Vaccine 32 (2014) 2645–2656

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Cost-effectiveness and equity impacts of three HPV vaccination programmes for school-aged girls in New Zealand

Tony Blakely[a,*], Giorgi Kvizhinadze[a], Tanja Karvonen[b,**], Amber L. Pearson[a], Megan Smith[c], Nick Wilson[a]

[a] Department of Public Health, University of Otago, Wellington, New Zealand
[b] MSc Programme in Health Economics, University of York, United Kingdom
[c] Prince of Wales Clinical School, University of New South Wales, Sydney, Australia

ARTICLE INFO

Article history:
Received 2 July 2013
Received in revised form 14 October 2013
Accepted 25 February 2014
Available online 22 March 2014

Keywords:
HPV vaccination
Cost-effectiveness
Cervical cancer
Anogenital warts
Markov model
Cost-utility analysis
Equity
Māori health

ABSTRACT

Background: As with many high-income countries, vaccination coverage against human papilloma virus (HPV) infection is not high in New Zealand (NZ) at 47% in school-aged girls for three doses. We estimate the health gains, net-cost and cost-effectiveness of the currently implemented HPV national vaccination programme of vaccination dispersed across schools and primary care, and two alternatives: school-based only (assumed coverage as per Australia: 73%), and mandatory school-based vaccination but with opt-out permitted (coverage 93%). We also generate estimates by social group (sex, ethnic and deprivation group).
Methods: A Markov macro-simulation model was developed for 12-year-old girls and boys in 2011, with future health states of: cervical cancer, pre-cancer (CIN I–III), genital warts, and three other HPV-related cancers (oropharyngeal, anal, vulvar cancer). In each state health sector costs, including additional health sector costs from extra life, and quality-adjusted life years (QALYs) were accumulated.
Results: The current HPV vaccination programme has an estimated cost-effectiveness of NZ$18,800/QALY gained (about US$9700/QALY gained using the OECD's purchasing power parities; 95% UI: US$6900 to $33,700) compared to the status quo in NZ prior to 2008 (no vaccination, screening alone). The incremental cost-effectiveness ratio (ICER) of an intensive school-based only programme of girls, compared to the current situation, was US$33,000/QALY gained. Mandatory vaccination appeared least cost-effective (ICER compared to school-based of US$117,000/QALY gained, but with wide 95% uncertainty limits from $56,000 to $220,000). All interventions generated more QALYs per 12-year-old for Māori (indigenous population) and people living in deprived areas (range 5–25% greater QALYs gained).
Interpretation: A more intensive school-only vaccination programme seems warranted. Reductions in vaccine price will greatly improve cost-effectiveness of all options, possibly making a law for mandatory vaccination optimal from a health sector perspective. All interventions could reduce ethnic and socioeconomic disparities in HPV-related disease.

1. Introduction

There is widespread acceptance that human papilloma virus (HPV) vaccination of adolescent girls, regardless of setting, is cost-effective [1,2]. Existing economic evaluations of HPV vaccination have addressed issues such as bivalent versus quadrivalent vaccines [2], inclusion of multiple future diseases (e.g., cancers other than cervical cancer, anogenital warts and cervical intraepithelial neoplasia states) [2,3], cross-protection [4], the marginal impact of vaccinating boys [2], and interacting effects with cervical screening programmes [5–7]. This paper presents disease modelling and economic evaluation of a quadrivalent vaccine using a multiple disease model for New Zealand, with a particular focus on two issues not yet well addressed internationally: (i) variation in health gains, costs and cost-effectiveness by socioeconomic and ethnic groups, and hence quantifying the impact of HPV vaccination on health inequalities; and (ii) examination of the incremental cost-effectiveness of interventions to increase vaccine coverage of girls, including a law for mandatory immunization (with opt-out permitted).

* Corresponding author. Tel.: +64 21 918608.
** Corresponding author.
E-mail address: tony.blakely@otago.ac.nz (T. Blakely).

http://dx.doi.org/10.1016/j.vaccine.2014.02.071
0264-410X/

Disease sequelae of HPV infection contribute to health inequalities. Between countries, there are higher rates of cervical cancer in low income countries. Projected increased HPV vaccination globally from 2011 to 2020 has been estimated to be capable of averting half a million future deaths, or 15.1 deaths per 1000 girls vaccinated [8], which will inevitably contribute to reducing between country cervical cancer inequalities. Within countries, cervical cancer rates [9–12] and other HPV-associated cancer rates are higher among lower socioeconomic, and minority and indigenous populations [13,14]. Accordingly, HPV vaccination should – so long as vaccine coverage is not lower among socially disadvantaged populations – lead to future reductions in health inequalities. Some modelling of the impact on HPV prevalence in social groups when either or both the vaccine coverage and the number of lifetime sexual partners vary has been undertaken [15]. But to our knowledge there has not previously been modelling which includes actual data on social group differences in baseline epidemiological parameters (e.g., cancer rates) taken through to quantified health gains (mortality and morbidity) and cost-effectiveness by social group.

In New Zealand there are also social inequalities in HPV-related disease [12], but at least the HPV vaccination uptake to date appears to be somewhat higher among Māori (indigenous) and Pacific peoples (compared to other New Zealanders), and so might be modestly contributing in closing health gaps [16]. But it is ideal to explore the potential for health inequalities reduction further by considering a wider range of vaccination scenarios and also the cost-effectiveness of vaccination by social group.

Many countries have struggled to obtain high HPV vaccination coverage. Herd immunity will reduce the marginal impact for further increases in vaccination coverage – especially for HPV 6/11 caused disease (i.e., largely anogenital warts) which appears to have more marked herd immunity than HPV 16/18 caused disease (primarily cancers) [17]. Most economic evaluations have assumed that the incremental cost of increasing vaccination coverage is simply that due to increased use of vaccine and delivery costs. However, increasing vaccination coverage may require a restructuring of current programmes or more intensive effort at the margin, both carrying costs; although prior modelling studies have suggested that this can be a cost-effective investment [18]. In New Zealand, a national girls' HPV vaccination programme began in 2008 with a catch-up phase (older adolescent girls), followed since by routine vaccination of 12-year-old girls either in school or through primary care providers. Achieved coverage is 47% for the third dose (Unpublished data for 2011 from the National Immunization Register), although higher coverage of 56% has been achieved for Māori (indigenous population) and Pacific peoples [16]. Possible reasons for low coverage are that the programme is not exclusively school-based (as in Australia, where coverage is 73%) [19], and that HPV immunization is free for females up to their 20th birthday, suggesting that 'choice' in provider and timing can also result in failure to be vaccinated.

The purpose of this study was to assess the health impact (quality-adjusted life years gained [QALY]), cost (health system perspective) and cost-effectiveness for three interventions: (1) the 2008 'as implemented' HPV vaccination programme of girls only in New Zealand; (2) modification to 'as implemented' to be a school-only programme as per Australia; (3) added inclusion of a new mandatory law requiring active opting-out of vaccination (as per some US states). All three interventions are compared to a baseline of no vaccination programme (i.e., business as usual pre-2008), as well as to each other. Due to existing social inequalities in HPV-related cancers and HPV infection rates and the rich availability of data in New Zealand by social group, different impacts (or heterogeneity) by ethnicity and socioeconomic deprivation was also a specific focus. Included in the evaluations are the spill-over effects for males and unvaccinated females (i.e., herd immunity leading to less HPV infection among these groups) and multiple disease and health state outcomes (e.g., anal cancers, cervical cancer, cervical neoplasia and anogenital warts). Scenario or sensitivity analyses about a range of variables are included, most importantly vaccine price, lesser herd immunity benefits in the first vaccinated cohort and the discount rate.

2. Methods

2.1. Perspective and general approach

Study methods followed the Burden of Disease Epidemiology, Equity and Cost-Effectiveness Programme (BODE^3) Protocol [20]. Briefly, a health system perspective was used, and so the various costs and consequences beyond the health system were out of scope (e.g., productivity costs). The eligible vaccination population was 12-year-old girls in 2011. This cohort, and the equivalent cohort of boys, was modelled through to death or age 110 years. HPV vaccination was modelled as contributing to the prevention of cervical cancer, a range of other cancers (oropharyngeal, anal, vulvar; vaginal and penile were not included as they contribute only 2–3% of HPV16/18-related cancer burden), cervical intraepithelial neoplasia (CIN I and CIN II/III) and anogenital warts. As much of the recurrent respiratory papillomatosis (RRP) burden is through vertical transmission to children, and the data on its incidence, severity, morbidity, mortality and health services utilization in New Zealand is sparse, we could not include it in the model. A 3% discount rate was applied to costs and QALYs gained, and unrelated health system costs were included (i.e., average expected costs to health system by sex and age).

2.2. Core model structure

The core model was a Markov macro-simulation model, with annual cycles (Fig. 1). The population of 12-year-olds in 2011 commenced in a disease-free 'healthy state' and were followed for 98 cycles, until the residual cohort members reached age 110. The model structure was such that individuals could only have one disease condition at one time. Neither did we allow for different cancer rates based on previous CIN status. Disadvantages of our approach include that we may slightly misestimate costs and utilities (but given most states are rare these will be inconsequential compared with other uncertainties such as health-related quality of life for CIN states), and also that we could not extend our model to evaluate additional interventions (e.g., modifications to cervical screening programmes). The advantages include simplicity, parsimony to answer our research questions regarding HPV vaccination and ethnic and socioeconomic heterogeneity, and adherence to the available data (e.g., detailed data by socio-demographics of incidence and survival).

For equity analyses, we stratified the New Zealand 12-year-old population by sex, ethnicity (Māori, non-Māori) and area-based socioeconomic deprivation tertile, giving 12 discrete cohort populations.

2.3. Quality-adjusted life years

The QALY metric captures both years of life lost from premature death, and loss of quality of life through morbidity. QALYs use many different health status valuation methods (e.g., EuroQol (EQ5D) and Health Utilities Index questionnaire); we used disability weights (DW) on a scale from 0 (full health) to 1.0 (death) applied to the non-fatal health state in question (Supplementary Table 1). Expected population morbidity due to other diseases and injury was allowed for by using the average ethnic and age-specific prevalent years of