Online-Only Supplemental Material

**For:** **Costs Implications of Pneumococcal Vaccination of Adults aged 30-60 with a recent diagnosis of Diabetes**

**Methods**

**Dataset Creation**

Our first step in establishing the dataset was to extract enrollment data from the Truven Health MarketScan® Database (MarketScan) Annual Summary Enrollment tables from 2005 through 2014 requiring 12 months of continuous enrollment in each year and continuous enrollment over the 10 year period by enrollee. We then defined a 2 year diabetes washout period by extracting inpatient and outpatient data for 2003 and 2004 to remove individuals who had a prior diabetes diagnosis. The following variables were extracted for both years from the Inpatient Admissions table and the Outpatient Services table: Enrollee ID, Enrollee Date of Birth, Date of Service, Year of Service. Place of Service, Procedure, Provider, Primary Diagnosis, Diagnoses (up to 5), Geographic Location, Sex, Payment, and Net Payment. The washout period data (4 datasets – 2 years, inpatient and outpatient) was then merged with the continuous enrollment dataset, keeping only enrollees with 10 years of continuous enrollment from 2005 – 2014. Any duplicates were deleted. An indicator variable was created for inpatient data (inpatient file OR outpatient file with Place of Service = Inpatient Hospital). Any observation with a diabetes-related diagnosis was identified. A confirmed diabetes indicator was created for those enrollees with more than one diabetes diagnosis thirty days or more apart in the outpatient file or a single diabetes diagnosis in the inpatient file. The final washout dataset included only enrollees that are confirmed to be adults with diabetes. There were 5,124,289 enrollees on January 1 of 2005, 839,707 of which were continuously enrolled for ten years and included in this analysis without prior diabetes.

Before the confirmed diabetes indicator was formed, an indicator variable was also created for any enrollees who received PPSV23 vaccination during the washout period. A separate dataset (washout\_PPSV23) was formed of enrollees with the PPSV23 vaccination indicator for the washout period (2003 – 2004).

Following the same procedures and extracting the same variables as the washout period, data was extracted from 2005 – 2014 keeping each year as a separate file with the addition of age limitations *to ensure the same enrollees were included in each year* and not aging out of the cohort.

* 2005 age limit: 30-51
* 2006 age limit: 31-52
* 2007 age limit: 32-53
* 2008 age limit: 33-54
* 2009 age limit: 34-55
* 2010 age limit: 35-56
* 2011 age limit: 36-57
* 2012 age limit: 37-58
* 2013 age limit: 38-59
* 2014 age limit: 39-60

Inpatient and outpatient datasets were merged in each year, followed by merging each year with the final washout dataset extracting adults with confirmed diabetes prior to 2005. Each year was also merged with the washout\_PPSV23 dataset so that each year contains an indicator variable designating whether the enrollee had PPSV23 vaccination during the washout period.

Pneumococcal vaccination recommendations have been complex over this time period. Many conditions were recommended for PPSV23 vaccination in adults in 2010. In 2012, additional recommendations were made to add PCV13 vaccination to a subset of these conditions. Because some of the increased-risk conditions for PPSV23 are also indicators for PCV13 vaccination, some adults with diabetes might have received a vaccine which is not recommended for them (PCV13) based on that specific condition.

Indicator variables were created for the influenza vaccination, PPSV23 vaccination, PCV13 vaccination (starting in 2010), pneumococcal disease or pneumococcal-related disease diagnosis, and each comorbidity in the Charlson Index (excluding diabetes). Charlson weights for each of the corresponding diseases in the index were also added to the dataset in each year. Sub payment and net payment variables were created for total inpatients costs, total outpatient costs, and pneumococcal disease or pneumococcal-related disease costs (total, inpatient, outpatient). All costs were adjusted to 2016 dollars using the Consumer Price Index for Medical Care(1). In the inpatient files, a variable was created for the number of outpatient visits per year for each enrollee. In the outpatient files, a variable was created for the number of inpatient visits per year for each enrollee. The inpatient and outpatient files with the additional variables described above are henceforth referred to as the ‘main datasets’.

Separate datasets were created for each year including only the diabetes indicator, the date of service, and the year of service. Years were merged and a confirmed diabetes indicator was created for those enrollees with more than one diabetes diagnosis ≥30 days apart in the outpatient file or a single diabetes diagnosis in the inpatient file. Individuals were classified as incident diabetic in the year of their diagnosis and prevalent diabetic in the year of their diagnosis and all following years. These files are referred to as the ‘diabetes datasets’.

Following the same criteria as with diabetes, we also added an indicator variable for each of the following medical conditions, because they are indications for pneumococcal vaccination: chronic heart disease, chronic lung disease, cerebrospinal fluid leaks, cochlear implants, alcoholism, chronic liver disease, cigarette smoking, sickle cell anemia, asplenia, immunodeficiencies, hiv, chronic renal failure, nephrotic syndrome, leukemia, lymphoma, hodgkin's disease, generalized malignancy, iatrogenic immunosuppression, solid organ transplant, and multiple myeloma. Separate datasets were created for each disease and year, and then a confirmed diagnosis indicator was created for those enrollees with more than one diagnosis or procedure seven days or more apart in the outpatient file or a single diagnosis in the inpatient file (following Shea et al.(2) with the exception of Alcoholism and Cigarette Smoking). These files are referred to as the ‘high risk datasets’.

The separate year files for each dataset (main, diabetes, and each of the high risk conditions) were transformed so that only one observation per enrollee per year existed. In this transformation, cost variables were summed over the year. For example, Enrollee 123 was linked to a sum of total payments for the year, total PPSV23 vaccination payments for the year, total vaccination administration fee payments, and total inpatient payments for the year.

The separate year files were merged together so that the new file includes one observation per enrollee per year to create one dataset.

For diabetes and each of the other high risk medical conditions, four sets of indicator variables were created. Indicator 1 was the index indicator =1 only in the year of diagnosis, Indicator 2 was a cumulative indicator =1 in the index year and all years after, Indicator 3 was =1 only in the years after diagnoses, and Indicator 4 was =1 in every year if ever diagnosed during the study period. We also created a combined ‘high risk’ indicator variable for the high risk medical conditions with the same 4 criteria (e.g. Indicator 1 was the index indicator =1 for the first diagnosis of any of the high risk medical conditions).

These same criteria were followed for vaccination, combining PPSV23 and PCV13; Indicator 1 was the index indicator =1 for the year of vaccination, Indicator 2 was a cumulative indicator =1 in the year of vaccination and all years after, Indicator 3 was =1 only in the years after vaccination, and Indicator 4 was =1 in every year if ever vaccinated during the study period or the washout period.

Eight group variables were created based on whether the enrollees had an influenza vaccination, a PPSV23 vaccination, and/or were diagnosed with pneumococcal disease or a pneumococcal-related disease.

For only the cost analysis, we added enrollees by year who had no encounters. These enrollees had zero costs and no diagnoses and procedure code observations but included birthdate, sex, age, and geographic location.

**Charlson Comorbidity Index components**

We used the Charlson comorbidity index for several analysis. Diabetes, which is one of the elements of the Charlson Comorbidity Index, was always included in the regressions. Supplemental table 1 lists all the elements of the Charlson Comorbidity Index and their associated ICD-9 diagnosis codes:

**Supplemental Table 1: Diagnosis Codes Associated with Charlson Comorbidities**

|  |  |
| --- | --- |
| **Condition** | **ICD-9 Diagnosis Codes** |
| Diabetes | 25000, 25001, 25002, 25003, 25010, 25011, 25012, 25013, 25020, 25021, 25022, 25023, 25030, 25031, 25032, 25033, 25040, 25041, 25042, 25043, 25050, 25051, 25052, 25053, 25060, 25061, 25062, 25063, 25070, 25071, 25072, 25073, 25080, 25081, 25082, 25083, 25090, 25091, 25092, 25093 |
| Myocardial infarction  | 410, 412 |
| Congestive heart failure | 39891, 40201, 40211, 40291, 40401, 40403, 40411, 40413, 40491, 40493, 4254, 4255, 4257, 4258, 4259, 428 |
| Peripheral vascular disease | 0930, 4373, 440, 441, 4431, 4432, 4438, 4439, 4471, 5571, 5579, V434 |
| Cerebrovascular disease | 36234, 430, 431, 432, 433, 434, 435, 436, 437, 438 |
| Dementia | 290, 2941, 3312 |
| Chronic pulmonary disease | 4168, 4169, 490, 491, 492, 493, 494, 495, 496, 500, 501, 502, 503, 504, 505, 5064, 5081, 5088 |
| Connective tissue disease | 4465, 7100, 7101, 7102, 7103, 7104, 7140, 7141, 7142, 7148, 725 |
| Peptic ulcer disease | 531, 532, 533, 534 |
| Mild liver disease | 07022, 07023, 07032, 07033, 07044, 07054, 0706, 0709, 570, 571, 5733, 5734, 5738, 5739, V427 |
| Paraplegia and hemiplegia | 3341, 342, 343, 3440, 3441, 3442, 3443, 3444, 3445, 3446, 3449 |
| Renal disease | 40301, 40311, 40391, 40402, 40403, 40412, 40413, 40492, 40493, 582, 5830, 5831, 5832, 5834, 5836, 5837, 585, 586, 5880, V420, V451, V56 |
| Cancer | 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 170, 171, 172, 174, 175, 176, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 200, 201, 202, 203, 204, 205, 206, 207, 208, 2386 |
| Moderate or severe liver disease | 4560, 4561, 4562, 5722, 5723, 5724, 5728 |
| Metastatic carcinoma | 196, 197, 198, 199 |
| AIDS or HIV | 042, 043, 044 |

**Increased-Risk Conditions Recommended for Pneumococcal Vaccination**

Diabetes was one condition for which PPSV23 vaccination before age 65 was routinely recommended. Other increased-risk conditions for which PPSV23 vaccination prior to age 65 was recommended were included. Individuals were coded as having the condition if they had at least one of either the CPT procedure codes or ICD-9 diagnosis codes listed in the supplemental table 2:

**Supplemental Table 2: Codes Associated with Increased-Risk Conditions Recommended for PPSV23 Vaccination <65 years**

|  |  |  |
| --- | --- | --- |
| **Increased-Risk Conditions Recommended for PPSV23 Vaccination <65 years** | **CPT Procedure Codes** | **ICD-9 Diagnosis Codes** |
| Diabetes |  | 25000, 25001, 25002, 25003, 25010, 25011, 25012, 25013, 25020, 25021, 25022, 25023, 25030, 25031, 25032, 25033, 25040, 25041, 25042, 25043, 25050, 25051, 25052, 25053, 25060, 25061, 25062, 25063, 25070, 25071, 25072, 25073, 25080, 25081, 25082, 25083, 25090, 25091, 25092, 25093 |
| Alcoholism  | G0396, G0397, H0001, H0003, H0005, H0006, H0007, H0008, H0009, H0010, H0011, H0012, H0013, H0014, H0015, H0016, H0020, H0021, H0022, H0026, H0027, H0028, H0029, H0047, H0048, H0049, H0050, H2034, H2035, H2036, J2315, T1006, T1007, T1009, T1010, T1012, 9461, 9462, 9463, 9467, 9468, 9469 | 291, 2910, 2911, 2912, 2913, 2914, 2915, 2918, 29181, 29182, 29189, 2919, 303, 3030, 30300, 30301, 30302, 30303, 3039, 3039, 30391, 30392, 30393, 305, 3050, 30501, 30502, 30503, 571, 5711, 5712, 5713, 7903, 9773, 980, 9800, 9801, 9802, 9803, 9808, 9809, E860, E8600, 9461, 9462, 9463, 9467, 9468, 9469, |
| Asplenia\* | 38100, 38101, 38102, 38115, 38120, 48140, 48145, 49220, 56345, 412, 4142, 4143, 415, 4194 | 28951, 28952, 412, 4142, 4143, 415, 4194 |
| Cerebrospinal fluid leaks\* |  | 34981, 38861 |
| Chronic heart disease | G8027, G8028, G8029, G8030, G8031, G8032, G8184, 3766 | 40201, 40211, 40291, 40401, 40403, 40411, 40413, 40491, 40493, 428, 4280, 4281, 4282, 4282, 42821, 42822, 42823, 4283, 42830, 42831, 42832, 42833,4284, 42840, 42841, 42842, 42843, 4289, 425, 4250, 4251, 4252, 4253, 4254, 4255, 4257, 4258, 4259 |
| Cigarette smoking | G0375, G0376, G8093, G8094, G8402, G8403, G8453, G8454, G8455, G9016, G9276, G9458 | 3051, V1582, 649, 6490, 64901, 64902, 64903, 64904, 98984 |
| Cochlear implants\* | 69930, 92601, 92602, 92603, 92604, 2096, 2097, 2098 | L8614, L8615, L8616, L8617, L8618, L8619, L8623, L8624, L8627, L8628, L8629, 2096, 2097, 2098 |
| Chronic lung disease |  | 490, 491, 4910, 4911, 4912, 4912, 49121, 49122, 4918, 4919, 492, 4920, 4928, 493, 4930, 49300, 49301, 49302, 4931, 4931, 49311, 49312, 4932, 49320, 49321, 49322, 4938, 49381, 49382, 4939, 49390, 49391, 49392, 494, 4940, 4941, 496, 277, 2770, 27701, 27702, 27703, 27709 |
| Chronic renal failure\* |  | 5851, 5852, 5853, 5854, 5855, 5856, 5859, 586 |
| Generalized malignancy\* |  | 140, 1401, 1403, 1404, 1405, 1406, 1408, 1409, 141, 1411, 1412, 1413, 1414, 1415, 1416, 1418, 1419, 142, 1421, 1422, 1428, 1429, 143, 1431, 1438, 1439, 144, 1441, 1448, 1449, 145, 1451, 1452, 1453, 1454, 1455, 1456, 1458, 1459, 146, 1461, 1462, 1463, 1464, 1465, 1466, 1467, 1468, 1469, 147, 1471, 1472, 1473, 1478, 1479, 148, 1481, 1482, 1483, 1488, 1489, 149, 1491, 1498, 1499, 150, 1501, 1502, 1503, 1504, 1505, 1508, 1509, 151, 1511, 1512, 1513, 1514, 1515, 1516, 1518, 1519, 152, 1521, 1522, 1523, 1528, 1529, 153, 1531, 1532, 1533, 1534, 1535, 1536, 1537, 1538, 1539, 154, 1541, 1542, 1543, 1548, 155, 1551, 1552, 156, 1561, 1562, 1568, 1569, 157, 1571, 1572, 1573, 1574, 1578, 1579, 158, 1588, 1589, 159, 1591, 1598, 1599, 160, 1601, 1602, 1603, 1604, 1605, 1608, 1609, 161, 1611, 1612, 1613, 1618, 1619, 162, 1622, 1623, 1624, 1625, 1628, 1629, 163, 1631, 1638, 1639, 164, 1641, 1642, 1643, 1648, 1649, 165, 1658, 1659, 170, 1701, 1702, 1703, 1704, 1705, 1706, 1707, 1708, 1709, 171, 1712, 1713, 1714, 1715, 1716, 1717, 1718, 1719, 172, 1721, 1722, 1723, 1724, 1725, 1726, 1727, 1728, 1729, 173, 17301, 17302, 17309, 1731, 17311, 17312, 17319, 1732, 17321, 17322, 17329, 1733, 17331, 17332, 17339, 1734, 17341, 17342, 17349, 1735, 17351, 17352, 17359, 1736, 17361, 17362, 17369, 1737, 17371, 17372, 17379, 1738, 17381, 17382, 17389, 1739, 17391, 17392, 17399, 174, 1741, 1742, 1743, 1744, 1745, 1746, 1748, 1749, 175, 1759, 176, 1761, 1762, 1763, 1764, 1765, 1768, 1769, 179, 180, 1801, 1808, 1809, 181, 182, 1821, 1828, 183, 1832, 1833, 1834, 1835, 1838, 1839, 184, 1841, 1842, 1843, 1844, 1848, 1849, 185, 186, 1869, 1871, 1872, 1873, 1874, 1875, 1876, 1877, 1878, 1879, 188, 1881, 1882, 1883, 1884, 1885, 1886, 1887, 1888, 1889, 189, 1891, 1892, 1893, 1894, 1898, 1899, 190, 1901, 1902, 1903, 1904, 1905, 1906, 1907, 1908, 1909, 191, 1911, 1912, 1913, 1914, 1915, 1916, 1917, 1918, 1919, 192, 1921, 1922, 1923, 1928, 1929, 193, 194, 1941, 1943, 1944, 1945, 1946, 1948, 1949, 195, 1951, 1952, 1953, 1954, 1955, 1958, 196, 1961, 1962, 1963, 1965, 1966, 1968, 1969, 197, 1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 198, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 19881, 19882, 19889, 199, 1991, 1992, 200, 20001, 20002, 20003, 20004, 20005, 20006, 20007, 20008, 2001, 20011, 20012, 20013, 20014, 20015, 20016, 20017, 20018, 2002, 20021, 20022, 20023, 20024, 20025, 20026, 20027, 20028, 2003, 20031, 20032, 20033, 20034, 20035, 20036, 20037, 20038, 2004, 20041, 20042, 20043, 20044, 20045, 20046, 20047, 20048, 2005, 20051, 20052, 20053, 20054, 20055, 20056, 20057, 20058, 2006, 20061, 20062, 20063, 20064, 20065, 20066, 20067, 20068, 2007, 20071, 20072, 20073, 20074, 20075, 20076, 20077, 20078, 2008, 20081, 20082, 20083, 20084, 20085, 20086, 20087, 20088, 201, 20101, 20102, 20103, 20104, 20105, 20106, 20107, 20108, 2011, 20111, 20112, 20113, 20114, 20115, 20116, 20117, 20118, 2012, 20121, 20122, 20123, 20124, 20125, 20126, 20127, 20128, 2014, 20141, 20142, 20143, 20144, 20145, 20146, 20147, 20148, 2015, 20151, 20152, 20153, 20154, 20155, 20156, 20157, 20158, 2016, 20161, 20162, 20163, 20164, 20165, 20166, 20167, 20168, 2017, 20171, 20172, 20173, 20174, 20175, 20176, 20177, 20178, 2019, 20191, 20192, 20193, 20194, 20195, 20196, 20197, 20198, 202, 20201, 20202, 20203, 20204, 20205, 20206, 20207, 20208, 2021, 20211, 20212, 20213, 20214, 20215, 20216, 20217, 20218, 2022, 20221, 20222, 20223, 20224, 20225, 20226, 20227, 20228, 2023, 20231, 20232, 20233, 20234, 20235, 20236, 20237, 20238, 2024, 20241, 20242, 20243, 20244, 20245, 20246, 20247, 20248, 2025, 20251, 20252, 20253, 20254, 20255, 20256, 20257, 20258, 2026, 20261, 20262, 20263, 20264, 20265, 20266, 20267, 20268, 2027, 20271, 20272, 20273, 20274, 20275, 20276, 20277, 20278, 2028, 20281, 20282, 20283, 20284, 20285, 20286, 20287, 20288, 2029, 20291, 20292, 20293, 20294, 20295, 20296, 20297, 20298, 203, 20301, 20302, 2031, 20311, 20312, 2038, 20381, 20382, 204, 20401, 20402, 2041, 20411, 20412, 2042, 20421, 20422, 2048, 20481, 20482, 2049, 20491, 20492, 205, 20501, 20502, 2051, 20511, 20512, 2052, 20521, 20522, 2053, 20531, 20532, 2058, 20581, 20582, 2059, 20591, 20592, 206, 20601, 20602, 2061, 20611, 20612, 2062, 20621, 20622, 2068, 20681, 20682, 2069, 20691, 20692, 207, 20701, 20702, 2071, 20711, 20712, 2072, 20721, 20722, 2078, 20781, 20782, 208, 20801, 20802, 2081, 20811, 20812, 2082, 20821, 20822, 2088, 20881, 20882, 2089, 20891, 20892, 209, 20901, 20902, 20903, 2091, 20911, 20912, 20913, 20914, 20915, 20916, 20917, 2092, 20921, 20922, 20923, 20924, 20925, 20926, 20927, 20929, 2093, 20931, 20932, 20933, 20934, 20935, 20936, 2094, 20941, 20942, 20943, 2095, 20951, 20952, 20953, 20954, 20955, 20956, 20957, 2096, 20961, 20962, 20963, 20964, 20965, 20966, 20967, 20969, 2097, 20971, 20972, 20973, 20974, 20975, 20979, 210, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 211, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 212, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 213, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 214, 2141, 2142, 2143, 2144, 2148, 2149, 215, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 216, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 217, 218, 2181, 2182, 2189, 219, 2191, 2198, 2199, 220, 221, 2211, 2212, 2218, 2219, 222, 2221, 2222, 2223, 2224, 2228, 2229, 223, 2231, 2232, 2233, 22381, 22389, 2239, 224, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 225, 2251, 2252, 2253, 2254, 2258, 2259, 226, 227, 2271, 2273, 2274, 2275, 2276, 2278, 2279, 228, 22801, 22802, 22803, 22804, 22809, 2281, 229, 2298, 2299, 230, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 231, 2311, 2312, 2318, 2319, 232, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 233, 2331, 2332, 2333, 23331, 23332, 23339, 2334, 2335, 2336, 2337, 2339, 234, 2348, 2349, 235, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 236,2361, 2362, 2363, 2364, 2365, 2366, 2367, 2369, 23691, 23699, 237, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 23771, 23772, 23773, 23779, 2379, 238, 2381, 2382, 2383, 2384, 2385, 2386, 23871, 23872, 23873, 23874, 23875, 23876, 23877, 23879, 2388, 2389, 239, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 23981, 23989, 2399 |
| Hodgkin's disease\* |  | 201, 201, 201, 20101, 20102, 20103, 20104, 20105, 20106, 20107, 20108, 2011, 20111, 20112, 20113, 20114, 20115, 20116, 20117, 20118, 2012, 20121, 20122, 20123, 20124, 20125, 20126, 20127, 20128, 2014, 20141, 20142, 20143, 20144, 20145, 20146, 20147, 20148, 2015, 20151, 20152, 20153, 20154, 20155, 20156, 20157, 20158, 2016, 20161, 20162, 20163, 20164, 20165, 20166, 20167, 20168, 2017, 20171, 20172, 20173, 20174, 20175, 20176, 20177, 20178, 2019, 20191, 20192, 20193, 20194, 20195, 20196, 20197, 20198 |
| HIV\* |  | 42, 7953, 79571 |
| Iatrogenic immunosuppression\* | G6002, G6003, G6004, G6005, G6006, G6007, G6008, G6009, G6010, G6011, G6012, G6013, G6014, G6015, 922, 922, 9221, 9222, 9223, 9224, 9225, 9226, 9227, 9228, 9229, 923, 923, 9291, 9232, 9233, 9239, 924, 9241, 01, 96400, 96401, 96402, 96405, 96406, 96408, 96409, 96410, 96411, 96412, 96413, 96414, 96415, 96416, 96417, 96420, 96422, 96423, 96425, 96440, 96445, 96446, 96450, 96542, 96545, 96549, C1086, C1166, C1167, C1178, C8953, C8954, C8955, C9012, C9017, C9127, C9129, C9205, C9207, C9213, C9218, C9231, C9239, C9240, C9243, C9253, C9265, C9414, C9415, C9418, C9419, C9420, C9421, C9422, C9423, C9424, C9425, C9426, C9427, C9429, C9431, C9432, C9433, C9437, C9440, J8501, J8510, J8515, J8520, J8521, J8530, J8540, J8560, J8562, J8565, J8597, J8600, J8610, J8650, J8700, J8705, J8999, J9000, J9001, J9002, J9010, J9015, J9017, J9019, J9020, J9025, J9027, J9031, J9032, J9033, J9035, J9039, J9040, J9041, J9043, J9045, J9047, J9050, J9055, J9060, J9062, J9065, J9070, J9080, J9090, J9091, J9092, J9093, J9094, J9095, J9096, J9097, J9098, J9100, J9110, J9120, J9130, J9140, J9150, J9151, J9155, J9160, J9165, J9170, J9171, J9175, J9178, J9179, J9180, J9181, J9182, J9185, J9190, J9200, J9201, J9202, J9206, J9207, J9208, J9209, J9211, J9212, J9213, J9214, J9215, J9216, J9217, J9218, J9219, J9225, J9226, J9228, J9230, J9245, J9250, J9260, J9261, J9262, J9263, J9264, J9265, J9266, J9267, J9268, J9270, J9271, J9280, J9290, J9291, J9293, J9299, J9300, J9301, J9302, J9303, J9305, J9306, J9307, J9308, J9310, J9315, J9320, J9328, J9330, J9340, J9350, J9351, J9354, J9355, J9357, J9360, J9370, J9371, J9375, J9380, J9390, J9395, J9400, J9600, J9999, Q0083, Q0084, Q0085, Q2017, J7500, J7501, J7502, J7503, J7504, J7505, J7507, J7508, J7509, J7510, J7511, J7512, J7513, J7515, J7516, J7517, J7518, J7520, J7525, J7527, J7599 | 922, 922, 9221, 9222, 9223, 9224, 9225, 9226, 9227, 9228, 9229, 923, 923, 9291, 9232, 9233, 9239, 924, 9241, V580, V581, V5811, V5812, 01 |
| Congenital or acquired immunodeficiency\* |  | 279, 27901, 27902, 27903, 27904, 27905, 27906, 27909, 2791, 2791, 27911, 27912, 27913, 27919, 2792, 2793, 2794, 27941, 27949, 2795, 2795, 27951, 27952, 27953, 2798, 2799, 28409, 28489, 28801, 28802, 2881, 2882, 2884, 2885, 28851, 28859, 38101, 38102, 38115 |
| Liver disease |  | 571, 571, 5711, 5712, 5713, 5714, 5714, 57141, 57142, 57149, 5715, 5716, 5718, 5719 |
| Leukemia\* |  | 2024, 2024, 20241, 20242, 20243, 20244, 20245, 20246, 20247, 20248, 2031, 2031, 20311, 20312, 204, 204, 204, 20401, 20402, 2041, 2041, 20411, 20412, 2042, 2042, 20421, 20422, 2048, 2048, 20481, 20482, 2049, 2049, 20491, 20492, 205, 205, 205, 20501, 20502, 2051, 2051, 20511, 20512, 2052, 2052, 20521, 20522, 2053, 2053, 20531, 20532, 2058, 2058, 20581, 20582, 2059, 2059, 20591, 20592, 206, 206, 206, 20601, 20602, 2061, 2061, 20611, 20612, 2062, 2062, 20621, 20622, 2068, 2068, 20681, 20682, 2069, 2069, 20691, 20692, 207, 207, 207, 20701, 20702, 2071, 2071, 20711, 20712, 2072, 2072, 20721, 20722, 2078, 2078, 20781, 20782, 208, 208, 208, 20801, 20802, 2081, 2081, 20811, 20812, 2082, 2082, 20821, 20822, 2088, 2088, 20881, 20882, 2089, 2089, 20891, 20892 |
| Lymphoma\* |  | 200, 200, 200, 20001, 20002, 20003, 20004, 20005, 20006, 20007, 20008, 2001, 2001, 20011, 20012, 20013, 20014, 20015, 20016, 20017, 20018, 2002, 2002, 20021, 20022, 20023, 20024, 20025, 20026,20027, 20028, 2003, 2003, 20031, 20032, 20033, 20034, 20035, 20036, 20037, 20038, 2004, 2004, 20041, 20042, 20043, 20044, 20045, 20046, 20047, 20048, 2005, 2005, 20051, 20052, 20053, 20054,20055, 20056, 20057, 20058, 2006, 2006, 20061, 20062, 20063, 20064, 20065, 20066, 20067, 20068, 2007, 2007, 20071, 20072, 20073, 20074, 20075, 20076, 20077, 20078, 2008, 2008, 20081, 20082, 20083, 20084, 20085, 20086, 20087, 20088, 202, 202, 20201, 20202, 20203, 20204, 20205, 20206, 20207, 20208, 2021, 2021, 20211, 20212, 20213, 20214, 20215, 20216, 20217, 20218, 2022, 2022,20221, 20222, 20223, 20224, 20225, 20226, 20227, 20228, 2023, 2023, 20231, 20232, 20233, 20234, 20235, 20236, 20237, 20238, 2025, 2025, 20251, 20252, 20253, 20254, 20255, 20256, 20257, 20258,2026, 2026, 20261, 20262, 20263, 20264, 20265, 20266, 20267, 20268, 2027, 2027, 20271, 20272, 20273, 20274, 20275, 20276, 20277, 20278, 2028, 2028, 20281, 20282, 20283, 20284, 20285, 20286,20287, 20288, 2029, 2029, 20291, 20292, 20293, 20294, 20295, 20296, 20297, 20298 |
| Multiple myeloma\* |  | 203, 20301, 20302 |
| Nephrotic syndrome\* |  | 581, 581, 5811, 5812, 5813, 5818, 58181, 58189, 5819 |
| Hemaglobinopathies (includes sickle cell disease)\* |  | 2826, 2826, 28261, 28262, 28263, 28264, 28268, 28269, 2827 |
| Solid organ transplant\* | 093, 335, 335, 3351, 3352, 336, 3751, 4194, 4697, 505, 5051, 5059, 528, 528, 5281, 5282, 5283, 5284, 5285, 5286, 556, 5561, 5569, 6592, 41, 41, 4101, 4102, 4103, 4104, 4105, 4106, 4107, 4108, 4109, 38240, 38241, 32851, 32852, 32853, 32854, 33935, 33945, 44135, 44136, 47135, 47136, 48160, 48554, 50360, 50365, 50380, 60512 | V420, V421, V422, V423, V426, V427, V4281, V4282, V4283, V4284, V4289, V429, 9968, 9968, 99681, 99682, 99683, 99684, 99685, 99686, 99687, 99688, 99689, 093, 335, 335, 3351, 3352, 336, 3751, 4194, 4697, 505, 5051, 5059, 528, 528, 5281, 5282, 5283, 5284, 5285, 5286, 556, 5561, 5569,6592, 41, 41, 4101, 4102, 4103, 4104, 4105, 4106, 4107, 4108, 4109 |

\* Condition was also recommended for PCV13 vaccination

**Pneumococcal Disease Costs**

Costs are categorized as pneumococcal disease costs if the inpatient or outpatient visit was associated with diagnosis codes that may be associated with pneumococcal disease. We broadly follow the conditions and codes used in Huang et al to define codes that may be associated with pneumococcal disease (Supplemental Table 3).(3)

**Supplemental Table 3: Diagnosis Codes Associated with Pneumococcal Disease Costs**

|  |  |
| --- | --- |
| ***Outpatient*** | **ICD-9 Diagnosis Codes** |
| Outpatient AOM (acute otitis media) | 38100, 38101, 38102, 38103, 38110, 38119, 38120, 38129, 3813, 3814, 38200, 38201, 38202, 3821, 3822, 3823, 3824, 3829 |
| Outpatient Sinusitis | 4610, 4611, 4612, 4613, 4618, 4619, 4730, 4731, 4732, 4733, 4738, 4739 |
| Outpatient AECB (acute exacerbation ofchronic bronchitis) | 4910, 4911, 49120, 49121, 49122, 4918, 4919 |
| Outpatient Pneumonia | 481, 4820, 4821, 4822, 48230, 48231, 48232, 48239, 48289, 4829, 4838, 4848, 485, 486, 4870 |
| ***Inpatient*** |  |
| Inpatient AECB | 4910, 4911, 49120, 49121, 49122, 4918, 4919 |
| Inpatient Pneumonia | 481, 4820, 4821, 4822, 48230, 48231, 48232, 48239, 48289, 4829, 4838, 4848, 485, 486, 4870 |
| Inpatient Meningitis | 3201, 3207, 3209, 3222, 3229  |
| Inpatient Bone and Joint Disease | 71100, 71101, 71102, 71103, 71104, 71105, 71106, 71107, 71108, 71109, 73000, 73001, 73002, 73003, 73004, 73005, 73006, 73007, 73008, 73009, 73020, 73021, 73022, 73023, 73024, 73025, 73026, 73027, 73028, 73029, 73030, 73031, 73032, 73033, 73034, 73035, 73036, 73037, 73038, 73039, 73080, 73081, 73082, 73083, 73084, 73085, 73086, 73087, 73088, 73089, 73090, 73091, 73092, 73093, 73094, 73095, 73096, 73097, 73098, 73099 |
| Inpatient Bacteremia | 7907, 412, 382 |

**Differences-in-Differences Cost Analysis**

In the first part of the model, we tested to determine whether to use a probit or logit model, and for the second part, we determined the appropriate family and link for the generalized linear model. We tested the family and then used Pregibon’s link test to check fit.(4, 5) We tested the Gaussian family, Poisson family, Gamma family, and the Inverse Gaussian family.

For the two-part model, any variable in either part of the model was included in both.

In our main difference-in-differences analysis, we included indicator variables for whether an enrollee was in the vaccinated group, the time (before or after matching), whether the enrollee had a diabetes diagnosis, and the interactions between these variables. We did not include other variables to avoid multicollinearity issues with the prior propensity-score matching step that *did*  include those variables.

In our robustness check where we run the two-part differences-in-differences analysis on the entire dataset (*without* using propensity score matching), we included all the variables: year, age, pneumococcal vaccination, diabetes status, individual Charlson comorbidity components, and individual increased-risk conditions recommended for pneumococcal vaccination

**Results**

**Regression Results for Rates of Pneumococcal Vaccination**

**Supplemental Table 4. Logistic regression predicting rates of PPSV23 vaccination: Main Model: Overall Recommendation for Pneumococcal Vaccination Control**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable**  | **Co-efficient (log odds)** | **95% Confidence Interval** | **Co-efficient (odds)** | **95% Confidence Interval** | **P-value** |
| Age | 0.057 | 0.055, 0.058 | 1.059 | 1.057,1.06 | <0.001 |
| Any condition recommended for pneumococcal vaccination | 0.786 | 0.767, 0.805 | 2.195 | 2.153,2.237 | <0.001 |
| Diabetes diagnosis in index year vs. no diabetes diagnosis in index year. | 0.673 | 0.634, 0.713 | 1.96 | 1.885,2.04 | <0.001 |
| Diabetes diagnosis, cumulative vs no diabetes diagnosis | 1.307 | 1.286, 1.329 | 3.695 | 3.618,3.777 | <0.001 |
| Constant | -8.364 | -8.438, -8.29 | 0 | 0,0 | <0.001 |

**Supplemental Table 5. Logistic regression predicting rates of PPSV23 vaccination: Alternative Model 1: Increased-Risk Conditions Controls**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable**  | **Co-efficient (log odds)** | **95% Confidence Interval** | **Co-efficient (odds)** | **95% Confidence Interval** | **P-value** |
| Age | 0.057 | 0.055, 0.059 | 1.059 | 1.057,1.061 | <0.001 |
| Alcoholism | 0.249 | 0.155, 0.343 | 1.283 | 1.168,1.409 | <0.001 |
| Asplenia | 0.562 | 0.484, 0.64 | 1.754 | 1.623,1.896 | <0.001 |
| Cerebrospinal fluid leaks | -0.042 | -0.641, 0.558 | 0.959 | 0.527,1.747 | 0.892 |
| Chronic heart disease | 0.304 | 0.255, 0.352 | 1.355 | 1.29,1.422 | <0.001 |
| Cigarette smoking | 0.353 | 0.318, 0.387 | 1.423 | 1.374,1.473 | <0.001 |
| Cochlear implants | 1.895 | 1.589, 2.201 | 6.653 | 4.899,9.034 | <0.001 |
| Chronic lung disease | 1.097 | 1.078, 1.117 | 2.995 | 2.939,3.056 | <0.001 |
| Chronic renal failure | 0.372 | 0.314, 0.429 | 1.451 | 1.369,1.536 | <0.001 |
| Generalized malignancy | 0.162 | 0.144, 0.181 | 1.176 | 1.155,1.198 | <0.001 |
| Hodgkin's disease | 0.446 | 0.18, 0.711 | 1.562 | 1.197,2.036 | 0.001 |
| HIV | 1.458 | 0.929, 1.986 | 4.297 | 2.532,7.286 | <0.001 |
| Iatrogenic immunosuppression | 0.607 | 0.563, 0.65 | 1.835 | 1.756,1.916 | <0.001 |
| Congenital or acquired immunodeficiency | 0.611 | 0.548, 0.674 | 1.842 | 1.73,1.962 | <0.001 |
| Liver disease | 0.239 | 0.158, 0.32 | 1.27 | 1.171,1.377 | <0.001 |
| Leukemia | 0.667 | 0.468, 0.866 | 1.948 | 1.597,2.377 | <0.001 |
| Lymphoma | 0.566 | 0.434, 0.699 | 1.761 | 1.543,2.012 | <0.001 |
| Multiple myeloma | 0.792 | 0.494, 1.091 | 2.208 | 1.639,2.977 | <0.001 |
| Nephrotic syndrome | 0.392 | 0.18, 0.604 | 1.48 | 1.197,1.829 | <0.001 |
| Hemaglobinopathies (includes sickle cell disease) | 0.954 | 0.68, 1.228 | 2.596 | 1.974,3.414 | <0.001 |
| Solid organ transplant | 0.491 | 0.428, 0.555 | 1.634 | 1.534,1.742 | <0.001 |
| Diabetes diagnosis in index year | 0.716 | 0.677, 0.756 | 2.046 | 1.968,2.13 | <0.001 |
| Diabetes diagnosis, cumulative | 1.184 | 1.162, 1.206 | 3.267 | 3.196,3.34 | <0.001 |
| Constant | -8.247 | -8.321, -8.173 | 0 | 0,0 | <0.001 |

**Supplemental Table 6. Logistic regression predicting rates of PPSV23 vaccination: Alternative Model 2, Charlson Cormorbidity Controls**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variable**  | **Co-efficient (log odds)** | **95% Confidence Interval** | **Co-efficient (odds)** | **95% Confidence Interval** | **P-value** |
| Age | 0.056 | 0.055, 0.058 | 1.058 | 1.057,1.06 | <0.001 |
| Myocardial infarction | 0.421 | 0.369, 0.474 | 1.523 | 1.446,1.606 | <0.001 |
| Congestive heart failure | 0.218 | 0.177, 0.26 | 1.244 | 1.194,1.297 | <0.001 |
| Peripheral vascular disease | 0.037 | -0.002, 0.075 | 1.038 | 0.998,1.078 | 0.06 |
| Cerebrovascular disease | 0.09 | 0.055, 0.124 | 1.094 | 1.057,1.132 | <0.001 |
| Dementia | 0.096 | -0.11, 0.301 | 1.101 | 0.896,1.351 | 0.362 |
| Chronic pulmonary disease | 0.911 | 0.892, 0.93 | 2.487 | 2.44,2.535 | <0.001 |
| Connective tissue disease | 0.6 | 0.564, 0.635 | 1.822 | 1.758,1.887 | <0.001 |
| Peptic ulcer disease | 0.034 | -0.027, 0.096 | 1.035 | 0.973,1.101 | 0.271 |
| Mild liver disease | 0.151 | 0.122, 0.18 | 1.163 | 1.13,1.197 | <0.001 |
| Paraplegia and hemiplegia | 0.197 | 0.104, 0.291 | 1.218 | 1.11,1.338 | <0.001 |
| Renal disease | 0.347 | 0.3, 0.394 | 1.415 | 1.35,1.483 | <0.001 |
| Cancer | 0.326 | 0.294, 0.357 | 1.385 | 1.342,1.429 | <0.001 |
| Moderate or severe liver disease | 0.395 | 0.27, 0.52 | 1.484 | 1.31,1.682 | <0.001 |
| Metastatic carcinoma | 0.281 | 0.209, 0.354 | 1.324 | 1.232,1.425 | <0.001 |
| AIDS or HIV | 1.958 | 1.893, 2.024 | 7.085 | 6.639,7.569 | <0.001 |
| Diabetes diagnosis in index year | 0.751 | 0.712, 0.791 | 2.119 | 2.038,2.206 | <0.001 |
| Diabetes diagnosis, cumulative | 1.144 | 1.121, 1.166 | 3.139 | 3.068,3.209 | <0.001 |
| Constant | -8.231 | -8.305, -8.156 | 0 | 0,0 | <0.001 |

Through 2009, all pneumococcal vaccination in adults with diabetes was PPSV23. It was less than 1 percent PCV13 after that. The fraction of pneumococcal vaccination that was PCV13 was 0.01% in 2010, 0.04% in 2011, 0.11% in 2012, 0.19% in 2013, and 0.66% in 2014.

**Details on propensity score matching**

We matched each vaccinated enrollee with one unvaccinated enrollee in each year 2007-2012 (this allows for 2 years pre-vaccination and 2-years post-vaccination). Starting with 2007, the propensity score matches those vaccinated in that year to unvaccinated individuals in that year based on age, age squared, sex, diabetes, other individual Charlson comorbidities, other individual increased-risk conditions recommended for pneumococcal vaccination, and numbers of inpatient and outpatient visits in each of the prior two years. We do not match on utilization after vaccination. We use one-to-one matching without replacement using the psmatch2 command in Stata. In the propensity score matching, we kept those with a propensity score ≤ 0.1 to ensure common support (supplement figures 2-7). We then repeat this process to match individuals vaccinated in 2008, 2009, 2010, 2011, and 2012.

Supplemental figures 1-6 show the propensity scores after matching:

**Supplemental Figure 1: Matching of Propensity Scores for 2007**

****

**Supplemental Figure 2: Matching of Propensity Scores for 2008**

****

**Supplemental Figure 3: Matching of Propensity Scores for 2009**

****

**Supplemental Figure 4: Matching of Propensity Scores for 2010**

****

**Supplemental Figure 5: Matching of Propensity Scores for 2011**

****

**Supplemental Figure 6: Matching of Propensity Scores for 2012**

****

After evaluating these matches, we used a caliper of 0.03 and dropped those with a propensity score > 0.1 to ensure common support.

Supplemental table 7 includes descriptive statistics before and after matching.

**Supplemental Table 7: Population Characteristics before and after matching:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Unmatched** |  | **Matched** |  |
|  | **Not Vaccinated** | **Vaccinated** | **Standardized Differences** | **Not Vaccinated** | **Vaccinated** | **Standardized Differences** |
| **n:** | **4,892,734** | **27,485** |  | **26,781** | **26,781** |  |
| Age of Patient |  46.53  |  49.29  |  0.43  |  49.56  |  49.24  |  0.06  |
| Sex |  0.55  |  0.58  |  0.06  |  0.58  |  0.58  |  0.02  |
| Inpatient visits in the current year |  0.18  |  0.84  |  0.27  |  0.53  |  0.72  |  0.07  |
| Outpatient visits in the current year |  6.34  |  13.56  |  0.86  |  12.50  |  12.93  |  0.04  |
| Inpatient visits one year ago |  0.17  |  0.54  |  0.17  |  0.39  |  0.49  |  0.04  |
| Outpatient visits one year ago |  6.14  |  11.01  |  0.61  |  10.44  |  10.67  |  0.03  |
| Inpatient visits two years ago |  0.17  |  0.42  |  0.14  |  0.33  |  0.40  |  0.03  |
| Outpatient visits two years ago |  5.93  |  10.15  |  0.55  |  9.69  |  9.88  |  0.02  |
| Total payments for year |  $ 3,210  |  $ 10,152  |  0.40  |  $ 7,813  |  $ 9,191  |  0.07  |
| Pneumococcal Disease total payments for year |  $ 73  |  $ 562  |  0.14  |  $ 236  |  $ 505  |  0.07  |
| Inpatient total payments for year |  $ 759  |  $ 3,402  |  0.22  |  $ 2,160  |  $ 2,953  |  0.06  |
| Inpatient Pneumococcal Disease total payments for year |  $ 25  |  $ 370  |  0.10  |  $ 108  |  $ 332  |  0.07  |
| Outpatient total payments for year |  $ 2,451  |  $ 6,751  |  0.42  |  $ 5,653  |  $ 6,238  |  0.05  |
| Outpatient Pneumococcal Disease total payments for year |  $ 48  |  $ 192  |  0.17  |  $ 128  |  $ 173  |  0.05  |
| Confirmed diabetic | 10.8% | 34.0% |  0.59  | 33.2% | 32.8% |  0.01  |
| Comorbidity\_ Myocardial Infarction | 0.9% | 2.9% |  0.15  | 2.4% | 2.7% |  0.01  |
| Comorbidity\_ Congestive Heart Failure | 1.6% | 5.1% |  0.20  | 4.1% | 4.7% |  0.03  |
| Comorbidity\_ Periphral Vascular Disease | 2.6% | 5.7% |  0.15  | 5.1% | 5.4% |  0.02  |
| Comorbidity\_Cerebrovascular Disease | 3.6% | 7.2% |  0.15  | 6.5% | 6.9% |  0.02  |
| Comorbidity\_Dementia  | 0.1% | 0.1% |  0.02  | 0.1% | 0.1% |  0.01  |
| Comorbidity\_Chronic Pulmonary Disease | 16.2% | 38.1% |  0.50  | 39.5% | 37.0% |  0.05  |
| Comorbidity\_Connective Tissue Disease-Rheumatic Disease | 2.3% | 6.5% |  0.21  | 5.7% | 6.2% |  0.02  |
| Comorbidity\_Peptic Ulcer Disease | 1.1% | 2.0% |  0.06  | 1.8% | 1.9% |  0.01  |
| Comorbidity\_Mild Liver Disease | 5.0% | 10.4% |  0.19  | 9.5% | 10.0% |  0.02  |
| Comorbidity\_Paraplegia and Hemiplegia | 0.4% | 0.8% |  0.05  | 0.7% | 0.8% |  0.01  |
| Comorbidity\_Renal Disease | 1.1% | 3.3% |  0.15  | 2.5% | 3.0% |  0.03  |
| Comorbidity\_Cancer | 4.9% | 9.4% |  0.17  | 8.7% | 9.0% |  0.01  |
| Comorbidity\_Moderate or Severe Liver Disease | 0.1% | 0.5% |  0.06  | 0.3% | 0.4% |  0.02  |
| Comorbidity\_Metastatic Carcinoma | 0.6% | 1.5% |  0.09  | 1.3% | 1.4% |  0.01  |
| Comorbidity\_AIDS/HIV | 0.2% | 1.5% |  0.17  | 0.8% | 1.3% |  0.05  |
| Confirmed alcoholism | 0.4% | 0.9% |  0.06  | 0.7% | 0.8% |  0.02  |
| Confirmed Congenital or Acquired Asplenia | 0.3% | 1.3% |  0.12  | 0.9% | 1.2% |  0.03  |
| Confirmed Cerebrospinal Fluid Leaks | 0.0% | 0.0% |  0.02  | 0.0% | 0.0% |  0.02  |
| Confirmed chronic heart disease | 1.0% | 3.6% |  0.19  | 2.7% | 3.3% |  0.04  |
| Confirmed cigarette smoking | 3.2% | 6.8% |  0.15  | 6.7% | 6.6% |  0.02  |
| Confirmed Cochlear Implants | 0.0% | 0.1% |  0.05  | 0.0% | 0.1% |  0.05  |
| Confirmed chronic lung disease | 9.5% | 29.8% |  0.53  | 29.6% | 28.7% |  0.02  |
| Confirmed Chronic Renal Failure | 0.7% | 2.4% |  0.14  | 1.8% | 2.1% |  0.03  |
| Confirmed Generalized Malignancy | 35.9% | 45.1% |  0.17  | 45.0% | 44.6% |  0.01  |
| Confirmed Hodgkin's Disease | 0.0% | 0.1% |  0.04  | 0.1% | 0.1% |  0.02  |
| Confirmed HIV | 0.0% | 0.0% |  0.02  | 0.0% | 0.0% |  0.02  |
| Confirmed Hodgkin's Disease | 0.0% | 0.1% |  0.04  | 0.1% | 0.1% |  0.02  |
| Confirmed HIV | 0.0% | 0.0% |  0.02  | 0.0% | 0.0% |  0.02  |
| Confirmed Iatrogenic Immunosuppression | 1.4% | 4.4% |  0.18  | 3.6% | 4.0% |  0.03  |
| Confirmed Congenital or Acquired Immunodeficiencies | 0.6% | 1.9% |  0.12  | 1.4% | 1.7% |  0.03  |
| Confirmed Chronic Liver Disease | 0.4% | 1.1% |  0.09  | 0.8% | 1.0% |  0.02  |
| Confirmed leukemia | 0.0% | 0.2% |  0.05  | 0.1% | 0.2% |  0.02  |
| Confirmed Lymphoma (Excluding Hodgkin's Disease) | 0.1% | 0.5% |  0.08  | 0.3% | 0.4% |  0.02  |
| Confirmed Multiple Myeloma | 0.0% | 0.1% |  0.03  | 0.0% | 0.1% |  0.03  |
| Confirmed Nephrotic Syndrome | 0.0% | 0.2% |  0.04  | 0.1% | 0.1% |  0.02  |
| Confirmed Sickle Cell Disease and Other Hemaglobinopathies | 0.0% | 0.1% |  0.03  | 0.0% | 0.1% |  0.02  |
| Confirmed Solid Organ Transplant (Including Bone Marrow Transplant) | 0.7% | 2.0% |  0.11  | 1.4% | 1.8% |  0.03  |

**Assessment of Parallel Trends**

To evaluate whether the trends in pneumococcal disease costs were significantly different in the pre-vaccination periods, we estimated a relative-time specification (e.g., Autor, 2003(6); Angrist and Pischke, 2008(7)) that interacts our treatment variable (and it’s interactions) with a set of year-specific indicators. The parameters are a little cumbersome to interpret directly given the use of a two-part model and the number of interactions, so we calculate the pre-treatment difference-in-differences between periods t-2 and t-1. As displayed in Supplemental Table 8 and Supplemental Figure 7, the treatment group has a slightly higher increase in the conditional average cost from period t-2 to t-1. The difference corresponds to $54 in total annual per-person medical expenditures, but this difference is not statically significant, with a 95% CI of -$8.6 to $117.0. This finding is consistent with the assumptions for our fixed effects identification strategy.

**Supplemental Table 8: Estimates of marginal effects of pre-treatment period and being in the treatment group.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Period** | **Treated** | **mean** | **stdev** |
| -2 | 0 | 145.5232 | 10.6406 |
| -1 | 0 | 170.6857 | 12.9182 |
| -2 | 1 | 186.5613 | 17.0208 |
| -1 | 1 | 266.3705 | 20.9790 |

**Supplemental Figure 7: Costs in years before and after matching**

 

Total Annual Pneumococcal Disease Payments

Vaccinated

Not Vaccinated

Year Relative to Matching

**Determining the proper GLM approach**

To evaluate how to properly use the GLM, we used a two-part model. We used a few steps to help us determine the proper family to use. We conducted these steps on the full, unmatched dataset.

The first regression looked at pneumococcal disease-related costs. The probit model showed those in the “ever having pneumococcal vaccination” group are more likely to have non-zero expenses than those who did not get pneumococcal vaccination. But, it also suggests that following pneumococcal vaccination, those enrollees who were vaccinated were less likely to have positive pneumococcal disease costs. This was a statistically significant finding.

The next stages dropped those with zero pneumococcal disease costs and used a GLM (with gamma family and log link) and the same variables. The results were qualitatively similar here. This suggested those in the “ever having pneumococcal vaccination” group had higher pneumococcal disease expenses than those who did not get pneumococcal vaccination. But, it also suggests that following pneumococcal vaccination, those enrollees who were vaccinated had lower pneumococcal disease costs. This was a statistically significant finding.

We next examined the proper family using Pregibon's Link Test. Here was where we ran into some minor issues. We tested the Gaussian family, Poisson family, Gamma family, and the Inverse Gaussian family. None had a chi2 probability that was >0.05. Gamma was the closest at 0.026. This suggests we could run this as gamma, but realized the standard errors may be inefficient. We ultimately used the probit model with GLM (gamma family, log link) to best fit the data distribution (albeit with inefficient standard errors).

**Supplemental Table 9: Regression Results**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Probit** | **GLM** |
|  | **Coefficient** | **p-value** | **95% CI** | **Coefficient** | **p-value** | **95% CI** |
| Never Pneumococcal Vaccinated (ref) |  |  |  |  |  |  |
| Ever Pneumococcal Vaccinated | 0.054 | p<0.001 | [0.033, 0.075] | 0.318 | p<0.001 | [0.159, 0.477] |
| Pre Pneumococcal Vaccination (ref) |  |  |  |  |  |  |
| Post Pneumococcal Vaccination Period | 0.032 | 0.005 | [0.01, 0.055] | 0.129 | 0.177 | [-0.058, 0.317] |
| Interaction of Ever Pneumococcal Vaccinated and Post Pneumococcal Vaccination Period | -0.015 | 0.231 | [-0.04, 0.01] | -0.233 | 0.039 | [-0.455, -0.012] |
| No Diabetes Diagnosis (ref) |  |  |  |  |  |  |
| Diabetes Diagnosis | -0.093 | p<0.001 | [-0.126, -0.059] | 0.069 | 0.517 | [-0.139, 0.276] |
| Interaction of Ever Pneumococcal Vaccinated and Diabetes | -0.107 | p<0.001 | [-0.154, -0.06] | -0.012 | 0.952 | [-0.391, 0.367] |
| Interaction of Post Pneumococcal Vaccination Period and Diabetes | -0.016 | 0.404 | [-0.053, 0.021] | 0.144 | 0.409 | [-0.198, 0.485] |
| Interaction of Ever Pneumococcal Vaccinated and Post Pneumococcal Vaccination Period and Diabetes | 0.007 | 0.8 | [-0.046, 0.06] | -0.223 | 0.379 | [-0.719, 0.274] |
| Year |  |  |  |  |  |  |
| 2005 (ref) |  |  |  |  |  |  |
| 2006 | -0.01 | 0.617 | [-0.048, 0.029] | 0.013 | 0.938 | [-0.301, 0.327] |
| 2007 | 0.015 | 0.49 | [-0.027, 0.056] | -0.104 | 0.519 | [-0.421, 0.213] |
| 2008 | 0.015 | 0.447 | [-0.023, 0.053] | -0.055 | 0.69 | [-0.327, 0.216] |
| 2009 | 0.021 | 0.278 | [-0.017, 0.059] | 0.175 | 0.222 | [-0.106, 0.457] |
| 2010 | 0.001 | 0.974 | [-0.039, 0.04] | 0.191 | 0.181 | [-0.088, 0.47] |
| 2011 | -0.014 | 0.496 | [-0.056, 0.027] | 0.212 | 0.139 | [-0.068, 0.492] |
| 2012 | -0.031 | 0.187 | [-0.077, 0.015] | 0.603 | p<0.001 | [0.267, 0.938] |
| 2013 | -0.017 | 0.466 | [-0.063, 0.029] | 0.445 | 0.005 | [0.132, 0.759] |
| 2014 | -0.013 | 0.616 | [-0.062, 0.037] | 0.282 | 0.11 | [-0.064, 0.627] |
|   |  |  |  |  |  |  |
| Constant | -0.713 | p<0.001 | [-0.749, -0.676] | 6.368 | p<0.001 | [6.123, 6.612] |

**Detailed Results from the Robustness Check:**

The results from the Stata Margins commands evaluating the differences-in-differences are as follows. Supplemental table 10 shows the results for the whole cohort, with and without diabetes:

**Supplemental Table 10: Differences-in-Differences Results Regardless of Diabetes Status**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Ever Received Pneumococcal Vaccination** | **Before/After** | **Marginal Effect ($)** | **Std. Err.** | **95% CI** | **P-value** |
| No | Before | 96.36 | 1.42 | 93.58, 99.14 | <0.001 |
| No | After | 83.06 | 3.68 | 75.85, 90.27 | <0.001 |
| Yes | Before | 156.81 | 5.13 | 146.76, 166.86 | <0.001 |
| Yes | After | 134.88 | 3.99 | 127.06, 142.69 | <0.001 |

The unvaccinated group saw a decrease in costs of $13.30 whereas the vaccinated group saw a decrease in costs of $21.93, with a differences-in-differences result of $8.63 in savings.

Supplemental Table 11 shows the results broken out by those without and with diabetes:

**Supplemental Table 11: Differences-in-Differences Results by Diabetes Status**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Diabetes Diagnosis** | **Ever Received Pneumococcal Vaccination** | **After** | **Margin** | **Std. Err.** | **95% CI** | **P-value** |
| No | No | Before | 84.12 | 0.91 | 82.32, 85.91 | <0.001 |
| No | No | After | 71.24 | 3.04 | 65.29, 77.19 | <0.001 |
| No | Yes | Before | 143.21 | 4.81 | 133.78, 152.64 | <0.001 |
| No | Yes | After | 121.46 | 3.46 | 114.69, 128.24 | <0.001 |
| Yes | No | Before | 251.53 | 10.05 | 231.82, 271.23 | <0.001 |
| Yes | No | After | 232.91 | 29.96 | 174.2, 291.62 | <0.001 |
| Yes | Yes | Before | 329.14 | 30.23 | 269.89, 388.39 | <0.001 |
| Yes | Yes | After | 304.83 | 27.54 | 250.85, 358.82 | <0.001 |

For those without diabetes, the unvaccinated group saw a decrease in costs of $12.88 whereas the vaccinated group saw a decrease in costs of $21.75, with a differences-in-differences result of $8.87 in savings.

For those with diabetes, the unvaccinated group saw a decrease in costs of $18.62 whereas the vaccinated group saw a decrease in costs of $24.31, with a differences-in-differences result of $5.69 in savings.

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