

Calculating the Indirect Costs of Adult Pneumococcal Disease and the Rate of Return to the 13-Valent Pneumococcal Conjugate Vaccine (PCV13) in Older Adults, With an Application to Denmark



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BACKGROUND

- Standard health technology assessments (HTAs) focus mainly on quality-of-life (QALY) benefits of health technologies and occasionally consider market productivity gains. QALY benefits are important, but HTAs should also consistently and systematically consider the broader non-QALY benefits of vaccination. These include community health externalities, risk reduction gains, and most relevant to this work, gains in market and nonmarket productivity (avoided indirect costs, ICs).¹
- HTAs should consider decision criteria that incorporate such broad benefits, like social rates of return (RoRs).¹

OBJECTIVES

- To develop methods for measuring ICs of disease, incorporating both market and nonmarket productivity, and productivity-based RoRs to vaccination
- To apply these methods to adult pneumococcal disease and the 13 valent pneumococcal conjugate vaccine (PCV13) in Danish older adults

METHODS

- We measure ICs per treatment episode of inpatient community-acquired pneumonia (ICAP), outpatient CAP (OCAP), bacteremia, and meningitis. Each episode has a set of possible outcomes (ICAP and bacteremia: death and temporary disability [TD]; OCAP: TD; meningitis: death, TD, persistent vegetative state [PVS], moderate disability [MD], and severe disability [SD]). The expected ICs per episode equal the sum across outcomes of the probability of the outcome times its IC.
- ICs of an outcome equal the expected present discounted value of market and nonmarket productivity losses. Market productivity equals earnings. Nonmarket productivity equals housework, caregiving, and volunteering time valued at the unskilled wage.
- ICs of death span the rest of life facing background mortality risks. ICs of TD include periods of no productivity, reduced productivity on returning to work, and caregivers' foregone market productivity (eg, for ICAP, these periods last 11.14 and 2.36 days and 16.25 hours, respectively).^{2*} PVS lasts 4 years with zero productivity followed by death.^{3*} SD means zero lifetime productivity and elevated mortality risks.^{4*} and MD means the loss of 2 years of productivity followed by full recovery.^{5,6*} PVS and SD require long-term formal care during disability.
- The social RoR equals the ratio of direct costs (DCs) and ICs averted by PCV13 Adult to the cost of vaccination, minus one.
- Baseline vaccine efficacy for CAP/IPD: 0.80/0.95 at age 50 years, 0.27/0.58 at age 85 years; constant proportional decline at intermediate ages.
 - Waning: Efficacy is constant for 5 years, declines 5% annually for 5 years, declines 10% annually for the next 5 years, and is zero thereafter.^{7,8}
- We allow for herd effects from pediatric PCV13 vaccination, similar in size to those from PCV7, but no severity effects from PCV13 Adult.
- We study the Danish general population aged 50–85 years and people with diabetes aged 65–85 years.
- We discount costs and benefits at 4% and grow wages at 0.9% annually.^{9*}
- We scale general population incidence and case fatality rates, earnings, and background mortality for our analysis of people with diabetes.
- We average ICs across ages by weighting each age in proportion to its population size and incidence. We average RoRs across ages weighting only by population size.

*Denotes that presented values are calculated by the authors and cannot be found directly in the cited sources.

CONCLUSIONS

- ICs per episode approach or exceed per capita gross domestic product for ICAP and IPD, and are 20 times the DCs for OCAP.^{30,32*}
- ICs are largely driven by the value of foregone housework from death (eg, for ICAP deaths among adults aged 50–85 y, lost housework costs €323,096.78, followed by lost earnings [€73,119.72], lost caregiving [€22,414.03], and lost volunteering [€8804.46]). Thus, ICs are high even among retirees.
- The RoR is large, driven mostly by averted ICAP costs (because ICAP's preventable burden is high relative to IPD's), and compares favorably with highly regarded public investments like primary education, which has an RoR of 19%.³³
- ICs for people with diabetes are similar to those for the general population, but the RoR is an order of magnitude larger because of much higher incidence and case fatality rates and therefore likelihood of averting ICs through vaccination.
- Main results are robust to 1-way deterministic sensitivity analyses.
- Failing to account for productivity in valuing vaccination can result in considerable undervaluation.

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RESULTS

Table 1. Sample Epidemiologic Input Parameter Values by Age Group

Parameter	Age, y								Source
	50–54	55–59	60–64	65–69	70–74	75–79	80–84	≥85	
Incidence per 1000, ICAP	3.77	5.62	9.16	11.15	20.81	30.99	51.67	130.13	10, 11*
Incidence per 1000, OCAP	1.22	1.43	3.05	2.84	4.75	7.07	7.13	17.76	11, 12*
Incidence per 100,000, bacteremia	17.57	17.57	17.57	47.07	47.07	47.07	47.07	47.07	13, 14*
Incidence per 100,000, meningitis	1.43	1.43	1.43	2.33	2.33	2.33	2.33	2.33	13, 14*
Case fatality rate, ICAP	0.084	0.084	0.084	0.14	0.14	0.14	0.25	0.25	15
Case fatality rate, OCAP	0	0	0	0	0	0	0	0	Assumed
Case fatality rate, bacteremia	0.025	0.025	0.025	0.11	0.11	0.11	0.11	0.11	13
Case fatality rate, meningitis	0.26	0.26	0.26	0.38	0.38	0.38	0.33	0.33	16
Probability of meningitis causing									
Persistent vegetative state	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	17
Severe disability	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	17
Moderate disability	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	17
Prevalence of diabetes	N/A	N/A	N/A	0.18	0.20	0.21	0.23	0.24	18*
For people with diabetes, parameters scaled by									
Incidence, ICAP	N/A	N/A	N/A	1.50	1.50	1.50	1.50	1.50	7, 11*
Incidence, OCAP	N/A	N/A	N/A	1.55	1.55	1.55	1.55	1.55	7, 11*
Incidence, bacteremia/meningitis	N/A	N/A	N/A	1.56	1.56	1.56	1.56	1.56	7, 11*
Case fatality rate, ICAP/OCAP	N/A	N/A	N/A	1.29	1.29	1.29	1.29	1.29	7, 11*
Case fatality rate, bacteremia/meningitis	N/A	N/A	N/A	1.40	1.40	1.40	1.40	1.40	7, 11*

ICAP=inpatient community-acquired pneumonia; OCAP=outpatient community-acquired pneumonia.
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Table 2. Sample Economic Input Parameter Values by Age Group

Parameter	Age, y							Source
	50–54	55–59	60–64	65–69	70–74	75–85		
Annual earnings, AO (€)	58,112	58,112	86,118	65,654	65,654	0	19–22*	
Hourly earnings, AO (€)	29.41	29.41	29.73	29.73	29.73	29.73	23	
Hourly earnings, EO (€)	22.88	22.88	22.73	22.73	22.73	22.73	23	
Average hourly earnings (aged ≥15 y), EO (€)	21.46	21.46	21.46	21.46	21.46	21.46	23	
Average hourly earnings (aged ≥15 y), PO (€)	31.75	31.75	31.75	31.75	31.75	31.75	23	
Employment rate	0.82	0.80	0.49	0.15	0.071	0	24	
Average employment rate (aged ≥15 y)	0.58	0.58	0.58	0.58	0.58	0.58	24	
Weekly hours working	33.50	33.50	33.50	33.50	33.50	33.50	25	
Daily minutes doing housework	229.18	229.18	229.18	285.71	285.71	285.71	26*	
Daily minutes volunteering	5.00	5.00	5.00	8.00	8.00	8.00	26*	
Daily minutes caregiving	24.82	24.82	24.82	18.29	18.29	18.29	26*	
For long-term care, monthly hours of								
Informal care	3790	3790	3790	3790	3790	3790	27	
Nursing care	2.70	2.70	2.70	2.70	2.70	2.70	27	
Paid domestic help	9.30	9.30	9.30	9.30	9.30	9.30	27	
Earnings scale factor for people with diabetes	N/A	N/A	N/A	0.89	0.89	0.89	28*	
Cost of vaccine (€)	76.85	76.85	76.85	76.85	76.85	76.85	29, 30*	
Cost to administer vaccine (€)	36.97	36.97	36.97	36.97	36.97	36.97	30, 31*	

AO=all occupations; EO=elementary occupations; PO=professional occupations.
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Table 3. Average ICs per Treatment Episode (Percentage of Per Capita GDP)⁹ by Manifestation and Population (2014 Euros)

Manifestation	Adults Aged 50–85 y		People With Diabetes Aged 65–85 y	
	IC	IC	IC	IC
ICAP	54,859.59 (117)		53,589.86 (114)	
OCAP	2,014.25 (4)		1,997.53 (4)	
Bacteremia	40,044.52 (85)		53,227.95 (113)	
Meningitis	253,365.01 (539)		215,555.71 (459)	

GDP=gross domestic product; IC=indirect cost; ICAP=inpatient community-acquired pneumonia; OCAP=outpatient community-acquired pneumonia.

Table 4. Average ICs per Treatment Episode by Manifestation, Adults Aged 50–85 y (Monetary Figures in 2014 Euros)

Manifestation	Average IC	Death		TD		PVS		SD		MD	
		Probability	IC	Probability	IC	Probability	IC	Probability	IC	Probability	IC
ICAP	54,859.59	0.16	427,434.98	0.84	3050.32	-	-	-	-	-	-
OCAP	2,014.25	-	-	1.00	2,014.25	-	-	-	-	-	-
Bacteremia	40,044.52	0.082	568,109.93	0.92	3956.88	-	-	-	-	-	-
Meningitis	253,365.01	0.33	636,495.80	0.47	4116.03	0.010	663,793.26	0.050	713,745.90	0.14	116,410.17

IC=indirect cost; ICAP=inpatient community-acquired pneumonia; MD=moderate disability; OCAP=outpatient community-acquired pneumonia; PVS=persistent vegetative state; SD=severe disability; TD=temporary disability.

Table 5. Average RoR to PCV13 Adult by Population

Population	RoR, %
Adults aged 50–85 y	149.35
People with diabetes aged 65–85 y	1190.81

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