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03. Assessment of the Broader Economic Consequences of HPV Prevention from a Government-Perspective, A Fiscal Analytic Approach

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Title

Assessment of the broader economic consequences of HPV prevention from a government-perspective: A fiscal analytic approach

Abstract

Background: HPV infection poses a substantial burden in terms of morbidity, mortality, and economic losses, especially in low/middle-income countries. HPV vaccination and/or cervical cancer screening among females may reduce the burden of HPV-related diseases. However, limited funds may impede the implementation of population-based programmess. Governmental investments in the prevention of infectious disease may have broader economic and fiscal benefits, which are not accounted for in conventional economic analyses. This study estimates the broader economic and fiscal impacts of implementation of HPV vaccination and/or cervical cancer screening in Indonesia from the perspective of the government.

Methods: A government-perspective quantitative analytic framework was applied to assess the Net Present Value (NPV) of investment on cervical cancer prevention strategies including HPV vaccination, cervical screening and its combination in Indonesia.

Results: Based on a cohort of 10,888,500 Indonesian 12-year-old females, it was estimated that HPV vaccination and/or cervical cancer screening result in a positive NPV for the Indonesian government. The combination of cervical screening and HPV vaccination generated a substantial reduction of cervical cancer incidence and HPV-related mortality of 95,668 and 21,079, respectively. It was estimated that HPV vaccination in combination with cervical screening is the most favorable option for cervical cancer prevention (NPV I$2.212.310.000), followed by HPV vaccination alone (NPV I$2.026.113.000) and cervical screening alone (NPV I$408.584.000).

Conclusion: In addition to clinical benefits, investing in HPV vaccination and cervical screening may yield considerable fiscal benefits for the Indonesian governments due to lifelong benefits resulting from reduction of HPV-related morbidity and mortality. (worldwidescience.org)

Keywords

HPV, HPV vaccination, cervical cancer, cervical cancer screening, (www.cancerindex.org) broader economic analysis

Introduction

High-risk human papillomaviruses (HPV), in particular HPV16 and HPV18, are responsible for cervical cancer and premalignant cervical disease among woman (1–5). Although cervical cancer is considered as a preventable disease when detected and managed in the early stages, (www.cancerindex.org) it is still posing a serious health and economic burden, especially in developing countries (6–8). The WHO recommends primary prevention through vaccination against HPV and secondary prevention through cervical screening for pre-cancerous lesions (9). Numerous studies have shown that cervical screening is beneficial in terms of lowering of the incidence of pre-

cancerous lesions and cervical cancer (8,10,11). Moreover, the two approved prophylactic vaccines against HPV have also demonstrated considerable benefits in terms of reduction of HPV infection and Cervical Intraepithelial Neoplasia (CIN) (9,12–15).

Several health-economic analyses have shown that HPV vaccination combined with cervical cancer screening results in an efficient use of healthcare resources (16–19). Such analyses typically assess the cost-effectiveness of adding HPV vaccination to screening. Hence, most economic analyses focus on evaluating the technical efficiency of the healthcare budget (20). Implementation of vaccination and cervical cancer screening programmes is dependent on affordability and local infrastructure especially in low/middle-income countries, which have limited infrastructure, human resources and funds. In low/middle-income countries, implementation of population-based HPV vaccination and screening programmes may require funds additional to the healthcare budget. Hence, economic analyses should be capable of providing decision-makers with measures for the broader economic impact and cross-sectorial consequences of resource allocation decisions.

In Indonesia, HPV infection and cervical cancer pose a substantial morbidity and mortality burden. In 2012, there were over 20,000 new cases of cervical cancer and 9,000 cervical-cancer related deaths (7). The implementation of a population-based HPV vaccination and screening programme require a substantial investment but it potentially reduce the burden of cervical cancer. An additional benefits including more women who are able to work, more women gain income, and on the government perspective, there will be more worker who pay the taxes and health/social security premium. Notably, health-economic and broader economic benefits including fiscal benefits for the Indonesian government could be achieved. In this study, we assess the broader economic consequences of introduction of HPV vaccination in Indonesia with emphasis on the potential positive and negative fiscal effects of the latest policy of the Indonesian National Social Security System (*SJSN*) for HPV prevention.

Methods & Data

The natural history of HPV infection for Indonesian women was modelled, based on a previously published population-based Markov model (21). The fiscal analysis described here simulates the natural history and costs of cervical cancer patients in Indonesia. Susceptible, cervical cancer and death states were modelled and a simulation was run for a cohort of 10,888,500 Indonesian 12-year-old girls over their lifetime (22,23). Cervical cancer prevention strategies, that were assessed, included (i) cervical screening, (ii) HPV vaccination and (iii) HPV vaccination plus cervical cancer screening. (worldwidescience.org) The reduction of HPV-related morbidity and mortality resulting from each of the assessed strategies was quantified and translated into changes in gross tax revenue and government transfer costs over the lifetime of the cohort. Specifically, based on previously published methods for assessment of the broader economic consequences of (worldwidescience.org) health-care interventions (24–26), morbidity and mortality reductions were translated into discounted, lifetime fiscal benefits for the Indonesian government. Hence, prevention of HPV-related mortality and morbidity benefits were converted into discounted lifetime (i) additional gross, direct and indirect tax revenues, (ii) health-care cost savings and (iii) social insurance cost-savings. Fiscal expenses, i.e. the cost of vaccination and the additional governmental transfers (i.e. pensions) resulting from the additional survival produced by HPV prevention in Indonesia, were discounted and

deducted from the fiscal benefits of HPV prevention to produce the Net Present Value (NPV) of each HPV prevention strategy.

In order to estimate the lifetime earnings of and, thus, the lifetime tax revenues to be gained from the average Indonesian female, earnings distribution was categorized into three levels (20% high-income earners, 40% middle-income earners, and 40% low-income earners) and the average of each earnings level, based on the Indonesian Gross Domestic Product (GDP) using Gini index of 0.41 (27,28), was estimated. Furthermore, annual earnings were adjusted for future productivity based on the labor productivity index from The Organization for Economic Cooperation and Development (OECD) (29). Earnings were also adjusted to reflect the proportion of female workforce participation (22,30). Moreover, the average age of entering the workforce and the average retirement age of Indonesian civil servants were considered in the model (31,32). Direct tax was estimated based on the Indonesian earnings tax law (33,34) and applied for each level of income. (studysoup.com) Thus, the model assumed that tax revenue stems from middle- and high-income earnings only, since the average earnings of the low-income (scholarship.law.cornell.edu) population lies below the taxable earnings threshold. Indirect tax was estimated based on the Value Added Tax (VAT) policy (35,36) and household consumption expenditure per capita (37). Furthermore, we assumed that (studysoup.com) VAT adherence and collectability rate was 50% (38) (Table 1).

Table 1.

Governmental transfers to citizens were estimated based on the national social and health security system. The benefits provided by the social security system are pension fund-, and work-related accident- and death-benefits (41,42). Old-age pensions were estimated based as 60% of the earnings in the (scholarship.law.cornell.edu) last employment year (45). Direct costs related to pre-cancerous lesions, cervical cancer and investment costs for prevention programs were included in the model based on the study by Setiawan, *et al.* (21). Costs were inflated to current prices using an inflation rate of 6.42% which reflects the average inflation in 2014 (40). Direct costs attributed to genital warts have not been included in this analysis as they are likely to have limited fiscal consequences in the context of treatment in Indonesia.

In order to obtain the present value of cash inflows and outflows from this analysis, the results were presented in terms of the Net Present Value (NPV) of the investment decision for each of the (studysoup.com) cervical cancer prevention strategies under study as follows:

$$NPV = \sum_{t=0}^{T} \left(\frac{R_t - E_t}{(1+r)^t} \right) - K_0$$

NPVs were calculated by subtracting incremental expenses (E_t), including vaccine cost at t=0 (K_0) from incremental revenues (R_t) for each of strategy. Increments refer to the difference between (studysoup.com) the revenue and expenses with and without the HPV prevention strategy under consideration. All values were discounted (r) by 3% according to WHO recommendation and also consistent with previous cost-effectiveness studies on cervical cancer prevention programmes in Indonesia.

In order to examine the sensitivity of the model to its parameters, univariate sensitivity analyses were conducted for the NPV of each HPV prevention strategy. The ranges around input parameters

including inflation rate, discount rate, Gross domestic products (GDP), tax compliance, membership of health and social security, percentage of earnings consumed and percentage of work-related accident premium. Inflation and discount rates were varied by the lowest and highest value of Indonesian inflation rate in 2014 (40) and acceptable discount rates from various countries (46), respectively. The lower and upper limits for GDP were defined by the lowest ad highest GDP value of the previous 5 years (47), while the ranges for the proportion of earnings consumed were based on previous 3 years' data (48). Tax compliance, health and social security membership were varied based on assumptions since the distributions for this parameters were not available.

Results

Based on a (scholarship.law.cornell.edu) single cohort of 10,888,500 girls in Indonesia, our model showed that in the absence of any cervical cancer prevention strategy, 160,749 cases of cervical cancer will ultimately occur within the cohort. The implementation of cervical cancer prevention strategies, including screening alone, HPV vaccination alone, or cervical screening in combination with HPV vaccination were projected to prevent 17,030, 87,924 or 95,668 cases of cervical cancer, respectively. Furthermore, the combination of cervical screening and HPV vaccination generated the highest reduction of deaths caused by cervical cancer (21,079), followed by HPV vaccination alone (worldwidescience.org) (19,099) and screening alone (4,360) (Table 2).

Table 2.

The lifetime NPV for the study cohort of Indonesian 12-year-old females (worldwidescience.org) is illustrated in Table 3 (scholarship.law.cornell.edu) for the three HPV prevention strategies. All three strategies resulted in a positive NPV. HPV vaccination in combination with cervical screening generates the highest NPV for the government (I$2,212,310,000), followed by HPV vaccination only (I$2,026,113,000) and cervical screening alone (worldwidescience.org) (I$408,584). Indirect tax produces the highest revenue for the government compared to direct tax, social- or health-security contributions. With respect to HPV-related governments' expenses, the highest saving is generated by treatment cost savings. HPV vaccination in combination with cervical cancer screening (worldwidescience.org) results in the highest healthcare cost-savings. Similarly, the combined prevention strategy resulted in the highest savings in terms of social security (scholarship.law.cornell.edu) costs. All prevention strategies resulted in increased governments' expenses in terms of health security and pension costs.

Table 3.

Figure 1 illustrates the results of the univariate sensitivity analyses evaluating the influence of several input parameters on the NPV. The analysis shows that inflation and discount rate are the most influential parameters in this study. Further analysis (hrmars.com) illustrates that NPV is also sensitive to GDP and tax compliance. Health and social security membership, percentage of earnings consumed, and percentage of work-related accident premium are considered as non-influential parameters to the NPV.

Discussion

Implementation of population-based healthcare intervention unambiguously results in fiscal costs that influence national accounts. However, similar to other public investments, investment in healthcare interventions may also result in measurable, long-term fiscal benefits attributed to changes in population health that may outweigh or considerably offset the costs (49). In this study we evaluated how different levels of investment in HPV prevention influence the Indonesian governments' fiscal accounts. The study showed that investing in HPV vaccination in combination with cervical screening yields long-term fiscal benefits for the Indonesian (worldwidescience.org) government. These results are supplementary to a previously published study on the cost-effectiveness of cervical cancer prevention strategies in Indonesia. Both studies suggest that cervical cancer prevention strategies (worldwidescience.org) are not only beneficial for the health of Indonesian women, they also improve the efficiency of healthcare resource use and have a long-term fiscal benefit for the government by increasing the quality and quantity of the human capital and thus by increasing the tax base in the country compared to not investing in HPV prevention.

The main clinical benefit of cervical cancer prevention programmes is the reduction of morbidity and mortality (16,50–52). In traditional health-economic analyses the comparative clinical benefits and associated costs would be reflected in the incremental cost effectiveness ratio (ICER) in terms of cost per quality-adjusted survival as a result of vaccination. The latter ratio responds to the question of which is the most (www.biceps.org) efficient use of healthcare resources for a given healthcare budget. A cost-effectiveness analysis may also quantify productivity losses from premature mortality and/or absenteeism or presentism and thus reflect the benefits from a societal perspective.

The underlying assumption of taking a broader economic analytic perspective with emphasis on fiscal effects is that changes in health status or the prevention of infectious diseases have several external effects. The benefits of HPV prevention imply that more women who would be able to work thus, gain more earnings and pay more taxes and security premiums for the government. As a result of this, it is expected that the prevention of HPV infection and HPV-related diseases will yield increased governmental fiscal revenues from (direct and indirect) taxes and also (health and social) security insurance premium. Moreover, there are significant cost-savings resulting from reduced need for cervical cancer treatment which is captured in conventional cost-effectiveness analyses and also demonstrated by application of a "government-perspective" framework to assess different HPV investment strategies. A key limitation of this type of study is that it is largely dependent on the mathematical modelling of long-term clinical, economic and fiscal parameters. Some of the key parameters dynamically change over time in the real life. Sensitivity analyses may address some of the uncertainty around these parameters. However, further observational data may be needed to assess the real-life fiscal effect of HPV prevention programmes. In addition, the current analysis does not take into account the (www.biceps.org) effects of herd immunity as well as the benefits that HPV vaccination may have in terms of (i) protection of males and (ii) prevention of genital warts.

By conducting a broader economic analysis, evidence is produced to inform analyses regarding the cross-sectorial allocation of resources and perhaps the transfer of funds from other sectors of the public economy to universal population-based vaccination and screening programmes. The evidence generated in this study may address the affordability of implementing an HPV prevention program in Indonesia. Our study results suggest that investments in HPV prevention programmes may generate

epidemiological benefits that translate into health-economic and fiscal benefits for the Indonesian government that may fully offset the investment costs and thus may have a positive impact on national accounts in the long-run.

Disclosures

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