

Economic Analysis and Public Health Impact of PCV use for Adults Aged ≥ 50 Years

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Conflicts of Interest

- ❑ **Dr. Stoecker has no conflicts of interest to declare.**

Acronyms

- ❑ PCV: pneumococcal conjugate vaccine
- ❑ PCV20: 20 valent PCV
- ❑ PCV21: 21 valent PCV
- ❑ VE: vaccine effectiveness
- ❑ VT: vaccine type
- ❑ ST: serotype
- ❑ NBP: non-bacteremic pneumonia
- ❑ IPD: invasive pneumococcal disease
- ❑ IPT: inpatient
- ❑ OPT: outpatient
- ❑ QALY: quality adjusted life year
- ❑ IC: immunocompromised
- ❑ CMC: chronic medical conditions, but not IC
- ❑ NIS: National Immunization Survey
- ❑ ABCs: Active Bacterial Core Surveillance System

Methods: Study Question

- ❑ **Evaluate cost effectiveness of an age-based recommendation for PCV20 or PCV21 in adults younger than age 65**
 - Motivation is to get higher coverage among risk-based adults
 - Additionally get coverage among general population
- ❑ **Evaluate**
 - Program cost/savings
 - Changes in disease, medical costs, nonmedical costs, and work productivity costs
 - Limited societal perspective
 - Population
 - Cohort of 4,051,078 50-year-olds
 - Separate model buckets for:
 - Immunocompromised (IC) – HIV, Cancer, Organ Transplants, Dialysis
 - Chronic medical conditions (CMC)– Diabetes, Heart Disease, Lung Disease, Liver Disease, Alcoholism
 - Others –“General”

Two Modeling Strategies

❑ Moving Strategies

- Moving age-based recommendation from 65 to age 50
- Shifts disease burden from younger to older adults
- Moving strategy will overcount benefits
 - Overstates savings from not vaccinating at age 65 years
 - Overstates unprotected time if waning is longer than 15 years
 - If the future policy considerations will add a later age-based vaccination after reevaluation in the future
 - Reevaluations could be motivated by waning evaluation or higher valency vaccinations

❑ Adding Strategies

- Adding vaccination at 50 in addition to 65
- In the future, clinicians may prefer to administer a booster dose at age 65 years in the "moving strategy" to ensure protection for older adults
- Maintains protective benefits for older adults from current age-based recommendation

Specific Strategies to Evaluate

❑ Moving Strategies

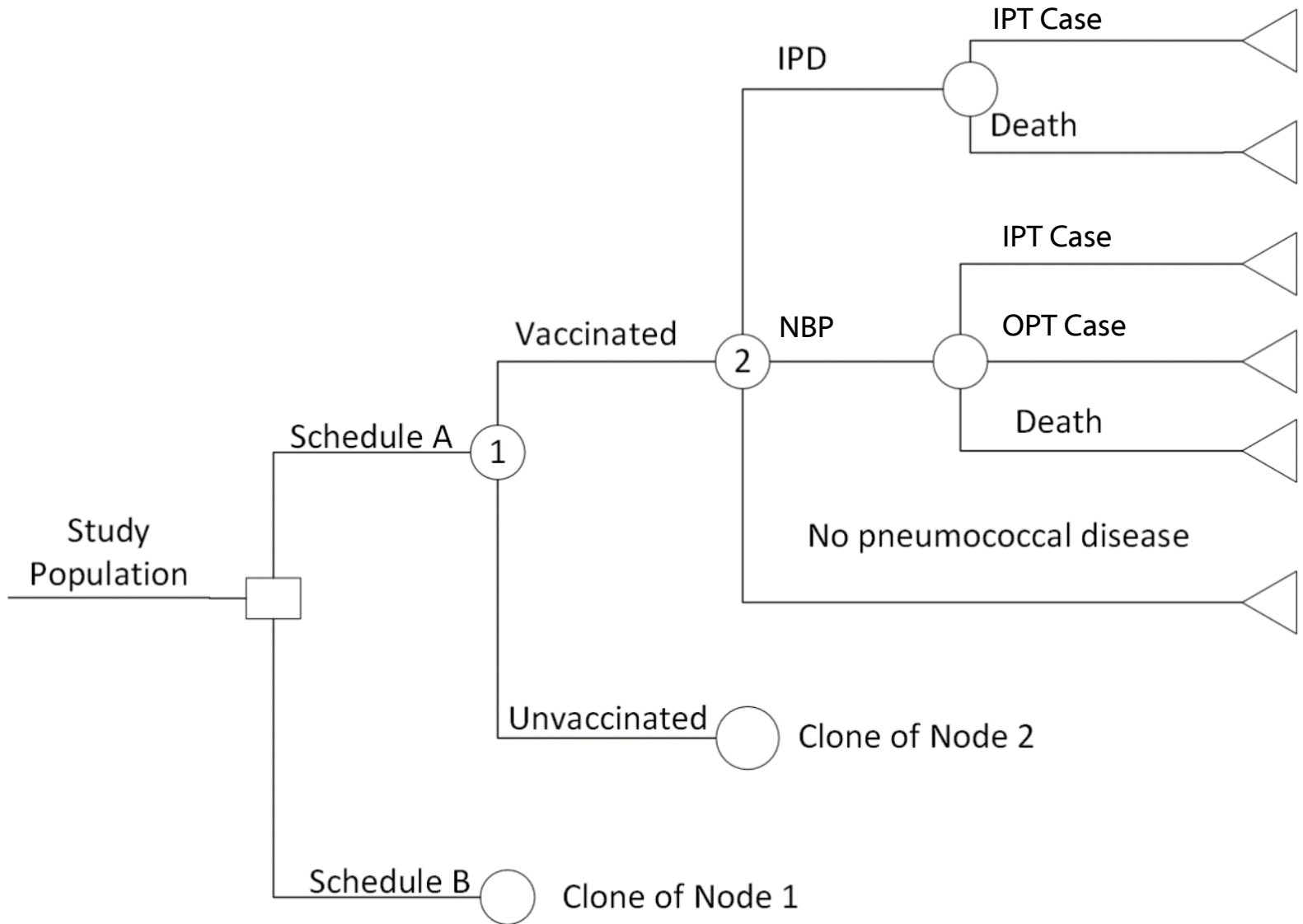
Intervention	Comparator
PCV20 at age 50	PCV20 at CMC/IC & PCV20 at age 65
PCV20 at age 60	PCV20 at CMC/IC & PCV20 at age 65

❑ Adding Strategies

Intervention	Comparator
PCV20 at ages 50 & 65	PCV20 at CMC/IC & PCV20 at age 65
PCV20 at ages 60 & 75	PCV20 at CMC/IC & PCV20 at age 65

❑ Repeat with PCV21

Conceptual Model



Background mortality from non-pneumococcus related illness is included in all branches, but not displayed in the model for brevity.
Abbreviations: IPT-inpatient case, OPT-outpatient case, IPD-invasive pneumococcal disease, NBP-non-bacteremic pneumonia

Model Inputs

- ❑ **IPD rates, all-cause IPT and OPT NBP rates, IPD cases resulting in fatality were estimated by age- and risk group (general/CMC/IC).**
- ❑ **Age-group specific IPT NBP case fatality rates were applied to the 3 risk groups**
- ❑ **Vaccine effectiveness (VE) was estimated by risk group and outcome (IPD/NBP)**
 - VE against serotype 3 was lower than other VT
 - Vaccine serotype effectiveness was the same across PCV20 and PCV21
- ❑ **Vaccine coverage was estimated separately by age group (50–64, 65+) and for existing risk-based recommendations (age 50-64)**
 - Updated from June 2024 presentation with more granular data

Vaccine Price

- ❑ **PCV20 \$288.66^a**
- ❑ **PCV21 \$319.43^b**

- ❑ **Administration 50-64 years: \$30.49^c**
- ❑ **Administration 65+ years: \$21.07^d**
- ❑ **Travel + patient time cost: \$44.46^e**

^a Payment Allowance Limits for Medicare Part B for PCV20.

^b Applied ratio of PCV21 to PCV20 price from manufacturer model and applied to PCV20 Medicare price. Sensitivity analysis uses upper bound of manufacturer PCV21 price range.

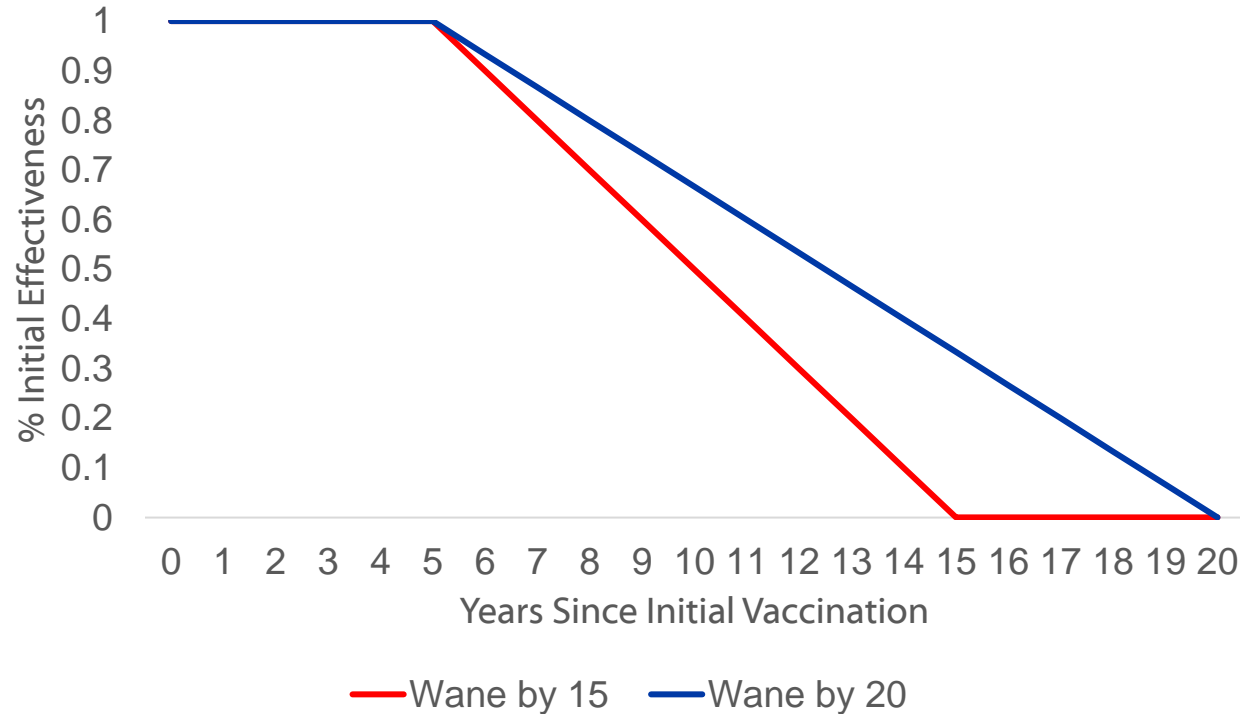
^c Tsai et al. AJPM 2019. Updated to 2023 dollars.

^d Average Medicare maximum allowable reimbursement for immunization administration (HCPCS code 90471) across all Medicare Administrative Contractors, 2023.

^e Travel cost from Maciosek et al. Am J Prev Med 2006. Updated to 2023 dollars.

Waning Immunity Assumptions

- ❑ No decline in effectiveness for first five years ^a
- ❑ Wane to zero over next 10 or 15 years ^b



^aPatterson S, Webber C, Patton M, Drews W, Huijts SM, Bolkenbaas M, et al. A post hoc assessment of duration of protection in CAPiTA (Community Acquired Pneumonia immunization Trial in Adults). *Trials in Vaccinology*. 2016;5:.92-96.

^bvan Werkhoven CH, Huijts SM, Bolkenbaas M, Grobbee DE, Bonten MJ. The Impact of Age on the Efficacy of 13-valent Pneumococcal Conjugate Vaccine in Elderly. *Clin Infect Dis* 2015;61(12):1835-8.

Herd Effects from PCV20 in Children

- ❑ **Apply serotype group-specific declines observed in PCV13 types (+6C, -3, -19F) in adults after PCV13 introduction in children**
- ❑ **Apply to additional types in PCV20 but not in PCV13**
- ❑ **Run versions of the model with and without these herd effects to assess importance**

Year	Remaining Proportion of Disease
1	0.755161
2	0.496227
3	0.339094
4	0.244074
5	0.187125
6	0.156599
7+	No further declines

Moving Strategies

15 Year Waning, With Herd Effects

	PCV20	PCV20	PCV21	PCV21
	50 vs. 65	60 vs. 65	50 vs. 65	60 vs. 65
IPD Cases	44	32	458	464
Hospitalized Pneumonia Cases	871	808	1,925	1,977
Non-hospitalized Pneumonia Cases	722	590	1,498	2,017
Deaths due to IPD	12	9	69	66
Deaths due to Hospitalized Pneumonia	37	35	83	83
QALYs	66	-102	-210	-671
Total Cost (million\$)	-\$76	-\$206	-\$121	-\$218
\$ Saved / QALY Lost	Cost-Saving	2,023,745	575,614	324,164
Undiscounted Cases 50-64	-4,031	-3,217	-9,338	-6,265
Undiscounted Cases 65+	9,681	6,374	22,261	14,735
Undiscounted Deaths 50-64	-69	-54	-154	-106
Undiscounted Deaths 65+	203	136	530	356

Adding Strategies

15 Year Waning, With Herd Effects

	PCV21 at Age 50 and 65	PCV21 at Age 60 and 75	PCV20 at Age 50 and 65	PCV20 at Age 60 and 75
IPD Cases	-932	-941	-434	-354
Hospitalized Pneumonia Cases	-1,367	-4,117	-600	-1,868
Non-hospitalized Pneumonia Cases	-6,000	-7,233	-2,635	-3,467
Deaths due to IPD	-100	-133	-46	-46
Deaths due to Hospitalized Pneumonia	-38	-171	-17	-77
QALYs	2,070	1,581	956	741
Life-years	2,633	2,407	1,214	1,092
Costs (million \$)				
Total Cost	\$444	\$189	\$523	\$270
Medical Costs	-\$141	-\$177	-\$64	-\$82
Vaccine Costs	\$689	\$403	\$635	\$372
Work Loss	-\$103	-\$37	-\$48	-\$20
Cost Ratios (\$)				
Cost/QALY	214,430	119,665	546,811	364,497
Cost/Life-year	168,533	78,612	430,913	247,411

20 Year Waning, With Herd Effects

	PCV21 at Age 50 and 65	PCV21 at Age 60 and 75	PCV20 at Age 50 and 65	PCV20 at Age 60 and 75
IPD Cases	-989	-949	-449	-355
Hospitalized Pneumonia Cases	-1,455	-3,595	-618	-1,649
Non-hospitalized Pneumonia Cases	-6,386	-7,075	-2,710	-3,389
Deaths due to IPD	-106	-153	-48	-51
Deaths due to Hospitalized Pneumonia	-40	-155	-17	-70
QALYs	2,144	1,445	967	676
Life-years	2,747	2,199	1,234	992
Costs (million \$)				
Total Cost	\$433	\$206	\$521	\$278
Medical Costs	-\$150	-\$162	-\$66	-\$75
Vaccine Costs	\$689	\$403	\$635	\$372
Work Loss	-\$105	-\$35	-\$48	-\$19
Cost Ratios (\$)				
Cost/QALY	202,019	142,373	539,097	411,202
Cost/Life-year	157,728	93,531	422,657	280,039

15 Year Waning, No Herd Effects

	PCV21 at Age 50 and 65	PCV21 at Age 60 and 75	PCV20 at Age 50 and 65	PCV20 at Age 60 and 75
IPD Cases	-1,283	-1,275	-795	-704
Hospitalized Pneumonia Cases	-1,781	-6,587	-1,115	-5,139
Non-hospitalized Pneumonia Cases	-7,819	-10,216	-4,892	-7,346
Deaths due to IPD	-137	-184	-84	-100
Deaths due to Hospitalized Pneumonia	-49	-281	-31	-223
QALYs	2,778	2,177	1,725	1,480
Life-years	3,541	3,390	2,193	2,310
Costs (million \$)				
Total Cost	\$364	\$109	\$433	\$170
Medical Costs	-\$189	-\$253	-\$118	-\$178
Vaccine Costs	\$689	\$403	\$635	\$372
Work Loss	-\$136	-\$41	-\$84	-\$25
Cost Ratios (\$)				
Cost/QALY	131,028	50,122	251,037	114,909
Cost/Life-year	102,804	32,186	197,417	73,619

Limitations

- ❑ **Uncertainty around waning & herd effects**
- ❑ **Sequelae from IPD not modeled explicitly**
- ❑ **Uncertainties about the pneumococcal disease trends due to pneumococcal serotypes that are no longer included in PCV21 (e.g., serotype 4, 19F)**
- ❑ **Disruption from changing pneumococcal schedule not modeled**

Moving Strategy Summary

- **Moving age-based vaccination from age 65 to lower ages:**
 - All scenarios result in increased net cases
 - Lowers cases and deaths in ages 50-64
 - Increases cases and deaths in ages 65+
 - Lower cost
 - Also true under longer vaccine waning scenarios and scenarios without herd immunity from childhood program (Appendix)

Adding Strategy Summary

- ❑ **Adding a second age-based vaccination results in increased QALYs and costs compared with the current recommendation**
 - ICERs range from \$50k/QALY to \$500k/QALY
 - ICERs are always lower for PCV21 recommendations than PCV20 recommendations
- ❑ **Assuming no herd effects improves economic efficiency of both PCV20 & PCV21**
 - Change in \$/QALY is greater in PCV20 than PCV21
 - But this change is not large enough to make PCV20 more efficient than PCV21
- ❑ **Assumptions surrounding vaccine waning are minimally impactful on ICERs**
 - Waning is extended in both the intervention and comparison strategies
- ❑ **Vaccination at later ages is more economically efficient**
 - Vaccination at 60 & 75 is lower \$/QALY than vaccination at 50 & 65 (or 55 & 70)

Thank you!

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IPD Serotype Distributions, General

Serotype Group	18-49 Years	50-64 Years	65-74 Years	75-84 Years	85+ Years
% PCV20 only -4-19F (1, 5, 6B, 9V, 14, 18C, 23F, 15B, including isolates reported as 15BC)	1.99%	1.52%	3.09%	1.01%	1.08%
% PCV20 & PCV21 -3 (6A, 7F, 19A, 22F, 33F, 8, 10A, 11A, 12F) +6C	34.44%	41.95%	32.72%	32.32%	33.33%
% PCV21 only -35B (9N, 17F, 20, 15A, 15C, 16F, 23A, 23B, 24F, 31)	30.13%	30.70%	31.48%	29.29%	35.48%
% serotype 3	13.91%	12.46%	17.28%	21.21%	14.25%
% serotype 4	4.97%	2.43%	1.23%	0.00%	0.00%
% serotype 19F	4.97%	4.56%	3.70%	3.03%	3.01%
% serotype 35B	2.65%	0.91%	4.32%	5.05%	3.23%
Ratio PCV21 only:PCV20 only serotypes	2.75	3.71	4.46	8.50	9.46

IPD Serotype Distributions, CMC

Serotype Group	18-49 Years	50-64 Years	65-74 Years	75-84 Years	85+ Years
% PCV20 only -4-19F (1, 5, 6B, 9V, 14, 18C, 23F, 15B, including isolates reported as 15BC)	0.49%	0.71%	1.88%	2.17%	1.81%
% PCV20 & PCV21 -3 (6A, 7F, 19A, 22F, 33F, 8, 10A, 11A, 12F) +6C	36.99%	33.62%	30.36%	32.79%	28.62%
% PCV21 only -35B (9N, 17F, 20, 15A, 15C, 16F, 23A, 23B, 24F, 31)	30.33%	32.67%	30.83%	32.52%	33.70%
% serotype 3	11.34%	17.96%	21.91%	17.07%	17.39%
% serotype 4	9.99%	4.35%	1.25%	0.27%	0.72%
% serotype 19F	3.08%	2.45%	2.66%	2.44%	2.17%
% serotype 35B	2.59%	3.01%	4.23%	5.15%	6.88%
Ratio PCV21 only:PCV20 only serotypes	2.43	4.75	6.06	7.72	8.63

IPD Serotype Distributions, IC

Serotype Group	18-49 Years	50-64 Years	65-74 Years	75-84 Years	85+ Years
% PCV20 only -4-19F (1, 5, 6B, 9V, 14, 18C, 23F, 15B, including isolates reported as 15BC)	6.02%	3.92%	3.30%	2.88%	0.00%
% PCV20 & PCV21 -3 (6A, 7F, 19A, 22F, 33F, 8, 10A, 11A, 12F) +6C	28.92%	31.63%	30.03%	37.50%	48.31%
% PCV21 only -35B (9N, 17F, 20, 15A, 15C, 16F, 23A, 23B, 24F, 31)	31.33%	33.73%	33.99%	26.44%	25.84%
% serotype 3	15.66%	8.43%	11.55%	10.10%	4.49%
% serotype 4	1.20%	1.20%	1.32%	0.00%	0.00%
% serotype 19F	3.61%	3.61%	3.30%	1.44%	5.62%
% serotype 35B	6.02%	6.63%	8.91%	9.62%	5.62%
Ratio PCV21 only:PCV20 only serotypes	3.45	4.62	5.42	8.35	5.60

NBP Serotype Distributions

Serotype Group	18-49 Years	50-64 Years	65+ Years
% PCV20 only -4-19F (1, 5, 6B, 9V, 14, 18C, 23F, 15B)	0.6%	0.7%	1.1%
% PCV20 & PCV21 -3 (6A, 7F, 19A, 22F, 33F, 8, 10A, 11A, 12F) +6C	3.0%	4.5%	3.9%
% PCV21 only -35B (9N, 17F, 20, 15A, 15C, 16F, 23A, 23B, 24F, 31)	3.2%	4.2%	2.4%
% serotype 3	1.1%	2.0%	1.4%
% serotype 4	0.0%	0.2%	0.2%
% serotype 19F	0.1%	0.9%	0.7%
% serotype 35B	0.8%	0.6%	0.7%
Ratio PCV21 only:PCV20 only serotypes	5.7	2.7	1.6

Source: Merck adjusted SSUAD serotype distribution data.

Note that the serotype distribution is among all community-acquired pneumonia, not limited to pneumococcal pneumonia.

For multivariate sensitivity analyses distributions are beta-pert with +/-20% for low and high.

IPD Rates per 100k

Risk Group	19-49 Years	50-64 Years	65-74 Years	75-84 Years	85+ Years
General	2.09	6.09	8.25	13.90	33.06
CMC	8.09	24.04	25.89	33.34	58.57
IC	16.22	37.28	35.10	36.81	46.38

NBP Hospitalization Rates per 100k

Risk Group	19-49 Years	50-64 Years	65-74 Years	75+ Years
General	35 (35, 36)	88 (87, 90)	191 (185, 197)	957 (938, 975)
CMC	207 (202, 212)	429 (423, 425)	941 (925, 957)	2745 (2717, 2774)
IC	701 (681, 721)	1226 (1207, 1244)	2124 (2087, 2162)	3992 (3944, 4040)

NBP Outpatient Rates per 100k

Risk Group	19-49 Years	50-64 Years	65-74 Years	75-84 Years	85+ Years
General	322.92	385.04	491.98	1366.22	2378.97
CMC	1872.91	1886.72	2410.70	3962.03	6899.00
IC	6361.40	5352.10	5461.00	5738.10	9991.70

IPD Cases Resulting in Fatality

Risk Group	19-49 Years	50-64 Years	65-74 Years	75-84 Years	85+ Years
General	5.54%	8.73%	7.93%	11.25%	17.30%
CMC	7.24%	11.06%	12.22%	12.82%	22.97%
IC	10.04%	14.27%	13.97%	11.33%	17.62%

IPT NBP Cases Resulting in Fatality

	Base	Low	High
18-49 Years	1.6	0.4	2.9
50-64 Years	2.8	1.1	4.4
65-74 Years	3.5	1.5	5.5
75-84 Years	4.1	2.2	6.0
85+ Years	5.3	3.3	7.2

Vaccine Effectiveness

	General	CMC	IC
PCV vs VT (-ST3) IPD ^a	75.0 (41.4, 90.8)	75.0 (41.4, 90.8)	25.0 (13.8, 30.3)
PCV vs ST3 IPD ^b	26.0 (0, 53.4)	26.0 (0, 53.4)	8.7 (0, 17.8)
PCV vs VT (-ST3) NBP ^c	66.7 (11.8, 89.3)	40.3 (11.4, 60.2)	15.0 (4.7, 21.8)
PCV vs ST3 NBP ^d	15.6 (0, 32.0)	15.6 (0, 32.0)	5.2 (0, 10.7)

a. Bonten NEJM 2015 (per protocol)

b. Point estimate from Pilishvili et al. ISPPD2018 abstract, lower bound set to 0, upper bound from Lewis 2020 ISPPD poster

c. Suaya Vaccine 2018; 1477-1483.

d. Applied the ratio of IPD VE/Pneumonia VE for all PCV13 types to the point estimate for ST3 IPD VE.

Coverage Rates

	June 2024	
	Inputs	Updated
PCV Age-based 50-64	39.65 ^b	47.6 ^e
PCV Age-based 65+	56 ^c	70 ^f
Risk-based (50-64)	22.2 ^a	37.5 ^f

a. NHIS 2021 data <https://www.cdc.gov/vaccines/imz-managers/coverage/adultvaxview/pubs-resources/vaccination-coverage-adults-2021.html> ;

b. Mean of NHIS 2021 for Zoster Vaccine in adults 60-64 years; and estimate for PCV15/PCV20 coverage in adults 65 years and older

c. Mean of NHIS 2021 any pneumococcal coverage; and any PCV13 coverage data in Medicare beneficiaries aged ≥65 years, 2019

e. Applied the ratio of vaccine coverage among ages 50-64/65+ for Influenza and COVID-19 vaccines to age-based pneumococcal vaccine coverage in adults aged 65+years

f. BRFSS 2022, any pneumococcal vaccine coverage

Utility Decrements

Variable	QALY Decrements ^a	Implied Healthy Days Lost ^b
IPD	0.0709 (0.0509, 0.0909)	25.9
IPT NBP	0.0709 (0.0509, 0.0909)	25.9
OPT NBP	0.0045 (0.00399, 0.00501)	1.6

Alternate Utility Decrements^c

Pneumococcal Disease Treatment Intensity, Age	QALY Decrement
Outpatient, 19-64	0.0094
Inpatient, 19-64	0.0396
Outpatient, 65+	0.0586
Inpatient, 65+	0.0087

^a QALY values from Mangen et al. 2015 Eur Respir J (95% CIs in parenthesis)

^b Health days lost were include on this slide to illustrate in relatable terms the magnitude of health loss associated with QALY decrements. Healthy days lost calculated by multiplying QALY decrement by 365.

^c Alternate values are inverse variance weighted values from Tang et al. 2021 J Pub Health. Source material places higher decrement on outpatient disease than inpatient disease for age 65+.

Baseline QALY Values

Age	General	CMC/IC
50-55	0.83 (0.78,0.88)	0.72 (0.67,0.77)
56-60	0.81 (0.76,0.86)	0.69 (0.64,0.74)
61-65	0.77 (0.72,0.82)	0.63 (0.58,0.68)
66-70	0.76 (0.71,0.81)	0.57 (0.52,0.62)
71-75	0.74 (0.69,0.79)	0.54 (0.49,0.59)
76-80	0.7 (0.65,0.75)	0.52 (0.47,0.57)
81-85	0.63 (0.58,0.68)	0.51 (0.46,0.56)
86+	0.51 (0.46,0.56)	0.51 (0.46,0.56)

Disease Cost (2023\$)

	Disease	Setting	Cost	95% CI	
19-64 Years	IPD	IPT	\$64,018.10	\$61,559.31	\$66,424.61
	NBP	IPT	\$58,423.99	\$55,923.53	\$60,908.13
	NBP	OPT	\$362.38	\$339.44	\$385.24
65+ Years	IPD	IPT	\$27,564.22	\$27,039.18	\$28,149.20
	NBP	IPT	\$21,300.64	\$20,825.64	\$21,800.98
	NBP	OPT	\$318.22	\$308.06	\$328.70

ICD-10 Codes for Medical Cost Extraction

Disease	ICD-10 Codes
IPD	A40.3, A40.9+B95.3, A41.9+B95.3, R78.81+B95.3, G00.1, G00.2+B95.3, G00.9+B95.3, G03.9+B95.3, J86.x+B95.3, J85.1+B95.3, A40.3 + at least one code from "All-cause", A40.9+B95.3 + at least one code from "All-cause", A41.9+B95.3 + at least one code from "All-cause", R78.81+B95.3 + at least one code from "All-cause", A40.9 & J13, A41.9 & J13, R78.81 & J13, M00.1x, K65.8+B95.3, I30.1+B95.3, I33.0+B95.3, I33.9 +B95.3, K65.2+B95.3, M86.1x/M86.2x/M86.9+B95.3, M00.0x, M00.2x, M00.8x, M00.9 + B95.3
NBP	J13, J15.9+B95.3, J18.0/J18.1+B95.3, J18.8/J18.9+B95.3
All-cause (for satisfying some definitions of IPD)	J12.x (J12.0, J12.1, J12.2, J12.3, J12.81, J12.89, J12.9), J13, J18.1, A48.1, J14, J15.0, J15.1, J15.2x (J15.20, J15.211, J15.212, J15.29), J15.3, J15.4, J15.5, J15.6, J15.8, J15.9, J15.7, J16.x (J16.0, J16.8), A22.1, A37.X1, B25.0, B44.0, J17, J18.0, J18.2, J18.8, J18.9, J09.X1, J10.0x (J10.00, J10.01, J10.08), J11.0x (J11.00, J11.08)

Work Loss

Labor Force Participation and Daily Wage

Age	Labor Force Participation Rate (%) ^a	Median Daily Wage (\$) ^b
19 to 24	71	99.71
25 to 34	83.2	148.86
35 to 44	83	175.57
45 to 54	81.1	176.14
55 to 64	65.2	169.43
65 to 74	26.6	157.29
75+	8.2	157.29

Duration of Work Loss

	Base	High	Low
Inpatient ^c	34	17	51
Outpatient ^d	26.4	13.2	39.7

^a US Bureau of Labor Statistics.

^b Current Population Survey, 2023.

^c Altawalbeh SM, Wateska AR, Nowalk MP, Lin CJ, Harrison LH, Schaffner W, Zimmerman RK, Smith KJ. Societal cost of racial pneumococcal disease disparities in US adults aged 50 years or older. Applied Health Economics and Health Policy. 2024 Jan;22(1):61-71.

^d Used ratio of days of work loss from outpatient (14) to inpatient pneumonia (18) allowed by Marine Corps policy and applied to inpatient durations of illness from Altawalbeh 2024. Vold Pepper P, Owens DK. Cost-effectiveness of the pneumococcal vaccine in the United States Navy and Marine Corps. Clinical infectious diseases. 2000 Jan 1;30(1):157-64.

15 Year Waning, With Herd Effects (Moving)

	PCV20	PCV20	PCV20	PCV21	PCV21	PCV21
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IPD Cases	44	34	32	458	459	464
Hospitalized Pneumonia Cases	871	897	808	1,925	2,032	1,977
Non-hospitalized Pneumonia Cases	722	647	590	1,498	1,529	2,017
Deaths due to IPD	12	10	9	69	69	66
Deaths due to Pneumonia	37	39	35	83	88	83
QALYs	66	-9	-102	-210	-419	-671
Total Cost (million\$)	-\$76	-\$133	-\$206	-\$121	-\$171	-\$218
\$ Saved / QALY Lost	Cost-Saving	14,014,611	2,023,745	575,614	407,176	324,164
Undiscounted Cases 50-64	-4,031	-4,269	-3,217	-9,338	-9,579	-6,265
Undiscounted Cases 65+	9,681	8,757	6,374	22,261	20,177	14,735
Undiscounted Deaths 50-64	-69	-72	-54	-154	-160	-106
Undiscounted Deaths 65+	203	184	136	530	482	356

20 Year Waning, With Herd Effects (Moving)

	PCV20	PCV20	PCV20	PCV21	PCV21	PCV21
	50 vs. 65	55 vs. 65	60 vs. 65	50 vs. 65	55 vs. 65	60 vs. 65
IPD Cases	71	59	65	560	559	571
Hospitalized Pneumonia Cases	1,269	1,299	1,129	2,742	2,890	2,655
Non-hospitalized Pneumonia Cases	1,193	1,131	1,042	2,283	2,479	2,915
Deaths due to IPD	16	14	13	84	83	80
Deaths due to Pneumonia	54	56	48	118	124	111
QALYs	-20	-96	-184	-376	-606	-848
Total Cost (million\$)	-\$67	-\$121	-\$194	-\$106	-\$145	-\$194
\$ Saved / QALY Lost	3,325,061	1,252,046	1,056,802	283,008	239,889	228,155
Undiscounted Cases 50-64	-4,263	-4,095	-2,999	-10,237	-9,311	-5,866
Undiscounted Cases 65+	12,226	10,605	7,643	27,976	24,322	17,557
Undiscounted Deaths 50-64	-73	-70	-51	-168	-155	-99
Undiscounted Deaths 65+	261	228	165	678	594	432

15 Year Waning, No Herd Effects (Moving)

	PCV20	PCV20	PCV20	PCV21	PCV21	PCV21
	50 vs. 65	55 vs. 65	60 vs. 65	50 vs. 65	55 vs. 65	60 vs. 65
IPD Cases	418	438	482	796	825	881
Hospitalized Pneumonia Cases	3,598	3,747	3,432	3,941	4,134	3,928
Non-hospitalized Pneumonia Cases	5,861	5,917	5,638	5,226	5,327	5,730
Deaths due to IPD	63	64	66	116	118	120
Deaths due to Pneumonia	141	148	135	160	169	158
QALYs	-830	-1,038	-1,185	-876	-1,203	-1,537
Total Cost (million\$)	-\$40	-\$86	-\$136	-\$101	-\$141	-\$165
\$ Saved / QALY Lost	48,348	82,895	114,542	114,808	116,909	107,388
Undiscounted Cases 50-64	-7,694	-8,032	-4,831	-12,353	-12,711	-7,613
Undiscounted Cases 65+	30,465	27,551	20,002	38,099	34,498	25,117
Undiscounted Deaths 50-64	-130	-134	-80	-211	-217	-131
Undiscounted Deaths 65+	586	534	396	847	771	571

20 Year Waning, No Herd Effects (Moving)

	PCV20	PCV20	PCV20	PCV21	PCV21	PCV21
	50 vs. 65	55 vs. 65	60 vs. 65	50 vs. 65	55 vs. 65	60 vs. 65
IPD Cases	489	514	567	938	974	1,038
Hospitalized Pneumonia Cases	4,845	4,991	4,408	5,391	5,625	5,100
Non-hospitalized Pneumonia Cases	7,221	7,246	6,845	6,659	6,921	7,202
Deaths due to IPD	74	75	77	137	139	140
Deaths due to Pneumonia	194	201	176	222	232	207
QALYs	-1,059	-1,280	-1,402	-1,143	-1,508	-1,819
Total Cost (million\$)	-\$18	-\$54	-\$107	-\$77	-\$100	-\$128
\$ Saved / QALY Lost	16,782	42,282	76,328	67,272	66,407	70,122
Undiscounted Cases 50-64	-8,627	-7,815	-4,503	-13,830	-12,398	-7,117
Undiscounted Cases 65+	38,671	33,563	24,125	48,108	41,795	30,100
Undiscounted Deaths 50-64	-146	-131	-75	-236	-212	-122
Undiscounted Deaths 65+	770	677	493	1,096	962	700

15 Year Waning, With Herd Effects (Adding)

	PCV21 at Age 50 and 65	PCV21 at Age 55 and 70	PCV21 at Age 60 and 75	PCV20 at Age 50 and 65	PCV20 at Age 55 and 70	PCV20 at Age 60 and 75
IPD Cases	-932	-930	-941	-434	-402	-354
Hospitalized Pneumonia Cases	-1,367	-2,584	-4,117	-600	-1,141	-1,868
Non-hospitalized Pneumonia Cases	-6,000	-6,699	-7,233	-2,635	-2,990	-3,467
Deaths due to IPD	-100	-104	-133	-46	-44	-46
Deaths due to Pneumonia	-38	-93	-171	-17	-41	-77
QALYs	2,070	1,768	1,581	956	829	741
Life-years	2,633	2,420	2,407	1,214	1,116	1,092
Costs (million \$)						
Total Cost	\$444	\$330	\$189	\$523	\$416	\$270
Medical Costs	-\$141	-\$171	-\$177	-\$64	-\$77	-\$82
Vaccine Costs	\$689	\$570	\$403	\$635	\$526	\$372
Work Loss	-\$103	-\$69	-\$37	-\$48	-\$33	-\$20
Cost Ratios (\$)						
Cost/QALY	214,430	186,838	119,665	546,811	501,851	364,497
Cost/Life-year	168,533	136,496	78,612	430,913	372,691	247,411

20 Year Waning, With Herd Effects (Adding)

	PCV21 at Age 50 and 65	PCV21 at Age 55 and 70	PCV21 at Age 60 and 75	PCV20 at Age 50 and 65	PCV20 at Age 55 and 70	PCV20 at Age 60 and 75
IPD Cases	-989	-995	-949	-449	-419	-355
Hospitalized Pneumonia Cases	-1,455	-2,522	-3,595	-618	-1,115	-1,649
Non-hospitalized Pneumonia Cases	-6,386	-6,966	-7,075	-2,710	-3,083	-3,389
Deaths due to IPD	-106	-123	-153	-48	-49	-51
Deaths due to Pneumonia	-40	-93	-155	-17	-41	-70
QALYs	2,144	1,798	1,445	967	827	676
Life-years	2,747	2,480	2,199	1,234	1,120	992
Costs (million \$)						
Total Cost	\$433	\$333	\$206	\$521	\$418	\$278
Medical Costs	-\$150	-\$169	-\$162	-\$66	-\$75	-\$75
Vaccine Costs	\$689	\$570	\$403	\$635	\$526	\$372
Work Loss	-\$105	-\$69	-\$35	-\$48	-\$33	-\$19
Cost Ratios (\$)						
Cost/QALY	202,019	184,959	142,373	539,097	505,534	411,202
Cost/Life-year	157,728	134,122	93,531	422,657	373,616	280,039

15 Year Waning, No Herd Effects (Adding)

	PCV21 at Age 50 and 65	PCV21 at Age 55 and 70	PCV21 at Age 60 and 75	PCV20 at Age 50 and 65	PCV20 at Age 55 and 70	PCV20 at Age 60 and 75
IPD Cases	-1,283	-1,284	-1,275	-795	-765	-704
Hospitalized Pneumonia Cases	-1,781	-3,846	-6,587	-1,115	-2,776	-5,139
Non-hospitalized Pneumonia Cases	-7,819	-8,896	-10,216	-4,892	-5,715	-7,346
Deaths due to IPD	-137	-145	-184	-84	-85	-100
Deaths due to Pneumonia	-49	-143	-281	-31	-106	-223
QALYs	2,778	2,357	2,177	1,725	1,490	1,480
Life-years	3,541	3,285	3,390	2,193	2,096	2,310
Costs (million \$)						
Total Cost	\$364	\$247	\$109	\$433	\$318	\$170
Medical Costs	-\$189	-\$237	-\$253	-\$118	-\$155	-\$178
Vaccine Costs	\$689	\$570	\$403	\$635	\$526	\$372
Work Loss	-\$136	-\$86	-\$41	-\$84	-\$52	-\$25
Cost Ratios (\$)						
Cost/QALY	131,028	104,656	50,122	251,037	213,705	114,909
Cost/Life-year	102,804	75,085	32,186	197,417	151,924	73,619

20 Year Waning, No Herd Effects (Adding)

	PCV21 at Age 50 and 65	PCV21 at Age 55 and 70	PCV21 at Age 60 and 75	PCV20 at Age 50 and 65	PCV20 at Age 55 and 70	PCV20 at Age 60 and 75
IPD Cases	-1,389	-1,382	-1,278	-860	-818	-699
Hospitalized Pneumonia Cases	-1,931	-3,780	-5,748	-1,209	-2,749	-4,499
Non-hospitalized Pneumonia Cases	-8,476	-9,491	-10,120	-5,305	-6,258	-7,363
Deaths due to IPD	-148	-173	-212	-91	-100	-113
Deaths due to Pneumonia	-53	-145	-256	-33	-109	-204
QALYs	2,928	2,422	1,958	1,817	1,526	1,305
Life-years	3,761	3,394	3,046	2,328	2,150	2,028
Costs (million \$)						
Total Cost	\$344	\$247	\$133	\$421	\$319	\$188
Medical Costs	-\$205	-\$235	-\$230	-\$127	-\$154	-\$161
Vaccine Costs	\$689	\$570	\$403	\$635	\$526	\$372
Work Loss	-\$140	-\$87	-\$39	-\$87	-\$53	-\$23
Cost Ratios (\$)						
Cost/QALY	117,514	102,083	68,174	231,438	208,701	144,205
Cost/Life-year	91,491	72,848	43,822	180,616	148,188	92,771