



Decreased incidence of pertussis in young adults after the introduction of booster vaccine in military conscripts: Epidemiological analyses of pertussis in Finland, 1995–2015



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ABSTRACT

Introduction: In 2005, in Finland, the whole-cell pertussis vaccine was replaced by acellular given at 3–5–12 months, and boosters at 4 and 11–15 years of age. From July 2012, military conscripts have been offered a pertussis booster dose. Conscription is mandatory for Finnish men, and >95% were 19–21 years old when enrolled during 2012–2015. We describe the epidemiology of pertussis in Finland during 1995–2015, and show the indirect effect of the booster in conscripts on pertussis incidence in the Finnish population.

Materials and methods: We extracted data on laboratory confirmed notified pertussis cases from the National Infectious Diseases Register. We calculated annual incidence using as denominator population data and incidence rate ratios (IRR) using Poisson regression.

Results: The overall pertussis incidence peaked in 2004 (31/100,000) and was lowest in 2015 (3.0/100,000), with 66 reported cases in <3 months infants in 2004 versus 6 in 2015. The majority of the cases were female (59%) with a male-to-female case ratio of 1:1.5. Cases were spread throughout the year with highest incidence during August–February.

Among the 19- to 21-year-olds in the general population, incidence decreased from 49/100,000 in 2011 to 0.51/100,000 in 2015 (IRR = 0.01; 95%CI, 0.00–0.16). Among the same age group, comparing the 3.5-year period before and after July 2012, incidence decreased from 33/100,000 to 5.3/100,000 (IRR = 0.16; 95%CI, 0.06–0.40) in males and from 16/100,000 to 5.0/100,000 (IRR = 0.31; 95%CI, 0.11–0.84) in females.

Conclusions: Implementation of the pertussis booster dose in Finnish military conscripts was followed by a significant decrease in pertussis incidence both among the 19- to 21-year-old males and females, possibly reflecting herd immunity effect. Together with booster doses in adolescents this has resulted in low incidence in the whole population including infants. Our results support the implementation of the booster dose for conscripts. We recommend continuing monitoring pertussis epidemiology to optimize pertussis vaccination strategies in Finland.

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Abbreviations: aP, acellular pertussis vaccine; dtap, diphtheria-tetanus-acellular booster pertussis vaccine, with reduced amount of antigens; DTaP, diphtheria-tetanus-acellular pertussis vaccine; NIDR, National Infectious Diseases Register; wP, whole-cell pertussis vaccine.

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1. Introduction

Pertussis, caused by *Bordetella pertussis*, is acquired through transmission of large respiratory droplets generated by coughing or sneezing. The disease may occur at any age, though it is most severe in infants and young children. Protection provided by the currently used acellular pertussis vaccines (aP) wanes within years

[1]. Adolescents, adults and children partially protected by the vaccine may become infected but may have milder disease than infants and young children [2–4]. Siblings and parents constitute a reservoir and are the main source of transmission to young children [5–7].

From 2010, several countries with longstanding pertussis vaccination programmes such as Norway, the Netherlands, the United Kingdom, and the United States have experienced increased pertussis activity or outbreaks but this has not been the case in Finland [8]. Potential reasons given to explain the increase are waning immunity, genetic changes in *B. pertussis*, change from whole-cell vaccines (wP) to aP vaccines, introduction of non-culture-based methods of diagnosis, improved case finding (especially among the adults) and vaccine refusal [8–11]. Other challenges biasing the comparison of pertussis situation analysis across countries might be the under- or delayed reporting and under-diagnosis that are related to the atypical clinical characteristics of the disease in adolescents and adults, and lack of laboratory confirmation.

In Finland, nationwide official pertussis reporting of laboratory confirmed cases began in 1995; however unofficial historical pertussis mortality and morbidity data is available since 1920 [12]. Over decades, the national vaccination programme has gone through several major changes for pertussis protection. The wP vaccine was used from 1952 until 2005 (Table 1). During the wP era the schedule, consisting of primary doses given at 3, 4, and 5 months of age, was in 1957 supplemented by a recommendation for booster doses at 3–4 and 6–7 years of age. From 1977, a vaccination schedule of 3–4–5 and 24 months of age was implemented. A preschool booster dose at 6 years of age was included in the schedule in January 2003 and given until 2010. In 2005, when the use of the nationally produced DTwP vaccine was discontinued (the production was stopped in 2002), the whole cell pertussis component was replaced by the acellular pertussis component in a commercial combination vaccine (Table 1). Since 2005 the universal vaccination schedule in Finland includes a primary series of a combination vaccine (DTaP-IPV-Hib) given at 3, 5 and 12 months of age, plus boosters at 4 (DTaP-IPV) and 14–15 years of age (dtap, the lower case letters indicate reduced amount of antigens). During 2005–2009 a dtap booster was administered at the age of 11–13 years, and starting from 2011 at the age of 14–15 years, respectively. The booster dose at 4 years of age was first distributed in 2008 [13].

From July 2012 onwards, a pertussis booster dose have been administered to the military conscripts on entry into the service as part of the scheduled diphtheria and tetanus boosting, i.e. dtap

(Fig. 1). In 2015, the vaccination coverage for the completed primary childhood series of three doses (3–5–12 months) was 94.5%. Coverage among adults is not well known as data transfer from the private sector, where most of the adult doses are given as part of occupation health service, to the National Vaccine Register is still inadequate [14].

Here we describe the epidemiology of laboratory confirmed pertussis in Finland during the period 1995–2015 and the effect of an adult booster to military conscripts as part of the evaluation of pertussis transmission patterns and optimizing national pertussis vaccination strategies.

2. Material and methods

Since 1995, laboratory confirmed pertussis cases have been reported by microbiological laboratories to the National Infectious Diseases Register (NIDR). The diagnostic methods include serology, polymerase chain reaction (PCR), and conventional culture. In serology, which is the predominant method (80–90% of the reported cases), a high cut-off has been used in order to provide high specificity of the diagnosis [15]. Pertussis cases notified from 1 January 1995 to 31 December 2015 were extracted from the NIDR. The notification system is based on the unique personal identification number, and records include the date of birth, sex, date of onset of symptoms, and the diagnostic method used.

Incidence rates were calculated per 100,000 population per calendar year, based on annual population data from Statistics Finland in the defined age categories.

Among Finnish men, conscription is mandatory, and military or non-military service is carried out between the ages of 18 and 30. Women can apply for voluntary military service [16]. The number and age distribution of military conscripts (both armed forces and civil servants) were available from the Finnish Defence Forces. Due to the old communicable diseases law and act, vaccination was mandatory in the Defence Forces until the end of February 2017.

In analysing the effect of the booster dose in military conscripts, we calculated the incidence rates among 19–21 years old males and females for the 3.5-year periods before and after July 2012. Then we calculated incidence rate ratios (IRR) by dividing incidence rates of the reference period (from January 2009 to July 2011) by incidence rates of the period between the implementation of the pertussis booster dose in Finnish military conscripts and the end of our study period (from July 2012 to December 2015), using Poisson regression.

Data analysis was performed by Microsoft Office Excel and STATA 14 (StataCorp, College Station, TX).

Table 1
Vaccines against pertussis distributed in the national vaccination programme, Finland, 1952–2016.^a

Type of vaccine	Year of introduction	Brand name	Manufacturer	Years of distribution
DwP	1952	Per-Dif-vaccin	Orion	Until 1960
DTwP	1957	Per-forte-vaccin	Orion	Until 1960
		Per-Dif-Tet-vaccin	Orion	1957–1970s
dtap	2003	Kolmoisrokote/Trippelvaccin	KTL	1970s–2004 ^b
DTaP-IPV-Hib	2005	Boostrix [®]	GSK	2003–2016
		Pentavac [®]	SPMSD	2005–2009; 2016
DTaP-IPV	2005	Infanrix-Polio + Hib [®]	GSK	2009–2016
		Tetravac [®]	SPMSD	2005–2016
dtap for military conscripts	2012	Infanrix-Polio [®]	GSK	2009–2011
		Boostrix [®]	GSK	2012–2016

Orion – Orion Ltd (Espoo, Finland).

KTL – Kansanterveyslaitos (National Public Health Institute, Helsinki, Finland; predecessor to current National Institute for Health and Welfare).

GSK – GlaxoSmithKline.

SPMSD – Sanofi Pasteur MSD.

^a In the private sector, outside the national programme, to boost adults for Td protection every 10th year, also Tdap may be used.

^b The production was stopped in 2002.

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