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Factors influencing on influenza vaccination and its trends of coverage in patients with diabetes in Korea: A population-based cross-sectional study

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ABSTRACT

Background: Influenza infection is a contagious disease and annual influenza vaccination is recommended to the patients with chronic diseases. Although diabetes is an indication for influenza vaccination, the global rate of influenza vaccination is insufficient. Therefore, our study aimed to elucidate influenza vaccination statuses among patients with diabetes and the related factors in Korea.
Methods: A total of 32,268 subjects (4,540 with and 27,728 without diabetes) from the Korea National Health and Nutrition Examination Survey III–VI (2005–2015) were included. Socioeconomic factors and health-related factors were analyses for the relation of influenza vaccination by Student's *t*-test, the chi-squared test and a multivariate logistic regression analysis.
Results: The influenza vaccination coverage rates were 50.0% in the diabetes mellitus (DM) group and 38.2% in the non-DM group. The trends in influenza vaccination rates during KNHANES III–VI were not significant in each group (P trend = 0.24 in the DM group, 0.30 in the non-DM group). Socioeconomic (older age, female sex, higher family income, and medical aid insurance) and health-related factors (lack of risky alcohol consumption, obesity, and recent health check-ups) were associated with influenza vaccination among patients with DM.
Conclusions: The rate of influenza vaccination among patients with diabetes is insufficient in Korea. More efforts are needed to increase the influenza vaccination rates among vulnerable at-risk populations.
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1. Introduction

Influenza infection is a contagious disease that has caused serious public health issues worldwide [1]. Infection with the influenza virus often causes mild to severe complications, particularly in high-risk populations [2]. According to the World Health Organization, the global burden of influenza includes 3–5 million cases of severe illness and 250,000–500,000 deaths [2]. Annual influenza vaccination is considered the most effective preventive measure against infection and is recommended for elderly people, those with chronic diseases, cancer patients, immunosuppressed patients, health care workers, pregnant women, and children [2,3]. In Korea, the Ministry of Health and Welfare reported that the coverage rate of influenza vaccination has increased from 26.3% in 2009 to 31.7% in 2012 due to improvements in public awareness through national campaigns and by strengthening preventive activities by the government [4]. Another survey from Korea indicated that influenza vaccination coverage was 34.3% in the general population and 61.3% in high risk groups in 2007 [5]. In particular, the rate of elderly and children from 6 months to <12 months of age sharply increased up to 82.3% and 87.6% after a cost-free influenza vaccination program provided by the Korean government since 2015 and 2016, respectively [6,7].

Globally, diabetes mellitus (DM) is another disease with major ramifications for public health. Currently, the prevalence of diabetes in Korea has increased to 13.7% [8]. The consideration of diabetes as an indication for influenza vaccination is supported by

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evidence indicating the efficacy and cost-effectiveness of this measure for decreasing hospital admissions and mortality [9–11]. Still, the global rate of influenza vaccination is insufficient. Moreover, the following vaccination rates have been reported among diabetes patients: 61.6% in the USA, 65.7% in Spain, 53.7% in France, 27–63.3% in Turkey, 54.5% in Hong Kong, and 31–35% in Taiwan [12–17]. In Korea, only 57.2% of patients admitted to hospitals for chronic diseases and 75.8% of elderly people were vaccinated against influenza [18,19]. However, the current influenza vaccination status among Korean patients with diabetes has not been evaluated. Therefore, our study aimed to elucidate differences in influenza vaccination statuses between patients with and without diabetes and the related factors, using data collected nationwide from 2005 to 2015.

2. Methods

2.1. Study participants

The Korea National Health and Nutrition Examination Survey (KNHANES) is a cross-sectional, nationally representative survey conducted by the Korean Ministry of Health and Welfare. To date, this survey has been performed in 6 phases: KNHANES phases I (1998), II (2001), III (2005), IV (2007–2009), V (2010–2012), and VI (2013–2015) [20]. Data from 2005 to 2015 (KNHANES III, IV, V, VI) were included in this study. The KNHANES comprises a Health Interview Survey, a Health Behavior Survey, a Health Examination Survey, and a Nutrition Survey. Households were defined as sampling units and stratified, and data were collected from household registries using a multistage, probability-based sampling design based on sex, age, and geographic area. After completing this survey, participants provided written informed consent for the use of their data in further analyses and were given the right to refuse to participate in accordance with the National Health Enhancement Act.

From among the 107,498 subjects who participated in the KNHANES III–VI (2005–2015), we excluded subjects younger than 40 years and those who did not provide information about influenza vaccination and/or diabetes prevalence (n = 75,230). Subsequently, a total of 32,268 subjects (4540 with and 27,728 without diabetes) were included in the final analysis. The institutional review board of the Korea Centers for Disease Control and Prevention approved the study protocol, and all participants signed informed consent forms.

2.2. Questionnaire and anthropometric measurements

For the Health Interview Survey, a self-administered questionnaire was used to gather information about socioeconomic factors (age, sex, marital status, employment status, education level, family monthly income, residential area, and medical insurance status) and health-related factors (smoking status, alcohol consumption, physical activity, self-rated health status, other disease, influenza vaccination, and health check-up participation). The employment status was classified as "yes" or "No". The marital status was classified as "married", "single," or "divorced/separated/widowed". The education level was classified as "college or higher", "high school", "middle school", or "elementary school or lower." The household income was categorized into "low," "low middle", "middle high", and "high" quartiles. The residential area was classified as "urban" or "rural". The medical insurance status was classified as "National health insurance" and "Medicaid/none". Patients' self-rated health status was further divided into "excellent/good", "fair", and "poor/very poor" groups. Participants provided "yes" or "no" responses to questions regarding health check-ups, such as "Have you undergone a health check-up within the last 2 years?". Other diseases included angina, myocardial infarction, asthma, obstructive lung disease, restrictive lung disease, cancer (e.g., stomach, liver, colon, breast, cervix, lung, and thyroid), liver cirrhosis, and renal disease.

Smokers were classified as current, former, or non-smokers. Risky alcohol consumption was defined as ingesting more than 5 alcoholic beverages during a single occasion. Regular exercise was defined as routine walking at least five times per week for at least 30 min at a time or engaging in regular moderate (at least five times per week for at least 30 min at a time) or strenuous (at least three times per week for at least 20 min at a time) exercise, as defined by the American College of Sports Medicine Guidelines during the survey period [21]. Physical examinations were performed by trained medical staff according to standardized procedures. The body weight and height were measured to the nearest 0.1 kg and 0.1 cm, respectively, while subjects wore light indoor clothing without shoes. The body mass index (BMI) was calculated as the ratio of weight in kilograms to height in meters squared (kg/m^2).

2.3. Blood collection and biochemical analyses

For clinical chemistry assays, serum was obtained from each participant via separation from peripheral venous blood collected after a minimum fasting period of 8 h. Fasting glucose and hemoglobin (Hb) A1C levels were measured by high performance liquid chromatography on a Tosoh G8 device (Tosoh Corporation, Tokyo, Japan).

2.4. Diabetes mellitus definition and influenza vaccination status

DM was defined as a serum fasting blood glucose level ≥126 mg/dL, the use of medication (oral drug, insulin) for DM by self-reporting, and/or an HbA1C value ≥6.5% [22]. The influenza vaccination status was assessed using the question "have you received an influenza vaccination within the past 1 year?", to which the participant answered "yes" or "No". The Korean government provides free influenza vaccinations to elderly people (≥65 years) and infants 6–12 months of age. Moreover, although the indications differ slightly among self-governing areas, public health centers usually provide free influenza vaccines to disabled individuals, those with medical aid insurance, and men of national merit including national veteran honorees.

2.5. Data analysis

All sampling and weight variables used in the present study were stratified, and all statistical analyses used the SAS survey procedure to ensure appropriate estimates and standard errors. In addition, all statistical procedures used survey sample weights to produce unbiased estimates for the descriptive and analytical data analyses. Descriptive statistical methods were used to describe the basic characteristics of the study population, and numbers and percentages were reported for each variable. All clinical characteristics were compared among the participants, and Student's *t*-test and the chi-squared test were used for continuous and categorical variables, respectively. A multivariate logistic regression analysis was also used to assess the data by adjusting for age, sex, marital status, occupation, education, family income, living area, medical insurance, smoking, binge alcohol drinking, regular exercise, self-health status, HbA1C, body mass index, other disease, and health check-up. P trends were calculated for serial trends of influenza vaccination with increasing age. Student's *t*-test was used to compare the vaccination rates between participants with and without

Table 1
Clinical characteristics of study populations.

	DM[a] (n = 4540)	Non-DM[a] (n = 27,728)	P-value[b]
Socioeconomic factors			
Age (years)			<.001
40–64 years	2378 (52.4)	19,626 (70.8)	
≥65 years	2162 (47.6)	8102 (29.2)	
Sex			<.001
Men	2309 (50.9)	11,593 (41.8)	
Women	2231 (49.1)	16,135 (58.2)	
Marital status			<.001
Married	3420 (75.6)	22,429 (81.1)	
Single	69 (1.5)	458 (1.7)	
Divorced/separated/ widowed	1037 (22.9)	4780 (17.3)	
Occupation			<.001
No	2386 (52.8)	11,008 (39.9)	
Yes	2130 (47.2)	16,601 (60.1)	
Education			<.001
≦Elementary	2178 (48.2)	9718 (35.2)	
Middle school	724 (16.0)	4200 (15.2)	
High school	1052 (23.3)	8240 (29.8)	
≧College	565 (12.5)	5477 (19.8)	
Family income			<.001
Low	1519 (34.0)	6441 (23.6)	
Moderate-low	1233 (27.6)	6773 (24.8)	
Moderate-high	884 (19.8)	6783 (24.8)	
High	827 (18.5)	7332 (26.8)	
Residency			.52
Rural	1711 (37.7)	10,313 (37.2)	
Urban	2829 (62.3)	17,415 (62.8)	
Health insurance			<.001
National health insurance	3729 (93.3)	23,780 (96.4)	
Medical aid or none	267 (6.7)	890 (3.6)	
Health-related factors			
BMI (kg/m^2)	25.3 ± 0.09	23.9 ± 0.02	<.001
Fasting glucose (mg/dl)	141.9 ± 1.0	94.4 ± 0.09	<.001
HbA1C (%)	7.4 ± 0.03	5.6 ± 0.01	<.001
Smoking status			<.001
Never/past smoker	3576 (79.5)	22,668 (82.1)	
Current smoker	923 (20.5)	4943 (17.9)	
Binge drinking			.05
No	2676 (73.2)	17,444 (74.7)	
Yes	980 (26.8)	5904 (25.3)	
Regular exercise			.33
No	1560 (44.2)	9585 (43.5)	
Yes	1967 (55.8)	12,525 (56.6)	
Self-rated health			<.001
Poor	1887 (41.6)	6431 (23.2)	
Fair	1727 (38.0)	11,842 (42.7)	
Good	926 (20.4)	9449 (34.1)	
Other disease			<.001
No	3146 (69.3)	22,271 (80.3)	
Yes	1394 (30.7)	5457 (19.7)	
Health screening (recent 2 year)			<.001
No	1806 (39.8)	9312 (33.6)	
Yes	2733 (60.2)	18,402 (66.4)	
Influenza vaccination (%)	57.7%	43.3%	<.001
Duration of diabetes (year)	6.4 ± 0.4		

Alcohol consumption was indicated as 'yes' for participants who consumed at least two units of alcohol every week over the last year. Regular exercise was defined as moderate or strenuous exercise performed on a regular basis (>30 min at a time five times per week for moderate exercise; >20 min at a time five times per week for strenuous exercise) or walking >30 min at a time more than five times per week.

[a] n/weighted %.

[b] Chi-square test or student *t*-test. Abbreviations: DM, diabetes mellitus.

Table 2
Influenza vaccination coverage according to the variables in diabetes and non-diabetes group.

	DM[a] (%) (n = 4540)	Non-DM[a] (%) (n = 27,728)	P-value[b]
Overall	50.0 ± 1.0	38.2 ± 0.4	<.001
Socioeconomic factors			
Age (years)			
40–64 years	34.3 ± 1.3	28.0 ± 0.5	<.001
≥65 years	78.7 ± 1.2	77.7 ± 0.7	.31
Sex			
Men	42.6 ± 1.3	32.8 ± 0.6	<.001
Women	58.9 ± 1.5	42.8 ± 0.6	<.001
Marital status			
Married	46.8 ± 1.1	35.4 ± 0.5	<.001
Single	16.8 ± 3.3	22.6 ± 2.5	.28
Divorced/separated/widowed	64.7 ± 2.1	53.4 ± 1.0	<.001
Occupation			
No	62.0 ± 1.4	50.7 ± 0.7	<.001
Yes	38.8 ± 1.4	30.8 ± 0.5	<.001
Education			
≦Elementary	63.4 ± 1.4	58.1 ± 7.8	<.001
Middle school	42.3 ± 2.4	40.3 ± 1.1	.32
High school	40.8 ± 2.0	27.6 ± 0.7	<.001
≧College	36.3 ± 2.4	25.0 ± 0.8	<.001
Family income			
Low	62.5 ± 1.7	56.3 ± 1.0	<.001
Moderate-low	45.5 ± 2.1	37.9 ± 0.8	<.001
Moderate-high	43.3 ± 2.2	31.2 ± 0.8	<.001
High	45.1 ± 2.2	31.6 ± 0.8	<.001
Residency			
Rural	52.4 ± 1.6	43.7 ± 0.8	<.001
Urban	48.8 ± 1.3	35.3 ± 0.5	<.001
Health insurance			
National health insurance	49.1 ± 1.2	37.5 ± 0.5	<.001
Medical aid or none	55.6 ± 4.1	50.3 ± 2.3	.15
Health-related factors			
Obesity (BMI ≥ 25 kg/m^2)			
No	48.8 ± 1.4	35.6 ± 0.5	<.001
Yes	49.8 ± 1.4	35.9 ± 0.7	<.001
Smoking status			
Never/past smoker	54.5 ± 1.1	41.0 ± 0.5	<.001
Current smoker	36.7 ± 2.2	27.2 ± 0.8	<.001
Binge drinking			
No	54.6 ± 1.4	41.6 ± 0.6	<.001
Yes	32.2 ± 1.7	24.8 ± 0.7	<.001
Regular exercise			
No	49.3 ± 1.7	36.7 ± 0.7	<.001
Yes	50.4 ± 1.6	39.0 ± 0.7	<.001
Self-rated health			
Poor	57.1 ± 1.6	50.6 ± 0.9	<.001
Fair	46.0 ± 1.7	36.2 ± 0.6	<.001
Good	43.3 ± 2.1	32.3 ± 0.7	<.001
Health screening (recent 2 year)			
No	46.9 ± 1.6	32.7 ± 0.7	<.001
Yes	52.3 ± 1.4	41.0 ± 0.5	<.001
Other disease			
No	47.3 ± 1.2	35.7 ± 0.5	<.001
Yes	57.6 ± 1.7	49.8 ± 0.9	<.001
Angina, myocardial infarction	66.2 ± 3.7	63.6 ± 2.7	.46
Asthma, obstructive lung disease, restrictive lung disease	54.2 ± 2.1	44.9 ± 1.0	<.001
Cancer (e.g., stomach, liver, colon, breast, cervix, lung, and thyroid)	64.0 ± 4.0	49.0 ± 3.1	.005
Liver cirrhosis	39.3 ± 5.1	46.6 ± 5.1	.54
Renal disease	62.6 ± 5.0	49.9 ± 6.0	.25

(*continued on next page*)

Table 2 (*continued*)

	DM[a] (%) (n = 4540)	Non-DM[a] (%) (n = 27,728)	*P*-value[b]
KNHANES phases			
KNHANES3 (2005)	52.3 ± 2.9	44.3 ± 1.1	.003
KNHANES4 (2007–2009)	48.3 ± 1.7	34.8 ± 0.8	<.001
KNHANES5 (2010–2012)	50.1 ± 1.7	35.6 ± 0.7	<0.001
KNHANES6 (2013–2015)	49.5 ± 2.0	37.4 ± 0.9	<.001
P for trend	0.30	0.24	

Alcohol consumption was indicated as 'yes' for participants who consumed at least two units of alcohol every week over the last year. Regular exercise was defined as moderate or strenuous exercise performed on a regular basis (>30 min at a time five times per week for moderate exercise; >20 min at a time five times per week for strenuous exercise) or walking >30 min at a time more than five times per week.
[a] n/weighted %.
[b] Student *t*-test. Abbreviations: DM, diabetes mellitus.

DM in each KNHANES phase. All data were analyzed using SAS statistical software (version 9.2; SAS Institute, Inc., Cary, NC, USA).

3. Results

The basic characteristics of the participants (4540 and 287,728 participants with and without DM, respectively) are summarized in Table 1. Compared with the non-DM group, the DM group had higher rate of old age group (≥65 years) than middle age group (40–64 years), higher rate of men than women, a lower employment status, education level, family income, and national health insurance coverage rate than the non-DM group (P value < .001 in all). Moreover, diabetes group had significantly higher BMI, fasting glucose level, HbA1C value, current smoking rate, poor self-health status frequency and comorbidity prevalence (P value < .0 01 in all). Table 2 shows that the overall influenza vaccination coverage rates were 50.0% in the DM group and 38.2% in the non-DM group. The subgroup analysis showed that except for old age, being single, educational level of middle school, Medicaid insurance or none, cardiovascular disease, liver disease, and renal disease, the influenza vaccination rate in the diabetes group was statistically higher than in the no diabetes group . The trends in influenza vaccination rates are displayed in Fig. 1. The influenza vaccination rates were significantly higher in the DM group than those in the non-DM group across the analysis period (KNHANES III, IV, V, VI: DM group, 52.3%, 48.3%, 50.1%, 49.5%, respectively; non-DM group, 44.3%, 34.8%, 35.6%, 37.4%, respectively; P-values: .003, <.001, <.001, <.001, respectively). However, changes in the vaccination rates in each phase were not significant (P trend = 0.24 in the DM group, 0.30 in the non-DM group). Logistic regression analyses of influenza vaccination coverage in four groups (DM group < 65 years vs. DM group > 65 years, non-DM group < 65 yea rs vs. non-DM group > 65 years) are shown in Table 3. An older age and health check-up within the previous 2 years were common factors associated with influenza vaccination in all four groups. Among participants younger than 65 years, medical aid was the prominent factor associated with influenza vaccination in both the DM and non-DM groups (odds ratio [OR]: 3.24, 95% confidence interval [CI]: 1.52–6.90 and OR: 2.24, 95% CI: 1.23–4.06, respectively); in addition, a high BMI, lack of risky alcohol consumption, and a high family income level were associated with influenza vaccination among participants with DM younger than 65 years (OR: 1.05, 95% CI: 1.01–1.10; OR: 0.71, 95% CI: 0.51–0.99; and OR: 1.50, 95% CI: 1.07–2.10, respectively). Elderly women with diabetes were more likely to undergo influenza vaccination than men (OR: 1.65, 95% CI: 1.05–2.59). The influenza vaccination coverage rates by age group are presented in Fig. 1. A linear increase was observed from 40 to 64 years of age, and sharp increases from 65 to >75 years of age were observed in both the DM and non-DM groups (P trend <.001 and <.001, respectively).

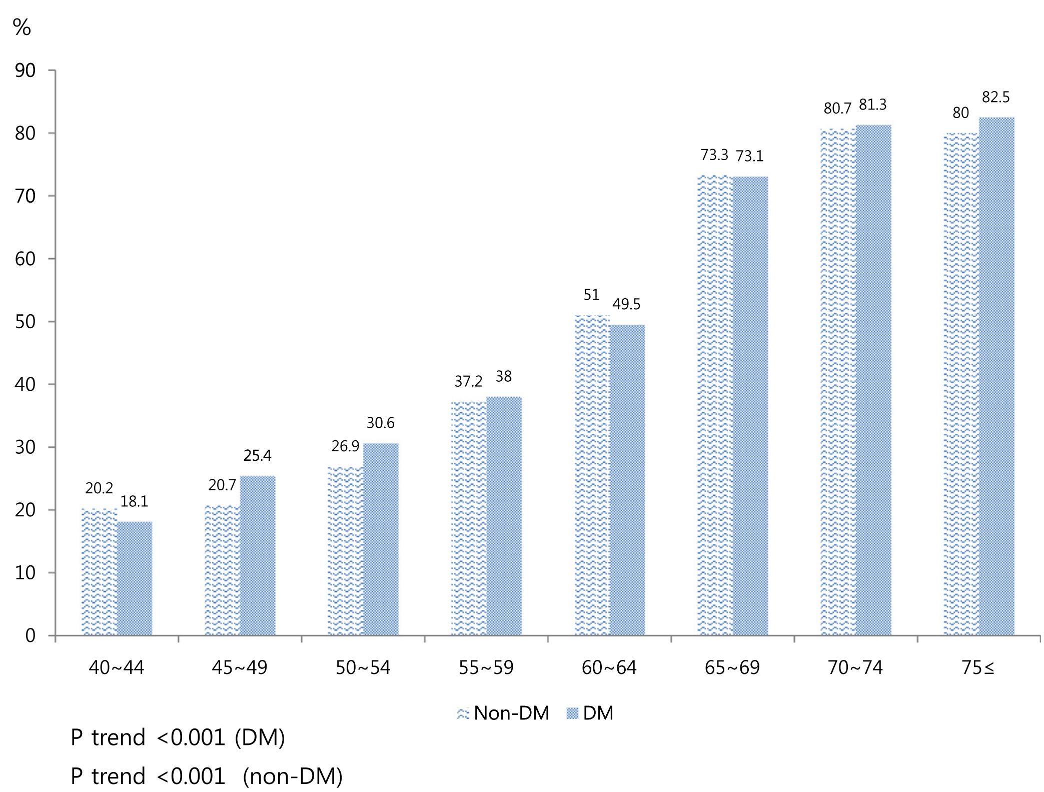

Fig. 1. Influenza vaccination coverage rate by age groups in DM and non-DM groups.

Table 3
Multivariate logistic regression analysis for influenza vaccination of DM and non-DM population.

Variables	DM				Non-DM			
	Age < 65 (N = 2378)		Age ≥ 65 (N = 2162)		Age < 65 (N = 8102)		Age ≥ 65 (N = 19,626)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Socioeconomic factors								
Age	1.09	1.06–1.12	1.05	1.01–1.09	1.04	1.02–1.06	1.06	1.02–1.10
Sex	1.28	0.87–1.88	1.65	1.05–2.59	1.20	0.95–1.50	1.00	0.65–1.53
Marital status (married vs single)	0.82	0.53–1.28	0.72	0.44–1.17	1.14	0.85–1.54	1.13	0.69–1.84
Occupation	1.07	0.76–1.48	0.79	0.51–1.21	0.86	0.71–1.06	0.74	0.52–1.05
Education	1.10	0.77–1.56	1.63	0.96–2.78	0.66	0.54–0.80	0.75	0.49–1.14
Family income	1.50	1.07–2.10	0.88	0.53–1.46	0.94	0.76–1.16	0.89	0.60–1.31
Living area (rural vs urban)	0.97	0.69–1.35	0.88	0.59–1.32	0.89	0.71–1.10	0.98	0.68–1.42
Medical insurance (NHI vs Medical aid/none)	3.24	1.52–6.90	0.55	0.28–1.07	2.24	1.23–4.06	0.81	0.33–1.99
Health- related factors								
Smoking	0.93	0.65–1.35	1.02	0.62–1.68	0.89	0.68–1.17	1.07	0.69–1.64
Binge alcohol drinking	0.71	0.51–0.99	1.23	0.70–2.18	0.79	0.61–1.03	0.68	0.43–1.08
Regular exercise	0.90	0.67–1.22	1.25	0.84–1.85	0.97	0.81–1.17	1.03	0.75–1.42
Self-health status (good vs poor)	1.24	0.90–1.70	1.08	0.74–1.59	1.00	0.80–1.24	1.17	0.80–1.69
HbA1C	0.99	0.90–1.08	0.88	0.76–1.01	1.02	0.81–1.30	1.05	0.74–1.49
Body mass index (kg/m^2)	1.05	1.01–1.10	1.02	0.96–1.08	1.01	0.98–1.04	1.05	0.99–1.12
Other disease	1.11	0.80–1.54	1.33	0.89–1.99	1.06	0.86–1.31	1.25	0.89–1.76
Health check-up	1.54	1.11–2.13	1.81	1.24–2.63	1.54	1.24–1.93	1.86	1.33–2.62

Abbreviations: DM, diabetes mellitus; OR, odds ratio; CI, confidence interval; NHI, national health insurance.

4. Discussion

Our analysis determined that the rate of influenza vaccination among Korean patients with DM was 57.7%, and the vaccination rate has not changed in recent years. Both socioeconomic (older age, female sex, higher family income, and medical aid insurance) and health-related factors (lack of risky alcohol consumption, obesity, and recent health check-ups) were associated with influenza vaccination among patients with DM in a representative national survey.

Adherence to influenza vaccination is closely related to the social economic status and availability of a universal vaccination program [23,24] and also age is the strongest determinant of influenza vaccination compliance [7]. We attribute the strong associations of old age and medical aid with influenza vaccination among both the DM and non-DM groups in our study to these factors.

However, among patients with DM who did not have access to a universal immunization program, influenza vaccination was associated with a higher family income level, suggesting the presence of social inequalities [19,25,26].

Among elderly patients with DM in our study, women were more likely than men to undergo influenza vaccination. This result corroborated the findings by Yu in a study from Taiwan [17]. In general, women are more likely to prefer a healthier lifestyle and to be more conscious about health information and disease prevention than men are; accordingly, vaccination compliance is likely to be higher among women [27,28]. However, other previous studies reported a higher influenza vaccination rate among men, which suggested either that men might be more concerned about chronic conditions or that women might be more concerned about vaccine safety [14,24]. Further studies are needed to elucidate this association.

Regarding health-related factors, healthy behaviors, including a lack of risky alcohol consumption and participation in recent health screenings, were positively associated with influenza vaccination among middle-aged patients with DM. Again, these results agreed with those reported by Yu from Taiwan, and suggest that people who are better educated about vaccination are not only more likely to participate in vaccination but also more likely to exhibit healthy behaviors [17].

Interestingly, a high BMI was also positively associated with influenza vaccination among patients with DM in our study. However, this association remains controversial, in light of previous studies. A study by Alcusky reported there were no significant BMI-related differences in influenza vaccination rates in a US cohort [29]. A recent meta-analysis found that obese people were more likely to undergo influenza vaccination, than those with normal weights (OR: 1.11, 95% CI 0.97–1.25) [30]. Several hypotheses might explain this result. First, obese people tend to exhibit more concern about their health. Second, obese patients with DM are more likely to experience uncontrolled blood glucose levels, leading to more frequent hospitalization and additional opportunities for physicians to recommend vaccination. Third, recent studies have suggested that obesity people might be more likely to contract an influenza infection; accordingly, the need for or awareness of influenza vaccination might higher among this population than that among non-obese people [31,32].

In our analysis of trends in Korean influenza vaccination rates, we observed no obvious changes from 2005 to 2015 in either diabetic or non-diabetic participants. Furthermore, the differences in influenza vaccination rates did not differ significantly between diabetic and non-diabetic participants according to age groups.

Previous studies have shown that a lack of knowledge regarding the effectiveness of vaccination, concerns about vaccine safety, the economic burdens faced by patients with DM, and physicians' indifference or forgetfulness regarding preventive measures during routine visits of diabetic patients can result in poor compliance among patients and unsatisfactory improvements in vaccination rates [13,15,17,18]. Several strategies have been suggested to enhance the influenza vaccination uptake: first, awareness and educational campaigns regarding the importance and benefits of vaccination should be provided to patients with DM and medical staff members [17]. Second, alerts or tracking record systems for vaccination should be implemented to allow physicians and patients to determine the vaccination status and make or receive recommendations regarding seasonal vaccination [15,33]. Third, the efforts to expand free vaccination programs to individuals with chronic diseases should be considered. Fourth, vaccination rate-dependent incentives for physicians could be considered [34]. In summary, various approaches are needed to allocate the medical resources required to increase the uptake of influenza vaccination.

The current study has several limitations. First, the study featured a cross-sectional design, and accordingly it was difficult to identify cause-and-effect relationships. Second, the survey asked whether participants had received influenza vaccinations during the past year, and therefore might not reflect more current situations and previous vaccination histories. Third, influenza vaccination receipt data were collected via self-reports, which may have introduced a recall bias. Fourth, the KNHANES does not include people admitted to a hospital or nursing home and does not consider diabetes severity, which might be closely associated with risky health behaviors. Furthermore, the information of diabetes type (Type 1 or 2) was not differentiated in our study; therefore, the analysis may have included a larger proportion of individuals with relatively mild diabetes. Despite these limitations, to our knowledge, this is the first study to evaluate current and recent trends in influenza vaccination among Korean patients with DM from a nationally representative database.

In the USA, the Healthy People 2020 initiative has set a target influenza vaccination rate of up to 90% among high-risk adults, and the European Union Council has recommended influenza vaccination rates of up to 75% among at-risk populations [35,36]. Recently, the Korean government has expanded the free influenza vaccination program to include all infants, children, and elderly people. More efforts are needed to increase the influenza vaccination rates among vulnerable at-risk populations, and these should involve setting target goals, increasing awareness of the benefits of vaccination, and providing strategic programs to minimize influenza infection.

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Conflicts of interest

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Author contribution

HY Shin, HJ Hwang, JH Chung and TH Kim made substantial contributions to conception, design, and development of methodology, and HY Shin and TH Kim did acquisition of data, analysis and interpretation of data. HY Shin wrote the manuscript and then, HJ Hwang and TH Kim reviewed and revised it together. HY Shin and JH Chung did administrative, technical, or material support, and HJ Hwang and TH Kim supervised all the study process.

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