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Pneumococcal vaccination coverage and vaccination-related factors among older adults in Japan: LIFE Study

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ABSTRACT

Purpose: To investigate individual and environmental vaccination-related factors among the older adults in Japan, using administrative data.

Methods: We conducted a cohort study and included people who reached the relevant age (≥65 years) for routine pneumococcal vaccination of older adults between April 2015 and March 2020. Monthly data of residents in the two municipalities from April 2014 to March 2020 and vaccination records from April 2015 to March 2020 were used. We defined five cohorts according to the year in which routine vaccinations were available. Each cohort was followed for a total of two years, with the first year being the "baseline period" and second year being the "vaccine follow-up period." Pneumococcal vaccination data was extracted from vaccination records at "first dose." Age, sex, socioeconomic status, comorbidities, hospital visit history, hospitalization history, Specific Health Check-ups participation, and information on contracted hospitals for pneumococcal vaccination were used as covariates. A multivariate logistic regression model was used to investigate the relationship between pneumococcal vaccination and vaccination-related factors. Odds ratios (OR) and 95 % confidence intervals (95 % CI) were calculated.

Results: Analysis included 17,991 patients. Vaccination coverage was 33.6 % for all subjects. Multivariate analysis found the following as significant vaccination-related factors: female (OR: 1.18, 95 % CI: 1.11–1.26), not low income (1.76, 1.17–2.76), hospital visits: ≥once/month (1.27, 1.19–1.35), and Specific Health Check-ups participation (2.10, 1.95–2.27). No significant results were found for hospitals that contracted pneumococcal vaccination.

Conclusions: Individual factors, such as sex and Specific Health Check-ups participation, were found to be important factors affecting pneumococcal vaccination among older adults in Japan. Environmental factors, such as the characteristics of residential areas, should be evaluated in further investigations.

1. Introduction

Respiratory diseases, including pneumonia, are the major causes of death worldwide [1]. In Japan, pneumonia is one of the five leading causes of death [2]. The annual mortality rate of pneumonia among Japanese adults is estimated at 59.6 per 100,000 persons [2]. Pneumococcal infection is one of the most common and serious vaccine-preventable diseases (VPD), with severe forms (pneumonia, sepsis, and meningitis) being more common in older adults with compromised immune function [3,4]. Pneumococcal vaccination is a globally important preventive measure against pneumococcal infections, and understanding the gap between vaccinated and unvaccinated individuals is important for improving coverage [3,5].

Globally, pneumococcal vaccination of older adults is recommended,

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with pneumococcal polysaccharide vaccine (PPSV) 23 coverage among older adults aged over 65 years reported to be 60 % in the United States, 70 % in the United Kingdom, and 54 % in Australia [6–8]. In Japan, a routine vaccination program for older adults over 65 years was initiated in October 2014 through an amendment to the Immunization Law [9]. The vaccination policy is mainly based on the US Advisory Committee on Immunization Practices (ACIP) [10]. While the recommended number of vaccinations remains largely the same, the policy of subsidizing the cost of vaccination is unique to Japan. The program is subsidized for persons over 65 years old, over a 5-year roll-out period. This means that those who turn 65, 70, 75, 80, 85, 90, 95, and 100 years old are eligible for the grants, while those waiting to reach the ages of 65, 70, and 75 are ineligible. Individuals who met this age criterion were eligible for public medical assistance for their first vaccination [11]. Regardless of the age criterion, persons over 65 years old may voluntarily receive the vaccination.

However, as of 2014–2018, after the immunization program began, only approximately 30–40 % of the population was covered in Japan [12]. For the PPSV23, the government subsidized 30 % of the vaccination costs to the municipality. The operational procedure is left to each municipality, and the subsidies for inoculators and educational activities differ from one municipality to another [13]. Although vaccination coverage in Japan has increased since the introduction of routine vaccinations [12,14,15], it remains low compared to that in other countries. It is important to promote an understanding of the factors associated with vaccination to achieve a high vaccination coverage.

Various vaccination-related factors have been reported. Some studies identified significant factors such as age, ethnicity, preventive services, comorbidities, use of medical services, and health literacy [16,17]. Environmental factors have also been examined, with some studies reporting higher vaccination rates for those living in urban areas [18]. Studies in Japan have also found that the recommendation from a family physician and health literacy, including awareness of the pneumococcal vaccine, and knowledge of its safety, are associated with vaccination [19,20]. It has also been shown that having received influenza vaccination in the past 3 years is also strongly associated with pneumococcal vaccination. [19]. Factors such as health literacy and influenza vaccination may work effectively to increase pneumococcal vaccination coverage. In order to improve vaccination coverage in Japan, it is important to recommend research on vaccination-related factors and identify more effective factors.

Most of the studies reported in the literature have limitations, such as the use of questionnaire-based subjective measures, surveys in limited geographic areas, and lack of consideration of environmental factors. It is necessary to conduct more objective, multi-regional studies on vaccination-related factors, particularly considering that immunization programs in Japan are at the discretion of municipalities. To the best of our knowledge, no study has examined individual and environmental factors using large-scale real-world data in Japan. The purpose of this study was to conduct an exploratory study of pneumococcal vaccination coverage and individual and environmental vaccination-related factors among older adults in Japan using administrative data. The limitations of previous studies can be overcome by considering individual and environmental factors using large data that include medical claims data. We hypothesized that the results would be similar to those of previous studies on individual and environmental factors. Conducting an exploratory study is predicted to add new knowledge about vaccination-related factors.

2. Methods

2.1. Data sources

This cohort study was conducted using a database produced by the Longevity Improvement and Fair Evidence (LIFE) Study [21]. The LIFE is a longitudinal cohort study that includes information on National Health Insurance enrollees, Latter-Stage Older Persons Health Care system enrollees, and Long-Term Care (LTC) Insurance enrollees in Japan. The database contained information from the target municipality's residents enrolled in the National Health Insurance System, Latter-Stage Older Persons Health Care System, and LTC Insurance System. The National Health Insurance System is a public health insurance program that covers people aged < 75 years who are self-employed, employed part-time, retired, or working in the agriculture, forestry, or fishery industries. The Latter-Stage Older Persons Health Care System is a public health insurance program that covers all people aged ≥ 75 years and those aged 65–74 years with specific disabilities [22]. The LTC Insurance System is a public health insurance program that provides coverage for LTC services to people aged ≥ 65 years and those aged 40–64 years with specific diseases. Approximately 75 % of those 65–74 years old are enrolled in the National Health Insurance System [23], and people are automatically enrolled in the Latter-Stage Older Person Health Care System on their 75th birthday. The LIFE database lists all the people in these three insurance systems, which means that more than 70 % of older adults aged 65 and over in the target municipalities are included. It includes claims data for outpatient care, inpatient care, long-term care, and vaccination records.

Our study database consisted of claims data from April 2014 to March 2020 and vaccination records from April 2015 to March 2020 linked to the individual resident level. The claims data included claims for all insurance-covered healthcare (inpatient and outpatient) and LTC services. The vaccination records included the vaccine name, date of vaccination, and number of vaccine doses. The record linkage process was performed in a municipal government building, and individual residents were identified using unique research ID codes. All data were anonymized prior to the analysis. This study was approved by the Kyushu University Institutional Review Board for Clinical Research (approval number: 2021-399).

2.2. Study design and setting

In this study, we included people who reached the relevant age (65, 70, 75, …, 100 years) for routine pneumococcal vaccination of older adults between April 2015 and March 2020. The birth date was used for sampling, and those who were ineligible for routine vaccination (aged 66, 68, 72 years, etc.) were not included. Next, we defined five cohorts according to the year in which routine vaccinations were available. For example, eligible population for pneumococcal vaccination from April 2015 to March 2016 were defined as the "2015 vaccination cohort," eligible population for pneumococcal vaccination from April 2016 to March 2017 were defined as the "2016 vaccination cohort." and the "2017 vaccination cohort," "2018 vaccination cohort," and "2019 vaccination cohort" were defined in the same way. Each cohort was followed for a total of two years, with the first year being the "baseline period," and the second year being the "vaccine follow-up period." For the "2015 vaccination cohort," the "baseline period" was from April 2014 to March 2015 and the "vaccine follow-up period" was from April 2015 to March 2016. During the vaccine follow-up period, information was collected from the routine pneumococcal vaccination records of older adults, and during the baseline period, information was collected on vaccination-related factors (Fig. 1). The following exclusion criteria were used: (1) lack of claims data during the 2-year follow-up period (to ensure vaccination-related factor data and vaccination records), (2) continuous hospitalization during the baseline or vaccine follow-up period (to eliminate negative influence on the availability of vaccination experience), (3) voluntary pneumococcal vaccination (to conduct factor analysis for routine vaccination only), and (4) missing data.

2.3. Outcome

The outcome was the first pneumococcal vaccination within the routine vaccination coverage period. Pneumococcal vaccination was

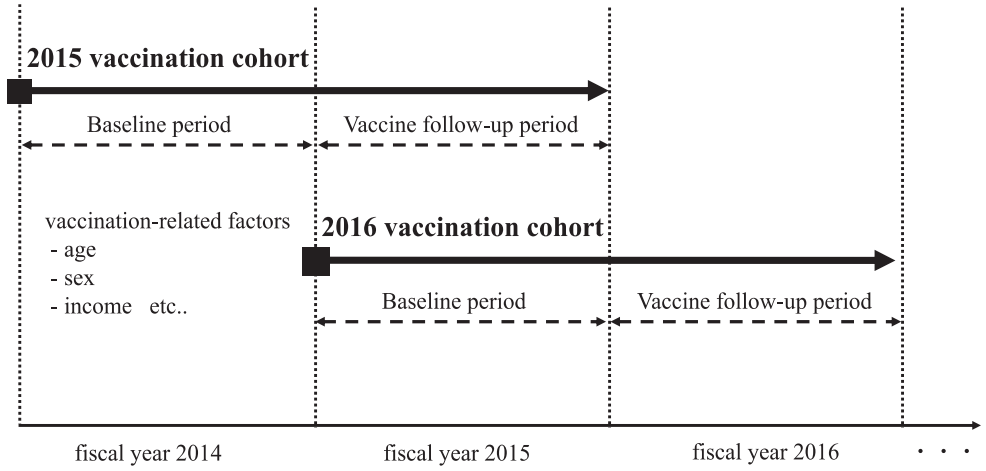

Fig. 1. Study design regarding five cohorts (2015–2019 vaccination cohort) and variables.

extracted from the vaccination records during the vaccine follow-up period of each cohort, i.e., records with the vaccine name as "pneumococcal vaccine for older adults" and "first dose." The vaccination coverage rate was calculated as vaccinated population per eligible population.

2.4. Covariates

As individual factors, data on age, sex, socioeconomic status, comorbidities, hospital visit history, hospitalization history, and Specific Health Checkups' participation were extracted from the claims data. Data were taken from the "baseline period" of each cohort. The classification of the tax burden calculated from income was used as socioeconomic status and categorized as "low income," and "not low income." For comorbidities, the presence of the 17 diseases included in the Charlson Comorbidity Index was used [24]. The prevalence status was defined as having at least one recorded diagnostic code during the baseline period. Hospital visit history was calculated as the number of outpatient visits during the baseline period and categorized as "<once/month" or "≥once/month." Hospitalization history was defined as having a record of hospitalization even for one day, and categorized as "hospitalized" or "not hospitalized." Participation in Specific Health Checkups was categorized as "participation" and "no participation." Specific Health Checkups refers to a medical examination that is recommended to be taken once a year for people aged 40–74 years [25]. Some local municipalities conduct health checkups with similar contents for the elderly aged ≥ 75 years, and the target area of this study also falls under this category. The main examination items include the following: lifestyle-related questions (medication, smoking and drinking history, etc.), physical measurements (height, weight, BMI, abdominal circumference), blood pressure measurement, lipid test, and liver function test. Patients can choose whether to receive individual checkups at medical facilities specified by each municipality or group checkups at public facilities. The checkups are conducted by doctors, nurses, and other medical checkup staff.

Regarding environmental factors, information on hospitals contracted for pneumococcal vaccination was used. We used Geographic Information Systems to calculate the number of hospitals in which vaccinations were available for each elementary school district. Data on the population of the elementary school districts (Ministry of Land, Infrastructure, Transport, and Tourism), hospital data (Ministry of Land, Infrastructure, Transport, and Tourism), data on residential elementary school districts (LIFE Study), and a list of hospitals where pneumococcal vaccinations were available (each municipality). For each elementary school district, the number of hospitals where vaccination was available per population was calculated and classified as "high" or "low" based on the median value.

2.5. Statistical analyses

The demographic variables of the patients are presented as mean ± standard deviation (SD) for continuous variables or as numbers (percentages) for categorical variables.

The relationship between pneumococcal vaccination and vaccination-related factors was investigated using a logistic regression model. Individual factors included age, sex, socioeconomic status, comorbidities, hospital visit history, hospitalization history, and Specific Health Checkups' participation. Environmental factors included hospitals contracting pneumococcal vaccination. In this study, the participation rate in Specific Health Check-ups was dependent on age. As a sensitivity analysis, a stratified analysis was conducted for the two age groups of "≤75 years" and ">75 years." All the statistical analyses were performed using all four cohorts as a single population. The free software R version 4.1.3 (R Foundation for Statistical Computing, Vienna, Austria) was used [26].

3. Results

3.1. Participants

From the 54,188 municipal residents whose claim records were registered during the study period, 30,569 persons were selected who reached the relevant age for routine pneumococcal vaccination between April 2015 and March 2020 (Fig. 1). After applying the exclusion criteria, 17,991 participants were included in the final analysis. Of the 9,080 individuals who lacked claims data, 248 individuals who remained hospitalized during the baseline period, 69 individuals who remained hospitalized during the vaccine follow-up period, 32 individuals who took the vaccine, 506 individuals lacking comorbidity data, and 2,643 individuals who lacked residential elementary school district data were excluded (Fig. 2).

3.2. Demographic characteristics

The demographic characteristics of the overall population and municipalities are shown in Table 1. The age distribution of the participants was as follows: 2,517 (14.0 %) were 65 years old, 4,024 (22.4 %) were 70 years old, 3680 (20.5 %) were 75 years old, 3,335 (18.5 %) were 80 years old, 2482 (13.8 %) were 85 years old, and 1,953 (10.9 %) were 90 years old. Vaccination coverage was 33.6 % for all participants. The overall demographic variables according to the vaccination status are shown in Table 2. The vaccinated group had a significantly higher

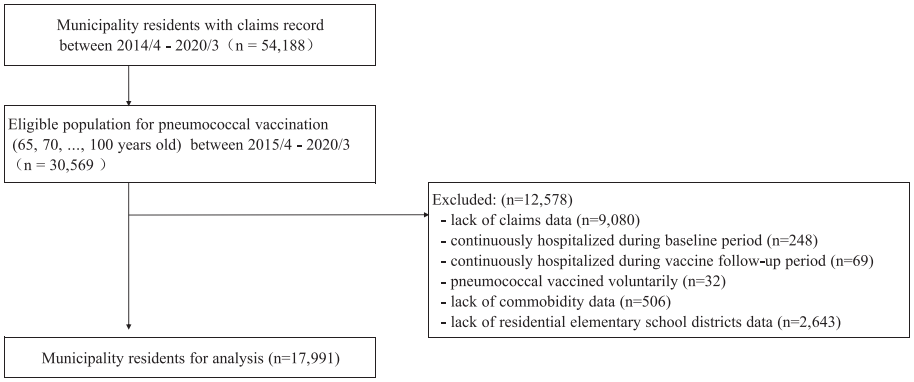

Fig. 2. Flow chart of the population selection.

Table 1
Demographic variables and vaccination status overall (N = 17,991).

Age (years)	
65	2,517 (14.0)
70	4,024 (22.4)
75	3,680 (20.5)
80	3,335 (18.5)
85	2,482 (13.8)
≥ 90	1,953 (10.9)
Sex (female)	10,778 (59.9)
Vaccination (vaccinated)	6,052 (33.6)
Socioeconomic status (not low income)	17,841 (99.2)
Comorbidity	
Myocardial infarction	434 (2.4)
Congestive heart failure	2,490 (13.8)
Peripheral vascular disease	2,361 (13.1)
Cerebrovascular disease	3,865 (21.5)
Dementia	1,319 (7.3)
Chronic pulmonary disease	4,025 (22.4)
Rheumatic disease	718 (4.0)
Peptic ulcer disease	2,535 (14.1)
Mild liver disease	3,932 (21.9)
Diabetes without chronic complication	763 (4.2)
Diabetes with chronic complication	1,135 (6.3)
Hemiplegia or paraplegia	321 (1.8)
Renal disease	791 (4.4)
Any malignancy	2,285 (12.7)
Moderate or severe liver disease	82 (0.5)
Metastatic solid tumor	304 (1.7)
AIDS	2 (0.0)
Hospital visits (≥once/month)	8,169 (45.4)
Hospitalization in baseline period (hospitalized)	3,269 (18.2)
Specific Health Check-ups (participation)	4,653 (25.9)
Contracted hospitals for pneumococcal vaccination (high)	9,181 (51.0)

Note. Numbers (%).

Table 2
Demographic variables overall by vaccination status.

	Unvaccinated	Vaccinated	P
N	11,939	6,052	
Age (years)			<0.001
65	1,546 (12.9)	971 (16.0)	
70	2,420 (20.3)	1,604 (26.5)	
75	2,182 (18.3)	1,498 (24.8)	
80	2,297 (19.2)	1,038 (17.2)	
85	1,873 (15.7)	609 (10.1)	
≥ 90	1,621 (13.6)	332 (5.5)	
Sex (female)	7,071 (59.2)	3,707 (61.3)	0.009
Socioeconomic status (not low income)	11,816 (99.0)	6,025 (99.6)	<0.001
Comorbidity			
Myocardial infarction	332 (2.8)	102 (1.7)	<0.001
Congestive heart failure	1,884 (15.8)	606 (10.0)	<0.001
Peripheral vascular disease	1,633 (13.7)	728 (12.0)	0.002
Cerebrovascular disease	2,696 (22.6)	1,169 (19.3)	<0.001
Dementia	1,074 (9.0)	245 (4.0)	<0.001
Chronic pulmonary disease	2,693 (22.6)	1,332 (22.0)	0.416
Rheumatic disease	509 (4.3)	209 (3.5)	0.01
Peptic ulcer disease	1,709 (14.3)	826 (13.6)	0.234
Mild liver disease	2,516 (21.1)	1,416 (23.4)	<0.001
Diabetes without chronic complication	586 (4.9)	177 (2.9)	<0.001
Diabetes with chronic complication	813 (6.8)	322 (5.3)	<0.001
Hemiplegia or paraplegia	220 (1.8)	101 (1.7)	0.44
Renal disease	576 (4.8)	215 (3.6)	<0.001
Any malignancy	1,553 (13.0)	732 (12.1)	0.087
Moderate or severe liver disease	56 (0.5)	26 (0.4)	0.8
Metastatic solid tumor	217 (1.8)	87 (1.4)	0.071
AIDS	0 (0.0)	2 (0.0)	0.216
Hospital visits (≥once/month)	5,289 (44.3)	2,880 (47.6)	<0.001
Hospitalization in baseline period (hospitalized)	2,305 (19.3)	964 (15.9)	<0.001
Specific Health Check-ups (participation)	2,342 (19.6)	2,311 (38.2)	<0.001
Contracted hospitals for pneumococcal vaccination (high)	6,129 (51.3)	3,052 (50.4)	0.257

Note. Numbers (%).

proportion of women (61.3 %), not a low income (99.6 %), hospital visits: ≥once/month (47.6 %), and Specific Health Check-ups' participation (38.2 %), compared to the unvaccinated group. The hospitalization rate (15.9 %) in the vaccinated group was significantly lower than that in the non-vaccinated group. Demographic characteristics by age group are shown in Supplemental Table 1. The main differences were in sex, vaccination coverage, hospital visits, hospital visit history, and Specific Health Check-ups' participation. The demographic variables of each age group according to vaccination status are shown in Supplemental Tables 2 and 3. Considerable differences were found in the Specific Health Check-ups' participation for both age groups.

3.3. Vaccination-related factors

Table 3 shows the results of the univariate and multivariable logistic regression analyses with vaccination status as the outcome variable and vaccination-related factors as the explanatory variables. Individual factors related to vaccination including specific age "85″ (OR: 0.70, 95 % CI: 0.61–0.80), "≥90″ (OR: 0.47, 95 % CI: 0.40–0.54), "female" (OR: 1.18, 95 % CI: 1.11–1.26), "not low income" (OR: 1.76, 95 % CI: 1.17–2.76), "hospital visits: ≥once/month" (OR: 1.27, 95 % CI: 1.19–1.35), and "Specific Health Check-ups participation" (OR: 2.10, 95

Table 3
The association between pneumococcal vaccination and individual and environmental factors in logistic regression analysis.

	Univariate		Multivariate	
N = 17,991	OR	95%CI	OR	95%CI
Age				
65	ref	ref	ref	ref
70	1.06	0.95–1.17	1.07	0.96–1.18
75	1.09	0.99–1.21	1.10	0.98–1.22
80	0.72***	0.65–0.80	0.93	0.83–1.05
85	0.52***	0.46–0.58	0.70***	0.61–0.80
≥ 90	0.33***	0.28–0.38	0.47***	0.40–0.54
Sex				
Male	ref	ref	ref	ref
Female	1.09**	1.02–1.16	1.18***	1.11–1.26
Socioeconomic status				
low income	ref	ref	ref	ref
not low income	2.32***	1.56–3.60	1.76*	1.17–2.76
Comorbidity (ref: no)				
Myocardial infarction	0.60***	0.48–0.75	0.83	0.65–1.05
Congestive heart failure	0.59***	0.54–0.65	0.82***	0.73–0.91
Peripheral vascular disease	0.86*	0.79–0.95	0.99	0.90–1.10
Cerebrovascular disease	0.82***	0.76–0.89	1.05	0.97–1.15
Dementia	0.43***	0.37–0.49	0.69***	0.59–0.80
Chronic pulmonary disease	0.97	0.90–1.04	1.03	0.95–1.11
Rheumatic disease	0.80**	0.68–0.94	0.82*	0.69–0.97
Peptic ulcer disease	0.95	0.86–1.03	1.03	0.94–1.14
Mild liver disease	1.14**	1.06–1.23	1.17***	1.08–1.27
Diabetes without chronic complication	0.58***	0.49–0.69	0.67***	0.56–0.80
Diabetes with chronic complication	0.77***	0.67–0.88	0.89	0.77–1.02
Hemiplegia or paraplegia	0.9	0.71–1.14	1.08	0.84–1.39
Renal disease	0.73***	0.62–0.85	0.93	0.79–1.10
Any malignancy	0.92	0.84–1.01	1.04	0.94–1.16
Moderate or severe liver disease	0.92	0.57–1.44	0.89	0.54–1.43
Metastatic solid tumor	0.79	0.61–1.01	0.82	0.62–1.08
AIDS	–	–	–	–
Hospital visits				
<once/month	ref	ref	ref	ref
≥once/month	1.14***	1.07–1.21	1.27***	1.19–1.35
Hospitalization in baseline period				
not hospitalized	ref	ref	ref	Ref
hospitalized	0.79***	0.73–0.86	1.04	0.95–1.14
Specific Health Check-ups				
no participation	ref	ref	ref	ref
participation	2.53***	2.36–2.71	2.10***	1.95–2.27
Contracted hospitals for pneumococcal vaccination				
low	ref	ref	ref	ref
high	0.96	0.91–1.03	1.01	0.95–1.08

*: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; OR: odds ratio; CI: confidence interval.

% CI: 1.95–2.27) showed significant associations. No significant associations were found for "contracted hospitals for pneumococcal vaccination." The results of the univariate and multivariable logistic regression analyses by age group are shown in Supplementary Table 4. Significant associations were found between age, hospital visit history, and Specific Health Check-ups' participation in both age groups.

4. Discussion

This is the first study to examine pneumococcal vaccination coverage and individual and environmental vaccination-related factors among persons aged 65 years or older in Japan using administrative data. The vaccination coverage was 33.6 % for the entire population. Significant vaccination-related factors that were identified in this study were the variables "specific age," "female," "not low income," "hospital visits: ≥once/month," " and Specific Health Check-ups' participation."

The vaccination coverage was 33.6 % for the entire eligible population. Pneumococcal vaccination coverage among older adults in the United States is approximately 70 %, indicating that vaccination coverage in Japan remains low [27]. From April 2015 to March 2020, the period covered in this study, pneumococcal vaccination coverage in Japan for this five-year period was 33.5 %, 37.8 %, 35.0 %, 32.4 %, and 13.7 % respectively [12], averaging 30.5 %. The results of this study likely reflect the current vaccination prevalence in Japan.

This study identified several significant individual factors associated with vaccination. These results were supportive of those of previous studies with respect to sex, socioeconomic status, hospital visit history, and Specific Health Check-ups' participation. Some studies in the United States have reported higher vaccination coverage among women than men among older adults (65 years and older) [16,28], predicting that women are more literate than men. In addition, a higher proportion of the vaccinated group received advice from a physician (80.2 %) and recommendations from their family physician, and those who were aware of the vaccine were more likely to be vaccinated [19,20]. Moreover, hospital visits are considered an important vaccination factor, as it has been reported that higher vaccination coverage is associated with more outpatient visits [18,28]. It has been found that vaccination coverage is higher among those who have received preventive services and Specific Health Check-ups [16], and this study reinforces the importance of receiving Specific Health Check-ups in Japan. Regarding household income, in Japan, the median co-payment for people receiving the vaccination in routine vaccination programs is approximately 3,000 Japanese yen (approx. $27) [13]. Thus, income may be a factor influencing vaccination [29]. Studies conducted overseas have also reported that socioeconomic status affects vaccination [27,30].

However, no findings were found regarding the age at vaccination, which could be an important factor, since one study found that the higher the age, the higher the vaccination rate among those aged ≥ 65 years [28]. The vaccination rate among those aged ≥ 75 years was relatively higher than that among those aged 74 years and younger [31]. Older adults may be more likely to take preventive actions [32] and visit a physician who recommends vaccination [33]. However, these previous studies examined the participants' vaccination experience, which differs from the present study, which examined vaccination histories for one year, concerning routine vaccination. It is thus difficult to compare the results of this study with those of previous studies. In contrast, other study has shown that the older the age, the lower the vaccination rate among those aged 65 years and older [16]; further research on age is therefore needed. Our results, however, are similar to previous data on age-specific vaccination coverage for pneumococcal vaccines in Japan [34] and appear to reflect the characteristics of vaccination in Japan.

Environmental factors associated with vaccination included a low number of contracted hospitals for pneumococcal vaccination per population. Previous studies have reported that poor access to healthcare is associated with a lower likelihood of vaccination [28], and that the closer the distance to the nearest vaccine-available facility, the higher the likelihood of vaccination [35]. When assessing access to medical facilities as an environmental factor affecting vaccination rates, it is necessary to investigate not only the "number" of hospitals, but also the "distance" between the place of residence and the vaccination facility, taking into account transportation and other factors. In future, it will be necessary to study the environmental factors based on a more multifaceted survey.

This study had several limitations. The first was selection bias. In this study, those who were not enrolled in the National Health Insurance System, Latter-Stage Older Person Health Care System, and Long-Term Care (LTC) Insurance System, and hence individuals who did not receive any medical services, were not included. Japan has its National Health Insurance (NHI) system. Most older adults are covered by medical insurance and have access to inexpensive medical care. Most municipalities participating in the LIFE Study should have older adults receiving medical services [36]. Therefore, selection bias was small because the study reflected a large older population. Future studies should use all population registry data to reduce the selection bias.

Second, this study does not use household income based on specific figures for socioeconomic status. While previous studies may have used categorical variables based on actual household income [27], this study used the "Standard Copayment Classification for Partial Payment, Meal Treatment and Living Care" based on medical receipts, and considered two categories: "low income" and "not low income." Many local municipalities in Japan exempt tax-exempt households with low incomes from paying immunization fees. It is difficult to assume that simply having a higher income means a better economic standard and easier access to vaccination. Future research using specific annual household incomes is needed.

5. Conclusions

This study is the first to use administrative data to investigate pneumococcal vaccination coverage and vaccination-related factors among older adults in Japan. This study revealed the importance of individual factors, such as sex and Specific Health Check-ups' participation, as factors affecting pneumococcal vaccination among older adults by using more objective large-scale data. In particular, "participation in Specific Health Check-ups" was a newly significant factor associated with vaccination. The participation rate of Specific Health Check-ups in the target population of this study is still at a low level. In order to improve the pneumococcal vaccination coverage in the future, it is essential to promote participation in Specific Health Check-ups. No significant findings were obtained for environmental factors. Future research is needed to investigate more detailed environmental factors, such as accessibility to medical care and transportation networks. Comprehensive surveys are needed in the future, as approaches to both individual and environmental factors can more effectively increase vaccination coverage.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2023.12.009.

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