Yeo et al. BMC Public Health (2025) 25:42
https://doi.org/10.1186/s12889-024-21254-6

BMC Public Health

RESEARCH

Open Access

Socioeconomic disparities in influenza vaccination uptake: impact of the COVID-19 pandemic in South Korea

Muhan Yeo[1], Jeongmin Seo[1,2] and Juwon Lim[3*]

Abstract

Background This study aimed to investigate the sociodemographic and behavioral factors related to increased influenza vaccination uptake during the COVID-19 pandemic in South Korea, particularly among adults not eligible for free vaccination.

Methods Analyzing data from 78,815 participants in the Korea National Health and Nutrition Examination Survey (2010–2021), we assessed trends in influenza vaccination coverage. Various sociodemographic factors, behavioral aspects, and psychological stress levels were assessed using multivariable logistic regression to evaluate the difference in vaccination response during pre-/post-COVID-19 periods.

Results Lowest income quartile households exhibited decreased influenza vaccination uptake during the pandemic (adjusted odds ratio 0.67, $p=0.011$), whereas higher income quartiles exhibited increased uptake. In the lowest income households, unemployed status of household was additionally associated with decreased influenza vaccine uptake (adjusted odds ratio 0.50, $p=0.003$).

Conclusions This study identified income-based disparities in the responsive increase of influenza vaccination during the COVID-19 pandemic. Lower-income households exhibited a disproportionate reduction in influenza vaccine uptake, emphasizing the need for targeted support systems and expanded free vaccination for prioritized groups to address these disparities.

Keywords Influenza vaccines, COVID-19, Vaccination hesitancy, Socioeconomic disparities in Health, Health Policy

*Correspondence:
Juwon Lim
imvacsa@gmail.com
[1]Department of Medicine, Seoul National University College of Medicine, Seoul, Korea
[2]Department of Internal Medicine, Seoul National University Bundang Hospital, Seongnam, Korea
[3]International Healthcare Center, Seoul National University Hospital, Seoul, Korea

Background

The decision to receive vaccinations, including the influenza vaccine, often hinges on a careful balance between perceived benefits and potential drawbacks [1, 2]. These benefits comprise not just personal protection against severe illnesses but also broader societal advantages, including curbing disease transmission and fostering community health through herd immunity. Conversely, potential deterrents may encompass apprehensions about side effects, injection-related discomfort, and, in certain instances, financial implications [3]. Hence, detailed comprehension of these aspects is pivotal for healthcare policymakers to foster strategies promoting vaccine uptake [4].

National policies endorsing free immunization programs serve as an efficacious instrument in mitigating these barriers. Since 1997, the Republic of Korea has been implementing free influenza vaccination for children, the elderly, and pregnant women [5, 6]. The coverage of this program has been systematically expanded over time, supplemented by diverse promotional activities to bolster vaccination rates. In response to that, the influenza vaccination coverages of these specific groups increased steeply after the onset of free vaccination support [7, 8, 9].

After the outbreak of COVID-19 pandemic in early 2020, influenza vaccination uptake increased in the majority of OECD countries [10, 11, 12, 13, 14, 15]. And plenty of studies presented that the COVID-19 pandemic increased the intention for influenza vaccination internationally [12, 16]. This change is attributed to promotional efforts undertaken by the nations to mitigate the threat of concurrent respiratory illnesses, and proactive behavior changes of individuals to protect their health against the co-infection. In South Korea, a similar increase in influenza vaccination was observed in the working age population, who were not the target of the free vaccination policy [9]. This increase in influenza vaccination in response to COVID-19 could be influenced by various factors, such as sociodemographic aspects, financial status of households, or intrinsic health-related behaviors.

The objective of this study is to identify such factors associated with the increase of influenza vaccination uptake during a respiratory pandemic, within the context of the COVID-19 pandemic in South Korea. We especially focused on the adults who were not supported by free influenza vaccination, to effectively investigate the effect of sociodemographic and behavioral factors. Ultimately, our goal is to provide insights for future research and policymaking on the promotion of influenza vaccination, by analyzing diverse public responses to the heightened sense of crisis prompted by the COVID-19 pandemic.

Methods

Study population and design

We employed data sourced from the Korea National Health and Nutrition Examination Survey (KNHANES), and annual cross-sectional survey conducted by the Korea Disease Control and Prevention Agency (KDCA) from 2010 to 2021. KNHANES assesses the health and nutritional status of the South Korean population through comprehensive health screenings, interviews, and nutritional assessments. Conducted by specialized teams, the survey collects an array of data encompassing clinical, biochemical, physical, and lifestyle data, as well as information on education, economic activities, and oral hygiene practices. All participants provided written informed consent [5, 17].

Our analysis includes data from KNHANES V (2010–2012), VI (2013–2015), VII (2016–2018), and VIII (2019–2021). However, data from the 2013 KNHANES were excluded due to the unavailability of the influenza survey data for that year. Participants who either overlooked the influenza survey question (13,229) or responded with “I do not know” (3,266) were also excluded from the study. This resulted in a final participant count of 78,815, out of an initial pool of 95,310 respondents.

We first analyzed trends in influenza vaccination coverage from 2010 to 2021, stratifying the data based on prioritized groups of influenza vaccination. Subsequently, influenza vaccination coverage during the pre-COVID-19 (2018/2019) and post-COVID-19 (2020/2021) periods were compared. Furthermore, we performed multivariable logistic regression analyses to examine the interaction effect on influenza vaccination uptake, between the temporal difference (pre-/post-COVID-19) and other factors including sociodemographic variables, behavioral aspects such as dining out and walking out frequency, and mental health parameters like psychological stress level.

Free vaccination groups

The prioritized group for influenza vaccine designated by the Centers for Disease Control and Prevention (CDC) and KDCA is presented in Table 1. Free vaccination groups in South Korea were selected based on these national guidelines: children, the elderly, and pregnant women. Free vaccination program started first in 2005 for adults aged ≥ 65 and has been expanded to children aged 6 months to 5 years in 2017, children aged 6 to 12 years in 2018, pregnant women in 2019, and children aged 13 years in 2020. In addition, adults aged 62–64, children aged 14–18, and some disabled and medical beneficiaries temporarily received free vaccination during the 2020–2021 season under the COVID-19 outbreak [18]. According to the 2023 KDCA, children aged 13 or less, adults aged 65 or more, and pregnant women were currently eligible for free vaccination. Adults with chronic diseases, immunosuppressed, and health care personnel had not been provided with the free vaccination despite being included in the prioritized group.

Measures

Influenza vaccination status was assessed by self-reported responses gathered through health interviews, querying individuals about their receipt of influenza vaccines within the past 12 months. The vaccination rate was computed as the ratio of individuals responding ‘Yes’ to the sum of individuals responding either ‘Yes’ or ‘No’.

Table 1 The prioritized groups for influenza vaccine designated by CDC and KDCA

CDC	KDCA
· Children aged 6–59 months	· Children aged 6–59 months
	· Children aged 5–18 years
· The elderly aged ≥ 65	· The elderly aged ≥ 65
· People aged ≥ 50	· People aged 50–64
· People with chronic diseases [a]	· People with chronic diseases [a]
· People who are immunosuppressed	· People who are immunosuppressed
· Pregnant women	· Pregnant women [b]
· People aged 6 months – 18 years on long-term aspirin or salicylate-containing medications	· People aged 6 months – 18 years on long-term aspirin or salicylate-containing medications
· People who live in nursing homes and other long-term care facilities	· People who live in nursing homes and other long-term care facilities
· American Indian or Alaska Native persons	
· Obese people with BMI ≥ 40	
· Health care personnel	· Health care personnel
· Household contacts and caregivers of children aged < 5, adults aged ≥ 50, and people with medical conditions	· Household contacts and caregivers of infant aged < 6 months, adults aged ≥ 65, pregnant women, and people with medical conditions

[a] Chronic pulmonary (including asthma), cardiovascular (excluding isolated hypertension), renal, hepatic, neurologic, hematologic, or metabolic disorders (including diabetes mellitus)

Data labeled as 'Unknown' or 'null' were excluded from the analysis.

Chronic diseases were categorized as follows: malignancies (including lung, breast, stomach, colon, liver, cervical, thyroid, and others), kidney diseases (diabetes mellitus and chronic renal disease), heart diseases (coronary heart disease, angina, myocardial infarction, and stroke), liver diseases (chronic viral hepatitis and liver cirrhosis), and lung diseases (bronchial asthma and tuberculosis).

The following sociodemographic factors were assessed: sex (male or female), smoking status (current smoker or not, only in adults), residency area (rural or city), education years (≤9, 10–12, and ≥13 years), and household income (in four quartiles).

We further examined the frequency of eating out and walking out, as well as psychological stress levels, to explain the behavioral aspect of the change in the influenza vaccine uptake during the COVID-19 pandemic. Psychological stress levels were assessed based on respondent's subjective stress level in daily life, categorized into four levels. The two higher levels and the two lower levels were specified as "high" and "low", respectively.

The employment status of households was additionally analyzed and categorized into three groups depending on the employment status of household members: all unemployed, all part-time or self-employed except unemployed members, or any full-time employment within the household.

Statistical analysis

Bivariate associations of categorical variables were evaluated by chi-square tests. Associations between influenza vaccination uptakes and COVID-19 periods, sociodemographic factors, behavioral factors, and psychological stress level were assessed using multivariable logistic regression. Fully interacted models, including all two-way interaction terms between COVID-19 periods and the other factors, were constructed to assess the effect of COVID-19 periods on influenza vaccination uptake across various subgroups. The adjusted odds ratios (aORs) of COVID-19 periods for each subgroup were calculated from the weighted sum of coefficients of the COVID-19 period and all interaction terms, except the interaction term of the subgroup itself, which was added or excluded according to the subgroup's class. Standard errors were calculated as the square roots of the weighted sum of their covariances. The aOR ratios were also calculated using the coefficients of the interaction terms to compare the effect of COVID-19 periods on influenza vaccination among the subgroups' classes. The coefficients, standard errors, and covariance matrices of all multivariable regression models used in the study are presented in Additional file 2. Changes in vaccination rates over time were assessed using p for trend. Statistical significance was determined for two-tailed p-values below 0.05. P-values, p-values for trend, 95% confidence intervals (CIs), and aORs were reported as indicated. Sample weights were adjusted to account for selection probability, survey non-response, post-stratification, and trimming of extreme weights. These data were analyzed using STATA® version 18 for Windows (StataCorp LLC, College Station, TX, USA) and R Statistical Software version 4.2.1 for Windows (R Core Team).

Results

Demographic characteristics of the study population

Table 2 summarizes the general characteristics of the study population. The total number of participants was 78,815 (50.1% female). Approximately two out of three participants were between 19 and 61 years of age. The majority of participants resided in urban areas (83.7%). Education year groups (9 or fewer years, 10–12 years, and 13 or more years) comprised similarly between 30 and 40%. A higher proportion of participants belonged to the upper household income quartiles (3Q 30.2%, 4Q 30.2%), and the proportion of current smokers at the

Table 2 General characteristics of the study population ($n=78,815$)

Sociodemographic factors		Total n	Total weighted %(95%CI)
Age groups (years)	≤ 12	11,588	11.5(11.3–11.8)
	13–18	4,916	7.0(6.8–7.3)
	19–61	42,719	64.8(64.5–65.2)
	62–64	3,570	3.6(3.4–3.7)
	≥ 65	16,022	13.0(12.8–13.3)
Sex	Men	35,578	49.9(49.5–50.3)
	Women	43,237	50.1(49.7–50.5)
Region	City	64,012	83.7(83.4–84.0)
	Rural	14,803	16.3(16.0-16.6)
Education (years)	≤ 9	36,251	37.7(37.3–38.1)
	10–12	20,928	30.8(30.4–31.2)
	≥ 13	21,428	31.5(31.1–31.9)
Household income	1Q	13,300	14.2(14.0-14.5)
	2Q	19,966	25.4(25.0-25.7)
	3Q	22,593	30.2(29.8–30.6)
	4Q	22,520	30.2(29.8–30.6)
Smoking(adults)	No	49,992	76.7(76.3–77.2)
	Yes	11,817	23.3(22.8–23.7)
Eat Out Frequency (per week)	≥ 3	38,009	60.1(59.7–60.5)
	≤ 2	31,028	39.9(39.5–40.3)
Walk Outside (per week)	≤ 2	22,298	32.8(32.4–33.2)
	≥ 3	43,303	67.2(66.8–67.6)
Psychological stress	Low	60,969	72.4(71.9–72.8)
	High	17,846	27.6(27.2–28.1)
Not prioritized groups of influenza vaccine			
Age 19–64, no diseases, no pregnant		38,327	57.6(57.1–58.1)
Prioritized groups of influenza vaccine			
Age(years)	≤ 18	16,504	18.6(18.3–18.9)
	≥ 65	16,022	13.0(12.8–13.3)
Current pregnant		279	0.4(0.3–0.4)
Age 19–64 with diseases		7,683	10.4(10.2–10.7)
Diseases type	Malignancies	1,264	15.3(14.4–16.2)
	Kidney diseases	2,207	27.9(26.8–29.1)
	Heart diseases	881	10.5(9.7–11.3)
	Lung diseases	2,574	36.1(34.8–37.4)
	Liver diseases	766	10.2(9.4–11.0)

Heart diseases: coronary heart disease, angina, myocardial infarction, stroke

Kidney diseases: chronic renal disease, diabetes mellitus

Lung diseases: bronchial asthma, tuberculosis

Liver diseases: chronic hepatitis, liver cirrhosis

1Q-4Q; 1Q=lowest quartile, 4Q=highest quartile, aOR: adjusted odds ratio, 95% CI: 95% confidence interval

investigation was 23.3%. Also, 60.1% ate out three or more times a week, 32.8% walked outside two or fewer times a week, and 27.6% reported high levels of stress. Furthermore, four prioritized groups of influenza vaccine were examined. Children aged 18 or less, adults aged 65 or more, pregnant women, and adults aged 19–64 with chronic diseases constituted 18.6%, 13.0%, 0.4%, and 10.4%, respectively.

Trends in vaccination coverages among the different age groups

Figure 1 presents the trend in influenza vaccination coverages in South Korea over the 11-year period from 2010 to 2021. Influenza vaccination uptakes of children aged 0–13 years exhibited steep increases after the start of free vaccination in the years 2017, 2018, and 2020. Adults aged 65 and older, who had received free vaccination since 2005, presented a gradual increase in vaccination uptake until 2019. However, after the COVID-19 pandemic, it decreased conversely and remained low in 2021. In contrast, the influenza vaccination uptake in adults aged 19–61 gradually increased from 2010 and also comparably increased after the COVID-19 pandemic.

Table 3 compares the influenza vaccination uptakes between the two periods: pre-COVID-19 (year 2018 and 2019) and post-COVID-19 (year 2020 and 2021). Compared to pre-COVID-19, the influenza vaccination uptake in adults aged 19–61 increased in the post-COVID-19 period, with odds ratios of 1.29(1.11–1.50) and 1.38(1.26–1.50) for those without or with chronic diseases, respectively. In free vaccination groups, vaccination uptake in children increased highly, and those in older adults and pregnant women decreased or equivocally changed.

In addition, the influenza vaccination uptakes of the total population during 1st year (2020) and 2nd year (2021) of the COVID-19 pandemic were compared. Influenza vaccination uptake in total was higher in 2020 than in pre-COVID-19 years (46.9% and 43.1%, respectively), and higher in 2021 than in 2020 (50.0% and 46.9%, respectively). The increase in influenza vaccination uptake in 2021 was mostly driven by people who were not eligible for free vaccination. In particular, vaccination uptake in adults aged 19–61 with chronic diseases was notably increased from 31.2 to 36.9% in 2021. Detailed results are presented in Additional file 1: Table S1.

Influenza vaccine uptakes in population without free vaccination during pre- and post-COVID-19 periods

Table 4 presents the influenza vaccination uptakes in adults without free vaccination support during pre- and post-COVID-19 periods. The adjusted odds ratios were not significantly different from each other subgroup in most of the variables, however, the lowest household income subgroup presented a different pattern of change compared to the other household income subgroups with an adjusted odds ratio of 0.67 (95% CI 0.49–0.91, $p=0.011$).

Furthermore, the aOR ratios among the subgroups were calculated from the interaction terms between the COVID-19 period and other predictor variables. Compared to the subgroup with the lowest household income, the odds ratios for influenza vaccination were

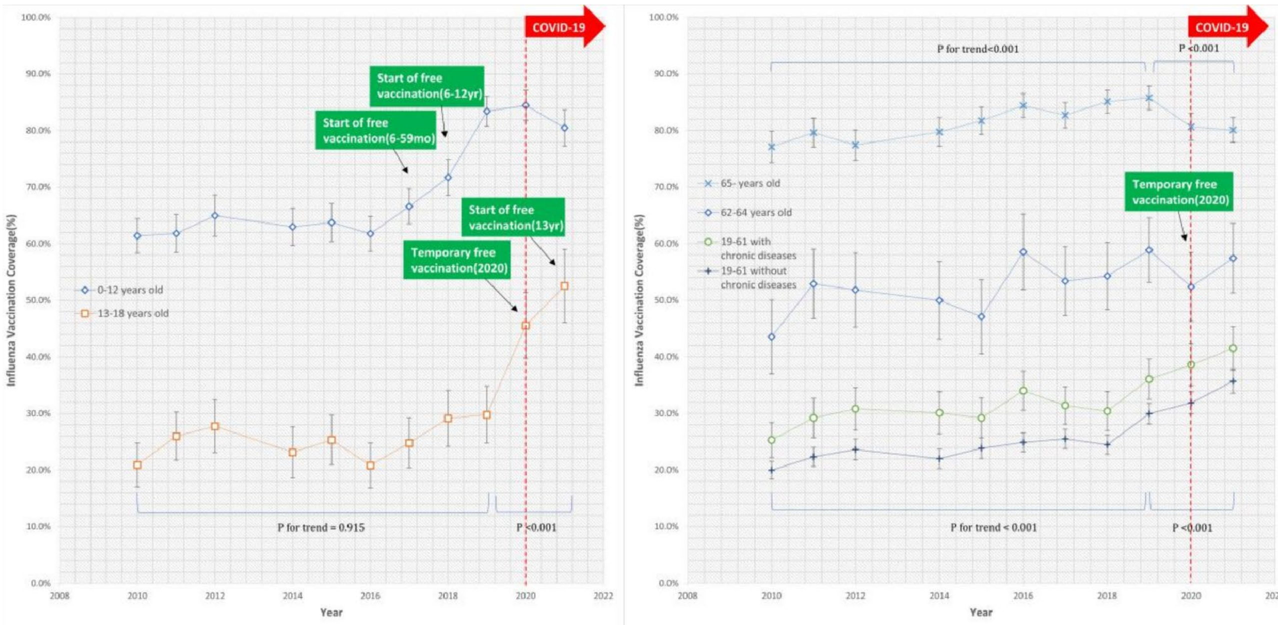

Fig. 1 Trends of influenza vaccination coverages in South Korea during 2010–2021

Table 3 Comparison of Influenza vaccination coverage between pre- and post-covid-19 pandemic

		Pre Covid-19 (2018–2019)		Post Covid-19 (2020–2021)		
		weighted IVC(95%CI)	OR	weighted IVC(95%CI)	OR	*p*-value
Total		43.1(42.1–44.0)	1 (ref.)	48.5(47.5–49.5)	1.24(1.19–1.30)	**0.000**
Free vaccination group						
Age(years)	≤ 12	77.5(75.4–79.6)	1 (ref.)	82.5(80.4–84.6)	1.37(1.16–1.61)	**0.000**
	13–18	29.5(25.9–33.0)	1 (ref.)	49.0(44.6–53.3)	2.30(1.86–2.84)	**0.000**
	62–64	56.7(52.6–60.8)	1 (ref.)	55.0(50.6–59.3)	0.93(0.75–1.15)	0.516
	≥ 65	85.4(84.0-86.9)	1 (ref.)	80.4(78.7–82.0)	0.70(0.61–0.80)	**0.000**
Currently pregnant		61.7(46.2–77.1)	1 (ref.)	53.8(29.2–78.4)	0.72(0.29–1.96)	0.524
Unsupported group						
Age 19–61 without chronic diseases		34.6(31.9–37.3)	1 (ref.)	40.5(37.5–43.6)	1.29(1.11–1.50)	**0.001**
Age 19–61 with chronic diseases		27.3(26.0-28.7)	1 (ref.)	34.1(32.5–35.8)	1.38(1.26–1.50)	**0.000**

IVC: influenza vaccination coverage (proportions vaccinated), OR: odds ratio

p-values were obtained by chi-square test

approximately two times higher in the other subgroups during the post-COVID-19 period. Figure 2 demonstrates this difference in changes in influenza vaccination uptakes before and after the COVID-19 outbreak, by household income quartile.

Additionally, the same regression analysis was performed only in adults aged 19–61 with chronic diseases, who are the priority target of influenza vaccination (Additional file 1: Table S2). A similar two-fold discrepancy among household income quartiles was observed. Also, the subgroup of adults aged 50–61 also exhibited a weaker response compared to the subgroup of adults aged 19–49. We also analyzed data comparing 2020 and 2021, observing similar numerical increase among the four household income groups (Additional file 1: Tables S3). No specific variable was associated with a paradoxical decrease during this period, yet individuals in rural areas exhibited a greater increase in uptake than those in urban areas (aOR ratio 1.47, 95% CI 1.02–2.13).

Factors related to decreased influenza vaccination response in the lowest household income quartile during the post-COVID-19 period

We further performed regression analyses only in the lowest household income quartile subgroup, to identify the factors related to the exceptional decrease in influenza vaccination uptake. The patterns of influenza vaccination uptake change were different by education year: vaccination uptake numerically decreased in the higher education year subgroup (24.6–16.5%), whereas it numerically increased in the lower education year subgroup (33.9–36.8%), and the aOR ratio was 0.41 (95% CI

Table 4 Multivariable regression analysis in adults aged 19–61

		Pre Covid-19 (2018–2019)		Post Covid-19 (2020–2021)			aOR ratio**	*p*-value2**
		weighted IVC(95%CI)	aOR*	weighted IVC(95%CI)	aOR*	*p*-value1*		
Total		28.3(27.1–29.4)	1 (ref.)	35.2(33.9–36.4)	1.36(1.25–1.47)	0.000	-	-
Sociodemographic factors								
Age groups (years)	19–49	26.7(25.3–28.1)	1 (ref.)	33.9(32.2–35.6)	1.43(1.30–1.58)	0.000	1 (ref.)	-
	50–61	31.4(29.2–33.6)	1 (ref.)	36.1(33.7–38.6)	1.17(1.06–1.29)	0.002	0.82(0.68–0.99)	0.037
Sex	Men	24.1(22.4–25.8)	1 (ref.)	28.9(26.9–30.8)	1.29(1.14–1.45)	0.000	1 (ref.)	-
	Women	32.2(30.6–33.9)	1 (ref.)	40.5(38.6–42.5)	1.41(1.25–1.59)	0.000	1.11(0.93–1.33)	0.232
Smoking	No	30.2(28.8–31.6)	1 (ref.)	37.3(35.7–39.0)	1.38(1.26–1.51)	0.000	1 (ref.)	-
	Yes	21.9(19.5–24.2)	1 (ref.)	25.9(23.1–28.7)	1.25(1.14–1.38)	0.000	0.91(0.74–1.12)	0.368
Region	City	28.0(26.7–29.2)	1 (ref.)	34.3(32.8–35.9)	1.34(1.23–1.46)	0.000	1 (ref.)	-
	Rural	29.1(25.8–32.4)	1 (ref.)	36.1(32.4–39.8)	1.44(1.32–1.56)	0.000	1.07(0.84–1.37)	0.572
Education (years)	≤ 9	33.5(29.4–37.5)	1 (ref.)	40.9(35.7–46.1)	1.65(1.22–2.22)	0.001	1 (ref.)	-
	10–12	24.7(22.9–26.6)	1 (ref.)	32.5(30.4–34.7)	1.49(1.11–2.01)	0.009	0.91(0.66–1.25)	0.550
	≥ 13	29.8(28.1–31.5)	1 (ref.)	35.3(33.3–37.2)	1.19(0.88–1.61)	0.247	0.72(0.52-1.00)	0.052
Income	**1Q**	**26.3(22.3–30.3)**	1 (ref.)	**19.6(15.8–23.3)**	**0.67(0.49–0.91)**	**0.011**	1 (ref.)	-
	2Q	26.9(24.4–29.3)	1 (ref.)	32.9(29.9–36.0)	1.32(0.96–1.80)	0.086	**1.98(1.39–2.82)**	**0.000**
	3Q	27.0(24.9–29.1)	1 (ref.)	33.9(31.5–36.4)	1.38(1.01–1.89)	0.044	**2.07(1.47–2.92)**	**0.000**
	4Q	30.1(28.1–32.1)	1 (ref.)	38.9(36.6–41.2)	1.56(1.14–2.13)	0.006	**2.34(1.66–3.29)**	**0.000**
Chronic diseases	0	26.6(25.2–27.9)	1 (ref.)	33.2(31.6–34.8)	1.35(1.23–1.48)	0.000	1 (ref.)	-
	1+	33.9(31.2–36.6)	1 (ref.)	39.3(36.3–42.3)	1.34(1.23–1.47)	0.000	1.00(0.82–1.21)	0.970
Eat Out Frequency	≥ 3	26.9(25.5–28.3)	1 (ref.)	33.7(31.9–35.5)	1.37(1.24–1.51)	0.000	1 (ref.)	-
(per week)	≤ 2	30.8(28.7–33.0)	1 (ref.)	35.9(33.7–38.1)	1.31(1.19–1.45)	0.000	0.96(0.81–1.14)	0.653
Walk Outside	≤ 2	27.6(25.6–29.7)	1 (ref.)	33.1(30.7–35.5)	1.30(1.13–1.49)	0.000	1 (ref.)	-
(per week)	≥ 3	28.3(26.8–29.7)	1 (ref.)	35.3(33.5–37.0)	1.38(1.20–1.58)	0.000	1.06(0.90–1.26)	0.479
Stress	Low	28.3(26.9–29.7)	1 (ref.)	34.2(32.5–35.9)	1.31(1.19–1.44)	0.000	1 (ref.)	-
	High	27.6(25.4–29.8)	1 (ref.)	35.4(32.8–38.0)	1.44(1.31–1.59)	0.000	1.10(0.93–1.31)	0.272

1Q-4Q; 1Q: lowest quartile, 4Q: highest quartile, aOR: adjusted odds ratio, 95% CI: 95% confidence interval

IVC: influenza vaccination coverage (propotions vaccinated)

Model: Vaccination status ~ covid-19 period + age + gender + smoking + region + education + income + chronic diseases + eat out frequency + walk outside + stress + covid-19 period * age + covid-19 period * sex + covid-19 period * smoking + covid-19 period * region + covid-19 period * education + covid-19 period * income + covid-19 period * chronic diseases + covid-19 period * eat out frequency + covid-19 period * walk outside + covid-19 period * stress

*aORs of COVID-19 period in each subgroup were obtained from weighted sum of coefficients of COVID-19 period and all interaction terms except the interaction term of the subgroup itself, which was fully added or excluded by the subgroup's class. Standard errors were calculated by square root of the weighted sum of their covariances

**aOR ratios were obtained from the coefficients of the interaction terms

0.17–0.98, $p=0.046$). Otherwise, the results were statistically inconclusive due to a relatively low number of respondents in the lowest household income quartile ($n=1090$). The full analysis result is presented in Additional file 1: Table S4.

We additionally compared the influenza vaccine uptake by the employment status of the household, divided as 'all unemployed', 'part-time or self-employed', or 'at least one full-time employed'. In adults aged 19–61, the numbers of respondents in the three employment status subgroups were similar between pre- and post-COVID-19 periods, and influenza vaccination uptakes increased similarly among the three subgroups. However, in the lowest household income subgroup, the proportion of full-time employed households largely decreased in the post-COVID-19 period. Although it was challenging to statistically conclude due to a low number of respondents, the influenza vaccination uptake in 'all unemployed' subgroup decreased (aOR 0.50, 95% CI 0.32–0.80) whereas that in 'part-time or self-employed' subgroup stayed similar (aOR 1.00, 95% CI 0.63–1.59). Detailed result is provided in Additional file 1: Table S5.

Discussion

This study effectively examined the impact of sociodemographic and behavioral factors on the change in influenza vaccine uptake during the COVID-19 pandemic using KNHANES data. The lowest household income quartile was related to a weak response to influenza vaccination increment during the COVID-19 pandemic, while the other factors did not present significant differences.

A noticeable decline in influenza vaccination coverages among adults aged 65 or older is evident during COVID-19 pandemic, as illustrated in Fig. 1 and summarized in Table 3. According to our previous studies, it was attributed to the conflict between receiving influenza

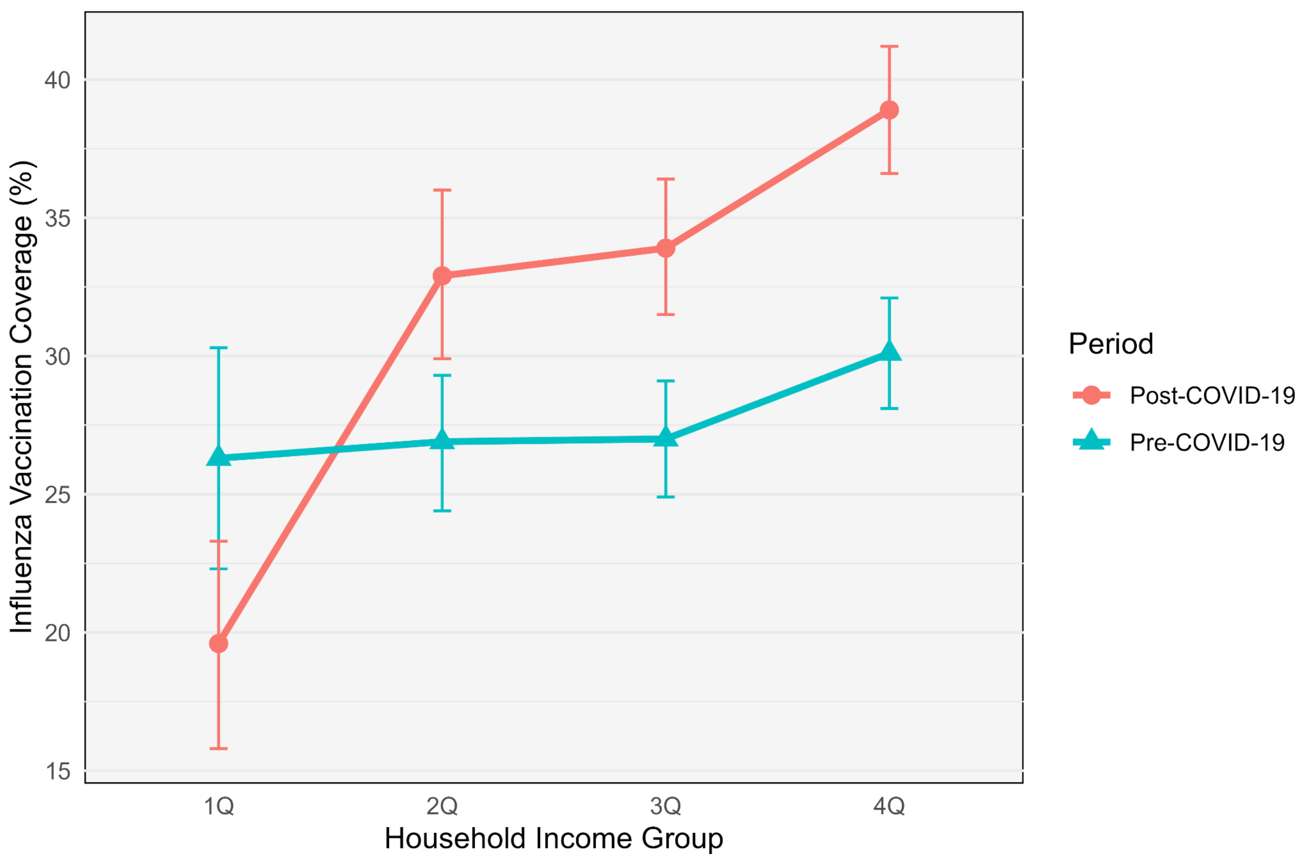

Fig. 2 Adjusted influenza vaccination coverage in adults aged 19–61 (% with 95% CIs) by household income quartile

vaccinations in crowded South Korean hospitals and the imperative for social distancing to curb COVID-19 transmission, especially among older adults [9]. In addition, the vaccination uptake in Korean adults aged 65 or older was already high before the COVID-19 outbreak, which was about 84% [19].

Other free vaccination targets such as adults aged 62–64 and pregnant women also exhibited numerical decreases in influenza vaccination uptakes, despite the recent introduction to the free influenza vaccination (from 2019 for pregnant women, and adults aged 62–64 in 2020). However, in 2021, their vaccination uptakes were recovered to the pre-COVID-19 levels. It can be speculated that the initial decreases in 2020 were attributed to similar risk-reducing behaviors against the COVID-19 outbreak, and they seemed to play a more significant role in determining the influenza vaccination behavior than free vaccination policy, especially in these two delicate groups compared to younger and non-pregnant people.

Influenza vaccination uptake in adults without free vaccination support increased moderately in the post-COVID-19 period. This response exhibited similarly in specific prioritized subgroups, such as adults with chronic diseases or adults aged 50 or older. All regression analyses demonstrated the absolute and relative decrease of influenza vaccine uptake in the lowest household income subgroup compared to higher income subgroups. As these groups are not covered by the national vaccination program, they had to get the flu vaccine at their own expense. In South Korea, the flu vaccine was not covered by health insurance, and its price was about $20 to $30 on average in 2020 [20]. Although the price was not extremely expensive, it appears to have been a financial burden in relatively poor households. Therefore, while COVID-19 has had a positive influence on flu vaccination, it is likely that the actual increase in uptake has been driven by those who were capable and willing to cover vaccination costs.

There are several study results suggested that COVID-19 affected more negatively to socioeconomically vulnerable populations and worsened economic inequality [21, 22, 23]. In South Korea, income inequality did not appear to worsen in 2020 owing to the existed income maintenance system and disaster relief fund [24, 25]. However, while income inequality was numerically similar, we can glimpse that households of lower income's actual financial ability to consume healthcare services was weakened during the COVID-19 pandemic through this study result.

We included several behavioral variables such as eating out frequency, walking out frequency, and psychological stress level expecting that they could be a bridge to explain the behavioral aspect underlying influenza vaccination. However, the data presented no definite relationship among them. In the lowest-income households, there was a correlation between high education level and larger decrease in influenza vaccination uptake. There are several research findings suggest that higher education levels may increase vaccination hesitancy in some settings [26, 27, 28]. However, it is intriguing that in this study, such results are particularly pronounced in the low-income households. It can be speculated that several vaccine hesitancy factors associated with educational level such as health literacy had combined effect with financial barrier on influenza vaccination in this population. Unemployment was also found to be associated with reduced influenza vaccination in low-income households, which also implies the increased financial burden for vaccine uptake and the limited role of the income maintenance system during the post-COVID-19 years.

The initiation of COVID-19 vaccination in 2021 may have influenced the vaccination behaviors. In Korea, the COVID-19 vaccination program began on February 26th, 2021, targeting specific high-risk population, and was extended to the general population in August 2021 [29, 30]. Since the survey data in this study was collected evenly throughout the year, some responses likely reflected the influenza vaccination during the 2021–2022 season. The observed increase in influenza vaccination uptake in 2021 compared to 2020 may be partially attributed to the COVID-19 vaccination program. This program naturally exposed individuals to healthcare facilities, where they may have received advice to also get vaccinated against influenza. Although simultaneous administration of COVID-19 and influenza vaccines was permitted, it was not explicitly recommended to ensure smooth monitoring of adverse reactions to the COVID-19 vaccine—only 0.46% of influenza vaccine recipients received both vaccines simultaneously during the 2021–2022 season [31, 32]. Nonetheless, policies such as sequential vaccination campaigns and increased exposure to healthcare messaging from medical professionals may have positively influenced influenza vaccination uptake. According to KDCA data, the vaccination rate among adults aged 65 and older rose from 77.4% in the 2020–2021 season to 80.5% in the 2021–2022 season [18]. In our study, the increase was more pronounced among individuals with chronic diseases in unsupported groups, suggesting that this population may have been more responsive to behavioral changes due to their comorbidities than healthy individuals. Additionally, no significant income-based disparities were observed in the increase in vaccination uptake during this period.

Free vaccination has been especially powerful in South Korea to achieve high vaccination uptake in prioritized groups. In respiratory pandemic situations such as COVID-19, the cost-effectiveness of influenza vaccination becomes much higher than usual, and accomplishing a sufficient level of vaccination uptake in the working age population becomes also important. Furthermore, they still include a significant number of priority targets of influenza vaccination who are currently not financially supported for vaccination, such as people with chronic diseases, immunocompromised, and middle-aged adults. Therefore, we must consider the economic inequality in response to pandemic situations and its influence on influenza vaccination to effectively distribute government finances. Moreover, solid and specific supporting system and policies focusing on influenza vaccination seems to be needed other than general financial support to cope with the respiratory pandemic. Last but not least, the current scope of free influenza vaccination must be expanded at least in the unsupported prioritized groups to mitigate the underlying income-based vaccination inequality. Among adults without free vaccination support, adults aged 50–64 accounted for about the two-third (63.8%) of people with chronic diseases in post-COVID-19 years. Therefore, gradually lowering the age limit of free vaccination would be one of the simplest and most effective approaches to assist the remaining high-risk groups for influenza.

The study has several limitations. First, the generalization issue is present because the study only collected data from South Korea. Differences in geographical and sociocultural backgrounds such as accessibility to healthcare facilities, level of stay-at-home orders during the pandemic, price of flu vaccine, and psychological hesitancy are all related to vaccination, and the influence can vary from one country to another. Second, subgroup analysis in the lowest income quartile group was statistically inconclusive because relatively lower number of people in that subgroup participated in the survey. Third, the KNHANES data did not obtain the data about the vaccination intention. We estimated this indirectly from the vaccination uptakes and other behavioral factors, however, it could not fully represent the actual individuals' intention for vaccination. Lastly, as the survey used in this study did not include COVID-19 vaccination-related questions or other COVID-19-specific factors, we were unable to directly analyze their influence on our findings.

Conclusions

The identified income-based disparities in influenza vaccination uptake during the COVID-19 pandemic highlight the need for targeted strategies to address financial barriers faced by lower-income households. Public health initiatives should focus on providing accessible and affordable vaccination options, incorporating specific supporting systems including subsidies for vaccination or outreach programs tailored to lower-income households. Ultimately, the pivotal step in addressing these disparities is the expansion of free vaccination within prioritized groups, ensuring that cost is not an obstacle to achieving widespread coverage and promoting community resilience.

Abbreviations

aOR	Adjusted Odds Ratio
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
KDCA	Korea Disease Control and Prevention Agency
KNHANES	Korea National Health and Nutrition Examination Survey
OR	Odds Ratio

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-024-21254-6.

Additional file 1: Supplementary Tables

Additional file 2: Coefficients, standard errors, and covariance matrix of multivariable regression models in Table 4, S2, S3, S4, and S5

Acknowledgements
Not applicable.

Author contributions
MY, JS, and JL contributed to the conceptualization of the study, the design of the methodology, data acquisition, and interpretation with statistical analysis of the data. MY was involved in implementation of computer code and writing the original draft. All authors participated in the thorough review and editing process of the manuscript.

Funding
The authors received no specific funding for this work.

Data availability
This research utilized the dataset from the Korean National Health and Nutrition Examination Survey (KNHANES), administered by the Korea Disease Control and Prevention Agency (KDCA). Access to the KNHANES dataset for research purposes is provided to authorized individuals. Authorization process and requests for the raw dataset can be completed at the KDCA website (https://knhanes.kdca.go.kr/knhanes/eng/index.do).

Declarations

Ethics approval and consent to participate
This study was approved by the institutional review board of Seoul National University Hospital (IRB no. E-2311-008-1480) and utilized national survey data for which all participants provided written informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 18 February 2024 / Accepted: 30 December 2024
Published online: 06 January 2025

References

1. Schmid P, Rauber D, Betsch C, Lidolt G, Denker ML. Barriers of Influenza Vaccination Intention and behavior - A systematic review of Influenza Vaccine Hesitancy, 2005–2016. PLoS ONE. 2017;12(1):e0170550. https://doi.org/10.1371/journal.pone.0170550.
2. Troiano G, Nardi A. Vaccine hesitancy in the era of COVID-19. Public Health. 2021;194:245–51. https://doi.org/10.1016/j.puhe.2021.02.025.
3. Shon EJ, Lee L. Effects of Vaccine Literacy, Health beliefs, and Flu Vaccination on Perceived Physical Health Status among Under/Graduate students. Vaccines (Basel). 2023;11(4). https://doi.org/10.3390/vaccines11040765.
4. Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger J. Vaccine hesitancy: an overview. Hum Vaccin Immunother. 2013;9(8):1763–73. https://doi.org/10.4161/hv.24657.
5. Kweon S, Kim Y, Jang M-j, et al. Data Resource Profile: the Korea National Health and Nutrition Examination Survey (KNHANES). Int J Epidemiol. 2014;43(1):69–77. https://doi.org/10.1093/ije/dyt228.
6. Division of Immunization, Korea Disease Control and Prevention Agency. 2023–2024 Instruction Guidelines for Influenza National Immunization Program [in Korean]. 2023.
7. Seo J, Lim J. Trends in influenza vaccination coverage rates in South Korea from 2005 to 2014: effect of public health policies on vaccination behavior. Vaccine. 2018;36(25):3666–73. https://doi.org/10.1016/j.vaccine.2018.05.024.
8. Seo J, Lim J. The impact of free vaccination policies under the Korean Influenza National Immunization Program: Trends in influenza vaccination rates in South Korea from 2010 to 2019. PLoS ONE. 2022;17(1):e0262594. https://doi.org/10.1371/journal.pone.0262594.
9. Yeo M, Seo J, Lim J. The impact of the COVID-19 pandemic and the expansion of free vaccination policy on influenza vaccination coverage: an analysis of vaccination behavior in South Korea. PLoS ONE. 2023;18(2):e0281812. https://doi.org/10.1371/journal.pone.0281812.
10. Beard F, Hendry A, Macartney K. Influenza vaccination uptake in Australia in 2020: impact of the COVID-19 pandemic? Commun Dis Intell (2018). 2021;45. https://doi.org/10.33321/cdi.2021.45.10
11. OECD. Influenza vaccination rates (indicator). 2023. https://data.oecd.org/healthcare/influenza-vaccination-rates.htm. Accessed 01 Nov, 2023. https://doi.org/10.1787/e452582e-en
12. Bachtiger P, Adamson A, Chow JJ, Sisodia R, Quint JK, Peters NS. The impact of the COVID-19 pandemic on the Uptake of Influenza Vaccine: UK-Wide observational study. JMIR Public Health Surveill. 2021;7(4):e26734. https://doi.org/10.2196/26734.
13. McGovern I, Bogdanov A, Cappell K, Whipple S, Haag M. Influenza vaccine uptake in the United States before and during the COVID-19 pandemic. Vaccines (Basel). 2022;10(10). https://doi.org/10.3390/vaccines10101610.
14. Kuehn BM. Influenza vaccination increased during the COVID-19 pandemic. JAMA. 2021;326(24):2465. https://doi.org/10.1001/jama.2021.22390.
15. Leuchter RK, Jackson NJ, Mafi JN, Sarkisian CA. Association between Covid-19 Vaccination and Influenza Vaccination Rates. N Engl J Med. 2022;386(26):2531–2. https://doi.org/10.1056/NEJMc2204560.
16. Kong G, Lim NA, Chin YH, Ng YPM, Amin Z. Effect of COVID-19 pandemic on Influenza Vaccination Intention: a Meta-analysis and systematic review. Vaccines (Basel). 2022;10(4). https://doi.org/10.3390/vaccines10040606.
17. Korea Disease Control and Prevention Agency, About KNHANES. Nov, : Survey Overview. https://knhanes.kdca.go.kr/knhanes/eng/index.do. Accessed 03 2023.
18. Ahn S-H, Kwon SL, Song M-J, et al. The Republic of Korea National Influenza Vaccination Project: outcomes of the 2022–2023 season. Public Health Wkly Rep. 2023;16(40):1354–66. https://doi.org/10.56786/PHWR.2023.16.40.2.
19. Division of Immunization, Korea Disease Control and Prevention Agency. 2020–2021 Instruction Guidelines for Influenza National Immunization Program [in Korean]. 2020.
20. Health Insurance Review and Assessment Service. Information of Medical Expenses Uncovered by Health Insurance. 2023. https://www.hira.or.kr/npay/index.do. Accessed 03 Nov, 2023.
21. Wildman J. COVID-19 and income inequality in OECD countries. Eur J Health Econ. 2021;22(3):455–62. https://doi.org/10.1007/s10198-021-01266-4.
22. Pereira M, Oliveira AM. Poverty and food insecurity may increase as the threat of COVID-19 spreads. Public Health Nutr. 2020;23(17):3236–40. https://doi.org/10.1017/s1368980020003493.
23. Tan AX, Hinman JA, Abdel Magid HS, Nelson LM, Odden MC. Association between Income Inequality and County-Level COVID-19 cases and deaths in the US. JAMA Netw Open. 2021;4(5):e218799. https://doi.org/10.1001/jamanetworkopen.2021.8799.

24. Choi J. COVID-19 and Household Income Inequality: focused on the role of the Income Security System and Disaster Relief funds. Health Social Welf Rev. 2023;43(1):246–64. https://doi.org/10.15709/HSWR.2023.43.1.246.
25. Park KH, Lee HM, Min SH, Kang MJ, Kim SJ, Choi YS. Challenges in addressing inequality and promoting Balanced Development Post-COVID-19 Pandemic. Korea Research Institute for Human Settlements; 2022.
26. Larson HJ, Jarrett C, Eckersberger E, Smith DM, Paterson P. Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007–2012. Vaccine. 2014;32(19):2150–9. https://doi.org/10.1016/j.pcl.2022.11.003.
27. MacDonald NE. Vaccine hesitancy: definition, scope and determinants. Vaccine. 2015;33(34):4161–4. https://doi.org/10.1016/j.vaccine.2015.04.036.
28. Tarik J. Vaccine hesitancy: A growing challenge for immunization programmes. World Health Organization. 2015. https://www.who.int/en/news-room/detail/18-08-2015-vaccine-hesitancy-a-growing-challenge-for-immunization-programmes. Accessed 29 Dec, 2023.
29. Kwon SL, Oh J. COVID-19 vaccination program in South Korea: a long journey toward a new normal. Health Policy Technol. 2022;11(2):100601. https://doi.org/10.1016/j.hlpt.2022.100601.
30. Kim SY. Nationwide COVID-19 vaccination coverage and COVID-19 incidence in South Korea, January 2022: a national official report. Life Cycle. 2022;2:e2. https://doi.org/10.54724/lc.2022.e2.
31. Choi WS, Cheong HJ. Should the COVID-19 vaccine be administered simultaneously with other vaccines? Infect Chemother. 2021;53(3):589–91. https://doi.org/10.3947/ic.2021.0307.
32. Park H, Kwon S, Park J, et al. Immunization program against influenza in the Republic of Korea, 2021–2022 season. Public Health Wkly Rep. 2022;15(26):1844–49.

Publisher's note