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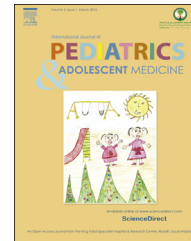


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INVITED REVIEW

Adolescent immunization – Protecting youth and preparing them for a healthy future



Joanne M. Langley ^{a,b,c,*}

^a Department of Pediatrics, Dalhousie University, Canada

^b Department of Community Health and Epidemiology, Dalhousie University, Canada

^c Canadian Center for Vaccinology, IWK Health Centre, Capital Health District and Dalhousie University, Canada

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Abstract Adolescence is a period of profound biological, physical, intellectual and neuro-cognitive growth and development, during which new social roles and responsibilities are acquired. Vaccination has the potential to avert acute and chronic illness during this period and to decrease the risk of illness, disability, and cancer in adult life. Here, the vaccines recommended for adolescents are reviewed, and the essential role of health care providers in providing education to adolescents about immunization is highlighted. Each health care encounter is an opportunity to ensure that the adolescent has the benefit of all available vaccines.

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1. Introduction

The adolescent years, during which children make the transition into adulthood, are characterized by profound biological, physical, intellectual and neuro-cognitive growth and development and the acquisition of new social roles and responsibilities. In many ways, adolescent health is a product of child and maternal health, and it lays the framework for adult well-being [1,2]. Immunization is one of the 10 public health achievements of the 20th century [3], and it plays an integral role in the prevention of

* IWK Health Centre, 4th floor Goldbloom Building, 5850 University Avenue, Halifax, Nova Scotia B3K 6R8, Canada. Tel.: +1 902 4708141; fax: +1 902 470 7232.

E-mail address: joanne.langley@dal.ca.

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acute and chronic infectious diseases, including cancer. Health care providers play an essential role in ensuring that adolescents have the opportunity to be immunized and in helping adolescents understand that immunization prevents morbidity and mortality for them and their families throughout their lives. In this narrative review, the vaccines that are recommended for adolescents are described. It is recognized that the specific vaccines that are recommended for adolescents vary across countries based on local disease epidemiology and available economic resources for implementing vaccine programs.

2. Background – adolescence as a life stage

The importance of adolescent health to societal prosperity was highlighted by the 2014 World Health Organization (WHO) report *Health for the world's adolescents. A second chance for the second decade*: "Promoting healthy practices during adolescence, and taking steps to better protect young people from health risks are critical for the prevention of health problems in adulthood, and for countries' future health and social infrastructure" [4]. Indeed, the sheer numbers of adolescents, estimated at 1.2 billion, merits the attention of health care planners.

As a "social construct", the concept of adolescence as a distinct life stage was developed relatively recently [2,5]. Non-governmental societies focused on adolescent health were developed in the last century [6,7]. Definitions of the adolescent age span vary; adolescence has been proposed to begin as early as 10 years of age and to extend to as late as 24 years of age [2]. The recognition that brain maturation continues to as late as 25 years of age [5] supports a more extended duration for the adolescent stage of life. The WHO considers the adolescent age span to be from 10 to 19 years of age [4].

For the immunization provider, adolescent patients should be evaluated in terms of whether they have received all recommended childhood vaccines, whether new vaccines have been introduced that they should receive, and which vaccines may require a boosting dose. Each encounter between a health care provider and an adolescent is an opportunity to discuss vaccine-preventable diseases and, more broadly, preventive health. These "teachable moments" can deepen adolescents' understanding of their health and help them recognize their role as active agents in maintaining their own health and the health of their community.

3. Are recommended childhood vaccines up-to-date?

Immunization in childhood has dramatically reduced the worldwide burden of diphtheria, pertussis, tetanus, polio, *Streptococcus pneumoniae*, tuberculosis, meningococcal disease, *Haemophilus influenzae* type B (Hib), hepatitis B and A, rotavirus, human papilloma virus (HPV) measles, mumps, rubella and varicella [3]. In certain regions and in certain populations, vaccines are also recommended to protect against Japanese encephalitis, yellow fever, tick-borne encephalitis, cholera, typhoid, rabies or hepatitis A [8]. The WHO position papers on recommended

immunization provide detailed guidance for immunization providers on childhood, adolescent and adult vaccines at the country and individual level [9].

The vaccine records of adolescents should be reviewed at every visit to prevent missed opportunities for immunization. If the adolescent is un-immunized or under-immunized or vaccine doses have been delayed, the appropriate vaccine, dose, route, and catch-up schedule can be determined from the product monograph, the country department of health or useful resources such as the WHO [8]. If a reliable history of previous immunization does not exist, most experts recommend assuming that the person is unimmunized and providing all necessary vaccines [10]. In general, fewer doses are needed to immunize an older child, and a vaccine series does not need to be restarted in an older child, regardless of the interval between doses.

4. Adolescent vaccines

The immunity induced by a full series of a childhood vaccines may be considered lifelong (e.g. measles vaccine) or may be known to wane over time (e.g. tetanus toxoid vaccine). Inactivated vaccines, such as tetanus, diphtheria and pertussis, are more likely to require boosting doses, whereas live vaccines, such as measles, mumps, rubella and varicella, are more likely to produce a longer duration of protection. A boosting dose in adolescence provides protection through the adolescent and early adult years. Other vaccines may be given for the first time in adolescence to protect against a disease that is more common or is not encountered until the second decade of life (e.g. human papilloma virus, HPV vaccine).

The vaccine provider should be able to explain the disease that will be prevented by the vaccine and provide non-judgmental answers to questions that the adolescent may have.

4.1. Tetanus – diphtheria – pertussis vaccine (Tdap)

The recommendation for a combined tetanus toxoid (T) and diphtheria toxoid (D) vaccine every 10 years is longstanding [11]. The addition of an acellular pertussis component to the adolescent Td dose occurred approximately 10 years ago, when major outbreaks in this age group were recognized in North America and elsewhere [12,13].

Tetanus (lockjaw) is a neurologic illness caused by spores of *Clostridia tetani*, an organism that is ubiquitous in the environment. Tetanus is characterized by muscle spasms that can prevent respiration, leading to death, and it most commonly occurs in newborns born in conditions that are not adequately aseptic and when open wounds are exposed to soil, feces or environmental contamination. Diphtheria is a respiratory illness caused by exotoxin-producing strains of *Corynebacterium diphtheriae*. Pharyngitis can progress to upper airway obstruction and respiratory failure, while the systemic spread of diphtheria toxin can cause myocarditis and damage to other organs, including organs of the central nervous system and the kidneys. Pertussis (whooping cough), a respiratory illness caused by the bacteria

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