



# Longitudinal Study of Diabetic Differences between International Migrants and Natives among the Asian Population

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## Abstract

Migration presents a substantial social and public health issue. However, it is unclear whether diabetes is worse among Asian migrants than natives of South Korea over time. This longitudinal study investigated the nationwide population, including 2,680,495 adults aged 20 years and older (987,214 Asian migrants and 1,693,281 natives), who received health check-ups, using the Korean National Health Insurance Service data (2009-2015). Joinpoint regression was used to estimate the annual percentage change of diabetes, and multivariable logistic regression was used to examine differences in incident type 2 diabetes between Asian migrants and natives adjusting for age, sex, economic status, body mass index, smoking status, any alcohol use, and physical activity. The age-adjusted prevalence of diabetes increased among native men (from 8.8% in 2009 to 9.7% in 2015, APC=1.64,  $p<0.05$ ) compared to Asian migrant men, and the age-adjusted prevalence of diabetes increased among native women (from 6.0% in 2009 to 6.7% in 2015, APC=1.88,  $p<0.05$ ) compared to Asian migrant women. In the multivariate analyses, Asian migrants were less likely to get type 2 diabetes than natives (odds ratio, 0.82; 95% CI, 0.78 to 0.86) between the first and last health check-ups. However, the odds ratio for developing type 2 diabetes was 1.15 (95% CI, 1.10 to 1.20) among low-income levels compared to high-income levels, regardless of whether they were Asian migrants or natives. The results could help to establish a new strategy for prevention, treatment, and management of diabetes among the Asian population.

**Key Words:** Diabetes, Asian migrant, Native, South Korea, National Health Insurance Service data

## INTRODUCTION

In recent years, the number of international migrants has reached 258 million; this has resulted in an important set of social and public health problems (Abubakar *et al.*, 2018). Moreover, Asia and Europe have more than 60% of all international migrants, comprising 80 million and 78 million, respectively (United Nation, 2018). Of 258 million international migrants, 106 million are Asian-born, and a report from the International Labor Organization estimates that 164 million international migrants are labor workers (International Labor Organization, 2015). However, most international migrant workers, from low-income and middle-income countries to high-income countries, have poor living and working conditions in the host country, with labor situations likely to be particularly harmful, especially in low income settings (Abubakar *et al.*, 2018). As a result, it is necessary to improve the healthcare and welfare

system among international migrants worldwide.

In South Korea, 1.9 million international migrants, representing 3.7% of the total population, were reported to be staying in 2015 (Ministry of Justice, 2016). Among the international migrants in South Korea, China accounts for 50.3%, including Korean-Chinese. Following China, other international migrants are from the United States (7.3%), Vietnam (7.2%), Thailand (4.9%), Philippines (2.9%), and Japan (2.5%). In addition, the majority of the international migrants are labor workers in South Korea; therefore, meeting the health care and treatment needs among international migrants, especially in low-income migrant workers in South Korea, will improve global health equity.

Diabetes is increasing throughout the world, including Asia and South Korea, and the prevention, treatment, and management of diabetes is needed to reduce the global burden (Rhee, 2015; NCD Risk Factor Collaboration (NCD-RisC),

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2016; Noh, 2016). In addition, the management of adults with type 2 diabetes by lifestyle modification, social support, and medication adherence is important to reduce the risk of cardiovascular problems and other complications (Osborn *et al.*, 2010; Mayberry and Osborn, 2012). However, it is unclear how diabetes among international migrants and natives may

have changed over time within the Asian population. Furthermore, it is also important to analyze the determinants of type 2 diabetes among international migrants and natives, especially in Asians, to provide basic evidence for targeting high risk groups, as well as to improve policy development.

The current study aimed to investigate the annual preva-

**Table 1.** Characteristics of Asian migrant and native population aged 20 years and older who received health check-ups, from 2009 to 2015\*

Variable	Year						
	2009	2010	2011	2012	2013	2014	2015
Asian migrant, n	93,845	113,414	129,827	132,226	142,275	175,082	200,545
Age (years, %)							
20-44	88.0	85.5	81.6	75.1	72.4	71.4	66.2
45-64	11.5	13.9	17.8	23.8	26.4	26.9	31.4
≥65	0.5	0.6	0.6	1.1	1.2	1.7	2.4
Sex (%)							
Men	80.5	78.7	76.7	72.4	71.3	70.8	68.3
Women	19.5	21.3	23.3	27.6	28.7	29.2	31.7
Economic status (%)							
1st quartile (low)	54.4	52.4	40.8	34.1	32.3	27.2	26.0
2nd quartile	38.9	39.9	48.2	50.0	50.3	52.2	49.7
3rd quartile	4.6	5.4	8.6	13.1	14.5	17.6	21.1
4th quartile (high)	2.1	2.3	2.4	2.8	2.9	3.0	3.2
Body mass index (kg/m <sup>2</sup> )	22.9 ± 3.0	23.0 ± 3.0	23.1 ± 3.1	23.1 ± 3.1	23.1 ± 3.1	23.3 ± 3.2	23.4 ± 3.2
Smoking status (%)							
Ex-smoker	4.6	4.9	5.3	5.7	6.0	6.5	7.6
Current smoker	32.8	32.6	32.1	31.3	31.0	29.9	27.6
Any alcohol use (%)	43.9	45.0	44.7	43.0	43.0	43.1	42.6
Physical activity (%)	36.9	38.8	40.4	41.7	42.9	46.4	49.6
Obesity (%)	22.3	23.5	24.6	25.2	25.6	27.5	28.9
Hypertension (%)	9.7	9.4	10.0	11.1	11.3	11.7	12.8
Diabetes (%)	3.1	3.3	3.5	4.0	4.1	4.4	4.7
Hypercholesterolemia (%)	7.9	8.4	8.3	8.2	8.2	8.4	8.8
Native, n	208,772	231,881	236,751	244,443	243,592	261,680	266,162
Age (years, %)							
20-44	44.7	43.8	43.6	42.0	42.1	40.5	39.2
45-64	42.0	43.2	43.3	44.4	43.6	45.0	45.9
≥65	13.3	13.0	13.1	13.6	14.3	14.5	14.9
Sex							
Men	54.5	54.3	54.1	53.9	53.8	53.6	53.1
Women	45.5	45.7	45.9	46.1	46.2	46.4	46.9
Economic status (%)							
1st quartile (low)	15.0	14.0	15.8	13.7	15.2	14.0	15.5
2nd quartile	26.7	25.4	26.5	24.6	25.4	25.5	25.0
3rd quartile	21.6	21.7	21.3	21.6	21.7	21.1	21.3
4th quartile (high)	36.7	38.9	36.4	40.1	37.7	39.4	38.2
Body mass index (kg/m <sup>2</sup> )	23.7 ± 3.2	23.7 ± 7.3	23.8 ± 3.3	23.8 ± 3.3	23.8 ± 3.3	23.8 ± 3.4	24.0 ± 3.4
Smoking status (%)							
Ex-smoker	14.6	15.5	15.6	15.9	15.9	16.6	18.0
Current smoker	26.0	24.9	25.1	24.2	24.4	23.3	21.5
Any alcohol use (%)	49.1	48.9	49.3	48.9	49.6	49.9	50.1
Physical activity (%)	62.0	63.8	65.0	66.0	67.4	69.1	70.2
Obesity (%)	32.9	33.0	33.4	33.4	33.9	34.1	35.6
Hypertension (%)	24.4	24.6	25.1	25.5	25.4	25.4	25.4
Diabetes (%)	8.9	8.9	9.1	9.4	9.8	10.1	10.4
Hypercholesterolemia (%)	11.2	11.0	10.9	11.2	11.4	11.2	11.8

\*Data are expressed as the means ± SD, or %.

lence trends of diabetes among Asian migrants and natives from 2009 to 2015 in South Korea. We also aimed to examine differences between Asian migrants and natives in developing type 2 diabetes among the nationwide population. The results of this study can help to understand the recent trends of diabetes and suggest potential strategies to prevent, treat and manage diabetes for Asians.

## MATERIALS AND METHODS

### Study design and data collection

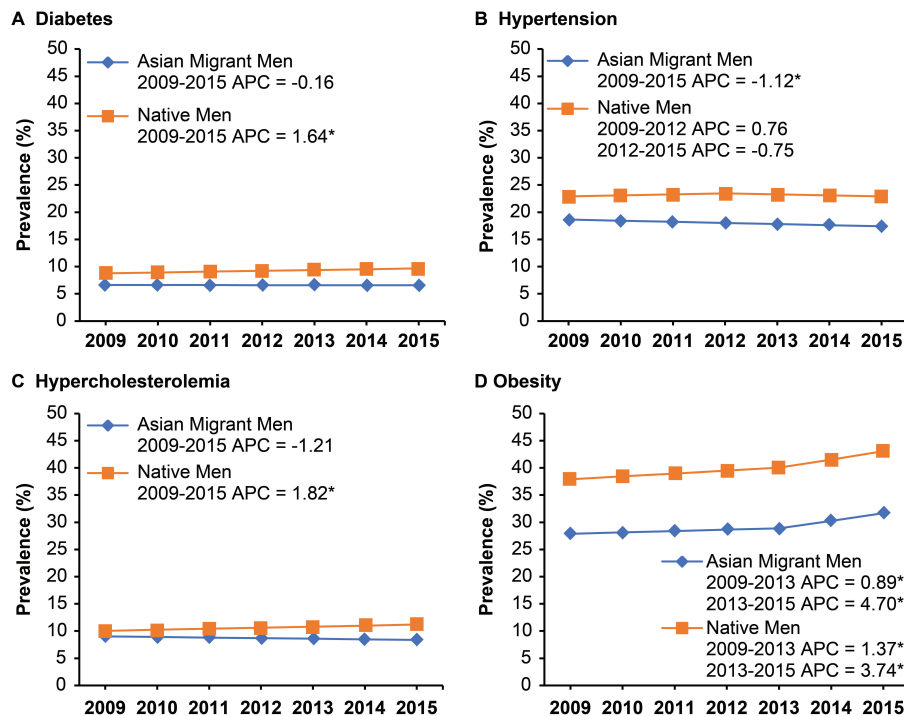
We conducted a population-based case ascertainment among Asian migrants and natives aged 20 years old and older who received health check-ups from 2009-2015, using the National Health Insurance Service (NHIS) data in South Korea. The health check-up database of the NHIS and its data configuration process for the diabetic research can refer to published context (Song *et al.*, 2014; Lee *et al.*, 2016; Seong *et al.*, 2016). Moreover, the health check-up database among the native population was obtained from a sample cohort of 1 million, which represents the nationwide population in South Korea (Lee *et al.*, 2017). In our study, Asian migrants were from China, Japan, Vietnam, Philippines, Indonesia, Thailand, Uzbekistan, Sri Lanka, Mongolia, Bangladesh, Pakistan, and India. The Institutional Review Board of the Seoul National University Hospital approved the study.

Age, sex, and monthly insurance premium were included in the collected data by the NHIS, and the insurance premium was determined by income levels in South Korea (Lee *et al.*,

2015). In our study, monthly insurance premium was used to indicate economic status, and economic status (first, second, third, and fourth quartiles) was also regarded as vital statistics representing income levels (low, middle-low, high-middle, and high, respectively). The health check-up participation data was obtained from the health check-up database of the NHIS. According to the information in the health questionnaires, participants were categorized as non-smoker, ex-smoker, or current smoker, as any alcohol use  $\geq 1$  time/week (yes), or  $< 1$  time/week (no), and as physical activity  $\geq 3$  times/week (yes), or  $< 3$  times/week (no). Measurements of weight, height, and blood pressure were included in the physical exams, and we calculated body mass index (BMI) as weight (kg) divided by the square of height (m). Obesity was defined as a BMI  $\geq 25$  kg/m<sup>2</sup>. Hypertension was defined as blood pressure  $\geq 140/90$  mm Hg, a record of a diagnosis of hypertension, or prescription of antihypertensive drugs in the health questionnaires. Furthermore, total cholesterol and fasting blood glucose were included in the laboratory tests, and hypercholesterolemia was defined as total cholesterol  $\geq 240$  mg/dL.

### Study outcomes

The primary outcome of this study was the prevalence of diabetes; diabetes was defined as a fasting blood glucose  $\geq 126$  mg/dL, previous diabetes diagnosis, or prescription of antidiabetic drugs in the health questionnaires. The secondary outcome was incident type 2 diabetes; for ascertainment of type 2 diabetes, we excluded participants with diabetes at the first check-ups. Incident type 2 diabetes was determined for each participant between the first and last health check-ups.



**Fig. 1.** Age-adjusted prevalence of health status estimates among Asian migrant and native men. The prevalence of the health status was assessed in men aged 20 years and older, among the Asian migrant and native population from 2009 to 2015, in South Korea. Health status estimates included (A) diabetes, (B) hypertension, (C) hypercholesterolemia, and (D) obesity. \**p* for the Annual Percentage Change (APC)  $< 0.05$ .

## Statistical analysis

We conduct two sets of analyses. For the primary analyses, we conducted Joinpoint regression in order to estimate the annual percentage change (APC) of the age-adjusted prevalence of diabetes in men and women among Asian migrants and natives from 2009 to 2015 in South Korea. Additionally, we estimated the APC of the age-adjusted prevalence of hypertension, hypercholesterolemia, obesity, lifestyle factors, and economic status. The age-adjusted prevalence was calculated separately by sex using direct standardization, while the age groups consisted of those 20-44, 45-64, and  $\geq 65$  years. Prevalence was defined as the number of participants with cases that existed in a given year/number of participants in the population who received a health check-up during this period. The Korean mid-year population in 2005 was used as the standard population.

In order to examine the differences between Asian migrants and natives in developing type 2 diabetes, we conducted multivariable logistic regression analysis and adjusted for the following covariates: age (continuous, years), sex, economic status, BMI (continuous, kg/m<sup>2</sup>), smoking status, any alcohol use, and physical activity. For the second analysis, we explored the adjusted odds ratios (aORs) and 95% confidence intervals (CIs) of the incident type 2 diabetes determinants between the first and last health check-ups.

All analyses were performed using the Joinpoint Regression Program, version 4.6.0 (National Cancer Institute, Rockville, MD, USA) and SAS, version 9.3 (SAS Institute Inc., Cary, NC, USA), and  $p < 0.05$  was considered statistically significant.

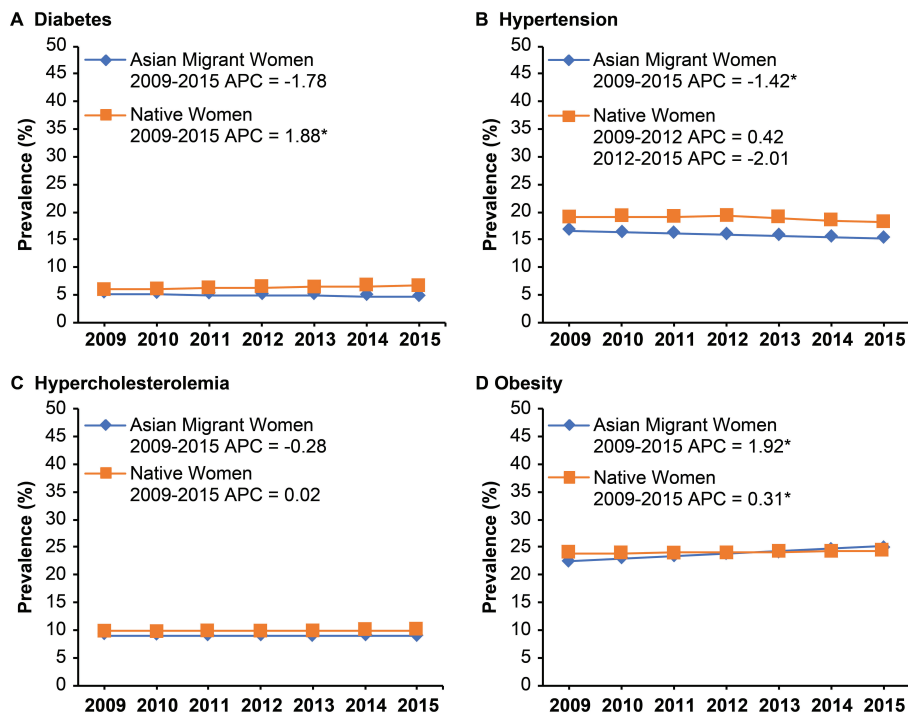
## RESULTS

### Study population

This longitudinal study investigated the nationwide population of South Korea (2,680,495 adults). From 2009-2015, a total of 987,214 Asian migrants aged 20 years and older who received health check-ups were identified in South Korea. In addition, 1,693,281 natives aged 20 years and older who received health check-ups from the national 1 million sample cohort were also identified. The characteristics of Asian migrants and natives based on the 1-year moving averages are shown in Table 1.

### Health status among Asian migrant and the native population

The age-adjusted prevalence of diabetes increased among native men (from 8.8% in 2009 to 9.7% in 2015, APC=1.64,  $p < 0.05$ ) compared to Asian migrant men. However, the age-adjusted prevalence of hypertension decreased among Asian migrant men (from 18.6% in 2009 to 17.4% in 2015, APC=-1.12,  $p < 0.05$ ) compared to native men. In addition, the age-adjusted prevalence of hypercholesterolemia increased among native men (from 10.0% in 2009 to 11.2% in 2015, APC=1.82,  $p < 0.05$ ), compared to Asian migrant men. Moreover, increasing prevalence trends of obesity were shown among Asian migrant men (from 27.9% in 2009 to 28.9% in 2013, APC=0.89,  $p < 0.05$ ; from 28.9% in 2013 to 31.7% in 2015, APC=4.70,  $p < 0.05$ ) and native men (from 37.9% in 2009 to 40.0% in 2013, APC=1.37,  $p < 0.05$ ; from 40.0% in 2013 to 43.1% in 2015, APC=3.74,  $p < 0.05$ ) (Fig. 1).



**Fig. 2.** Age-adjusted prevalence of health status estimates among Asian migrant and native women. The prevalence of the health status was assessed in women aged 20 years and older, among Asian migrant and native population from 2009 to 2015, in South Korea. Health status estimates included (A) diabetes, (B) hypertension, (C) hypercholesterolemia, and (D) obesity. \* $p$  for the Annual Percentage Change (APC)  $< 0.05$ .



The age-adjusted prevalence of diabetes increased among native women (from 6.0% in 2009 to 6.7% in 2015, APC=1.88,  $p<0.05$ ) compared to Asian migrant women. However, the age-adjusted prevalence of hypertension decreased among Asian migrant women (from 16.7% in 2009 to 15.3% in 2015, APC=-1.42,  $p<0.05$ ) compared to native women. In addition, increasing prevalence trends of obesity were shown among Asian migrant women (from 22.5% in 2009 to 25.2% in 2015, APC=1.92,  $p<0.05$ ) and native women (from 23.9% in 2009 to 24.3% in 2015, APC=0.31,  $p<0.05$ ). Moreover, the age-adjusted prevalence of obesity among Asian migrant and native women in 2014 was 24.7% and 24.2%, respectively (Fig. 2).

### Lifestyle factors and socioeconomic situation among Asian migrant and the native population

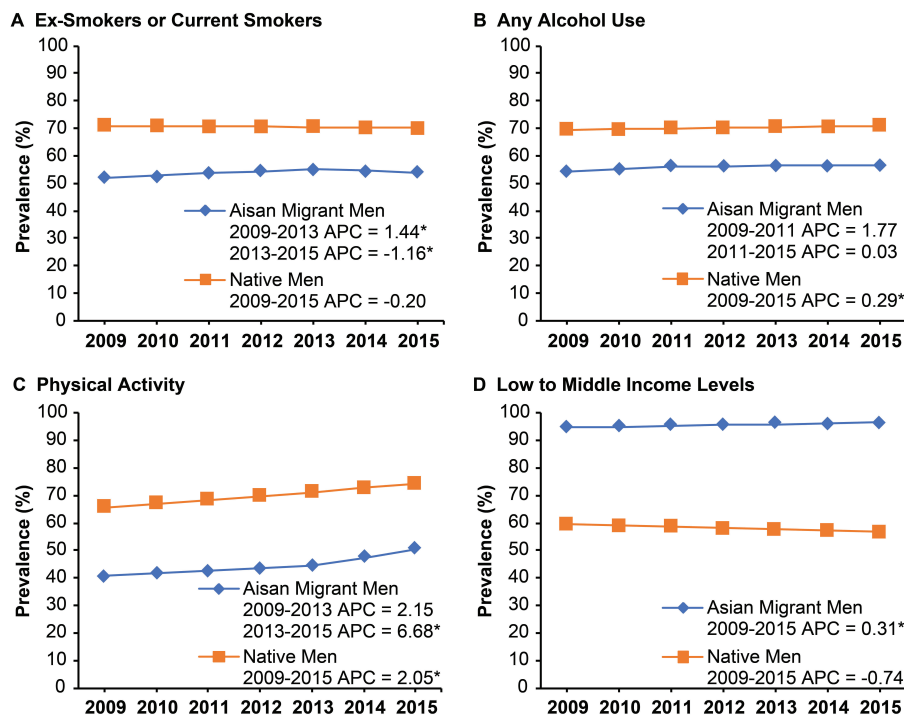
From 2009 to 2013, the age-adjusted prevalence of ex-smokers or current smokers increased among Asian migrant men (52.1% in 2009 and 55.1% in 2013, APC=1.44,  $p<0.05$ ) compared to native men. However, the age-adjusted prevalence of ex-smokers or current smokers among Asian migrant men has decreased since 2013 (55.1% in 2013 and 53.9% in 2015, APC=-1.16,  $p<0.05$ ). In addition, the age-adjusted prevalence of any alcohol use increased among native men (from 69.6% in 2009 to 70.8% in 2015, APC=0.29,  $p<0.05$ ) compared to Asian migrant men. Moreover, the age-adjusted prevalence of physical activity increased among Asian migrant men (from 44.4% in 2013 to 50.6% in 2015, APC=6.68,  $p<0.05$ ) and native men (from 65.7% in 2009 to 74.2% in 2015, APC=2.05,  $p<0.05$ ). Furthermore, the age-adjusted prevalence of low to middle income levels increased among

Asian migrant men (from 94.7% in 2009 to 96.5% in 2015, APC=0.31,  $p<0.05$ ) compared to native men. Among native men, the age-adjusted prevalence of low to middle income levels in 2009 and 2015 was 59.4% and 56.8%, respectively (Fig. 3).

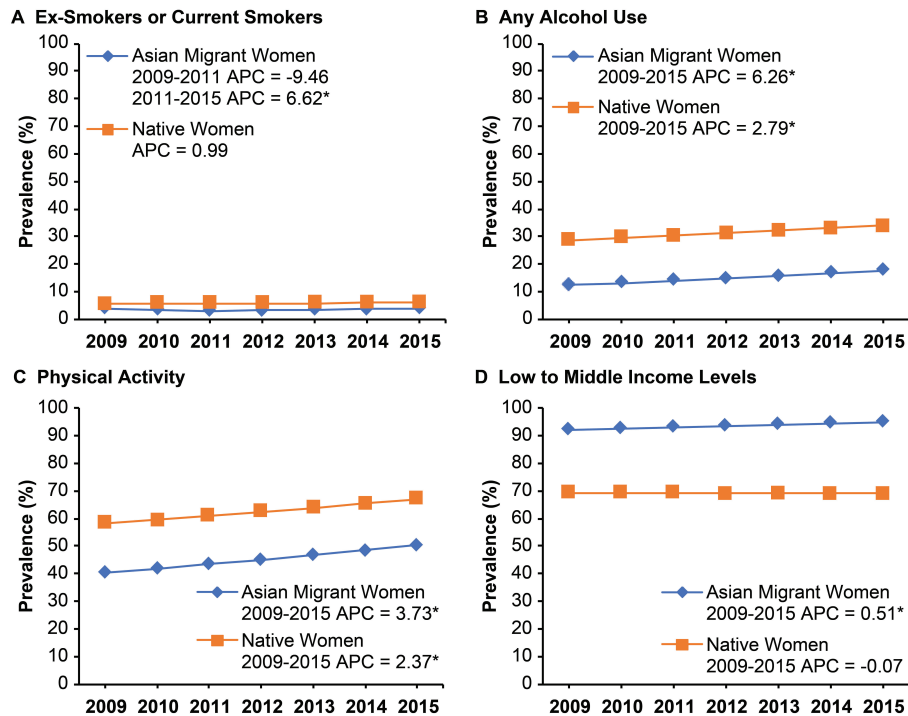
The age-adjusted prevalence of ex-smokers or current smokers among Asian migrant women has increased since 2011 (3.0% in 2011 to 3.9% in 2015, APC=6.62,  $p<0.05$ ) compared to native women. In addition, the age-adjusted prevalence of any alcohol use increased among Asian migrant women (from 12.4% in 2009 to 17.8% in 2015, APC=6.26,  $p<0.05$ ) and native women (from 28.8% in 2009 to 33.9% in 2015, APC=2.79,  $p<0.05$ ). Moreover, the age-adjusted prevalence of physical activity increased among Asian migrant women (from 40.4% in 2009 to 50.3% in 2015, APC=3.73,  $p<0.05$ ) and native women (from 58.2% in 2009 to 67.0% in 2015, APC=2.37,  $p<0.05$ ). Furthermore, the age-adjusted prevalence of low to middle income levels increased among Asian migrant women (from 92.1% in 2009 to 95.0% in 2015, APC=0.51,  $p<0.05$ ) compared to native women. Among native women, the age-adjusted prevalence of low to middle income levels in 2009 and 2015 was 69.3% and 69.1%, respectively (Fig. 4).

### Determinants of incident type 2 diabetes

From 2009-2015, the number of participants who received health check-ups more than once and had diabetic information was 505,342, and the number of participants with incident type 2 diabetes between the first and last health check-up was 22,284. In the multivariable logistic regression model, Asian



**Fig. 3.** Age-adjusted prevalence of lifestyle factors and socioeconomic situation estimates among Asian migrant and native men. The prevalence of lifestyle factors and socioeconomic situation was assessed in men aged 20 years and older, among the Asian migrant and native population from 2009 to 2015, in South Korea. Lifestyle factors and socioeconomic situation estimates included (A) smoking, (B) alcohol, (C) physical activity, and (D) economic status. \* $p$  for the Annual Percentage Change (APC)  $<0.05$ .



**Fig. 4.** Age-adjusted prevalence of lifestyle factors and socioeconomic situation estimates among Asian migrant and native women. The prevalence of lifestyle factors and socioeconomic situation was assessed in women aged 20 years and older, among the Asian migrant and native population from 2009 to 2015, in South Korea. Lifestyle factors and socioeconomic situation estimates included (A) smoking, (B) alcohol, (C) physical activity, and (D) economic status. \* $p$  for the Annual Percentage Change (APC) <0.05.

migrants were less likely to get type 2 diabetes than natives (aOR, 0.82; 95% CI, 0.78 to 0.86) after adjustment for covariates. However, the aORs for developing type 2 diabetes were 1.15 (95% CI, 1.10 to 1.20) among low-income levels, 1.14 (95% CI, 1.10 to 1.18) among middle-low income levels, and 1.09 (95% CI, 1.05 to 1.14) among high-middle income levels, compared to high-income levels, regardless of whether they were Asian migrants or natives. In addition, older age, men, higher BMI, smoking status, alcohol consumption, and physical inactivity were also associated with an increasing risk of type 2 diabetes (Fig. 5, 6).

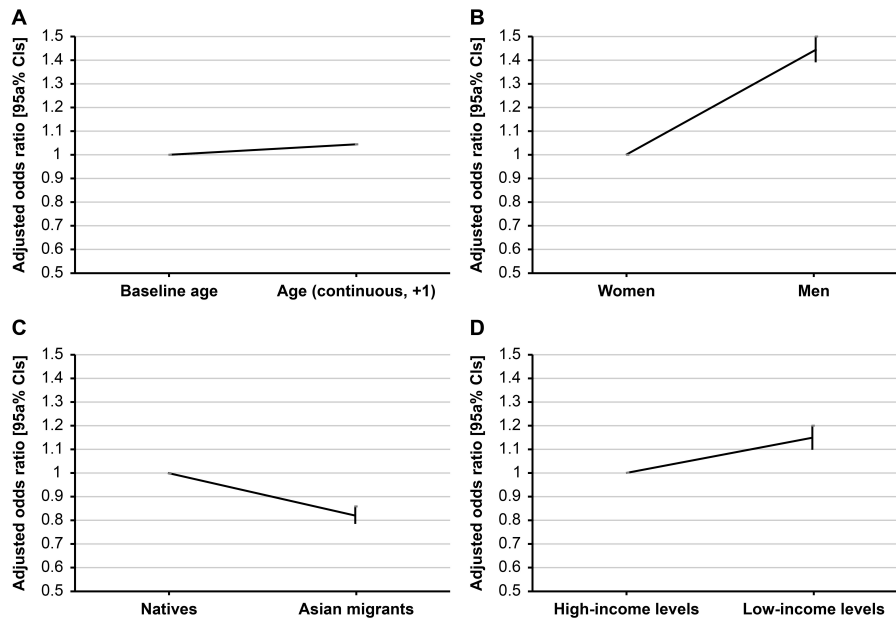
## DISCUSSION

From 2009-2015, we found that the age-adjusted prevalence of diabetes, hypertension, hypercholesterolemia, ex-smokers or current smokers, and any alcohol use were lower among the majority of Asian migrants than natives in South Korea, regardless of whether they were male or female. Although most of the Asian migrant men also had less obesity than native men from 2009 to 2015, since 2014, obesity has become more common among Asian migrant women compared to native women. However, we estimated that the majority of the Asian migrants were healthier than natives. In South Korea, in both men and women, the age-adjusted prevalence of diabetes among natives showed a significant increase from 2009-2015 compared to Asian migrants. These results are consistent with a recent systematic review and meta-analysis on migration health that shows that interna-

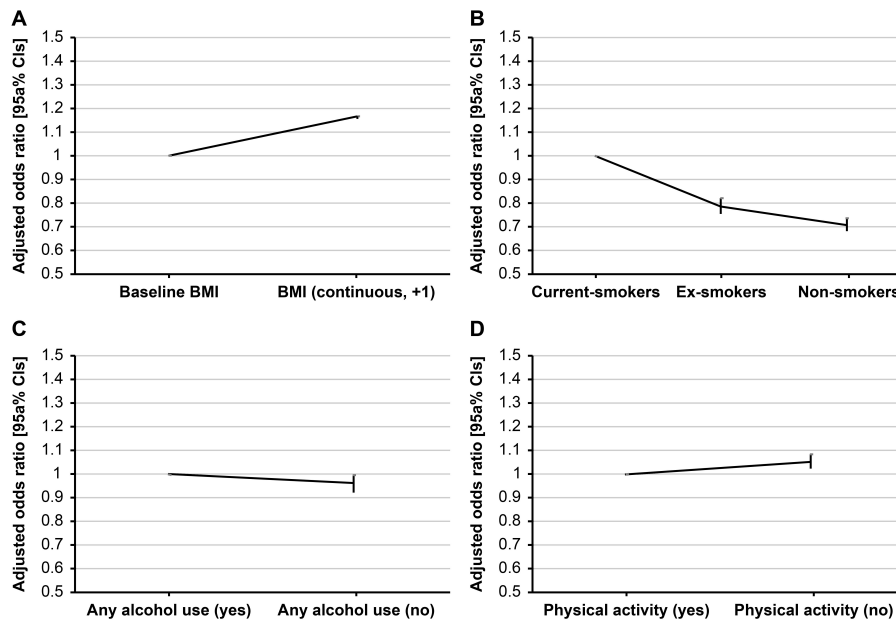
tional migrants who were studying, working, or who had joined family members in high-income countries had lower mortality of diabetes compared to natives in destination countries (Aldridge *et al.*, 2018). However, another study found that the incidence of diabetes among migrants from Africa, Asia, and the Middle East was 2.5 times higher than Natives in Denmark (Andersen *et al.*, 2016).

An accumulating body of evidence indicates that genetic, epigenetic, and lifestyle factors interacting with each other and operating within the larger physical-sociocultural environment can play important role in the pathophysiology of type 2 diabetes, especially for Asians (Zheng *et al.*, 2018). In addition, although clinical measurements, including age, BMI, fasting levels of glucose, and dyslipidemia, are more important for clinical prediction, genetic variants might help clarify the pathogenesis of type 2 diabetes (Zheng *et al.*, 2018). In the USA, Asian migrants are more likely to have type 2 diabetes than natives, even those with a considerably lower BMI (Lee *et al.*, 2011). This finding could be attributed to differences between Asians and Whites with respect to fat distributions, body fat percentage, and abdominal adiposity (Deurenberg *et al.*, 2002; Chan *et al.*, 2009; Kong *et al.*, 2013). However, in this large-scale longitudinal study, after adjustment for covariates, Asian migrants were less likely to get type 2 diabetes than natives in South Korea. Moreover, we also found that the likelihood of developing type 2 diabetes was associated with older age, men, lower income levels, higher BMI, smoking status, alcohol consumption, and physical inactivity regardless of whether they were Asian migrants or natives.

Although genetic variants have only a modest effect on the



**Fig. 5.** The aORs and 95% CIs of incident type 2 diabetes between the first and last health check-ups. (A) In age (continuous, +1 year) versus baseline age (continuous, years) adjusting for sex, nationality, economic status, BMI (continuous, kg/m<sup>2</sup>), smoking status, any alcohol use, and physical activity. (B) In men versus women for age (continuous, years), nationality, economic status, BMI (continuous, kg/m<sup>2</sup>), smoking status, any alcohol use, and physical activity. (C) In Asian migrants versus natives adjusting for age (continuous, years), sex, economic status, BMI (continuous, kg/m<sup>2</sup>), smoking status, any alcohol use, and physical activity. (D) In low-income levels versus high-income levels adjusting for age (continuous, years), sex, nationality, BMI (continuous, kg/m<sup>2</sup>), smoking status, any alcohol use, and physical activity.



**Fig. 6.** The aORs and 95% CIs of incident type 2 diabetes between the first and last health check-ups. (A) In BMI (continuous, +1 kg/m<sup>2</sup>) versus baseline BMI (continuous, kg/m<sup>2</sup>) adjusting for age (continuous, years), sex, nationality, economic status, smoking status, any alcohol use, and physical activity. (B) In smoking status adjusting for age (continuous, years), sex, nationality, economic status, BMI (continuous, kg/m<sup>2</sup>), any alcohol use, and physical activity. (C) In any alcohol use (no versus yes) adjusting for age (continuous, years), sex, nationality, economic status, BMI (continuous, kg/m<sup>2</sup>), smoking status, and physical activity. (D) In physical activity (no versus yes) adjusting for age (continuous, years), sex, nationality, economic status, BMI (continuous, kg/m<sup>2</sup>), smoking status, and any alcohol use.

pathophysiology of type 2 diabetes (through  $\beta$ -cell dysfunction and insulin resistance [Stumvoll *et al.*, 2005; Fuchsberger *et al.*, 2016]), a genetic predisposition towards type 2 diabetes might be a little stronger among South Korean natives than the majority of Asian migrants within the gene-environment interaction. Therefore, natives might be more susceptible to type 2 diabetes than most of the Asian migrants in South Korea. A recent study has shown that 72% of South Koreans had medium or high genetic risk scores for impaired insulin secretion by  $\beta$ -cell dysfunction, and the risk of type 2 diabetes was aggravated when gene factors interacted with a low carbohydrate Western-style diet (Kim *et al.*, 2018). In addition, due to dramatically changing diet habits over the past 2 or 3 decades in South Korea (Ley *et al.*, 2014), a mismatch of nutritional environments between intrauterine and adulthood contributes to the increasing risk of type 2 diabetes, which can be explained by the thrifty phenotype hypothesis (Zheng *et al.*, 2018). The hypothesis suggests that permanent changes in impaired insulin secretion and insulin resistance to adapt to fetal undernutrition in early life might lead to a subsequent increased risk of type 2 diabetes, and even transgenerational risk transmission via an epigenetic process (Hales and Barker, 2001; Ong and Ozanne, 2015).

In our study, in both men and women, the problems of lower income levels, physical inactivity, and increasing obesity were associated with incident type 2 diabetes among Asian migrants, compared to natives. Among Asian migrant women, rapid increasing trends of ex-smokers or current smokers, and alcohol consumption were also related to incident type 2 diabetes. We found that the age-adjusted prevalence of low to middle income levels were much greater, and increased, among Asian migrants compared to natives in both men and women. We also estimated that health inequalities in type 2 diabetes among most of the Asian migrants, especially for low-income migrants, may be more serious than natives in South Korea. Moreover, we found that the age-adjusted prevalence of physical activity was lower among Asian migrants than natives from 2009 to 2015. In addition, the age-adjusted prevalence of obesity increased faster among Asian migrant men than native men from 2013 to 2015; and the age-adjusted prevalence of obesity increased faster among Asian migrant women than native women from 2009 to 2015, and has continued to decline since 2014. Furthermore, we found that the age-adjusted prevalence of ex-smokers or current smokers increased faster from 2011 to 2015, while the age-adjusted alcohol consumption increased faster from 2009 to 2015 among Asian migrant women compared to native women. Therefore, it is necessary to conduct a primary and secondary prevention program for type 2 diabetes among the majority of Asian migrants, especially targeting low-income migrants and migrant women.

There are several limitations in our study. First, cases of diabetes were likely undiagnosed since we only selected people who had national health insurance and who had received health check-ups. Moreover, the study population may be healthier than whole population because they pay more attention to their health and were more likely to utilize health care and access to health services. However, the increasing prevalence trends of diabetes among natives in our study are consistent with the recent study based on Korean national health and nutrition examination surveys (Lee *et al.*, 2018). In addition, underestimation of undiagnosed diabetes may be

more serious among Asian migrants than natives in our study. For example, although international migrant workers have national health insurance when employed, they may not make the most use of necessary health services, or they may not even understand that they were insured (Ang *et al.*, 2017). Second, we did not take nutritional factors into account, and for this reason, it is not possible to determine the association between nutritional factors and incident type 2 diabetes. Third, because of limited data on the type of migrant, we did not consider the migrant status factor; however, we substituted economic status for migrant status in an effort to compensate for this.

In conclusion, although Asian migrants were less likely to get type 2 diabetes than natives in South Korea, primary and secondary prevention for type 2 diabetes among the majority of Asian migrants, especially in low-income migrants and migrant women, is required. In addition, further studies are needed to understand the effect of genetic background and phenotype on the incidence of diabetes, as well as the examination of ethnic differences by nationalities between genetic, epigenetic, and lifestyle factors within various environments in order to reveal and verify possible aetiological mechanism underlying type 2 diabetes development. The results could help to establish a new strategy to develop an effective and efficient healthcare system for the prevention, treatment, and management of diabetes among the Asian population.

## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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