Chapter 15

School-Based Delivery of Vaccines to 5- to 19-Year Olds

D. Scott LaMontagne, Tania Cernuschi, Ahmadu Yakubu, Paul Bloem, Deborah Watson-Jones, and Jane J. Kim

INTRODUCTION

Significant progress has been achieved in the social, economic, educational, and health status of many populations. Compared with previous generations, the educational status of those born after 1990 has improved, as reflected in higher rates of school enrollment, especially in low- and middle-income countries (LMICs) (UNESCO 2014). Countries have started to expand their immunization programs beyond infants to young children, adolescents, and adults, with the goal of preventing, controlling, and where possible, eliminating vaccine-preventable diseases (WHO 2013a).

The combination of increased school attendance and expanded target populations for vaccines has created a rich opportunity for exploring vaccine delivery in schools (annex 15A, figure 15A.1). Meningitis, measles, hepatitis B, tetanus toxoid (TT), and human papillomavirus (HPV) are examples of vaccines offered in schools, either as routine primary or booster vaccinations or through campaigns for catch-up strategies or disease control (Grabowsky and others 2005; Mackroth and others 2010; WHO 2012a). These vaccines have demonstrated efficacy in preventing significant morbidity and mortality among school-age children, adolescents, and adults (Mehlhorn, Balcer, and Sucher 2006; WHO 2009). Understanding country experiences with the operational and logistical factors that have enabled successful delivery of vaccines through school-based programs—and the challenges encountered—can provide salient lessons for other countries, irrespective of income status. This chapter highlights the promise of school-based delivery of vaccines in LMICs, using the experience of TT and HPV vaccine delivery as examples. Definitions of age groupings and age-specific terminology used in this volume can be found in chapter 1 (Bundy and others 2017).

TETANUS AND HPV EPIDEMIOLOGY AND PREVENTION

Tetanus

Tetanus is caused by the bacterium *Clostridium tetani*, the spores of which are widespread in the environment (Black, Huber, and Curlin 1980). The bacterium is introduced into umbilical stump tissue during unclean delivery or unclean cord care practices, or occasionally at the site of traditional surgery and deep penetrating wounds. The disease is caused by the action of a neurotoxin produced by the bacteria when they grow in the absence of oxygen. Tetanus is characterized by muscle spasms, initially in the jaw. As the disease progresses, mild stimuli may trigger generalized tetanic seizure-like activity, which contributes to serious complications and eventually to death unless supportive treatment is given (Black, Huber, and Curlin 1980).

Vaccines containing TT are the primary prevention strategy against infection and have been in use

Corresponding author: D. Scott LaMontagne, PATH, Seattle, WA, United States; slamontagne@path.org.

for decades. Both the efficacy and the effectiveness of the TT vaccine are well documented (Newell and others 1971). TT vaccines, particularly the widespread expansion of maternal tetanus immunization services, have been largely responsible for the marked reduction in neonatal tetanus deaths, from 787,000 deaths in 1988 to 49,000 by 2013 (Liu and others 2015; Vandelaer and others 2003).

According to the World Health Organization (WHO), effective and full immunization against the tetanus infection requires five doses between infancy and adolescence (WHO 2006). An additional dose during the first pregnancy will protect a woman and her fetus throughout this and future pregnancies, provided that she has received all previous recommended doses (Rahman and others 1982). Countries have been using TT vaccines, including school-based vaccination, as a main strategy to eliminate maternal and neonatal tetanus and to maintain elimination status. The success of such strategies has been demonstrated in Tanzania (WHO 2013c).

Cervical Cancer

Cervical cancer is caused by several types of HPV (zur Hausen 1977). Two types, 16 and 18, account for approximately 70 percent of all cases (Denny and others 2015; Ferlay and others 2010). This virus is sexually transmitted, and most people are exposed within the first few years of engaging in sexual relations (Moscicki 2007). If the infection persists long term, women can develop precancerous lesions; if left untreated, these lesions can develop into cervical cancer (zur Hausen 1977). The progression from infection to disease takes, on average, 20 years. Globally, there are more than 528,000 new cases of cervical cancer and more than 266,000 deaths each year among women; more than 85 percent of the disease burden occurs in LMICs (Ferlay and others 2010).

Cervical cancer can be prevented through either primary prevention (vaccination) or secondary prevention (screening and treatment) (Denny and others 2015). Vaccines against HPV are effective when administered to individuals not yet exposed to HPV vaccine types, which for most people is before sexual debut (Denny and others 2015). Screening through cervical smears (Papanicolaou or Pap smears), visual inspection with acetic acid, or HPV DNA (deoxyribonucleic acid)-based testing is effective in detecting precancerous lesions that can be treated. Accordingly, HPV vaccination is recommended for girls ages 9–13 years (WHO 2014b), and screening is recommended for adult women generally beginning at age 25 or 30 years to age 49 years (Denny and others 2015).

Prevention

Both TT and HPV vaccinations have been demonstrated to be cost-effective in schools (Goldie and others 2008; Griffiths and others 2004). Targeting children at the beginning and end of primary school for booster doses of TT vaccines and targeting young adolescents before completing primary school for HPV vaccines have been two successful delivery strategies (LaMontagne and others 2011; Steinglass 1998). Young adolescents ages 9–11 years produce higher levels of antibodies to HPV vaccines, which are maintained at higher levels over time, compared with older adolescents (Block and others 2006). Additionally, delivering HPV vaccines at this young age generally ensures that girls receive the vaccine before sexual exposure to HPV (Moscicki 2007; WHO 2014b).

Since adolescents do not regularly attend health facilities, schools may offer advantages for reaching this population (Mackroth and others 2010). Increasingly high levels of primary school enrollment and attendance throughout LMICs have created an opportunity to identify and efficiently reach a large proportion of the population eligible for school-based vaccination (Grabowsky and others 2005; UNESCO 2014). Schools can also be used to leverage additional services or interventions (Broutet and others 2013) that might be needed by the age groups receiving TT or HPV vaccine, such as antihelmintics for deworming, vision screening, and bednet distribution (Broutet and others 2013).

PROGRAM DESIGN FOR SCHOOL-BASED VACCINE DELIVERY OF TT AND HPV VACCINES

TT Vaccine Delivery Strategies

The childhood tetanus immunization schedule recommended by the WHO includes five doses:

- Primary series of three doses of DTP (diphtheria/tetanus/pertussis) or other tetanus-containing vaccine, such as DTwP (diphtheria/tetanus/whole pertussis) or DTaP/TDaP (diphtheria/tetanus/acellular pertussis) given before age one year
- Booster dose of a TT vaccine at ages four to seven years
- Second booster dose between ages 12 and 15 years (WHO 2006).

Resources available through existing school health services are used to give the TT booster doses in adolescence while ensuring that out-of-school children are also served through routine activities of national immunization programs (WHO 2008b).

Many low- and lower-middle-income countries implement some school-based vaccination (annex 15A, table 15A.1), targeting the school grades where the largest proportion of children are found. Several countries have conducted household and school-based surveys to tabulate age-by-grade distributions to determine which grade is most appropriate for capturing the largest proportion of children—ages 4–7 years or ages 12–15 years. Indonesia found that most children ages 6–9 years are enrolled in grades one to three (Kim-Farley and others 1987). Nepal and Tunisia determined that entry in primary school was the optimal time to provide TT vaccination (Vandelaer, Partridge, and Suvedi 2009; WHO 2008c).

An email survey was sent to all 192 WHO member countries in 2008 (WHO-UNICEF 2009). Of the 143 countries responding, 61 countries (43 percent) reported conducting some school-based immunization. Among these 61 countries, the TT-containing vaccine was one of the interventions given; 41 countries (67 percent) start from primary school grade 1, and 54 percent target ages 9–13 years. Data from the 2012 WHO-UNICEF Expanded Programme on Immunization Joint Reporting Form indicate that, among 86 low- and lower-middle-income countries, 21 countries (24 percent) administer TT-containing vaccines; 10 of these countries deliver the vaccine in grade 1, and 16 deliver TT vaccines through grade 6 (on average, capturing children ages 12–15 years) (WHO-UNICEF 2013). The relatively low levels of school vaccination in these countries, combined with increasing school enrollment, particularly among girls, suggests an untapped opportunity to increase vaccination coverage through school-based programs.

Information, education, and communication components are essential in ensuring the success of school-based TT vaccination in LMICs. Parents and community leaders need to know why the children are being vaccinated; have resources for further information, as well as know when the vaccination activities will take place; and understand what to do if their children miss the vaccine. To prevent rumors that TT vaccination is connected to fertility control and to address the immunity gap that results in lack of a second opportunity for TT vaccination in adolescent boys and adult men, both boys and girls are often vaccinated. Information on the protection conferred by the vaccine against tetanus caused by injuries during sports, planting, and other activities helps achieve community acceptance (Steinglass 1998). The active engagement, collaboration, and training of the ministries of health and education on the requirements of the school-based TT vaccination are crucial (WHO 2008c).

HPV Vaccine Delivery Strategies

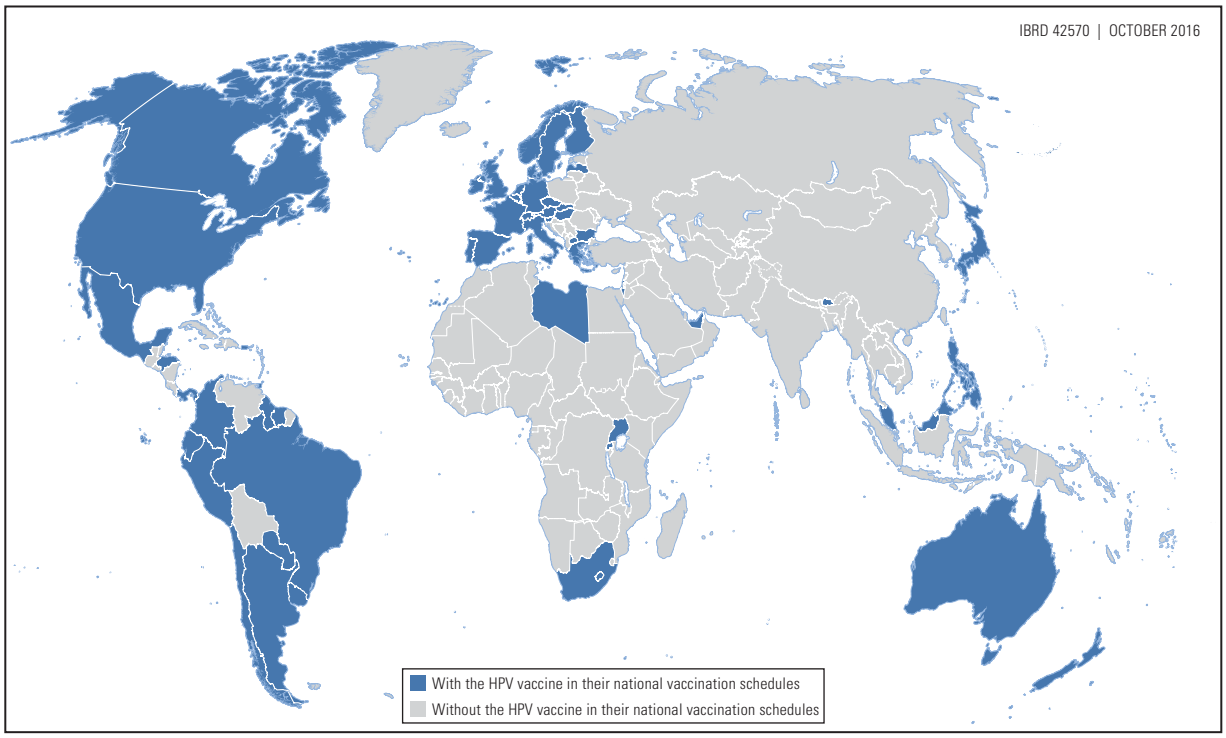
The WHO recommends that the HPV vaccine be given to girls between ages 9 and 13 years, including immunocompromised individuals (WHO 2014b). As of early 2016, three HPV vaccines are available—a quadrivalent vaccine (Gardasil, Merck & Co.), a bivalent vaccine (Cervarix, GlaxoSmithKline), and a nonavalent vaccine (Gardasil9, Merck & Co.). Licensure recommendations vary by country; in general, Gardasil and Gardasil9 are registered for use in females ages 9–26 years in 130 and 39 countries, respectively. In some countries, these two HPV vaccines are also registered for use in males of the same age for the prevention of genital warts. Cervarix is generally registered for use in females ages 9–44 years in more than 120 countries; it is not registered for males because no clinical trial of the efficacy of this vaccine in males has been conducted.

Although all HPV vaccines were licensed for a three-dose schedule, the European Medicines Agency (EMA) (EMA 2013, 2014) and the WHO Strategic Advisory Group of Experts on Immunization recently concluded there was sufficient evidence for the bivalent and quadrivalent HPV vaccines to recommend a two-dose schedule for young immunocompetent adolescent girls up to age 14 years, with a minimum interval of six months between doses (WHO 2014c). As of early 2016, 46 countries had adopted the revised two-dose schedule, or schedules with two initial doses and a delayed third-dose booster after five years, for young immunocompetent adolescent girls in their national immunization programs (Brotherton and Bloem 2015; Institute of Social and Preventive Medicine 2014).

As of early 2016, HPV vaccination is part of the recommended national schedule in nearly 80 countries or territories, of which approximately 25 percent are low- or middle-income (comprising both lower-middle and upper-middle income) countries. As of June 2016, 89 countries and territories have HPV vaccination on a national schedule (map 15.1; annex 15A, table 15A.2). However, an additional 37 LMICs have piloted the introduction of the vaccine in one or more urban and rural districts, 20 of which are in Sub-Saharan Africa (annex 15A, table 15A.3).

Based on experiences with pilot demonstration programs, school-based vaccination is most often used as the primary delivery strategy, usually accompanied by a secondary strategy based in health centers to reach out-of-school and underserved girls (Ladner and others 2012; LaMontagne and others 2011; Paul and Fabio 2014; Watson-Jones and others 2012). Countries introducing HPV vaccines through schools seem to use grade- and age-based eligibility equally (Gallagher and others 2016; LaMontagne and others 2011; Paul and Fabio 2014).

Map 15.1 HPV National Vaccine Introduction Globally, June 2016



Note: HPV = human papillomavirus.

Several elements make HPV vaccine delivery unique. These considerations may create operational challenges for implementation (WHO 2014a).

- There is often lack of awareness of cervical cancer and of HPV infection as a causal agent (Rama and others 2010).
- Unlike other immunization programs that target infants of both genders, HPV vaccination is targeted to girls ages 9–13 years (before sexual debut) (WHO 2014b).
- Because the recommended age group for HPV vaccination may not routinely attend health facilities, and visits by health workers to schools for vaccination may be one-time events, such as vaccination campaigns, delivery platforms and strategies used for HPV vaccine delivery may be new for LMICs (WHO 2012b).
- Consent procedures for HPV vaccines are not standardized; both opt-in and opt-out are used (Cover and others 2012; Moodley and others 2013; WHO 2014a).

HPV vaccination can be integrated with other health services for this underserved age group, which may enhance the efficiency and sustainability of vaccination programs (Broutet and others 2013; Mugisha and others 2015; Watson-Jones and others 2016). Some countries also use the opportunity to sensitize girls and women to the importance of adhering to the screening guidelines, the delivery of cervical cancer screening of adult women, or other child health programs (Wamai and others 2012).

HPV vaccination requires special attention to social mobilization and communication efforts to ensure acceptability and high coverage (Bingham, Drake, and LaMontagne 2009). In most low- and lower-middle-income countries, messages were disseminated through meetings in schools and communities, during home visits, and through written materials and radio announcements (Kabakama and others 2016; LaMontagne and others 2011). In Rwanda, Uganda, and Vietnam, teachers play an important role in communication efforts (Binagwaho and others 2012; Galagan and others 2013). The WHO encourages all countries to develop communication strategies with multisectoral stakeholders and engage communities at the start of planning the program (WHO 2013b). Among LMICs that have completed pilot delivery of HPV vaccine, all have chosen to focus messages on cervical cancer prevention and the importance of vaccination rather than to stress the sexual transmission of HPV because these messages have been proven to be

the most important for parental acceptability (Bingham, Drake, and LaMontagne 2009; Kabakama and others 2016; LaMontagne and others 2011).

Some pilot programs followed extensive informed consent processes (Moodley and others 2013). In others, the government used the same consenting procedures applied to other vaccines, including those delivered to children up to age 17 years, principally through an opt-out or implied consent approach (LaMontagne and others 2011). Pending developments that could facilitate easier delivery of HPV vaccines to young adolescent populations include expanded in-country licensure for delivery to boys (Markowitz and others 2012), alternative dosing schedules for three-dose regimens (Esposito and others 2011; LaMontagne and others 2013), and the recent approval of two-dose schedules for immunocompetent adolescent girls younger than age 15 years (WHO 2014c). Moreover, opportunities for reduced procurement prices through Gavi, the Vaccine Alliance and the Pan American Health Organization Revolving Fund, as well as potential cost reductions through the pooled purchase for middle-income countries by the United Nations Children's Fund, are likely to increase the number of countries that will introduce HPV vaccines by 2020 (Gavi, the Vaccine Alliance 2016).

EVIDENCE OF EFFECTIVE SCHOOL-BASED DELIVERY OF HPV AND TT VACCINES

TT Vaccine

Although some country programs have added delivery of TT vaccines to those as young as age 10 years, documentation of the implementation method, successes, and challenges has been largely absent in the literature. Among the 27 low- and lower-middle-income countries administering TT-containing vaccines in schools, 19 have reported coverage data (WHO-UNICEF 2013). In Indonesia, consistently high coverage of more than 95 percent of children enrolled in schools has been reported (Kim-Farley and others 1987; WHO-UNICEF 2013). Sri Lanka monitors the proportion of schools reached for immunization in each province, and 92 percent of all schools were covered by 2005 (WHO 2008b). Data from the 2014 WHO-UNICEF Joint Reporting Form show nine additional countries (Afghanistan, the Arab Republic of Egypt, Honduras, Mongolia, Mozambique, Nepal, Sierra Leone, Tonga, and Vanuatu) reported coverage levels for TT-containing vaccines of more than 80 percent for the population targeted in schools between 2011 and 2013 (WHO-UNICEF 2014). However, the lack of adequate documentation of TT-containing vaccines in schools continues to be a major obstacle to meaningful conclusions about school-based delivery for this intervention. A summary of facilitators and barriers to TT-containing vaccine delivery in schools is provided in annex 15A, table 15A.4).

HPV Vaccine

Schools have been a primary delivery strategy for HPV vaccine in a number of LMICs (Gallagher and others 2016; Ladner and others 2012; LaMontagne and others 2011; Raesima and others 2015). The rising levels of primary school attendance in many LMICs has enhanced this delivery approach (UNESCO 2014). The vaccine is usually offered at specific times during the school year, and school-based delivery may be combined with outreach or health facility vaccine delivery. High three-dose coverage (75 percent to 100 percent) has been achieved in pilot studies and demonstration programs using school-based delivery strategies, which is similar to the coverage levels achieved in national programs that also used school-based delivery (Brotherton and Bloem 2015; Markowitz and others 2012; Sinka and others 2013). A systematic review of HPV vaccine delivery experiences in 47 LMICs reported coverage levels of 70 percent or greater in the vast majority of programs that used a school-based delivery component (Gallagher and others 2016). Differences in coverage between the previously recommended three-dose schedule and the revised two-dose schedule were not observed; however, only 10 countries had reported coverage data from two-dose delivery. Further information about the possible impact of fewer doses on feasibility of school-based HPV vaccine delivery will be available in future years as this schedule becomes established.

Countries implementing school-based programs need to decide whether to establish age- or grade-based eligibility. A demonstration project in Tanzania found significantly higher coverage with grade-based vaccination, compared with age-based vaccination, at slightly lower cost (Watson-Jones and others 2012). Bhutan has reported national coverage of more than 90 percent through school-based delivery (Dorji and others 2015). A summary of facilitators and barriers to HPV vaccine delivery in schools can be found in annex 15A, table 15A.5.

COSTS AND COST-EFFECTIVENESS OF SCHOOL-BASED TT AND HPV VACCINE DELIVERY

Consideration of the costs and cost-effectiveness of school-based vaccination programs are instrumental in decisions for national introduction and scale-up (WHO 2006, 2014b). Given the shortage of routine

health services for adolescents (UNICEF 2007), the opportunities to leverage existing programs are limited (Broutet and others 2013; WHO 2008a). Accordingly, the incremental costs associated with implementation and delivery of TT and HPV vaccinations, both targeted to adolescents, are expected to be high relative to new childhood interventions. School-based delivery of vaccines provides an opportunity to access young adolescent populations who may not attend regular health services. To date, the empirical data on the added costs of school-based vaccination programs have been limited, with little to no coverage of TT vaccination (Griffiths and others 2004). However, several demonstration studies have emerged on the financial and economic costs of school-based HPV vaccination (Levin and others 2013; Levin and others 2014; Levin and others 2015).

Costs of HPV Vaccine Delivery

Several published studies have estimated the incremental costs of school-based HPV vaccine delivery in Bhutan, India, Peru, Tanzania, Uganda, and Vietnam, which are all LMICs (Levin and others 2015). Each of the analyses distinguished financial costs, reflecting actual expenditures, from economic costs, including the value of donated and shared resources, to more fully assess the opportunity costs of the HPV vaccination program. Results from three studies largely resulted in consistent estimates for economic and financial costs per HPV vaccine dose and per fully immunized girl (table 15.1; Levin and others 2013). In these studies, the incremental financial cost ranged from US$1.65 to US$2.25 per dose and US$4.96 to US$7.49 per fully immunized girl for a three-dose vaccination schedule. The economic costs were higher, ranging from US$2.11 to US$4.62 per dose and US$6.37 to US$16.10 per fully immunized girl. A two-dose vaccine schedule would reduce both financial and economic costs per fully immunized girl, but start-up costs are expected to be similar. As hypothesized, these costs are higher than the delivery costs of other routine immunizations reported in LMICs, which have ranged between US$0.75 and US$1.40 per dose, depending upon vaccine, country, and year of implementation (Brenzel and others 2006).

Specific findings from the studies also suggested interesting trends in the cost of HPV vaccine delivery mechanisms. For example, Quentin and others (2012) found that HPV vaccine delivery in urban schools was cheaper than delivery in rural schools, mainly due to higher costs of procurement and transport to rural areas. Irrespective of location, grade-based delivery was less costly by roughly 30 percent than age-based delivery in schools because of higher coverage and number of eligible girls. Hutubessy and others (2012) found that the recurrent costs for delivering HPV vaccines in schools were higher than delivery in health facilities by US$1.65 for three doses per eligible girl (US$0.55 per dose). Similarly, Levin and others (2013) found that school-based delivery had higher economic costs than an integrated (school and health center) approach or delivery solely in a health center, mainly due to the additional personnel and transportation costs required to reach the schools.

Table 15.1 Financial and Economic Costs for School-Based HPV Vaccine Delivery Using a Three-Dose Schedule (Excluding Vaccine Cost), 2013

U.S. dollars

	Tanzania (Hutubessy and others 2012)	Tanzania (Quentin and others 2012)	Peru (Levin and others 2013)	Uganda (Levin and others 2013)	Vietnam (Levin and others 2013)
Program scale	Scaled-up national program	Scaled-up regional program	Demonstration project	Demonstration project	Demonstration project
Method of estimation	Projected (using WHO C4P tool)	Projected	Microcosting approach	Microcosting approach	Microcosting approach
Financial cost, per dose	2.2	2.3	2.2	2.2	1.7
Financial cost, per FIG	7.5	7.1	6.5	6.9	5.0
Economic cost, per dose	4.6	4.0	4.1	3.2	2.1
Economic cost, per FIG	16.1	12.7	12.4	10.4	6.4

Note: FIG = fully immunized girl for recommended three-dose schedules at the time of study; HPV = human papillomavirus; WHO C4P tool = World Health Organization Cervical Cancer Prevention and Control Costing tool. Methods for estimating costs differed across studies, except in Peru, Uganda, and Vietnam.

Main Contributors to Costs

Head-to-head comparison of the main cost contributors across all settings was precluded by differences in categorizations of costs across studies. The cost of procurement, including receiving and transporting vaccines to the appropriate locations, was the largest cost component of scaled-up delivery of HPV vaccination in schools (46 percent to 70 percent of financial costs) (Hutubessy and others 2012; Quentin and others 2012). Of the remaining costs, service delivery, comprising health worker salary and allowances; social mobilization, comprising information, education, and communication (IEC); and supervision of vaccinations were important contributors to the total delivery costs (LSHTM and PATH, forthcoming).

In one study, costs were broadly categorized as start-up costs (for example, social mobilization and IEC, training, and microplanning) and recurrent (for example, personnel) costs (Levin and others 2013). Start-up costs of school-based vaccination programs were a large share of the total financial cost per dose (69 percent in Peru, 41 percent in Uganda, and 72 percent in Vietnam). When shared and donated resources were taken into account, start-up costs were far lower at 36 percent, 27 percent, and 56 percent of the total economic cost per dose, respectively.

The cost estimates may not be widely generalizable to other countries because the unit costs were setting specific. Accordingly, the experience of school-based delivery of HPV vaccines may not be generalizable to other adolescent vaccines such as TT, although the same principles may well apply. Furthermore, simultaneous delivery of TT and HPV vaccines in schools—to the same or different age cohorts or grades—may allow for the sharing of cost drivers, such as transport, which can reduce delivery costs.

Cost-Effectiveness of HPV Vaccination

According to several cost-effectiveness analyses in LMICs, HPV vaccination of preadolescent girls is likely to be good value for money, even at the higher cost of school-based delivery (Levin and others 2015). Several studies have estimated that the economic cost per fully vaccinated girl for a three-dose vaccination schedule was I$25 (25 international dollars) when the vaccine cost was US$5 per dose (Goldie and others 2008). At this vaccine cost, under assumptions of lifelong high vaccine efficacy against HPV-16/18 cervical cancers, the analyses found that HPV vaccination was very cost-effective in most LMICs, according to a cost-effectiveness threshold of per capita gross domestic product (GDP) (Fesenfeld, Hutubessy, and Jit 2013). At lower vaccine costs that are more reflective of the subsidized price of HPV vaccines for countries eligible through Gavi, the Vaccine Alliance (for example, US$0.55–US$2.00 per dose), HPV vaccination was found to be cost-saving or had attractive cost-effectiveness ratios well below per capita GDP (Goldie and others 2008; Kim and others 2013; Levin and others 2015). In these analyses, the most influential drivers of cost-effectiveness were the cost per vaccinated girl (including vaccine price and delivery costs), vaccine coverage and efficacy, overall cancer and genital warts disease burden, and assumptions about the discount rate. With the recent change in the recommended schedule for HPV vaccine among young immunocompetent adolescent girls from three doses to two and increased flexibility in the interval between doses, adjustments to the cost and cost-effectiveness assumptions and analyses are likely to result in an increasingly favorable cost scenario for school-based delivery in a wider range of LMICs.

The question of male HPV vaccination has been evaluated in several high-income countries, but only a few cost-effectiveness analyses have addressed this question in LMICs, and the conclusions have been mixed. In Brazil (Kim, Andres-Beck, and Goldie 2007) and Vietnam (Sharma, Sy, and Kim 2015), including males in the HPV vaccination program yielded marginal health gains relative to vaccinating girls only. While the analysis in Vietnam found that at a low vaccine cost, vaccinating boys had a cost-effectiveness ratio below per capita GDP, both studies concluded that increasing coverage in girls was more cost-effective than extending coverage to boys. In contrast, in Mexico (Insinga and others 2007), the quadrivalent HPV vaccine in both girls and boys was found to be very cost-effective when including genital warts and cervical cancer benefits. As in analyses from high-income countries, the cost-effectiveness of male HPV vaccination depends heavily on the achievable HPV vaccine uptake in females, vaccine price, and health conditions (such as male and female cancers) included in the analysis.

Overall, these findings imply that at the estimated total cost of delivering HPV vaccination in schools, HPV vaccination of preadolescent girls is good value for money, but that vaccination of boys is less certain.

Summary of Cost-Effectiveness Analyses

Although the evidence on the cost of HPV vaccine delivery in LMICs is emerging, findings from a number of studies in selected settings affirm that the cost of school-based delivery of HPV vaccination is slightly higher relative to other traditional and new infant immunizations. Reaching a target group not routinely served by national immunization programs may require new or

modified delivery strategies (LaMontagne and others 2011; WHO 2014b); more intensive IEC activities (Galagan and others 2013; WHO 2013b); and additional logistics and staff time, resulting in higher start-up and recurrent costs. An analysis from Tanzania concluded that the financial cost of introducing HPV vaccination for a three-dose schedule to 26 regions over a five-year period (2011–15) was an estimated US$11.9 million, excluding vaccine cost; or US$40.9 million with vaccine at an unsubsidized price of US$5 per dose (Hutubessy and others 2012). To the extent that scaling up a program to the national level would result in economies of scale; or that the vaccination program could be integrated as part of an existing, efficient program; or that the vaccination schedule would be reduced from three doses to two, both financial and economic costs of HPV vaccine delivery may be lower than what has been estimated in these smaller-scale studies. Countries will need to commit substantial resources to initiate, scale up, and sustain HPV vaccination programs.

Based on the start-up and recurrent cost estimates of school-based delivery from published studies, the majority of cost-effectiveness analyses have found HPV vaccination to be good value for money, even in the poorest countries. Securing a low vaccine cost and achieving high vaccine uptake and adherence in adolescent girls will maximize the return on investment of school-based HPV vaccination in any setting.

CONCLUSIONS

School-based delivery of vaccines is a viable approach for the control of infections and diseases that cause significant morbidity and mortality. Increasing school enrollment and attendance by children and adolescents, particularly girls, has changed the landscape for health service delivery, providing an excellent opportunity to capture large proportions of populations eligible for TT-containing, HPV, and other vaccines. To ensure equitable access for the most vulnerable populations, school-based delivery of vaccines must be complemented by strategies to reach those not attending school, such as mobile teams, outreach, and provision of vaccines at health facilities.

The wide variety of experiences using schools to deliver TT-containing vaccines in 27 LMICs or HPV vaccines in 47 LMICs has provided valuable lessons about the factors that have resulted in success. Pilot programs have been useful in providing countries with the opportunity to test new delivery strategies and learn what works well in their contexts. Community acceptance can be achieved through effective sensitization and mobilization efforts. Feasible delivery strategies for LMICs, especially using two-dose schedules, can be implemented and reach high coverage. And a strong case for the cost-effectiveness of using schools as a location for adolescent vaccinations has been documented.

Government ownership, endorsement, and financial support; active and sustained involvement and leadership from ministries of health and education; and broad-based community support from health workers, teachers, community leaders, civil society, parents, and adolescents are critical elements in the success and sustainability of any vaccine delivery program, but especially those using schools.

Delivery of TT-containing and HPV vaccines is an opportunity to regalvanize school health programs and build a stronger foundation for the delivery of other important health interventions. A holistic approach combining vaccine delivery with other interventions may help sustain both and has the potential to lead to improvements in the overall health of children and adolescents.

ANNEX

The annex to this chapter is as follows. It is available at http://www.dcp-3.org/CAHD.

- Annex 15A. Supplemental Figures and Tables for School-Based Vaccinations

NOTES

Tania Cernuschi, MSc, MPH, represented Gavi, the Vaccine Alliance Secretariat, Geneva, Switzerland, at the time this work was performed.

World Bank Income Classifications as of July 2014 are as follows, based on estimates of gross national income (GNI) per capita for 2013:

- Low-income countries (LICs) = US$1,045 or less
- Middle-income countries (MICs) are subdivided:
  a) lower-middle-income = US$1,046 to US$4,125
  b) upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more.

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