71%	Sub-Saharan Africa, Central	70%	49%
Armenia	70%	Asia, Central	70%	80%
Azerbaijan	70%	Asia, Central	70%	80%
Bangladesh	84%	Asia, South	70%	71%
Benin	71%	Sub-Saharan Africa, West	70%	67%
Bhutan	84%	Asia, South	70%	77%
Bolivia	68%	Latin America, Andean	70%	38%
Burkina Faso	71%	Sub-Saharan Africa, West	70%	58%
Burundi	71%	Sub-Saharan Africa, East	70%	76%
Cambodia	60%	Asia, Southeast	70%	64%
Cameroon	71%	Sub-Saharan Africa, West	70%	49%
Central African Republic	71%	Sub-Saharan Africa, Central	70%	49%
Chad	71%	Sub-Saharan Africa, West	70%	49%
Comoros	71%	Sub-Saharan Africa, East	70%	76%
Congo, Democratic Republic	71%	Sub-Saharan Africa, Central	70%	49%
Congo, Rep of (Brazzaville)	71%	Sub-Saharan Africa, Central	70%	49%
Cote d'Ivoire	71%	Sub-Saharan Africa, West	70%	58%
Cuba	68%	Caribbean	70%	64%
Djibouti	71%	Sub-Saharan Africa, East	70%	76%
Eritrea	71%	Sub-Saharan Africa, East	70%	76%
Ethiopia	71%	Sub-Saharan Africa, East	70%	86%
Georgia	70%	Asia, Central	70%	80%
Ghana	71%	Sub-Saharan Africa, West	70%	58%
Guinea	71%	Sub-Saharan Africa, West	70%	51%
Guinea-Bissau	71%	Sub-Saharan Africa, West	70%	58%
Guyana	68%	Caribbean	70%	62%
Haiti	68%	Caribbean	70%	61%
Honduras	68%	Latin America, Central	70%	58%
India	84%	Asia, South	70%	79%
Indonesia	60%	Asia, Southeast	70%	75%

Table 3. Proportion of HPV 16,18 in cervical cancer used as model parameter estimate (cont.)

Country	Regional estimate	Region	Flat estimate	Country-specific estimate
Kenya	71%	Sub-Saharan Africa, East	70%	61%
Kiribati	60%	Oceania	70%	75%
Korea, Democratic Republic	70%	Asia, East	70%	72%
Kyrgyzstan	70%	Asia, Central	70%	77%
Lao People Dem Rep	60%	Asia, Southeast	70%	77%
Lesotho	71%	Sub-Saharan Africa, Southern	70%	62%
Liberia	71%	Sub-Saharan Africa, West	70%	58%
Madagascar	71%	Sub-Saharan Africa, East	70%	76%
Malawi	71%	Sub-Saharan Africa, East	70%	76%
Mali	71%	Sub-Saharan Africa, West	70%	53%
Mauritania	71%	Sub-Saharan Africa, West	70%	58%
Moldova	77%	Europe, Eastern	70%	80%
Mongolia	70%	Asia, Central	70%	48%
Mozambique	71%	Sub-Saharan Africa, East	70%	69%
Myanmar	60%	Asia, Southeast	70%	64%
Nepal	84%	Asia, South	70%	79%
Nicaragua	68%	Latin America, Central	70%	53%
Niger	71%	Sub-Saharan Africa, West	70%	58%
Nigeria	71%	Sub-Saharan Africa, West	70%	70%
Pakistan	84%	Asia, South	70%	94%
Papua New Guinea	60%	Oceania	70%	75%
Rwanda	71%	Sub-Saharan Africa, East	70%	76%
São Tomé and Príncipe	71%	Sub-Saharan Africa, West	70%	49%
Senegal	71%	Sub-Saharan Africa, West	70%	44%
Sierra Leone	71%	Sub-Saharan Africa, West	70%	58%
Solomon Islands	60%	Oceania	70%	75%
Somalia	71%	Sub-Saharan Africa, East	70%	76%
Sri Lanka	60%	Asia, Southeast	70%	77%
Sudan	71%	Sub-Saharan Africa, East	70%	69%
Tajikistan	70%	Asia, Central	70%	77%
Tanzania	71%	Sub-Saharan Africa, East	70%	76%
The Gambia	71%	Sub-Saharan Africa, West	70%	58%
Timor Leste	60%	Asia, Southeast	70%	64%

Table 3. Proportion of HPV 16,18 in cervical cancer used as model parameter estimate (cont.)

Country	Regional estimate	Region	Flat estimate	Country-specific estimate
Togo	71%	Sub-Saharan Africa, West	70%	58%
Uganda	71%	Sub-Saharan Africa, East	70%	73%
Ukraine	77%	Europe, Eastern	70%	80%
Uzbekistan	70%	Asia, Central	70%	77%
Viet Nam	60%	Asia, Southeast	70%	64%
Yemen	72%	North Africa/Middle East	70%	67%
Zambia	71%	Sub-Saharan Africa, East	70%	76%
Zimbabwe	71%	Sub-Saharan Africa, Southern	70%	76%

Comparison to previous published model (Goldie 2008a,b,c)

Previous applications of the model (e.g., Goldie 2008a,b,c) utilized different data sources: age-specific population size from the 2004 revision of the UN World Population Prospects (UN 2005), age-specific life expectancy from 2004 WHO life tables, and cervical cancer incidence data hierarchically ranked from national registries or regional pools in Cancer Incidence on Five Continents (CI5C) (Parkin 2005), Cancer in Africa (if applicable) (Parkin 2003), or Globocan 2002 (Ferlay 2004).

For these earlier analyses, we computed the prevalence of HPV 16,18 in women with cervical cancer using a homogeneous source, the comprehensive meta-analysis from Smith et al. (2007). For those countries with specific information, we used that or the pool of the country in cases where data were available from more than one citation. For those countries without specific information, we performed a regional pool. Smith et al. (2007) includes both single- and multiple-type HPV infections; women with multiple HPV types are counted more than once, so the overall prevalence of HPV types adds to more than 100%. Specifically, women with multiple types HPV 16 and 18 are counted twice; therefore the HPV 16,18 distribution is inflated. To avoid this, we utilized a hierarchical classification, whereby multiple types are assigned according to the most common type, and women are counted once. For example, a woman with multiple types 16 and 18 is classified as HPV 16. This classification implies that the prevalence of HPV 16 remains the same, while the prevalence of HPV 18 decreases in relation to that used in the meta-analysis, as well as the HPV16,18 distribution. For this purpose, the prevalence of HPV 18 was corrected for multiple types 16,18 when information was reported (provided by IARC). The final prevalence of HPV 18 is the prevalence presented in the meta-analysis less the prevalence of women with both types. For those studies with multiple types but no specific information available, we used a 3.3% correction (overall average of the articles with available information on multiple types 16,18).

Finally, costs associated with cervical cancer were estimated in the same way, e.g., based on published studies and previously described approximation methods, which leverage available data in select countries and extrapolate to other countries based on per capita gross domestic product (GDP) and other indicators (WHO CHOICE, Goldie 2005, Goldhaber-Fiebert 2006), but we utilized recently

available data from the WHO on bed day costs and per capita GDP. Any differences in results between the original published analyses and the current model are due to the combination of updating multiple parameters (e.g., population estimates, life expectancy, cervical cancer incidence, type distribution in cervical cancer, and costs); basic model assumptions, however, remained consistent between model versions.

II. COMPARATIVE VALIDATION: COMPANION MODEL AND STOCHASTIC MODELS

Overview of stochastic models

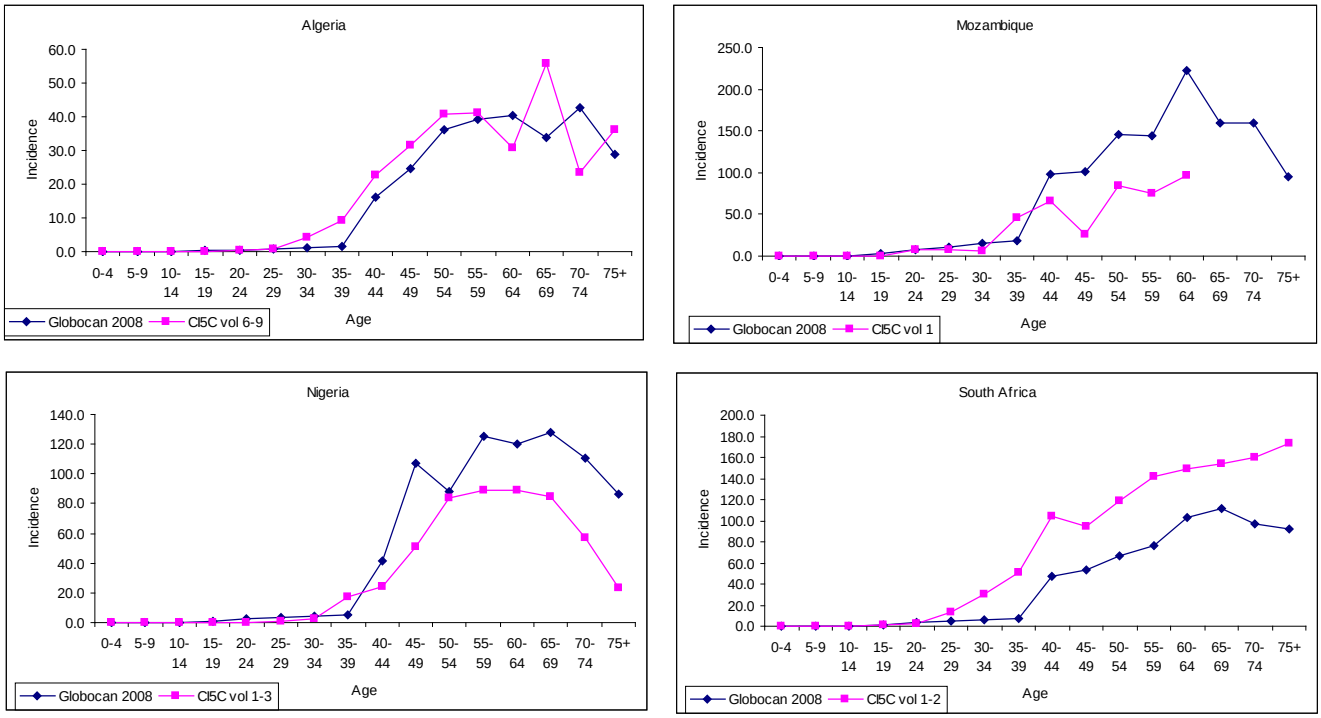
We have previously described a series of cervical cancer models that include an individual-based stochastic model to simulate cervical carcinogenesis associated with all high-risk HPV types and a dynamic model to simulate sexual transmission of HPV-16 and -18 infections between males and females (Goldie 2007, Kim 2007a, Kim 2007b, Diaz 2008, Kim 2008, Diaz 2010, Sharma 2011, Campos 2011). A likelihood-based approach is used to calibrate these models to empirical data, including age- and type-specific HPV prevalence, age-specific prevalence of cervical lesions, HPV type distribution within women with normal cytology, cancer precursors and cervical cancer, and age-specific incidence of cervical cancer. Our empirically calibrated models include countries in Asia (India, Thailand, and Vietnam – Hanoi and Ho Chi Minh City), Africa (Zimbabwe, Tanzania, Nigeria, Kenya, Uganda, Mozambique, South Africa), Latin America and the Caribbean (Brazil, Argentina, Chile, Colombia, Costa Rica, Mexico, Peru), and the Middle East/North Africa (Lebanon, Algeria, Turkey).

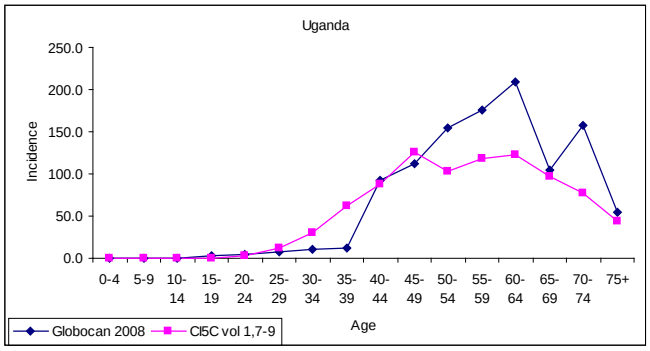
Comparison of data inputs

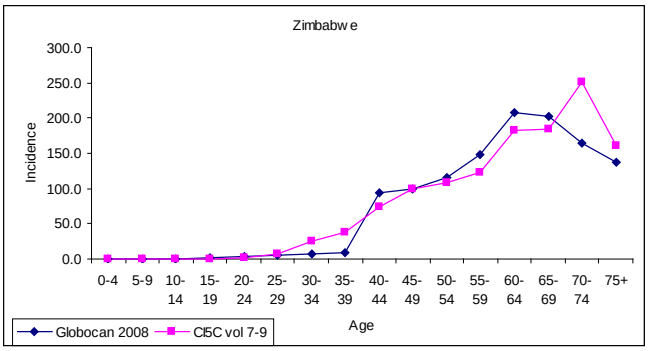
Our companion and stochastic models differ on one major input, the source of cervical cancer incidence. We have explained above our reasons to use Globocan 2008 (Ferlay 2010) estimates for the companion model. For the stochastic models, we selected countries with the best available country-specific epidemiological data, and therefore decided to use cancer incidence as reported in Cancer Incidence in Five Continents (Curado 2007). The overall objective of the Cancer Incidence in Five Continents (CI5C) series is to make available comparable data on cancer incidence from as wide a range of geographical locations worldwide as possible. Traditionally, this has been through publication of a volume containing tabulations of cancer incidence rates at approximately five-year intervals. The volumes contain three basic elements:

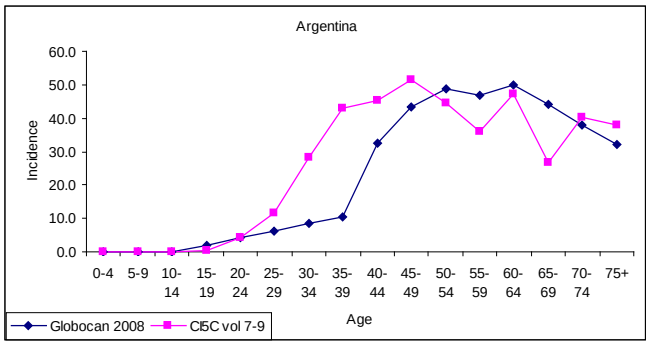
1. tabulations from individual registries presenting incidence rates according to sex, age group, and cancer site;
2. summary tables permitting comparisons between registries;
3. tables presenting indices of the validity and completeness of the different contributions.

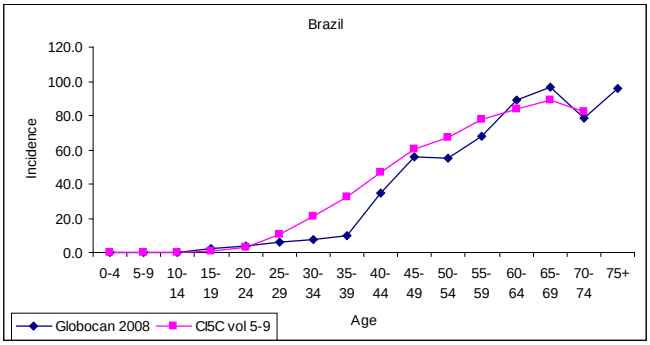
Figure 2. Comparison of incidence rates as reported in Globocan 2008 and CI5C

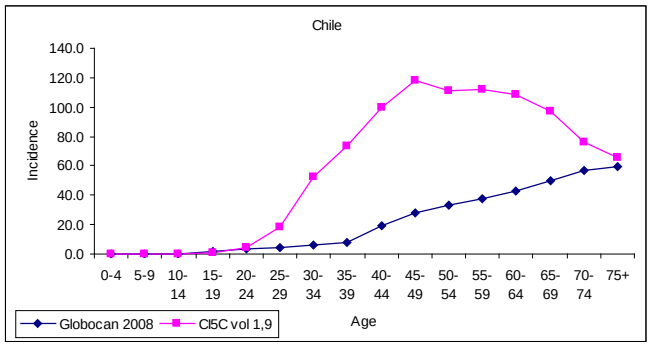


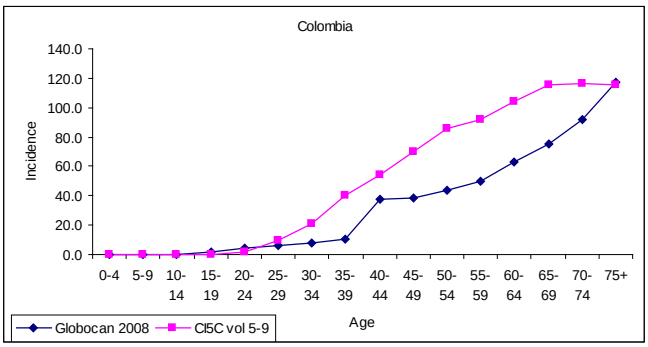

Uganda
Incidence
250.0
200.0
150.0
100.0
50.0
0.0
0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
Age
Globocan 2008
CI5C vol 1,7-9

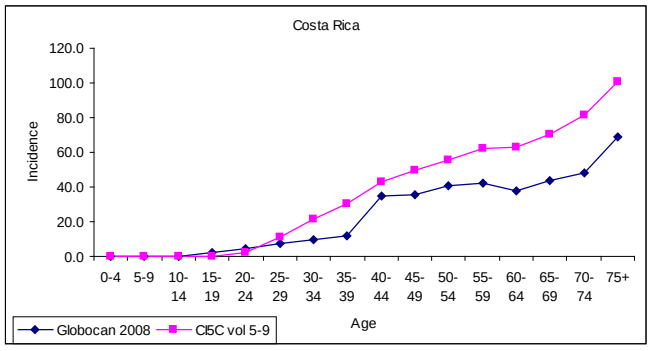

Zimbabwe
Incidence
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
Age
Globocan 2008
CI5C vol 7-9

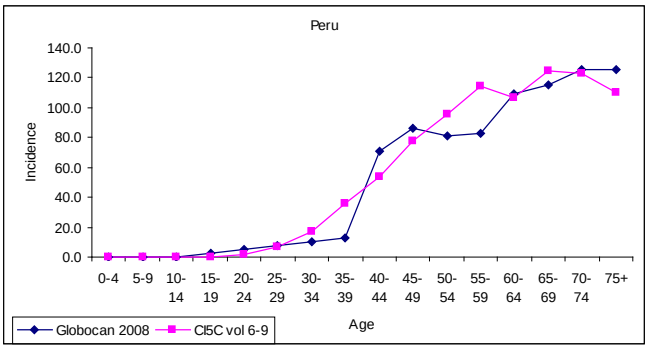

Argentina
Incidence
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
Age
Globocan 2008
CI5C vol 7-9

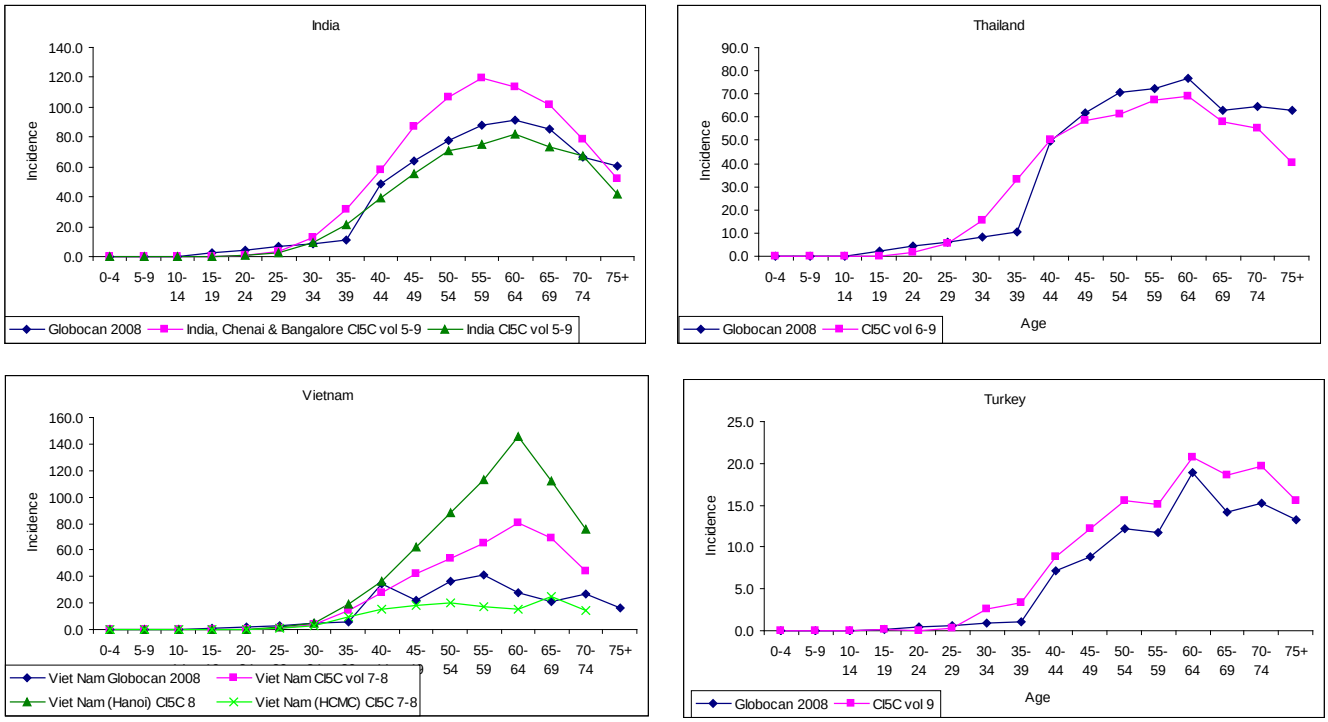

Brazil
Incidence
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
Age
Globocan 2008
CI5C vol 5-9


Chile
Incidence
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
Age
Globocan 2008
CI5C vol 1,9


Colombia
Incidence
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
Age
Globocan 2008
CI5C vol 5-9

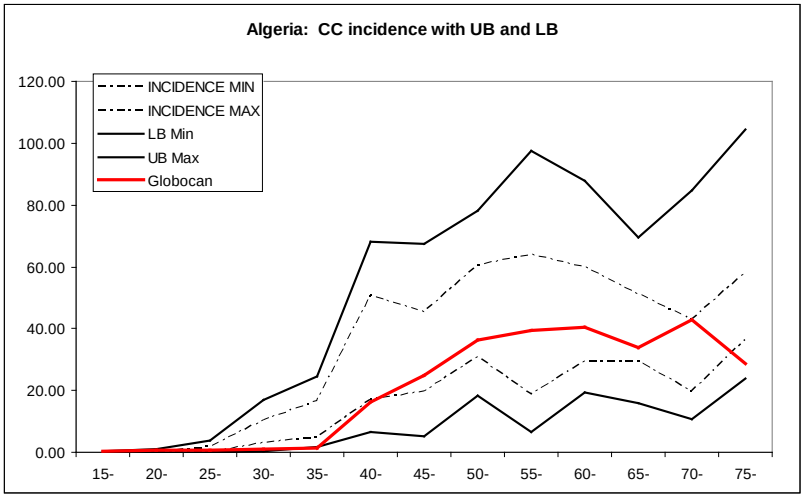

Costa Rica
Incidence
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
Age
Globocan 2008
CI5C vol 5-9

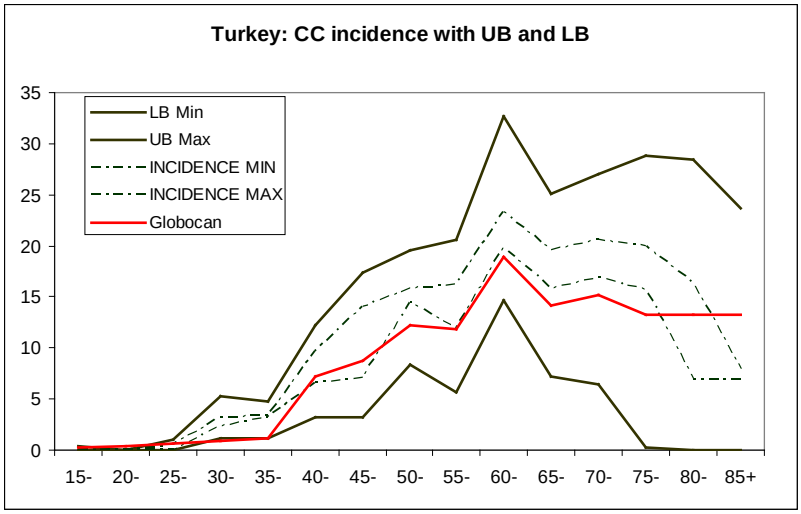

Peru
Incidence
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0-4 5-9 10-14 15-19 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 60-64 65-69 70-74 75+
Age
Globocan 2008
CI5C vol 6-9

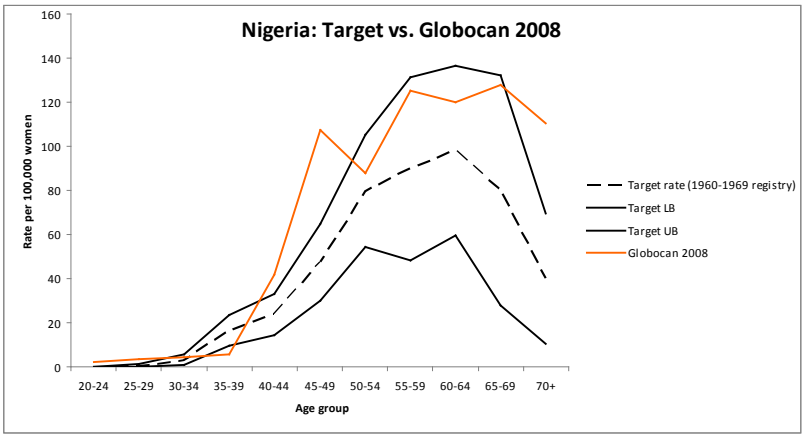


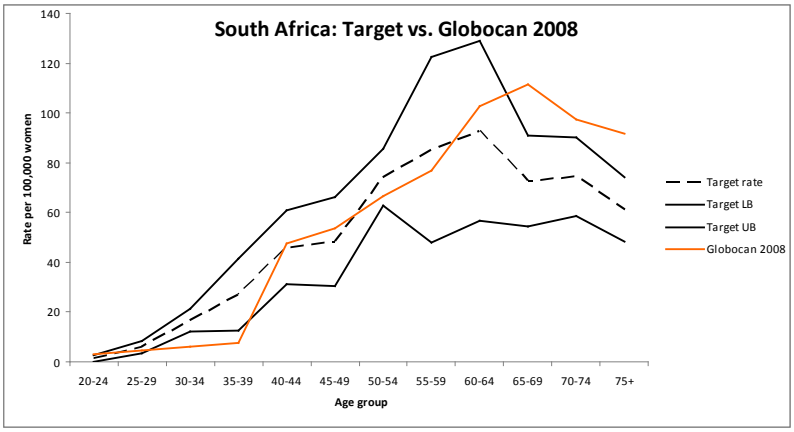
As shown below in the graphs of incidence rates from the two sources, the Globocan 2008 estimates fall within the incidence estimates reported by CI5C.

Figure 3. Comparison of incidence rates from two sources and model bounds




Turkey: CC incidence with UB and LB
LB Min
UB Max
INCIDENCE MIN
INCIDENCE MAX
Globocan
35
30
25
20
15
10
5
0
15-
20-
25-
30-
35-
40-
45-
50-
55-
60-
65-
70-
75-
80-
85+

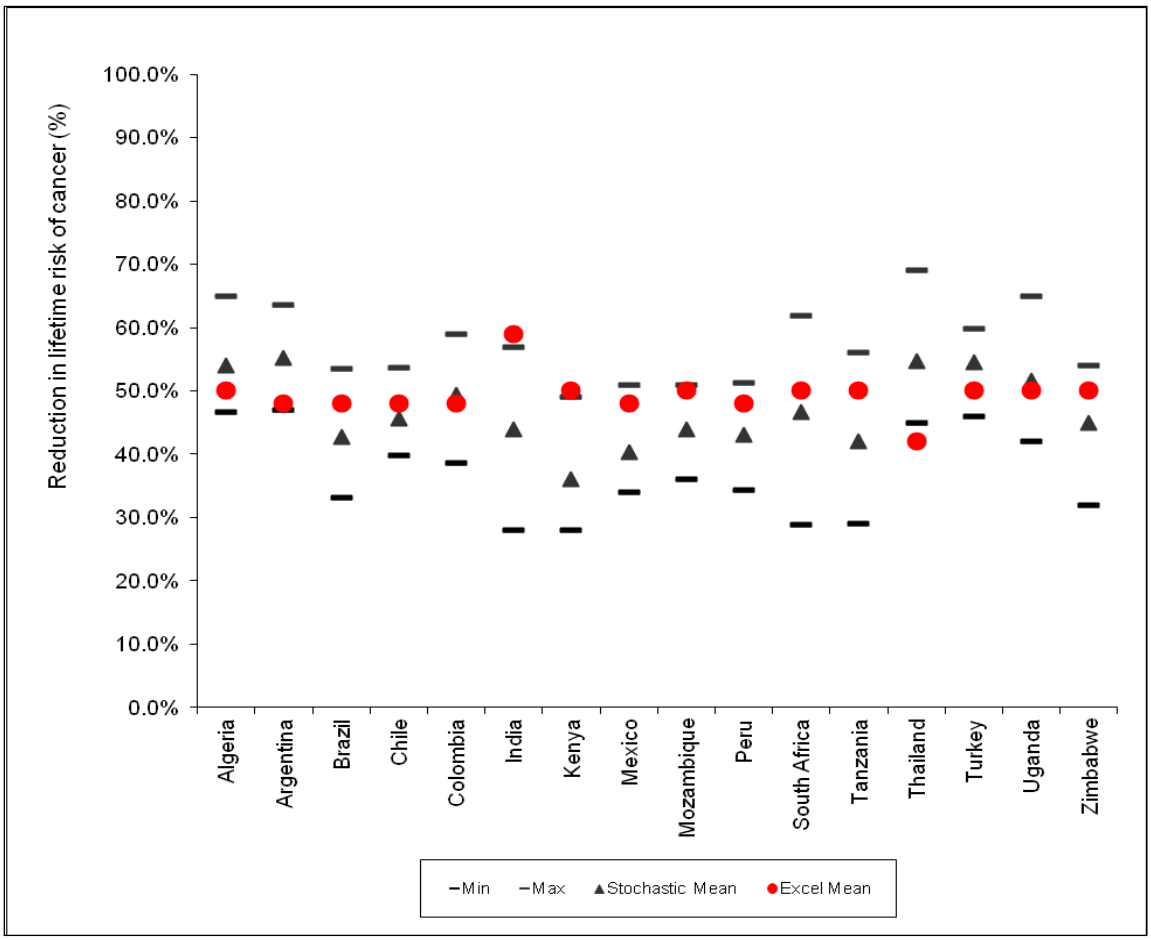

Nigeria: Target vs. Globocan 2008
Rate per 100,000 women
160
140
120
100
80
60
40
20
0
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70+
Age group
Target rate (1960-1969 registry)
Target LB
Target UB
Globocan 2008


South Africa: Target vs. Globocan 2008
Rate per 100,000 women
140
120
100
80
60
40
20
0
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75+
Age group
Target rate
Target LB
Target UB
Globocan 2008

Comparative validation

To ensure the validity of simplifying assumptions identified for the companion population-based model we compared results to our micro-simulation models when subject to those same assumptions. The figure below presents the results of a comparison exercise assuming vaccination coverage of 70%. For each country, an upper and lower bound of reduction in lifetime cancer risk is denoted by horizontal bars as well as an expected mean (denoted by a black triangle) projected using the micro-simulation model, and the corresponding mean reduction generated by the companion population-based model (denoted with a red circle). While the mean reduction in lifetime risk of cancer varies reflecting epidemiological differences in the proportion of HPV 16- and 18-related cancer, the average reduction in cancer predicted with the Excel-based companion model falls within these bounds.

Figure 4. Comparative validity: reduction in lifetime risk of cancer as predicted by two models



III. SCALE-UP SCENARIOS [updated analyses conducted for GAVI available elsewhere]

Table 4. Projected HPV vaccination coverage by year and country, Sample of a Strategic Demand Forecast

Geography	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Afghanistan	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Angola	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Armenia	0%	0%	0%	0%	0%	0%	0%	38%	71%	94%
Azerbaijan	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Bangladesh	0%	0%	0%	0%	0%	0%	24%	48%	71%	95%
Benin	0%	0%	0%	0%	0%	36%	68%	90%	90%	90%
Bhutan	0%	0%	0%	0%	0%	38%	72%	96%	96%	96%
Bolivia	0%	0%	36%	68%	90%	90%	90%	90%	90%	90%
Burkina Faso	0%	0%	0%	0%	0%	0%	0%	36%	68%	90%
Burundi	0%	0%	0%	0%	0%	40%	74%	99%	99%	99%
Cambodia	0%	0%	0%	0%	0%	0%	0%	38%	71%	94%
Cameroon	0%	0%	0%	0%	0%	0%	0%	0%	0%	36%
Central African Republic	0%	0%	0%	0%	0%	0%	0%	25%	48%	65%
Chad	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Comoros	0%	0%	0%	0%	0%	0%	0%	36%	68%	90%
Congo, DR	0%	0%	0%	0%	0%	0%	0%	0%	22%	44%
Congo, Rep.	0%	0%	0%	0%	0%	0%	0%	0%	36%	68%
Cote d'Ivoire	0%	0%	0%	0%	0%	0%	0%	36%	68%	90%
Cuba	0%	0%	40%	74%	99%	99%	99%	99%	99%	99%
Djibouti	0%	0%	0%	0%	0%	0%	0%	0%	0%	36%
Eritrea	0%	0%	0%	0%	0%	0%	0%	0%	0%	40%
Ethiopia	0%	0%	0%	0%	0%	0%	0%	0%	0%	23%
Gambia	0%	0%	0%	0%	39%	74%	98%	98%	98%	98%
Georgia	0%	0%	0%	0%	0%	0%	0%	0%	39%	74%
Ghana	0%	0%	0%	0%	38%	71%	94%	94%	94%	94%
Guinea	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 4. Projected HPV vaccination coverage by year and country, Sample of a Strategic Demand Forecast (cont)

Geography	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Guinea-Bissau	0%	0%	0%	0%	0%	0%	0%	0%	31%	59%
Guyana	0%	0%	0%	0%	39%	74%	98%	98%	98%	98%
Haiti	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Honduras	0%	0%	0%	0%	39%	74%	98%	98%	98%	98%
India	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Indonesia	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Kenya	0%	0%	0%	0%	20%	41%	62%	84%	85%	86%
Kiribati	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Korea, DPR	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Kyrgyzstan	0%	0%	0%	0%	0%	0%	40%	74%	99%	99%
Lao PDR	0%	0%	0%	0%	0%	0%	0%	0%	0%	27%
Lesotho	0%	0%	35%	66%	89%	90%	90%	90%	90%	90%
Liberia	0%	0%	0%	0%	0%	0%	0%	29%	56%	75%
Madagascar	0%	0%	0%	0%	0%	0%	0%	0%	35%	67%
Malawi	0%	0%	0%	0%	0%	0%	40%	74%	99%	99%
Mali	0%	0%	0%	0%	0%	0%	0%	33%	63%	85%
Mauritania	0%	0%	0%	0%	0%	0%	0%	0%	0%	30%
Moldova	0%	0%	0%	0%	0%	0%	0%	38%	71%	96%
Mongolia	0%	0%	40%	74%	99%	99%	99%	99%	99%	99%
Mozambique	0%	0%	0%	0%	0%	33%	63%	85%	86%	87%
Myanmar	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Nepal	0%	0%	0%	0%	0%	36%	68%	90%	90%	90%
Nicaragua	0%	0%	40%	74%	99%	99%	99%	99%	99%	99%
Niger	0%	0%	0%	0%	0%	0%	0%	0%	0%	32%
Nigeria	0%	0%	0%	0%	0%	0%	0%	0%	10%	21%
Pakistan	0%	0%	0%	0%	0%	0%	0%	0%	18%	36%
Papua New Guinea	0%	0%	0%	0%	0%	0%	0%	0%	0%	25%

Table 4. Projected HPV vaccination coverage by year and country, Sample of a Strategic Demand Forecast (cont)

Geography	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Rwanda	0%	0%	0%	40%	74%	99%	99%	99%	99%	99%
Sao Tome e Principe	0%	0%	0%	0%	0%	0%	40%	74%	99%	99%
Senegal	0%	0%	0%	0%	0%	37%	71%	94%	94%	94%
Sierra Leone	0%	0%	0%	0%	0%	0%	33%	63%	85%	86%
Solomon Islands	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Somalia	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sri Lanka	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sudan: North	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Sudan: South	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tajikistan	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tanzania	0%	0%	0%	0%	23%	46%	70%	94%	95%	95%
Timor-Leste	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Togo	0%	0%	0%	0%	0%	0%	36%	68%	90%	90%
Uganda	0%	0%	0%	17%	35%	53%	72%	73%	74%	75%
Ukraine	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Uzbekistan	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Vietnam	0%	0%	0%	25%	50%	74%	99%	99%	99%	99%
Yemen	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Zambia	0%	0%	0%	0%	0%	35%	67%	90%	90%	90%
Zimbabwe	0%	0%	0%	0%	0%	32%	61%	82%	83%	84%

Comparison of Sample Strategic Demand Forecast and previous vaccine roll-out scenarios (Wolfson 2008)

In a previous analysis (Goldie 2008c), we modeled *vaccine roll-out scenarios* (i.e., vaccination introduced at different coverage levels) over a 10-year period, in which the year of introduction, years to coverage, and maximum achievable coverage rate were based on the general framework and assumptions used by Wolfson et al. (2008). We categorized the 72 GAVI-eligible countries according to their achieved coverage for DPT3 (for Diptheria, Pertussis, and Tetanus) childhood vaccination and 2003 per capita gross national income (GNI). To reflect the additional challenges that are likely to be posed by a three-dose vaccine for young adolescent girls, we conservatively constrained the maximum coverage rate using an additional development indicator, the percentage of girls who are enrolled in fifth grade (World Bank WDI). Based on the six categories used by Wolfson et al. (2008), the 72 GAVI countries were characterized as follows: (1) high coverage (>80%), higher per capita GNI (US$ 480–970); (2) high coverage (>80%), lower per capita GNI (US$ 170–450); (3) moderate coverage (>70%) and per capita GNI (US$ 100–950); (4) India, moderate coverage (59%) and per capita GNI (US$ 530); (5) lower coverage (50–69%) and per capita GNI (US$ 90–880); and (6) low coverage (25–49%) and per capita GNI (US$ 250–740).

We assumed Category 1 rolls out in Year 1 (2010), maximum coverage is achieved in 3 years; Category 2 rolls out in Year 2 (2011)with maximum coverage achieved in 3 years; Category 3 rolls out in Year 3 (2012), maximum coverage achieved in 4 years; Category 4 (India) rolls out in Year 3 (2012), maximum coverage achieved in 5 years; Categories 5 and 6 roll out in Years 4 (2013) and 5 (2014) respectively, maximum coverage achieved in 5 years. We assumed coverage achieved in the initial year was a category-specific percentage of country-specific DTP3 vaccination levels; for countries in categories 1 and 2 this was 50%, for those in categories 3 and 4 coverage was 30%, and for those in categories 5 and 6 it was 15%. The maximum coverage rate was constrained using the development indicator of the percentage of girls enrolled in fifth grade (World Bank WDI) to reflect the challenges of a vaccine targeting young adolescent girls. When this indicator was not available for a specific country, we used the weighted average of the other countries within that category.

Table 5. Previous roll-out scenario - vaccination coverage by year and country for 10-year vaccination scenario *

ASR	Countries	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
87.3	Haiti					6.5	14.3	22.2	30.0	37.9	**45.8**
68.6	Tanzania		40.5	55.8	71.2	86.5	86.5	86.5	86.5	86.5	86.5
61.6	Lesotho	41.5	50.6	59.7	68.9	68.9	68.9	68.9	68.9	68.9	68.9
55.0	Bolivia	40.5	55.2	69.9	84.7	84.7	84.7	84.7	84.7	84.7	84.7
53.7	Zambia		43.0	54.7	66.4	78.1	78.1	78.1	78.1	78.1	78.1
52.1	Zimbabwe	45.0	53.7	62.4	71.2	71.2	71.2	71.2	71.2	71.2	71.2
49.4	Rwanda		30.5	36.6	42.6	48.7	48.7	48.7	48.7	48.7	48.7
47.3	Guyana	46.5	52.7	58.8	65.0	65.0	65.0	65.0	65.0	65.0	65.0
47.2	Nicaragua	43.0	47.5	51.9	56.4	56.4	56.4	56.4	56.4	56.4	56.4
46.6	Malawi		30.5	33.9	37.2	40.6	40.6	40.6	40.6	40.6	40.6
42.8	Solomon Islands	40.0	55.1	70.3	85.4	85.4	85.4	85.4	85.4	85.4	85.4
42.7	Burundi			22.2	33.7	45.2	56.7	68.2	68.2	68.2	68.2
42.7	Comoros		10.0	33.2	56.3	79.5	79.5	79.5	79.5	79.5	79.5
42.7	Djibouti			21.3	37.2	53.1	69.0	84.9	84.9	84.9	84.9
42.7	Eritrea		35.5	48.4	61.2	74.1	74.1	74.1	74.1	74.1	74.1
42.7	Madagascar				9.2	18.0	26.8	35.7	44.5	53.4	53.4
42.7	Somalia					5.3	14.6	24.0	33.3	42.7	52.0
40.4	Papua New Guinea				9.2	20.8	32.5	44.2	55.9	67.6	67.6
38.7	Cambodia		37.0	46.3	55.5	64.8	64.8	64.8	64.8	64.8	64.8
36.3	Uganda		41.0	46.5	52.0	57.5	57.5	57.5	57.5	57.5	57.5
35.9	Ethiopia				10.4	12.9	15.4	17.9	20.4	23.0	23.0
35.7	Cameroon	40.0	47.8	55.6	63.5	63.5	63.5	63.5	63.5	63.5	63.5
35.2	Mali		46.5	58.8	71.0	83.3	83.3	83.3	83.3	83.3	83.3
35.0	Liberia			26.1	39.4	52.7	65.9	**79.2**	**79.2**	**79.2**	**79.2**
33.6	Mozambique			21.6	30.8	40.0	49.2	58.4	58.4	58.4	58.4
30.7	India			17.7	28.7	39.8	50.8	61.9	72.9	72.9	72.9
30.6	Honduras	45.5	54.6	63.8	72.9	72.9	72.9	72.9	72.9	72.9	72.9
30.5	Congo, Dem. Rep.			21.9	28.9	36.0	43.0	50.1	50.1	50.1	50.1
30.1	Cote d'Ivoire				8.4	24.1	39.7	55.4	71.0	86.7	86.7

Table 5. Vaccination coverage by year and country for 10-year vaccination scenario * (cont.)

ASR	Countries	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
29.3	Benin		44.0	52.4	60.7	69.1	69.1	69.1	69.1	69.1	69.1
29.3	Ghana		42.0	49.6	57.2	64.7	64.7	64.7	64.7	64.7	64.7
29.3	Guinea-Bissau			24.0	36.9	49.9	62.8	**75.7**	**75.7**	**75.7**	**75.7**
29.3	Mauritania			21.3	29.7	38.0	46.4	54.7	54.7	54.7	54.7
29.3	Sierra Leone				9.6	20.8	32.0	43.3	54.5	**65.7**	**65.7**
29.3	Togo		27.5	41.7	55.9	70.1	70.1	70.1	70.1	70.1	70.1
28.8	Gambia, The		34.5	49.7	64.9	80.0	80.0	80.0	80.0	80.0	80.0
28.7	Kenya			22.8	38.4	53.9	69.5	85.1	85.1	85.1	85.1
28.6	Angola					7.1	15.2	23.3	31.5	39.6	**47.8**
28.5	Nigeria					3.8	17.9	32.1	46.2	60.4	74.6
28.0	Central African Republic					6.0	9.1	12.2	15.3	18.4	21.5
28.0	Chad					3.0	8.8	14.6	20.5	26.3	32.1
28.0	Guinea				10.4	23.0	35.6	48.2	60.8	73.4	73.4
27.6	Bangladesh		46.5	53.4	60.4	67.3	67.3	67.3	67.3	67.3	67.3
26.4	Bhutan	47.5	62.7	78.0	93.2	93.2	93.2	93.2	93.2	93.2	93.2
26.4	Nepal			22.5	37.6	52.6	67.7	82.8	82.8	82.8	82.8
26.2	Senegal	42.0	51.8	61.6	71.4	71.4	71.4	71.4	71.4	71.4	71.4
25.1	Congo, Rep.				9.8	21.2	32.7	44.2	55.7	67.2	67.2
24.6	Myanmar			21.9	34.4	47.0	59.5	72.1	72.1	72.1	72.1
23.4	Burkina Faso		40.5	52.4	60.7	76.1	76.1	76.1	76.1	76.1	76.1
21.6	Kyrgyz Republic		39.5	54.2	69.0	**83.7**	**83.7**	**83.7**	**83.7**	**83.7**	**83.7**
20.2	Cuba	49.5	65.7	81.9	98.1	98.1	98.1	98.1	98.1	98.1	98.1
20.0	Vietnam	47.5	60.5	73.5	86.5	86.5	86.5	86.5	86.5	86.5	86.5
19.9	Niger		43.0	49.8	56.7	63.5	63.5	63.5	63.5	63.5	63.5
18.0	Moldova	49.0	61.7	74.3	**87.0**	**87.0**	**87.0**	**87.0**	**87.0**	**87.0**	**87.0**
18.0	Mongolia	49.5	62.2	74.8	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**	**87.5**
17.9	Korea, Dem. Rep.			23.7	36.6	49.5	62.3	75.2	75.2	75.2	75.2
17.5	Georgia	42.0	54.7	67.3	**80.0**	**80.0**	**80.0**	**80.0**	**80.0**	**80.0**	**80.0**
17.2	Sri Lanka	49.5	63.9	78.2	92.6	92.6	92.6	92.6	92.6	92.6	92.6

Table 5. Vaccination coverage by year and country for 10-year vaccination scenario * (cont.)

ASR	Countries	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
16.8	Armenia	45.0	57.7	70.3	**83.0**	**83.0**	**83.0**	**83.0**	**83.0**	**83.0**	**83.0**
16.8	Lao PDR					7.4	18.3	29.3	40.3	51.3	62.3
15.7	Indonesia			21.0	37.5	53.9	70.4	86.9	86.9	86.9	86.9
15.4	Sudan				8.9	23.0	37.1	51.2	65.3	79.4	79.4
14.1	Ukraine	48.0	51.7	55.4	59.1	59.1	59.1	59.1	59.1	59.1	59.1
10.7	Uzbekistan		48.0	60.1	72.2	**84.2**	**84.2**	**84.2**	**84.2**	**84.2**	**84.2**
9.9	Tajikistan		29.5	44.7	60.0	**75.2**	**75.2**	**75.2**	**75.2**	**75.2**	**75.2**
8.2	Azerbaijan	46.5	59.2	71.8	**84.5**	**84.5**	**84.5**	**84.5**	**84.5**	**84.5**	**84.5**
8.0	Yemen, Rep.	43.0	51.0	58.9	66.9	66.9	66.9	66.9	66.9	66.9	66.9
6.9	Afghanistan			22.8	35.5	48.3	61.0	**73.7**	**73.7**	**73.7**	**73.7**
6.5	Pakistan			21.6	34.3	47.0	59.7	72.4	72.4	72.4	72.4
‡	Kiribati				9.3	25.1	40.9	56.8	72.6	88.4	88.4
‡	Sao Tome and Principe		47.5	57.3	67.1	76.9	76.9	76.9	76.9	76.9	76.9
‡	Timor-Leste				8.3	18.8	29.4	40.0	50.6	**61.2**	**61.2**

* Bold numbers indicate countries where the percentage of girls enrolled in 5th grade is not available, and is an estimated average of other countries within the category and the country-specific coverage of immunization with DPT3.

Category	Description	Start Year	Year at max	# of yrs at max
Category 1	High Coverage, Higher GNI	2010	2013	7
Category 2	High Coverage, Lower GNI	2011	2014	6
Category 3	Moderate Coverage	2012	2016	4
Category 4	India (Moderate Coverage)	2012	2017	3
Category 5	Lower Coverage	2013	2018	2
Category 6	Low Coverage	2014	2019	1

In general, in contrast with the **Sample Strategic Demand Forecast**, the **roll-out scenario based on Wolfson et al. (2008)** predicted a more gradual scale-up for all countries, achieving lower maximum coverage rates, but introducing the HPV vaccine earlier within a ten-year program. Noticeable differences between the two roll-out scenarios include:

- Of the 72 GAVI-eligible countries, the Sample Strategic Demand Forecast assumes that 20 countries will not implement HPV vaccine in the next 10 years, most significant being India. The roll-out scenario based on Wolfson et al. (2008) reflected scale-up scenarios for all 72 countries, achieving a maximum coverage of 32.1% to 92.6% in the 20 countries excluded by the Sample Strategic Demand Forecast, including 72.9% in India.
- Of the remaining 52 GAVI-eligible countries, the Sample Strategic Demand Forecast predicts none will implement HPV vaccine in the next two years. The roll-out scenario based on Wolfson et al. (2008) predicted 19 of these countries would delay implementation until year 3 of the program.
- The Sample Strategic Demand Forecast estimates that 8 of the countries will not introduce the HPV vaccine until year 10 of the program. The latest start year under the roll-out scenario based on Wolfson et al. (2008) is year 5.
- For the majority (39) of the 52 GAVI-eligible countries predicted to introduce the HPV vaccine, the Sample Strategic Demand Forecast is more optimistic about the maximum coverage achieved by year 10 of the program, than the roll-out scenario based on Wolfson et al. (2008). Many (nearly 30) maximum coverage levels in the Sample Strategic Demand Forecast reach 90% or above while only 3 countries in the roll-out scenario based on Wolfson et al. (2008) are expected to reach this level.
- In the Sample Strategic Demand Forecast, maximum coverage levels are expected to be reached fairly quickly, with four countries reaching maximum coverage by year 5, two by year 6, and five each by years 7, 8, and 9. Of the countries introducing the vaccine, five will initiate a program in year 3, three in year 4, six in year 5, eight in year 6, six in year 7, nine in year 8, and seven in year 9. In the roll-out scenario based on Wolfson et al. (2008), the majority of countries (40) are forecast to introduce the HPV vaccine in years 1 or 2 of a 10-year program, with maximum coverage achieved in years 4 or 5, respectively.

IV. RESULTS

Table 6. Cases of cervical cancer averted, years of life saved (YLS), disability-adjusted life years (DALYs) averted for 1 year (2011) and over 10 years (2011-2020) with HPV16/18 vaccination at 70% coverage of 9-year-old girls for the 72 GAVI-eligible countries *

	1 year (2011) at 70% coverage of 9-year-old girls			10 years (2011-2020) at 70% coverage of 9-year-old girls		
Country	**# of cases averted**	**YLS (3% discounting**	**DALYs (3% discounting)**	**# of cases averted**	**YLS (3% discounting**	**DALYs (3% discounting)**
Afghanistan	1,113	3,925	4,050	12,038	37,350	38,534
Angola	2,913	9,679	10,010	31,225	91,337	94,455
Armenia	192	561	579	1,923	5,129	5,290
Azerbaijan	396	1,117	1,155	3,989	10,141	10,477
Bangladesh	30,209	98,250	101,350	303,296	858,736	885,938
Benin	1,908	6,289	6,488	20,598	60,064	61,958
Bhutan	87	308	317	889	2,742	2,826
Bolivia	1,786	6,598	6,787	18,235	59,138	60,830
Burkina Faso	2,410	9,102	9,386	26,666	90,476	93,278
Burundi	2,120	6,652	6,881	22,259	61,761	63,886
Cambodia	1,940	6,107	6,300	19,944	55,065	56,810
Cameroon	2,203	7,575	7,870	23,413	71,479	74,261
Central African Republic	382	1,218	1,263	3,978	11,146	11,553
Chad	1,173	3,776	3,911	12,735	36,173	37,466
Comoros	189	615	634	1,985	5,762	5,943
Congo, Democratic Republic	7,125	29,130	30,086	75,876	273,567	282,546
Congo, Republic of	525	1,717	1,773	5,492	15,822	16,331
Cote d'Ivoire	3,365	8,773	9,096	35,644	81,779	84,786
Cuba	675	2,993	3,068	6,379	24,475	25,093
Djibouti	60	181	187	625	1,652	1,706
Eritrea	401	1,249	1,294	4,282	11,927	12,357
Ethiopia	8,425	26,276	27,365	89,139	246,106	256,310
Georgia	111	352	363	1,099	3,188	3,280
Ghana	4,842	16,524	17,040	51,118	153,588	158,382
Guinea	3,399	10,864	11,221	36,671	103,694	107,084

Table 6. Cases cervical cancer averted, years of life saved (YLS), disability-adjusted life years (DALYs) averted for 1 year (2011) and over 10 years (2011-2020) with HPV16/18 vaccination at 70% coverage of 9-year-old girls for the 72 GAVI-eligible countries * (cont.)

	1 year (2011) at 70% coverage of 9-year-old girls			10 years (2011-2020) at 70% coverage of 9-year-old girls		
Country	**# of cases averted**	**YLS (3% discounting**	**DALYs (3% discounting)**	**# of cases averted**	**YLS (3% discounting**	**DALYs (3% discounting)**
Guinea-Bissau	272	927	957	2,932	8,836	9,119
Guyana	81	323	332	725	2,460	2,529
Haiti	1,020	1,981	2,059	10,468	17,808	18,511
Honduras	1,531	5,728	5,890	15,723	51,602	53,059
India	180,803	639,420	658,613	1,823,514	5,649,527	5,819,305
Indonesia	12,069	38,828	40,012	120,914	340,919	351,333
Kenya	4,661	15,788	16,272	50,203	151,776	156,396
Kiribati	5	16	17	47	145	149
Korea, Democratic Republic	505	2,303	2,363	4,890	19,324	19,833
Kyrgyzstan	499	1,727	1,779	5,058	15,657	16,123
Lao People Democratic Republic	612	2,240	2,307	6,271	20,003	20,609
Lesotho	198	742	765	2,000	6,565	6,769
Liberia	975	3,018	3,118	10,380	28,329	29,266
Madagascar	3,191	10,831	11,168	33,830	100,859	103,999
Malawi	3,634	14,081	14,521	39,042	133,082	137,230
Mali	2,256	9,324	9,593	24,495	89,927	92,504
Mauritania	597	2,061	2,125	6,266	19,086	19,680
Moldova	150	591	608	1,504	5,460	5,610
Mongolia	338	1,283	1,319	3,427	11,519	11,838
Mozambique	4,574	16,801	17,331	48,601	157,739	162,697
Myanmar	5,190	17,498	18,040	52,411	155,924	160,736
Nepal	6,478	24,532	25,240	66,126	217,422	223,731
Nicaragua	1,084	4,366	4,479	10,941	38,716	39,721
Niger	1,441	5,112	5,270	16,437	52,024	53,609
Nigeria	23,931	76,328	78,844	252,228	710,824	734,174

Table 6. Cases cervical cancer averted, years of life saved (YLS), disability-adjusted life years (DALYs) averted for 1 year (2011) and over 10 years (2011-2020) with HPV16/18 vaccination at 70% coverage of 9-year-old girls for the 72 GAVI-eligible countries * (cont.)

	1 year (2011) at 70% coverage of 9-year-old girls			10 years (2011-2020) at 70% coverage of 9-year-old girls		
Country	**# of cases averted**	**YLS (3% discounting**	**DALYs (3% discounting)**	**# of cases averted**	**YLS (3% discounting**	**DALYs (3% discounting)**
Pakistan	22,968	82,819	85,304	240,581	764,507	787,399
Papua New Guinea	682	2,759	2,838	7,125	25,304	26,026
Rwanda	1,875	6,547	6,750	20,184	62,634	64,569
Sao Thome	21	79	81	222	718	741
Senegal	2,382	8,657	8,917	25,392	81,806	84,257
Sierra Leone	1,153	3,829	3,955	12,405	36,392	37,576
Solomon Islands	44	166	171	464	1,529	1,572
Somalia	1,010	3,163	3,287	11,014	30,476	31,670
Sri Lanka	932	2,535	2,616	9,253	22,429	23,135
Sudan	1,764	4,436	4,596	18,326	40,387	41,841
Tajikistan	313	1,174	1,209	3,204	10,563	10,875
Tanzania	11,547	38,893	40,161	125,999	377,894	390,154
The Gambia	294	1,243	1,279	3,148	11,718	12,054
Timor Leste	90	335	345	983	3,245	3,342
Togo	1,211	3,525	3,644	12,727	32,564	33,659
Uganda	8,550	30,423	31,394	93,672	295,444	304,831
Ukraine	1,586	6,301	6,475	15,844	57,389	58,957
Uzbekistan	1,485	4,725	4,873	14,944	41,687	42,993
Viet Nam	3,741	14,139	14,540	37,416	123,878	127,394
Yemen	478	1,240	1,284	5,069	11,597	12,005
Zambia	2,858	9,490	9,816	30,862	90,719	93,825
Zimbabwe	3,069	10,093	10,409	31,986	92,229	95,114
Totals	**402,093**	**1,392,251**	**1,435,443**	**4,138,748**	**12,592,941**	**12,983,899**

* Our base case (70% coverage of 9-year-old girls) utilizes regional estimates for the proportion of 16/18 in cancer.

COMPARISON TABLE (current model results, results originally reported in Goldie 2008c, and rotavirus results): DALYs averted and number of cervical cancer or rotavirus-associated deaths averted with a 1-year vaccination program at 70% coverage (9-year-old females for HPV; 0-year-old males and females for rotavirus) *

	DALYs averted (3% discounting)			# of deaths averted (no discounting)		
Country	**Current model**	**Goldie 2008c**	**Rotavirus**	**Current model**	**Goldie 2008c**	**Rotavirus**
Afghanistan	4,050	5,338	245,807	890	1,062	10,114
Angola	10,010	6,302	171,102	2,330	1,328	6,953
Armenia	579	785	1,087	154	115	38
Azerbaijan	1,155	1,424	17,017	317	210	599
Bangladesh	101,350	90,193	206,289	24,167	19,038	7,335
Benin	6,488	5,604	42,154	1,526	1,222	1,567
Bhutan	317	1,457	1,031	70	297	36
Bolivia	6,787	6,764	13,050	1,429	1,275	455
Burkina Faso	9,386	6,141	112,303	1,928	978	4,368
Burundi	6,881	7,283	45,301	1,696	1,594	1,754
Cambodia	6,300	10,872	62,918	1,552	2,788	2,216
Cameroon	7,870	6,977	78,905	1,762	1,456	3,012
Central African Republic	1,263	1,054	19,112	306	239	749
Chad	3,911	3,419	78,341	938	839	3,093
Comoros	634	1,018	991	151	206	35
Congo, Democratic Republic	30,086	25,135	491,511	5,700	5,458	18,983
Congo, Republic of	1,773	2,048	6,830	420	407	254
Cote d'Ivoire	9,096	7,569	15,805	2,692	1,557	589
Cuba	3,068	2,355	403	540	528	13
Djibouti	187	854	2,311	48	169	84
Eritrea	1,294	5,398	10,877	321	1,057	384
Ethiopia	27,365	76,541	448,089	6,740	13,941	16,358
Georgia	363	1,168	1,725	89	136	59
Ghana	17,040	9,579	50,697	3,874	2,021	1,860
Guinea	11,221	113	47,863	2,719	26	1,780

COMPARISON TABLE (current model results, results originally reported in Goldie 2008c, and rotavirus results): DALYs averted and number of cervical cancer or rotavirus-associated deaths averted with a 1-year vaccination program at 70% coverage (9-year-old females for HPV; 0-year-old males and females for rotavirus) * (cont.)

	DALYs averted			# of deaths averted (no discounting)		
Country	**Current model**	**Goldie 2008c**	**Rotavirus**	**Current model**	**Goldie 2008c**	**Rotavirus**
Guinea-Bissau	957	1,297	10,488	218	254	400
Guyana	332	425	1,140	65	70	40
Haiti	2,059	12,314	27,032	816	2,311	960
Honduras	5,890	4,023	6,973	1,225	846	237
India	658,613	531,789	1,793,955	144,642	120,131	63,489
Indonesia	40,012	79,675	186,020	9,655	14,915	6,454
Kenya	16,272	18,047	138,038	3,729	4,922	5,164
Kiribati	17	24	121	4	5	4
Korea, DR	2,363	6,548	13,778	404	1,244	478
Kyrgyzstan	1,779	2,658	8,654	399	431	302
Lao PDR	2,307	2,435	16,116	490	460	578
Lesotho	765	789	882	158	145	36
Liberia	3,118	1,711	30,510	780	326	1,209
Madagascar	11,168	22,010	67,616	2,553	4,333	2,434
Malawi	14,521	11,952	89,813	2,907	2,409	3,455
Mali	9,593	5,624	102,390	1,805	1,455	4,013
Mauritania	2,125	1,506	11,199	478	316	405
Moldova	608	1,153	165	120	166	6
Mongolia	1,319	866	2,672	270	179	92
Mozambique	17,331	9,402	97,202	3,659	2,092	3,721
Myanmar	18,040	24,008	90,581	4,152	5,004	3,221
Nepal	25,240	18,235	48,412	5,182	3,738	1,725
Nicaragua	4,479	5,503	3,482	867	1,110	118
Niger	5,270	4,994	196,473	1,153	924	8,013
Nigeria	78,844	27,048	772,011	19,145	7,123	30,021

COMPARISON TABLE (current model results, results originally reported in Goldie 2008c, and rotavirus results): DALYs averted and number of cervical cancer or rotavirus-associated deaths averted with a 1-year vaccination program at 70% coverage (9-year-old females for HPV; 0-year-old males and females for rotavirus) * (cont.)

	DALYs averted			# of deaths averted (no discounting)		
Country	**Current model**	**Goldie 2008c**	**Rotavirus**	**Current model**	**Goldie 2008c**	**Rotavirus**
Pakistan	85,304	21,801	364,919	18,374	5,430	12,877
Papua New Guinea	2,838	6,528	19,719	546	1,216	699
Rwanda	6,750	8,786	71,870	1,500	2,024	2,716
Sao Thome	81	66	442	17	17	16
Senegal	8,917	7,168	51,820	1,906	1,368	1,870
Sierra Leone	3,955	2,156	57,351	922	475	2,358
Solomon Islands	171	609	528	35	113	18
Somalia	3,287	8,853	84,592	808	1,899	3,122
Sri Lanka	2,616	5,878	4,293	746	1,454	145
Sudan	4,596	10,637	71,235	1,411	2,535	2,552
Tajikistan	1,209	1,938	26,528	250	274	936
Tanzania	40,161	50,119	179,548	9,238	9,997	6,921
The Gambia	1,279	774	4,515	235	119	162
Timor L'Este	345	403	4,238	72	94	147
Togo	3,644	2,986	19,434	969	622	704
Uganda	31,394	33,813	160,191	6,840	7,026	6,173
Ukraine	6,475	7,211	693	1,269	1,051	24
Uzbekistan	4,873	7,460	38,891	1,188	1,168	1,349
Viet Nam	14,540	54,570	24,045	2,993	13,222	814
Yemen	1,284	3,783	67,792	382	974	2,406
Zambia	9,816	10,159	68,125	2,286	2,110	2,793
Zimbabwe	10,409	6,684	22,401	2,455	1,715	937
Total	**1,435,440**	**1,331,809**	**7,230,412**	**321,677**	**287,759**	**269,002**

* HPV vaccination program assumes introduction in 2011; rotavirus vaccination program assumes introduction in 2012. HPV vaccination program targets only girls; rotavirus program targets both boys and girls.

COMPARISON TABLE (current model results, results originally reported in Goldie 2008c, and rotavirus results): Total financial costs (US$) at I$10/girl, number vaccinated, and deaths averted per 1000 vaccinated, for a 1-year and a 10-year program at 70% coverage of 9 year old females (HPV) or 0-year-old males and females (rotavirus)*

	Total Costs (US$)			Number vaccinated			Deaths averted per 1000 vaccinated		
	Current model	**Goldie 2008c**	**Rotavirus**	**Current model**	**Goldie 2008c**	**Rotavirus**	**Current model**	**Goldie 2008c**	**Rotavirus**
1-year program	$175 million	$164 million	$402 million	22,967,896	21,686,147	52,638,998	14.01	12.70	5.11
10-year program	$1.6 billion	$1.5 billion	$4 billion	238,253,187	224,796,020	533,827,703	13.90	12.68	5.18

* For Cuba, Korea, Somalia, Timor Leste and Zimbabwe, as these countries do not have conversion rates, I$ = US$ was used. For all countries, future financial costs (i.e., years 2013 – 2021) are discounted 3% annually to reflect net present value.

Table 7. Sensitivity analysis: cases of cervical cancer averted with HPV16/18 vaccination at 70% coverage of 9-year-old girls in a one-year program (2011), under various estimates of HPV16/18 proportion in cancer, for 72 GAVI-eligible countries

	1 year (2011) at 70% coverage of 9-year-old girls		
Country	**Regional estimates of HPV16/18 in cancer**	**70% estimate of HPV16/18 in cancer**	**Country-specific estimate of HPV16/18 in cancer**
Afghanistan	1,113	925	966
Angola	2,913	2,881	2,036
Armenia	192	191	219
Azerbaijan	396	395	452
Bangladesh	30,209	25,101	25,568
Benin	1,908	1,887	1,797
Bhutan	87	72	80
Bolivia	1,786	1,831	1,002
Burkina Faso	2,410	2,383	1,974
Burundi	2,120	2,096	2,276
Cambodia	1,940	2,280	2,091
Cameroon	2,203	2,178	1,540
Central African Republic	382	377	267
Chad	1,173	1,160	820
Comoros	189	187	202
Congo, Democratic Republic	7,125	7,045	4,981
Congo, Republic of	525	519	367
Cote d'Ivoire	3,365	3,327	2,757
Cuba	675	692	637
Djibouti	60	59	64
Eritrea	401	397	431
Ethiopia	8,425	8,331	10,224
Georgia	111	111	127
Ghana	4,842	4,788	3,967
Guinea	3,399	3,361	2,458
Guinea-Bissau	272	269	223
Guyana	81	83	74
Haiti	1,020	1,046	911
Honduras	1,531	1,570	1,289
India	180,803	150,235	169,550
Indonesia	12,069	14,185	15,178
Kenya	4,661	4,610	4,043
Kiribati	5	5	6
Korea, Democratic Republic	505	504	515
Kyrgyzstan	499	498	551
Lao People Democratic Republic	612	719	795
Lesotho	198	196	174

Table 7. Cases of cervical cancer averted with HPV16/18 vaccination at 70% coverage of 9-year-old girls in a one-year program (2011), under various estimates of HPV16/18 proportion in cancer, for 72 GAVI-eligible countries (cont.)

	1 year (2011) at 70% coverage of 9-year-old girls		
Country	**Regional estimates of HPV16/18 in cancer**	**70% estimate of HPV16/18 in cancer**	**Country-specific estimate of HPV16/18 in cancer**
Liberia	975	964	799
Madagascar	3,191	3,155	3,426
Malawi	3,634	3,594	3,902
Mali	2,256	2,231	1,679
Mauritania	597	591	489
Moldova	150	135	155
Mongolia	338	337	233
Mozambique	4,574	4,523	4,433
Myanmar	5,190	6,100	5,595
Nepal	6,478	5,383	6,052
Nicaragua	1,084	1,112	842
Niger	1,441	1,425	1,181
Nigeria	23,931	23,664	23,495
Pakistan	22,968	19,085	25,492
Papua New Guinea	682	801	857
Rwanda	1,875	1,854	2,013
Sao Thome	21	21	15
Senegal	2,382	2,355	1,470
Sierra Leone	1,153	1,140	944
Solomon Islands	44	52	56
Somalia	1,010	999	1,085
Sri Lanka	932	1,095	1,211
Sudan	1,764	1,744	1,707
Tajikistan	313	312	345
Tanzania	11,547	11,418	12,397
The Gambia	294	291	241
Timor Leste	90	105	97
Togo	1,211	1,197	992
Uganda	8,550	8,454	8,841
Ukraine	1,586	1,435	1,642
Uzbekistan	1,485	1,482	1,639
Viet Nam	3,741	4,397	4,033
Yemen	478	465	447
Zambia	2,858	2,826	3,068
Zimbabwe	3,069	3,035	3,308
Totals	**402,093**	**364,277**	**384,794**

Table 8. Incremental cost-effectiveness ratios (ICERs, discounted $/DALY averted, and expressed as percentage of per capita GDP) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl, for 72 GAVI-eligible countries *

Country	Per capita GDP (newest year available)	I$5 per vaccinated girl		I$10 per vaccinated girl		I$25 per vaccinated girl	
		ICER ($/DALY averted)	ICER as % of per capita GDP	ICER ($/DALY averted)	ICER as % of per capita GDP	ICER ($/DALY averted)	ICER as % of per capita GDP
Afghanistan	955	250	26%	600	63%	1,670	175%
Angola	6,035	C/S	C/S	C/S	C/S	210	3%
Armenia	5,354	C/S	C/S	70	1%	400	7%
Azerbaijan	9,869	20	0%	200	2%	760	8%
Bangladesh	1,643	C/S	C/S	C/S	C/S	170	10%
Benin	1,576	C/S	C/S	10	1%	210	13%
Bhutan	5,289	C/S	C/S	C/S	C/S	210	4%
Bolivia	4,816	C/S	C/S	C/S	C/S	180	4%
Burkina Faso	1,247	C/S	C/S	60	5%	310	25%
Burundi	405	C/S	C/S	30	7%	190	47%
Cambodia	2,150	10	0%	90	4%	350	16%
Cameroon	2,264	C/S	C/S	60	3%	400	18%
Central African Republic	783	70	9%	240	31%	730	93%
Chad	1,360	10	1%	160	12%	600	44%
Comoros	1,089	C/S	C/S	0	0%	140	13%
Congo, Democratic Republic	345	60	17%	180	52%	530	154%
Congo, Republic of	4,214	C/S	C/S	50	1%	340	8%
Cote d'Ivoire	1,885	C/S	C/S	C/S	C/S	250	13%
Cuba	N/A	C/S	C/S	50	N/A	270	N/A
Djibouti	2,288	60	3%	250	11%	810	35%
Eritrea	542	100	18%	290	54%	850	157%
Ethiopia	1,033	60	6%	210	20%	660	64%
Georgia	5,035	60	1%	260	5%	840	17%
Ghana	1,625	C/S	C/S	0	0%	180	11%
Guinea	1,083	C/S	C/S	C/S	C/S	110	10%

Table 8. Incremental cost-effectiveness ratios (ICERs, discounted $/DALY averted, and expressed as percentage of per capita GDP) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl, for 72 GAVI-eligible countries * (cont.)

Country	Per capita GDP (newest year available)	I$5 per vaccinated girl		I$10 per vaccinated girl		I$25 per vaccinated girl	
		ICER ($/DALY averted)	ICER as % of per capita GDP	ICER ($/DALY averted)	ICER as % of per capita GDP	ICER ($/DALY averted)	ICER as % of per capita GDP
Guinea-Bissau	1,177	C/S	C/S	50	4%	300	25%
Guyana	3,092	C/S	C/S	70	2%	310	10%
Haiti	1,102	120	11%	320	29%	930	84%
Honduras	3,890	C/S	C/S	C/S	C/S	160	4%
India	3,586	C/S	C/S	C/S	C/S	180	5%
Indonesia	4,293	100	2%	280	7%	810	19%
Kenya	1,635	C/S	C/S	110	7%	470	29%
Kiribati	2,450	160	7%	420	17%	1,170	48%
Korea, Democratic Republic	N/A	130	N/A	380	N/A	1,100	N/A
Kyrgyzstan	2,257	0	0%	100	4%	390	17%
Lao PDR	2,543	40	2%	150	6%	490	19%
Lesotho	1,533	0	0%	120	8%	480	31%
Liberia	416	C/S	C/S	60	14%	250	60%
Madagascar	961	C/S	C/S	80	8%	340	35%
Malawi	876	C/S	C/S	30	3%	200	23%
Mali	1,057	C/S	C/S	30	3%	230	22%
Mauritania	1,930	C/S	C/S	C/S	C/S	190	10%
Moldova	3,087	C/S	C/S	100	3%	400	13%
Mongolia	3,997	C/S	C/S	20	1%	190	5%
Mozambique	935	C/S	C/S	50	5%	250	27%
Myanmar	1,201	C/S	C/S	50	4%	300	25%
Nepal	1,190	C/S	C/S	C/S	C/S	140	12%
Nicaragua	2,766	C/S	C/S	20	1%	170	6%
Niger	723	70	10%	230	32%	690	95%
Nigeria	2,363	C/S	C/S	30	1%	300	13%

Table 8. Incremental cost-effectiveness ratios (ICERs, discounted $/DALY averted, and expressed as percentage of per capita GDP) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl, for 72 GAVI-eligible countries * (cont.)

Country	Per capita GDP (newest year available)	I$5 per vaccinated girl		I$10 per vaccinated girl		I$25 per vaccinated girl	
		ICER ($/DALY averted)	ICER as % of per capita GDP	ICER ($/DALY averted)	ICER as % of per capita GDP	ICER ($/DALY averted)	ICER as % of per capita GDP
Pakistan	2,674	C/S	C/S	40	1%	300	11%
Papua New Guinea	2,454	30	1%	140	6%	460	19%
Rwanda	1,155	C/S	C/S	40	3%	260	23%
Sao Thome	1,880	C/S	C/S	70	4%	350	19%
Senegal	1,917	C/S	C/S	C/S	C/S	200	10%
Sierra Leone	821	C/S	C/S	60	7%	270	33%
Solomon Islands	2,689	50	2%	190	7%	590	22%
Somalia	N/A	40	N/A	180	N/A	600	N/A
Sri Lanka	5,040	130	3%	340	7%	990	20%
Sudan	2,239	270	12%	680	30%	1,910	85%
Tajikistan	2,147	150	7%	390	18%	1,100	51%
Tanzania	1,423	C/S	C/S	C/S	C/S	160	11%
The Gambia	1,400	C/S	C/S	20	1%	220	16%
Timor Leste	921	110	12%	270	29%	750	81%
Togo	991	C/S	C/S	70	7%	320	32%
Uganda	1,263	C/S	C/S	10	1%	180	14%
Ukraine	6,658	C/S	C/S	50	1%	360	5%
Uzbekistan	3,090	80	3%	260	8%	800	26%
Viet Nam	3,181	90	3%	260	8%	780	25%
Yemen	2,485	740	30%	1,640	66%	4,340	175%
Zambia	1,550	C/S	C/S	20	1%	220	14%
Zimbabwe	N/A	C/S	C/S	C/S	C/S	110	N/A

* Our base case (70% coverage of 9-year-old girls) utilizes regional estimates for the proportion of 16/18 in cancer.

Table 9. Sensitivity analysis: incremental cost effectiveness ratios (ICERs, discounted $/DALY averted) for a one-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl and under various estimates of HPV16/18 proportion in cancer, for 72 GAVI-eligible countries *

Country	I$5 per vaccinated girl			I$10 per vaccinated girl			I$25 per vaccinated girl		
	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate
Afghanistan	250	320	300	600	750	710	1,670	2,030	1,940
Angola	C/S	C/S	C/S	C/S	C/S	10	210	220	420
Armenia	C/S	C/S	C/S	70	70	40	400	400	330
Azerbaijan	20	20	C/S	200	210	160	760	760	640
Bangladesh	C/S	C/S	C/S	C/S	20	20	170	230	230
Benin	C/S	C/S	C/S	10	10	10	210	210	230
Bhutan	C/S	C/S	C/S	C/S	10	C/S	210	290	250
Bolivia	C/S	C/S	C/S	C/S	C/S	90	180	170	410
Burkina Faso	C/S	C/S	C/S	60	60	100	310	320	400
Burundi	C/S	C/S	C/S	30	30	30	190	190	170
Cambodia	10	C/S	0	90	70	80	350	280	320
Cameroon	C/S	C/S	C/S	60	60	160	400	410	650
Central African Rep.	70	80	140	240	240	380	730	740	1,090
Chad	10	10	80	160	160	290	600	610	920
Comoros	C/S	C/S	C/S	0	0	C/S	140	140	120
Congo, Dem. Rep.	60	60	110	180	180	280	530	530	780
Congo, Republic of	C/S	C/S	C/S	50	50	130	340	340	540
Cote d'Ivoire	C/S	C/S	C/S	C/S	C/S	C/S	250	260	370
Cuba	C/S	C/S	C/S	50	50	60	270	260	290
Djibouti	60	60	40	250	250	220	810	830	750
Eritrea	100	100	90	290	290	260	850	860	780
Ethiopia	60	60	30	210	210	160	660	660	530
Georgia	60	70	40	260	260	210	840	840	720
Ghana	C/S	C/S	C/S	0	0	30	180	190	250

Table 9. Sensitivity analysis: incremental cost effectiveness ratios (ICERs, discounted $/DALY averted) for a one-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl and under various estimates of HPV16/18 proportion in cancer, for 72 GAVI-eligible countries * (cont.)

Country	I$5 per vaccinated girl			I$10 per vaccinated girl			I$25 per vaccinated girl		
	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate
Guinea	C/S	C/S	C/S	C/S	C/S	10	110	110	190
Guinea-Bissau	C/S	C/S	C/S	50	50	90	300	300	380
Guyana	C/S	C/S	C/S	70	60	80	310	300	350
Haiti	120	110	140	320	310	370	930	900	1,050
Honduras	C/S	C/S	C/S	C/S	C/S	20	160	150	210
India	C/S	C/S	C/S	C/S	20	0	180	250	200
Indonesia	100	70	60	280	220	200	810	680	630
Kenya	C/S	C/S	10	110	110	150	470	470	560
Kiribati	160	130	110	420	340	310	1,170	980	910
Korea, Dem. Rep.	130	130	130	380	380	370	1,100	1,110	1,080
Kyrgyzstan	0	0	C/S	100	100	80	390	390	340
Lao PDR	40	20	10	150	120	100	490	410	360
Lesotho	0	0	20	120	130	160	480	490	570
Liberia	C/S	C/S	10	60	60	90	250	250	320
Madagascar	C/S	C/S	C/S	80	80	60	340	340	310
Malawi	C/S	C/S	C/S	30	30	20	200	200	180
Mali	C/S	C/S	C/S	30	40	80	230	240	350
Mauritania	C/S	C/S	C/S	C/S	C/S	20	190	200	270
Moldova	C/S	10	C/S	100	120	90	400	450	380
Mongolia	C/S	C/S	C/S	20	20	70	190	190	320
Mozambique	C/S	C/S	C/S	50	50	50	250	260	260
Myanmar	C/S	C/S	C/S	50	20	30	300	240	270
Nepal	C/S	C/S	C/S	C/S	10	C/S	140	180	150
Nicaragua	C/S	C/S	C/S	20	20	50	170	160	240
Niger	70	80	110	230	230	300	690	700	860

Table 9. Sensitivity analysis: incremental cost effectiveness ratios (ICERs, discounted $/DALY averted) for a one-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl and under various estimates of HPV16/18 proportion in cancer, for 72 GAVI-eligible countries * (cont.)

Country	I$5 per vaccinated girl			I$10 per vaccinated girl			I$25 per vaccinated girl		
	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate
Nigeria	C/S	C/S	C/S	30	30	30	300	310	310
Pakistan	C/S	C/S	C/S	40	80	30	300	390	260
Papua New Guinea	30	10	10	140	100	90	460	380	350
Rwanda	C/S	C/S	C/S	40	50	30	260	260	230
Sao Thome	C/S	C/S	10	70	70	150	350	350	550
Senegal	C/S	C/S	C/S	C/S	C/S	80	200	210	420
Sierra Leone	C/S	C/S	C/S	60	60	90	270	280	350
Solomon Islands	50	30	30	190	150	130	590	490	450
Somalia	40	40	30	180	180	160	600	610	550
Sri Lanka	130	90	80	340	280	240	990	830	740
Sudan	270	270	280	680	690	710	1,910	1,930	1,980
Tajikistan	150	150	130	390	390	340	1,100	1,100	990
Tanzania	C/S	C/S	C/S	C/S	C/S	C/S	160	170	140
The Gambia	C/S	C/S	C/S	20	20	50	220	220	290
Timor Leste	110	80	90	270	220	240	750	630	690
Togo	C/S	C/S	0	70	70	110	320	330	410
Uganda	C/S	C/S	C/S	10	10	10	180	190	170
Ukraine	C/S	C/S	C/S	50	70	50	360	410	340
Uzbekistan	80	80	60	260	260	220	800	800	720
Viet Nam	90	60	80	260	210	240	780	650	710
Yemen	740	770	810	1,640	1,690	1,770	4,340	4,460	4,650
Zambia	C/S	C/S	C/S	20	20	10	220	230	200
Zimbabwe	C/S	C/S	C/S	C/S	C/S	C/S	110	110	90

* Our base case (70% coverage of 9-year-old girls) utilizes regional estimates for the proportion of 16/18 in cancer.

Table 10. Sensitivity analysis: incremental cost effectiveness ratios (ICERs, discounted $/YLS) for a one-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl and under various estimates of HPV16/18 proportion in cancer, for 72 GAVI-eligible countries *

Country	I$5 per vaccinated girl			I$10 per vaccinated girl			I$25 per vaccinated girl		
	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate
Afghanistan	260	330	310	620	770	730	1,720	2,090	2,000
Angola	C/S	C/S	C/S	C/S	C/S	10	220	220	430
Armenia	C/S	C/S	C/S	70	70	50	410	410	340
Azerbaijan	20	20	C/S	210	210	160	780	780	660
Bangladesh	C/S	C/S	C/S	C/S	20	20	180	240	230
Benin	C/S	C/S	C/S	10	10	10	210	220	230
Bhutan	C/S	C/S	C/S	C/S	10	C/S	220	300	250
Bolivia	C/S	C/S	C/S	C/S	C/S	90	180	180	420
Burkina Faso	C/S	C/S	C/S	60	60	100	320	330	420
Burundi	C/S	C/S	C/S	30	40	30	190	200	180
Cambodia	10	C/S	0	100	70	80	360	290	330
Cameroon	C/S	C/S	C/S	60	60	160	420	420	670
Central African Rep.	80	80	150	250	250	390	760	770	1,130
Chad	10	10	80	160	170	300	620	630	950
Comoros	C/S	C/S	C/S	0	0	C/S	140	150	130
Congo, Dem. Rep.	70	70	120	190	190	290	550	550	800
Congo, Republic of	C/S	C/S	C/S	50	50	130	350	350	560
Cote d'Ivoire	C/S	C/S	C/S	C/S	C/S	C/S	260	270	380
Cuba	C/S	C/S	C/S	50	50	60	280	270	300
Djibouti	60	60	40	250	260	230	840	850	770
Eritrea	110	110	90	300	300	270	880	890	810
Ethiopia	60	60	40	220	220	160	680	690	550
Georgia	70	70	40	270	270	220	860	860	740
Ghana	C/S	C/S	C/S	0	0	30	190	190	260

Table 10. Sensitivity analysis: incremental cost effectiveness ratios (ICERs, discounted $/YLS) for a one-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl and under various estimates of HPV16/18 proportion in cancer, for 72 GAVI-eligible countries * (cont.)

Country	I$5 per vaccinated girl			I$10 per vaccinated girl			I$25 per vaccinated girl		
	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate
Guinea	C/S	C/S	C/S	C/S	C/S	10	110	110	190
Guinea-Bissau	C/S	C/S	C/S	50	60	90	300	310	400
Guyana	C/S	C/S	C/S	70	70	90	320	310	360
Haiti	120	120	150	330	320	380	960	940	1,090
Honduras	C/S	C/S	C/S	C/S	C/S	20	160	150	210
India	C/S	C/S	C/S	C/S	20	0	190	250	210
Indonesia	100	70	60	280	230	210	840	700	650
Kenya	C/S	C/S	10	110	120	150	480	490	570
Kiribati	170	130	120	430	350	320	1,200	1,010	940
Korea, Dem. Rep.	140	140	130	390	390	380	1,130	1,140	1,110
Kyrgyzstan	0	0	C/S	100	100	80	400	400	350
Lao PDR	40	20	10	160	120	100	510	420	370
Lesotho	0	0	20	130	130	160	500	510	590
Liberia	C/S	C/S	10	60	60	90	250	260	330
Madagascar	C/S	C/S	C/S	80	80	70	350	350	320
Malawi	C/S	C/S	C/S	30	30	20	200	210	180
Mali	C/S	C/S	C/S	40	40	80	240	240	360
Mauritania	C/S	C/S	C/S	C/S	C/S	20	200	200	280
Moldova	C/S	10	C/S	100	120	90	410	460	390
Mongolia	C/S	C/S	C/S	20	20	80	200	200	330
Mozambique	C/S	C/S	C/S	50	50	60	260	260	270
Myanmar	C/S	C/S	C/S	50	20	30	310	240	280
Nepal	C/S	C/S	C/S	C/S	10	C/S	140	190	160
Nicaragua	C/S	C/S	C/S	20	20	50	170	170	250
Niger	80	80	110	240	240	310	720	720	890

Table 10. Sensitivity analysis: incremental cost effectiveness ratios (ICERs, discounted $/YLS) for a one-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, at various costs per vaccinated girl and under various estimates of HPV16/18 proportion in cancer, for 72 GAVI-eligible countries * (cont.)

Country	I$5 per vaccinated girl			I$10 per vaccinated girl			I$25 per vaccinated girl		
	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate	Regional estimate	70% estimate	Country-specific estimate
Nigeria	C/S	C/S	C/S	30	30	30	310	320	320
Pakistan	C/S	C/S	C/S	40	80	30	310	410	270
Papua New Guinea	30	10	10	140	110	100	470	390	360
Rwanda	C/S	C/S	C/S	50	50	40	270	270	240
Sao Thome	C/S	C/S	10	70	70	150	360	360	570
Senegal	C/S	C/S	C/S	C/S	C/S	90	210	210	430
Sierra Leone	C/S	C/S	C/S	60	60	90	280	290	370
Solomon Islands	50	30	30	190	150	140	600	500	460
Somalia	40	40	30	180	190	160	620	630	570
Sri Lanka	130	100	80	350	290	250	1,020	850	760
Sudan	280	280	290	700	710	730	1,980	2,000	2,050
Tajikistan	150	150	130	400	400	350	1,130	1,130	1,020
Tanzania	C/S	C/S	C/S	C/S	C/S	C/S	170	170	150
The Gambia	C/S	C/S	C/S	20	30	50	220	230	300
Timor Leste	110	80	100	270	220	250	770	650	710
Togo	C/S	C/S	0	70	70	110	330	340	430
Uganda	C/S	C/S	C/S	10	10	10	190	190	180
Ukraine	C/S	C/S	C/S	50	80	50	370	420	350
Uzbekistan	80	80	60	270	270	230	830	830	740
Viet Nam	90	70	80	270	220	240	800	670	730
Yemen	770	800	840	1,700	1,750	1,830	4,490	4,620	4,820
Zambia	C/S	C/S	C/S	20	20	10	230	230	210
Zimbabwe	C/S	C/S	C/S	C/S	C/S	C/S	110	120	90

* Our base case (70% coverage of 9-year-old girls) utilizes regional estimates for the proportion of 16/18 in cancer.

Table 11. Sensitivity analysis: incremental cost-effectiveness ratios (ICERs, discounted $/DALY averted) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, 72 GAVI-eligible countries, at various costs per vaccinated girl and under various assumptions regarding cancer costs *

	1 year (2011) at 70% coverage of 9-year-old girls			1 year (2011) at 70% coverage of 9-year-old girls (cancer costs at 50%)		
Country	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**
Afghanistan	250	600	1,670	300	660	1,720
Angola	C/S	C/S	210	C/S	60	340
Armenia	C/S	70	400	40	140	470
Azerbaijan	20	200	760	100	290	840
Bangladesh	C/S	C/S	170	C/S	60	230
Benin	C/S	10	210	0	70	270
Bhutan	C/S	C/S	210	C/S	70	300
Bolivia	C/S	C/S	180	C/S	60	240
Burkina Faso	C/S	60	310	30	110	360
Burundi	C/S	30	190	20	70	220
Cambodia	10	90	350	50	130	390
Cameroon	C/S	60	400	30	140	490
Central African Republic	70	240	730	120	280	780
Chad	10	160	600	80	230	670
Comoros	C/S	0	140	0	50	190
Congo, Democratic Republic	60	180	530	90	210	550
Congo, Republic of	C/S	50	340	20	120	410
Cote d'Ivoire	C/S	C/S	250	C/S	70	400
Cuba	C/S	50	270	30	100	320
Djibouti	60	250	810	120	310	880
Eritrea	100	290	850	140	330	890
Ethiopia	60	210	660	100	250	700
Georgia	60	260	840	130	320	900
Ghana	C/S	0	180	0	60	240
Guinea	C/S	C/S	110	C/S	30	160

Table 11. Incremental cost-effectiveness ratios (ICERs, discounted $/DALY averted) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, 72 GAVI-eligible countries, at various costs per vaccinated girl and under various assumptions regarding cancer costs * (cont.)

	1 year (2011) at 70% coverage of 9-year-old girls			1 year (2011) at 70% coverage of 9-year-old girls (cancer costs at 50%)		
Country	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**
Guinea-Bissau	C/S	50	300	30	110	350
Guyana	C/S	70	310	30	110	350
Haiti	120	320	930	160	360	970
Honduras	C/S	C/S	160	C/S	50	210
India	C/S	C/S	180	C/S	60	250
Indonesia	100	280	810	140	320	860
Kenya	C/S	110	470	60	170	530
Kiribati	160	420	1,170	210	460	1,210
Korea, Democratic Republic	130	380	1,100	190	430	1,160
Kyrgyzstan	0	100	390	50	150	440
Lao PDR	40	150	490	80	190	530
Lesotho	0	120	480	60	180	540
Liberia	C/S	60	250	30	90	280
Madagascar	C/S	80	340	40	130	390
Malawi	C/S	30	200	10	70	240
Mali	C/S	30	230	20	80	280
Mauritania	C/S	C/S	190	C/S	60	270
Moldova	C/S	100	400	50	150	450
Mongolia	C/S	20	190	10	70	240
Mozambique	C/S	50	250	20	90	300
Myanmar	C/S	50	300	20	110	360
Nepal	C/S	C/S	140	C/S	40	190
Nicaragua	C/S	20	170	10	60	210
Niger	70	230	690	110	270	730
Nigeria	C/S	30	300	10	110	380

Table 11. Incremental cost-effectiveness ratios (ICERs, discounted $/DALY averted) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, 72 GAVI-eligible countries, at various costs per vaccinated girl and under various assumptions regarding cancer costs * (cont.)

	1 year (2011) at 70% coverage of 9-year-old girls			1 year (2011) at 70% coverage of 9-year-old girls (cancer costs at 50%)		
Country	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**
Pakistan	C/S	40	300	20	110	370
Papua New Guinea	30	140	460	70	180	500
Rwanda	C/S	40	260	20	90	310
Sao Thome	C/S	70	350	30	130	410
Senegal	C/S	C/S	200	C/S	70	270
Sierra Leone	C/S	60	270	30	100	320
Solomon Islands	50	190	590	90	230	630
Somalia	40	180	600	90	230	650
Sri Lanka	130	340	990	170	390	1,030
Sudan	270	680	1,910	340	750	1,980
Tajikistan	150	390	1,100	190	430	1,140
Tanzania	C/S	C/S	160	C/S	50	220
The Gambia	C/S	20	220	10	80	270
Timor Leste	110	270	750	130	290	780
Togo	C/S	70	320	30	120	370
Uganda	C/S	10	180	10	60	240
Ukraine	C/S	50	360	30	130	440
Uzbekistan	80	260	800	130	310	860
Viet Nam	90	260	780	130	300	820
Yemen	740	1,640	4,340	820	1,720	4,410
Zambia	C/S	20	220	10	80	280
Zimbabwe	C/S	C/S	110	C/S	30	190

* Our base case (70% coverage of 9-year-old girls) utilizes regional estimates for the proportion of 16/18 in cancer.

Table 12. Incremental cost-effectiveness ratios (ICERs, discounted $/YLS) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, 72 GAVI-eligible countries, at various costs per vaccinated girl and under various assumptions regarding cancer costs *

	1 year (2011) at 70% coverage of 9-year-old girls			1 year (2011) at 70% coverage of 9-year-old girls (cancer costs at 50%)		
Country	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**
Afghanistan	260	620	1,720	310	680	1,780
Angola	C/S	C/S	220	C/S	60	360
Armenia	C/S	70	410	40	150	490
Azerbaijan	20	210	780	110	300	860
Bangladesh	C/S	C/S	180	C/S	60	240
Benin	C/S	10	210	0	70	280
Bhutan	C/S	C/S	220	C/S	70	310
Bolivia	C/S	C/S	180	C/S	60	250
Burkina Faso	C/S	60	320	30	120	370
Burundi	C/S	30	190	20	70	230
Cambodia	10	100	360	50	140	400
Cameroon	C/S	60	420	30	150	510
Central African Republic	80	250	760	120	290	810
Chad	10	160	620	80	240	690
Comoros	C/S	0	140	0	50	190
Congo, Democratic Republic	70	190	550	90	210	570
Congo, Republic of	C/S	50	350	20	120	420
Cote d'Ivoire	C/S	C/S	260	C/S	70	410
Cuba	C/S	50	280	30	100	330
Djibouti	60	250	840	130	320	910
Eritrea	110	300	880	150	340	920
Ethiopia	60	220	680	110	260	730
Georgia	70	270	860	130	330	930
Ghana	C/S	0	190	0	60	250
Guinea	C/S	C/S	110	C/S	30	160

Table 12. Incremental cost-effectiveness ratios (ICERs, discounted $/YLS) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, 72 GAVI-eligible countries, at various costs per vaccinated girl and under various assumptions regarding cancer costs * (cont.)

	1 year (2011) at 70% coverage of 9-year-old girls			1 year (2011) at 70% coverage of 9-year-old girls (cancer costs at 50%)		
Country	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**
Guinea-Bissau	C/S	50	300	30	110	360
Guyana	C/S	70	320	30	120	360
Haiti	120	330	960	170	380	1,000
Honduras	C/S	C/S	160	C/S	50	220
India	C/S	C/S	190	C/S	60	260
Indonesia	100	280	840	140	330	880
Kenya	C/S	110	480	60	180	550
Kiribati	170	430	1,200	210	470	1,250
Korea, Democratic Republic	140	390	1,130	190	440	1,190
Kyrgyzstan	0	100	400	50	150	450
Lao PDR	40	160	510	80	200	550
Lesotho	0	130	500	60	190	560
Liberia	C/S	60	250	30	90	290
Madagascar	C/S	80	350	40	130	400
Malawi	C/S	30	200	20	70	250
Mali	C/S	40	240	20	90	290
Mauritania	C/S	C/S	200	C/S	70	280
Moldova	C/S	100	410	50	150	460
Mongolia	C/S	20	200	10	70	250
Mozambique	C/S	50	260	30	100	300
Myanmar	C/S	50	310	20	110	370
Nepal	C/S	C/S	140	C/S	40	200
Nicaragua	C/S	20	170	10	60	220
Niger	80	240	720	120	280	760
Nigeria	C/S	30	310	10	110	400

Table 12. Incremental cost-effectiveness ratios (ICERs, discounted $/YLS) for a 1-year program (2011) of HPV16/18 vaccination at 70% coverage of 9-year-old girls, 72 GAVI-eligible countries, at various costs per vaccinated girl and under various assumptions regarding cancer costs * (cont.)

	1 year (2011) at 70% coverage of 9-year-old girls			1 year (2011) at 70% coverage of 9-year-old girls (cancer costs at 50%)		
Country	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**	**I$5 per vaccinated girl**	**I$10 per vaccinated girl**	**I$25 per vaccinated girl**
Pakistan	C/S	40	310	20	110	380
Papua New Guinea	30	140	470	70	180	510
Rwanda	C/S	50	270	20	100	320
Sao Thome	C/S	70	360	30	130	420
Senegal	C/S	C/S	210	C/S	70	280
Sierra Leone	C/S	60	280	30	100	330
Solomon Islands	50	190	600	100	230	650
Somalia	40	180	620	90	240	670
Sri Lanka	130	350	1,020	180	400	1,070
Sudan	280	700	1,980	350	780	2,050
Tajikistan	150	400	1,130	200	440	1,180
Tanzania	C/S	C/S	170	C/S	60	230
The Gambia	C/S	20	220	10	80	280
Timor Leste	110	270	770	140	300	800
Togo	C/S	70	330	40	120	380
Uganda	C/S	10	190	10	70	240
Ukraine	C/S	50	370	30	130	450
Uzbekistan	80	270	830	130	320	880
Viet Nam	90	270	800	130	310	840
Yemen	770	1,700	4,490	850	1,780	4,570
Zambia	C/S	20	230	10	80	290
Zimbabwe	C/S	C/S	110	C/S	30	200

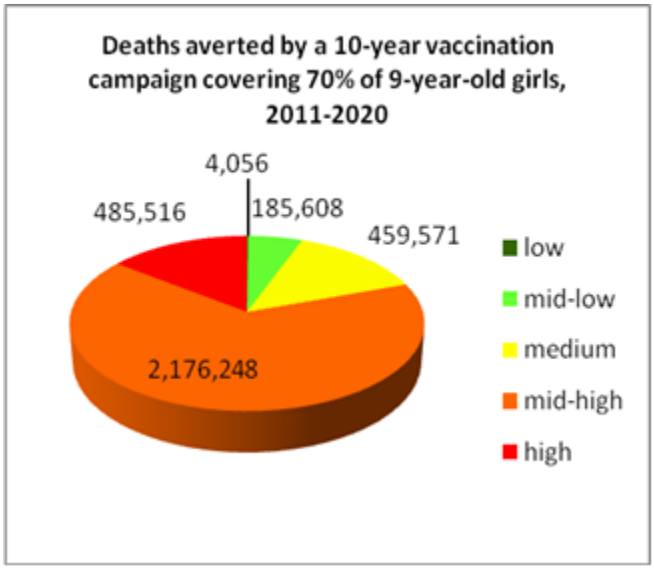
* Our base case (70% coverage of 9-year-old girls) utilizes regional estimates for the proportion of 16/18 in cancer.

Table 13. Cervical cancer deaths averted, deaths averted per 1000 girls vaccinated, years of life saved (YLS), and disability-adjusted life years (DALYs) averted in a 10-year (2011-2020) HPV16/18 vaccination program at various coverage levels of 9-year-old girls for the 72 GAVI-eligible countries *

	10 years (2011-2020)			
	# of deaths averted	**Deaths averted per 1000 vaccinated**	**YLS (3% discounting)**	**DALYs (3% discounting)**
70% coverage	**3,311,000**	**13.9**	**12,592,940**	**12,983,900**
90% coverage	**4,257,000**	**13.9**	**16,190,920**	**16,693,580**
GAVI Strategic Demand Forecast (v4)	**525,870**	**15.1**	**1,860,230**	**1,917,980**

* Our base case (70% coverage of 9-year-old girls) utilizes regional estimates for the proportion of 16/18 in cancer

Figure 5. Cervical cancer deaths averted and deaths averted per 1000 vaccinated in a 10-year (2011-2020) vaccination campaign under various coverage assumptions of 9-year-old girls, presented by cervical cancer incidence rate.



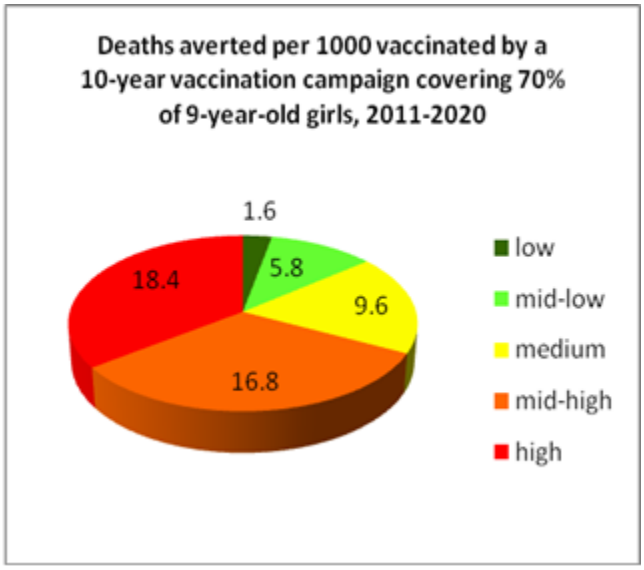


Figure 6. Cervical cancer deaths averted and deaths averted per 1000 vaccinated in a 10-year (2011-2020) vaccination campaign under various coverage assumptions of 9-year-old girls, presented by geographical region.

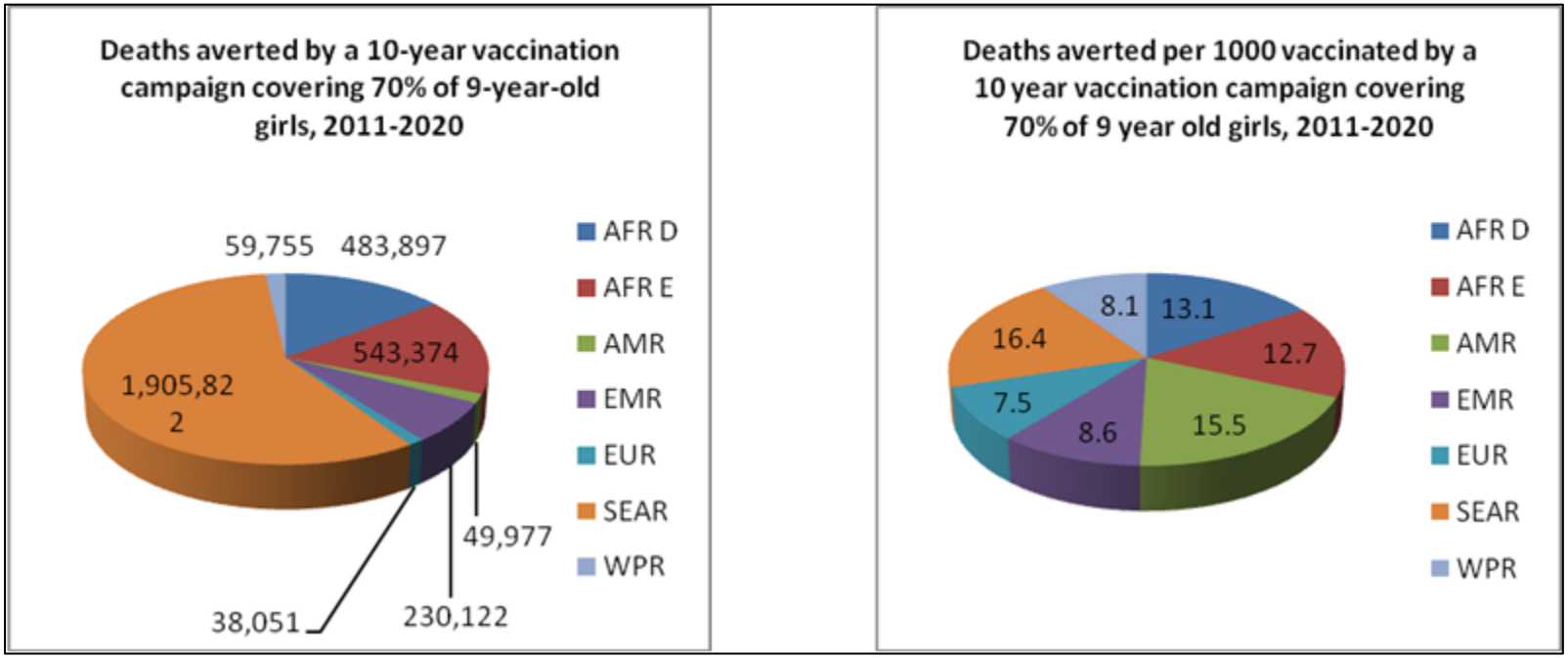
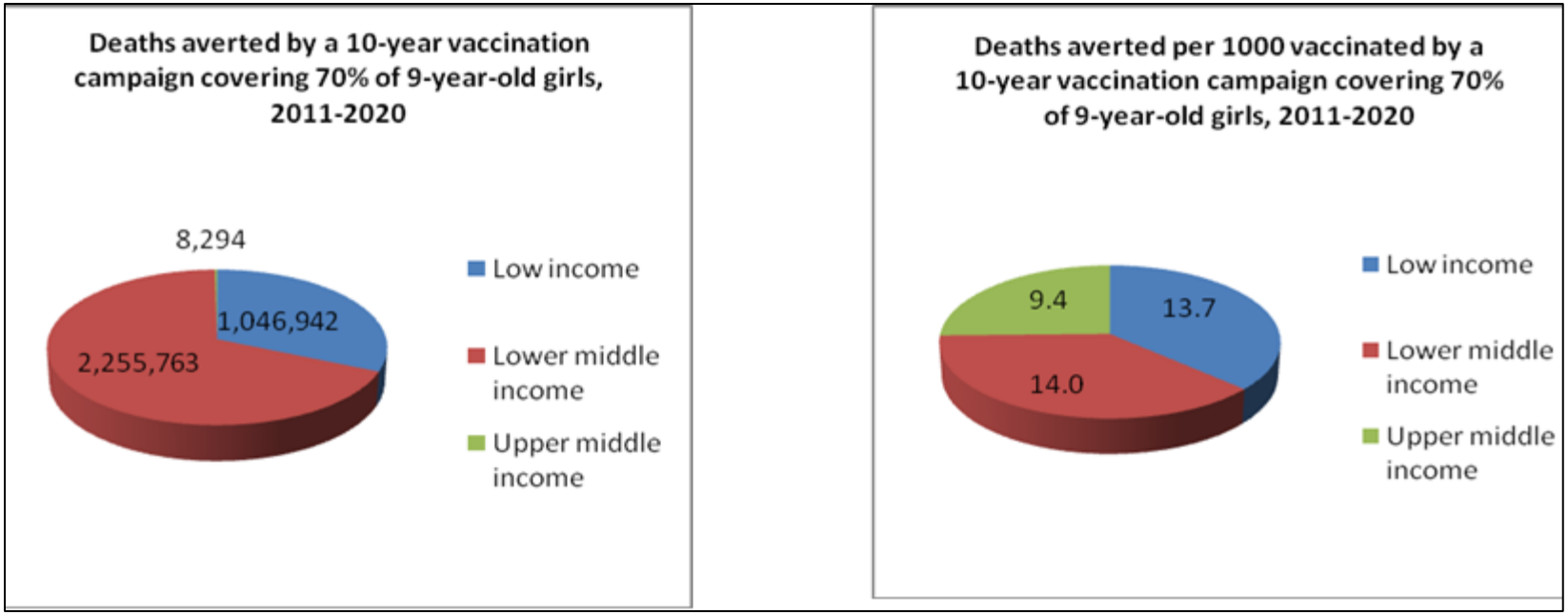


Figure 7. Cervical cancer deaths averted and deaths averted per 1000 vaccinated in a 10-year (2011-2020) vaccination campaign under various coverage assumptions of 9-year-old girls, presented by income group.



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VI. APPENDIX

APPROXIMATION OF COSTS

Overview

Since the country-specific programmatic costs to deliver the HPV vaccine to a young adolescent age group are not yet known, we use a composite value defined as the 'cost per vaccinated girl', which we assume includes the vaccine cost per dose multiplied by the three required doses, wastage of vaccine and supplies, freight and supplies, administration, immunization support and programmatic costs (Acharya 2002, Kou 2002, Walker 2004, Wolfson 2008, WHO CHOICE, WHO 2005). As described in previously published manuscripts (Goldie 2008a,b,c), we distinguish costs dependent on vaccine price (e.g., vaccine wastage, insurance and security fees associated with freight into the country) from those that would theoretically be independent and therefore fixed (e.g., supplies, administration, vaccine support and monitoring/programmatic expenses). We do not include the incremental costs of scaling up vaccination that might be expected after certain thresholds of coverage (e.g., 60%, 70%, 80%) are attained, although explore a wide range of incremental costs associated with initiating a new program.

Cancer treatment costs

Other costs required for the model (e.g., cancer costs) are based on published studies and previously described approximation methods, which leverage available data in select countries and extrapolate to other countries based on per capita gross domestic product (GDP) and other indicators (Goldie 2008 a,b,c, Goldie 2007; Goldhaber-Fiebert 2006). We use previously documented methods to estimate costs associated with cervical cancer (Goldie 2008 a,b,c, Goldie 2007, Goldhaber-Fiebert 2006). We reviewed the published literature, national economic data, manufacturer prices, and unpublished reports to produce initial cost estimates. Costs originally reported in dollars from other years were converted to local currency units (LCUs) using year-specific exchange rates, adjusted for inflation using country-specific inflation rates, and then converted from local currency units to International dollars using Purchasing Power Parity (PPP) exchange rates (World Bank WDI). When data are unavailable for country-specific cost estimates for cervical cancer treatment, we adapt primary cost data collected

from countries within the same region (Goldie 2005, Goldhaber-Fiebert 2006) by scaling costs appropriately to the new country using a relationship between hospital bed day costs and the country-specific per capita GDP. Because the relationship between GDP and hospital bed day charges is unlikely to be linear, the hospital inpatient day costs for each country are plotted against the natural log of the per capita GDP for selected regions, as fully detailed by Goldie et al. (2008 a,b,c).

Vaccination costs

Since the country-specific programmatic costs to deliver the HPV vaccine to a young adolescent age group are not yet known, we use a composite value defined as the 'cost per vaccinated girl', which contains the following components:

Appendix Table 1. Components of the "cost per vaccinated girl"

Component	Depends on vaccine price
Vaccine dose (three doses)	yes
Vaccine wastage	yes
Immunization supplies (syringes etc.)	no
Supplies wastage	no
Freight into the country	yes (security fees)
Administration charges	no
Vaccine support (cold chain, injection safety and operational costs such as delivery within the country)	no
Monitoring and programmatic services (incremental costs for implementing a young adolescent vaccination program)	no

Categories directly dependent on vaccine price include vaccine wastage and freight into the country (since this component also includes insurance and security, which tend to increase as costs of items shipped increase). These costs are considered tradable goods and carry an international dollar price that is independent of the country setting. These costs are converted to and from Local Currency Units

using U.S. dollar direct exchange rates, since by definition, for tradable goods, 1 International Dollar is equal to 1 U.S. dollar.

Categories less dependent on vaccine price include supplies and supplies wastage (although supply wastage does depend on the supply price), administration, vaccine support and monitoring/programmatic expenses. Categories such as administration, support and programmatic components are considered non-tradable inputs (mostly salaries), and tend to vary with the level of development (i.e., GDP) of a country; as relative salaries increase, so do the costs for these inputs when expressed in International dollars. These costs are converted to and from Local Currency Units using Purchasing Power Parity conversion rates. A fully detailed explanation of the methods used, can be found in Goldie et al. (2008 a,b,c).

Appendix Table 2. Country-specific cervical cancer treatment costs (2005 International $)

Country	Direct medical costs - treatment cervical cancer	
	Stage I	Stage II-IV
Afghanistan	967.53	1409.03
Angola	2807.71	3481.85
Armenia	1722.32	1953.59
Azerbaijan	1810.42	2053.53
Bangladesh	1111.47	1618.65
Benin	1381.12	1712.73
Bhutan	1665.07	2424.85
Bolivia	2163.16	1821.93
Burkina Faso	1199.68	1487.72
Burundi	713.07	884.28
Cambodia	889.51	1008.95
Cameroon	1804.90	2238.26
Central African Republic	936.72	1161.63
Chad	1403.17	1740.07
Comoros	965.93	1197.86
Congo, Democratic Republic	660.40	818.97
Congo, Repub of (Brazzaville)	1547.64	1919.23
Cote d'Ivoire	2742.38	3400.83
Cuba	1868.32	1573.60
Djibouti	1201.46	1749.70
Eritrea	922.78	1144.34
Ethiopia	919.29	1140.01
Georgia	1613.72	1830.41
Ghana	1303.25	1616.17
Guinea	1139.65	1413.29
Guinea-Bissau	1154.01	1431.09
Guyana	1660.22	1398.33
Haiti	1056.62	889.94
Honduras	1974.42	1662.97
India	1304.54	1899.80
Indonesia	1007.14	1142.38
Kenya	1401.16	1737.59
Kiribati	1141.25	1294.51
Korea, Democratic Republic	1203.14	1752.13
Kyrgyzstan	1188.97	1348.63
Lao People Dem Republic	946.17	1073.22
Lesotho	1308.64	1622.85
Liberia	700.99	869.30
Madagascar	1091.67	1353.78
Malawi	900.44	1116.64
Mali	1162.20	1441.25
Mauritania	1621.08	2010.30
Moldova	1333.11	1512.13
Mongolia	1217.15	1380.60
Mozambique	942.98	1169.40

Appendix Table 2. Country-specific cervical cancer treatment costs (2005 Int $) cont.

Country	Direct medical costs - treatment cervical cancer	
	Stage I	Stage II-IV
Myanmar	1186.63	1728.09
Nepal	1103.30	1606.75
Nicaragua	1597.28	1345.32
Niger	899.74	1115.77
Nigeria	1663.45	2062.85
Pakistan	1278.16	1861.39
Papua New Guinea	1005.36	1140.36
Rwanda	1076.54	1335.03
Sao Thome	1452.43	1801.17
Senegal	1583.11	1963.23
Sierra Leone	933.23	1157.31
Solomon Islands	1060.84	1203.29
Somalia	912.69	1329.15
Sri Lanka	1062.96	1205.70
Sudan	1144.80	1667.17
Tajikistan	1132.30	1284.35
Tanzania	1216.67	1508.80
The Gambia	1268.84	1573.49
Timor Leste	698.99	792.85
Togo	1015.84	1259.75
Uganda	1104.71	1369.96
Ukraine	2048.88	2324.02
Uzbekistan	1251.17	1419.18
Viet Nam	1085.65	1231.43
Yemen	1280.44	1864.71
Zambia	1258.70	1560.92
Zimbabwe	1768.92	2193.65