Cost-effectiveness analysis

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1. *Cost-effectiveness of female human papillomavirus vaccination in 179 countries: a PRIME modelling study*

Mark Jit PhD, Marc Brisson PhD †, Allison Portnoy MSPH †, Dr Raymond Hutubessy PhD

Abstract

Introduction of human papillomavirus (HPV) vaccination in settings with the highest burden of HPV is not universal, partly because of the absence of quantitative estimates of country-specific effects on health and economic costs. We aimed to develop and validate a simple generic model of such effects that could be used and understood in a range of settings with little external support. We developed the Papillomavirus Rapid Interface for Modelling and Economics (PRIME) model to assess cost-effectiveness and health effects of vaccination of girls against HPV before sexual debut in terms of burden of cervical cancer and mortality. PRIME models incidence according to proposed vaccine efficacy against HPV 16/18, vaccine coverage, cervical cancer incidence and mortality, and HPV type distribution. It assumes lifelong vaccine protection and no changes to other screening programmes or vaccine uptake. We validated PRIME against existing reports of HPV vaccination cost-effectiveness, projected outcomes for 179 countries (assuming full vaccination of 12-year-old girls), and outcomes for 71 phase 2 GAVI-eligible countries (using vaccine uptake data from the GAVI Alliance). We assessed differences between countries in terms of cost-effectiveness and health effects. HPV vaccination was very cost effective (with every disability-adjusted life-year averted costing less than the gross domestic product per head) in 156 (87%) of 179 countries. Introduction of the vaccine in countries without national HPV vaccination at present would prevent substantially more cases of cervical cancer than in countries with such programmes, although the disparity has narrowed since 2012. If 71 phase 2 GAVI-eligible countries adopt vaccination according to forecasts, then in 2070 GAVI Alliance-funded vaccination could prevent 200 000 cases of cervical cancer and 100 000 deaths in some of the highest-burden countries. Support from the GAVI Alliance could help to reduce disparities between countries, but a substantial burden will remain even after presently projected vaccine introductions.

2. *Decision-making on malaria vaccine introduction: the role of cost–effectiveness analyses*

Moorthy VS, Hutubessy R, Newman RD, Hombach J.

Abstract

Policy-makers in countries where malaria is endemic are facing increasingly complex decisions about which vaccines and malaria prevention measures to include in national immunization and malaria control programmes. Several new vaccines and malaria preventive measures are already competing for limited financing in developing countries. African countries with endemic malaria should be ready to make a national policy decision on the introduction of RTS,S/AS01, a first-generation malaria vaccine, by 2015. If clinical trials progress according to schedule, that same year the World Health Organization (WHO) will issue a policy recommendation on the public health use of this vaccine based on the findings of the full Phase III efficacy trial in progress, which will be available in late 2014. The vaccine's manufacturers are targeting infants in malaria-endemic African countries who undergo routine vaccination through the Expanded Programme on Immunization (EPI) at 6, 10 and 14 weeks of age, with the possibility of a booster dose being needed at 9–18 months. At present WHO is assessing the evidence base for a policy position on this vaccine. Cost–effectiveness is an important consideration in public health decision-making. This article summarizes critical parameters driving malaria vaccine cost–effectiveness predictions and discusses major uncertainties that remain in the cost–effectiveness modelling arena. It also highlights the need for ongoing work by modelling groups to further refine cost–effectiveness predictions

3. *Are current cost-effectiveness thresholds for low- and middle-income countries useful? Examples from the world of vaccines.*

Newall AT, Jit M, Hutubessy R.

Abstract

The World Health Organization's CHOosing Interventions that are Cost Effective (WHO-CHOICE) thresholds for averting a disability-adjusted life-year of one to three times per capita income have been widely cited and used as a measure of cost effectiveness in evaluations of vaccination for low- and middle-income countries (LMICs). These thresholds were based upon criteria set out by the WHO Commission on Macroeconomics and Health, which reflected the potential economic returns of interventions. The CHOICE project sought to evaluate a variety of health interventions at a subregional level and classify them into broad categories to help assist decision makers, but the utility of the thresholds for within-country decision making for individual interventions (given budgetary constraints) has not been adequately explored. To examine whether the 'WHO-CHOICE thresholds' reflect funding decisions, we examined the results of two recent reviews of cost-effectiveness analyses of human papillomavirus and rotavirus vaccination in LMICs, and we assessed whether the results of these studies were reflected in funding decisions for these vaccination programmes. We found that in many cases, programmes that were deemed cost effective were not subsequently implemented in the country. We consider the implications of this finding, the advantages and disadvantages of alternative methods to estimate thresholds, and how cost perspectives and the funders of healthcare may impact on these choices.

4. *Cost-effectiveness of human papillomavirus vaccination in low and middle income countries: a systematic review*

Fesenfeld M, Hutubessy R, Jit M.

Abstract

The World Health Organization recommends establishing that human papillomavirus vaccination is cost-effective before vaccine introduction. We searched Pubmed, Embase and the Cochrane Library to 1 April 2012 for economic evaluations of human papillomavirus vaccination in low and middle income countries. We found 25 articles, but almost all low income countries and many middle income countries lacked country-specific studies. Methods, assumptions and consequently results varied widely, even for studies conducted for the same country. Despite the heterogeneity, most studies conclude that vaccination is likely to be cost-effective and possibly even cost saving, particularly in settings without organized cervical screening programmes. However, study uncertainty could be reduced by clarity about vaccine prices and vaccine delivery costs. The review supports extending vaccination to low income settings where vaccine prices are competitive, donor funding is available, cervical cancer burden is high and screening options are limited.

5. *Cost-effectiveness of rotavirus immunization in Indonesia: Taking breastfeeding patterns into account*

Auliya A. Suwantika, Hong Anh T. Tu, Maarten J. Postma

Keywords

Abstract

Objective This study aims to assess the cost-effectiveness of rotavirus immunization in Indonesia, taking breastfeeding patterns explicitly into account.

Method An age-structured cohort model was developed for the 2011 Indonesia birth cohort. Next, we

compared two strategies, the current situation without rotavirus immunization versus the alternative of a national immunization program. The model applies a 5 year time horizon, with 1 monthly analytical cycles for children less than 1 year of age and annually thereafter. Three scenarios were compared to the base case reflecting the actual distribution over the different breastfeeding modes as present in Indonesia; i.e., the population under 2 years old with (i) 100% exclusive breastfeeding, (ii) 100% partial breastfeeding and (iii) 100% no breastfeeding. Monte Carlo simulations were used to examine the economic acceptability and affordability of the rotavirus vaccination.

Results Rotavirus immunization would effectively reduce severe cases of rotavirus during the first 5 years of life of a child. Under the market vaccine price the total yearly vaccine cost would amount to US$ 65 million. The incremental cost per quality-adjusted-life-year (QALY) in the base case was US$ 174 from the societal perspective. Obviously, it was much lower than the 2011 Indonesian Gross Domestic Product (GDP) per capita of US$ 3495. Affordability results showed that at the Global Alliance for Vaccines and Immunization (GAVI)-subsidized vaccine price, rotavirus vaccination could be affordable for the Indonesian health system. Increased uptake of breastfeeding might slightly reduce cost-effectiveness results.

Conclusion Rotavirus immunization in Indonesia would be a highly cost-effective health intervention even under the market vaccine price. The results illustrate that rotavirus immunization would greatly reduce the burden of disease due to rotavirus infection. Even within increased uptake of breastfeeding, cost-effectiveness remains favorable.

6. *Cost-effectiveness of a new rotavirus vaccination program in Pakistan: A decision tree model*

Hiten D. Patel, Eric T. Roberts, Dagna O. Constenla

Keywords

Abstract

Background Rotavirus gastroenteritis places a significant health and economic burden on Pakistan. To determine the public health impact of a national rotavirus vaccination program, we performed a cost-effectiveness study from the perspective of the health care system.

Methods A decision tree model was developed to assess the cost-effectiveness of a national vaccination program in Pakistan. Disease and cost burden with the program were compared to the current state. Disease parameters, vaccine-related costs, and medical treatment costs were based on published epidemiological and economic data, which were specific to Pakistan when possible. An annual birth cohort of children was followed for 5 years to model the public health impact of vaccination on health-related events and costs. The cost-effectiveness was assessed and quantified in cost (2012 US$) per disability-adjusted life-year (DALY) averted and cost per death averted. Sensitivity analyses were performed to assess the robustness of the incremental cost-effectiveness ratios (ICERs).

Results The base case results showed vaccination prevented 1.2 million cases of rotavirus gastroenteritis, 93,000 outpatient visits, 43,000 hospitalizations, and 6700 deaths by 5 years of age for an annual birth cohort scaled from 6% current coverage to DPT3 levels (85%). The medical cost savings would be US$1.4 million from hospitalizations and US$200,000 from outpatient visit costs. The vaccination program would cost US$35 million at a vaccine price of US$5.00. The ICER was US$149.50 per DALY averted or US$4972 per death averted. Sensitivity analyses showed changes in case–fatality ratio, vaccine efficacy, and vaccine cost exerted the greatest influence on the ICER.

Conclusions Across a range of sensitivity analyses, a national rotavirus vaccination program was predicted to decrease health and economic burden due to rotavirus gastroenteritis in Pakistan by ~40%. Vaccination was highly cost-effective in this context. As discussions of implementing the intervention intensify, future studies should address affordability, efficiency, and equity of vaccination introduction.

7. *Cost-Effectiveness Analysis of a Universal Infant Immunization Program with Meningococcal C*

Conjugate Vaccine in Brazil

Patricia Coelho de Soarez, Ana Marli C. Sartori, Laura de Andrade Lagoa Nóbrega, Alexander Itria, Hillegonda Maria Dutilh Novaes

Keywords

Abstract

Objective To analyze the cost-effectiveness of a meningococcal C vaccination program in Brazil.

Methods A hypothetical cohort of 3,194,038 children born in Brazil in 2006 was followed for 10 years. A decision tree model was developed using the TreeAge Pro 2007 software program to compare universal infant vaccination with the current program. Epidemiological and cost estimates were based on data retrieved from National Health Information Systems and the literature. The analysis was conducted from the public health care system and societal perspectives. Costs are expressed in 2006 Brazilian reals (R$).

Results At 94% coverage, the program would avoid 1,218 cases, 210 deaths, and 14,473 life-years lost, a reduction of, respectively, 45%, 44%, and 44%, for the 10-year period. Vaccination costs of R$320.9 million would not be offset by R$4 to R$7.9 million decreases in disease treatment costs. A national vaccination program would cost R$21,620 per life-year saved from the perspective of the health-care system and R$21,896 per life-year saved from society's perspective. Results were most sensitive to case fatality rate, disease incidence, and vaccine cost.

Conclusions A universal childhood vaccination program against meningococcal C proved to be a cost-effective strategy, supporting the recent decision of the Brazilian government. These results could contribute to defining the most favorable price of the vaccine and to monitoring its impact on the population.

8. *Cost-effectiveness of rotavirus vaccination programs in Taiwan*

Wan-Chi Chang, Catherine Yen, Cheng-Liang Chi, Fang-Tzy Wu, Yhu-Chering Huang, Jen-Shiou Lin, Fu-Chen Huang, Jacqueline E. Tate, Ho-Sheng Wu, Chao A. Hsiung

Keywords

Abstract

Background In Taiwan, two rotavirus vaccines are available on the private market, but are not included in the National Immunization Program (NIP). To help assess whether to include rotavirus vaccines in the NIP, we examined the potential impact and cost-effectiveness of vaccination, from the health care system perspective alone.

Methods We used a Microsoft Excel-based model to assess rotavirus vaccination impact on rotavirus disease burden and the cost-effectiveness of 2-dose and 3-dose vaccination programs among a birth cohort of Taiwanese children followed for 5 years. Principal model inputs included data on rotavirus disease burden and related healthcare costs, vaccination cost and coverage rates, and vaccine efficacy. Principal model outputs included the number of health-related events and costs averted and incremental cost per disability-adjusted life year averted.

Results A national rotavirus vaccination program, regardless of number of doses per course, would prevent 4 deaths, >10,500 hospitalizations, and >64,000 outpatient visits due to rotavirus infection among children <5 years annually, resulting in ~80%, 90%, and 70% declines in these outcomes, respectively, and a ~$7 million decline in annual medical costs. A national 2- or 3-dose vaccination program would be cost-saving up to $13.30/dose ($26.60/course) or $7.98/dose ($23.94/course), respectively; very cost-effective up to $24.08 per dose ($48.16/course) or $15.18/dose ($45.54/course), respectively; and cost-effective up to $45.65/dose ($91.30/course) or $29.59/dose ($88.77/course), respectively.

Conclusions A national rotavirus vaccination program could substantially reduce rotavirus disease burden

among Taiwanese children and be potentially cost-effective, depending on the vaccine price.

9. Cost-effectiveness and economic benefits of vaccines in low- and middle-income countries: A systematic review

Sachiko Ozawa, Andrew Mirelman, Meghan L. Stack, Damian G. Walker, Orin S. Levine

Keywords

Abstract

Background Public health interventions that prevent mortality and morbidity have greatly increased over the past decade. Immunization is one of these preventive interventions, with a potential to bring economic benefits beyond just health benefits. While vaccines are considered to be a cost-effective public health intervention, implementation has become increasingly challenging. As vaccine costs rise and competing priorities increase, economic evidence is likely to play an increasingly important role in vaccination decisions.

Methods To assist policy decisions today and potential investments in the future, we provide a systematic review of the literature on the cost-effectiveness and economic benefits of vaccines in low- and middle-income countries from 2000 to 2010. The review identified 108 relevant articles from 51 countries spanning 23 vaccines from three major electronic databases (Pubmed, Embase and Econlit).

Results Among the 44 articles that reported costs per disability-adjusted life year (DALY) averted, vaccines cost less than or equal to $100 per DALY averted in 23 articles (52%). Vaccines cost less than $500 per DALY averted in 34 articles (77%), and less than $1000 per DALY averted in 38 articles (86%) in one of the scenarios. 24 articles (22%) examined broad level economic benefits of vaccines such as greater future wage-earning capacity and cost savings from averting disease outbreaks. 60 articles (56%) gathered data from a primary source. There were little data on long-term and societal economic benefits such as morbidity-related productivity gains, averting catastrophic health expenditures, growth in gross domestic product (GDP), and economic implications of demographic changes resulting from vaccination.

Conclusions This review documents the available evidence and shows that vaccination in low- and middle-income countries brings important economic benefits. The cost-effectiveness studies reviewed suggest to policy makers that vaccines are an efficient investment. This review further highlights key gaps in the available literature that would benefit from additional research, especially in the area of evaluating the broader economic benefits of vaccination in the developing world.

10. Health economics of rotavirus immunization in Vietnam: Potentials for favorable cost-effectiveness in developing countries

Hong-Anh T. Tu, Mark H. Rozenbaum, Peter C. Coyte, Shu Chuen Li, Herman J. Woerdenbag, Maarten J. Postma

Keywords

Abstract

Introduction

Rotavirus is the most common cause of severe diarrhoea worldwide. Vietnam is situated in the region of high rotavirus infection incidence and eligible for financial support to introduce rotavirus vaccines into the Expanded Program of Immunization (EPI) from the GAVI. This study was designed to assess the cost-effectiveness of rotavirus immunization in Vietnam, explicitly the use of Rotateq® and to assess the affordability of implementing universal rotavirus immunization based on GAVI-subsidized vaccine price in the context of Vietnamese healthcare system for the next 5 years.

Methodology

An age-structured cohort model was developed for the 2009 birth cohort in Vietnam. Two strategies were compared: one being the current situation without vaccination, and the other being mass universal rotavirus vaccination. The time horizon of the model was 5 years with time cycles of 1 month for children less than 1 year of age and annual analysis thereafter. Outcomes included mild, moderate, severe cases and death. Multiple outcomes per rotavirus infection are possible in the model. Monte Carlo simulations were used to examine the acceptability and affordability of the rotavirus vaccination. All costs were expressed in 2009 US$.

Results

Rotavirus vaccination would not completely protect young children against rotavirus infection due to partial nature of vaccine immunity, however, would effectively reduce severe cases of rotavirus by roughly 55% during the first 5 years of life. Under GAVI-subsidized vaccine price (US$ 0.3/dose), the vaccine cost would amount to US$ 5.5 million per annum for 3-dose of the Rotateq® vaccine. In the base-case, the incremental cost per quality-adjusted-life-year (QALY) was US$ 665 from the health system perspective, much lower than per-capita GDP of ~US$ 1150 in 2009. Affordability results showed that at the GAVI-subsidized vaccine price, rotavirus vaccination could be affordable for Vietnamese health system.

Conclusion

Rotavirus vaccination in Vietnam would be a cost-effective health intervention. Vaccination only becomes affordable if the country receives GAVI's financial support due to the current high market vaccine price. Given the high mortality rate of under-five-year children, the results showed that rotavirus immunization is the "best hope" for prevention of rotavirus-related diarrhoeal disease in Vietnam. In the next five years, Vietnam is definitely in debt to financial support from international organizations in implementing rotavirus immunization. It is recommended that new rotavirus vaccine candidates be developed at cheaper price to speed up the introduction of rotavirus immunization in the developing world in general.

11. ***Comparative Cost-Effectiveness of HPV Vaccines in the Prevention of Cervical Cancer in Malaysia***

Sharifa WP Ezat, Syed Aljunid

Keywords

Abstract

Objectives Cervical cancer (CC) had the second highest incidence of female cancers in Malaysia in 2003-2006. Prevention is possible by both Pap smear screening and HPV vaccination with either the bivalent vaccine (BV) or the quadrivalent vaccine (QV). In the present study, cost effectiveness options were compared for three programs i.e. screening via Pap smear; modeling of HPV vaccination (QV and BV) and combined strategy (screening plus vaccination). A scenario based sensitivity analysis was conducted using screening population coverages (40-80%) and costs of vaccines (RM 100-200/dose) were calculated.

Methods This was an economic burden, cross sectional study in 2006-2009 respondents were interviewed from six public Gynecology-Oncology hospitals. Methods included expert panel discussions to estimate treatment costs of CC, Genital warts and Vulva Vagina Cancers by severity and direct interviews with respondents using costing and SF-36 quality of life questionnaires.

Results A total of 502 cervical cancer patients participated with a mean age at 53.3±11.2 years and a mean marriage length of 27.7±12.1 years, Malays accounting for 44.2%. Cost/quality adjusted life year (QALY) for Pap smear in the base case was RM 1,215 and RM 1,100 at increased screening coverage. With QV only, in base case it was RM 15,662 and RM 24,203 when the vaccination price was increased. With BV only, the respective figures were RM 1,359,057 and RM 2,530,018. For QV combined strategy cost/QALY in the base case it was RM 4,937, reducing to RM 3,395 in the best case and rising to RM 7,992 in the worst-case scenario. With the BV combined strategy, these three cost/QALYs were RM 6,624, RM 4,033 and RM 10,543. Incremental cost-effectiveness ratio (ICER) showed that screening at 70% coverage or higher was highly cost effective at RM 946.74 per QALYs saved but this was preceded by best case combined strategy

with QV at RM 515.29 per QALYs saved.

Conclusions QV is more cost effective than BV. The QV combined strategy was more CE than any method including Pap smear screening at high population coverage.

12. *Cost-effectiveness analysis of universal childhood hepatitis A vaccination in Brazil: Regional analyses according to the endemic context*

Ana Marli C. Sartori, Patrícia Coelho de Soárez, Hillegonda Maria Dutilh Novaes, Marcos Amaku, Raymundo Soares de Azevedo, Regina Célia Moreira, Leila Maria Moreira Beltrão Pereira, Ricardo Arraes de Alencar Ximenes, Celina Maria Turchi Martelli

Keywords

Abstract

Objective To conduct a cost-effectiveness analysis of a universal childhood hepatitis A vaccination program in Brazil.

Methods An age and time-dependent dynamic model was developed to estimate the incidence of hepatitis A for 24 years. The analysis was run separately according to the pattern of regional endemicity, one for South + Southeast (low endemicity) and one for the North + Northeast + Midwest (intermediate endemicity). The decision analysis model compared universal childhood vaccination with the current program of vaccinating high risk individuals. Epidemiologic and cost estimates were based on data from a nationwide seroprevalence survey of viral hepatitis, primary data collection, National Health Information Systems and literature. The analysis was conducted from both the health system and societal perspectives. Costs are expressed in 2008 Brazilian currency (Real).

Results A universal immunization program would have a significant impact on disease epidemiology in all regions, resulting in 64% reduction in the number of cases of icteric hepatitis, 59% reduction in deaths for the disease and a 62% decrease of life years lost, in a national perspective. With a vaccine price of R$16.89 (US$7.23) per dose, vaccination against hepatitis A was a cost-saving strategy in the low and intermediate endemicity regions and in Brazil as a whole from both health system and society perspective. Results were most sensitive to the frequency of icteric hepatitis, ambulatory care and vaccine costs.

Conclusions Universal childhood vaccination program against hepatitis A could be a cost-saving strategy in all regions of Brazil. These results are useful for the Brazilian government for vaccine related decisions and for monitoring population impact if the vaccine is included in the National Immunization Program.

13. *Cost-effectiveness of human papillomavirus vaccination in low and middle income countries: a systematic review.*

Michaela Fesenfeld, Raymond Hutubessy, Mark Jit

Keywords

Abstract

The World Health Organization recommends establishing that human papillomavirus vaccination is cost-effective before vaccine introduction. We searched Pubmed, Embase and the Cochrane Library to 1 April 2012 for economic evaluations of human papillomavirus vaccination in low and middle income countries. We found 25 articles, but almost all low income countries and many middle income countries lacked country-specific studies. Methods, assumptions and consequently results varied widely, even for studies conducted for the same country. Despite the heterogeneity, most studies conclude that vaccination is likely to be cost-effective and possibly even cost saving, particularly in settings without organized cervical screening programmes. However, study uncertainty could be reduced by clarity about vaccine prices and

vaccine delivery costs. The review supports extending vaccination to low income settings where vaccine prices are competitive, donor funding is available, cervical cancer burden is high and screening options are limited.

14. *Cost-effectiveness of augmenting universal hepatitis B vaccination with immunoglobin treatment.*

Solomon Chih-Cheng Chen, MD, PhD, Mehlika Toy, DrPH, PhD, Jennifer M. Yeh, PhDd, Jung-Der Wang, MD, ScD, and Stephen Resch, MPH, PhD

Key Words

hepatitis B, carrier rate, vaccination, cost-effectiveness analysis, immunoglobulin

Abstract

Objective To compare the cost-effectiveness of hepatitis B virus (HBV) control strategies combining universal vaccination with hepatitis B immunoglobulin (HBIG) treatment for neonates of carrier mothers.

Methods Drawing on Taiwan's experience, we developed a decision-analytic model to estimate the clinical and economic outcomes for 4 strategies: (1) strategy V-universal vaccination; (2) strategy S-V plus screening for hepatitis B surface antigen (HBsAg) and HBIG treatment for HBsAg-positive mothers' neonates; (3) strategy E-V plus screening for hepatitis B e-antigen (HBeAg), HBIG for HBeAg-positive mothers' neonates; (4) strategy S&E-V plus screening for HBsAg then HBeAg, HBIG for all HBeAg-positive, and some HBeAg-negative/HBsAg-positive mothers' neonates.

Results Strategy S averted the most infections, followed by S&E, E, and V. In most cases, the more effective strategies were also more costly. The willingness-to-pay (WTP) above which strategy S was cost-effective rose as carrier rate declined and was <$4000 per infection averted for carrier rates >5%. The WTP below which strategy V was optimal also increased as carrier rate declined, from $1400 at 30% carrier rate to $3100 at 5% carrier rate. Strategies involving E were optimal for an intermediate range of WTP that narrowed as carrier rate declined.

Conclusions HBIG treatment for neonates of HBsAg carrier mothers is likely to be a cost-effective addition to universal vaccination, particularly in settings with adequate health care infrastructure. Targeting HBIG to neonates of higher risk HBeAg-positive mothers may be preferred where WTP is moderate. However, in very resource-limited settings, universal vaccination alone is optimal.

15. *Model-based impact and cost-effectiveness of cervical cancer prevention in sub-Saharan Africa.*

Jane J. Kima, Nicole G. Camposa, b, Meredith O'Sheaa, Mireia Diazc, Innocent Mutyabad

Keywords

Cost-effectiveness; HPV; Mathematical model; Sub-Saharan Africa

Abstract

Using population and epidemiologic data for 48 countries in sub-Saharan Africa, we used a model-based approach to estimate cervical cancer cases and deaths averted, disability-adjusted life years (DALYs) averted and incremental cost-effectiveness ratios (I$ (international dollar) per DALY averted) for human papillomavirus (HPV) vaccination of pre-adolescent girls. Additional epidemiologic data from Uganda and South Africa informed estimates of cancer risk reduction and cost-effectiveness ratios associated with pre-adolescent female vaccination followed by screening of women over age 30. Assuming 70% vaccination coverage, over 670,000 cervical cancer cases would be prevented among women in five consecutive birth cohorts vaccinated as young adolescents; over 90% of cases averted were projected to occur in countries eligible for GAVI Alliance support. There were large variations in health benefits across countries attributable to differential cancer rates, population size, and population age structure. More than half of DALYs averted in sub-Saharan Africa were in Nigeria, Tanzania, Uganda, the Democratic Republic of the Congo, Ethiopia, and Mozambique. When the cost per vaccinated girl was I$5 ($0.55 per dose), HPV vaccination was cost-saving in 38 sub-Saharan African countries, and cost I$300 per DALY

averted or less in the remaining countries. At this vaccine price, pre-adolescent HPV vaccination followed by screening three times per lifetime in adulthood cost I\$300 per year of life saved (YLS) in Uganda (per capita GDP I\$1,140) and I\$1,000 per YLS in South Africa (per capita GDP I\$9,480). In nearly all countries assessed, HPV vaccination of pre-adolescent girls could be very cost-effective if the cost per vaccinated girl is less than I\$25-I\$50, reflecting a vaccine price being offered to the GAVI Alliance. In-country decision makers will need to consider many other factors, such as affordability, acceptability, feasibility, and competing health priorities, when making decisions about cervical cancer prevention. This article forms part of a regional report entitled "Comprehensive Control of HPV Infections and Related Diseases in the Sub-Saharan Africa Region" Vaccine Volume 31, Supplement 5, 2013. Updates of the progress in the field are presented in a separate monograph entitled "Comprehensive Control of HPV Infections and Related Diseases" Vaccine Volume 30, Supplement 5, 2012.

16. *Model-Based Impact and Cost-Effectiveness of Cervical Cancer Prevention in the Extended Middle East and North Africa (EMENA)*

Jane J. Kima, Monisha Sharmaa, Meredith O'Sheaa, Steven Sweeta, Mireia Diazb, Hélène Sancho-Garnierc, Muhieddine Seoudd

Keywords

HPV; Mathematical model; Cost-effectiveness; Extended Middle East; North Africa

Abstract

To date, no studies have evaluated the cost-effectiveness of human papillomavirus (HPV) vaccination in countries in the Extended Middle East and North Africa (EMENA) region. We synthesized population and epidemiologic data for 20 EMENA countries using a model-based approach to estimate averted cervical cancer cases and deaths, disability-adjusted life years (DALYs) and cost-effectiveness ratios (I\$ [international dollars] per DALY averted) associated with HPV vaccination of pre-adolescent girls. We utilized additional epidemiologic data from Algeria, Lebanon, and Turkey to evaluate select cervical cancer screening strategies either alone or in combination with vaccination. Results showed that pre-adolescent vaccination of five consecutive birth cohorts at 70% coverage has the potential to prevent over 180,000 cervical cancer cases. Cases averted varied by country, largely due to differences in cancer burden and population size; 69% of cases averted occurred in the three GAVI-eligible countries in EMENA. Despite the low cervical cancer incidence in EMENA, we found that HPV vaccination was cost-effective using a threshold of each country's gross domestic product per capita (a common metric for evaluating cost-effectiveness) in all but five countries at a cost per vaccinated girl of I\$25 (\$5 per dose). However, cost-effectiveness diminished with increasing vaccine cost; at a cost of I\$200 per vaccinated girl, HPV vaccination was cost-effective in only five countries. When the cost per vaccinated girl exceeded I\$50 in Lebanon and Turkey and I\$150 in Algeria, screening alone was most attractive. We identified opportunities to improve upon current national screening guidelines, involving less frequent screening every 3–5 years. While pre-adolescent HPV vaccination promises to be a cost-effective strategy in most EMENA countries at low costs, decision makers will need to consider many other factors, such as affordability, acceptability, feasibility, and competing health priorities, when making decisions about cervical cancer prevention.

This article forms part of a regional report entitled *"Comprehensive Control of HPV Infections and Related Diseases in the Extended Middle East and North Africa Region"* Vaccine Volume 31, Supplement 6, 2013. Updates of the progress in the field are presented in a separate monograph entitled *"Comprehensive Control of HPV Infections and Related Diseases"* Vaccine Volume 30, Supplement 5, 2012.

17. *Benefits, cost requirements and cost-effectiveness of the HPV16,18 vaccine for cervical cancer prevention in developing countries: policy implications*

Sue J Goldie, Meredith O'She, Mirei Diaz, Sun-Young Kim

Keywords

Cervical cancer; human papillomavirus vaccine; cost-effectiveness; priority setting; health policy and programmes

Abstract

Approximately 70% of cases of cervical cancer worldwide are caused by genotypes 16 and 18 of human papillomavirus (HPV), which is sexually transmitted. With the availability of an effective vaccine against these HPV types, there is real hope for reducing the global burden of cervical cancer in developing countries. Stakeholders faced with decisions about where to invest money to improve health must consider the burden of disease caused by cervical cancer relative to other priorities and the comparative benefits of different interventions. We conducted a series of analyses to obtain information for agencies drafting immunisation policy recommendations, financing coordination mechanisms, and country decision-makers on the benefits, cost requirements and cost-effectiveness of the HPV16,18 vaccine. We found that making an HPV16,18 vaccine accessible to 70% of young adolescent girls in 72 of the poorest countries, China, Thailand, and all of Latin America and the Caribbean, could prevent the future deaths of more than four million women vaccinated over the next decade. Provided the cost per vaccinated girl is less than $10–$25, adolescent HPV16,18 vaccination would be cost-effective even in relatively poor countries. Concerns about financial costs and affordability highlight the need for lowering vaccine prices, cost-efficient mechanisms for delivery of vaccinations to adolescents, and creative sources of financing.

18. *Human papillomavirus vaccine introduction in low-income and middle-income countries: guidance on the use of cost-effectiveness models.*

Mark Jit, Nadia Demarteau, Elamin Elbasha, Gary Ginsberg, Jane Kim, Naiyana Praditsitthikorn, Edina Sinanovic and Raymond Hutubessy

Abstract

Background The World Health Organization (WHO) recommends that the cost effectiveness of introducing human papillomavirus (HPV) vaccination is considered before such a strategy is implemented. However, developing countries often lack the technical capacity to perform and interpret results of economic appraisals of vaccines. To provide information about the feasibility of using such models in a developing country setting, we evaluated models of HPV vaccination in terms of their capacity, requirements, limitations and comparability.

Methods A literature review identified six HPV vaccination models suitable for low-income and middle-income country use and representative of the literature in terms of provenance and model structure. Each model was adapted by its developers using standardised data sets representative of two hypothetical developing countries (a low-income country with no screening and a middle-income country with limited screening). Model predictions before and after vaccination of adolescent girls were compared in terms of HPV prevalence and cervical cancer incidence, as was the incremental cost-effectiveness ratio of vaccination under different scenarios.

Results None of the models perfectly reproduced the standardised data set provided to the model developers. However, they agreed that large decreases in type 16/18 HPV prevalence and cervical cancer incidence are likely to occur following vaccination. Apart from the Thai model (in which vaccine and non-vaccine HPV types were combined), vaccine-type HPV prevalence dropped by 75% to 100%, and vaccine-type cervical cancer incidence dropped by 80% to 100% across the models (averaging over age groups). The most influential factors affecting cost effectiveness were the discount rate, duration of vaccine protection, vaccine price and HPV prevalence. Demographic change, access to treatment and data resolution were found to be key issues to consider for models in developing countries.

Conclusions The results indicated the usefulness of considering results from several models and sets of modelling assumptions in decision making. Modelling groups were prepared to share their models and expertise to work with stakeholders in developing countries.

19. *Comparative cost-effectiveness of the quadrivalent and bivalent human papillomavirus vaccines: A transmission-dynamic modeling study*

Marc Brisson, Jean-François Laprise, Mélanie Drolet, Nicolas Van de Velde, Eduardo L. Franco, Erich V. Kliewer, Gina Ogilvie, Shelley L. Deeks, Marie-Claude Boily

Keywords

Abstract

Background The quadrivalent and bivalent human papillomavirus (HPV) vaccines are now licensed in several countries. We compared the cost-effectiveness of the HPV vaccines to provide evidence for policy decisions.

Methods We developed HPV-ADVISE, a multi-type individual-based transmission-dynamic model of HPV infection and disease (anogenital warts, and cervical, anogenital and oropharyngeal cancers). We calibrated the model to sexual behavior and epidemiologic data from Canada, and estimated quality-adjusted life-years (QALYs) lost and costs ($CAN 2010) from the literature. Vaccine-type efficacy was based on a systematic literature review. The analysis was performed from the healthcare provider perspective, and costs and benefits were discounted at 3%. Predictions are presented using the median [10th; 90th percentiles] of simulations.

Results Under base-case assumptions (vaccinating 10-year-old girls, 80% coverage, $95/dose), using the quadrivalent and bivalent vaccines is estimated to cost $15,528 [12,056;19,140] and $20,182 [15,531;25,240] per QALY-gained, respectively. At equal price, the quadrivalent vaccine is more cost-effective than bivalent under all scenarios investigated, except when assuming longer duration of protection for the bivalent and minimal anogenital warts burden. Under base-case assumptions, the maximum additional cost per dose for the quadrivalent vaccine to remain more cost-effective than the bivalent is $32 [17;46] (using a $40,000/QALY-gained threshold). Results were most sensitive to discounting, time-horizon, differences in durations of protection and anogenital warts burden.

Conclusions Vaccinating pre-adolescent girls against HPV is predicted to be highly cost-effective. If equally priced, the quadrivalent is the most economically desirable vaccine. However, ultimately, the most cost-effective HPV vaccine will be determined by their relative price.

20. *Exploring the cost-effectiveness of HPV vaccination in Vietnam: Insights for evidence-based cervical cancer prevention policy*

Jane J. Kim, Katie E. Kobus, Mireia Diaz, Meredith O'Shea, Hoang Van Minhd, Sue J. Goldie

Keywords

Abstract

Using mathematical models of cervical cancer for the northern and southern regions of Vietnam, we assessed the cost-effectiveness of cervical cancer prevention strategies and the tradeoffs between a national and region-based policy in Vietnam. With 70% vaccination and screening coverage, lifetime risk of cancer was reduced by 20.4–76.1% with vaccination of pre-adolescent girls and/or screening of older women. Only when the cost per vaccinated girl was low (i.e., <I$25) was vaccination combined with screening (three times per lifetime or every 5 years) favored in both regions; at high costs per vaccinated girl (i.e., >I$100), screening alone was most cost-effective. When optimal policies differed between regions, implementing a national strategy resulted in health and economic inefficiencies. HPV vaccination appears to be an attractive cervical cancer prevention strategy for Vietnam, provided high coverage can be achieved in young pre-adolescent girls, cost per vaccinated girl is <I$25 (i.e., <$5 per dose), and screening is offered at older ages.

21. ***Systematic review of incremental non-vaccine cost estimates used in cost-effectiveness analysis on the introduction of rotavirus and pneumococcal vaccines.***

Fernando De la Hoz-Restrepo, Carlos Castañeda- Orjuela, Angel Paternina, Nelson Alvis-Guzman,

Keywords

Abstract

Objective To review the approaches used in the cost-effectiveness analysis (CEAs) literature to estimate the cost of expanded program on immunization (EPI) activities, other than vaccine purchase, for rotavirus and pneumococcal vaccines.

Methods A systematic review in PubMed and NHS EED databases of rotavirus and pneumococcal vaccines CEAs was done. Selected articles were read and information on how EPI costs were calculated was extracted. EPI costing approaches were classified according to the method or assumption used for estimation.

Results Seventy-nine studies that evaluated cost effectiveness of rotavirus ($n = 43$) or pneumococcal ($n = 36$) vaccines were identified. In general, there are few details on how EPI costs other than vaccine procurement were estimated. While 30 studies used some measurement of that cost, only one study on pneumococcal vaccine used a primary cost evaluation (bottom-up costing analysis) and one study used a costing tool. Twenty-seven studies (17 on rotavirus and 10 on pneumococcal vaccine) assumed the non-vaccine costs. Five studies made no reference to additional costs. Fourteen studies (9 rotavirus and 5 pneumococcal) did not consider any additional EPI cost beyond vaccine procurement. For rotavirus studies, the median for non-vaccine cost per dose was US$0.74 in developing countries and US$6.39 in developed countries. For pneumococcal vaccines, the median for non-vaccine cost per dose was US$1.27 in developing countries and US$8.71 in developed countries.

Conclusions Many pneumococcal (52.8%) and rotavirus (60.4%) cost-effectiveness analyses did not consider additional EPI costs or used poorly supported assumptions. Ignoring EPI costs in addition to those for vaccine procurement in CEA analysis of new vaccines may lead to significant errors in the estimations of ICERs since several factors like personnel, cold chain, or social mobilization can be substantially affected by the introduction of new vaccines.

22. ***Cost-effectiveness of HPV vaccination compared with Pap smear screening on a national scale: A literature review***

Win Techakehakij, Roger D. Feldman,

Keywords

Abstract

Recommendations for worldwide use of human papillomavirus (HPV) vaccine are increasing. This study conducted a systematic review of articles related to cost-effectiveness analysis of wide-range HPV vaccination programs compared with Pap smear screening published before August 2007. Eight articles were identified using predefined inclusion and exclusion criteria. After excluding two outliers, the range of incremental cost-effectiveness ratios (ICERs) from six articles is between $16,600 and $27,231 per quality-adjusted life year (QALY) gained. The World Health Organization's guideline that compares incremental cost-effectiveness ratios (ICERs) with per capita Gross Domestic Product (GDP) was used to determine whether nation-wide application of HPV vaccine would be cost-effective. The HPV vaccination program is cost-effective in only 46 countries where per capita GDP is high. Further cost-effectiveness studies in developing and third-world countries are needed for making policy decisions.

23. *Screening, prevention and treatment of cervical cancer—A global and regional generalized cost-effectiveness analysis*

Gary Michael Ginsberg, Tessa Tan-Torres Edejer, Jeremy A. Lauer, Cecilia Sepulveda

Keywords

Abstract

The paper calculates regional generalized cost-effectiveness estimates of screening, prevention, treatment and combined interventions for cervical cancer.

Using standardised WHO-CHOICE methodology, a cervical cancer model was employed to provide estimates of screening, vaccination and treatment effectiveness. Intervention effectiveness was determined via a population state-transition model (PopMod) that simulates the evolution of a sub-regional population accounting for births, deaths and disease epidemiology. Economic costs of procedures and treatment were estimated, including programme overhead and training costs.

In regions characterized by high income, low mortality and high existing treatment coverage, the addition of any screening programme to the current high treatment levels is very cost-effective. However, based on projections of the future price per dose (representing the economic costs of the vaccination excluding monopolistic rents and vaccine development cost) vaccination is the most cost-effective intervention.

In regions characterized by low income, low mortality and existing treatment coverage around 50%, expanding treatment with or without combining it with screening appears to be cost-effective or very cost-effective. Abandoning treatment in favour of screening in a no-treatment scenario would not be cost-effective. Vaccination is usually the most cost-effective intervention. Penta or tri-annual PAP smears appear to be cost-effective, though when combined with HPV-DNA testing they are not cost-effective.

In regions characterized by low income, high mortality and low treatment levels, expanding treatment with or without adding screening would be very cost-effective. A one off vaccination plus expanding treatment was usually very cost-effective. One-off PAP or VIA screening at age 40 are more cost-effective than other interventions though less effective overall.

From a cost-effectiveness perspective, consideration should be given to implementing vaccination (depending on cost per dose and longevity of efficacy) and screening programmes on a worldwide basis to reduce the burden of disease from cervical cancer. Treatment should also be increased where coverage is low.

24. *Benefits, cost requirements and cost-effectiveness of the HPV16,18 vaccine for cervical cancer prevention in developing countries: policy implications*

Sue J Goldie , Meredith O'Sea, Mireia Diaz, Sun-Young Kim

Keywords

Abstract

Approximately 70% of cases of cervical cancer worldwide are caused by genotypes 16 and 18 of human papillomavirus (HPV), which is sexually transmitted. With the availability of an effective vaccine against these HPV types, there is real hope for reducing the global burden of cervical cancer in developing countries. Stakeholders faced with decisions about where to invest money to improve health must consider the burden of disease caused by cervical cancer relative to other priorities and the comparative benefits of different interventions. We conducted a series of analyses to obtain information for agencies drafting immunisation policy recommendations, financing coordination mechanisms, and country decision-makers on the benefits, cost requirements and cost-effectiveness of the HPV16,18 vaccine. We found that making an HPV16,18 vaccine accessible to 70% of young adolescent girls in 72 of the poorest countries, China, Thailand, and all of Latin America and the Caribbean, could prevent the future deaths of more than four

million women vaccinated over the next decade. Provided the cost per vaccinated girl is less than $10–$25, adolescent HPV16,18 vaccination would be cost-effective even in relatively poor countries. Concerns about financial costs and affordability highlight the need for lowering vaccine prices, cost-efficient mechanisms for delivery of vaccinations to adolescents, and creative sources of financing.

25. *Cost-effectiveness analysis of a cervical cancer vaccine in five Latin American countries*

Lisandro Colantonio, Jorge A. Gómez, Nadia Demarteaud, Baudouin Standaert, Andrés Pichón-Rivière, Federico Augustovski

Keywords

Abstract

Implementation of cervical cancer (CC) vaccination in Latin America is expected to reduce the high CC burden in those countries. But the efficiency of such vaccination programs in the region still remains unknown. This study assesses the cost-effectiveness and cost-utility of introducing vaccination into the current CC disease management of five Latin American countries (Argentina, Brazil, Chile, Mexico, and Peru). The modelling results indicate that universal mass vaccination is cost-effective in the current health care setting of each country (<3× gross domestic product per capita, per country) with a substantial number of CC cases and deaths avoided in addition to an increase of quality-adjusted life years. This study will help guide the design of future clinical programmes and health-related policies. It will assist early and effective decision-making processes related to vaccine implementation in Latin America.

26. *Efficacy and effectiveness of seasonal and pandemic A (H1N1) 2009 influenza vaccines in low and middle income countries: A systematic review and meta-analysis*

Janna K. Breteler, John S. Tam, Mark Jit, Johannes C.F. Ket, Michiel R. De Boer

Keywords

Abstract

Purpose

Influenza vaccines have been recommended for populations at risk for severe infection in low and middle income countries (LMICs) although knowledge of the evidence-base for their effectiveness and efficacy is limited in these countries. The aim of this systematic review is to provide an overview of the evidence-base for the effectiveness and efficacy of influenza vaccines in LMICs and to explore critical knowledge gaps.

Methods

PubMed, EMBASE, and Cochrane were searched for seasonal and pandemic A (H1N1) 2009 influenza vaccine effectiveness and efficacy studies performed in LMICs. Eligible studies included RCTs and observational studies, published in English, French, Spanish or Portuguese between 1960 and 2011, which assessed laboratory-confirmed influenza and/or influenza-related outcomes in any population. Risk of bias was assessed by two reviewers independently. Random effects pooled estimates were obtained when sufficient data were available.

Results

A total of 6465 articles were screened. Forty-one studies were included on seasonal influenza vaccine effectiveness and efficacy and one study on pandemic vaccine effectiveness. In middle income countries (MICs), efficacy of seasonal influenza vaccines was shown against laboratory-confirmed influenza in children (pooled efficacy 72% (95%CI: 65–77) and 81% (95%CI: 69–89), for one and two years follow-up respectively) and in the elderly (pooled efficacy 43% (95%CI: 25–56) and 58% (95%CI: 23–78), for live attenuated and inactivated vaccine respectively). Inactivated influenza vaccines were also found to be effective against cardiovascular outcomes in patients with coronary syndromes.

Conclusions

Seasonal influenza vaccines can provide protection in children, the elderly and patients with coronary syndromes in MICs, and seem to be equally effective as compared to high income countries. Data for other high risk groups and from low income countries were limited or prone to bias, and are needed to further facilitate evidence-based decision making regarding influenza vaccination in LMICs.

27. *Influenza cost and cost-effectiveness studies globally--a review.*

Peasah SK1, Azziz-Baumgartner E, Breese J, Meltzer MI, Widdowson MA.

Keywords

Cost effectiveness analysis; Global; Influenza; Vaccination

Abstract

Every year, approximately 10-20% of the world's population is infected with influenza viruses, resulting in a significant number of outpatient and hospital visits and substantial economic burden both on health care systems and society. With recently updated WHO recommendations on influenza vaccination and broadening vaccine production, policy makers in middle- and low-income countries will need data on the cost of influenza disease and the cost effectiveness of vaccination. We reviewed the published literature to summarize estimates of cost and cost-effectiveness of influenza vaccination. We searched PUBMED (MEDLINE), EMBASE, WEB of KNOWLEDGE, and IGOOGLE using the key words 'influenza', 'economic cost', 'cost effectiveness', and 'economic burden'. We identified 140 studies which estimated either cost associated with seasonal influenza or cost-effectiveness/cost-benefit of influenza vaccination. 118 of these studies were conducted in World Bank-defined high income, 22 in upper-middle income, and no studies in low and lower-middle income countries. The per capita cost of a case of influenza illness ranged from $30 to $64. 22 studies reported that influenza vaccination was cost-saving; reported cost-effectiveness ratios were $10,000/outcome in 13 studies, $10,000 to $50,000 in 13 studies, and ≥$50,000 in 3 studies. There were no studies from low income countries and few studies among pregnant women. Substantial differences in methodology limited the generalization of results. Decision makers in lower income countries lack economic data to support influenza vaccine policy decisions, especially of pregnant women. Standardized cost-effectiveness studies of influenza vaccination of WHO-recommended risk groups' methods are urgently needed.

28. *Cost-effectiveness of vaccination against herpes zoster and postherpetic neuralgia: a critical review.*

Kawai K, Preaud E, Baron-Papillon F, Largeron N, Acosta CJ.

Keywords

Cost-effectiveness; herpes zoster; postherpetic neuralgia; shingles; vaccination; vaccine

Abstract

Objective The objective of this study was to systematically review cost-effectiveness studies of vaccination against herpes zoster (HZ) and postherpetic neuralgia (PHN).

Methods We searched MEDLINE and EMBASE databases for eligible studies published prior to November 2013. We extracted information regarding model structure, model input parameters, and study results. We compared the results across studies by projecting the health and economic impacts of vaccinating one million adults over their lifetimes.

Results We identified 15 cost-effectiveness studies performed in North America and Europe. Results ranged from approximately US$10,000 to more than US$100,000 per quality-adjusted life years (QALY) gained. Most studies in Europe concluded that zoster vaccination is likely to be cost-effective. Differences in results among studies are largely due to differing assumptions regarding duration of vaccine protection and a loss in quality of life associated with HZ and to a larger extent, PHN. Moreover, vaccine efficacy against PHN,

age at vaccination, and vaccine cost strongly influenced the results in sensitivity analyses.

Conclusion Most studies included in this review shows that vaccination against HZ is likely to be cost-effective. Future research addressing key model parameters and cost-effectiveness studies in other parts of the world are needed.

29. ***Cost-effectiveness analysis of the bivalent and quadrivalent human papillomavirus vaccines from a societal perspective in Colombia.***

Aponte-González J, Fajardo-Bernal L, Diaz J, Eslava-Schmalbach J, Gamboa O, Hay JW.

Abstract

Objective To compare costs and effectiveness of three strategies used against cervical cancer (CC) and genital warts: (i) Screening for CC; (ii) Bivalent Human Papillomavirus (HPV) 16/18 vaccine added to screening; (iii) Quadrivalent HPV 6/11/16/18 vaccine added to screening.

Methods A Markov model was designed in order to simulate the natural history of the disease from 12 years of age (vaccination) until death. Transition probabilities were selected or adjusted to match the HPV infection profile in Colombia. A systematic review was undertaken in order to derive efficacy values for the two vaccines as well as for the operational characteristics of the cytology test. The societal perspective was used. Effectiveness was measured in number of averted Disability Adjusted Life Years (DALYS).

Results At commercial prices reported for 2010 the two vaccines were shown to be non-cost-effective alternatives when compared with the existing screening strategy. Sensitivity analyses showed that results are affected by the cost of vaccines and their efficacy values, making it difficult to determine with certainty which of the two vaccines has the best cost-effectiveness profile. To be 'cost-effective' vaccines should cost between 141 and 147 USD (Unite States Dollars) per vaccinated girl at the most. But at lower prices such as those recommended by WHO or the price of other vaccines in Colombia, HPV vaccination could be considered very cost-effective.

Conclusion HPV vaccination could be a convenient alternative for the prevention of CC in Colombia. However, the price of the vaccine should be lower for this vaccination strategy to be cost-effective. It is also important to take into consideration the willingness to pay, budgetary impact, and program implications, in order to determine the relevance of a vaccination program in this country, as well as which vaccine should be selected for use in the program.

30. ***The use of cost-effectiveness analysis for pediatric immunization in developing countries.***

Gauvreau CL1, Ungar WJ, Köhler JC, Zlotkin S.

Keywords

Abstract

Context Developing countries face critical choices for introducing needed, effective, but expensive new vaccines, especially given the accelerated need to decrease the mortality of children under age five and the increased immunization resources available from international donors. Cost-effectiveness analysis (CEA) is a tool that decision makers can use for efficiently allocating expanding resources. Its use in developing countries, however, lags behind that in industrialized countries.

Methods We explored how CEA could be made more relevant to immunization policymaking in developing countries by identifying the limitations for using CEA in developing countries and the impact of donor funding on the CEA estimation. We conducted a comprehensive literature search using formal search protocols and hand searching indexed and gray literature sources. We then systematically summarized the application of CEA in industrialized and developing countries through thematic analysis, focusing on pediatric immunization and methodological and contextual issues relevant to developing countries.

Findings Industrialized and developing countries use CEA differently. The use of the Disability-Adjusted

Life Year (DALY) outcome measure and an alternative generalized cost-effectiveness analysis approach is restricted to developing countries. In pediatric CEAs, the paucity of evaluations and the lack of attention to overcoming the methodological limitations pertinent to children's cognitive and development distinctiveness, such as discounting and preference characterization, means that pediatric interventions may be systematically understudied and undervalued. The ability to generate high-quality CEA evidence in child health is further threatened by an inadequate consideration of the impact of donor funding (such as GAVI immunization funding) on measurement uncertainty and the determination of opportunity cost.

Conclusions Greater attention to pediatric interventions and donor funding in the conduct of CEA could lead to better policies and thus more worthwhile and good-value programs to benefit children's health in developing countries.

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31. *Probabilistic cost-effectiveness analysis of the long-term effect of universal hepatitis B vaccination: an experience from Taiwan with high hepatitis B virus infection and Hepatitis B e Antigen positive prevalence.*

Hung HF, Chen TH.

Abstract

Aim To assess cost-effectiveness of hepatitis B virus (HBV) vaccination strategies from health care payer and societal perspectives, focusing on the long-term effect, in Taiwan where prevalence of HBV and Hepatitis B e Antigen (HBeAg) is high.

Methods A decision analysis was performed to compare total costs and effectiveness between two vaccination strategies: universal vaccination and no-vaccination. The Markov process was defined as a series of states including acute HBV infection, asymptomatic carrier, chronic hepatitis, compensated and decompensated liver cirrhosis, hepatoma, and death. Direct and indirect costs were also imputed based on estimates. The incremental cost-effectiveness ratio (ICER) per life-year gained and quality-adjusted life years gained were calculated at a 3% discount rate. By assigning a series of specific distributions to each parameter, a probabilistic cost-effective analysis using Monte Carlo simulation was conducted to yield 5000 ICER replicates.

Results The effectiveness of a universal vaccination program for reducing hepatocellular carcinoma cases and deaths was approximately 86%. The average life years gained per subject as a result of such a universal vaccination was 3.9. The vaccination program dominated over a no-vaccination program (less cost and more effectiveness).

Conclusions A universal vaccination program against hepatitis B infection is not only effective for reducing long-term sequelae but is also a cost-saving primary preventive strategy, which supports a universal infant immunization in endemic area with high prevalence of HBV and HBeAg.

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32. *Economic evaluation of hepatitis B vaccination in low-income countries: using cost-effectiveness affordability curves.*

Sun-Young Kim, Joshua A Salomon, Sue J Goldie

Abstract

Objective We sought to describe a method that explicitly considers both a health-care programme's cost-effectiveness and its affordability. For illustration, we apply the method to the programme to vaccinate infants against hepatitis B in the Gambia.

Methods We synthesized selected data and developed a computer-based model from the societal and payer perspectives to evaluate the cost-effectiveness of routine infant vaccination against hepatitis B in the Gambia compared with no vaccination. The primary outcome measure was cost per averted disability-adjusted life year (DALY), which was expressed in 2002 US dollars. We used Monte Carlo methods for uncertainty analysis to examine the affordability of the programme from the payer's perspective, and we derived an affordability curve and cost-effectiveness affordability curves for the programme.

Findings In the Gambia, vaccinating infants against hepatitis B is highly cost-effective. Compared with offering no intervention, the vaccination programme would cost US$ 28 per DALY averted from the societal perspective or US$ 47 per DALY averted from the payer's perspective. The programme also has the potential to be affordable, starting at a relatively low budget of US$ 160 000 per year. Combining the two dimensions of the outcome measure, the probability that vaccinating infants would be both cost-effective and affordable is 40% at an annual programme budget of US$ 182 000 (the estimated total programme cost from the payer's perspective), given a threshold cost-effectiveness value of US$ 47 per DALY averted.

Conclusion In the face of uncertainties about both the health and economic consequences of a vaccine programme, as well as the availability and magnitude of resources needed to fund the programme, cost-effectiveness affordability curves can provide information to decision-makers about the probability that a programme will be both cost-effective and affordable: these are distinct but equally relevant considerations in resource-poor settings.

Résumé

Objectif

Nous avons recherché une méthode permettant de prendre en compte explicitement à la fois le rapport coût/efficacité d'un programme et son accessibilité économique.

A titre illustratif, nous avons appliqué cette méthode au programme de vaccination des nourrissons contre l'hépatite B en Gambie.

Méthodes

Nous avons fait la synthèse de données sélectionnées et mis au point un modèle informatique pour évaluer le rapport coût/efficacité pour la société d'une part et pour ceux qui financent le programme d'autre part de la vaccination systématique des nourrissons contre l'hépatite B en Gambie par rapport à l'absence de vaccination.

La principale mesure des résultats programmatiques est le coût par année de vie corrigée de l'incapacité évitée (DALY), exprimé en US$ de 2002.

Dans le cadre de l'analyse d'incertitude, nous avons étudié l'accessibilité économique du programme pour ceux qui le financent par des méthodes de Monte Carlo, ce qui nous a permis d'établir une courbe d'accessibilité économique et des courbes rapport coût/efficacité en fonction de l'accessibilité économique pour ce programme.

Résultats

En Gambie, le rapport coût/efficacité de la vaccination des nourrissons contre l'hépatite B est très bon.

Par comparaison avec la situation en l'absence d'intervention, ce programme vaccinal devrait coûter US$28 par DALY évitée pour la société ou US$ 47 par DALY évitée pour ceux qui le financent.

Ce programme pourrait aussi être abordable économiquement en débutant avec un budget relativement faible de US$ 160 000 par an.

Si l'on combine ces deux dimensions de la mesure de résultats, la probabilité que cette vaccination des nourrissons soit à la fois d'un bon rapport coût/efficacité et abordable économiquement est de 40% pour un budget annuel du programme de US$ 182 000 (coût total estimé du programme pour ceux qui le financent), sachant que la valeur seuil du rapport coût/efficacité est de US$ 47 par DALY évitée.

Conclusion

Face aux incertitudes quant aux conséquences tant sanitaires qu'économiques d'un programme de vaccination et quant à la disponibilité et à l'ampleur des ressources nécessaires pour financer ce programme, les présentes courbes coût/efficacité fonction de l'accessibilité économique peuvent fournir aux décideurs des indications sur la probabilité qu'il soit à la fois d'un bon rapport coût/efficacité et abordable, ces deux aspects étant distincts, mais tout aussi pertinents l'un que l'autre dans les pays à faible revenu.

33. *Costs of illness due to cholera, costs of immunization and cost-effectiveness of an oral cholera mass vaccination campaign in Zanzibar.*

Schaetti C, Weiss MG, Ali SM, Chaignat CL, Khatib AM, Reyburn R, Duintjer Tebbens RJ, Hutubessy R.

Abstract

Background The World Health Organization (WHO) recommends oral cholera vaccines (OCVs) as a supplementary tool to conventional prevention of cholera. Dukoral, a killed whole-cell two-dose OCV, was used in a mass vaccination campaign in 2009 in Zanzibar. Public and private costs of illness (COI) due to endemic cholera and costs of the mass vaccination campaign were estimated to assess the cost-effectiveness of OCV for this particular campaign from both the health care provider and the societal perspective.

Methodology/Principal Findings Public and private COI were obtained from interviews with local experts, with patients from three outbreaks and from reports and record review. Cost data for the vaccination campaign were collected based on actual expenditure and planned budget data. A static cohort of 50,000 individuals was examined, including herd protection. Primary outcome measures were incremental cost-effectiveness ratios (ICER) per death, per case and per disability-adjusted life-year (DALY) averted. One-way sensitivity and threshold analyses were conducted. The ICER was evaluated with regard to WHO criteria for cost-effectiveness. Base-case ICERs were USD 750,000 per death averted, USD 6,000 per case averted and USD 30,000 per DALY averted, without differences between the health care provider and the societal perspective. Threshold analyses using Shanchol and assuming high incidence and case-fatality rate indicated that the purchase price per course would have to be as low as USD 1.2 to render the mass vaccination campaign cost-effective from a health care provider perspective (societal perspective: USD 1.3).

Conclusions/Significance Based on empirical and site-specific cost and effectiveness data from Zanzibar, the 2009 mass vaccination campaign was cost-ineffective mainly due to the relatively high OCV purchase price and a relatively low incidence. However, mass vaccination campaigns in Zanzibar to control endemic cholera may meet criteria for cost-effectiveness under certain circumstances, especially in high-incidence areas and at OCV prices below USD 1.3.

34. ***Distributional impact of rotavirus vaccination in 25 GAVI countries: estimating disparities in benefits and cost-effectiveness.***

Rheingans R, Atherly D, Anderson J.

Keywords

Rotavirus; Cost-effectiveness; Equity; Disparities; Vaccination

Abstract

Background Other studies have demonstrated that the impact and cost effectiveness of rotavirus vaccination differs among countries, with greater mortality reduction benefits and lower cost-effectiveness ratios in low-income and high-mortality countries. This analysis combines the results of a country level model of rotavirus vaccination published elsewhere with data from Demographic and Health Surveys on within-country patterns of vaccine coverage and diarrhea mortality risk factors to estimate within-country distributional effects of rotavirus vaccination. The study examined 25countries eligible for funding through the GAVI Alliance.

Methods For each country we estimate the benefits and cost-effectiveness of vaccination for each wealth quintile assuming current vaccination patterns and for a scenario where vaccine coverage is equalized to the highest quintile's coverage. In the case of India, variations in coverage and risk proxies by state were modeled to estimate geographic distributional effects.

Results In all countries, rates of vaccination were highest and risks of mortality were lowest in the top two wealth quintiles. However countries differ greatly in the relative inequities in these two underlying variables. Similarly, in all countries examined, the cost-effectiveness ratio for vaccination ($/Disability-Adjusted Life Year averted, DALY) is substantially greater in the higher quintiles (ranging from 2-10 times higher). In all countries, the greatest potential benefit of vaccination was in the poorest quintiles. However, due to reduced vaccination coverage, projected benefits for these quintiles were often lower. Equitable coverage

was estimated to result in an 89% increase in mortality reduction for the poorest quintile and a 38% increase overall.

Conclusions Rotavirus vaccination is most cost-effective in low-income groups and regions. However in many countries, simply adding new vaccines to existing systems targets investments to higher income children, due to disparities in vaccination coverage. Maximizing health benefits for the poorest children and value for money require increased attention to these distributional effects.

35. *How cost effective is universal varicella vaccination in developing countries? A case-study from Colombia.*

Paternina-Caicedo A, De la Hoz-Restrepo F, Gamboa-Garay O, Castañeda-Orjuela C, Velandia-González M, Alvis-Guzmán N.

Abstract

Objective Varicella vaccination has not been introduced worldwide, especially in developing countries. The present study assesses the potential epidemiological and economic impact of one-dose and two-dose varicella vaccination schemes in Colombia, a south American upper middle-income country.

Methods A decision-tree based model was developed. Varicella cases were estimated based on previous reports of seropositivity within the country. Cost per life-year gained (LYG) was the main outcome measure. Costs from the health care system perspective were expressed in 2008 American dollars. Deterministic and probabilistic sensitivity analyses were performed.

Results In Colombia, there would be 700,197 varicella cases in an average year plus 60 yearly deaths without vaccination. It was estimated that health care costs for all cases during 30 years period could be around US $88,734,735 (with discount). Cost per LYG of one-dose vaccination was US $2519 and using a two-dose scheme was US $5728.

Conclusion Vaccinating against varicella in Colombia, an upper middle-income South American country is cost-effective under the assumptions used in this study. Decision-makers should consider introducing universal varicella vaccination in Colombia, given the effectiveness, safety and cost-effectiveness of this intervention.

36. *Evaluation of cost-effective strategies for rabies post-exposure vaccination in low-income countries.*

Hampson K, Cleaveland S, Briggs D.

Abstract

Background Prompt post-exposure prophylaxis (PEP) is essential in preventing the fatal onset of disease in persons exposed to rabies. Unfortunately, life-saving rabies vaccines and biologicals are often neither accessible nor affordable, particularly to the poorest sectors of society who are most at risk and upon whom the largest burden of rabies falls. Increasing accessibility, reducing costs and preventing delays in delivery of PEP should therefore be prioritized.

Methodology/Principal Findings We analyzed different PEP vaccination regimens and evaluated their relative costs and benefits to bite victims and healthcare providers. We found PEP vaccination to be an extremely cost-effective intervention (from $200 to less than $60/death averted). Switching from intramuscular (IM) administration of PEP to equally efficacious intradermal (ID) regimens was shown to result in significant savings in the volume of vaccine required to treat the same number of patients, which could mitigate vaccine shortages, and would dramatically reduce the costs of implementing PEP. We present financing mechanisms that would make PEP more affordable and accessible, could help subsidize the cost for those most in need, and could even support new and existing rabies control and prevention programs.

Conclusions/Significance We conclude that a universal switch to ID delivery would improve the affordability and accessibility of PEP for bite victims, leading to a likely reduction in human rabies deaths, as well as

being economical for healthcare providers.

37. *Using cost-effectiveness analysis to support research and development portfolio prioritization for product innovations in measles vaccination.*

Garrison LP Jr, Bauch CT, Bresnahan BW, Hazlet TK, Kadiyala S, Veenstra DL.

Abstract

Background Several potential measles vaccine innovations are in development to address the shortcomings of the current vaccine. Funders need to prioritize their scarce research and development resources. This article demonstrates the usefulness of cost-effectiveness analysis to support these decisions.

Methods This study had 4 major components: (1) identifying potential innovations, (2) developing transmission models to assess mortality and morbidity impacts, (3) estimating the unit cost impacts, and (4) assessing aggregate cost-effectiveness in United Nations Children's Fund countries through 2049.

Results Four promising technologies were evaluated: aerosol delivery, needle-free injection, inhalable dry powder, and early administration DNA vaccine. They are projected to have a small absolute impact in terms of reducing the number of measles cases in most scenarios because of already improving vaccine coverage. Three are projected to reduce unit cost per dose by $0.024 to $0.170 and would improve overall cost-effectiveness. Each will require additional investments to reach the market. Over the next 40 years, the aggregate cost savings could be substantial, ranging from $98.4 million to $689.4 million.

Conclusions Cost-effectiveness analysis can help to inform research and development portfolio prioritization decisions. Three new measles vaccination technologies under development hold promise to be cost-saving from a global perspective over the long-term, even after considering additional investment costs.

38. *Cost-benefit comparisons of investments in improved water supply and cholera vaccination programs.*

Jeuland M, Whittington D.

Keywords

Abstract

This paper presents the first cost-benefit comparison of improved water supply investments and cholera vaccination programs. Specifically, we compare two water supply interventions -- deep wells with public hand pumps and biosand filters (an in-house, point-of-use water treatment technology) -- with two types of cholera immunization programs with new-generation vaccines -- general community-based and targeted and school-based programs. In addition to these four stand-alone investments, we also analyze five combinations of water and vaccine interventions: (1) borehole+hand pump and community-based cholera vaccination, (2) borehole+hand pump and school-based cholera vaccination, (3) biosand filter and community-based cholera vaccination, (4) biosand filter and school-based cholera vaccination, and (5) biosand filter and borehole+hand pump. Using recent data applicable to developing country locations for parameters such as disease incidence, the effectiveness of vaccine and water supply interventions against diarrheal diseases, and the value of a statistical life, we construct cost-benefit models for evaluating these interventions. We then employ probabilistic sensitivity analysis to estimate a frequency distribution of benefit-cost ratios for all four interventions, given a wide variety of possible parameter combinations. Our results demonstrate that there are many plausible conditions in developing countries under which these interventions will be attractive, but that the two improved water supply interventions and the targeted cholera vaccination program are much more likely to yield attractive cost-benefit outcomes than a community-based vaccination program. We show that implementing community-based cholera vaccination programs after

borehole+hand pump or biosand filters have already been installed will rarely be justified. This is especially true when the biosand filters are already in place, because these achieve substantial cholera risk reductions on their own. On the other hand, implementing school-based cholera vaccination programs after the installation of boreholes with hand pump is more likely to be economically attractive. Also, if policymakers were to first invest in cholera vaccinations, then subsequently investing in water interventions is still likely to yield positive economic outcomes. This is because point-of-use water treatment delivers health benefits other than reduced cholera, and deep boreholes+hand pumps often yield non-health benefits such as time savings. However, cholera vaccination programs are much cheaper than the water supply interventions on a household basis. Donors and governments with limited budgets may thus determine that cholera vaccination programs are more equitable than water supply interventions because more people can receive benefits with a given budget. Practical considerations may also favor cholera vaccination programs in the densely crowded slums of South Asian and African cities where there may be insufficient space in housing units for some point-of-use technologies, and where non-networked water supply options are limited.

39. *Economic costs of rotavirus gastroenteritis and cost-effectiveness of vaccination in developing countries.*

Rheingans RD, Antil L, Dreibelbis R, Podewils LJ, Bresee JS, Parashar UD.

Abstract

Background Rotavirus is the leading cause of severe gastroenteritis in children worldwide. We evaluated the economic burden of rotavirus and the cost-effectiveness of vaccination from the health care perspective.

Methods Estimates were based on existing epidemiological data, cost estimates, vaccine coverage, and efficacy data, as well as hypothetical vaccine prices. Outcome measures included health care and societal costs of rotavirus and benefits and incremental cost-effectiveness ratio of vaccination. Sensitivity analyses evaluated the impact of estimate uncertainty.

Results Treatment costs increased with income level, and health burden decreased; however, burden varied across regions. On the basis of current vaccination coverage and timing, rotavirus vaccination would annually prevent 228,000 deaths, 13.7 million hospital visits, and 8.7 million disability-adjusted life-years, saving $188 million in treatment costs and $243 million in societal costs. At $5 per dose, the incremental cost-effectiveness ratio in low-, lower-middle-, and upper-middle-income countries was $88, $291, and $329 per disability-adjusted life-year averted, respectively, and $3,015, $9,951 and $11,296 per life saved, respectively. Vaccination would prevent approximately 45% of deaths and approximately 58% of associated medical visits and costs.

Conclusions Vaccination is a cost-effective strategy to reduce the health and economic burden of rotavirus. The cost-effectiveness of vaccination depends mostly on vaccine price and reaching children at highest risk of mortality.

40. *Rotavirus vaccination: cost-effectiveness and impact on child mortality in developing countries.*

Atherly D, Dreibelbis R, Parashar UD, Levin C, Wecker J, Rheingans RD.

Abstract

Background Rotavirus is the leading cause of severe gastroenteritis in children <5 years of age and is responsible for >500,000 deaths annually; approximately 85% of this burden is in low-income countries eligible for financial support from the GAVI Alliance. We projected the uptake, health impact, and cost-effectiveness of introducing rotavirus vaccination in GAVI-eligible countries to help policy makers in prioritizing resources to gain the greatest health improvements for their constituencies.

Methods A demand forecast model was used to predict adoption of rotavirus vaccine in the poorest countries in the world. We then modeled health outcomes and direct costs of a hypothetical birth cohort in the target population for scenarios with and without a rotavirus vaccine with use of data on health outcomes of rotavirus infection, vaccine effectiveness, and immunization rates.

Results Vaccination would prevent 2.4 million rotavirus deaths and >82 million disability-adjusted life-years (DALYs) in 64 of the 72 GAVI-eligible countries introducing vaccine from 2007 through 2025. The cost per DALY averted decreases over time, from a high of US$450 per DALY averted in the first year to a sustained low of $30 per DALY during 2017-2025, with a cumulative figure of $43 per DALY averted during 2008-2025. By applying the baseline scenario with an initial vaccine price of $7 per dose for a 2-dose vaccine, with a gradual decrease beginning in 2012 and stabilizing at $1.25 per dose by 2017, vaccination was very cost-effective in all GAVI-eligible countries with use of each country's gross domestic product per DALY averted as a threshold.

Conclusions Introduction of rotavirus vaccines into the world's poorest countries is very cost-effective and is projected to substantially reduce childhood mortality.

41. *Cost-effectiveness of new-generation oral cholera vaccines: a multisite analysis.*

Jeuland M1, Cook J, Poulos C, Clemens J, Whittington D; DOMI Cholera Economics Study Group.

Maskery B, Lauria D, Stewart J, Lucas M, Islam Z, Malik R, Najib M, Chatterjee S.

Abstract

Objectives We evaluated the cost-effectiveness of a low-cost cholera vaccine licensed and used in Vietnam, using recently collected data from four developing countries where cholera is endemic. Our analysis incorporated new findings on vaccine herd protective effects.

Methods Using data from Matlab, Bangladesh, Kolkata, India, North Jakarta, Indonesia, and Beira, Mozambique, we calculated the net public cost per disability-adjusted life year avoided for three immunization strategies: 1) school-based vaccination of children 5 to 14 years of age; 2) school-based vaccination of school children plus use of the schools to vaccinate children aged 1 to 4 years; and 3) community-based vaccination of persons aged 1 year and older.

Results We determined cost-effectiveness when vaccine herd protection was or was not considered, and compared this with commonly accepted cutoffs of gross domestic product (GDP) per person to classify interventions as cost-effective or very-cost effective. Without including herd protective effects, deployment of this vaccine would be cost-effective only in school-based programs in Kolkata and Beira. In contrast, after considering vaccine herd protection, all three programs were judged very cost-effective in Kolkata and Beira. Because these cost-effectiveness calculations include herd protection, the results are dependent on assumed vaccination coverage rates.

Conclusions Ignoring the indirect effects of cholera vaccination has led to underestimation of the cost-effectiveness of vaccination programs with oral cholera vaccines. Once these effects are included, use of the oral killed whole cell vaccine in programs to control endemic cholera meets the per capita GDP criterion in several developing country settings.

42. *Cost-benefit of WC/rBS oral cholera vaccine for vaccination against ETEC-caused travelers' diarrhea.*

Lundkvist J, Steffen R, Jönsson B.

Abstract

Background The most common infectious health problem encountered by travelers to countries in the developing region is travelers' diarrhea (TD), with enterotoxigenic Escherichia coli (ETEC) being the most common pathogen isolated. Although mild in most cases, the disease still leads to the loss of a significant part of a vacation or business trip. There is currently a lack of knowledge about the costs in relation to the benefits of vaccination against TD caused by ETEC, and the purposes of this study were to estimate and develop a cost-benefit analysis of vaccination using whole-cell/recombinant-B-subunit oral cholera vaccine.

Methods The consequences of the vaccination were identified and quantified in monetary terms. The cost-benefits for leisure and business travelers were assessed separately. The value of the travel was separated

into the cost of the trip and of lost leisure time/business opportunities. A person with TD was in base case estimated to lose on average 3.5 days of a 7-day leisure trip and 2.5 days of a 4-day business trip. Results are presented for a Canadian traveler to endemic areas in year 2007 in US$.

Results The average cost of a TD event was estimated at $1,460 and $1,996 for leisure and business travelers, respectively. The net value of the vaccination, however, varied with the risk of the disease. Through extensive literature searches, an updated ETEC map illustrating the proportion of ETEC-caused TD was created.

Conclusions The analysis indicated that vaccination would be considered cost-effective at incidence rates of ETEC-caused TD above about 13 and 9% for leisure and business travelers, respectively. It is, however, important to keep in mind that it is the value of the travel for the individual traveler that will decide if the vaccination provides good value for money.

43. *Cost-effectiveness of HPV vaccination compared with Pap smear screening on a national scale: a literature review.*

Keywords

Abstract

Recommendations for worldwide use of human papillomavirus (HPV) vaccine are increasing. This study conducted a systematic review of articles related to cost-effectiveness analysis of wide-range HPV vaccination programs compared with Pap smear screening published before August 2007. Eight articles were identified using predefined inclusion and exclusion criteria. After excluding two outliers, the range of incremental cost-effectiveness ratios (ICERs) from six articles is between $16,600 and $27,231 per quality-adjusted life year (QALY) gained. The World Health Organization's guideline that compares incremental cost-effectiveness ratios (ICERs) with per capita Gross Domestic Product (GDP) was used to determine whether nation-wide application of HPV vaccine would be cost-effective. The HPV vaccination program is cost-effective in only 46 countries where per capita GDP is high. Further cost-effectiveness studies in developing and third-world countries are needed for making policy decisions.

44. *Cost-effectiveness of introducing a rotavirus vaccine in developing countries: the case of Mexico.*

Valencia-Mendoza A, Bertozzi SM, Gutierrez JP, Itzler R.

Abstract

Background In developing countries rotavirus is the leading cause of severe diarrhoea and diarrhoeal deaths in children under 5. Vaccination could greatly alleviate that burden, but in Mexico as in most low- and middle-income countries the decision to add rotavirus vaccine to the national immunisation program will depend heavily on its cost-effectiveness and affordability. The objective of this study was to assess the cost-effectiveness of including the pentavalent rotavirus vaccine in Mexico's national immunisation program.

Methods A cost-effectiveness model was developed from the perspective of the health system, modelling the vaccination of a hypothetical birth cohort of 2 million children monitored from birth through 60 months of age. It compares the cost and disease burden of rotavirus in an unvaccinated cohort of children with one vaccinated as recommended at 2, 4, and 6 months.

Results Including the pentavalent vaccine in the national immunisation program could prevent 71,464 medical visits (59%), 5,040 hospital admissions (66%), and 612 deaths from rotavirus gastroenteritis (70%). At US$10 per dose and a cost of administration of US$13.70 per 3-dose regimen, vaccination would cost US$122,058 per death prevented, US$4,383 per discounted life-year saved, at a total net cost of US$74.7 million dollars to the health care system. Key variables influencing the results were, in order of importance, case fatality, vaccine price, vaccine efficacy, serotype prevalence, and annual loss of

efficacy. The results are also very sensitive to the discount rate assumed when calculated per life-year saved.

Conclusion At prices below US $15 per dose, the cost per life-year saved is estimated to be lower than one GNP per capita and hence highly cost effective by the WHO Commission on Macroeconomics and Health criteria. The cost-effectiveness estimates are highly dependent upon the mortality in the absence of the vaccine, which suggests that the vaccine is likely to be significantly more cost-effective among poorer populations and among those with less access to prompt medical care - such that poverty reduction programs would be expected to reduce the future cost-effectiveness of the vaccine.

45. ***The costs of scaling up vaccination in the world's poorest countries.***

Health Aff (Millwood). 2006 Mar-Apr;25(2):348-56.

Bishai D, McQuestion M, Chaudhry R, Wigton A.

Abstract

We examine the relationship between country-level average costs and coverage levels for diptheria-pertussis-tetanus (DTP) vaccines. Coverage data are from the World Health Organization, and cost data are from financial sustainability plans filed with the Global Alliance for Vaccines and Immunization (GAVI) by forty countries from 2000 to 2003. In this data set, average costs are lower for countries that vaccinate more children. At the highest numbers of covered children, there was no trend toward higher average costs. Vaccine programs in this set of poor countries have not yet scaled up to the point at which diminishing marginal returns are observed.

46. ***Cost effectiveness and delivery study for future HIV vaccines.***

AIDS. 2005 Sep 2;19(13):w1-6.

Barth-Jones DC, Cheng H, Kang LY, Kenya PR, Odera D, Mosqueira NR, Mendoza W, Portela MC, Brito C, Tangcharoensathien V, Akaleephan C, Supantamart S, Patcharanarumol W, de Macedo Brigido LF, Fonseca MG, Sanchez M, Chang ML, Osmanov S, Avrett S, Esparza J, Griffiths U; WHO-UNAIDS collaborative group on cost-effectiveness, delivery and future access to HIV vaccines

Abstract

Research teams from five countries, Brazil, China, Kenya, Peru and Thailand, have initiated a policy-maker survey on vaccine delivery, cost studies for future HIV vaccination programmes, and associated simulation modeling exercises analysing the relative cost-effectiveness of potential HIV vaccination strategies. The survey assesses challenges and opportunities for future country-level HIV vaccination strategies, providing data on the vaccine characteristics (e.g. vaccine efficacies for susceptibility, infectiousness and disease progression) and vaccination programme strategies to be considered in the cost-effectiveness modeling analyses. The study will provide decision-makers with modeling data on vaccination policy considerations that will assist in developing country-level capacities for future HIV vaccine policy adoption and effective delivery systems, and will help delineate the long-term financial requirements for sustainable HIV vaccination programmes. The WHO-UNAIDS HIV Vaccine Initiative and the collaborating researchers welcome comments or questions from policy makers, health professionals and other stakeholders in the public and private sectors about this effort to help advance policy and capacity related to future potential HIV vaccines.