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& THERAPEUTICS

Comparing Non-Communicable Disease Risk Factors in Asian Migrants and Native Koreans among the Asian Population

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Abstract

Assessing the health of international migrants is crucial in the Republic of Korea, Asia, and even worldwide. We compared the risk factors for non-communicable diseases among Asian migrants in Korea and the Korean population. This cross-sectional (2015) and longitudinal (2009-2015) observational study comprised a population-wide analysis spanning 2009 to 2015. Asian migrants (n=987,214) in Korea and Korean nationals (n=1,693,281) aged ≥20 were included. The Asian migrants were classified as Chinese, Japanese, Filipino, Vietnamese, and other. The prevalence of risk factors for non-communicable diseases (current smoking, obesity, diabetes mellitus, and hypertension) were analyzed. Regarding the age-adjusted prevalence, direct age standardization was conducted separately by sex using 10-year age bands; the World Standard Population was used as the standard population. Among the participants aged ≥20, the age-adjusted prevalence of current smoking was higher among Chinese and other Asian migrant men than among Korean men and women (p<0.001 and p<0.001, respectively). The age-adjusted prevalence of obesity was higher among Chinese, Filipino, and other Asian migrant women than in Korean women (p<0.001, p=0.002, and p<0.001, respectively). Among the participants aged 20-49, the age-adjusted prevalence of diabetes mellitus and hypertension was higher in Filipino migrant women than in Korean women (p=0.009 and p<0.001, respectively). Current rates of smoking and obesity were worse among Asian migrants of specific nationalities than among native Koreans. The health inequalities among Filipino migrant women in Korea, especially those aged 20-49, should be addressed.

Key Words: Obesity, Current smoking, Asian migrant, Korean, Filipino migrant women, National database

INTRODUCTION

Recent systematic reviews and meta-analyses of migrant health have supported the Healthy Migration Hypothesis that international migrants have health advantages (Vang *et al*., 2017; Aldridge *et al*., 2018). This hypothesis states that international migrants, particularly new migrants, are healthier than the overall host country population (Vang *et al*., 2017). Although these observations could be attributed to self-selection or immigration policies (Marmot *et al*., 1984; Vang *et al*., 2017), they are inversely associated with the duration of residence in the host country (Rechel *et al*., 2013; Vang *et al*., 2017). Conversely, in Israel, a Sick Migration Effect is shown

among international migrants during the initial 20 years of residence. This implies that international migrants may also have health *disadvantages* compared with the native population in the host country (Constant *et al*., 2018).

Compared with other ethnic groups, South Asians are more likely to have diabetes mellitus (DM) and cardiovascular disease (CVD), possibly due to socioeconomic influences, the region of residence, and migration (Misra *et al*., 2017). The South Asian migrant population has a higher risk of DM than Europeans, with an average disease onset 5-10 years earlier, despite having a lower average body mass index (BMI) (Sattar and Gill, 2015). Compared with Korean natives, obesity among Asian migrants in the Republic of Korea has been in-

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creasing. Since 2014, the prevalence of obesity has increased among Asian migrant women than in Korean native women (Piao *et al*., 2020).

Few studies have involved Asian migrants (those born in an Asian country who move to another high-income East Asian country) using nationwide data (Rechel *et al*., 2013; Sattar and Gill, 2015; Aldridge *et al*., 2018). Therefore, we investigated differences in the prevalence of risk factors for non-communicable diseases (NCDs) between Asian migrants of different nationalities and the Korean population to evaluate whether there is a Healthy Migration Effect in Korea. We used high-quality health check-up data from the National Health Insurance Service (NHIS) to investigate differences in obesity, DM, and elevated blood pressure among Chinese, Filipino, and Vietnamese migrants in Korea. We compared these individuals with the general population of their home countries. Our previous study (Piao *et al*., 2020) hypothesized that Asian migrants of different nationalities have fewer NCD risk factors than native Koreans.

MATERIALS AND METHODS

Study population

We conducted an observational retrospective population-based analysis of longitudinal data. The study population constituted Asian migrants and the general Korean population aged ≥20 years who underwent health check-ups between 2009 and 2015; data were obtained from the National Health Information Database (NHID) established by the Korean NHIS (Cheol Seong *et al*., 2017; Piao *et al*., 2020). The NHID included eligibility data, national health check-up data, healthcare utilization, long-term care insurance, and health care provider information (Cheol Seong *et al*., 2017). Information on income-based insurance contributions, demographic variables, and death were included (Cheol Seong *et al*., 2017). The NHID is suitable for population-based studies aimed at the primary and secondary prevention of diseases (Song *et al*., 2014; Cheol Seong *et al*., 2017). The health check-up data for Asian migrants could be extracted from customized NHID data, representing most Asian migrants who underwent annual voluntary health check-ups in Korea (Cheol Seong *et al*., 2017; Heng, 2020). General Korean population health check-up data were obtained from a 1 million sample cohort of the NHID. We used a random sample representing 2.2% of the Korean-born population, determined to be representative of the nationwide Korean population (Lee *et al*., 2017). Since the NHID is more extensive than it appears, the NHIS conducted systematic stratified random sampling with 2.2% within each stratum for the construction of the 1 million-sample cohort, among which the target variable for sampling was the individual's total annual medical expenses (Lee *et al*., 2017). Asian migrants originated from China, Japan, Vietnam, the Philippines, Indonesia, Thailand, Uzbekistan, Sri Lanka, Mongolia, Bangladesh, Pakistan, and India. They were divided into Chinese, Japanese, Filipino, Vietnamese, and other subgroups to ensure adequate power after age standardization in 2015 (Supplementary Methods).

Among the 2,691,010 participants aged ≥20 who underwent health check-ups between 2009 and 2015, we excluded 350 who lacked information on blood pressure, fasting blood glucose, and total cholesterol levels. Furthermore, 10,165 in-

dividuals with missing information on smoking status, alcohol use, or physical inactivity were excluded. Finally, the study population of 2,680,495 participants included 987,214 Asian migrants and 1,693,281 Republic of Korea nationals (Piao *et al*., 2020). The numbers of Asian migrants by year between 2009 and 2015 were 93,845 (2009), 113,414 (2010), 129,827 (2011), 132,226 (2012), 142,275 (2013), 175,082 (2014), and 200,545 (2015). Similarly, the numbers of native Koreans by year were 208,772 (2009), 231,881 (2010), 236,751 (2011), 244,443 (2012), 243,592 (2013), 261,680 (2014), and 266,162 (2015) (Piao *et al*., 2020). In 2015, the mean (standard deviation) age (years) among Korean natives and Chinese, Japanese, Filipino, Vietnamese, and other Asian migrants was 49.4 (14.0), 46.4 (11.4), 47.4 (9.2), 32.5 (6.0), 30.3 (9.2), and 30.3 (6.3) , respectively. Women comprised 124,850 Korean natives (46.9%), 47,808 Chinese (47.2%), 3,171 Japanese (71.3%), 2,347 Filipino (19.7%), 5,600 Vietnamese (29.1%), and 4,648 other (7.3%) (Table 1).

Measurements

The health check-up participation data were obtained from the NHIS Health Check-Up Database. The age, sex, and monthly insurance premiums (determined by income level in Korea) are included in the data collected by the NHIS (Lee *et al*., 2015; Piao *et al*., 2020) and were therefore used to indicate economic status (first, second, third, and fourth quartiles), representing income level (low, middle-low, high-middle, and high, respectively). For example, individuals whose monthly insurance premiums were within the first quartile were considered "low-income." Based on the information obtained from the health questionnaires, the participants were categorized according to their smoking status as non-smokers, former smokers, or current smokers. Any alcohol use was defined as alcohol consumption of ≥once/week. The participants were categorized as physically active if physical activity was ≥three times/week or physically inactive if physical activity was <three times/week. Weight, height, and blood pressure measurements were extracted from physical examination data, and body mass index (BMI) was calculated according to the standard formula as weight (kg) divided by height (m^2). Obesity was defined as a BMI of ≥25 kg/m^2. Elevated blood pressure was defined as blood pressure ≥140/90 mm Hg on the health questionnaire. Hypertension (HTN) was defined as blood pressure ≥140/90 mm Hg, a diagnosis of HTN, or reported use of antihypertensive drugs on the health questionnaire. Furthermore, total cholesterol and fasting blood glucose were included in the laboratory tests. Hypercholesterolemia (HLP) was defined as a total cholesterol level of ≥240 mg/dL. DM was defined as a fasting blood glucose level of ≥126 mg/dL, a previous DM diagnosis, or reported use of antidiabetic drugs on the health questionnaires (Heng, 2020).

Prevalence was defined as the number of participants with cases in a given year per number of participants in the population who underwent a health check-up. Incidence was defined as the number of new cases during a specified period per number of participants in the population who underwent health check-ups more than once during the same period.

The primary outcome was the prevalence of NCD risk factors, including current smoking, physical inactivity, obesity, DM, HTN, and HLP in 2015 (Grundy *et al*., 2005; O'Donnell and Elosua, 2008; Di Cesare *et al*., 2013). The secondary outcomes were the incidence of type 2 diabetes mellitus (T2DM)

Table 1. Health characteristics of Asian migrants and Koreans aged ≥20 years in 2015

Variable	Native	Migrant				
	Korean	Chinese	Japanese	Filipino	Vietnamese	Other Asian
N	266,162	101,223	4,445	11,888	19,224	63,765
Age (years)	49.4 ± 14.0	46.4 ± 11.4	47.4 ± 9.2	32.5 ± 6.0	30.3 ± 9.2	30.3 ± 6.3
Sex (%)						
Men	53.1	52.8	28.7	80.3	70.9	92.7
Women	46.9	47.2	71.3	19.7	29.1	7.3
Economic status (%)						
First quartile (low)	15.5	23.4	24.5	34.9	27.4	28.0
Second quartile	25.0	45.1	19.2	53.2	53.1	57.5
Third quartile	21.3	27.9	25.3	10.6	18.0	12.9
Fourth quartile (high)	38.2	3.6	31.0	1.3	1.5	1.6
Body mass index (kg/m^2)	24.0 ± 3.4	23.7 ± 3.3	23.2 ± 3.6	24.1 ± 3.1	21.8 ± 2.4	23.3 ± 3.2
Systolic blood pressure (mm Hg)	122.1 ± 14.5	121.6 ± 14.8	117.6 ± 14.3	121.2 ± 12.8	115.7 ± 12.0	118.8 ± 12.0
Fasting serum glucose (mg/dL)	99.8 ± 24.2	97.7 ± 21.9	95.4 ± 19.1	94.5 ± 18.6	90.3 ± 14.9	91.4 ± 16.8
Total serum cholesterol (mg/dL)	195.3 ± 38.9	190.4 ± 38.0	205.4 ± 38.2	192.0 ± 37.6	182.8 ± 37.5	185.0 ± 37.5
Smoking status (%)						
Former smokers	18.0	10.7	10.6	4.2	4.1	4.1
Current smokers	21.5	28.7	9.5	19.8	20.1	30.9
Any alcohol use (%)	50.1	46.2	30.5	46.4	39.9	37.9
Physical inactivity (%)	29.8	48.4	35.6	50.1	50.9	54.6

Data are presented as the mean ± standard deviation or %. The first quartile of monthly insurance premiums represented the low income level. Body mass index was calculated as weight in kilograms (kg) divided by height in meters squared (m^2); smoking status was categorized into non-smokers, former smokers, or current smokers; any alcohol use was defined as alcohol consumption of ≥once/week; and physical inactivity was defined as physical activity of <3 times/week.

and HTN from 2009 to 2015. To ascertain incident T2DM and HTN, we excluded participants with DM and HTN at the first health check-up between 2009 and 2014. Incident T2DM and HTN were determined for each participant between the first and last health check-ups (Heng, 2020).

IRB Approval
The Institutional Review Board (IRB) of Seoul National University Hospital (Seoul, Korea) approved the study on August 21, 2018 (IRB number: E-1808-093-966) and waived the need for informed consent.

Statistics
The research design and the statistical analyses performed for this and previous studies are shown in Supplementary Fig. 1. First, to calculate the age-adjusted prevalence of lifestyle, socioeconomic, and health-related factors among Chinese, Japanese, Filipino, Vietnamese, and other Asian migrants compared with Koreans aged ≥20, direct age standardization was conducted by sex using 10-year age bands. The World Standard Population was the standard population (Ahmad *et al*., 2001). For Asian migrants compared with Koreans aged 20-29, 30-39, and 40-49, we examined age-specific prevalence ratios (aPRs) and 95% log-normal confidence intervals (CIs) (Barros and Hirakata, 2003). Moreover, we conducted direct age standardization among Asian migrants compared with Koreans aged 20-49 using the World Standard Population (Ahmad *et al*., 2001). The demographic and risk factor variables were compared between the Asian migrants and Koreans, according to nationality, using unpaired two-tailed t-tests for continuous variables and χ^2 tests for categorical variables (Supplementary Methods).

Second, to examine the differences in the development of T2DM and HTN between Asian migrants—according to nationality—and the native Korean population, multivariable logistic regression analyses were conducted and adjusted for age (continuous, years), sex, economic status, BMI (continuous, kg/m^2), smoking status, alcohol use, and physical activity. The adjusted odds ratios (ORs) and 95% CIs for incident T2DM and HTN determinants were examined between the first and last health check-ups from 2009 to 2015. Further, we conducted multivariable logistic regression analyses stratified by age (20-39 and ≥40) and sex (Heng, 2020).

Finally, we examined the differences in the age-adjusted prevalence of obesity, elevated blood pressure, and DM among Chinese, Filipino, and Vietnamese migrants compared with the general population of their respective home countries (Heng, 2020). Age standardization was conducted using 10-year age bands, and the World Standard Population was used as the standard population (Ahmad *et al*., 2001). General population health data from China, the Philippines, and Vietnam were obtained from the World Health Organization (2016a, 2016b) (Supplementary Methods).

All analyses were performed using R software version 3.6.3 (R Foundation for Statistical Computing, Boston, MA, USA) and SAS version 9.3 (SAS Institute Inc., Cary, NC, USA). *P*-values <0.05 were considered statistically significant.

RESULTS
Table 1 presents the characteristics of Asian migrants by

Table 2. Comparison of health-related indicators between Asian migrant and Korean men aged ≥20 years in 2015

Variable Men	Age-adjusted prevalence (95% CI)							
	Smoking status (current)	Any alcohol use	Physical inactivity	Low income level	Obesity	Hypertension	Diabetes mellitus	Hypercholesterol-emia
Korean	39.9 (39.5-40.3)	70.3 (69.8-70.9)	24.8 (24.5-25.1)	10.9 (10.7-11.1)	41.7 (41.3-42.1)	22.4 (22.2-22.7)	9.6 (9.5-9.8)	10.2 (10.0-10.4)
Asian migrants								
Chinese	52.8 (52.1-53.6)	68.6 (67.8-69.4)	45.8 (45.1-46.4)	19.6 (19.2-20.1)	35.6 (35.0-36.2)	20.4 (20.0-20.8)	7.4 (7.2-7.7)	7.6 (7.4-7.9)
P-value for difference[a]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Japanese[b]	26.8 (22.1-31.5)	70.4 (63.3-77.5)	27.8 (23.4-32.3)	10.4 (6.7-14.0)	37.9 (32.5-43.3)	18.3 (15.7-20.9)	8.0 (6.3-9.7)	14.4 (11.6-17.1)
P-value for difference[a]	<0.001	0.990	0.161	0.778	0.187	0.006	<0.001	0.004
Filipino[c]	23.0 (20.0-26.0)	49.6 (40.1-59.1)	52.9 (49.4-56.5)	28.6 (20.9-36.2)	41.4 (31.9-51.0)	20.8 (10.3-31.3)	8.9 (3.2-14.5)	11.2 (5.9-16.5)
P-value for difference[a]	<0.001	<0.001	<0.001	<0.001	0.958	0.772	0.804	0.695
Vietnamese[c]	33.2 (30.8-35.5)	51.0 (47.0-54.9)	51.5 (47.1-55.9)	21.7 (18.8-24.7)	13.5 (11.3-15.6)	9.2 (6.7-11.6)	3.4 (2.1-4.8)	12.9 (10.4-15.4)
P-value for difference[a]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.016
Other Asian	35.8 (31.6-39.2)	45.4 (41.4-49.4)	52.9 (49.4-56.5)	24.0 (21.7-26.3)	38.3 (34.6-42.1)	18.4 (14.9-22.0)	5.1 (3.8-6.5)	9.9 (8.4-11.4)
P-value for difference[a]	0.026	<0.001	<0.001	<0.001	0.092	0.046	<0.001	0.709

Data are presented as %; age standardization with 10-year age bands; the World Standard Population was used as the standard population.
CI, confidence interval.
Participants were categorized according to their smoking status as non-smokers, former smokers, or current smokers; any alcohol use was defined as alcohol consumption of ≥once/week; and physical inactivity was defined as physical activity of <3 times/week. The first quartile of monthly insurance premiums represented the low income level. Obesity was defined as body mass index ≥25 kg/m², diabetes mellitus was defined as a fasting blood glucose level of ≥126 mg/dL, a previous diabetes mellitus diagnosis, or reported use of antidiabetic drugs; hypertension was defined as blood pressure of ≥140/90 mm Hg, hypertension diagnosis, or reported use of antihypertensive drugs according to the health questionnaires; and hyperlipidemia was defined as a total cholesterol level of ≥240 mg/dL.

[a]*P*-value for the difference was calculated among Asian migrant men compared with Korean men according to nationality.
[b]Age-adjusted prevalence of diabetes mellitus (95% CI) between Japanese migrant and Korean men aged ≥30 years: 8.0 (6.3-9.7) and 12.3 (12.1-12.5), respectively.
[c]Age-adjusted prevalence of current smoking (95% CI) among Filipino migrant, Vietnamese migrant, and Korean men aged 20-59 years: 23.0% (20.0-26.0%), 33.2% (30.8-35.5%), and 44.2% (43.7-44.7%), respectively.

Table 3. Comparison of health-related indicators between Asian migrant and Korean women aged ≥20 years in 2015

Variable / Women	Age-adjusted prevalence (95% CI)							
	Smoking status (current)	Any alcohol use	Physical inactivity	Low income level	Obesity	Hypertension	Diabetes mellitus	Hypercholesterol-emia
Korean	3.8 (3.7-4.0)	37.7 (37.3-38.2)	32.0 (31.6-32.3)	19.2 (19.0-19.5)	23.2 (22.9-23.4)	16.0 (15.8-16.2)	5.9 (5.8-6.0)	9.5 (9.3-9.7)
Asian migrants								
Chinese	2.9 (2.7-3.1)	23.4 (22.8-24.0)	46.5 (45.8-47.3)	29.6 (29.0-30.2)	25.6 (25.1-26.1)	14.6 (14.2-14.9)	4.4 (4.2-4.6)	8.3 (8.1-8.6)
P-value for difference[a]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Japanese[b]	4.7 (3.2-6.2)	28.9 (24.6-33.3)	34.5 (31.1-37.9)	22.8 (20.4-25.2)	18.3 (16.0-20.6)	13.2 (11.2-15.2)	5.6 (4.0-7.2)	13.8 (12.0-15.7)
P-value for difference[a]	0.207	<0.001	0.140	0.002	<0.001	0.012	0.040	<0.001
Filipino[c]	2.0 (1.3-2.7)	11.9 (8.8-15.0)	51.6 (44.9-58.4)	42.0 (36.9-47.0)	30.9 (25.2-36.6)	19.1 (13.2-24.9)	5.2 (2.2-8.2)	11.2 (6.9-15.6)
P-value for difference[a]	<0.001	<0.001	<0.001	<0.001	0.002	0.266	0.672	0.398
Vietnamese[c]	2.2 (1.1-3.2)	5.0 (4.2-5.7)	56.4 (52.9-59.8)	38.5 (35.9-41.1)	12.7 (10.8-14.6)	10.7 (8.4-13.0)	5.6 (3.9-7.3)	12.9 (10.6-15.2)
P-value for difference[a]	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	0.764	<0.001
Other Asian	6.4 (4.8-7.9)	12.8 (11.1-14.5)	53.2 (49.4-57.1)	36.3 (33.3-39.3)	35.5 (31.4-39.5)	16.1 (12.7-19.6)	6.0 (3.8-8.1)	11.4 (9.0-13.9)
P-value for difference[a]	<0.001	<0.001	<0.001	<0.001	<0.001	0.949	0.961	0.094

Data are presented as %; age standardization with 10-year age bands; the World Standard Population was used as the standard population.
CI, confidence interval.

Participants were categorized according to their smoking status as non-smokers, former smokers, or current smokers; any alcohol use was defined as alcohol consumption of at least once/ week; and physical inactivity was defined as physical activity of <3 times/week. The first quartile of monthly insurance premiums represented the low income level. Obesity was defined as body mass index ≥25 kg/m^2; diabetes mellitus was defined as a fasting blood glucose level of ≥126 mg/dL, a previous diabetes mellitus diagnosis, or reported use of antidiabetic drugs; hypertension was defined as blood pressure of ≥140/90 mm Hg, hypertension diagnosis, or reported use of antihypertensive drugs according to the health questionnaires; and hypercholesterolemia was defined as a total cholesterol level of ≥240 mg/dL.

[a] P-value for difference was calculated among Asian migrant women compared with Korean women according to nationality.

[b] Age-adjusted prevalence of diabetes mellitus (95% CI) between Japanese migrant and Korean women aged ≥30 years: 5.6 (4.0-7.2) and 7.6 (7.5-7.8), respectively.
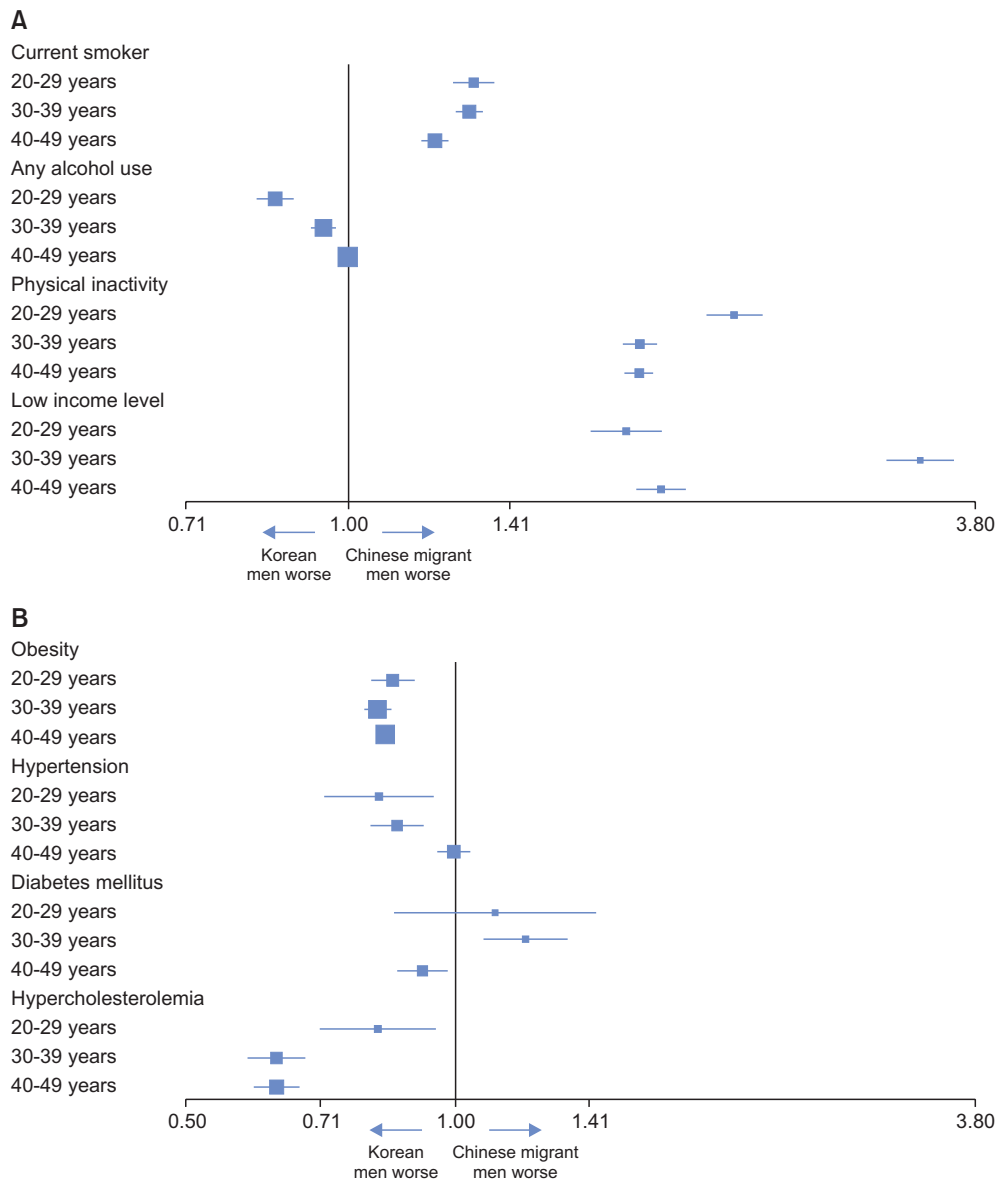
[c] Age-adjusted prevalence of current smoking (95% CI) among Filipino migrant, Vietnamese migrant, and Korean women aged 20-59 years: 2.0% (1.3-2.7%), 2.2% (1.1-3.2%), and 4.4% (4.2-4.5%), respectively.
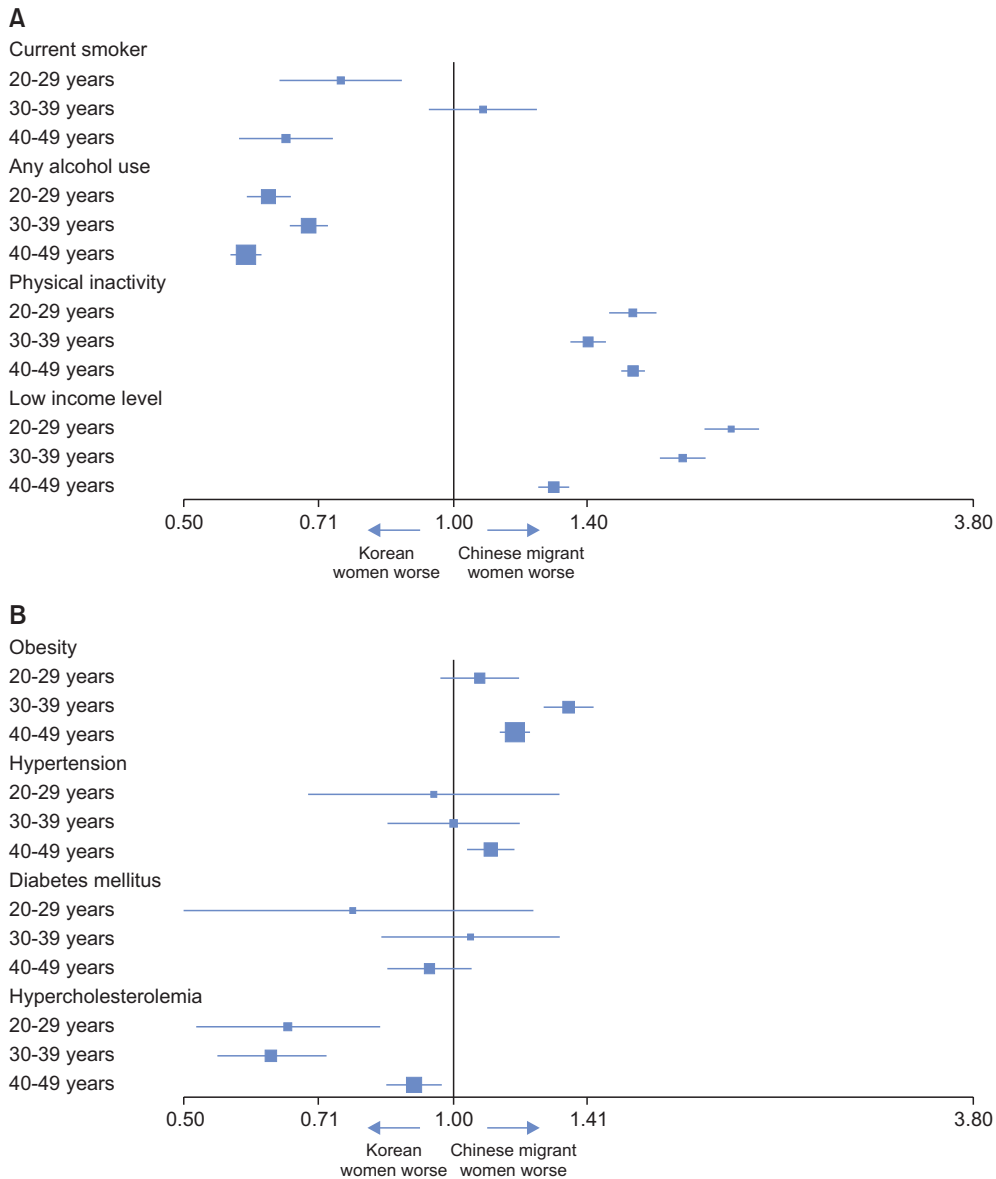
607

nationality and Koreans in 2015. The age-adjusted prevalence of current smoking in 2015 was higher among Chinese migrant men than Korean men (*p*<0.001; Table 2) and higher among other Asian migrant women than Korean women (*p*<0.001; Table 3). The age-adjusted prevalence of obesity was higher in Chinese, Filipino, and other Asian migrant women than in Korean women (*p*<0.001, *p*=0.002, and *p*<0.001, respectively; Table 3). The age-adjusted prevalence of HLP was higher among Japanese and Vietnamese migrant men than Korean men (*p*=0.004 and *p*=0.016, respectively; Table 2) and higher among Japanese and Vietnamese migrant women than Korean women (*p*<0.001 and *p*<0.001, respectively; Table 3).

In 2015, among the participants aged 30-39, the prevalence of DM was higher among Chinese migrant men than in Korean men (prevalence ratio [PR], 1.20; 95% CI: 1.07-1.33). Of those aged 40-49, the prevalence of obesity and HTN were higher among Chinese migrant women than in Korean women (PR, 1.17; 95% CI: 1.13-1.22 and PR, 1.10; 95% CI: 1.04-1.17, respectively) (Fig. 1, 2; Supplementary Table 1, 2).

In 2015, among the participants aged 20-29 and 30-39, the prevalence of HLP was higher among Filipino migrant men than in Korean men (PR, 1.37; 95% CI: 1.18-1.61 and PR, 1.09; 95% CI: 1.00-1.18, respectively). Among the participants aged 30-39, the prevalence of DM was higher among Filipino

Fig. 1. Health-related indicators comparing Chinese migrant men with Korean men aged 20-49 in 2015. While comparing Chinese migrant men with Korean men aged 20-29, 30-39, and 40-49, we examined the age-specific prevalence ratios (aPRs) and 95% log-normal confidence intervals (CIs). Obesity was defined as body mass index ≥25 kg/m²; diabetes mellitus was defined as a fasting blood glucose level of ≥126 mg/dL, a previous diabetes mellitus diagnosis, or antidiabetic drug prescription; hypertension was defined as blood pressure of ≥140/90 mm Hg, hypertension diagnosis, or antihypertensive drug prescription according to the health questionnaires; and hypercholesterolemia was defined as a total cholesterol level of ≥240 mg/dL.
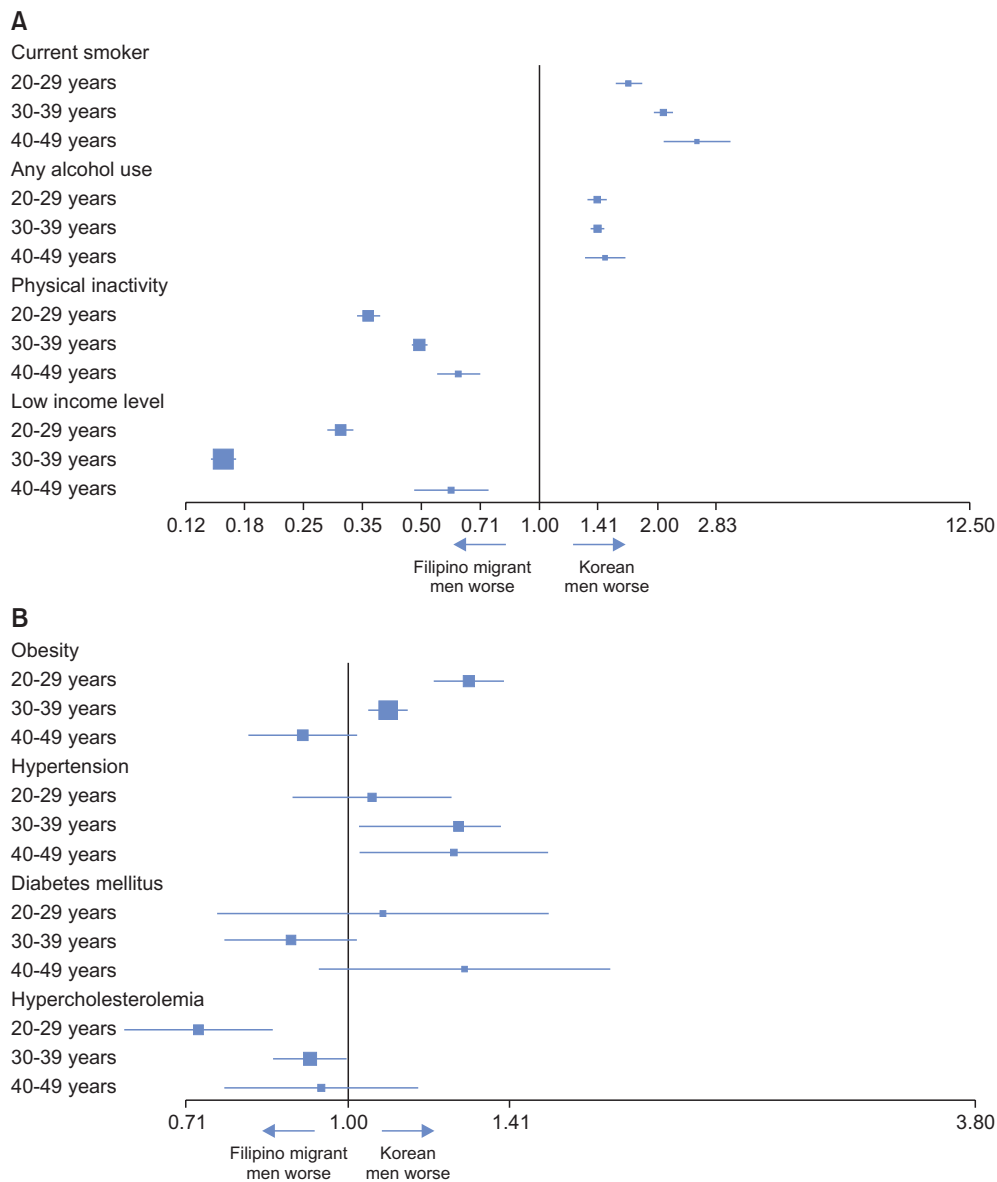
Fig. 2. Health-related indicators comparing Chinese migrant women with Korean women aged 20-49 in 2015. While comparing Chinese migrant women with Korean women aged 20-29, 30-39, and 40-49, we examined the age-specific prevalence ratios (aPRs) and 95% log-normal confidence intervals (CIs). Obesity was defined as body mass index ≥25 kg/m^2; diabetes mellitus was defined as a fasting blood glucose level of ≥126 mg/dL, a previous diabetes mellitus diagnosis, or antidiabetic drug prescription; hypertension was defined as blood pressure of ≥140/90 mm Hg, hypertension diagnosis, or antihypertensive drug prescription according to the health questionnaires; and hypercholesterolemia was defined as a total cholesterol level of ≥240 mg/dL.

migrant women than in Korean women (PR, 2.08; 95% CI: 1.47-2.94) (Fig. 3, 4, Supplementary Table 3, 4).

In 2015, among the participants aged 20-49, the age-adjusted prevalence of HLP was higher among Filipino migrant men than Korean men (*p*=0.010), DM was higher among Filipino migrant women than Korean women (aPR, 1.49; 95% CI: 1.11-2.02; *p*=0.009), and HTN was higher among Filipino migrant women than Korean women (aPR, 1.81; 95% CI: 1.48-2.21; *p*<0.001) (Fig. 5, Supplementary Table 5).

From 2009 to 2015, 505,324 participants underwent health check-ups more than once and had DM-related data. The number of participants who developed T2DM between the first

and last health check-ups was 22,284. In multivariate analyses, compared with native Koreans, the odds ratio (OR) for developing T2DM after adjusting for covariates was 0.82 (95% confidence interval [CI]: 0.78-0.86) among Asian migrants. However, among the Vietnamese migrant men aged 20-39, the OR for developing T2DM was 1.32 (95% CI: 1.11-1.57) compared to Korean men (Supplementary Fig. 2).

From 2009 to 2015, 431,433 participants underwent health check-ups more than once and had HTN-related data. The number of participants who developed HTN between the first and last health check-ups was 48,007. In multivariate analyses, compared with native Koreans, the OR for developing

609

Fig. 3. Health-related indicators compare Filipino migrant men with Korean men aged 20-49 in 2015. While comparing Filipino migrant men with Korean men aged 20-29, 30-39, and 40-49, we examined age-specific prevalence ratios (aPRs) and 95% log-normal confidence intervals (CIs). Obesity was defined as body mass index ≥25 kg/m^2; diabetes mellitus was defined as a fasting blood glucose level of ≥126 mg/dL, a previous diabetes mellitus diagnosis, or antidiabetic drug prescription; hypertension was defined as blood pressure of ≥140/90 mm Hg, hypertension diagnosis, or antihypertensive drug prescription according to the health questionnaires; and hypercholesterolemia was defined as a total cholesterol level of ≥240 mg/dL.
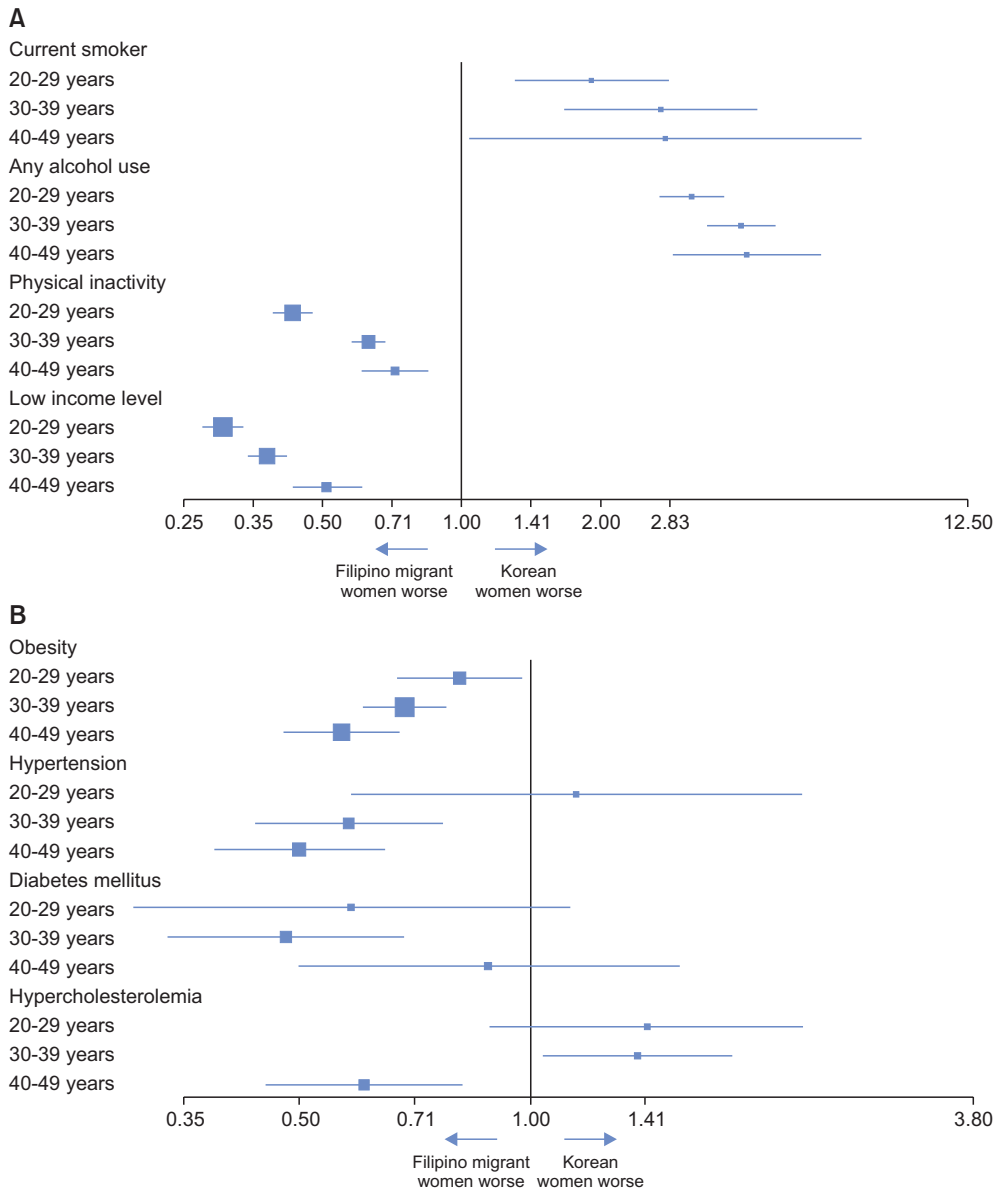
HTN after adjusting for covariates was 0.77 (95% CI: 0.75-0.79) among Asian migrants. However, compared with Korean women, the ORs for developing HTN were 1.49 (95% CI: 1.05-2.11) and 2.22 (95% CI: 1.17-4.19) among Filipino migrant women aged 20-39 and >40, respectively (Supplementary Fig. 3).

In 2015, the age-adjusted prevalence of obesity was higher among Filipino migrant men than general Filipino men. Moreover, in 2014, the age-adjusted prevalence of DM was higher among Filipino migrant men than that in general Filipino men (Fig. 6).

DISCUSSION

The age-adjusted prevalence of current smoking was higher among Chinese migrant men than Korean men and higher among other Asian migrant women than Korean women aged ≥20 in 2015. Smoking prevalence changes according to the situation at home and in the host countries (Weber *et al*., 2011; Abubakar *et al*., 2018). Smoking harms the health of both migrant and native populations. The risk factors attributed to social inequality may contribute to more than half of the major NCDs, especially CVD and lung cancer (Blakely *et al*., 2006; Di Cesare *et al*., 2013; Roth *et al*., 2020).

A

B

Fig. 4. Health-related indicators compare Filipino migrant women with Korean women aged 20-49 in 2015. While comparing Filipino migrant women with Korean women aged 20-29, 30-39, and 40-49, we examined age-specific prevalence ratios (aPRs) and 95% log-normal confidence intervals (CIs). Obesity was defined as body mass index ≥25 kg/m²; diabetes mellitus was defined as a fasting blood glucose level of ≥126 mg/dL, a previous diabetes mellitus diagnosis, or antidiabetic drug prescription; hypertension was defined as blood pressure of ≥140/90 mm Hg, hypertension diagnosis, or antihypertensive drug prescription according to the health questionnaires; and hypercholesterolemia was defined as a total cholesterol level of ≥240 mg/dL.

In 2015, the age-adjusted prevalence of obesity was higher among Chinese, Filipino, and other Asian migrant women than Korean women aged ≥20. In our previous study analyzing the characteristics of migrants, fewer women than men underwent health check-ups; however, the number of women increased each year from 2009 to 2015 (Piao *et al*., 2020). Obesity is a major health problem among migrant women (Meeks *et al*., 2016; Heng, 2020; Piao *et al*., 2020). Unhealthy lifestyles, socioeconomic and cultural factors, genetics, and gene-environment interactions may lead to obesity, DM, and HTN (Misra and Ganda, 2007; Agyemang and van den Born, 2019; Heng, 2020). Compared with Koreans, we could not demonstrate

concurrence between obesity and DM/HTN among Asian migrants, consistent with previous findings from the Western Pacific to Europe (Meeks *et al*., 2016). Nonetheless, there was a concurrence between obesity and HTN among Chinese migrant women aged 40-49. Socioeconomic inequalities, cultural stress, and obesity likely contribute to HTN among migrants (Di Cesare *et al*., 2013; Gibson *et al*., 2013; Rechel *et al*., 2013). Among Filipino migrant women aged 20-49, we found concurrence between obesity and DM/HTN compared with Korean women, probably because of unhealthy diets, lack of exercise, early life factors, poor adherence to prescribed medication regimens, low socioeconomic status, genetics,
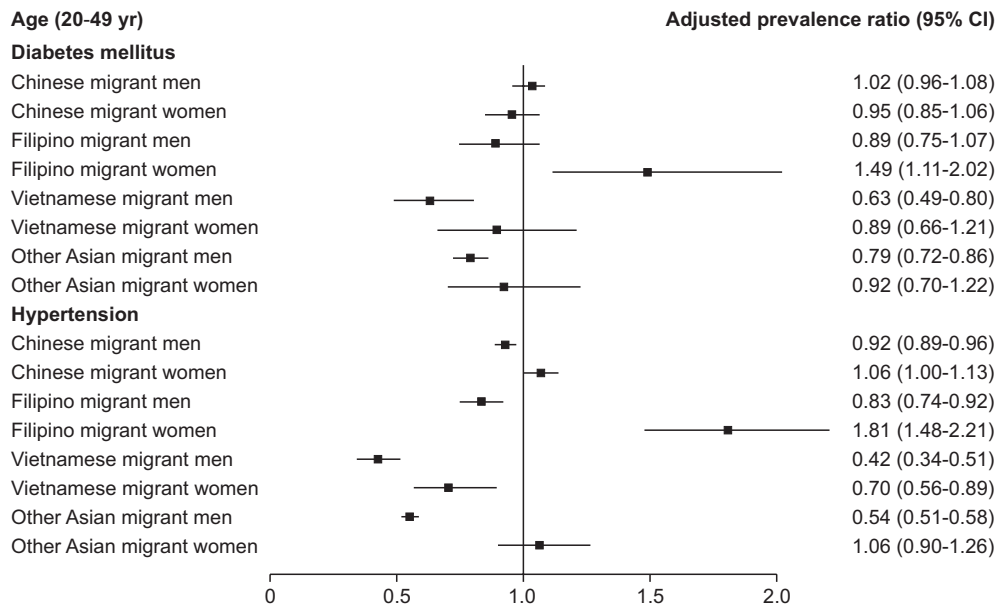
Fig. 5. Diabetes mellitus and hypertension in Asian migrants versus Koreans aged 20-49 in 2015. Age-adjusted prevalence ratios and 95% confidence intervals (CIs) of diabetes mellitus and hypertension were examined, with age standardization using 10-year age bands. The World Standard Population was used as the standard population. Diabetes mellitus was defined as fasting blood glucose level of ≥126 mg/dL, a previous diabetes mellitus diagnosis, or antidiabetic drug prescription. Hypertension was defined as blood pressure of ≥140/90 mm Hg, hypertension diagnosis, or antihypertensive drug prescription, according to the health questionnaires.
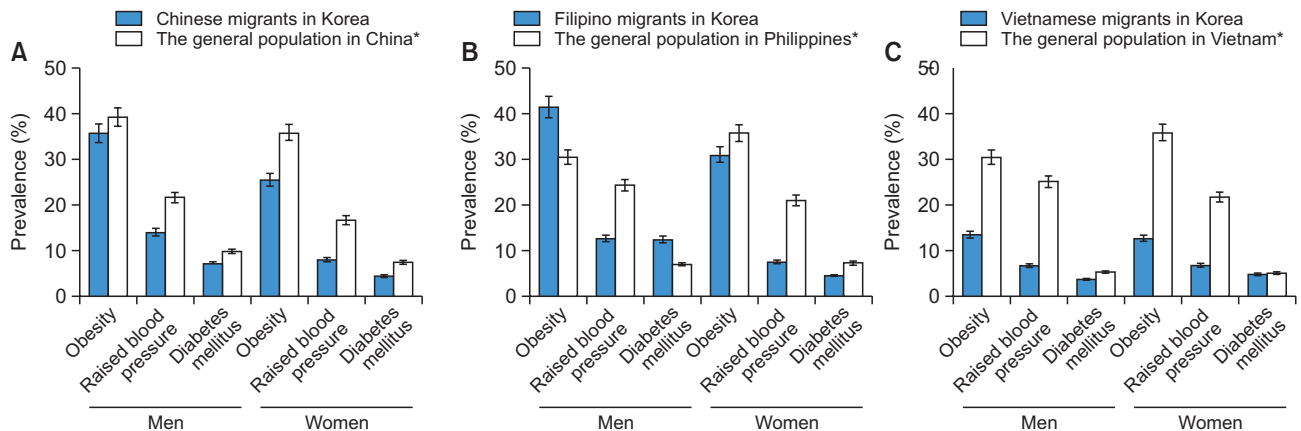
Fig. 6. Comparing health-related indicators in Asian migrants and the general population in their home countries. Data are presented as %. Age standardization was conducted using 10-year age bands. The World Standard Population was used as the standard population. Obesity was defined as a body mass index ≥25 kg/m^2 for the Asian population. Elevated blood pressure was defined as blood pressure ≥140/90 mmHg. Diabetes mellitus was defined as a fasting blood glucose level of ≥126 mg/dL, a previous diabetes mellitus diagnosis, or receipt of an antidiabetic drug prescription. Regarding obesity and elevated blood pressure, 2015 data were used; for diabetes mellitus, 2014 data were used. *World Health Organization (2016b).

and gene-environment interactions (Agyemang and van den Born, 2019; Heng, 2020; Misra and Ganda, 2007). The stress generated by cultural adaptation may contribute to a greater prevalence of HTN among Filipino migrant women aged 20-49; stress appears to be a more important factor than an unhealthy diet or lack of exercise (Steffen *et al*., 2006; Gibson *et al*., 2013).

Japanese and Vietnamese migrants had a higher prevalence of HLP than Koreans. Among the participants aged 20-49, Filipino migrant men had a higher prevalence of HLP than

Korean men, especially those aged 20-29 and 30-39. Previous studies have shown that increased intake of an "Americanized" diet (higher in fat than the traditional Japanese diet) has increased total cholesterol levels among Japanese Americans compared to Japanese natives (Marmot *et al*., 1975; Yano *et al*., 1978). Michael Marmot's doctoral thesis on coronary heart disease (CHD) among Japanese Americans illustrated that participants who adhered to Japanese culture and had closer social networks were less likely to develop CHD than those who were more deeply immersed in Western culture and life-

styles (Marmot and Syme, 1976). Although diet and HLP may increase the prevalence of CHD, the protective effect of Japanese culture on CHD is important, irreplaceable, and appears to operate independently of an unhealthy diet and smoking (Matsumoto, 1970; Marmot et al., 1975; Marmot and Syme, 1976). Therefore, the protective effect of social and cultural factors on cardiovascular health should be addressed while advocating healthy lifestyles.

In 2015, among participants aged 30-39, Chinese migrant men and Filipino migrant women had a greater prevalence of DM than Korean men and women, respectively. Migrants aged 30-39, compared with Koreans, may be more susceptible to DM due to migrant-related lifestyle changes (Misra and Ganda, 2007; Sattar and Gill, 2015; Heng, 2020). However, in multivariable analyses, from 2009 to 2015, among participants aged 20-39, Vietnamese migrant men were more likely to have T2DM than Korean men. This finding is consistent with previous studies showing that international migrants developed DM approximately 10-20 years earlier than the local population of their host countries (Sattar and Gill, 2015; Agyemang and van den Born, 2019; Heng, 2020). The Vietnamese migrant men aged 20-39 may be more susceptible to T2DM because of their greater vulnerability to stress from Korean society and culture, combined with an unhealthy diet, genetics, and gene-environment interactions (Di Cesare et al., 2013; Zheng et al., 2018).

Considering the important relationship between the pressure of cultural changes and elevated blood pressure among migrants, Asian migrants may be less likely to develop HTN than Koreans because of their similar cultures and relatively close proximity to their home country (Steffen et al., 2006; Gibson et al., 2013; Heng, 2020). Asian migrants may be more likely to adapt to Korean society and maintain large social networks, ensuring sufficient social support. These factors may help mitigate migration-related stress and help migrants cope with conflicts. Nevertheless, we cannot exclude the possibility that Asian migrants may return to their home countries either because of poor health or financial difficulties in Korea (Pablos-Mendez, 1994; Abubakar et al., 2018). Therefore, while the overall incidence of DM and HTN was lower among Asian migrants in this and previous studies, the true incidence may be higher. However, Filipino migrant women were more likely to develop HTN than Korean women, possibly due to social and cultural challenges encountered by Filipino women during acculturation to Korea (Steffen et al., 2006; Gibson et al., 2013).

Compared with the general population in their home countries, most Asian migrants in Korea demonstrated less obesity, DM, and elevated blood pressure (Heng, 2020). Nevertheless, the prevalence of obesity and DM was higher among Filipino migrant men than that among the general male Philippine population, potentially due to unhealthy lifestyles, low socioeconomic status, genetics, and gene-environment interactions (Misra and Ganda, 2007; Agyemang and van den Born, 2019; Heng, 2020). From 2009 to 2015, the age-adjusted prevalence of DM, HTN, and HLP were lower among most Asian migrants—regardless of sex—than among Koreans (Piao et al., 2020). Based on previous studies, the pursuit of better economic, educational, or social and living environment needs, combined with the self-selection of migrants and the immigration policy of the Korean government, may explain the healthy migration advantage in some NCD risk factors among

most Asian migrants in Korea (Kennedy et al., 2006; Vang et al., 2017; Aldridge et al., 2018). Turning our attention to Israel, the Sick Migration Effect might stem from the fact that many individuals migrate to Israel for ideological (and not economic) reasons. These findings contrast with the Healthy Migration Effect observed in other European countries (Constant et al., 2018).

Our study has several strengths. This was a large-scale observational study comparing the prevalence of NCD risk factors among Asian migrants of different nationalities and the host population in Korea. The design was cross-sectional in 2015 and longitudinal from 2009 to 2015 (Supplementary Discussion). Few similar studies have investigated the healthy migration effect among international migrant populations of various ethnic groups within the host populations of high-income countries in Asia using large data from a single source. Due to the lack of comprehensive worldwide migrant data, even a global-scale study that verified the healthy migration effects in high-income countries could only be conducted by pooling the mortality data and considering heterogeneity (high-quality data from different sources or sectors) and did not include international migrants in Asia (Aldridge et al., 2018). By comparing Asian migrants with Korean natives using health check-up data from the Korean NHIS, we conducted age standardization using the World Standard Population and compared the health data of Asian migrants with the health data in their home countries, targeting the general populations of China, the Philippines, and Vietnam, published by the Global Health Observatory Data Repository of the World Health Organization (Ahmad et al., 2001; World Health Organization 2016a, 2016b).

Our findings should be considered within the context of several limitations. First, we likely underestimated the total number of DM and HTN cases because we only selected individuals who had National Health Insurance and underwent health check-ups. Further, the study population could have been healthier than the entire population, assuming these individuals were more attentive to their health and utilized available medical resources. However, a previous study using the same data (from 2009 to 2015) showed an increasing prevalence of DM among Korean men and women aged ≥20, in line with the results of a recent study on Korean adults aged ≥30 based on the Korean National Health and Nutrition Examination Survey (Lee et al., 2018; Piao et al., 2020). Moreover, DM and HTN prevalence were more likely to have been underestimated in Asian migrants than in Koreans (Heng, 2020). For example, although international migrant workers have National Health Insurance when employed in Singapore, they may not utilize the necessary health services or even know they have health insurance coverage (Ang et al., 2017). Second, we did not consider family history, nutrition, stress, or depression when analyzing relationships among Asian migrants according to nationality, or among those newly diagnosed with T2DM or HTN, compared with Koreans. Third, because of the limited use of data on the type of international migrants (migrant workers, international students, and marriage migrants), the migrant status factors were not considered; however, we attempted to compensate for this shortfall by using economic status instead of the migrant status (Piao et al., 2020) (Supplementary Discussion).

In conclusion, considering the effects of socioeconomic and cultural factors on public health, strategies are needed to tar-

get smoking and obesity among Asian migrants of specific nationalities in Korea to address the primary and secondary prevention of NCD, especially CVD and lung cancer. Moreover, health inequalities exist among Filipino migrants, especially women aged 20-49. Future studies should use large-scale, high-quality longitudinal data, targeting the nationwide population of Korea from the National Health Insurance Service or the National Health and Nutrition Examination Surveys, to persistently monitor both communicable and NCDs and their respective risk factors for social and health policymaking among migrants in Korea and Asia compared with their home and host country populations. In addition, preventative medicine perspectives should be considered to investigate the healthy migrant effect over time while considering socioeconomic and cultural factors. To distinguish between genetics, environment, and their interaction, more rigorous and innovative study designs should be used to research the health effects of culture, social environment, and ethnicity/race on the occurrence of NCDs like HLP, CVD, and cancer.

CONFLICT OF INTEREST

ACKNOWLEDGMENTS

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