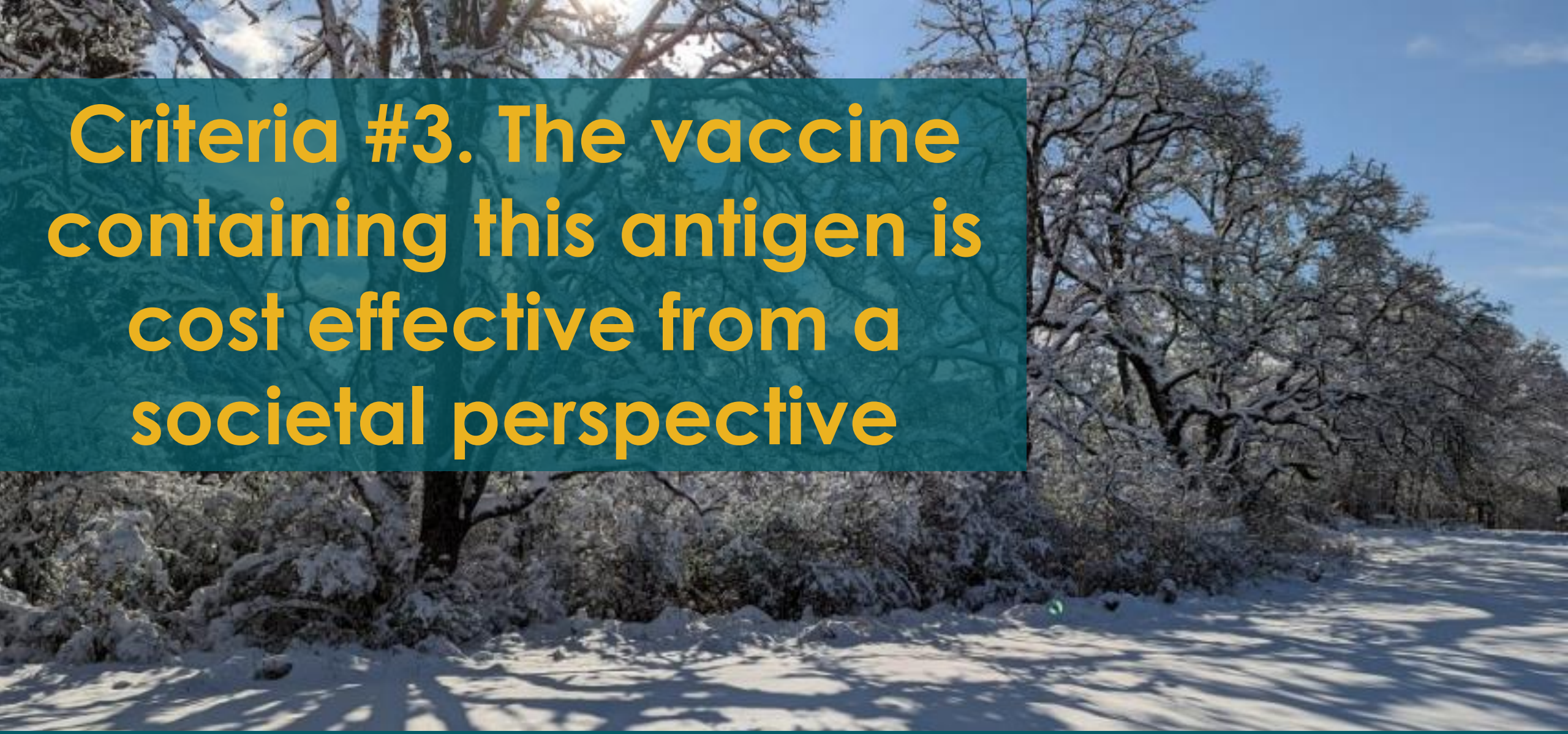
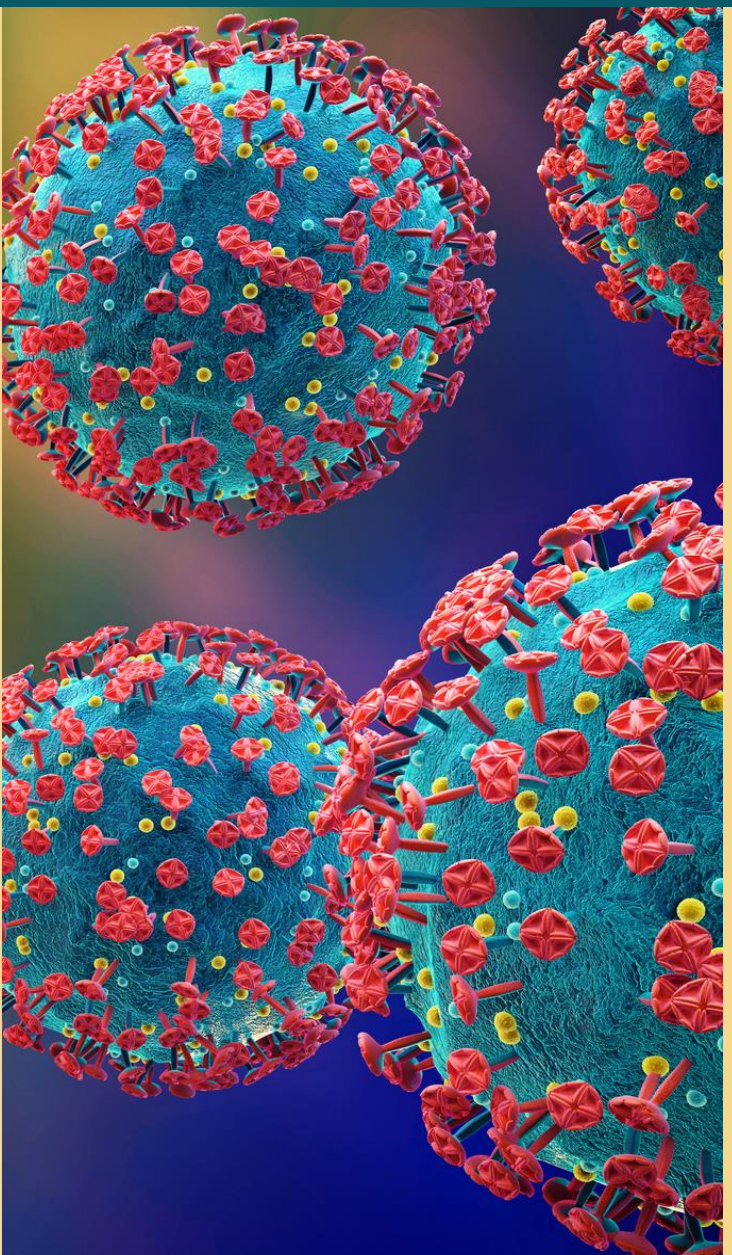


Criteria #3. The vaccine containing this antigen is cost effective from a societal perspective

Speaker

Anna Hidle, MPH
Public Health Economist
Pronouns: She/Her
Office of Policy, Planning, and Evaluation

Conflict of Interest



- The presenter reports no conflict of interest real or perceived.

Overview

- Understanding the criteria for potential inclusion in WAC 246-105-030
  - Cost Effectiveness Analysis (CEA)
- Literature Review
  - Cost Effectiveness of Childhood Vaccination
  - Cost Effectiveness of COVID-19 Vaccination
- Considerations
- Summary / Recommendation
- References

Understanding the criteria for potential inclusion in WAC 246-105-030

Cost Effectiveness Analysis (CEA)

Understanding the Criteria

Criteria for Reviewing Antigens for Potential Inclusion in WAC 246-105-030

I. Criteria on the effectiveness of the vaccine

3. The vaccine containing this antigen is cost effective from a societal perspective.

<u>The following are factors identified when evaluating this criteria:</u>

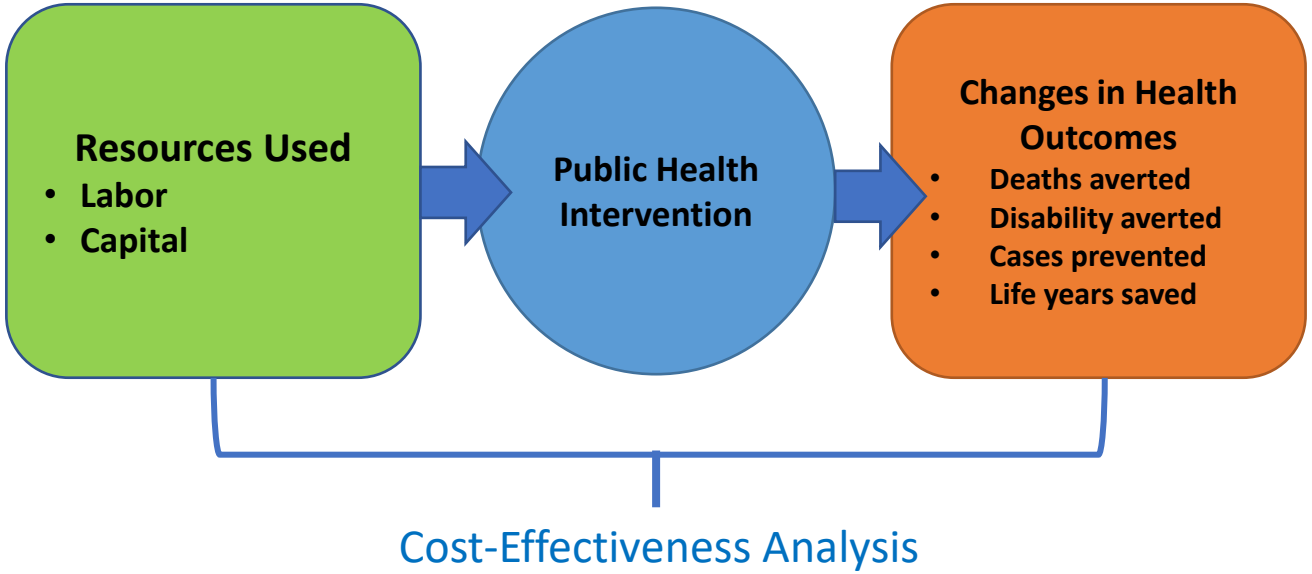
- **Net Costs**
  - This analysis should consider both the costs of the immunization (e.g., antigen, storage, administration, medial and societal costs of adverse reactions to the immunization, etc.) and the benefits of the immunization (e.g., lives saved, medical and societal benefits of preventing adverse reactions from vaccine-preventable disease, etc.).
- **Cost Effectiveness vs. Cost Savings**
  - Vaccines may be cost effective without being cost saving. In other words, the direct cost of some vaccines (e.g., antigen, storage, administration) balanced against direct savings (e.g., medical care, disability, death) may not result in net savings.
- **Costing Perspective**
  - Societal or indirect costs (e.g., lost productivity of care takers of ill children) will also need to be taken into consideration. These costs are much harder to quantify.
- ***ACIP vaccine approval when taking into account cost effectiveness****
  - Not all vaccines recommended by the ACIP are cost saving or equally effective, so some determination of the vaccine's relative cost effectiveness may need to be made for comparison purposes when applying the criteria.

*Criteria for #3, ACIP has not approved COVID-19 vaccine for the childhood immunization program at this time.

Cost-Effectiveness Analysis (CEA)

What is a Cost Effectiveness Analysis?

- A CEA is a way to examine both costs and health outcomes of interventions that have the same health outcome
  - including doing nothing / the status quo
- Compares the net costs to changes in health outcomes (effectiveness) resulting from an intervention
- The Objective of CEA is to maximize total health of the general population



Reference: Cost-Effectiveness Analysis | POLARIS | Policy and Strategy | CDC Introduction to Economic Evaluation Training

Cost-Effectiveness Analysis (cont.)

What is a Cost Effectiveness Analysis? (cont.)

CEA compares the net cost of an intervention to the changes in health outcomes

Net cost = Cost of Intervention − Costs Averted

Change in health outcomes = Outcomes with intervention − Outcomes without intervention

- Net cost is negative (i.e., saves money), results are reported as cost savings
- Net cost are positive (i.e., costs money), results are presented as a cost effectiveness (CE) ratio

$$\text{Cost effectiveness ratio} = \frac{\text{Net cost}}{\text{Change in health outcomes}}$$

References:
1.Cost-Effectiveness Analysis | POLARIS | Policy and Strategy | CDC Introduction to Economic Evaluation Training
2. Bertram et. al. Cost-effectiveness thresholds: pros and cons: Bulletin of the World Health Organization (who.int)

Cost-Effectiveness Analysis (cont.)

Understanding CE Thresholds

- **CE ratios are then compared to CE thresholds to decide if they are CE***
  - 1x to 3x per capita Gross Domestic Product (GDP)
    - Typically, in US health economics we use either $ 50,000 or $100,000
    - If the CE ratio is below these thresholds, we would say it is cost effective and if the net cost is negative, we would say it is cost saving
  - Willingness-to-pay (WTP)**
    - An estimate of what a consumer would be willing to pay for the health benefit

*Interpretation of which program/intervention/activity is cost-effective can vary widely by decision makers
**There is no 'correct' WTP threshold

References:
1.Cost-Effectiveness Analysis | POLARIS | Policy and Strategy | CDC Introduction to Economic Evaluation Training
2. Bertram et. al. Cost-effectiveness thresholds: pros and cons: Bulletin of the World Health Organization (who.int)
3. Robinson et. al. Understanding and improving the one and three times GDP per capita cost-effectiveness thresholds OP-HEAP160100 141..145 (silverchair.com)

Cost-Effectiveness Analysis (cont.)

Valuing Health Outcomes

- **Change in health outcome:** Cost averted by preventing cases of disease and morbidity
  - routine vaccination as compared to a no vaccination
- **To value:**
  - Morbidity (consequences and complications from disease other than death)
    - Work loss valued by number of missed workdays * estimated daily wage rate
  - Mortality (death)
    - Human capital approach values the future productivity lost by society due to premature death (lifetime earnings)

References: 1) Cost-Effectiveness Analysis | POLARIS | Policy and Strategy | CDC Introduction to Economic Evaluation Training
2) Economic Evaluation of the Routine Childhood Immunization Program in the United States, 2009 | Pediatrics | American Academy of Pediatrics (aap.org)
3) Haddix et al. Prevention Effectiveness.

Cost-Effectiveness Analysis (cont.)

Perspective: costs to whom

Health Care perspective

- Typically includes all direct health care costs:
  - Easier to value
    - Cost of intervention
    - Changes in Health Outcomes
      - Costs of morbidity and mortality

Social perspective

- Typically includes healthcare perspective plus may include:
  - Easier to value
    - Out-of-pocket costs (healthcare, transportation, etc.)
    - Productivity losses (caregiver)
  - More difficult to value
    - Productivity losses (non-wage earners)
    - Effects on Education sector (school closures)
    - Equity

References:
1) Resch S, Menzies N, Portnoy A, Clarke-Deelder E, O'Keeffe L, Suharlim C, Brenzel L. How to cost immunization programs: a practical guide on primary data collection and analysis. 2020. Cambridge, MA: immunizationeconomics.org/ Harvard T.H. Chan School of Public HealthtoCost_Digital_12.24.20.pdf (squarespace.com)
2) AJPH202032033_Bloom 1049..1054 (nih.gov)

Cost-Effectiveness Analysis (cont.)

Perspective: costs to whom

Example: *Childhood Vaccination Schedule*

Payer Perspective

Costs of implementation: $ 7.5 billion

Costs averted: - $20.3 billion

Net costs: **- $13.5 billion**

- **Changes in health outcome:** No difference from societal perspective

Societal Perspective

Costs of implementation: $ 7.5 billion

Costs averted: - $76.4 billion

Net costs: **- $68.9 billion**

- **Changes in health outcome:** No difference from payer perspective

References: 1) Cost-Effectiveness Analysis | POLARIS | Policy and Strategy | CDC Introduction to Economic Evaluation Training
2) Economic Evaluation of the Routine Childhood Immunization Program in the United States, 2009 | Pediatrics | American Academy of Pediatrics (aap.org)

Cost-Effectiveness Analysis (cont.)

Sensitivity Analysis

- Used in economic modeling studies
- Sensitivity analysis adjusts inputs/assumptions to look at how variations impact results
- Allows the study to consider the uncertainty of an input
- Often conducted with assumed values
- Examples of inputs/assumptions:
  - Effectiveness of a vaccine (%)
  - Vaccination rates (%)

References:
1) NIH. National Information Center on Health Services Research and Health Care Technology. Health Economics Information Resources: Health Economics Information Resources: A Self-Study Course: Module 4 (nih.gov)
2) Shiell et. al. Health economic evaluation | Journal of Epidemiology & Community Health (bmj.com)

Literature Review

Cost Effectiveness of Childhood Vaccination
Cost Effectiveness of COVID-19 Vaccination

Literature Review

In Summary:

- Reviewed 51 Journal articles, 2 WA State DOH Reports, and 3 other sources*
- Journal articles included published and not yet published articles (preprint, prepublication, draft and non peer reviewed articles)
  - Not yet published articles were selected due to the emerging and shifting nature of this landscape
- Literature review presentation includes:
  - 2 Childhood Immunization journal articles
  - 4 COVID-19 Immunization journal articles
- Selection Criteria included:
  - Potential relevancy to decisionmakers on CE findings

*Other sources included 2 CE Analysis repositories and a news article on costs of hospital stays

Literature Review: Classifying Literature

Classification	# 1, 2, X	Reason

In the Literature Review section, you will see this box in the top right corner that will identify the classification

Classification:

1. High- No concerns with using it for decision making
2. Low – Concerns with using it for decision making due to outdated assumptions

X. Unpublished

- If paper has not been peer reviewed or is in pre-publication or is in draft it will list as X

Literature Review

Included in Review: 6 articles

Author	Publication Year	Disease(s) / Antigen (s)	Setting	Perspective	Population explicitly include school age?	Vaccination CE as compared to…
De Boer et. al.	2020	Influenza	The Netherlands	Societal	Yes, children aged 2-16	Current vaccination program (vaccinating 60 and older and individuals of any age with health conditions)
Holubar et. al.	2017	Three Childhood Vaccines	Various	Societal and Health Care	Yes, children	Various
Padula et. al.	N/A	COVID-19	U.S.	Societal	No specific mention of age	Do nothing, social distancing, COVID-19 treatment
Kohli et. al.	2021	COVID-19	U.S.	U.S. Health Care System	No, does not include under 18	Do nothing, 3 prioritization schemes (age, risk, occupational)
Li et. al.	N/A	COVID-19 Booster	U.S.	U.S. Healthcare System	No, adults aged ≥65 years	2 doses of vaccine (no booster)
Hagens et. al.	2021	COVID-19	Turkey	Societal and Health Care	No specific mention of age	2 vaccination scenarios compared
IDEAL STUDY FOR CRITERIA		***COVID-19***	***U.S.***	***Societal***	***Yes, school-aged***	***Do nothing***

*Other sources included 2 CE Analysis repositories and a news article on costs of hospital stays.

Literature Review

Cost Effectiveness of Childhood Vaccination
Cost Effectiveness of COVID-19 Vaccination

Literature Review: CE of Childhood Vaccination

Summary from a modeling study from de Boer et. al. (2020)

Disease	Setting	Perspective	Vaccination CE as compared to…	CE outcome
Influenza	The Netherlands	Societal	Current vaccination program (vaccinating 60 and older and individuals of any age with health conditions)	In some scenarios (and when including productivity losses)

- By extending the vaccination to children aged 2-16 years, the influenza vaccination program was found to be cost-effective in 0.9% of the simulations.
- When the cost-effectiveness results are stratified in yearly age-groups:
  - highest net benefits found among older and working adults (aged 30–40).
  - lowest net benefits found in the targeted age 2-16.

Reference: de Boar et. al. Vaccinating children against influenza: overall cost-effective with potential for undesirable outcomes (nih.gov)

Literature Review: CE of Childhood Vaccination

Summary from a quantitative comparative analysis Holubar et. al. (2017)

Antigen(s)	Setting	Perspective	Vaccination CE as compared to…	CE outcome
Childhood Vaccination (Pneumo, Mena, Rota, Flu)	Various	Societal and Health Care System	Various	When the result in more developed countries was not CE, adding herd-protection always produced a more favorable result

- Collected and reviewed literature comparing 35 CE studies (with 99 analyses) with and without herd-immunity across 4 antigens.
- Adding herd immunity to the results resulted in crossing the CE threshold in 45% of examples.

Reference: Holubar et. al. Impact of vaccine herd-protection effects in cost-effectiveness analyses of childhood vaccinations. A quantitative comparative analysis (plos.org)

Literature Review

Cost Effectiveness of Childhood Vaccination
Cost Effectiveness of COVID-19 Vaccination

Classification	X – Unpublished	DRAFT Manuscript

Literature Review: CE of COVID-19 Vaccination

Summary from a modeling study from Padula et. al. (DRAFT Manuscript)

Disease	Setting	Perspective	Vaccination CE as compared to…	CE outcome
COVID-19	United States	Societal	…do nothing, social distancing, COVID-19 treatment (hypothetical)	CE in 71% of sensitivity simulations

- **Do nothing**
  - 67 million hospital days
  - 228,000 deaths
  - $669 billion in economic impact
- **Vaccination**
  - 30.8 million hospital days
  - 104,000 deaths
  - 9.9 billion in economic impact
  - Found to be cost-effective in 71% of sensitivity simulations (threshold of $100,000 per QALY)

- **Sensitivity analysis parameters with greatest impact to model results:**
  - treatment efficacy
  - treatment cost
  - societal cost of social distancing
  - vaccination rate
  - vaccine efficacy

Reference: Padula et. al. Economic Value of Treatment and Vaccine to Address the COVID-19 Pandemic: A U.S. Cost-effectiveness and Budget Impact Analysis

Classification	2 - Low	Hypothetical Vaccine

Literature Review: CE of COVID-19 Vaccination

Summary from a modeling study from Kohli et. al. (2021)

Disease	Setting	Perspective	Vaccination CE as compared to…	CE outcome
COVID-19	United States	U.S. Healthcare System	…do nothing, 3 prioritization schemes (age, risk, occupational)	In some scenarios

- Study shows COVID-19 vaccination CE for ages 65+, 50-64, nursing homes, serious medical conditions, and priority and other critical occupations when compared to other options within schema.
- When stratified, not cost effective (using a $50,000 threshold) for those 18-49 years (ICER $94,000) and those with no serious medical conditions (18-49 years) (ICER $340,000).
- Does not consider the benefit of reduced transmission to those who are older or are with serious medical conditions.

Reference: Kohli et. al. The potential public health and economic value of a hypothetical COVID-19 vaccine in the United States: Use of cost-effectiveness modeling to inform vaccination prioritization (nih.gov)

Classification	2 - Low	Hypothetical Vaccine

Literature Review: CE of COVID-19 Vaccination

Summary from a modeling study from Kohli et. al. (2021) (cont.)

Country	Author	Perspective	Outcome of Interest	Comparator	ICER/QALY
USA	Kohli et. al.	US Healthcare System	Vaccinating the US adult population	Do nothing	$8,200 (2020 USD)
USA	Kohli et. al.	US Healthcare System	Vaccinating tier by age: 1) 65+ 2) 50-64 3) 18-49	No vaccination	1) Vaccination Dominates 2) $ 8,000 3) $94,000 (2020 USD)
USA	Kohli et. al.	US Healthcare System	Vaccinating tier risk-based: 1) Nursing homes, 65+ 2) Serious medical conditions 18-64, no serious medical conditions 50-64 3) No serious medical condition, 18-49	No vaccination	1) Vaccination Dominates 2) $ 10,000 3) $340,000 (2020 USD)

Reference: Kohli et. al. The potential public health and economic value of a hypothetical COVID-19 vaccine in the United States: Use of cost-effectiveness modeling to inform vaccination prioritization (nih.gov)

Classification	X - Unpublished	PREPRINT Manuscript

Literature Review: CE of COVID-19 Vaccination

Summary from a modeling study from Li et. al. (PREPRINT, not peer reviewed)

Antigen	Setting	Perspective	Vaccination CE as compared to…	CE outcome
COVID-19 Booster	United States	U.S. Health Care System	…2 doses of vaccine (no booster)	High chance CE with high disease incidence

- Offering booster doses to older adults aged ≥65 years.
- The CE of offering a booster is highly sensitive to the population incidence of COVID-19 (cost-effectiveness threshold of 8.1/100,000 person-day).
- Giving boosters to older adults aged ≥65 years in the US is likely to be cost-effective.

Reference: Cost-Effectiveness Analysis of BNT162b2 COVID-19 Booster Vaccination in the United States by Rui Li, Hanting Liu, Christopher K. Fairley, Zhuoru Zou, Li Xie, Xinghui Li, Mingwang Shen, Yan Li, Lei Zhang :: SSRN

Classification	2 - Low	COVID-19 re-infections estimated the probability at 0.01%, vaccine effectiveness from clinical trials

Literature Review: CE of COVID-19 Vaccination

Summary from a modeling study from Hagens et. al. (2021)

Antigen	Setting	Perspective	Comparing	CE outcome
COVID-19	Turkey	Health Care and Societal	2 vaccination scenarios, 1) vaccine effectiveness = effectiveness on disease and 2) vaccine effectiveness = is 50% of effectiveness on disease	CE and likely cost-saving from a societal perspective

- Vaccination is cost-effective and likely cost-saving
- Less susceptible persons at the start of vaccination provided lower needed levels for vaccine effectiveness and vaccine uptake for CE
- The most influential data point in the sensitivity analysis was the number of susceptible persons in the population
- If a vaccine was over 80% effective, a minimum vaccine uptake for CE would be at minimum 30% (a higher vaccine uptake would be needed for lower vaccine efficacy)

Reference: COVID-19 Vaccination Scenarios: A Cost-Effectiveness Analysis for Turkey (nih.gov)

Literature Review: CE of COVID-19 Vaccination

Limitations

- Assumption used in the models:
  - Hypothetical vaccines
    - Effectiveness data from or before clinical trials
  - Duration of Immunity
  - Long-term health impacts
    - Many models considered a short time period and full recovery as long term-effects of COVID-19 are mostly unknown
- Effectiveness Thresholds
  - Effectiveness data in CE studies are often heavily criticized and with COVID-19 ever changing landscape this is an even more concerning limitation

Considerations

Considerations: Equity

Cost Effectiveness and Equity

- The Objective of CEA is to maximize total health of the general population
- Unfortunately, CE analysis does not typically consider equity
  1. Because equity measures can be complex and difficult to measure and value; and
  2. Because the framework for CEA does not currently exist to include such equity measures
- More inclusive and large-scale vaccination programs can promote health equity by:
  - Intergenerational equity
  - reducing disparities by infection rates (particularly if the disease disadvantages someone later in life)
  - by providing herd immunity

Reference:
1. Using Cost-Effectiveness Analysis to Address Health Equity Concerns | Elsevier Enhanced Reader
2. Luyten and Beutels. The Social Value Of Vaccination Programs: Beyond Cost-Effectiveness (healthaffairs.org)

Considerations: Quantifying Changing Outcomes

Cost Effectiveness and Changing Outcomes

- Smaller disease burden and smaller number of deaths in this age group than older age groups
- Strains that affect this age group
- Unknown future of COVID-19 variants (virulence in this age group)

References:

Considerations: Societal Benefits not included

Societal Benefits

- Societal Benefits are difficult to measure in infancy or child vaccination
  - Non-health benefits
  - Equity
  - Herd Immunity
  - School time missed
  - Secondary Transmission
    - In the United States, one child loses a caregiver for every four COVID-19 deaths[1]

Reference: More than 140,000 U.S. children lost a primary or secondary caregiver due to the COVID-19 pandemic | National Institutes of Health (NIH)

Summary / Recommendations

Summary: Literature (Childhood Vaccination)

What we learn from Literature

- Things that could make a vaccine cost-effective/or/more cost-effective…
  - To include costs of a secondary infection (caregiver) *(Influenza Study, de Boer et. al.)*
  - To include herd immunity *(Multi-antigen study, Holubar et. al.)*

Summary: Literature (COVID-19 Vaccination)

What we learn from Literature

- Things that could make a vaccine cost-effective/or/more cost-effective…
  - To consider the benefit of reduced transmission (secondary infection) to older ages or those with serious medical conditions *(Kahli et. al.)*
  - To consider stratifying by those with serious medical conditions *(Kahli et. al.)*
  - If the population of incidence of COVID-19 is high *(Li et. al. PREPRINT)*
  - The less susceptible people to disease at the beginning of a vaccination campaign, the less people you need to reach with vaccines for CE *(Hagens et. al.)*

Summary: Considerations

- Equity
  - CEA does not typically include
- Quantifying Changing Outcomes
  - Unknown future and unknown outcomes
- Additional Societal Benefits that are difficult to measure in infancy of child vaccination
  - Nonhealth benefits, Herd immunity, infection of caregiver, etc.

Summary

Criteria for Reviewing Antigens for Potential Inclusion in WAC 246-105-030

I. Criteria on the effectiveness of the vaccine

3. The vaccine containing this antigen is cost effective from a societal perspective.

- 6 studies were reviewed and presented on CE of vaccination that may provide insight into CE of COVID-19 vaccination
  - All studies (6/6) used different methods and produced different outcomes
  - All studies (6/6) concluded that vaccination could be CE under certain assumptions/conditions
- 4 studies were reviewed and presented on CE of COVID-19 vaccination that may provide insight.
  - No studies (0/4 of COVID-19) studies looked at school age population

References

Literature Review (included in presentation)

Author	Publication Year	Online Reference
De Boer et. al.	2020	Vaccinating children against influenza: overall cost-effective with potential for undesirable outcomes - PubMed (nih.gov)
Holubar et. al.	2017	Impact of vaccine herd-protection effects in cost-effectiveness analyses of childhood vaccinations. A quantitative comparative analysis (plos.org)
Padula et. al.	N/A	Economic Value of Treatment and Vaccine to Address the COVID-19 Pandemic: A U.S. Cost-Effectiveness and Budget Impact Analysis by William V. Padula, Shreena Malaviya, Natalie M. Reid, Jonothan Tierce, G. Alexander :: SSRN
Kohli et. al.	2021	The potential public health and economic value of a hypothetical COVID-19 vaccine in the United States: Use of cost-effectiveness modeling to inform vaccination prioritization (nih.gov)
Li et. al.	N/A	Cost-Effectiveness Analysis of BNT162b2 COVID-19 Booster Vaccination in the United States by Rui Li, Hanting Liu, Christopher K. Fairley, Zhuoru Zou, Li Xie, Xinghui Li, Mingwang Shen, Yan Li, Lei Zhang :: SSRN
Hagens et. al.	2021	COVID-19 Vaccination Scenarios: A Cost-Effectiveness Analysis for Turkey (nih.gov)

Literature Review

First Author	Publication Year	Online Reference
Wong et. al.	2020	Full article: The use of the health belief model to assess predictors of intent to receive the COVID-19 vaccine and willingness to pay (tandfonline.com)
Shaker et. al.	2021	A Cost-Effectiveness Evaluation of Hospitalizations, Fatalities, and Economic Outcomes Associated with Universal Versus Anaphylaxis Risk-Stratified COVID-19 Vaccination Strategies (nih.gov)
Goldman et. al.	2020	Caregiver willingness to vaccinate their children against COVID-19: Cross sectional survey - ScienceDirect
FAIR HEALTH	2020	https://www.fairhealth.org/article/costs-for-a-hospital-stay-for-covid-19
Kostoff et. al.	2021	Why are we vaccinating children against COVID-19? | Elsevier Enhanced Reader
Lavine et. al.	2021	Vaccinating children against SARS-CoV-2 (bmj.com)
de Boer et. al.	2020	Vaccinating children against influenza: overall cost-effective with potential for undesirable outcomes - PubMed (nih.gov)
Pike et. al.	2020	Societal Costs of a Measles Outbreak - PubMed (nih.gov)
Cataldi		The Many Costs of Measles Outbreaks and Undervaccination: Why We Need to Invest in Public Health | American Academy of Pediatrics (aappublications.org)
Zhao J et. al.	2021	Disease Burden Attributable to the First Wave of COVID-19 in China and the Effect of Timing on the Cost-Effectiveness of Movement Restriction Policies (nih.gov)
Bloom et. al.	2021	The Societal Value of Vaccination in the Age of COVID-19 (nih.gov)

Literature Review

First Author	Publication Year	Online Reference
Sheinson et. al.	2020	A Cost-Effectiveness Framework for COVID-19 Treatments for Hospitalized Patients in the United States (nih.gov)
Gros et. al.	2021	Containment efficiency and control strategies for the corona pandemic costs (nih.gov)
Del Valle et. al.	2005	(PDF) del valle 2005 effects of behavior changes smallpox attack model (researchgate.net)
Wen Bing Chua et. al.	2021	bmjopen-2021-051503.pdf (nih.gov)
Schnitzler et. al.	2021	S0266462321000155jra 1..4 (cambridge.org)
Sheinson et. al.	2021	A Cost-Effectiveness Framework for COVID-19 Treatments for Hospitalized Patients in the United States (nih.gov)
Padula et. al.	2020	Economic Value of Treatment and Vaccine to Address the COVID-19 Pandemic: A U.S. Cost-Effectiveness and Budget Impact Analysis by William V. Padula, Shreena Malaviya, Natalie M. Reid, Jonothan Tierce, G. Alexander :: SSRN
Kamal-Bahl et. al.	2020	The Case For Using Novel Value Elements When Assessing COVID-19 Vaccines And Therapeutics | Health Affairs
Prosser et. al.	2006	Health benefits, risks, and cost-effectiveness of influenza vaccination of children - PubMed (nih.gov)
WA DOH	2022	COVID-19 Cases Among Children and Youth in Washington

Literature Review

First Author	Publication Year	Online Reference
Odihi et. al.	2020	Economics of COVID-19 Vaccines - Johns Hopkins Coronavirus Resource Center (jhu.edu)
Kohli et. al.	2021	The potential public health and economic value of a hypothetical COVID-19 vaccine in the United States: Use of cost-effectiveness modeling to inform vaccination prioritization (nih.gov)
Padula et. al.	2020	Economic Value of Treatment and Vaccine to Address the COVID-19 Pandemic: A U.S. Cost-Effectiveness and Budget Impact Analysis by William V. Padula, Shreena Malaviya, Natalie M. Reid, Jonothan Tierce, G. Alexander :: SSRN
Opel et. al.	2020	jamapediatrics_opel_2020_vp_200030_1611604196.55086.pdf
Kim	2011	The Role of Cost-Effectiveness in U.S. Vaccination Policy | NEJM
Siedner et. al.	2021	Cost-effectiveness of COVID-19 vaccination in low- and middle-income countries | medRxiv
Li et. al.	2021	Cost-Effectiveness Analysis of BNT162b2 COVID-19 Booster Vaccination in the United States by Rui Li, Hanting Liu, Christopher K. Fairley, Zhuoru Zou, Li Xie, Xinghui Li, Mingwang Shen, Yan Li, Lei Zhang :: SSRN
Bartsch et. al.	2021	The Benefits of Vaccinating With the First Available COVID-19 Coronavirus Vaccine - ScienceDirect
Marco-Franco et al.		Mathematics | Free Full-Text | Simplified Mathematical Modelling of Uncertainty: Cost-Effectiveness of COVID-19 Vaccines in Spain (mdpi.com)
Hagens et. al.	2021	COVID-19 Vaccination Scenarios: A Cost-Effectiveness Analysis for Turkey (nih.gov)

Literature Review

First Author	Publication Year	Online Reference
Chua et. al.	2021	Assessment of Out-of-Pocket Spending for COVID-19 Hospitalizations in the US in 2020 | Health Care Economics, Insurance, Payment | JAMA Network Open | JAMA Network
Tufts	Various	Search the CEA Registry (tuftsmedicalcenter.org)
CDC	2014	Benefits from Immunization During the Vaccines for Children Program Era — United States, 1994–2013 (cdc.gov)
CDC	2014	Vaccines for Children (VFC): Publication on Cost-Benefits | CDC
Luyten et. al.	2016	The Social Value Of Vaccination Programs: Beyond Cost-Effectiveness (healthaffairs.org)
Gavin	2021	Patients hospitalized for COVID could pay thousands of dollars, study suggests (uofmhealth.org)
Harvy	2021	COVID-19 Hospital Cost: Price of COVID Treatment by State | Money
Holubar et. al.	2017	Impact of vaccine herd-protection effects in cost-effectiveness analyses of childhood vaccinations. A quantitative comparative analysis (plos.org)
Wang et. al.		Economic evaluation for mass vaccination against COVID-19 | Elsevier Enhanced Reader
Beutels et. al.	2008	Partially wrong? Partial equilibrium and the economic analysis of public health emergencies of international concern - Beutels - 2008 - Health Economics - Wiley Online Library
Stirling et al.	2009	Has the time come for cost-effectiveness analysis in US health care? (researchgate.net)

Literature Review

First Author	Publication Year	Online Reference
Neumann et. al.		A-strategic-plan-for-integrating-cost-effectiveness-analysis-into-the-US-Healthcare-System.pdf (researchgate.net)
Ehreth	2002	s0264-410x_2803_2900377-320210920-2678-1r1qebv-with-cover-page-v2.pdf (d1wqtxts1xzle7.cloudfront.net)
The American Journal of Managed Care	2020	A946_Article1_Update.pdf (sanity.io)
Philipson et. al.	2016	The Social Value of Childhood Vaccination in the United States (ajmc.com)
Leidner et. al.	2019	Cost-effectiveness of adult vaccinations: A systematic review (nih.gov)
Global Health CEA Registry		ghcearegistry.org/ghcearegistry/
Cohen		Vaccines Are Critical To Public Health, And Are Cost-Effective, Too (forbes.com)
Funk et. al.		Outcomes of SARS-CoV-2–Positive Youths Tested in Emergency Departments: The Global PERN–COVID-19 Study | Adolescent Medicine | JAMA Network Open | JAMA Network
WA DOH	December 2021	Multisystem Inflammatory Syndrome in Children Associated with COVID-19 in Washington State

Literature Review

First Author	Publication Year	Online Reference
Andronis et. al.	2019	Measuring, valuing and including forgone childhood education and leisure time costs in economic evaluation: Methods, challenges and the way forward (ox.ac.uk)
Stephenson et. al.		Long COVID - the physical and mental health of children and non-hospitalised young people 3 months after SARS-CoV-2 infection; a national matched cohort study (The CLoCk) Study. | Research Square
Lewis et. al.	2021	Closing schools is not evidence based and harms children | The BMJ
Boujaoude et. al.	2018	Accounting for equity considerations in cost-effectiveness analysis: a systematic review of rotavirus vaccine in low- and middle-income countries (biomedcentral.com)
Cookson et. al.	2017	Using Cost-Effectiveness Analysis to Address Health Equity Concerns | Elsevier Enhanced Reader

2022 – Working together for brighter tomorrow

Washington State Department of Health

To request this document in another format, call 1-800-525-0127. Deaf or hard of hearing customers, please call 711 (Washington Relay) or email civil.rights@doh.wa.gov.

Visit www.doh.wa.gov

@WaDeptHealth
@WaHealthSec