

Immunizations Against Respiratory Infections in Children in Primary Health Care in Poland: Coverage and Delays

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Abstract

Pneumococcal infections, pertussis, and influenza are vaccine-preventable diseases. The aim of this study was to determine vaccine coverage and compliance with the dosage regimen among children in Poland. We performed a retrospective chart analysis of 1,356 children in a large primary healthcare establishment. The complete primary pertussis vaccination, 3 doses in the first year of life, was administered to 1,310/1,356 patients (96.6 %). The self-paid combined acellular vaccine was given in 55.2 % of children. The first dose of the pertussis vaccine was administered in a timely manner to 67.1 % of children. The self-paid pneumococcal vaccine was administered in 499/1,356 (36.8 %) children. In 46.1 % of them immunization started within the first 6 months of life; in 12.6 % aged 7–11 months, in 12.6 % aged 12–23 months, and in 28.7 % aged over 24 months. The dosage regimen was compliant in 49.2 % of patients. Only 3.5 % of patients were immunized against both *pneumococci* and influenza. Compliance with the Polish immunization program should be increased by reducing the number of injections and the cost of vaccines. Education is essential to facilitate simultaneous administration of vaccines during one visit and to prepare the parents for judicious decision-making when it comes to vaccinations.

Keywords

Combination vaccines • Flu • Prevention • Public health • Risk

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1 Introduction

Pertussis, influenza, and pneumococcal disease are vaccine-preventable respiratory tract infections in children. Pertussis is a respiratory illness caused by Gram negative bacteria *Bordetella pertussis* and characterized by

paroxysmal coughing, inspiratory dyspnea (whooping cough in children), and a prolonged clinical course. The disease is most serious for newborns and young babies. The mortality rate peaks in infants younger than 6 months old, especially newborns. Infants too young to be fully immunized (<6 months old) are the most affected. Immunization-related risk factors include lack of vaccination, incomplete course of vaccinations, delayed vaccination, and increased time since last pertussis vaccination, because immunity following natural infection and vaccination wanes over time. Pertussis occurs six times more often in children exempt from the vaccination than in immunized children (Feikin et al. 2000). An incomplete course of vaccinations is a risk factor since at least 2 doses of the vaccine are needed for protection. Next, delayed immunization is associated with an increased risk of hospital admission for pertussis in infants (Grant et al. 2003). Another risk factor is exposure to contact with *Bordetella pertussis* and household members appear to be most common source of pertussis infection for infants (Wendelboe et al. 2007).

Children under five are the population group most likely to contract influenza, with an incidence rate greater than in the elderly. Influenza is a serious infectious disease for children especially for those under 2 years of age, who are at most risk (Poehling et al. 2006). Healthy infants and children under 2 years are hospitalized for influenza at similar rates to adults in high-risk groups (Neuzil et al. 2000). Infants are the most likely to develop serious complications such as pneumonia and secondary bacterial infections (Neuzil et al. 2002). Universal vaccination of healthy children is not widespread in Europe, despite clear demonstration of the benefits of vaccination in reducing the large health and economic burden of influenza (Cohen et al. 2011). The inactivated seasonal influenza vaccine, the only one available in Poland, can be used for any person >6 months old without contraindications (e.g., history of severe allergic reaction to any element in the vaccine). According to the updated recommendations on immunization of the Advisory Committee on Immunization

Practices of the National Center for Immunization and Respiratory Diseases (ACIP 2011), all children aged between 6 months and 8 years should receive 2 doses (≥ 4 weeks apart), instead of 1 dose, of the seasonal influenza vaccine. The seasonal influenza vaccine was proven to be highly effective for reducing laboratory-confirmed influenza in healthy children over 2 years old, but modestly effective for reducing flu-like illness (Jefferson et al. 2012). Immunization of children in daycare may reduce morbidity among household contacts (Hurwitz et al. 2000).

Streptococcus pneumoniae or *pneumococci* are Gram-positive, anaerobic bacteria recognized as a major cause of community-acquired pneumonia, otitis media, and a significant proportion of bacteremia and bacterial meningitis in humans (Verma and Khanna 2012). As *pneumococci* are responsible for 17–37 % of pneumonia, they are the most common causes of pneumonia in otherwise healthy children aged 2–59 months (Grant et al. 2009). The highest pneumococcal disease hospitalization rates (>200 per 100,000 person-years) were reported in children under 2 years following a preterm birth, a low birth weight, a low 5-min Apgar score, or birth defects (Mahon et al. 2007). *Pneumococci* lead to death of approximately one million children under the age of five every year: the vast majority in developing countries (Verma and Khanna 2012).

All children aged 2–59 months should be immunized with the pneumococcal conjugated vaccine. The World Health Organization recommends worldwide vaccination against childhood pneumococcal disease with a 13-valent (PCV13) or 10-valent (PCV10) pneumococcal conjugate vaccine. The dosage regimen is age-related with the preferred regimen consisting of 3 primary doses (3 + 0 schedule) for optimal protection. The pneumococcal immunization should begin at 6 weeks of age and be given with an interval of 4–8 weeks between doses. Alternatively, 2 primary doses plus booster (2 + 1 schedule) can begin at age 6 weeks with a second dose after at least 8 weeks for younger infants or 4–8 weeks later for infants aged ≥ 7 months; a booster should be given between the ages of 9–15 months.

The aim of our study was to present the coverage of vaccination against the most significant respiratory tract infections (pertussis, pneumococcal infections, and influenza) in children in Poland to assess the use of these feasible interventions to protect children and the impact of the cost of vaccines – the mandatory pertussis immunization is available free of charge, while influenza and conjugated pneumococcal immunizations are self-paid.

2 Methods

The study was approved by a local Ethics Committee. We analyzed the immunization charts of 1,356 children aged between 1 month and 18 years. All children were patients at a large primary healthcare establishment in a southern city of Wrocław, Lower Silesia, Poland. Vaccinations against pertussis, pneumococcal infections, and influenza were taken into account. In the case of the pertussis vaccination, we assessed the coverage of the complete primary vaccination (3 doses in the first year of life) and booster doses (in the second and sixth year of life). We assessed the age at which each dose was given and the time delay between the doses. Based on these results, we calculated the percentage of doses given in a timely manner according to the Polish National Immunization Program (Chief Sanitary Inspector 2012). We also analyzed the type of vaccine (whole-cellular or acellular). In the case of vaccination against *Streptococcus pneumoniae*, we analyzed the immunization coverage and the number of doses given. We also assessed the time the vaccination program started and compliance of the dosage regimen with the Polish National Immunization Program and guidelines from the vaccine's producers. Patients immunized against pneumococcal infections were assigned to one of the four groups according to the age at which they were immunized (first 6 months of life, 7–11th month of life, 12–23rd month of life, and 24th month of life or later). A correct schedule means the proper dosage regimen, number of doses, age at which each dose is given and

intervals between the doses. In the case of the influenza vaccination, we assessed the number of patients immunized once and more than once in their lifetime. Adherence to the correct schedule, which means the administration of two doses separated by 4 weeks in previously non-immunized children, was also analyzed. To evaluate the age and number of patients immunized each year, the patients were assigned to the following age groups: 0 to <12 months, ≥ 12 to <24 months, ≥ 2 to <5 years, and > 5 years. We also assessed the number of children immunized against both influenza and pneumococcal infections. Data were presented as means \pm SD and 95 % confidence intervals (CI). Calculations were performed using Statistica ver. 10.

3 Results

3.1 Pertussis Vaccination

Pertussis immunization coverage was high in our study group, 1,337/1,356 patients (98.6 %) received at least one dose of a vaccine. The complete primary vaccination (3 doses in the first year of life) was administered to 1,310/1,356 patients (96.6 %). Three doses in the first year of life and a fourth, a booster dose, in the second year, was administered to 1,152 patients (87.9 %), but in 91/1,310 children (7.0 %) the booster dose was not given due to a young age, so vaccine coverage might have approached 94.9 %. In the remaining 67 patients, the fourth dose was not given or delayed for an unknown reason. The first dose of pertussis vaccine was administered in a timely manner (i.e., within the second month of life) in only 910/1,337 of children (67.1 %). The mean age at which the first dose was given amounted to 2.1 ± 1.5 months (range: 0.8–24.5 months). The average delay in the first dose was 1.5 ± 2.4 months (range: 0.1–24.3 months), median: 0.8 months. The second dose was administered at the 3–4th month of life, according to the Polish National Immunization Program, in 988/1,330 of children (72.9 %), with the mean age being 3.9 ± 2.1 months (range:

2.0–49.7 months). The mean delay of the second dose was 1.8 ± 3.5 months, ranging 0.03–45.7 months, median: 0.8 months. One of the patients took the second dose of the vaccine earlier than recommended. The third dose was given at the 5–6th month of life in 985/1,310 children (72.6 %). The mean age at which this dose was given was 5.9 ± 2.7 months (range: 3.6–52.7 months) and the average delay of the dose was 2.6 ± 4.4 months (range: 0.7–46.7 months), median: 1.1 months. The third dose was given earlier than recommended in 7/1,310 children (0.5 %). The fourth dose was given at the 16–18th month of life in 408/1,152 patients (35.4 %) and the mean age at which the dose was given was 20.1 ± 5.4 months (range: 5.4–90.6 months). The mean delay of the fourth dose was 3.8 ± 6.1 months (range: 0.3–6.1 months), median: 2.0 months, while in 22/1,152 patients (1.9 %) the dose was given earlier than recommended. The second booster dose, i.e., the fifth dose of the vaccine was administered in the 6th year of life in 347/528 children (65.7 %). The mean age at which this dose was given was 5.2 ± 0.6 years (range: 4.3–11.1 years) and the average delay was 0.8 ± 1.1 years, ranging: 0.03–5.1 years, median: 0.4 years. In 145/528 children (27.5 %) the fifth dose was given earlier than recommended. In general, all three doses of the primary vaccination were given according to recommendations in 779/1,310 children (59.5 %).

The average age at which the whole-cellular or acellular vaccine was given did not differ significantly: the first dose of DTP was administered at the age of 64 vs. 64 days; the second dose at the age of 118 vs. 117 days, the third dose at the age of 178 vs. 174 days and the fourth dose at the age of 609 vs. 598 days, respectively, all $P > 0.05$.

The majority of the patients having received all three doses of the vaccination (748/1,310; 55.2 %) were given all the doses of acellular vaccine, which is still not subsidized in Poland, with the exception of some risk groups (preterm infants, infants with a low birth weight, and children with chronic neurological disorders). The complete whole-cellular

vaccine course was administered in 495/1,310 patients (36.5 %) and in 67/1,310 (4.9 %) patients both vaccines were used – some whole-cellular doses and some acellular vaccine doses.

3.2 Pneumococcal Vaccination

Pneumococcal vaccine was administered to 499 children (36.8 %). In most of the patients (230/499; 46.1 %) immunization started in the first 6 months of life as recommended, in 63/499 patients (12.6 %) at age 7–11 months, in 63/499 children (12.6 %) at age 12–23 months, and in 143 patients (28.7 %) at age 24 months or over. The mean age at which the first dose was given was 15.4 ± 18.5 months, the second dose – 8.0 ± 6.5 months, the third dose – 9.0 ± 6.0 months, and the fourth dose – 18.8 ± 4.1 months.

In the group of patients, who started the vaccination course in the first 6 months of life (between the 6th week and the 6th month of life), only 122/230 children (53.0 %) were given all the recommended four doses. Three doses of pneumococcal vaccine were given in the first year of life in 206/230 (89.6 %) children. The 4th dose, which should have been given between the 11–15th month of life, was administered in a timely manner in only 16/122 (13.1 %) children, who were given all four doses. Thus, only 16/230 children (7.0 %) in this group were vaccinated according to the correct vaccination dosage regimen based on the producer's recommendations.

In the group of children who started their pneumococcal immunization between the 7–11th month of life, 46/63 (73.0 %) received all three recommended doses. Two doses in the first year of life were administered in 54/63 patients (85.7 %). The third dose was given in a timely manner (i.e., in the second year of life) in 34/46 patients (73.9 %) who were given all three doses. The vaccination schedule was correct in only 4/63 patients (6.4 %).

In the group of children starting their vaccination between the 12–23rd month of life, the majority (58/63, 92.1 %) received two recommended doses and the vast majority,

Table 1 Influenza immunizations in children from different age groups in the period 1996–2012

Year of vaccination	Number of vaccinated patients				
		6 to <12 mo (%)	≥12 to <24 mo (%)	≥2 to <5 yr (%)	≥5 yr (%)
1996	1	1 (100)	–	–	–
1997	2	1 (50.0)	–	1 (50.0)	–
1998	2	–	1 (50.0)	1 (50.0)	–
1999	3	–	–	3 (100)	–
2000	3	–	–	1 (33.3)	2 (66.7)
2001	6	–	–	3 (50.0)	3 (50.0)
2002	6	–	–	1 (16.7)	5 (83.3)
2003	16	1 (6.3)	–	4 (25.0)	11 (68.8)
2004	7	–	–	1 (14.3)	6 (85.7)
2005	20	1 (5.0)	1 (5.0)	3 (15.0)	15 (75.0)
2006	14	2 (14.3)	4 (28.6)	2 (14.3)	6 (42.9)
2007	22	1 (4.6)	6 (27.3)	3 (13.6)	12 (54.6)
2008	4	–	2 (50.0)	1 (25.0)	1 (25.0)
2009	31	1 (3.2)	2 (6.5)	16 (51.6)	12 (38.7)
2010	24	2 (8.3)	1 (4.2)	12 (50.0)	9 (37.5)
2011	16	1 (6.3)	3 (18.8)	3 (18.8)	9 (56.3)
2012	1	1 (100)	–	–	–
Total	178	12 (6.7)	20 (11.2)	55 (30.9)	91 (51.1)

mo months, *yr* years

54/58 children (93.1 %), took the both doses separated by an interval of at least 2 months as recommended. The schedule was correct in the vast majority of children, 54/63 children (85.7 %), in this group.

To conclude, the pneumococcal vaccination schedule was correct in only 16 children (7.0 %), who started their immunization in the first 6 months of life, in only 4 children (6.4 %), who started their immunization at aged 7–11 months, and in 54 children (85.7 %) who started their pneumococcal immunizations at aged 12–23 months.

3.3 Influenza Vaccination

Finally, we focused on immunizations against influenza, which should be administered annually starting at the age of 6 months. The number of patients who received at least one dose of the influenza vaccine was 109/1,356 (8.0 %) including 48/109 (36.7 %) children vaccinated once in their lifetime. The proper dosage regimen,

meaning the administration of two doses separated by a 4-week interval in children under 9 years of age, was used in 30/61 patients (49.2 %) vaccinated more than once. Only 3.5 % of all the patients (47/1,356) took both recommended vaccinations against respiratory infections, influenza, and pneumococcal vaccine.

Patients immunized against influenza in the following years were assigned to the following age groups: 0 to <12 months, ≥12 to <24 months, ≥2 to <5 years, and ≥5 years. The distribution of patients within particular group in each vaccination year is presented in Table 1. The majority of children were immunized aged over 5 years. Children aged 2–5 years were immunized less frequently with the exception of 2009 and 2010. However, it should be taken into consideration that children immunized more than once, i.e., in subsequent years, were assessed each time as a new patient, because each vaccination was in a different age range. Younger children (infants and children under 24 months) forming the highest risk group were immunized very rarely.

4 Discussion

4.1 Pertussis Vaccination

Pertussis immunization has been mandatory and has been offered free of charge in Poland as the combined diphtheria, tetanus and whole cell pertussis vaccine (DTPw) since the 1950s. Official recommendations for the routine annual immunization of children in Poland are made annually by the Chief Sanitary Inspector in collaboration with the advisory committee. The recommendations specify the type of vaccines, the number of doses that should be given, and the age ranges for their administration. With the addition of new vaccines, the Polish immunization program is increasingly complex (Chief Sanitary Inspector 2012). Nevertheless, the uptake of mandatory vaccinations in Poland is generally high. Three doses of the combined diphtheria, tetanus, and pertussis vaccine (DTP3) were received by around 99 % of Polish children in 2011, the figure being very close to the results of our study (96.6 %) (WHO 2011). Pertussis immunization coverage in our study was similar to that in other developed countries (WHO 2011). The timely administration of the vaccine doses remains a major problem.

The most important finding of our study was that a significant proportion of children fell behind with the schedule set out by the Polish National Immunization Program (Chief Sanitary Inspector 2012). In our study only 2/3 of children received the first dose of the vaccine on time, with delays ranging from 0.1 to 24.3 months, median: 0.8 months. The second and the third doses were administered in about ¾ of children (72.9 % and 72.6 %), with delays ranging from 0.03 to 45.7 months (median: 0.8 months) and from 0.7 to 46.7 months (median: 1.1 months), respectively. The percentage of children who fell behind with vaccinations is also high in other developed countries. Our data correspond well with the results of the National Immunization Survey in the U.S. children, which revealed that about 28 % of children did not comply with official vaccination recommendations and 19 % of children had missed one or more doses (Luman et al. 2008).

There are many possible reasons for vaccinations delays. The reasons can be divided into missed vaccination visits and missed opportunities for simultaneous multiple immunizations during one visit. To start with, parents and doctors have concerns about false contraindications to immunization, e.g., common colds, low grade fever, history of neonatal jaundice, or contact with a patient suffering from an infectious disease (ACIP 2011). Secondly, the frequency of visits required during the first 2 years of life could be difficult to adhere to for busy parents. As a result, some of the vaccinations, if not most of them, may be missed unintentionally, e.g., forgetting appointments, lack of time after the mother returns to work, or another child in the family who needs care (Tickner et al. 2006). The migration of young people to large cities and the reorganization of public healthcare in Poland may also contribute negatively. From time to time children are exempt due to real medical contraindications, e.g., acute disease or serious allergy, but actual contraindications to vaccinations are either rare, e.g., severe allergic reaction after a prior dose, or more commonly are short-term acute febrile illness. Sometimes not vaccinating children or delaying the scheduled vaccination visit is a conscious decision. Lack of faith in the vaccines may be a significant barrier (Ozawa and Stack 2013). Lack of the perceived threat of childhood diseases is also significant – parents may not be familiar with infectious diseases and do not appreciate the benefit of immunization (Ozawa and Stack 2013). Parents who see fewer benefits are less likely to vaccinate their children (Meszaros et al. 1996). Additionally, there is a growing anti-vaccine movement and sometimes the media may spread disinformation that induces a negative attitude to immunizations in Polish society.

The results of a study of Luman and Chu (2009) were that while missed vaccination visits are responsible for children falling behind in the first 6 months of life, missed opportunities for simultaneous immunizations accounted for more than 90 % of children aged 7–16 months. The vaccination schedule set out by the Polish National Program on Immunization (Chief Sanitary Inspector 2012) in addition to

immunization given after birth at the hospital, includes 6 immunization visits in the first 2 years of life. Four visits consist of three injections and two of a single injection. Even parents who understand the long-term benefits of immunizations acknowledge a trade-off with short-term disadvantages such as pain related to injections (Bennett and Smith 1992). According to a study by Bedford and Lansley (2007), the majority of parents agree to no more than one or two injections during one visit as this is less painful for the child. However, a previous study of Melman et al. (1999) showed that despite potential resistance to multiple injections, parents overwhelmingly complied with a physician's recommendations of five injections during one visit. The study indicated that parental resistance may be less of a barrier than previously feared. Although we did not examine the reasons for delays in vaccinations directly, our results indicate that simultaneous administration of vaccinations may matter in Poland. While only 3.5 % of our study group were immunized with both influenza and pneumococcal vaccines, the indications for their use are very similar (i.e., age and risk factors) and as many as 55.2 % of children were given the self-paid acellular vaccine as a 'five in one' or 'six in one' combined vaccine, which reduces the number of injections.

4.2 Pneumococcal and Influenza Vaccinations

While pertussis immunization has been mandatory and offered free of charge in Poland for many years, the influenza and pneumococcal vaccines are relatively new immunizations. They are recommended by the Polish National Immunization Program (Chief Sanitary Inspector 2012), but not subsidized with the exception of the pneumococcal vaccine for infants born prematurely and with a low birth weight (since 2013). Patients or their guardians have to pay for the vaccines. The immunization rates for this self-paid vaccines were significantly lower in our study. Price was important but not the only factor contributing to the unfavorable situation from a health

perspective. While pneumococcal conjugated vaccines are expensive (regular retail price about 60 Euro), but perceived as very important, influenza vaccines are relatively low-cost (regular retail price about 7 Euro), but need annual administration and suffer from societal perception as being less effective. In our study, more than 1/3 of children received pneumococcal vaccines (36.8 %) while only 8.0 % were ever immunized against influenza. On the other hand, in less than half (46.1 %) of the children immunized with the pneumococcal vaccine, the vaccination program started in the first 6 months of life, when children benefit most from immunization but more doses (four) are necessary. We think this could be explained by economic factors because the dosage regimen between 12 and 23 months of life includes only 2 doses of vaccine, thus it is definitely less expensive.

The results of a recent study of Ganczak et al. (2013) performed in 3 randomly selected general practices in Poland were very similar. The authors showed that combination vaccines are the most commonly used (62.3 %) followed by pneumococcal (36.4 %) and influenza vaccines (14.7 %). The high cost of the vaccines is associated with immunization rates being more than five times lower.

Influenza vaccine coverage in our study group was relatively low (8.0 %), although much higher than that among all children in Poland (2.6 %). The city of Wroclaw is large, where access to medical services is easy, and parents are usually well educated. Influenza vaccination coverage was similar or higher than that in other developed countries. In the U.S., the estimated national coverage among children aged 6 months to 17 years (≥ 1 or more doses for children < 9 years) was 51.0 % ranging from 37.3 % in Montana to 79.3 % in Rhode Island (CDC 2011). In Spain, the influenza vaccine coverage rate among children older than 6 months was similar (6.8 %) (Jiménez-García et al. 2008). Considering the fact that indications for immunization against *Streptococcus pneumoniae* and influenza are similar and that coverage of the conjugated pneumococcal vaccine was relatively high (36.8 %), the very low immunization coverage

(3.5 %) with both recommended vaccinations indicates that Polish parents do not accept the influenza vaccination for children. We assume that neither doctors nor parents are conscious of the importance of this immunization in prophylaxis of this serious respiratory disease in children. Compliance with the dosage regimen is very important in inactivated vaccines against respiratory diseases. The recommended schedules are based on the results of controlled clinical trials assessing the effectiveness and immunogenicity of vaccines. While a single dose of a live vaccine is usually sufficient to produce immunity, inactivated vaccines require multiple doses to protect children.

Our study is subject to at least two limitations. Firstly, we analyzed data from children from a single healthcare establishment where the personal preferences of a few doctors could significantly influence the results. To minimize the aforementioned negative impact we selected a large primary healthcare practice characterized by high staff turnover (i.e., many doctors working for a short period of time). Secondly, we did not collect the information on medical contraindications to vaccinations. However, true contraindications to vaccinations are rare or temporary and should not have had much impact on our results. Our study, although relatively limited, clearly identifies problems complying with the Polish National Immunization Program (Chief Sanitary Inspector 2012).

Our study showed that although immunization rates of mandatory vaccinations remain high, a substantial proportion of children in Poland fall behind the schedule. The high rate of delays in our study (32.9 % of children had postponed the first dose of the combined pertussis vaccine) indicates an urgent need for action. Polish parents care about the number of injections, cost of vaccines, and opinions about their effectiveness. Immunizations against vaccine-preventable respiratory diseases should be used more effectively, e.g., immunization against one disease should be regarded as an opportunity for immunization against other respiratory diseases.

5 Conclusions

Compliance with the Polish National Immunization Program should be increased by reducing the number of injections and the cost of vaccines, and introducing combination vaccines. Furthermore, education about immunizations is essential to facilitate acceptance of simultaneous administration of several vaccines during one visit and to prepare parents for judicious decision-making when it comes to immunization.

Conflicts of Interest The authors have no financial or otherwise relations that might lead to a conflict of interest.

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