Cost-effectiveness of male HPV vaccination in the United States

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Cost-effectiveness of HPV vaccination
Background

- Vaccination of 12-year-old girls is cost-effective
  - Consistency across models
  - Estimates not particularly sensitive to uncertainty in natural history and epidemiology of HPV

- More uncertainty, less precision in cost-effectiveness estimates for:
  - Vaccination of adult women
    - February 2010 ACIP, June 2008 ACIP, February 2008 ACIP
  - Vaccination of males
    - October 2009 ACIP, June 2009 ACIP

Outline

- Review of cost-effectiveness ratios, QALYs
- Review of male HPV cost-effectiveness estimates
- Selected sensitivity analyses
- Male vaccination vs. increased female coverage
- Vaccination of men who have sex with men (MSM)
- Summary

Cost-effectiveness of vaccination

Vaccination costs minus health costs averted by vaccination

$$\frac{\text{Change in costs}}{\text{Change in health outcomes}}$$

Quality-adjusted life years (QALYs) gained by vaccination

QALY: Quality-adjusted life year

- QALYs account for quality and length of life
  - One year in perfect health = 1 QALY
  - Death = 0 QALY
  - One year of life in less than perfect health is given a value between 0 and 1 QALY
    - Example of QALY weights for HPV outcomes:
      - Genital warts: 0.93
      - Cervical cancer: 0.50

See Dasbach (1996). QALY weights are approximations based on recent cost-effectiveness studies.

Cost-effectiveness thresholds in the US

- No consensus on appropriate cost-per-QALY threshold for determining cost-effectiveness of public health interventions
- $50,000 to $100,000 threshold often cited
  - Described as arbitrary, lacking empirical or theoretical justification

See Grosse (2008), Weinstein (2008), and Weinstein et al. (2010).

Cost per QALY gained by childhood vaccines in the US

Vaccine	Cost per QALY gained (compared to no vaccine)	Source
DTaP	<$0 (cost-saving)	Ekwueme (2000); Zhou (2005)
Hib	<$0 (cost-saving)	Zhou (2005); Cochi (1985)
MMR	<$0 (cost-saving)	Zhou (2004, 2005); White (1985)
Polio	<$0 (cost-saving)	Zhou (2005); Thompson (2006)
Varicella	<$0 (cost-saving)	Zhou (2004,2008); Preblud (1985)
Influenza (LAIV)	≈ $10,000	Prosser (2006)
Hepatitis A	≈ $10,000 to $30,000	Das (1999); Rein (2007)
Meningococcal (MCV4)	≈ $120,000 to $230,000	Shepard (2005), Ortega-Sanchez (Feb 2010 ACIP)

QALY: quality-adjusted life year. DTaP: Diphtheria and tetanus toxoids and acellular pertussis. Hib: *Haemophilus influenzae* type b. MMR: Measles, mumps, and rubella. LAIV: live, attenuated influenza vaccine. MCV4: meningococcal conjugate.

Updated to 2009 US dollars and rounded. MCV4 estimates are for vaccination of toddlers. This table shows a collection of point estimates; the ranges shown for hepatitis A and MCV4 reflect base case results of two studies. For each vaccine, the actual range of plausible cost-effectiveness estimates varies (not shown). See the sensitivity analyses in the source studies.

Cost per QALY gained by adolescent vaccines in the US

Vaccine	Target group	Cost per QALY gained (compared to no vaccination)
Hepatitis B	College freshmen	<$0 (cost-saving) to ≈ $10,000
Hepatitis A	College freshmen	<$0 (cost-saving) to ≈ $15,000
HPV	**12-year-old girls**	**≈ $3,000 to $45,000**
Influenza	12- to 17-year-olds, high risk	≈ $10,000
Tdap	All 11-year-olds	≈ $25,000
Meningococcal (MCV4)	1-dose, all 15-year-olds	≈ $120,000
Influenza	12- to 17-year-olds, healthy	≈ $140,000
Meningococcal (MCV4)	2-dose, all 11 & 16-year-olds	≈ $160,000
Meningococcal (MCV4)	1-dose, all 11-year-olds	≈ $280,000

Source: Ortega-Sanchez et al. *Pediatrics* (2008), except HPV and MCV4 (see notes).

Tdap: Tetanus and diphtheria toxoids and acellular pertussis. Influenza estimates are for inactivated vaccine. For HPV, the lower and upper bound estimates [Elbasha (2007) AND Kim (2008), respectively] were published after the cutoff date for inclusion in the Ortega-Sanchez review. Estimates for MCV4 were presented by Ortega-Sanchez, October 2010 ACIP. All estimates updated to 2009 US dollars and rounded. This table shows a collection of point estimates; the range shown for HPV reflects base case results of two studies, and the ranges shown for hepatitis A & B reflect base case results from two perspectives. For each vaccine, the actual range of plausible cost-effectiveness estimates varies (not shown). For more details, see the sensitivity analyses in the source studies.

Estimates of cost-effectiveness of male HPV vaccination vary across models

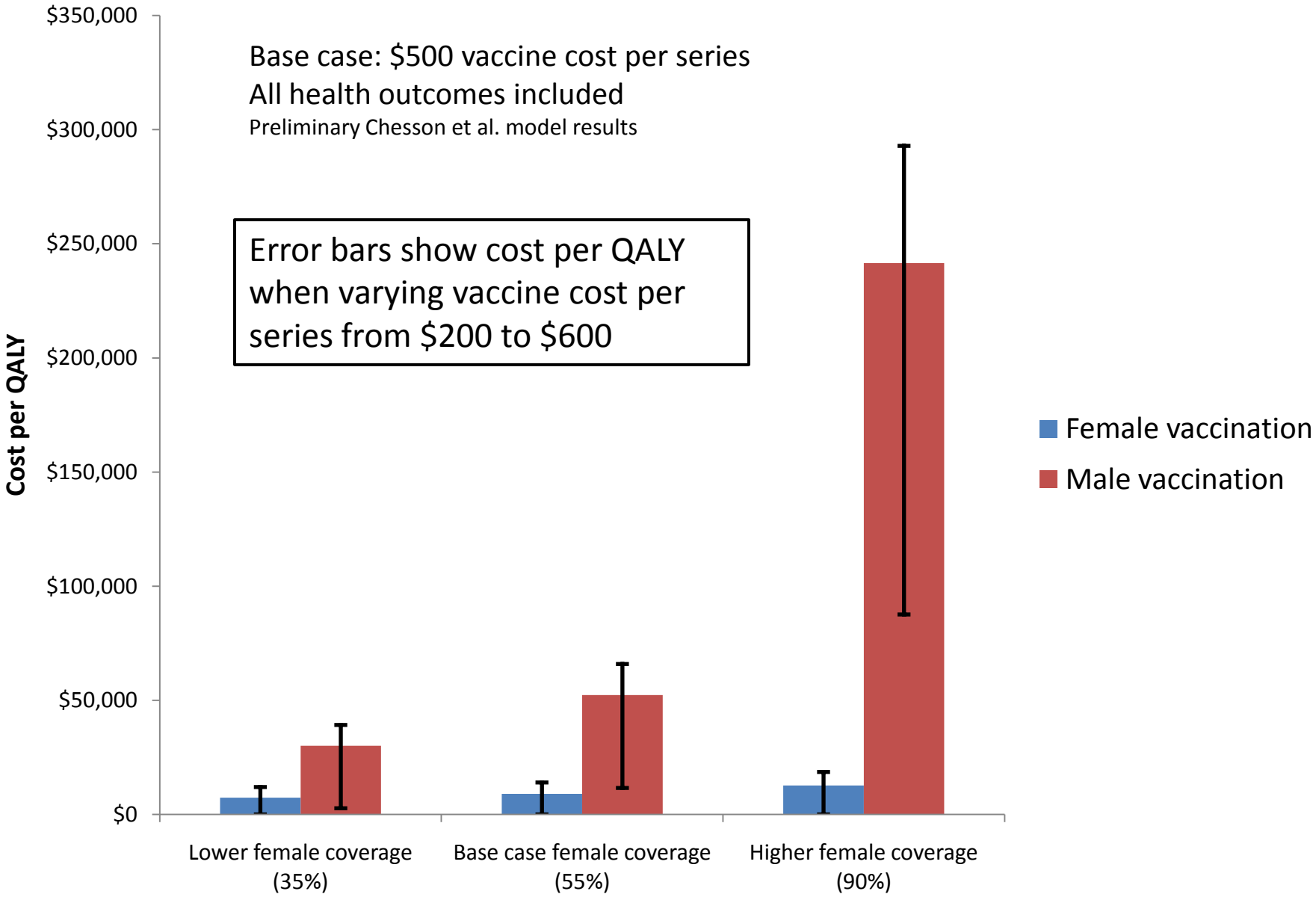
- Differences in models
  - Various approaches used to simulate the changing dynamics of HPV in the population (indirect effects, or “herd immunity”)
    - Degree and duration of natural immunity
- Health outcomes included
- Quality-of-life assumptions
- Vaccine characteristics
  - Cost, coverage, efficacy

Estimated cost per QALY of male vaccination

Outcomes included	Study	Female coverage (3-dose)			
		≈ 20% to 45%	≈ 50%	≈ 70% to 75%	≈ 80% to 90%
Cervical outcomes	Taira et al., 2004	$41,000	-	$442,000	
Cervical outcomes Genital warts (males and females)	Elbasha et al., (Merck), 2007	-	$24,000	$42,000	$128,000
	Jit et al., (UK), 2008	-	-		≈ $1,000,000
Cervical outcomes Genital warts (males and females) Non-cervical cancers (males and females) RRP (males and females)	Kim & Goldie (2009)	-	$62,000	$91,000	
	Elbasha & Dasbach (Merck), 2010	$24,000	$27,000		$39,000
	Chesson et al., preliminary	$30,000	$52,000	$103,000	$242,000

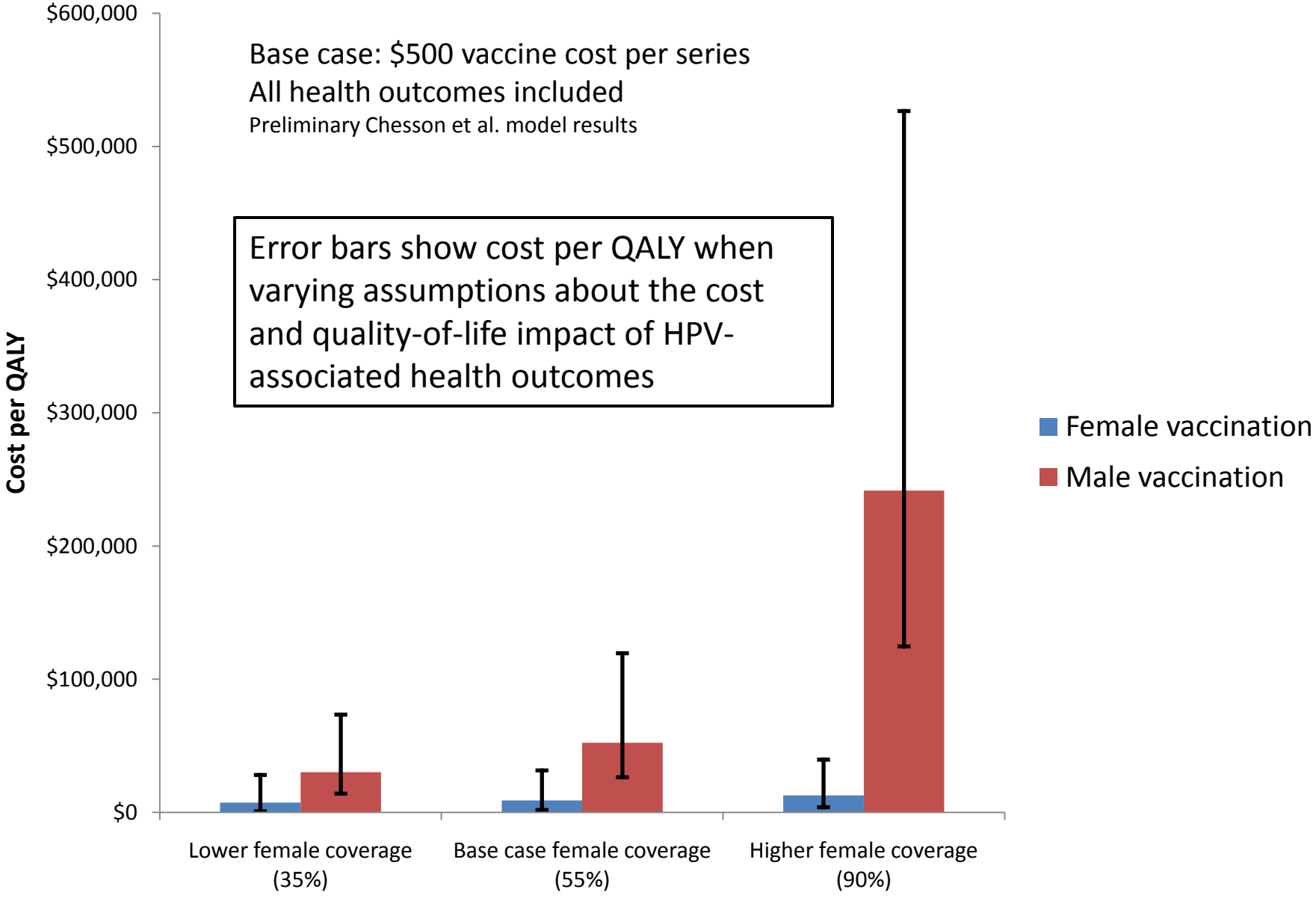
QALY: quality-adjusted life year. RRP: recurrent respiratory papillomatosis. The Kim and Goldie (2009) estimates shown are for 50% coverage and 75% coverage, under their most optimistic efficacy assumptions. See source studies for additional details and results under alternate assumptions, as estimates vary when model assumptions are changed. Cost per QALY estimates show the incremental cost per QALY of adding male vaccination to female-only vaccination. Results not updated for inflation.

Cost per QALY gained by HPV vaccination in three coverage scenarios



Chesson et al., preliminary

Cost per QALY gained by HPV vaccination in three coverage scenarios



Chesson et al., preliminary

Male vaccination vs. increased female coverage

- Published studies typically report cost-effectiveness of adding male vaccination to female-only vaccination
- An alternative option to male vaccination is to increase vaccine coverage of females
  - What is the cost-effectiveness of male vaccination compared to a strategy of increased vaccine coverage of females?

Comparison of three vaccination strategies

Preliminary Chesson et al. model results, all health outcomes included

Vaccination strategy	3-dose coverage of 12-year-olds	
	Girls	Boys
Strategy A: Female-only vaccination: Base case coverage	30%	0%
Strategy B: Female-only vaccination: Increased coverage	45%	0%
Strategy C: Male and female vaccination: Base case coverage	30%	30%

- Incremental cost per QALY of male vaccination (all outcomes included):
  - Strategy C vs. Strategy A: $31,700
  - Strategy C vs. Strategy B: $185,300*

*In this example, increased female vaccination coverage could incur outreach costs of $399 per additional girl vaccinated and still be more cost-effective than male vaccination.

QALY: quality-adjusted life year. Chesson et al., preliminary.

Cost-Effectiveness of HPV Vaccination of Men Who Have Sex With Men (MSM) in the US

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Kim JJ "Targeted human papillomavirus vaccination of men who have sex with men in the USA: a cost-effectiveness modelling analysis." Lancet Infect Dis; Published online November 3, 2010. DOI:10.1016/S1473-3099(10)70219-X.

Methods

- Intervention: HPV vaccination of one MSM age cohort
  - Vaccination ages 12, 20, or 26 years
- Adapted previously-developed Markov cohort models to synthesize data on the burden of HPV among MSM with and without HIV
  - Health outcomes included:
    - Anal cancer attributable to HPV 16/18
    - Genital warts attributable to HPV 6/11

Kim JJ. Lancet Infect Dis; Published online November 3, 2010. DOI:10.1016/S1473-3099(10)70219-X.

Methods: Inputs I

Variable	Anal cancer	Genital warts
Incidence rate (per 100,000)	0.01 to16.44 (HIV -) 0.09 to 97.92 (HIV +)	9 to 1,287
5-year survival (%)	64.1 (HIV -) 47.0 (HIV +)	N/A
% of cases attributable to HPV vaccine types	78.6	90.0
Quality of life adjustment	0.68	0.91
Cost per case ($)	31,300	430

Kim JJ. Lancet Infect Dis; Published online November 3, 2010. DOI:10.1016/S1473-3099(10)70219-X.

Methods: Inputs II

Vaccine characteristics	Value
Coverage	50%
Efficacy against 6/11 genital warts	90%
Efficacy against 16/18 anal cancer	90%
Vaccine duration	Lifelong
Cost per series	$500

Kim JJ. Lancet Infect Dis; Published online November 3, 2010. DOI:10.1016/S1473-3099(10)70219-X.

Results: Cost per QALY gained by HPV vaccination of MSM

when varying prior exposure to HPV

Including anal cancer and genital warts

Adjustment for prior exposure to 6/11/16/18	Vaccination age		
	Age 12	Age 20	Age 26
0%	15,290		
10%		17,850	19,160
20%		20,650	22,080
50%		35,740	37,830

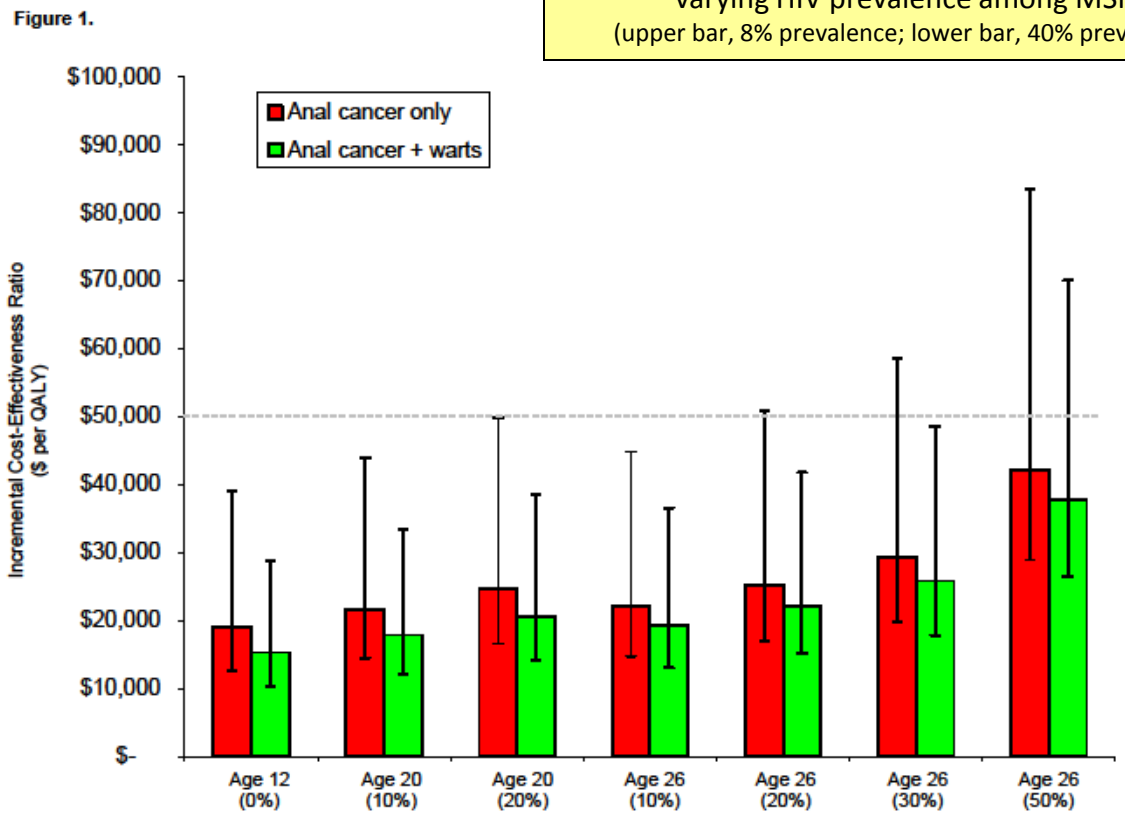
Values represent incremental cost-effectiveness ratios (additional cost divided by additional health benefit) of HPV vaccination of MSM, compared to no vaccination, under base case assumptions. Ratios are expressed as cost per quality-adjusted life year ($ per QALY) gained. Results include vaccine benefits in preventing vaccine-type anal cancer and genital warts among MSM. All costs are expressed in 2006 U.S. dollars.

Kim JJ. Lancet Infect Dis; Published online November 3, 2010. DOI:10.1016/S1473-3099(10)70219-X.

Results: Sensitivity analyses

Impact of age at vaccination, prior exposure to vaccine-targeted HPV infections, and HIV prevalence among MSM

The error bars represent results associated with varying HIV prevalence among MSM
(upper bar, 8% prevalence; lower bar, 40% prevalence)



The x-axis shows the age at vaccination and the adjustment for prior HPV exposure.

Kim JJ. Lancet Infect Dis; Published online November 3, 2010. DOI:10.1016/S1473-3099(10)70219-X.

Male HPV vaccination: Summary

- Estimates of cost-effectiveness of male vaccination vary
  - Within one model when key assumptions are changed
  - Across different models due to differences in model structure and/or assumptions
- Cost-effectiveness of male vaccination depends on health outcomes included
  - Most favorable scenario is when all potential health outcomes are included

Male HPV vaccination: Summary II

- Cost-effectiveness of male vaccination depends on vaccine coverage of females
  - Most favorable scenario for male vaccination is when coverage of females is low
  - Male vaccination estimated to cost $26,000 to $62,000 per QALY when female coverage ≤ 50%*
    - Compares favorably to many other recommended vaccines, other accepted public health interventions

*Under certain circumstances, when including a range of potential health benefits of vaccination. The $26,000 per QALY estimate is from Elbasha/Dasbach (2010) with 3-dose coverage by age 18 of 38% for females and 23% for males. The $62,000 per QALY estimate is from Kim/Goldie (2009) with 50% coverage (all 3 doses) of girls and boys by age 12, high efficacy scenario.

Male HPV vaccination: Summary III

- Improving vaccine coverage of females may be more cost-effective than male vaccination
  - Even if outreach costs are incurred to increase coverage
- HPV vaccination of MSM appears cost-effective
  - Kim (2010) found cost per QALY < $50,000 over range of assumptions about age at vaccination and prior exposure to HPV

QALY: Quality-adjusted life year. MSM: men who have sex with men.

Kim JJ. Lancet Infect Dis; Published online November 3, 2010. DOI:10.1016/S1473-3099(10)70219-X.

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