

Public health impact and return on investment of the pediatric immunization program in Poland

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Background

Poland's pediatric immunization program (PIP) includes 9 vaccines recommended for children aged 0 to 10 years by the National Institute of Public Health (Narodowy Instytut Zdrowia Publicznego – Państwowy Instytut Badawczy)¹:

- Diphtheria, tetanus, and whole-cell pertussis (DTwP)
- *Haemophilus influenzae* type b (Hib)
- Hepatitis B (HepB)
- Inactivated poliovirus (IPV)
- Measles, mumps, rubella (MMR)
- Pneumococcal conjugate (PCV-10)
- Rotavirus (RV)^a
- Tetanus, diphtheria, and acellular pertussis (Tdap)
- Tuberculosis (TB)

Previous research has estimated the economic value of pediatric immunization and concluded that immunization yields savings from both healthcare payer and societal perspectives, with vaccination costs being significantly offset by disease-related costs averted.^{2,3}

Yet, no previous research has specifically assessed the broad economic value of the PIP in Poland.

^aConsidered in Scenario 2 only

Objective

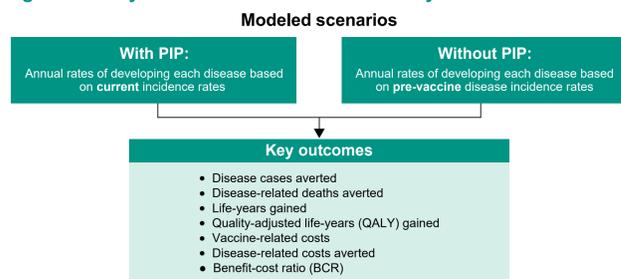
To evaluate the epidemiological impact and return on investment of the PIP in Poland from both healthcare payer and societal perspectives.

Methods

Model overview

- A previously published economic model was used to generate estimates of the public health and economic impact of routine childhood vaccination in Poland³
- The model structure included separate decision trees for each of the 12 pathogens covered in the Polish PIP (ie, diphtheria, tetanus, pertussis, poliomyelitis, *Haemophilus influenzae* type B, hepatitis B, measles, mumps, rubella, *Streptococcus pneumoniae*, rotavirus, and tuberculosis)
- The 2019 Polish birth cohort (388,178 people) was followed from birth to death, accounting for all-cause mortality and long-term disease complications (where applicable)
- The analysis is performed from two perspectives:
 - Healthcare payer perspective, which included the following costs:
 - Vaccination costs (acquisition-, administration-, and adverse events-related costs)
 - Direct medical costs of acute disease cases and long-term complications
 - Societal perspective, which, in addition to costs included in the healthcare payer perspective, contained the following costs:
 - Patient or caregiver productivity losses associated with acute disease cases and long-term complications
 - Value of time loss associated with disease-related mortality (ie, patient productivity using the human capital method)
- Two analytical scenarios were constructed: one in which routine pediatric immunization occurred according to Poland's PIP and one in which no immunization occurred (incidence of modeled diseases was assumed to reflect pre-vaccine levels) (Figure 1).
 - Because rotavirus vaccination was the most recently introduced vaccination into the Polish PIP and the full potential of the vaccination program may have not yet been demonstrated, two scenarios were assessed:
 - **Scenario 1:** Polish PIP excluding rotavirus vaccination (11 pathogens)
 - **Scenario 2:** Current Polish PIP (12 pathogens)

Figure 1. Analytical scenarios assessed and key incremental outcomes



Model inputs

- Vaccination followed the Polish childhood immunization schedule recommended by the National Institute of Public Health (Narodowy Instytut Zdrowia Publicznego PZH – Państwowy Instytut Badawczy)¹
- Vaccination costs included acquisition (based on public prices), administration, and adverse events (Table 1)
- Disease incidence estimates were used to calculate the annual number of disease cases (Table 2)
 - **With PIP:** Vaccine-era incidence for each disease was obtained from recent surveillance data (2013-2019) from the National Institute of Public Health, published incidence estimates for Poland or calculated by applying a reduction in disease incidence between the post- and pre-vaccine eras
 - **Without PIP:** Pre-vaccine incidence was obtained from published incidence estimates for Poland, Polish HTA analyses or calculated using annual published case estimates and Poland population data for the same period. Pre-vaccine incidence rates from other European countries were used for Poland when local data was unavailable
- Disease severity and cost data were obtained from previously published studies. Costs were presented in 2020 Polish zloty (currency exchange rate: 1 Euro = 4.45 zloty)
- Disease cases in both scenarios were assumed to be treated with the current standard of care in Poland to account for improvements in medical care over time
- The impact of the Polish PIP on quality of life was measured through inclusion of the following (with estimates obtained from the published literature):
 - QALYs lost due to vaccine-related adverse events
 - QALYs lost due to acute disease cases and long-term complications
 - QALYs lost due to disease-related mortality
- Analyses
 - Health outcomes were discounted at an annual rate of 3.5% and costs at an annual rate of 5%⁴
 - A financial benefit-cost ratio (BCR) was calculated for the Polish PIP by dividing the costs of disease cases averted by the net vaccination costs

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Table 1. Childhood immunization schedule, vaccine coverage estimates, and vaccine acquisition costs

Vaccine	Vaccination schedule ¹	Coverage ²				Acquisition cost per dose ³ (Zloty)
		Dose 1	Dose 2	Dose 3	Dose 4	
DTwP ^a	2, 3, 5, 16 months	95.2%	95.2%	95.2%	85.3%	31.05
Hepatitis B	Birth, 2, 7 months	97.8%	97.8%	90.9%	–	10.75
Hib ^a	3, 5, 16 months	95.1%	95.1%	95.1%	85.2%	26.70
MMR ^b	13 months and 6 years	92.9%	86.1%	–	–	26.45
Polio ^c	3, 5, 16 months and 6 years	95.1%	95.1%	85.2%	77.4%	29.48
PCV-10	2, 4, 13 months	94.1%	94.1%	84.3%	–	79.70
Rotavirus ^d	2, 3, 4 months	95.2%	95.2%	95.2%	–	36.54
Tuberculosis ^e	Birth	98.0%	–	–	–	12.96
Tdap ^f	6 years	77.6%	–	–	–	54.80

Note: Coverage data is from the 2017 birth cohort if not noted differently. ^aFor dose 4, vaccine coverage data from 2016 birth cohort. ^bFor dose 1, vaccine coverage data was based on 2016 birth cohort; for dose 2, vaccine coverage data from 2008 birth cohort. ^cFor dose 3, vaccine coverage data from 2016 birth cohort; for dose 4, 2012. ^dAssumed the same coverage as the DTwP vaccine, considered for Scenario 2. ^eCoverage data is from the 2018 birth cohort. ^fVaccine coverage was calculated using data from the 2012 birth cohort and coverage data for 4th dose of DTwP.

Table 2. Pre-vaccine and vaccine-era disease incidence estimates

Disease	Annual disease incidence per 100,000	
	Without PIP (pre-vaccine) ^a	With PIP (vaccine-era) ^a
Diphtheria ¹⁴	120	0
Hepatitis B ^{10-13, 15-17}	2-6	0-1
Hib ^{10-13, 17-19}	<1-4	0-1
Measles ^{10-13, 20, 21}	<1-3,313	0-3
Mumps ^{11-13, 17, 22-26}	<1-961	<1-34
Pertussis ^{27, 28}	10-1,041	6-49
<i>S pneumoniae</i> ^{b, 10, 111, 29-34}	–	–
Invasive pneumococcal disease	<1-5	<1-4 ^c
All-cause pneumonia hospitalizations	31-6,709	22-5,863 ^d
All-cause acute otitis media	0-30,427 ^e	0-17,132 ^e
Polio ^{10-13, 35, 36}	12	0
Rotavirus ^{5, 9, 34, 37-47}	–	–
Hospitalizations	2,152-2,660	511-714
ED visits	4,175-5,161	1,083-1,446
Outpatient visits	7,449-9,257	2,544-2,996
Rubella ^{10-13, 17, 22-26}	0-897	<1-45
Tetanus ⁴⁸⁻⁵²	<1-2	0-1
Tuberculosis ⁵³	174-371	1-24

Note: Sp, *S pneumoniae*. ^aRange indicates that incidence varies by age group within the presented range. ^bDefault all-cause pneumonia outpatient visit rates per 100,000 were assumed to be 0 due to a lack of Poland-specific data. All-cause pneumonia and acute otitis media were adjusted for the percentage of cases that were due to *S pneumoniae*. ^cNo Polish data available; Finnish data from the National Infectious Disease Register (Finnish Institute for Health and Welfare, THL) was used as a proxy. ^dSourced from Palmu et al. (2017) and Okasha et al. (2017). ^ePre-vaccine and post-vaccine incidence for ages 18 and older were assumed to be 0. ^fConsidered only for Scenario 2.

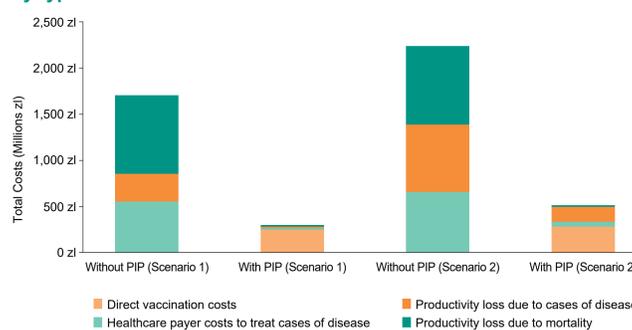
Results

Table 3. Incremental health outcomes by disease as per Scenario 1: Polish PIP excluding rotavirus vaccination (11 pathogens) and Scenario 2: Polish PIP (12 pathogens)

Disease	Cases averted		Premature deaths averted		LYs gained		QALYs gained	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Diphtheria	12,173		830		19,607		18,080	
Hepatitis B	1,137		18		387		1,090	
Hib	47		2		48		100	
Measles	79,133		63		1,697		2,178	
Pertussis	20,494		231		6,150		6,108	
Mumps	22,940		0		0		100	
<i>S pneumoniae</i>	268,167		196		2,905		3,908	
Polio	1,266		74		1,740		1,880	
Rotavirus	0	169,685	0		0		0	663
Rubella	20,525		0		2		82	
Tetanus	95		23		544		504	
Tuberculosis	26,351		211		4,846		4,806	
Total	452,329	622,014	1,648		37,926		38,835	39,498

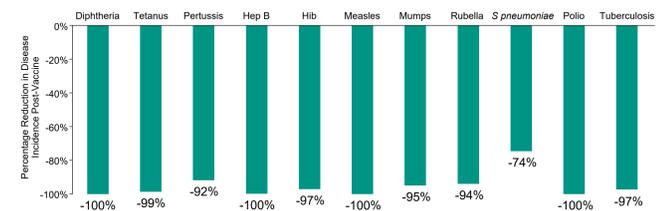
Note: LY, life-year; QALY, quality-adjusted life-year. Total cases of *S pneumoniae* are reported as a sum of invasive pneumococcal disease and estimated pneumococcal pneumonia hospitalizations and pneumococcal acute otitis media. Rotavirus total "cases" are reported as a sum of rotavirus-related hospitalizations, emergency department visits, and outpatient visits (may overestimate total rotavirus cases in the population, as some events may have multiple rotavirus-related visits).

Figure 2. Total costs, including societal costs with and without PIP, by type of costs



Note: Cost outcomes are discounted at an annual rate of 5% and are presented in 2020 Polish zloty.

Figure 3. Percentage reduction in disease incidence post-vaccine (Scenario 1)



Note: Percentage reductions in disease incidence rounded up to 100% for hepatitis B and measles, although there are still some cases observed in the post-vaccine era.

Table 4. Incremental costs and benefit-cost ratio for the Polish PIP as per Scenario 1 and Scenario 2

Incremental outcome	Healthcare payer perspective Zloty (million)		Societal perspective Zloty (million)	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Vaccination costs				
Acquisition	241	281	241	281
Adverse events	0.8	0.9	0.8	0.9
Disease-related costs averted				
Disease treatment	530	606	530	606
Productivity loss due to disease	–	–	287	571
Productivity loss due to disease-related mortality	–	–	835	835
Financial benefit-cost ratio	2.19	2.15	6.84	7.15
Total costs averted	289	324	1,411	1,730
Value of QALYs saved^a	–	–	6,039	6,142

Note: Costs are presented in 2020 zloty. ^aThe value of QALYs saved is calculated by multiplying the total QALYs saved with the PIP by the willingness-to-pay threshold in Poland (155,514 zloty per QALY gained in 2020).

Limitations

- Using epidemiology data from other European countries in cases where local data was not available
- Vaccine acquisition costs were sourced from public prices, which may not reflect tender prices and, hence, overestimate vaccine acquisition costs
- Although the model follows the birth cohort for their full lifetime, certain diseases were only modeled for younger ages based on the epidemiology of the disease and/or available data
- Potential underreporting was not explicitly considered in disease incidence estimates with and without the PIP
- A static modeling approach was applied for each disease; as such, important externalities (eg, community immunity) were not considered
- Limited data on complication costs and disease outcomes were available in literature, particularly for diseases that were no longer prevalent in Poland

Conclusions

- This analysis shows that for one birth cohort (2019), approximately 452,000 disease cases and 1,600 premature disease-related deaths were prevented by the Polish PIP
- Including rotavirus vaccination, the number of disease cases averted increases to approximately 622,000
- Each zloty invested in childhood immunization results in approximately 7 zloty and 2 zloty in societal disease-related and direct healthcare cost savings for the Polish PIP, respectively
- The Polish PIP, which has not previously been systematically assessed, brings large-scale prevention of disease-related morbidity, premature mortality, and associated costs. Results from this study highlight the value of the childhood immunization program in preventing disease-related morbidity, mortality, QALY losses, and associated costs

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