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Associations of influenza and pneumococcal vaccinations with burdens of older family caregivers: The Japan Gerontological Evaluation study (JAGES) cross-sectional study

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ABSTRACT

Background: Influenza and pneumonia tend to be severe in older adults; thus, vaccination is necessary to prevent these illnesses. Vaccination is especially important for older family caregivers (OFCs) not only to prevent them from becoming ill, but also to prevent secondary infections in the family care receivers (FCRs), who are mostly frail older adults and have a higher risk of severe illness. Thus, we investigated whether caregiving burdens were associated with the vaccinations among older adults.

Methods: We used cross-sectional data from the Japan Gerontological Evaluation Study (JAGES), which was conducted in 64 Japanese municipalities from November 2019 to January 2020. The target population consisted of 26,177 individuals aged 65 years or older who were independent and did not need public long-term care. The primary outcome was the uptakes of either or both influenza and pneumococcal vaccinations. Multinomial logistic regressions were performed, setting those who underwent neither vaccinations as the reference group.

Results: Among the participants, 23.3 %, 25.8 %, 9.4 %, or 41.5 % underwent neither, only influenza, only pneumococcal, or the both vaccinations, respectively. The caregiving frequency, time length in a day, or dementia of FCR were negatively associated with influenza vaccination (caregiving almost every day: relative risk ratio {RRR}: 0.39, 95 % confident interval {95 % CI} [0.24–0.63]; caregiving almost all day: 0.44, 95 % CI: 0.23–0.85; caregiving for FCR: RRR:0.55, 95 % CI: 0.34–0.91). On the other hand, those caregiving burdens were not associated with pneumococcal only or the both vaccinations. Having a family physician mitigated all the negative effect of the caregiving burdens on the vaccinations.

Conclusion: Our results suggest that the caregiving burden is a barrier to influenza vaccination but not to pneumococcal vaccination and that having a physician mitigates the negative effect regardless of the burden kind.

1. Introduction

Influenza and pneumonia are often more severe in older adults aged 65 years or older. Human influenza viruses typically cause mild respiratory illness and infection of the lower respiratory tract, which can progress to pneumonia, acute respiratory distress syndrome or secondary bacterial infection, or death from respiratory failure. [1] An average of 389,000 respiratory-related deaths were associated with influenza annually worldwide, which account for ~ 2 % of all annual respiratory deaths. Of this, 67 % involved older adults aged ≥ 65 years. [2] A recent systematic review estimated the annual influenza-related hospitalizations at 31,087,000, with a higher hospitalization rate among older adults aged ≥ 65 years than in those aged 20–64 years. [3] Pneumonia is a major cause of mortality and morbidity among older adults. *Streptococcus pneumoniae* is the leading cause of pneumonia globally, contributing to 1,189,937 deaths, which is higher than all

Abbreviations: CI, Confidence interval; FCR, Family care receivers; GAS, Good Aging in Skane; JAGES, Japan Gerontological Evaluation Study; OFC, Older family caregivers; RRR, Relative risk ratio; DAG, Directed Acyclic Graphic; LTCS, Long-Term Care System.

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other etiologies. [4] Particularly, frail older adults are more frequently hospitalized, show poor recovery, and have a higher mortality due to influenza or pneumonia compared with their non-frail counterparts. [5–7].

The World Health Organization has recommended that all countries develop a long-term care system (LTCS) that provide affordable and accessible services to older adults who require them, particularly for those with less access to resources and the system has been implemented in several countries including Japan [8]. Even under the relatively egalitarian system, a few reports suggested that there is socioeconomic inequality in the LTCS utilization in the countries, suggesting that alternative caregiving resources are necessary to compensate the inequality. [9,10] A family (informal) caregiver is defined as the person who (in contrast to professional caregivers) provides unpaid care to a family member, partner, friend or neighbor because of long-term physical or mental ill health, disability, or problems related to old age. [11] The prevalence of OFCs is high in several countries including Japan with aging populations. [12–14] Household transmission is a major infectious pathway of influenza viruses and *S. pneumoniae*. [15–17] Nosocomial infections with these pathogens frequently occur by transmissions from the nursing staff to the residents in nursing homes, suggesting that these infectious pathogens can be transmitted from caregivers to care receivers during the caregiving process. [18,19] Recommended influenza and pneumococcal vaccinations effectively prevent older adults from contracting severe illness. [20,21,43] These vaccinations are especially important for OFCs to prevent severe illness and subsequent transmission to FCRs through caregiving.

The association between caregiving and influenza or pneumococcal vaccination among older adults has not been established. McGuire et al. found no significant differences in influenza and pneumococcal vaccinations between OFCs and non-caregivers. [22] However, while they compared the immunization between OFCs and non-caregivers in a univariate analysis, they did not test whether caregiving was associated with these immunizations after adjusting for potential confounders. In the present study, we examined whether the caregiving burden was negatively associated with these vaccinations after adjusting for potential confounders among older adults aged ≥ 65 years. Furthermore, the presence of a family physician is associated with influenza or pneumococcal vaccination among older adults.[23,24] Therefore, we further hypothesized whether the potential negative effect of caregiving burden could be mitigated by having a family physician and assessed these associations.

2. Material and methods

2.1. Study design and participants

This study adopted a cross-sectional design and analyzed data obtained from the Japan Gerontological Evaluation Study (JAGES). This study looked at the social determinants of health among non-institutionalized and functionally independent people aged ≥ 65 years in Japan who were independent and did not require public long-term care. We mailed self-reported questionnaires to the participants in 64 municipalities from November 2019 to January 2020. We invited 45,974 individuals, of which 31,495 returned the questionnaire, corresponding to a 68.5 % response rate. We excluded 5,318 people from the study because they did not provide written informed consent, were aged < 65 years, or did not provide information about their age or sex. In all, the analyzed data were obtained from 26,177 individuals.

2.2. Vaccinations

In Japan, the national influenza and pneumococcal vaccination have started for adults aged ≥ 65 years as national vaccine program since 2001 and October 2014, respectively. [25,26] The outcome variables were recommended either or both of influenza and pneumococcal vaccinations. We asked, "Did you get an influenza vaccination in the last year?" and "Did you get a pneumococcal vaccination in the last 5 years?" We created a multiary variable for each vaccination, 1 indicating neither of the two vaccinations, 2 or 3 indicating only influenza or pneumococcal vaccination respectively, 4 indicating the both vaccinations.

2.3. The caregiving burdens

The explanatory variables were the caregiving burdens. We assessed the caregiving by asking participants the following: "Currently, do you care for (a) family member(s)?" In response, they chose one from the following: "Yes, I do. I'm the main caregiver"; "Yes, I do, but I mostly help someone else care for (a) family member(s)"; or "No, I don't." We considered those who chose the first as primary OFCs who provided mainly caregiving for FCR, those who chose the second as the secondary OFCs who helped the primary OFC, or those who chose third responses as non-caregivers. We assessed OFC's caregiving burdens according to caregiving frequency, duration in a day, and dementia status of the FCR. We assessed the caregiving frequency by asking OFCs, "On average, how often do you provide care for your family member(s)?" In response, they chose one from "Almost every day," "2 to 4 days a week," "Once a week," or "1 to 3 days a month." We assessed the duration of caregiving by asking OFCs to specify whether it was "Almost all day," "About half a day," "About 2 to 3 h," "When needed," or "Other." We assessed the dementia status of the FCRs by asking OFCs, "Does the person you care for have possible symptoms of dementia? The question refers to such symptoms as "forgetfulness more than standard with age"; "He or she doesn't know the time or place"; or "He or she cannot do what he or she used to do previously (If you are caring for more than one person, please circle here even if applicable to only one person)." The respondents chose a response from "Yes (A doctor has diagnosed them with dementia)"; "Yes (He or she has such symptoms but he or she has not been diagnosed with dementia)"; or "No.".

2.4. Covariates

The sociodemographic covariates consisted of sex, age group (65–74 and ≥ 75 years), marital status (married, widowed, divorced, never married, and others), educational attainment (<6, 6–9, 10–12, ≥13 years, and others), equivalized income (<0.5, 0.50–0.99, 1.00–1.99, 2.00–3.99, and ≥ 4.00 million yen), household structure (living alone, living with a spouse, living with offspring, living with a spouse and offspring, living in a three-generation household, and others) [27,28]. The health behavioral covariates consisted of smoking status (never smoked, quit smoking ≥ 5 years ago, quit smoking < 5 years ago, smokes sometimes, and smokes almost every day), alcohol consumption (do not drink, quit drinking ≥ 5 years ago, quit drinking < 5 years ago, currently drinks), self-rated health (excellent, good, fair, and poor), time of last medical checkup (within the previous year, between 1 and 4 years ago, >4 years ago, and never), whether they had a family physician, and the patient's inquiring attitude. The latter was determined by asking, "How would you rate how well you were able to ask your physician about something you did not understand in the last visit?" (1 = poor, 2 = fair, 3 = good, and 4 = excellent). [23] The health status covariates consisted of high-risk diseases associated with the severity of influenza and pneumonia

(stroke, heart disease, diabetes, respiratory disease, kidney/prostate disease, or blood/immune disease) [29,30], history of influenza or pneumonia in the past year, depressive symptoms (determined using the short form of the geriatric depression scale: not depressed, depressive tendency, or depression) [31]. The Tokyo metropolitan institute of gerontology index on competency was evaluated as follows: 0 = no incapable capacity/activity, −1 = one incapable capacity/activity, and −2 = two incapable capacity/activity = [32]. The social relationship covariates consisted of civic participation, social cohesion, and reciprocity [28,33]. The caregiving types were categorized into three as the primary, the secondary, or non-caregivers.

2.5. Statistical analyses

We performed directed acyclic graph (DAG) analysis to identify minimal sufficient adjustment sets of potential confounders to estimate the direct effects of caregiving types or burdens on influenza and pneumococcal vaccinations among older adults. [28] We generated 20 imputed data sets for handling missing data using Markov chains. [34] To satisfy the assumption that data were missing at random and to improve the quality of the imputed values, we included auxiliary variables associated with missing data for the imputation (see Supplemental Table 1 and the Methods). A multinomial logistic regression model was used to estimate relative risk ratio (RRR) and 95 % confidence interval (95 % CIs) of the associations between either or the both vaccinations and the caregiving burdens. Those who underwent neither vaccinations were set as the reference group. The RRRs and 95 % CIs were estimated after adjusted for covariates consisting of the caregiving types, age, sex, marital status, educational attainment, equivalized income, household structure, smoking status, alcohol consumption, self-rated health, medical checkup, family physician, patient's inquiring attitude, high-risk disease, history of influenza or pneumonia, geriatric depression, TMIG-IC, social participation, social cohesion, and reciprocity. The associations between the vaccinations and the caregiving burdens were evaluated by combining the estimations of the 20 imputed data sets with Rubin's rules. [35] We performed sensitivity analyses (SA) with the complete data set without missing data, as performed in the main analyses (MA) with imputed data sets (see Supplemental Tables). All P values were two-tailed, and the significance was set at 5 %. We performed all analyses using Stata version 17.0 (Lightstone Corp., College Station, TX, USA).

2.6. Patient and public involvement

No patients were involved in the development of the research questions, study design, or data interpretation in this study.

3. Results

Table 1 shows the basic characteristics of the recommended influenza and pneumococcal vaccinations among older adults aged ≥ 65 years.

Of the individuals studied, 23.3 %, 25.8 %, 9.4 %, or 41.5 % of older adults received neither of the two vaccinations, influenza, pneumococcal, or both of the two vaccinations, respectively. A percentage of the both vaccinations was greatest among OFCs who provided the primary or secondary caregiving, while the one pneumococcal only was greatest among non-caregivers. The tendency was almost the same among OFCs with relatively higher caregiving burdens as those with the two caregiving types (e.g., caregiving almost every day), while percentages of either of the two vaccinations were greatest among those with the other burdens (e.g., caregiving once a week).

A percentage of non-receipt of the both vaccinations was greatest among older adults who were men, divorced, never married, or in the other marital status than the four, had the other education than the four, had 0.50–0.99 million yen equivalized income, lived by alone, smoked almost every day, sometimes, or quit smoking < 5 years ago, self-rated health "Excellent", had no medical checkup within a year, rated patient's questioning attitude other than "Excellent", had no high-risk disease, had depression or the tendency, had one incapability in TMIG-IC. A percentage of influenza vaccination only was greatest among older adults who widowed or in the other marital status, had < 6 or 6–9 years education or the other education, had < 0.5 million or ≥ 4.00 yen equivalized income, lived with offspring or lived in households other than the five, smoking sometimes, quit drinking < 5 or ≥ 5 years ago, self-rated health "Fair" or "poor", had influenza or pneumonia history in the past year, had no social participation, no social cohesion, or no reciprocity. A percentage of pneumococcal vaccination only was greatest among older adults who aged 65–74, married, had 10–12 or ≥ 13 years education, had 1.00–1.99 or 2.00–3.99 million yen equivalized income, lived with a spouse only or together with offspring, quit smoking ≥ 5 years ago, consumed alcohol currently, self-rated health "Good", had no family physician, had no history of influenza or pneumonia in the past year, had social participation or reciprocity. A percentage of the both vaccinations was greatest among those who aged ≥ 75, were women, had the other education, lived in a three-generation household, never smoked, did not drink, had medical checkup within a year, had a family physician, rated the patient's questioning attitude "Excellent", had high-risk disease, were not depressed, had no incapability in TMIG-IC, or had social cohesion.

Table 2 shows RRRs and 95 % CIs of associations between the vaccinations and the caregiving burdens among older adults aged 65 years or more.

The caregiving frequencies, time lengths in a day, or dementia of FCR of OFC's caregiving were negatively associated with influenza vaccination after adjusting for covariates including the caregiving types compared with no caregiving (e.g., the caregiving almost every day: RRR: 0.39, 95 % CI: 0.24–0.63; the caregiving almost all day: RRR: 0.44, 95 % CI: 0.23–0.85; the caregiving for FCR who was diagnosed with dementia: RRR: 0.55, 95 % CI: 0.34–0.91). On the other hands, the caregiving burdens were not associated with pneumococcal and the both vaccinations. The results of SA showed almost similar trend with those of MA, while some of the associations showed positive trend with the vaccinations (Supplemental Table 2).

Table 3 shows RRRs and 95 % CIs of associations between the vaccinations and the caregiving burdens with or without a family physician.

Having a family physician mitigated the negative effect of the caregiving burden on influenza vaccinations (e.g., caregiving almost every day with the physician: RRR: 0.70, 95 % CI: 0.42–1.16 compared to the same burden without the physician: RRR: 0.45, 95 % CI: 0.25–0.82; caregiving almost all day: RRR: 0.89, 95 % CI: 0.45–1.78 compared to the same burden without the physician: RRR: 0.33, 95 % CI: 0.12–0.88). Having the physician enhanced the both vaccinations even in the presence of the caregiving burdens which had negative effect on influenza vaccination (e.g., caregiving almost every day with the physician: RRR: 2.08, 95 % CI: 1.43–3.03 compared to the same burden without the physician: RRR: 0.91, 95 % CI: 0.56–1.48; caregiving almost all day with the physician: RRR: 2.37, 95 % CI: 1.44–3.89 compared to the same burden without the physician: RRR: 0.79, 95 % CI: 0.37–1.68), The results of SA showed almost similar with those of MA (supplemental Table 3).

Table 1
Basic characteristic of influenza and pneumococcal vaccinations among older adults aged ≥ 65 years.

Pneumococcal [##]		Neither The both vaccinations [###] n = 6,336* (3.30) **		Influenza [#] n = 5,715 (17.99)		n = 2,900 (3.30)		n = 11,226 (17.99)	
		%	SD	%	SD	%	SD	%	SD
Do you care for a family member(s)?	Non-caregiver	91.9	0.35	91.4	0.39	**92.5**	0.49	90.3	0.28
	Primary	4.6	0.27	4.5	0.30	4.3	0.38	**5.0**	0.21
	Secondary	3.4	0.23	4.1	0.27	3.2	0.33	**4.7**	0.20
Frequency of caregiving	Non-caregiver	92.1	0.34	91.7	0.38	**92.6**	0.49	90.5	0.28
	Almost every day	4.9	0.28	5.2	0.31	4.3	0.38	**6.2**	0.23
	2 to 4 times a day	1.3	0.15	1.1	0.14	1.0	0.19	**1.5**	0.12
	Once a week	0.7	0.10	0.8	0.12	**0.9**	0.18	0.8	0.09
	1 to 3 times in a month, or less	1.0	0.12	1.1	0.14	**1.2**	0.20	1.0	0.09
Time length of caregiving in a day	Non-caregiver	91.9	0.35	91.4	0.39	**92.5**	0.49	90.3	0.28
	Almost all day	1.4	0.15	1.6	0.18	1.1	0.20	**1.9**	0.13
	About half a day	1.1	0.14	**1.3**	0.18	1.1	0.20	1.1	0.11
	About 2 to 3 h a day	1.2	0.14	1.3	0.17	1.3	0.21	**1.5**	0.12
	When needed	4.1	0.25	4.1	0.27	3.8	0.36	**4.9**	0.21
	Other	**0.3**	0.07	**0.3**	0.07	0.2	0.08	**0.3**	0.05
Dementia of FCR	Non-caregiver	92.0	0.35	91.4	0.39	**92.5**	0.49	90.3	0.28
	Diagnosed with dementia	2.8	0.21	3.2	0.26	2.0	0.27	**3.3**	0.18
	Have the symptoms but not diagnosed	1.8	0.17	**2.2**	0.21	1.9	0.26	2.1	0.14
	Neither of the two	3.5	0.23	3.1	0.23	3.5	0.34	**4.3**	0.19
Age	65–74	61.3	0.61	46.9	0.69	**64.8**	0.89	46.8	0.48
	≥75	38.7	0.61	53.1	0.69	35.2	0.89	**53.2**	0.48
Sex	Man	**54.2**	0.63	47.6	0.69	50.3	0.93	43.4	0.48
	Woman	45.8	0.63	52.4	0.69	49.7	0.93	**56.6**	0.48
Marital status	Married	71.2	0.57	70.8	0.63	**77.0**	0.79	73.4	0.42
	Widowed	17.0	0.48	**20.6**	0.56	14.5	0.66	20.1	0.38
	Divorced	**6.2**	0.30	4.5	0.28	5.0	0.41	3.8	0.18
	Never married	**4.6**	0.26	3.1	0.23	3.1	0.32	2.0	0.14
	Other	**1.0**	0.12	**1.0**	0.14	0.4	0.11	0.6	0.08
Educational attainment	<6	0.8	0.12	**1.6**	0.20	0.4	0.13	0.7	0.10
	6–9	23.8	0.54	**32.1**	0.64	19.3	0.74	27.0	0.43
	10–12	42.4	0.63	40.1	0.68	**45.6**	0.93	42.6	0.48
	≥13	32.2	0.59	25.4	0.61	**34.1**	0.88	28.9	0.44
	Others	**0.8**	0.12	**0.8**	0.12	0.6	0.14	**0.8**	0.08
Equivalized income, million yen	<0.5	12.0	0.41	**13.8**	0.47	8.5	0.52	10.8	0.30
	0.50–0.99	**33.1**	0.59	29.1	0.62	32.0	0.87	30.4	0.44
	1.00–1.99	20.0	0.50	17.5	0.51	**22.0**	0.77	20.7	0.38
	2.00–3.99	14.0	0.44	12.3	0.45	**17.2**	0.70	14.3	0.33
	≥4.00	20.9	0.51	**27.4**	0.61	20.3	0.75	23.8	0.41
Household structurer (living with who or by alone)	A spouse	50.1	0.63	47.5	0.71	**53.4**	0.93	50.9	0.48
	By alone	**17.7**	0.48	16.4	0.54	13.1	0.63	14.4	0.34
	Offspring	6.9	0.32	**8.6**	0.42	7.1	0.48	7.3	0.26
	A spouse and offspring	8.8	0.36	7.9	0.37	**10.9**	0.58	8.1	0.26
	Three-generation household	7.7	0.34	9.8	0.41	7.6	0.50	**10.9**	0.30
	Other than described above	8.8	0.36	**9.8**	0.40	7.9	0.50	8.4	0.27
Smoking status	Almost everyday	**13.8**	0.43	8.7	0.38	9.0	0.53	5.3	0.22
	Sometimes	**2.0**	0.18	**2.0**	0.20	1.1	0.20	1.2	0.11
	Quit < 5 years ago	**4.5**	0.27	3.9	0.28	3.8	0.37	2.9	0.17
	Quit ≥ 5 years ago	27.5	0.57	26.7	0.61	**30.9**	0.86	27.3	0.43
	Never	52.2	0.63	58.7	0.69	55.1	0.93	**63.3**	0.47
Alcohol consumption	Currently	45.5	0.63	38.8	0.67	**45.6**	0.94	38.4	0.48
	Quit < 5 years ago	4.7	0.29	**5.7**	0.34	4.0	0.41	5.1	0.22
	Quit ≥ 5 years ago	8.1	0.36	**8.5**	0.41	5.7	0.46	7.4	0.26
	Do not drink	41.7	0.63	47.0	0.70	44.7	0.94	**49.0**	0.49
Self-rated health	Excellent	**16.3**	0.47	13.3	0.47	15.3	0.68	13.5	0.33
	Good	70.2	0.58	70.7	0.62	**73.1**	0.83	72.8	0.43
	Fair	11.9	0.41	**13.9**	0.48	10.1	0.56	12.2	0.32
	Poor	1.6	0.16	**2.0**	0.19	1.5	0.22	1.6	0.12
Medical checkup	Within a year	50.6	0.63	59.6	0.69	67.8	0.87	**71.3**	0.44
	Sometime between 1 and 4 years ago	**16.2**	0.47	14.8	0.52	13.7	0.64	12.3	0.32
	≥4 years ago	**13.2**	0.43	9.4	0.39	8.7	0.53	7.3	0.25
	Never	**20.0**	0.50	16.2	0.50	9.8	0.56	9.1	0.28
Family physician	No	11.7	0.47	16.9	0.52	**22.9**	0.79	11.0	0.31
	Yes	88.3	0.47	83.1	0.52	77.1	0.79	**89.0**	0.31
Patient's questioning attitude	Excellent	59.7	0.64	65.0	0.69	62.3	0.93	**66.8**	0.48
	Good	**24.5**	0.58	22.6	0.60	23.6	0.82	21.9	0.42
	Fair	**9.5**	0.38	7.7	0.38	9.1	0.54	6.5	0.25
	Poor	**6.3**	0.31	4.7	0.29	5.0	0.41	4.7	0.20
High-risk disease	No	**74.3**	0.55	70.1	0.62	73.2	0.83	69.2	0.45
	1 or more	25.7	0.55	29.9	0.62	26.8	0.83	**30.8**	0.45

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Table 1 (*continued*)

Pneumococcal [##]		Neither The both vaccinations [###] n = 6,336* (3.30) **		Influenza [#] n = 5,715 (17.99)		n = 2,900 (3.30)		n = 11,226 (17.99)	
		%	SD	%	SD	%	SD	%	SD
History of influenza or pneumonia in the past year	No	88.3	0.47	75.6	0.70	**88.4**	0.69	80.9	0.42
	Yes	11.7	0.47	**24.4**	0.70	11.6	0.69	19.1	0.42
Geriatric depression	Not depressed	75.5	0.58	76.1	0.62	80.5	0.76	**80.7**	0.40
	Depression tendency	**19.1**	0.53	18.4	0.58	15.5	0.70	15.8	0.38
	Depression	**5.4**	0.28	**5.4**	0.31	4.0	0.37	3.5	0.18
TMIG-IC	0	55.3	0.64	60.6	0.72	61.4	0.92	**65.7**	0.46
	−1	**44.4**	0.64	39.2	0.72	38.4	0.92	34.1	0.46
	−2	0.2	0.08	0.2	0.09	0.1	0.10	0.1	0.04
Social participation	0	65.8	0.63	**68.4**	0.69	57.6	0.96	59.3	0.48
	1 or more	34.2	0.63	31.6	0.69	**42.4**	0.96	40.7	0.48
Social cohesion	0	16.7	0.48	**16.9**	0.52	14.2	0.66	13.1	0.34
	1 or more	83.3	0.48	83.1	0.52	85.8	0.66	**86.9**	0.34
Reciprocity	0	3.9	0.26	**5.1**	0.35	2.0	0.28	2.6	0.18
	1 or more	96.1	0.26	94.9	0.35	**98.0**	0.28	97.4	0.18

TMIG-IC: Tokyo Metropolitan Institute of Gerontology Index of Competency; TMIG-IC: 0: No incapable task/activity, −1: one incapable task/activity, −2: two incapable tasks/activities; *: an average number of the vaccination status in the twenty imputed datasets; **: a standard error of the average number in the twenty imputed datasets; [#]: received influenza vaccination but not pneumococcal one; [##]: received pneumococcal vaccination but not influenza one; [###]: received the both vaccinations. A greatest percentage was highlighted as bold of the four vaccination statuses in each category.

Table 2
Associations between vaccinations and the caregiving burdens among older adults aged 65 years and more (RRRs and 95 % CIs).

		Vaccination		
		Influenza[#]	Pneumococcal [##]	The both vaccinations [###]
Frequency of caregiving	Almost every day	0.39 (0.24–0.63)	0.84 (0.53–1.34)	0.76 (0.53–1.10)
	2 to 4 days a week	0.42 (0.26–0.69)	0.73 (0.43–1.23)	0.78 (0.53–1.15)
	Once a week	0.72 (0.42–1.24)	1.22 (0.69–2.17)	1.01 (0.64–1.59)
	1 to 3 days a month or less	0.68 (0.42–1.08)	1.08 (0.65–1.78)	0.78 (0.53–1.16)
Time length of caregiving in a day	Almost all day	0.44 (0.23–0.85)	0.84 (0.44–1.60)	0.80 (0.50–1.28)
	About half a day	0.59 (0.32–1.08)	1.00 (0.57–1.78)	0.76 (0.49–1.19)
	2 to 3 h	0.61 (0.36–1.03)	1.04 (0.60–1.82)	0.93 (0.61–1.41)
	When needed	0.51 (0.32–0.82)	0.89 (0.59–1.34)	0.85 (0.61–1.16)
	Other	0.47 (0.21–1.02)	0.54 (0.19–1.52)	0.79 (0.42–1.48)
FCR of dementia	Diagnosed with dementia	0.55 (0.34–0.91)	0.72 (0.44–1.16)	0.80 (0.57–1.13)
	Having the symptoms but not diagnosed	0.62 (0.39–1.01)	1.07 (0.66–1.73)	0.87 (0.60–1.27)
	Neither of the two	0.45 (0.28–0.72)	0.95 (0.63–1.45)	0.86 (0.62–1.19)

RRR: relative risk ratio; 95 % CI: 95 % confident interval; all the RRRs and 95 % CIs were adjusted for the caregiving type, age, sex, marital status, educational attainment, equivalized income, household structure, smoking status, alcohol consumption, self-rated health, medical checkup, family physician, patient's questioning attitude, high-risk disease, history of influenza or pneumonia, geriatric depression, TMIG-IC, social participation, social cohesion, and reciprocity. References of RRRs (1.00) were set at no caregiving. #: received influenza vaccination but not pneumococcal one; ##: received pneumococcal vaccination but not influenza one; ###: received the both vaccinations.

4. Discussion

We investigated the associations between recommended influenza and pneumococcal vaccinations and the caregiving burdens among older adults aged ≥ 65 years. Our results showed the caregiving burdens, including frequency, time length in a day, and dementia of FCR, were negatively associated with influenza vaccination, but not with pneumococcal and the both vaccinations. Having a family physician mitigated the negative effect of the caregiving burdens on influenza vaccinations and enhanced the both vaccinations even in the presence of the caregiving burdens. Our results suggest that the caregiving burdens have an effect on influenza vaccination but not on pneumococcal vaccination and that having a physician mitigate the negative effect regardless of the burden kind or extent.

Mounting evidence suggests that caregiving burden negatively affects an OFC's physical and mental health outcomes, as well as health behaviors. [12,36–38] We showed that the caregiving burdens had negative effects on influenza vaccination after adjusting for the caregiving types and the other covariates. Our result suggests a consistence with those evidences and that the caregiving is a barrier to influenza vaccination, but not pneumococcal vaccination among older adults. One possible reason why the burdens affect only influenza vaccination among older adults is a difference in immunization intervals. The revaccination of pneumococcal vaccination is recommended for people who need because of health reasons 5 years after the first one. [39,40] The influenza vaccine, on the other hand, is recommended to be administered every influenza season. However, due to the caregiving burden, it may be more inconvenient to avail of the yearly influenza vaccination. On the other hand, pneumococcal vaccination is recommended once every 5 years, which improves the possibility of arranging relief care for the patient. [41].

Our result showed that having a family physician mitigated the negative effect of the caregiving burdens on influenza vaccination and enhanced the both vaccinations even in the presence of the

Table 3
Associations of the vaccinations with the caregiving burdens in a presence of family physician among older adults aged 65 years and more (RRRs and 95 % CIs).

			Vaccination		
		Family physician	Influenza #	Pneumococcal ##	The both vaccinations ###
Frequency of caregiving	Almost every day	No	0.45 (0.25–0.82)	0.95 (0.51–1.75)	0.91 (0.56–1.48)
		Yes	0.70 (0.42–1.16)	1.14 (0.71–1.84)	2.08 (1.43–3.03)
	2 to 4 days a week	No	0.29 (0.11–0.80)	0.65 (0.25–1.66)	0.70 (0.32–1.52)
		Yes	0.89 (0.52–1.50)	1.10 (0.62–1.97)	2.39 (1.56–3.64)
	Once a week	No	0.57 (0.19–1.76)	0.56 (0.13–2.37)	1.30 (0.53–3.19)
		Yes	1.47 (0.81–2.65)	2.05 (1.09–3.86)	2.90 (1.76–4.78)
	1 to 3 days a month or less	No	0.56 (0.25–1.29)	1.01 (0.41–2.48)	0.98 (0.48–1.99)
		Yes	1.32 (0.79–2.21)	1.56 (0.88–2.75)	2.15 (1.39–3.34)
Time length of caregiving in a day	Almost all day	No	0.33 (0.12–0.88)	0.49 (0.15–1.62)	0.79 (0.37–1.68)
		Yes	0.89 (0.45–1.78)	1.36 (0.69–2.68)	2.37 (1.44–3.89)
	About half a day	No	0.72 (0.27–1.92)	1.15 (0.44–2.97)	1.10 (0.52–2.34)
		Yes	1.03 (0.54–1.96)	1.35 (0.71–2.55)	1.98 (1.22–3.22)
	2 to 3 h	No	0.70 (0.28–1.71)	1.37(0.53–3.51)	1.43 (0.67–3.06)
		Yes	1.10 (0.63–1.90)	1.36 (0.75–2.49)	2.44 (1.59–3.77)
	When needed	No	0.54 (0.30–0.96)	0.88(0.49–1.58)	0.91 (0.57–1.45)
		Yes	0.95 (0.58–1.55)	1.26 (0.82–1.94)	2.39 (1.72–3.32)
	Other	No	0.19 (0.004–96.43)	0.57 (0.06–5.28)	0.94 (0.19–4.62)
		Yes	0.95 (0.58–1.55)	0.76 (0.24–2.38)	2.26 (1.17–4.38)
FCR of dementia	Diagnosed with dementia	No	0.68 (0.36–1.28)	0.53 (0.24–1.20)	0.87 (0.52–1.48)
		Yes	1.00 (0.59–1.69)	1.10 (0.66–1.83)	2.26 (1.57–3.26)
	Having the symptoms but not diagnosed	No	0.67(0.32–1.38)	1.20 (0.56–2.56)	1.14 (0.61–2.14)
		Yes	1.14 (0.69–1.89)	1.47 (0.87–2.47)	2.36 (1.58–3.50)
	Neither of the two	No	0.35 (0.18–0.68)	1.03 (0.56–1.92)	0.99 (0.61–1.62)
		Yes	0.90 (0.55–1.45)	1.34 (0.87–1.92)	2.44 (1.75–3.40)

RRR: relative risk ratio; 95 % CI: 95 % confident interval; All the RRRs and 95 % CIs were adjusted for the caregiving types, age, sex, marital status, educational attainment, equivalized income, household structure, smoking status, alcohol consumption, self-rated health, medical checkup, family physician, patient's questioning attitude, high-risk disease, history of influenza or pneumonia, geriatric depression, TMIG-IC, social participation, social cohesion, and reciprocity. References of RRRs (1.00) were set at no caregiving. #: received influenza vaccination but not pneumococcal one; ##: received pneumococcal vaccination but not influenza one; ###: received the both vaccinations.

caregiving burdens which had the negative effect on the one of the two vaccinations. Our recent study also suggests that having the physician mitigates negative effects of cognitive and social incapability on either or the both vaccinations among older adults. [42] Our present and recent results indicate that having a family physician is beneficial to receive vaccination for older adults with such social or functional difficulties.

Our study has some limitations. First, this study has a cross-sectional design, so we did not determine causal pathways. The possibility of a reverse causal relationship between influenza or pneumococcal vaccination and the caregiving status cannot be completely excluded. However, the two vaccinations are unlikely to have an effect on the caregiving type or caregiving burden of OFCs. Second, given the nature of an observational study, we could not clarify causality because of unmeasured confounders. However, we tried to adjust for major confounding variables among the enrolled individuals and vaccinations. Third, we did not observe FCR-received medical services including vaccination with the caregiver's help, which potentially affect the caregiver's vaccination. However, the burden of the help could have been indirectly adjusted as the caregiving burdens which we adjusted to estimate the effects of caregiving on the vaccinations. Forth, our findings cannot be generalized to people who had been certified as needing long-term care. Fifth, a recall bias may have occurred in the survey on the vaccination statuses. The impact of this potential bias is unknown. Sixth, we did not assess the age of the FCRs; therefore, some FCRs may not have been aged $\geq$ 65 years. However, we assessed the family relationships between FCRs and OFCs and found that 81.2 % of OFCs responded that they were caring for their spouse, parents, or their spouse's parents (Supplemental Table 5). Seventh, we did not assess history of influenza or pneumococcal vaccination before the survey, which potentially had an effect on the vaccinations.

5. Conclusions

Recommended influenza and pneumococcal vaccinations are necessary to prevent OFCs and their FCRs from contracting severe influenza and pneumonia, either as primary or secondary infection. Our results showed that the caregiving burdens including frequency, duration, and dementia status of FCRs were negatively associated with influenza vaccination, while the burdens were neither associated with pneumococcal nor with the both vaccinations. Having a family physician mitigated the negative associations of the burdens on the vaccinations regardless of the caregiving burden kind. These results suggest that the caregiving burdens affect influenza vaccination and that having a family physician mitigates the negative effect. A vaccination program should be established to educate OFCs on the transmissibility of and more severe secondary infections due to influenza virus especially in frail FCRs. The program should recommend influenza vaccination to mitigate the vaccination gap based on the caregiving burden. Furthermore, an environment that encourages caregivers to avail the vaccinations can be promoted by improving long-term care insurance services.

6. Data availability

Data are from the JAGES study. All inquiries are to be addressed to the data management committee via e-mail: dataadmin.ml@-jages.net. All JAGES datasets have ethical and legal restrictions on public deposition due to the inclusion of sensitive information from human participants.

7. Author contributions

Author contributions: All authors (K.I.S., K.S., and K.K.) conceptualized the study and contributed to its design. K.I.S. performed

the statistical analysis under the supervision of K.S. All authors contributed to the interpretation of the data. K.I.S. wrote the first draft of the article, which was revised critically by K.S. and K.K. for important content. All authors have read and agreed to the published version of the manuscript.

Ethical approval

The process of obtaining informed consent in the present study was as follows: the questionnaire was sent by mail with the explanation of the study; the participants read the written explanation about the purpose of study and replied. Hence, we considered that informed consent was provided by those who replied and sent back the questionnaire. The JAGES protocol in 2019 was approved by the ethics committee of National Center for Geriatrics and Gerontology (No. 992), the ethics committee of Chiba University (No. 2493), and JAGES (No. 2019-01). We followed the STROBE statement to report our observational study. This study was performed in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all participants.

Data availability

Data are from the JAGES study. All inquiries are to be addressed to the data management committee via e-mail: dataadmin.ml@jages.net. All JAGES datasets have ethical and legal restrictions.

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.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2022.11.047.

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