**Appendix to** *Cost-Effectiveness of SARS-CoV-2 Testing and Isolation Strategies in Nursing Homes*

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*Costs and Economic Outcomes and Perspectives*

Each person accrues relevant intervention, direct medical costs, productivity losses, and health effects as he/she travels through the model and an event occurs (e.g., gets tested, is hospitalized, etc.). These then contribute to the calculation of cost-effectiveness of SARS-CoV-2 testing from different perspectives such as that of the third-party payer [e.g., Centers for Medicare and Medicaid Services (CMS)] and societal perspectives. The CMS perspective (a specific third-party payer) includes direct medical costs incurred by testing residents and staff as well as hospitalization costs for residents. Since 99% of U.S. adults 65 years and older were CMS beneficiaries in 20221, 2, we assume CMS incurs the costs for all residents. The total third-party payer perspective (e.g., CMS and other insurers/payers) includes all direct medical costs (e.g., testing, face masks, ambulatory care for staff, hospitalization for residents and staff). We assumed all intervention costs (testing, face masks) are direct medical costs and thus would eventually be borne by third-party payers. The societal perspective includes direct medical and indirect (i.e., productivity losses due to presenteeism and absenteeism) costs. Hourly wage serves as a proxy for productivity losses. Absenteeism (missing work/productive time due to illness) results in productivity losses for the duration of isolation, symptoms, or hospitalization, while presenteeism (lost productivity that occurs when employees are not fully functioning due to illness) results in losses for staff who work while ill. All COVID-19 cases accrue productivity losses, regardless of age, as everyone contributes to society.

Appendix Table 1. Key model input parameters, values, and sources

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Distribution Type** | **Mean/ Median** | **Range/ Standard Deviation** | **Source** |
| **Nursing Home Characteristics** |  |  |  |  |
| Number of: |  |  |  |  |
| Residents |  | 100 | - |  |
| Routine Care Staff |  | 120 | - |  |
| Specialty Care Staff |  | 19 | - |  |
| Non-Resident Facing Staff |  | 31 | - |  |
| Resident length of stay |  | 69.7 | 250.2 | 3 |
| Percentage of post-acute care residents (length of stay <100 days) |  | 0.87 | - | 3 |
| Number of non-mixing resident rooms |  | 32 | - |  |
| **COVID-19 Coronavirus Characteristics** |  |  |  |  |
| Incubation period (days) | Gamma | 3.5 | 2.4 | 4-7 |
| Days can transmit prior to disease onset | Point Estimate | 2 |  | 8 |
| Infectious period (days) | Beta Pert | 5 | 3-9 | 9 |
| **Intervention Characteristics** |  |  |  |  |
| Vaccine efficacy against infection |  |  |  |  |
| Primary series + booster (staff and residents)\* | Beta Pert | 0.348 | 0.313 – 0.383 | 10, 11 |
| Bivalent booster (staff and residents)\* | Beta Pert | 0.510 | 0.459 – 0.561 | 10-15\*\* |
| Vaccine efficacy against hospitalization |  |  |  |  |
| Primary series + booster (staff and residents) | Beta Pert | 0.55 | 0.46 – 0.62 | 12 |
| Bivalent booster (staff and residents) | Beta Pert | 0.80 | 0.71 – 0.85 | 12 |
| Vaccination coverage primary series and booster†† |  |  |  |  |
| Staff | Point Estimate | 0.879 | - | 16 |
| Residents | Point Estimate | 0.875 | - | 16 |
| Vaccination coverage bivalent booster†† |  |  |  |  |
| Staff | Point Estimate | 0.232 | - | 16 |
| Residents | Point Estimate | 0.485 | - | 16 |
| N95 respirator efficacy | Point Estimate | 0.99 | - | 17 |
| Surgical masks efficacy | Beta | 0.59 | 0.069 | 17 |
| Face mask compliance  | Point Estimate | 0.80 |  | Expert Opinion |
| Antigen test sensitivity | Beta Pert | 0.81 | 0.78 – 0.84 | 18 |
| PCR test sensitivity | Beta Pert | 0.98 | 0.95 – 0.99 | 19 |
| SARS-CoV-2 test specificity | Point Estimate | 1.0 | - | 18, 19 |
| **Probabilities** |  |  |  |  |
| Staff leave job, daily (turnover not due to COVID-19) | Point Estimate | 0.00017 | - | 20 |
| Tell have COVID-19 symptoms given infection |  |  |  |  |
| Staff |  | 0.5 | - | Assumption |
| Residents |  | 0.5 | - | Assumption |
| Other respiratory illnesses, daily | Point Estimate | 0.0015 |  | Calibrated ‡ |
| Asymptomatic / non-overt infection\* | Beta Pert | 0.324 | 0.253-0.3951 | 21 |
| Ambulatory care |  | 0.167 | 0.150-0.184 | 22 |
| Hospitalization (unvaccinated) |  |  |  |  |
| Staff | Triangular | 0.025 | 0.0225– 0.0275 | Assumption, 23 |
| Residents | Triangular | 0.05 | 0.045 – 0.055 | 24 |
| ICU admission, given hospitalization |  |  |  |  |
| Staff | Beta Pert | 0.095 | 0.0855 - 0.1045 | 25 |
| Residents | Beta Pert | 0.147 | 0.1323 - 0.1617 | 25 |
| Mortality, given hospitalization |  |  |  |  |
| Staff\* | Beta Pert | 0.023 | 0.0207-0.0253 | 25 |
| Residents\* | Beta Pert | 0.10 | 0.09 – 0.11 | 25 |
| Ventilator use among hospitalized patients |  |  |  |  |
| Staff | Beta Pert | 0.023 | 0.0207-0.0253 | 25 |
| Residents | Beta Pert | 0.043 | 0.0387-0.0473 | 26 |
| **Costs (2023 US$)**‡‡ |  |  |  |  |
| Annual wages (all occupations; proxy for residents)◊ | Triangular | 45,760 | 23,980 – 68,590 | 27 |
| Daily wage, NH staff |  |  |  |  |
| Routine care | Triangular | 220.12 | 97.26 – 490.65 | 27 |
| Specialty care | Triangular | 369.66 | 247.57 – 518.65 | 27 |
| Non-resident facing  | Triangular | 138.34 | 91.15 – 254.70 | 27 |
| Ambulatory care visit | Triangular | 133.66 | 94.81 – 188.56 | 28 |
| Over the counter medications, per dose | Gamma | 0.108 | 0.417 | 29 |
| Hospitalization  |  |  |  |  |
| Staff | Gamma | 22,155.04 | 296.13 | 30 |
| Residents† | Gamma | 21,181.95 | 6,736.20 – 52,891.53 | 31 |
| COVID-19 antigen test | Point Estimate | 12 | - | 32 |
| COVID-19 PCR test | Point Estimate | 51.31 | - | 33 |
| Surgical mask (each) | Uniform | - | 0.20 – 0.60  | 34 |
| N95 respirator (each) | Uniform | - | 0.76 – 1.42 | 35 |
| **Durations (days)** |  |  |  |  |
| Isolation given positive SARS-CoV-2 test | Point Estimate | 10 | - | Assumption |
| NH bed held during resident hospitalization | Point Estimate | 10 | - | Assumption |
| Ambulatory care  | Point Estimate | 0.5 | - | Assumption |
| Over the counter medication use | Uniform | - | 1 – 5 | Assumption based on symptom duration |
| Duration of symptoms with mild illness | Gamma | 6.87 | 5.21 | 23 |
| Duration of mild symptoms prior to hospital admission | Beta Pert | 7 | 3-9 | 36, 37 |
| Hospitalization LOS (ICU and general ward)^ | Gamma | 3.9 | 1.9-8.7 | 38 |
| **Numbers** |  |  |  |  |
| Over the counter medication doses per day | Uniform | - | 4 - 6 | Standard dosing |
| **Utility weights** |  |  |  |  |
| Healthy QALY |  |  |  |  |
| 18-64 years old | Point Estimate | 0.92 | - | 39 |
| ≥65 years old | Point Estimate | 0.84 | - | 39 |
| Mild non-specific symptoms | Beta | 0.8179 | 0.1210 | 40-50 |
| Severe infection, leading to hospitalization | Beta | 0.489 | 0.209 | 46, 51-58 |

◊Values are median, 10th and 90th percentiles

\*Values are +/-10% of median/mean value

^Values are median, interquartile range (IQR)

•Values are 95% confidence interval

†Average Medicare payment per fee-for-service COVID-19 hospitalization reported between January and June 2022

††Vaccination coverage of residents and staff reported through November 20, 2022

‡Value calibrated such that of those showing symptoms, 75% are due to COVID-19 and the remaining 25% are due to other respiratory pathogens during a respiratory virus season

\*\*Primary series plus booster value adjusted by average relative efficacy of bivalent booster to monovalent booster. Assumes individuals received bivalent booster within last 6 months, and has not waned much, based on titer data as randomized studies are not being conducted for vaccine efficacy against infection

‡‡All costs are reported in 2023 values, converting all past and future costs using a 3% annual rate

Appendix Table 2. Mixing parameters

|  |  |  |  |
| --- | --- | --- | --- |
| **Contact from** | **Contact with** | **Contact probability between groups** | **Average exposures per day** |
| Resident  | Resident’s roommate | 1\* | 88 |
| Resident^ | Specialty care staff | 0.077 | 7.7 |
| Social residents | Social residents (excluding roommate) | 0.1 | 6 |
| Resident | Routine staff | 0.385 | 7.7 |
| Resident | Non-resident facing staff | 0 | 0 |
| Routine staff  | Other routine staff | 0.051 | 4.3 |
| Routine staff | Specialty staff | 0.023 | 0.4 |
| Routine staff  | Non-resident facing staff | 0.054 | 1.7 |
| Specialty care staff  | Other specialty care staff | 0.26 | 4.7 |
| Specialty care staff | Non-resident facing staff | 0 | 0 |
| Non-resident facing staff  | Other non-resident facing staff | 0.24 | 7.1 |

\*Assumes roommates will have a 100% probability of contact in a given day

^Value for all residents; however, specialty care staff only interact with residents with a length of stay <100 days (post-acute care residents)

Note: The daily contact probabilities between individuals derived from empirical data on the number of daily contacts for residents and staff from surveyed and observed interactions from investigators with longstanding ties to Orange County, CA NHs. Using detailed shift-based data, we calculated daily contact probabilities by dividing the weekly number of daily contacts within and across residents and staff types by the number of staff working that week and distributing the weekly contacts equally across 7 days.

References

1. Centers for Medicare & Medicaid Services (CMS). Medicare Monthly Enrollment Baltimore, MD: U.S. Centers for Medicare & Medicaid Services; 2022 [updated August 2023. Available from: <https://data.cms.gov/summary-statistics-on-beneficiary-enrollment/medicare-and-medicaid-reports/medicare-monthly-enrollment>.

2. U.S. Census Bureau. American Community Survey 1-Year Data (2005-2022): U.S. Census Bureau; 2023 [updated August 23, 2023.

3. Centers for Medicare & Medicaid Services (CMS). Minimum Data Set (MDS) 3.0 Frequency Report. 2019.

4. Wu Y, Kang L, Guo Z, Liu J, Liu M, Liang W. Incubation Period of COVID-19 Caused by Unique SARS-CoV-2 Strains: A Systematic Review and Meta-analysis. *JAMA Netw Open*. 2022;5(8):e2228008.

5. Kim D, Ali ST, Kim S, et al. Estimation of Serial Interval and Reproduction Number to Quantify the Transmissibility of SARS-CoV-2 Omicron Variant in South Korea. *Viruses*. 2022;14(3).

6. Backer JA, Eggink D, Andeweg SP, et al. Shorter serial intervals in SARS-CoV-2 cases with Omicron BA.1 variant compared with Delta variant, the Netherlands, 13 to 26 December 2021. *Euro Surveill*. 2022;27(6).

7. Del Aguila-Mejia J, Wallmann R, Calvo-Montes J, Rodriguez-Lozano J, Valle-Madrazo T, Aginagalde-Llorente A. Secondary Attack Rate, Transmission and Incubation Periods, and Serial Interval of SARS-CoV-2 Omicron Variant, Spain. *Emerg Infect Dis*. 2022;28(6):1224-8.

8. Centers for Disease Control and Prevention. CDC Updates and Shortens Recommended Isolation and Quarantine Period for General Population 2022 [Available from: <https://www.cdc.gov/media/releases/2021/s1227-isolation-quarantine-guidance.html>.

9. Boucau J, Marino C, Regan J, et al. Duration of Shedding of Culturable Virus in SARS-CoV-2 Omicron (BA.1) Infection. *N Engl J Med*. 2022;387(3):275-7.

10. Lau JJ, Cheng SMS, Leung K, et al. Real-world COVID-19 vaccine effectiveness against the Omicron BA.2 variant in a SARS-CoV-2 infection-naive population. *Nat Med*. 2023.

11. Monge S, Rojas-Benedicto A, Olmedo C, et al. Effectiveness of mRNA vaccine boosters against infection with the SARS-CoV-2 omicron (B.1.1.529) variant in Spain: a nationwide cohort study. *Lancet Infect Dis*. 2022;22(9):1313-20.

12. Link-Gelles R, Levy ME, Gaglani M, et al. Effectiveness of 2, 3, and 4 COVID-19 mRNA Vaccine Doses Among Immunocompetent Adults During Periods when SARS-CoV-2 Omicron BA.1 and BA.2/BA.2.12.1 Sublineages Predominated - VISION Network, 10 States, December 2021-June 2022. *MMWR Morb Mortal Wkly Rep*. 2022;71(29):931-9.

13. Link-Gelles R, Ciesla AA, Roper LE, et al. Early Estimates of Bivalent mRNA Booster Dose Vaccine Effectiveness in Preventing Symptomatic SARS-CoV-2 Infection Attributable to Omicron BA.5- and XBB/XBB.1.5-Related Sublineages Among Immunocompetent Adults - Increasing Community Access to Testing Program, United States, December 2022-January 2023. *MMWR Morb Mortal Wkly Rep*. 2023;72(5):119-24.

14. Davis-Gardner ME, Lai L, Wali B, et al. Neutralization against BA.2.75.2, BQ.1.1, and XBB from mRNA Bivalent Booster. *N Engl J Med*. 2023;388(2):183-5.

15. Zhu FC, Guan XH, Li YH, et al. Immunogenicity and safety of a recombinant adenovirus type-5-vectored COVID-19 vaccine in healthy adults aged 18 years or older: a randomised, double-blind, placebo-controlled, phase 2 trial. *Lancet*. 2020;396(10249):479-88.

16. Centers for Medicare & Medicaid Services (CMS). Recent Facility Resident and Staff Vaccination Rates and Other Data, as reported for week ending 11/20/22 Baltimore, MD: Centers for Medicare & Medicaid Services; 2022 [updated November 30, 2022. Available from: <https://data.cms.gov/covid-19/covid-19-nursing-home-data>.

17. Lindsley WG, Blachere FM, Law BF, Beezhold DH. Efficacy of face masks, neck gaiters and face shields for reducing the expulsion of simulated cough-generated aerosols. *Aerosol Science and Technology*. 2021;55(4):449-57.

18. Hayden MK, Mustafa RA, Hanson KE, et al. Infectious Diseases Society of America Guidelines on the Diagnosis of COVID-19: Antigen Testing. *Infectious Disease Society of America*. 2022.

19. Hanson KE, Caliendo AM, Arias CA, et al. Infectious Diseases Society of America Guidelines on the Diagnosis of COVID-19: Molecular Diagnostic Testing. *Infectious Disease Society of America*. 2022.

20. Gandhi A, Yu H, Grabowski DC. High Nursing Staff Turnover In Nursing Homes Offers Important Quality Information. *Health Affairs*. 2021;40(3).

21. Shang W, Kang L, Cao G, et al. Percentage of Asymptomatic Infections among SARS-CoV-2 Omicron Variant-Positive Individuals: A Systematic Review and Meta-Analysis. *Vaccines (Basel)*. 2022;10(7).

22. Network H-R, Thompson MG, Yoon SK, et al. Association of mRNA Vaccination With Clinical and Virologic Features of COVID-19 Among US Essential and Frontline Workers. *JAMA*. 2022;328(15):1523-33.

23. Menni C, Valdes AM, Polidori L, et al. Symptom prevalence, duration, and risk of hospital admission in individuals infected with SARS-CoV-2 during periods of omicron and delta variant dominance: a prospective observational study from the ZOE COVID Study. *Lancet*. 2022;399(10335):1618-24.

24. Esper FP, Adhikari TM, Tu ZJ, et al. Alpha to Omicron: Disease Severity and Clinical Outcomes of Major SARS-CoV-2 Variants. *J Infect Dis*. 2023;227(3):344-52.

25. Iuliano AD, Brunkard JM, Boehmer TK, et al. Trends in Disease Severity and Health Care Utilization During the Early Omicron Variant Period Compared with Previous SARS-CoV-2 High Transmission Periods - United States, December 2020-January 2022. *MMWR Morb Mortal Wkly Rep*. 2022;71(4):146-52.

26. Naleway AL, Groom HC, Crawford PM, et al. Incidence of SARS-CoV-2 Infection, Emergency Department Visits, and Hospitalizations Because of COVID-19 Among Persons Aged >/=12 Years, by COVID-19 Vaccination Status - Oregon and Washington, July 4-September 25, 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(46):1608-12.

27. U.S. Bureau of Labor Statistics. Occupational Employment and Wage Statistics Washington DC: U.S. Bureau of Labor Statistics; 2021 [updated March 31, 2022. Available from: <https://www.bls.gov/oes/tables.htm>.

28. Centers for Medicare & Medicaid Services. Physicians Fee Schedule Baltimore, MD: U.S. Centers for Medicare & Medicaid Services; 2022 [updated January 1, 2022. Available from: <https://www.cms.gov/medicare/physician-fee-schedule/search/overview>.

29. IBM. Micromedex RED BOOK. 2022.

30. <https://datatools.ahrq.gov/hcupnet> [Internet]. Agency for Healthcare Research and Quality. 2020. Available from: <https://datatools.ahrq.gov/hcupnet>.

31. Centers for Medicare & Medicaid Services (CMS). Medicare COVID-19 Hospitalization Trends Report: Medicare Claims and Encounter Data: January 1, 2020 to June 30, 2022, Received by October 28, 2022. CMS.gov; 2022.

32. Dawson L, Amin K, Kates J, Cox C. How Are Private Insurers Covering At-Home Rapid COVID Tests? Kaiser Family Foundation: Kaiser Family Foundation; 2022 [Available from: <https://www.kff.org/policy-watch/how-are-private-insurers-covering-at-home-rapid-covid-tests/>.

33. Centers for Medicare & Medicaid Services (CMS). Clinical Laboratory Fee Schedule Files 2023 [Q1 2023:[Available from: <https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/ClinicalLabFeeSched/Clinical-Laboratory-Fee-Schedule-Files>.

34. MedEquip Depot. Dallas, TX [Available from: <https://www.medequipdepot.com>.

35. 3M. Get the Facts. N95 Respirator Pricing St. Paul, MN2021 [Available from: <https://multimedia.3m.com/mws/media/1862179O/get-the-facts-n95-respirator-pricing.pdf>.

36. Garg S, Kim L, Whitaker M, et al. Hospitalization Rates and Characteristics of Patients Hospitalized with Laboratory-Confirmed Coronavirus Disease 2019 — COVID-NET, 14 States, March 1–30, 2020. *Morbidity and Mortality Weekly Report*. ePub: 8 April 2020.

37. Wang D, Hu B, Hu C, et al. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. *JAMA*. 2020.

38. Havers FP, Patel K, Whitaker M, et al. Laboratory-Confirmed COVID-19-Associated Hospitalizations Among Adults During SARS-CoV-2 Omicron BA.2 Variant Predominance - COVID-19-Associated Hospitalization Surveillance Network, 14 States, June 20, 2021-May 31, 2022. *MMWR Morb Mortal Wkly Rep*. 2022;71(34):1085-91.

39. Gold MR, Franks P, McCoy KI, Fryback DG. Toward consistency in cost-utility analyses: using national measures to create condition-specific values. *Medical Care*. 1998;36(6):778-92.

40. Chen D, Ye Z, Pi Z, Mizukami S, Aoyagi K, Jiang Y. Cost-effectiveness of dual influenza and pneumococcal vaccination among the elderly in Shenzhen, China. *Vaccine*. 2021;39(16):2237-45.

41. Griffin AD, Perry AS, Fleming DM. Cost-effectiveness analysis of inhaled zanamivir in the treatment of influenza A and B in high-risk patients. *Pharmacoeconomics*. 2001;19(3):293-301.

42. Lee GM, Murphy TV, Lett S, et al. Cost effectiveness of pertussis vaccination in adults. *Am J Prev Med*. 2007;32(3):186-93.

43. Lee GM, Riffelmann M, Wirsing von Konig CH. Cost-effectiveness of adult pertussis vaccination in Germany. *Vaccine*. 2008;26(29-30):3673-9.

44. Mennini FS, Bini C, Marcellusi A, Rinaldi A, Franco E. Cost-effectiveness of switching from trivalent to quadrivalent inactivated influenza vaccines for the at-risk population in Italy. *Hum Vaccin Immunother*. 2018;14(8):1867-73.

45. Scholz SM, Weidemann F, Damm O, Ultsch B, Greiner W, Wichmann O. Cost-Effectiveness of Routine Childhood Vaccination Against Seasonal Influenza in Germany. *Value Health*. 2021;24(1):32-40.

46. Wu DBC, Chaiyakunapruk N, Pratoomsoot C, et al. Cost-utility analysis of antiviral use under pandemic influenza using a novel approach - linking pharmacology, epidemiology and heath economics. *Epidemiol Infect*. 2018;146(4):496-507.

47. Khazeni N, Hutton DW, Garber AM, Hupert N, Owens DK. Effectiveness and cost-effectiveness of vaccination against pandemic influenza (H1N1) 2009. *Ann Intern Med*. 2009;151(12):829-39.

48. Lee BY, Tai JHY, Bailey RR, Smith KJ, Nowalk AJ. Economics of influenza vaccine administration timing for children. *American Journal of Managed Care*. 2010;16(3):e75-e85.

49. Smith KJ, Lee BY, Nowalk MP, Raymund M, Zimmerman RK. Cost-effectiveness of dual influenza and pneumococcal vaccination in 50-year-olds. *Vaccine*. 2010;28:7620-5.

50. Prosser LA, Meltzer MI, Fiore A, et al. Effects of adverse events on the projected population benefits and cost-effectiveness of using live attenuated influenza vaccine in children aged 6 months to 4 years. *Arch Pediatr Adolesc Med*. 2011;165(2):112-8.

51. Elliott RA, Putman KD, Franklin M, et al. Cost effectiveness of a pharmacist-led information technology intervention for reducing rates of clinically important errors in medicines management in general practices (PINCER). *Pharmacoeconomics*. 2014;32(6):573-90.

52. Mohara A, Perez Velasco R, Praditsitthikorn N, Avihingsanon Y, Teerawattananon Y. A cost-utility analysis of alternative drug regimens for newly diagnosed severe lupus nephritis patients in Thailand. *Rheumatology (Oxford)*. 2014;53(1):138-44.

53. Chandra A, Snider JT, Wu Y, Jena A, Goldman DP. Robot-assisted surgery for kidney cancer increased access to a procedure that can reduce mortality and renal failure. *Health Aff (Millwood)*. 2015;34(2):220-8.

54. Fuller GW, Keating S, Goodacre S, et al. Prehospital continuous positive airway pressure for acute respiratory failure: the ACUTE feasibility RCT. *Health Technol Assess*. 2021;25(7):1-92.

55. Cox CE, Carson SS, Biddle AK. Cost-effectiveness of ultrasound in preventing femoral venous catheter-associated pulmonary embolism. *Am J Respir Crit Care Med*. 2003;168(12):1481-7.

56. Kip MMA, van Oers JA, Shajiei A, et al. Cost-effectiveness of procalcitonin testing to guide antibiotic treatment duration in critically ill patients: results from a randomised controlled multicentre trial in the Netherlands. *Crit Care*. 2018;22(1):293.

57. Fowler RA, Hill-Popper M, Stasinos J, Petrou C, Sanders GD, Garber AM. Cost-effectiveness of recombinant human activated protein C and the influence of severity of illness in the treatment of patients with severe sepsis. *J Crit Care*. 2003;18(3):181-91; discussion 91-4.

58. Kotirum S, Muangchana C, Techathawat S, Dilokthornsakul P, Wu DB, Chaiyakunapruk N. Economic Evaluation and Budget Impact Analysis of Vaccination against Haemophilus influenzae Type b Infection in Thailand. *Front Public Health*. 2017;5:289.