Economic analysis and public health impact of PCV15 use among children in the US

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Acknowledgements

- This presentation summarizes work conducted by two groups

- CDC model team
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- Merck model team
  - Min Huang, Tianyan Hu, Jessica Weaver, Kwame Owusu-Edusei

Conflict of interest statements

- Andrew J. Leidner: None
- CDC model team: None
- Merck model team: Merck manufacturers the PCV15 vaccine

Terminology

Abbreviation	Full term / description
IPD	Invasive pneumococcal disease
NBP	Non-bactaeremic pneumonia
AOM	Acute otitis media
PCV7	Pneumococcal conjugate vaccine, 7 serotypes
PCV13	Pneumococcal conjugate vaccine, 13 serotypes
PCV15	Pneumococcal conjugate vaccine, 15 serotypes
QALY	Quality-adjusted life-year
CER	Cost-effectiveness ratio

Background

- Pneumococcal vaccination (i.e., PCV7) of children has averted thousands of deaths and saved millions of dollars in direct medical costs[a]
  - PCV13 (vs PCV7) was estimated to be cost-saving[b,c]
- Two models have been used to examine the costs and benefits of including PCV15 as an option in the childhood immunization schedule
  - CDC model, Merck model
- The two models went through the CDC economic review, following the ACIP Guidance for Health Economic Studies[d]

a. Zhou et al. 2014.
b. Messonnier et al. 2009.
c. Rubin et al. 2010.
d. Leidner et al. 2019.

Outline

- Study questions
- Cost-effectiveness results
- Prevented disease burden
- Discussion

Study questions

- What is the cost-effectiveness and public health impact of including PCV15 as an option in the immunization schedule for children?
  - What is the cost-effectiveness of vaccinating children with PCV15 compared to vaccinating children with PCV13?
  - What is the disease burden that can be prevented by vaccinating children with PCV15 compared to vaccinating children with PCV13?

Key assumptions for the cost-effectiveness analyses in the two models

- Vaccine effectiveness
  - PCV15 and PCV13 have same VE for PCV13-type disease
  - PCV15 provides protective VE for two additional serotypes

- Vaccine cost[a]
  - The average cost for PCV15 is less than the cost of PCV13

[a.] Detailed information on these inputs are available in a supplemental slide.

Cost-effectiveness results

PCV15 vs. PCV13

Model scenarios	CDC model	Merck model
Base case results	Cost-saving	Cost-saving
Scenarios and sensitivity analyses Including scenarios with PCV15 public price set higher[a] than in base case	All cost-saving	All cost-saving

- Both models found that PCV15 is cost-saving compared to PCV13
  - "Cost-saving" means total costs are reduced and health outcomes are improved
  - This result is not surprising, given the assumptions
    - PCV15 prevents more disease than PCV13
    - PCV15 costs approximately the same[a] as PCV13

[a.] Both models explored the impact of higher vaccine dose cost, with the public price was set 5% and 2.5% higher than the base case, for the CDC and Merck models, respectively. Detailed information on these inputs are available in a supplemental slide. In the base case of both models, PCV15 costs less than PCV13 on average. In the scenarios with higher PCV15 public price, the cost of PCV15 was greater than PCV13 on average. These scenarios were found to be cost-saving overall, due to the additional reduced direct medical costs from prevented disease burden that was associated with the two additional serotypes included in PCV15.

Additional assumptions in the two models

Model characteristics	CDC model	Merck model
Model type	Single cohort	Multi-cohort • Includes all ages 0-100 • No adult vaccinations • New births added every year • Single cohort investigated in scenarios.
Model duration (years)	17	100
Incidence rates[a]	Higher for inpatient NBP	Higher for IPD, outpatient NBP, and AOM

[a.] Differences in incidence rates between the two models explain some of the differences in estimated prevented disease burden. Incidence rates in both models were age-adjusted, the term "higher" is used to broadly characterize the incidence assumptions relative to the other model. More detailed information on incidence inputs are available in a supplemental slide. IPD refers to invasive pneumococcal disease, NBP refers to outpatient or inpatient non-bactearemic pneumonia, AOM refers to acute otitis media.

Results, prevented disease burden

PCV15 vs. PCV13

Model, scenario	Population structure	IPD[a]	NBP[a]	AOM[a]	Deaths	QALYs[a] gained
CDC model, base case	Single cohort	220	3,900	80,600	22	760
Merck model, single cohort scenario	Single cohort	490	10,100	108,000	42	1,300
Merck model, base case	Multi-cohort	61,000	306,000	3,500,000	6,500	96,000

[a.] IPD refers to invasive pneumococcal disease, NBP refers to total (outpatient and inpatient) non-bactearemic pneumonia, AOM refers to acute otitis media, QALYs refers to quality-adjusted life-years.

Results, prevented disease burden
PCV15 vs. PCV13

- If one cohort of infants received PCV15 instead of PCV13[a]

Prevented outcomes	Range
IPD	220 to 490
NBP	3,900 to 10,100
AOM	80,600 to 108,000
Deaths	22 to 42

- Considerations
  - The benefits of vaccinating multiple cohorts would be greater
  - If adoption of PCV15 is lower[a], then total benefits would be smaller
  - If indirect effects from the vaccinated cohort to older individuals were included, then total benefits would be greater
    - Indirect effects may be modest if adult PCV15/PCV20 use is high and if indirect effects take a few years to develop

[a.] Both models assume PCV15 entirely replaces PCV13 under a given strategy with 4th dose vaccination coverage rate equal to 82%. Hypothetically, the use of PCV15 may only replace a portion of PCV13 use and therefore both vaccines could be in use at the same time.

Discussion & Conclusions

- Pneumococcal vaccination of children has been found to reduce direct medical costs and improve health[a]
  - PCV13 (vs. PCV7) was estimated to be cost-saving in previous studies[b,c]
  - PCV15 (vs. PCV13) was estimated to be cost-saving in models presented today
    - Models assume PCV15 prevents more disease than PCV13, PCV15 costs approximately the same as PCV13
- Pneumococcal vaccination of children may have a notable health impact
  - Vaccination of children with PCV15 (vs PCV13) may prevent thousands of cases of IDP, NBP, AOM
    - Models assume that PCV15 VE is equal to PCV13 VE for PCV13-type disease, and provides protection for two additional, non-PCV13 serotypes
    - Differences across models in prevented disease burden are due to differences in model structure and input values
      - CDC model is more conservative than the Merck model

[a.] Zhou et al. 2014.
[b.] Messonnier et al. 2009.
[c.] Rubin et al. 2010.

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  - Merck model team: Min Huang, Tianyan Hu, Jessica Weaver, Kwame Owusu-Edusei

- CDC colleagues:
  - Fangjun Zhou, Harrell Chesson, Jamie Pike, Bo-Hyun Cho, Yuping Tsai, Shannon Stokley

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Vaccine cost, model inputs

Model characteristics	CDC model	Merck model
Vaccine costs	*PCV13* Public, $151 Private, $226 *PCV15* Public, $151 (up to $158)[a] Private, $216	*PCV13* Public, $150 Private, $226 *PCV15* Public, $154 ($150 to $158)[a] Private, $215

[a.] In both models the public price of PCV15 could vary up to 5% greater than public price of PCV13. The base case of the Merck model assumed the public price of PCV15 would be 2.5% greater than the public price of the PCV13 vaccine.

Vaccine effectiveness and indirect effects, model inputs

Model characteristics	CDC model	Merck model
Vaccine Effectiveness (direct protection)	PCV15 and PCV13 have same VE for PCV13-type disease PCV15 has protective VE against two additional serotypes	PCV15 and PCV13 have same VE for PCV13-type disease PCV15 has protective VE against two additional serotypes
Indirect effects[a]	7.8% reduction per year for all PCV15-only disease outcomes (i.e., IPD, NBP, AOM), applied to single cohort until age 17 years	7.8% reduction per year for just IPD that is PCV15-only type In the base case, this is applied to all cohorts including elderly at the beginning of the model and vaccinated infants as they age

[a.] Because indirect effects were incorporated as a percent reduction that are independent of vaccination coverage, these models would not be considered dynamic transmission models.

IPD incidence, model inputs

Age	CDC model	Merck model
0-1	10-14	10-13
2-17	1-5	2-4
18-49	NA	3-7
>= 50	NA	17-24

NBP incidence, model inputs

	Outpatient NBP (per 100,000)	
Age	CDC model	Merck model
0-1	1,400-2,800	2,900
2-4	1,100-2,700	3,400
5-8	560-1,100	1,300
9-17	500	1,300

	Inpatient NBP (per 100,000)	
Age	CDC model	Merck model
0-1	490-680	340
2-4	190-450	170
5-8	84-170	45
9-17	75	45

AOM incidence, model inputs

Model characteristics	CDC model	Merck model
AOM incidence (per 100k)	62-65,000 for age 0-1 years 39,000 for age 2-4 years 0.0 for age 5-17 years	74,000 for age 0-1 years 41,000 for age 2-4 years 8,000 for age 5-17 years