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Running title: Work stress and Health Behaviours

An analysis of the association between work stress and health behaviours in Korean and Japanese ageing studies: a cross-sectional study

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Work stress; Effort-reward Imbalance; Health Behaviour; Smoking; Drinking

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ABSTRACT

Objectives: As limited research has focused on the association between work stress and health behaviours in Asian countries, this research aims to explore the effect of work stress on the two health behaviours among employees aged 45 or above in two countries with aging populations, Korea and Japan.

Setting and participants: This secondary data analysis cross-sectional study based on baseline data from the Korean Longitudinal Study of Aging (KLoSA, 2006) and Japanese Study of Aging and Retirement (JSTAR, 2007&2009). Responders who worked at baseline in KLoSA (N=3,478) or in JSTAR (N=1,504) without missing data were included in the analytical sample.

Main outcome measures: This study used logistic regression and multinomial logistic regression to investigate the association between work stress represented by the short version of the effort-reward imbalance (ERI) model and smoking (binary current smoking) and drinking (categorical volume of alcohol). In addition, socioeconomic and work-related characteristics variables were taken into consideration. Moreover, this research additionally examines the potential interaction between ERI and gender.

Results: Smoking and drinking were significantly associated with the effort-reward ratio in the Korean analysis (N=3,478). After the model was fully adjusted, the OR (95% CI) were 1.45 (1.17-1.80) and 1.44 (1.09-1.90), respectively. In Japan (N=1,504), smoking was associated with the effort-

reward ratio (OR 1.37 (1.01-1.89)); however, drinking was not. No statistically significant interaction was found between ERI and gender (p value of 0.82 in Korea and 0.19 in Japan).

Conclusions: The results of this study showed that work stress was statistically significantly associated with both health behaviours in the Korean sample and with smoking in Japan. These results potentially suggest the integration of long working time reduction health promotion programmes in these two Asian countries.

Key words: Work stress; Effort-reward Imbalance; Health Behaviours; Smoking; Drinking

INTRODUCTION

In the last few decades, many public health studies have highlighted the necessity of studying unhealthy behaviours such as smoking, drinking, poor diet and sedentary lifestyles.[1,2] Scholars have observed that smoking, binge drinking, less exercise and poor diet contribute significantly to the high level of morbidity and mortality witnessed in both developed and developing countries.[1,3,4] Some risk factors, such as work stress, associated with unhealthy behaviours have not been studied extensively in the past.[1,5] Even though moderate work stress can motivate people to become more productive, excessive or unmanageable stress may increase their risks of unhealthy behaviours.[6] Research has even shown that when people are not satisfied with their work or do not receive the desired rewards for their efforts, they are more likely to experience work stress.[7]

Two models for work stress evaluation

Two models that are widely used in many epidemiological studies to evaluate the level of work stress include Karasek's Job Demand-Control (JDC) model and Siegrist's Effort-Reward Imbalance (ERI) model.[8-14] The JDC model measures the magnitude of work-related stress from job demand and job control dimensions.[9] The model postulates that the most stressed people are those with high job demands combined with low work control.[9,10] However,

at the core of the ERI model, there is the principle of the work contract and social reciprocity.[14] This model predicts that the combination of high efforts and low rewards would significantly increase negative emotions and a high level of work stress.[15]

Reasons for studying the association between work stress and health behaviours in Korea and Japan

Previous research has indicated that health behaviours are likely to be associated with chronic and cardiovascular diseases.[16] In addition, most of the existing studies have focused on European and North American countries, and only a few have examined the association between job stress and health behaviours in East Asian countries.[1,5]

A paper utilised the ERI model to examine the relationship between work stress and smoking found that highly stressed people were more likely to smoke.[2] Another US study, using the job strain model, produced a similar result and concluded that high strain jobs were positively associated with smoking intensity.[17] In terms of drinking, Siegrist and Rödel, in their meta-analysis of 18 articles, investigated the association between work-related stress and alcohol consumption.[6] They indicated that most of the existing articles have used the JDC model to evaluate work stress, while few articles have used the ERI model.[6] Although some studies failed to determine the association between work-related stress and drinking, some European studies found that

work-related stress contributed to chronic heavy drinking and alcohol addiction.[18-20]

Middle-aged and older workers in the Asian region are particularly vulnerable to work-related stress.[21,22] Because of this and lack of relevant policies and welfare systems guaranteeing the rights of employees in Asia, it is predicted that work-related stress might have a more serious impact on employees in East Asian countries than in Western countries.[21,22] Two developed countries with similar economic development patterns, Japan and Korea, have witnessed an increased rate of work-related deaths in the last three decades.[7,23]

In Korea and Japan, evidence from the analysis of the relationships between work-related stress and health behaviours is limited.[24-27] Kawakami and Haratani pointed out that compared to some European countries, Japanese people felt less satisfied with their jobs, thereby making them more vulnerable to work-related stress.[25] In a Korean cohort study, job security was negatively associated with smoking status among people aged 20-59.[26] Similarly, in a cross-sectional study conducted in Japan, a considerable number of nurses with high job strains depended on heavy smoking.[27]

Additionally, Japan and South Korea have some similarities when exploring the association between work stress and healthy behaviour; however, no literature has compared the two countries simultaneously. Several Japanese and Korean studies found that a gender difference might exist in the association

between work stress and various health outcomes.[2,24,25,28] Lack of intrinsic work rewards and uncertainty about the future contributed to unhealthy behaviours more seriously in males than in females.[28,29] Moreover, existing evidence suggests that the role of work stress on health behaviours in Japan is similar to that in Korea. According to different cohort and cross-sectional studies, work stress was negatively associated with vegetable intake and positively associated with high calorie intake.[30-32] The results from two Japanese occupational cohort studies showed that high job strain and effort-reward ratio (ER ratio) were modestly related to physical inactivity.[33,34] Previous studies also found that age, gender, education level, marital status, occupational grade, socioeconomic status and working time might be covariates that need to be controlled for when studying the relationship between work-related stress and health behaviours in Korea and Japan.[2,25,26,35]

Research gaps in work stress and health behaviours

In summary, past Japanese and Korean work-stress research focused on the relationship between work-related stress and individual health behaviours in some specific occupations, but they had yet to look at several health behaviours in the same analysis in general population samples.[33] Thus, this paper focuses on the association between work stress and two unhealthy behaviours, current smoking status and heavy alcohol consumption, in Korea and Japan by using two well-known ageing datasets, JSTAR and KLoSA.[6,36] To focus on

a potentially more vulnerable population, the target population of this research is middle-aged and older workers aged 45 years and older in Korea and Japan.[37] To provide a comparative evaluation of work stress in these two potentially different socioeconomic and sociocultural contexts, this study uses the ERI model to assess work-related stress. The short form of ERI used in the KLoSA and JSTAR datasets, previously used and partially validated by Siegrist *et al*, will be used to measure the ERI model.[9,37,38]

The study has three objectives: (1) to examine the association between ERI and health behaviours in KLoSA and JSTAR, (2) to investigate the potential interactions between ERI and gender, and (3) to compare results from Korea and Japan and to identify any potential differences in findings.

METHODS

Study design

The Korean data and Japanese data were collected from the Korean Longitudinal Study of Aging (KLoSA) and the Japanese Study of Aging and Retirement (JSTAR), respectively. Both databases are public data with open access.[36,39] The KLoSA study was based on the random selection of men and women aged 45-98 in South Korea, excluding Jeju Island. The baseline data were obtained in 2006, and Computer Assisted Personal Interviewing (CAPI) was employed to ask questions related to work stress and health behaviours. Because of the large number of missing outcome variables in the

follow-up waves, it was decided that this study would focus on cross-sectional analysis using 2006 data (wave1).

The JSTAR survey was conducted by the Research Institute of Economy, Trade and Industry Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo.[36] This survey focused on men and women aged 50-78 in 2007. According to the JSTAR first results report, the data quality was evaluated by comparing the JSTAR database with the 2005 Japanese census data. JSTAR has a high response rate in terms of the Japanese standard, however, JSTAR datasets have various limitations, such as changing the questionnaire between waves.[36] Because of this, some variables are missing in different waves. Siegrist *et al.* pointed out that JSTAR data were not of enough quality for the longitudinal analysis of work stress, as many people dropped out in later waves.[9] Hence, this project uses the baseline JSTAR data to perform cross-sectional analyses. The data from 5 cities (Adachi, Kanazawa, Shirakawa, Sendai, and Takikawa) were collected in 2007, with an additional two cities (Tosi and Naha) obtained in 2009.

Overall, as KLoSA is a much larger study and past literature suggests that it is of better quality than JSTAR.[36,39] the present study will mainly focus on Korean results. Korean results will then be compared with Japanese results. Both studies were approved by relevant ethical committees in both countries, and all participants signed informed consent for participation in the study.

Study sample

Figures 1 and *2* present the analytical sample selection in this study. Responders who worked at wave1 in KLoSA (N=3,478) or in JSTAR (N=1,504) without missing data were included in the analytical sample. A total of 482 participants were excluded from the analysis due to missing data, which accounted for 12.2% of the total workers in the Korean baseline sample. According to the same inclusion and exclusion criteria, approximately 53.5% (N=1,504) of responders could be used from a Japanese sample. In summary, nearly 87.8% of the Korean eligible sample was analysed, while only approximately half of the eligible Japanese sample was included in the analysis.

(please put Figure 1 here)

(please put Figure 2 here)

Patient and Public Involvement

No patient involved

MEASUREMENTS

ERI evaluation

The ERI, the exposure of this project, was measured with three questions in KLoSA and six questions in JSTAR. The original ERI questionnaire consists of

17 items, 6 of which measure “efforts”, and the remaining items measure “rewards”.[40] Because of the limitations of the existing data, only one item is available for evaluating the effort dimension, while two items are available for assessing the reward dimension (“ERI [1+2]”) in Korea. In Japan, two and four questions were used to measure “efforts” and “rewards” (“ERI [2+4]”), respectively. In 2012, Siegrist *et al*. demonstrated in their study that the short version and the long version of the ERI model had similar properties.[9] Hence, this project used the short version to evaluate work stress in a Japanese sample.[40] In this way, the results from the analysis using a shorter version (“1+2”) will be directly comparable between Korean and Japanese samples.

Each item in the model was answered using a 4-point Likert scale. Higher scores indicate higher efforts, while lower scores reflect more work-related stress caused by lower occupational rewards.[40] The ER ratio is calculated by adding the score of the effort and then dividing the value by the total score of reward, adjusted for the different number of items (correction factor), which is 0.5 in the three-item ERI model and six-item ERI model. Then, the categorical ERI is obtained by dividing continuous ERI into tertiles.[9] Individual questions available in both datasets are shown in Table 1, with questions requiring reverse scoring marked with an asterisk.

Table 1 Questions related to ERI measurement

	KLoSA	JSTAR
Effort	*My job requires lots of physical effort.	*My current job involves physical labour.
	N/A	*I have a lot of work and always feel time pressure.
Reward	*I feel my job is secure.	Do you think it is likely that you could lose your current job for a reason other than retirement?
	*I am satisfied with current wage.	*Considering the effort I put in and the results I produce, I am satisfied with my current pay.
	N/A	*I receive appropriate evaluation on my work from co-workers.
	N/A	*When I have problems Doing my work, colleagues give me advice and help me.

* Reverse coding

Health behaviours

The main focus of the paper in terms of health behaviours is current smoking and drinking status. Used as a binary outcome in Korea, smoking was assessed by the question “Do you smoke cigarettes now?” Participants who answered “yes” to the question were classified as current smokers, and those whose response was “No” were considered non-smokers. In Japan, participants were asked, “Do you regularly use tobacco, or did you use it in the past?” Participants were given three options: (1) Yes, I smoke now; (2) I smoked in the past, but I have quit; (3) No, I have never smoked regularly. To ensure comparability between the two countries and considering this paper mainly studies the current

smoking situation, participants who chose Option (1) were regarded as current smokers, and those who selected (2) or (3) were classified as current non-smokers.

Drinking was used as a categorical outcome in the analysis. First, the weekly alcohol consumption was calculated by multiplying the weekly drinking frequency of different drinks by their alcohol content. Next, according to the criteria of different drinking levels among men and women, this research classified individuals in Korea and Japan into three groups: non-drinkers, moderate drinkers, and heavy drinkers.[25] Males who drank between 0~210 g alcohol per week (g/wk) were considered moderate drinkers, and those who consumed more than 210 g/wk were regarded as heavy drinkers. Similarly, females who drank approximately 0~140 g/wk and more than 140 g/wk were considered moderate drinkers and heavy drinkers, respectively.[41]

Covariates

All available covariates were categorised as demographic, social and socioeconomic, and work-related characteristics. The demographic variables included age and gender. Age was divided into 5-year age groups. The social variables included education and marital status. In each country, education was classified into four categories. Marital status was classified into five categories (married, separated, divorced, widowed, and never married) in Korea but was only available in two categories (married/not married) in Japan. The work-

related variables refer to the working position and weekly working hours. In both countries, the working position was classified as non-supervisor, supervisor and self-employed. Participants were asked “How many hours do you work per week on average?” to estimate weekly working hours.

Analytical strategy

This study employed the number (%) and mean (SD) for all variables of interest to describe the characteristics of the analytical sample. The associations between exposure (categorical ER-ratio) and outcomes (smoking and drinking) were examined in both countries separately. Given that smoking is a binary variable, logistic regression was used to explore the relationship between ERI and the prevalence of smoking, and odds ratios (ORs) were estimated. Multinomial logistic regression were used to evaluate the association between ERI and drinking. In both analyses, the associations between ERI and two outcomes were analysed in the same order of adjustment. For all the analyses, four adjusted models were fitted: (Model 1) adjusted for age; (Model 2) Model 1 + gender; (Model 3) Model 2 + education, marital status; and (Model 4) Model 3 + working position, working hours.

Considering that differences might be observed in the healthy behaviours of men and women, likelihood-ratio tests were performed to examine the interactions between ERI and gender. The goodness of fit indices of the regression models, including and excluding the corresponding interaction terms,

were compared. (Supplementary Table 1 and Table 2).

All the analyses mentioned above were conducted in STATA 15.1.

RESULTS

Characteristics of samples in Korea and Japan

Table 2 describes both analytical samples. The mean age of respondents in the Korean sample was 55.6 years (SD=8.3 years), while that of the Japanese sample was 59.2 years (SD=6.1 years). More than half of the participants had at least a high school education in both Korea (53.3%) and Japan (70.1%). A large proportion of subjects (Korea 88.6%, Japan 83.4%) were married. In both samples, men had a higher working position and were more likely to be self-employed than women.

The prevalence of smoking was 32.2% in Korea and 30.7% in Japan. In both countries, the prevalence of smoking was higher among men (Korea: 44.5%; Japan: 39.9%) than among women (Korea: 3.6%; Japan: 13.7%). While the prevalence of male heavy drinkers was 21.1% in Korea and 43.0% in Japan, it was 3.2% in Korea and 12.9% in Japan among women.

Table 2 Characteristics of the cross-sectional sample in Korea and Japan

Variables	Korea	Japan
	Number(%)	Number(%)
Sample	3,478	1,504
Age		
years mean (SD)	55.6(8.3)	59.2(6.1)
45-49years	1,055(30.3)	N/A
50-54years	787(22.6)	392(26.1)
55-59years	596(17.1)	513(34.1)

60-64years	444(12.8)	296(19.7)
65-69years	358(10.3)	191(12.7)
>70years	238(6.8)	112(7.5)
Gender		
male	2,431(69.9)	977(65.0)
female	1,047(30.1)	527(35.0)
Education		
elementary	988(28.4)	330(21.9)
middle	635(18.3)	
vocational school	N/A	120(8.0)
high	1,281(36.8)	715(47.5)
college/university	574(16.5)	339(22.5)
Marital status		
married	3,080(88.6)	1,255(83.4)
separated	36(1.0)	N/A
divorced	90(2.6)	N/A
widowed	238(6.8)	N/A
never married	34(1.00)	249(16.6)
Working position		
non-supervisor	1,366(39.3)	994(66.1)
supervisor	409(11.8)	101(6.7)
self-employed	1,703(49.0)	409(27.2)
Working hour		
hours per week(SD)	48.5(18.3)	41.7(16.4)
Location		
Seoul	536(15.4)	N/A
other places	2,942(84.6)	N/A
ERI(1+2)	3,478	1,504
lowest tertile	1,611(46.3)	543(36.1)
middle tertile	1,001(28.8)	579(38.5)
upper tertile(ERI)	866(24.9)	382(25.4)
ERI(2+4)	N/A	1,504
lowest tertile	N/A	559(37.2)
middle tertile	N/A	447(29.7)
upper tertile(ERI)	N/A	498(33.1)
Smoking		
no	2,359(67.8)	1,042(69.3)
yes	1,119(32.2)	462(30.7)
Drinking		
grams per week(SD)	201.7(289.2)	169.7(242.5)
never	1,490(42.8)	553(36.8)
moderate	1,441(41.4)	460(30.6)
heavy	547(15.7)	491(32.7)

Evaluation of potential gender effect modification

In terms of the association between ERI and smoking, no statistically significant interactions were found after adjusting for age, education and marital status, work position and weekly working hours constant ($p>0.05$). The p values for the likelihood-ratio tests were 0.20 and 0.82 in Korea and Japan, respectively. For drinking, after adjusting all the covariates, no statistically significant interaction was found; the p value was 0.82 in Korea and 0.19 in Japan. The complete results of gender-specific analyses are shown in Supplementary Table 1 and Table 2. Although there was no statistically significant gender interaction, the results were different between men and women; for example, the number of female smokers was quite low.

ERI and health behaviours in Korea

Based on Korean data (2007), the results of different adjusted models for smoking and drinking are presented in Table 3. The gender-specific association between ERI and health behaviours was also explored (Supplementary Table 1 and Table 2).

Smoking

As shown in Table 3, all the results were statistically significant ($p<0.05$) among people who experienced the highest level of work stress (T3-high effort and low reward) compared to T1. After adjusting for age (Model 1), the OR (95% CI) represents the ERI effect size on smoking behaviour, where the OR of upper ERI was 1.45 (1.22-1.73). A considerable change in the effect size of the upper

ERI group was observed after adjusting for gender (Model 2), and the OR (95% CI) was 1.81 (1.49-2.20). Further adjustment for social and work-related covariates reduced the effects of work stress but remained statistically significant (Models 3 and 4).

Drinking

The effect sizes of ERI on drinking are presented in the bottom part of Table 3. When comparing moderate-alcohol consumers to non-alcohol consumers, it was found that the OR (95% CI) of upper ERI compared to low ERI was 1.15 (0.93-1.42) in fully adjusted Model 4, although this association was not statistically significant ($p>0.05$). Statistically significant results were obtained when examining the association between the upper tertile of ERI and heavy drinking. The OR (95%CI) in Model 4 was 1.44 (1.09-1.90). Additionally, gender takes major accounts for the largest change in ORs in Model 2.

In addition, analysis, place of residence was taken into consideration. Participants were classified as living in the capital Seoul or elsewhere. The effect size of ERI did not change when the residence variable was added into the regression models. The result of the likelihood ratio test showed that residence did not play a role in the association between ERI and smoking or between ERI and drinking, as the p-value were 0.30 and 0.87, respectively.

Table 3 **ORs (95% CI) of the association between Effort-reward Imbalance and current smokers and drinkers in Korea**

Korea	Model1		Model2		Model3		Model4	
ERI(tertiles)	**OR(95%CI)**	**p value**	**OR(95%CI)**	**p value**	**OR(95%CI)**	**p value**	**OR(95%CI)**	**p value**
Smoking								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	1.07(0.90,1.27)	0.42	1.38(1.14,1.67)	0.001	1.23(1.01,1.50)	0.04	1.21(0.99,1.48)	0.06
T3(upper-ERI)	1.45(1.22,1.73)	<0.001	1.81(1.49,2.20)	<0.001	1.48(1.20,1.83)	<0.001	1.45(1.17,1.80)	0.001
p for linear trend		<0.001		<0.001		<0.001		0.001
Drinking								
non-drinker	1.00		1.00		1.00		1.00	
moderate drinker								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	0.83(0.70,0.99)	0.04	0.99(0.82,1.19)	0.88	0.99(0.81,1.19)	0.88	1.00(0.83,1.22)	0.98
T3(upper-ERI)	0.96(0.80,1.16)	0.69	1.11(0.91,1.36)	0.29	1.11(0.90,1.37)	0.32	1.15(0.93,1.42)	0.21
p for linear trend		0.45		0.34		0.36		0.24
heavy drinker								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	0.81(0.63,1.03)	0.08	1.01(0.78,1.31)	0.92	0.96(0.73,1.25)	0.75	0.94(0.72,1.23)	0.66
T3(upper-ERI)	1.32(1.04,1.67)	0.02	1.60(1.24,2.07)	<0.001	1.45(1.10,1.91)	0.008	1.44(1.09,1.90)	0.01
p for linear trend		0.07		0.001		0.01		0.02

Model1:Adjusted for age

Model2:Model1+gender

Model3:Model2+education, marital status

Model4:Model3+working position, working hours

ERI and health behaviours in Japan

The Japanese analysis was based on the JSTAR data in 2007 (5 cities) and 2009 (2 cities). In the short version of the ERI model, the higher ERI group had a higher proportion of smoking individuals among Japanese people. Compared to the lowest ERI group, the proportion of heavy drinkers slightly decreased in the upper tertile from 35.3% to 31.1%. Using the longer ERI model, the prevalence of smoking was the highest in the middle tertile. The characteristics of the drinking prevalence of the long ERI version were similar to those of the short version. Additionally, the ER ratios of the upper tertile (T3) in both ERI measurements had the widest range from 1.14 to 4 and from 0.93 to 3.20, respectively.

To compare the KLoSA and JSTAR datasets, the analytical process of JSTAR had the same sequence of adjustments of the covariates as it did in Korea. As more ERI-related questions were available in JSTAR, this study used a shorter version (1+2 questions, same as in Korea) to make available comparisons and a longer version of the ERI model (2+4) to perform the sensitivity analysis. The full results for smoking and drinking are presented in Tables 4 and *5.* Because the Japanese female data might not be reliable, this study also tested the gender-specific association between ERI and health behaviours (Supplementary Table 1 and Table 2).[15]

Smoking

Table 4 shows the relationship between ERI and dichotomized smoking in Japan. To compare the results from Japan and Korea, the results using the short version of the ERI evaluation (1+2) are presented in the top part of Table

4. The ORs (95% CI) of smoking for the upper tertile versus the lowest tertile of ER ratio were 1.49 (1.12-1.98) when adjusted for age (Model 1) and 1.55 (1.15-2.08) when additionally adjusted for gender (Model 2). The magnitude and strength of the association decreased when additionally adjusted for education and marital status. ERI remained associated with smoking in a similar way as in KLoSA.

Table 4 ORs (95% CI) of the association between ERI and current smoking in Japan

Japan-smoking	Model1		Model2		Model3		Model4	
ERI (tertiles)	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value
Japan(1+2)								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	1.31(1.01,1.70)	0.05	1.42(1.08,1.87)	0.01	1.33(1.01,1.75)	0.04	1.32(1.00,1.75)	0.05
T3(upper-ERI)	1.50(1.13,2.00)	0.005	1.56(1.16,2.10)	0.004	1.36(1.00,1.85)	0.05	1.37(1.01,1.89)	0.05
p for linear trend		0.004		0.003		0.04		0.04
Japan(2+4)								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	1.49(1.13,1.96)	0.004	1.71(1.28,2.28)	<0.001	1.62(1.21,2.17)	0.001	1.59(1.18,2.14)	0.002
T3(upper-ERI)	1.30(0.99,1.70)	0.05	1.31(0.99,1.73)	0.06	1.21(0.91,1.61)	0.19	1.17(0.87,1.58)	0.29
p for linear trend		0.05		0.05		0.19		0.29

Model1:Adjusted for age

Model2:Model1+gender

Model3:Model2+education, marital status

Model4:Model3+working position, working hours

Drinking

According to Table *5,* the relationship between ERI categorised into tertiles and drinking in Japan was different from the trend seen in Korea. When comparing people in different ERI groups, people with higher work stress were less likely to drink. Moreover, when adjusted for additional covariates, the effect size of ERI on drinking did not change much (Model 3 and Model 4).

Table 5 ORs (95% CI) of the association between ERI and drinking levels in Japan

Japan-drinking	Model1		Model2		Model3		Model4	
ERI (tertiles)	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value
Japan(1+2)								
Non-drinker	1.00		1.00		1.00		1.00	
moderate drinker								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	0.74(0.55,0.99)	0.04	0.74(0.55,1.00)	0.09	0.77(0.56,1.04)	0.09	0.76(0.56,1.04)	0.08
T3(upper-ERI)	0.90(0.65,1.24)	0.50	0.85(0.61,1.18)	0.33	0.92(0.65,1.30)	0.63	0.91(0.64,1.29)	0.59
p for linear trend		0.40		0.26		0.63		0.50
heavy drinker								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	0.71(0.54,0.94)	0.02	0.71(0.52,0.97)	0.03	0.71(0.52,0.97)	0.03	0.71(0.52,1.02)	0.02
T3(upper-ERI)	0.78(0.57,1.07)	0.12	0.72(0.51,1.02)	0.07	0.71(0.49,1.01)	0.06	0.71(0.50,1.04)	0.08
p for linear trend		0.08		0.05		0.04		0.05
Japan(2+4)								
moderate drinker								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	0.79(0.58,1.07)	0.13	0.83(0.60,1.14)	0.26	0.84(0.60,1.16)	0.28	0.85(0.61,1.17)	0.32
T3(upper-ERI)	0.89(0.66,1.20)	0.45	0.84(0.62,1.15)	0.28	0.87(0.64,1.20)	0.41	0.89(0.64,1.23)	0.47
p for linear trend		0.44		0.27		0.40		0.47
heavy drinker								
T1(reference)	1.00		1.00		1.00		1.00	
T2(middle)	0.75(0.56,1.02)	0.07	0.82(0.59,1.14)	0.24	0.80(0.57,1.11)	0.18	0.80(0.57,1.12)	0.19
T3(upper-ERI)	0.78(0.58,1.05)	0.10	0.72(0.52,0.99)	0.05	0.71(0.51,0.97)	0.04	0.71(0.51,0.99)	0.04
p for linear trend		0.09		0.04		0.04		0.04

Model1:Adjusted for age

Model2:Model1+gender

Model3:Model2+education, marital status

Model4:Model3+working position, working hour

Sensitivity analysis of JSTAR

The results of smoking sensitivity analysis are shown in the bottom part of Table 4. No statistically significant differences between the top and bottom ERI tertiles were found when a longer version of ERI was used, while the OR of smoking was significantly increased in the middle ER ratio group. In terms of drinking, the results of short version and long version ERI model evaluation presented a similar trend.

DISCUSSION

Main findings and comparison with previous studies

The results indicate that a higher ERI level was positively associated with a higher prevalence of smoking and heavy drinking among Korean workers. Moreover, it was found that work-related stress was associated with smoking among Japanese people. ERI was not, however, significantly associated with drinking in Japan. The Japanese results for alcohol consumption contradict some previous studies.[42,43-45] This might be because of the small sample size and selection bias. Nonetheless, the effect size and direction of ERI were consistent with the results from previous research in non-Asian regions.[46,47] Moreover, the results from Japan also provide some evidence for the validity of the short version of the ERI. In both analyses of Japanese data, the results using shorter and longer versions of ERI ("2+4" and "1+2") are mostly but not entirely similar.

This study also used the likelihood-ratio test to explore the potential interaction between ERI and gender factors. No gender interaction was in Korea or Japan. However, the associations between ERI and health behaviours

were significant among only men. This may be because only a few women in both datasets were smokers or heavy drinkers. In any case, this result was consistent with a previous US study.[48] Gender was not an effect modifier in the relationship between work-related stress and health behaviours. Contrary to most previous observational and experimental studies conducted in Western countries.[8] this study found that work-related stress might be a protective factor against heavy drinking among Japanese workers and that this type of stress was not statistically significantly associated with the outcomes among Japanese females. People with the highest ERI levels had low odds (OR<1) of becoming heavy drinkers in Japan. Moreover, no significant association existed between work stress and drinking by comparing moderate drinkers to non-drinkers in Japan. In Japan and Korea, the association between work-related stress and drinking was not similar.The following explanations account for the different results in Japan. First, occupational drinking subculture could contribute to job stress. The purpose of socialisation and career development could also make individuals more or less prone to heavy drinking.[49] In several Asian countries, such as Japan, drinking alcohol is considered an essential way of engaging in social interactions.[45,50,51] The difference in drinking patterns in both Japan and Korea accounts for the disparity in the results. Most drinkers in Japan are moderate drinkers, while those in Korea have a penchant to binge drinking.[52-54] Hence, in Japan, the influence of drinking culture tends to be greater than the impact of work-related stress. However, the subculture and culture norms represent difficult elements to control in the analysis.[49] One US study illustrated that even though work-related stress had more enormous effects on males' drinking behaviours than on females' drinking behaviours, the

results were usually statistically significant.[48] With a sample size of 26,946 people, this US study could be used to detect the significant association between stress and drinking.[48] In this study, there were few Japanese smoking and drinking cases to explore any statistically significant effect of job stress, which might be one of the limitations of this study.

Strengths and limitations of this study

This study utilised the ERI model to evaluate work stress levels. It also designed a cross-sectional study to examine the association between work stress and health behaviours in Korea and Japan. In previous research, only a few studies applied the ERI model to explore the association between work stress and health behaviours.[15,32] Of those few studies, only a small percentage focused on Asian countries. Acquired from two reliable organisations (KEIS and RIETI), the baseline data of this study were collected nationally. These data provided a representative sample in Korea and a male sample group in Japan. Although the representation of Japanese females was not very good, it has been previously stated that JSTAR provides more useful information than other existing female-based studies because many other existing studies were based on only a limited geographic area or a specific occupation or age group.[36,54-57]

This study fills the gaps in the research regarding the association between Asian workers' stress and health behaviours. Moreover, the study sample in this project comprised elderly people over 45 years old, who were more sensitive to the experience of work-related stress than younger people.[58] Multinomial logistic regression was applied in this project to explore the

association between work stress and health behaviours, thereby providing a better way to control various potential confounders simultaneously. However, the results of this study still have several limitations. One limitation is the small sample size of JSTAR after the selection process with the inclusion and exclusion criteria. The relationship between work-related stress and drinking behaviour might be indirectly proportional given that occupation had a potential effect modification.[59] Another limitation is the methodological considerations. Due to the cross-sectional nature, the results could be influenced by reporting/recall bias.[60] This tendency indicates that variation in personal response tendencies existed but was difficult to control.[61] Apart from the possibility of causing outcome misclassification, it is highly likely that the effect size of work-related stress on smoking and drinking becomes underestimated.[62,63]

The third limitation is that the effect of residual confounding from other risk factors, for example, drinking subcultures, individual occupation type and workload, were not taken into account because of the data limitations of the two datasets. [43] It might influence the association between stress and health behaviours, a behavioural pattern that may lead to under-estimation or over-estimation of the real ORs of the association.[46,64,65]

Suggestion for further research

This research is the first study to use the ERI model to analyse work-related stress and health behaviours in Korea and Japan simultaneously, even though non-significant results in terms of work-related stress and drinking were found in Japan due to the small sample size and reasons noted previously. Previous

evidence mainly supported the theory that people with more work-related stress were more likely to become smokers and heavy drinkers in European, Australian and North American countries.[17-21,66-69] The findings of this research also suggest that Asian countries may have the same consistent trend of ERI-smoking association found in other regions around the world.[8,70] By and large, this study fills the gap in this area of knowledge. In terms of the ERI-drinking association, significant results were found in Koreans and Japan. Therefore, in future research, it is pertinent to identify other datasets in Korea and Japan, evaluate associations to see whether results are consistent within national boundaries, and investigate whether any study has better alcohol data of drinking patterns to test the ERI-drinking association.

Furthermore, longitudinal studies based on a larger sample size are recommended by taking more possible confounders under control to explore the causality and clarify the relationship between work-related stress and health behaviours.

CONCLUSION

Overall, after accounting for available covariates, it was found that a higher work stress expressed by a short version of the ERI was positively associated with a higher prevalence of smoking and heavy drinking among senior workers over 45 years old in Korea but was negatively associated with the prevalence of heavy drinking in Japan. The results also indicated that the effects of work stress were not significantly modified by gender. Moreover, the ERI-smoking association was similar in Korea and Japan. The ERI-drinking association, however, was different in these two countries. This was because work stress

was a risk factor in Korea but a protective factor in Japan. Based on these findings, this paper recommends that governments enhance the balance between extrinsic efforts and work rewards in Asian countries. Doing so may improve the health behaviours, particularly smoking behaviour, of workers and accelerate social and economic development.

DECLARATION

Ethics approval and consent to participate

The Korean Longitudinal Study of Ageing (KLoSA) received approval from the National Statistical Office (Approval number: 33602) and the Institutional Review Board (IRB) of the Korea National Institute for Ethics Policy. The JSTAR survey was conducted by the Research Institute of Economy, the Research Institute of Economy, Trade and Industry Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo, Japan. Data from KLoSA and JSTAR are publicly available with all data anonymized. This study also received approval for the secondary use of the KLoSA and JSTAR data. All methods in this study were carried out in accordance with the relevant guidelines and regulations. Since the KLoSA and JSTAR databases have been released to the public for scientific use and no experimental treatment was conducted on either human or animal subjects in this study, ethical approval was not required for the study.

Consent for publication

Not applicable.

Availability of data and materials

The KLoSA data that support the findings of this study are available from Korea Employment Information Service (KEIS), but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of KEIS.

The JSTAR data that support the findings of this study are available from the Research Institute of Economy, Trade and Industry (RIETI), but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of RIETI.

Competing interests

We have read and understood BMJ policy on declaration of interests and declare that we have no competing interests.

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Authors' contributions

TC and HP designed this study. TC wrote the first draft of the manuscript, prepared the analysis and interpreted the data. HP helped with the analysis. All authors were involved in writing the manuscript, gave critical comments on multiple versions, and approve its final version.

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blood-based biomarkers: a cross-sectional study of 43,593 French men and women. *Scientific Reports*. 2017;7(1).

Figure 1 Flow chart of the Korean cross-sectional study sample selection

Figure 2 Flow chart of the Japanese cross-sectional study sample selection

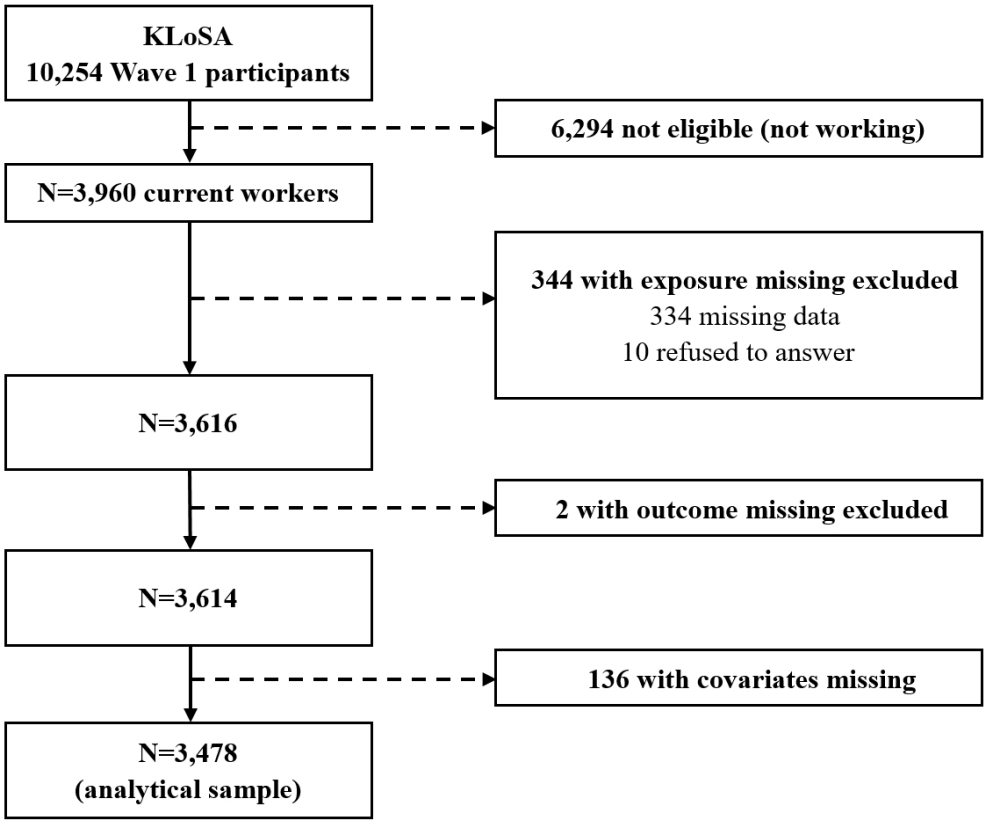

Figure 1 Flow chart of the Korean cross-sectional study sample selection

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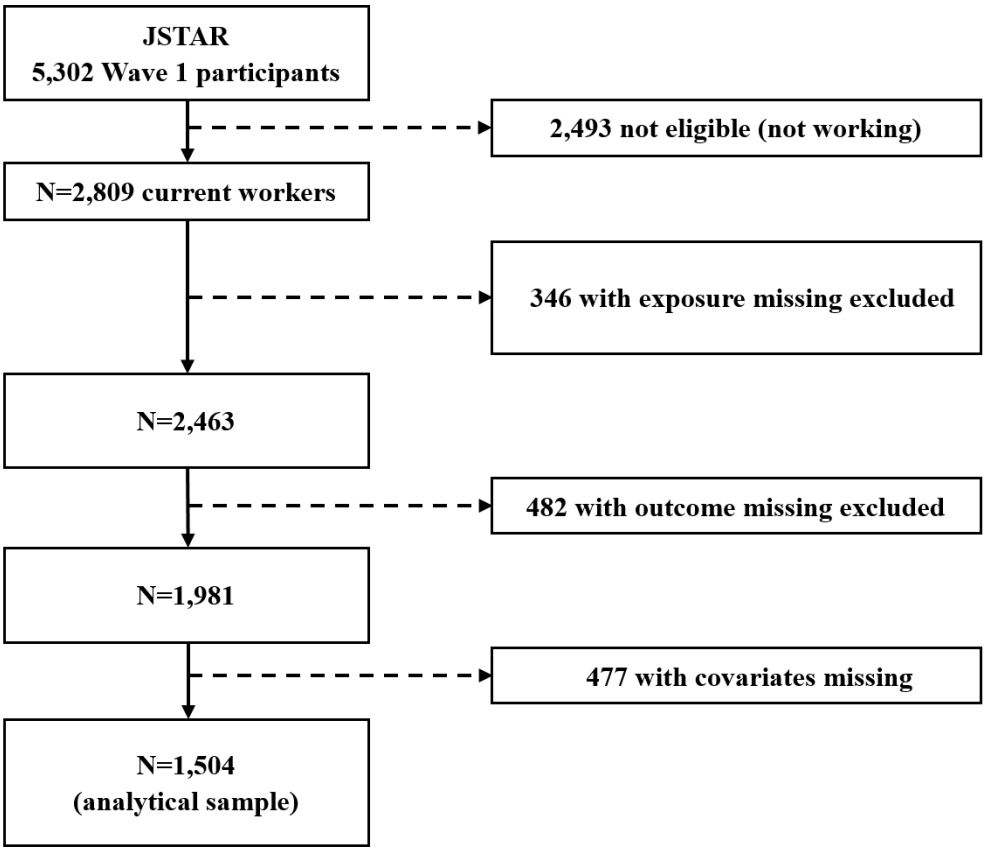

Figure 2 Flow chart of the Japanese cross-sectional study sample selection.tif

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Supplementary Information

Additional file 1：

Supplemental Table 1. ORs (95% CI) of the association between Effort-reward Imbalance and current smokers by gender

	Model1				Model2				Model3			
	male		female		male		female		male		female	
ERI(tertiles)	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value
Korea												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.45(1.20,1.76)	<0.001	0.65(0.28,1.50)	0.31	1.28(1.04,1.57)	0.02	0.64(0.26,1.56)	0.32	1.26(1.03,1.55)	0.03	0.63(0.26,1.55)	0.32
T3(upper-ERI)	1.84(1.50,2.25)	<0.001	1.27(0.59,2.73)	0.54	1.51(1.22,1.88)	<0.001	1.04(0.45,2.43)	0.92	1.49(1.19,1.85)	<0.001	1.03(0.44,2.42)	0.95
p for linear trend		<0.001		0.64		<0.001		0.93		<0.001		0.96
Japan(1+2)												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.44(1.0451.94)	0.02	1.34(0.73,2.46)	0.34	1.35(0.99,1.84)	0.06	1.25(0.67,2.31)	0.48	1.37(1.00,1.87)	0.05	1.23(0.65,2.30)	0.52
T3(upper-ERI)	1.62(1.16,2.27)	0.004	1.32(0.66,2.62)	0.43	1.45(1.02,2.05)	0.04	1.12(0.55,2.27)	0.75	1.52(1.06,2.17)	0.02	1.14(0.56,2.34)	0.72
p for linear trend		0.003		0.41		0.03		0.74		0.02		0.71
Japan(2+4)												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.49(1.10,2.01)	0.01	1.59(0.86.2,96)	0.14	1.42(1.04,1.92)	0.03	1.62(0.87,3.04)	0.13	1.41(1.03,1.93)	0.03	1.53(0.81,2.89)	0.19
T3(upper-ERI)	1.48(1.06,2.08)	0.02	1.33(0.69,2.55)	0.40	1.36(0.96,1.92)	0.09	1.27(0.65,2.46)	0.49	1.40(0.98,2.02)	0.07	1.13(0.58,2.21)	0.72
p for linear trend		0.01		0.39		0.06		0.48		0.05		0.73

Model1:Adjusted for age

Model2:Model1+ education, marital status

Model3:Model2+ working position, working hours

Supplemental Table 2. ORs (95% CI) of the association between Effort-reward Imbalance and drinking levels by gender

	Model1				Model2				Model3			
	male		female		male		female		male		female	
ERI(tertiles)	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value
Korea												
non-drinker(baseoutcome)	1.00		1.00		1.00		1.00		1.00		1.00	
moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.95(0.76,1.19)	0.66	1.06(0.76,1.47)	0.75	0.97(0.77,1.22)	0.76	1.01(0.71,1.43)	0.96	1.00(0.79,1.26)	0.98	1.05(0.74,1.50)	0.77
T3(upper-ERI)	1.09(0.86,1.38)	0.47	1.22(0.85,1.75)	0.29	1.14(0.89,1.48)	0.30	1.13(0.77,1.66)	0.53	1.20(0.92,1.55)	0.17	1.19(0.81,1.75)	0.39
p for linear trend		0.57		0.31		0.36		0.55		0.21		0.40
heavy drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.99(0.75,1.32)	0.97	0.97(0.43,2.18)	0.94	0.94(0.70,1.26)	0.69	0.92(0.39,2.16)	0.85	0.94(0.70,1.26)	0.68	1.01(0.43,2.39)	0.98
T3(upper-ERI)	1.63(1.23,2.16)	0.001	1.05(0.43,2.58)	0.92	1.53(1.13,2.06)	0.006	0.93(0.36,2.43)	0.89	1.53(1.13,2.08)	0.006	1.05(0.39,2.79)	0.92
p for linear trend		0.001		0.93		0.01		0.88		0.01		0.92
Japan(1+2)												
moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.63(0.42,0.94)	0.03	0.89(0.55,1.45)	0.65	0.66(0.44,1.00)	0.05	0.92(0.57,1.50)	0.74	0.66(0.44,1.00)	0.05	0.92(0.56,1.49)	0.72
T3(upper-ERI)	0.63(0.40,0.97)	0.04	1.33(0.76,2.22)	0.34	0.68(0.43,1.08)	0.10	1.39(0.80,2.39)	0.24	0.66(0.41,1.05)	0.08	1.37(0.79,2.39)	0.27
p for linear trend		0.03		0.39		0.09		0.29		0.08		0.31
heavy drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.61(0.41,0.89)	0.01	0.94(0.51,1.73)	0.85	0.61(0.41,0.90)	0.01	0.93(0.50,1.73)	0.82	0.61(0.41,0.91)	0.02	0.97(0.52,1.82)	0.92
T3(upper-ERI)	0.56(0.36,0.85)	0.007	1.09(0.54,2.21)	0.82	0.54(0.35,0.84)	0.006	1.10(0.53,2.26)	0.80	0.54(0.35,0.85)	0.008	1.17(0.56,2.44)	0.68
p for linear trend		0.005		0.84		0.005		0.84		0.006		0.71
Japan(2+4)												

moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.80(0.54,1.20)	0.29	1.00(0.61,1.65)	0.99	0.84(0.56,1.26)	0.39	0.97(0.59,1.61)	0.91	0.84(0.55,1.27)	0.40	0.99(0.60,1.65)	0.97
T3(upper-ERI)	0.58(0.37,0.90)	0.02	1.23(0.74,2.03)	0.43	0.62(0.39,0.97)	0.04	1.27(0.76,2.12)	0.36	0.59(0.37,0.95)	0.03	1.32(0.78,2.22)	0.30
p for linear trend		0.02		0.43		0.04		0.37		0.03		0.31
heavy drinker												
T1(reference)	1.00				1.00				1.00			
T2(middle)	0.79(0.54,1.15)	0.22	0.89(0.48,1.65)	0.70	0.78(0.53,1.16)	0.22	0.87(0.46,1.62)	0.65	0.78(0.53,1.17)	0.23	0.89(0.48,1.68)	0.73
T3(upper-ERI)	0.56(0.37,0.85)	0.007	0.74(0.38,1.44)	0.38	0.55(0.36,0.84)	0.006	0.74(0.38,1.45)	0.38	0.54(0.35,0.85)	0.007	0.78(0.39,1.54)	0.47
p for linear trend		0.007		0.38		0.007		0.38		0.007		0.47

Model1:Adjusted for age

Model2:Model1+ education, marital status

Model3:Model2+ working position, working hours

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-8
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	8-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10-14
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	10-14
Bias	9	Describe any efforts to address potential sources of bias	26,29
Study size	10	Explain how the study size was arrived at	10
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	14
		(*b*) Describe any methods used to examine subgroups and interactions	14
		(*c*) Explain how missing data were addressed	10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	20,26
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	10
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	15-17
		(b) Indicate number of participants with missing data for each variable of interest	10
Outcome data	15*	Report numbers of outcome events or summary measures	15-17
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	17-26

		(*b*) Report category boundaries when continuous variables were categorized	10-13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14,17, 26
Discussion			
Key results	18	Summarise key results with reference to study objectives	26
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	28-29
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	26-28
Generalisability	21	Discuss the generalisability (external validity) of the study results	30-31
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	33

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The association between work stress and health behaviours in Korean and Japanese ageing studies: a cross-sectional secondary data analysis study

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Keywords:	EPIDEMIOLOGY, MENTAL HEALTH, PUBLIC HEALTH

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The association between work stress and health behaviours in Korean and Japanese ageing studies: a cross-sectional secondary data analysis study

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Key words:

Work stress; Effort-reward Imbalance; Health Behaviour; Smoking; Drinking

Word count: 4825

ABSTRACT

Objectives: As limited research has focused on the association between work stress and health behaviours in Asian countries, this research aims to explore the effect of work stress on two health behaviours among employees aged 45 or above in two countries with aging populations, Korea and Japan.

Design: A cross-sectional study.

Setting: This secondary data analysis was based on baseline data from the Korean Longitudinal Study of Aging (KLoSA, 2006) and the Japanese Study of Aging and Retirement (JSTAR, 2007&2009).

Participants: Responders aged 45 years old who worked at baseline in KLoSA (N=3,478) or in JSTAR (N=1,504) without missing data were included in the analytical sample.

Main outcome measures: This study used logistic regression and multinomial logistic regression to investigate the association between work stress represented by the short version of the effort-reward imbalance (ERI) model and smoking (binary current smoking) and drinking (categorical volume of alcohol). In addition, socioeconomic and work-related characteristics were taken into consideration. Moreover, this research additionally examined the potential interaction between ERI and gender.

Results: Effort-reward ratio were significantly associated with smoking and drinking in the Korean analysis (N=3,478). After the model was fully adjusted,

the OR (95% CI) were 1.45 (1.17-1.80) and 1.44 (1.09-1.90), respectively. In Japan (N=1,504), the effort-reward ratio was associated with smoking (OR 1.37 (1.01-1.89)); however, ERI was not associated with drinking. No statistically significant interaction was found between ERI and gender in all models (p value of 0.82 in Korea and 0.19 in Japan).

Conclusions: The results of this study showed that work stress was statistically significantly associated with both health behaviours in the Korean sample and with smoking in Japan. These results potentially suggest that government could integrate the effort-reward-balance programmes and health promotion programmes to promote population health in these two Asian countries effectively.

Strengths and limitations of this study

- This research is the first study to use the ERI model to analyse work-related stress and health behaviours in Korea and Japan simultaneously.
- This study acquired baseline data from two reliable organisations (KEIS and RIETI), which provided a representative sample in Korea and Japan.
- The target population of this study is people aged 45 or older, who were sensitive to experiencing work stress and their health behaviours also need more attention.
- The limitation of this study is that the results may influence by recall bias since both datasets consisted of self-reporting questions.
- We were not able to test the effect of residual confounding from other risk factors like drinking subcultures due to the data limitations of the two datasets.

INTRODUCTION

In the last few decades, many public health studies have highlighted the necessity of studying unhealthy behaviours such as smoking, drinking, poor diet and sedentary lifestyles.[1,2] Scholars have observed that smoking, binge drinking, less exercise and poor diet contribute significantly to the high level of morbidity and mortality witnessed in both developed and developing countries.[1,3-4] Some risk factors, such as work stress, associated with unhealthy behaviours have not been studied extensively in the past.[5,6] Even though moderate work stress can motivate people to become more productive, excessive or unmanageable stress may increase their risks of unhealthy behaviours.[7] Research has even shown that when people are not satisfied with their work or do not receive the desired rewards for their efforts, they are more likely to experience work stress.[7] According to the stress-coping theory proposed by Lazarus and Folkman (1984) that individual responds to threat situations depending on primary appraisal and secondary appraisal. [8] Primary appraisal focused on the process of assessing potential threats posed by stressors, while secondary appraisal mainly aims to find solutions for preventing or reducing the harm from stress. [8] Therefore, health behaviours may play an important role in the secondary appraisal process.[8] It is plausible for this study to assume a possible link between work stress and

health behaviours.

Two models for work stress evaluation

Two models that are widely used in many epidemiological studies to evaluate the level of work stress include Karasek's Job Demand-Control (JDC) model[9–11] and Siegrist's Effort-Reward Imbalance (ERI) model[12–15]. The JDC model measures the magnitude of work-related stress from job demand and job control dimensions.[16] The model postulates that the most stressed people are those with high job demands combined with low work control.[17,18] However, at the core of the ERI model, there is the principle of the work contract and social reciprocity.[15] This model predicts that the combination of high efforts and low rewards would significantly increase negative emotions and may lead to a high level of work stress.[19]

Reasons for studying the association between work stress and health behaviours in Korea and Japan

Previous research has indicated that health behaviours are likely to be associated with chronic and cardiovascular diseases.[16] In addition, most of the existing studies have focused on European and North American countries, and only a few have examined the association between job stress and health behaviours in East Asian countries.[1,5]

A research utilised the ERI model to examine the relationship between work stress and smoking and found that highly stressed people were more likely to smoke.[2] Another US study, using the job strain model, produced a similar result and concluded that high strain jobs were positively associated with smoking intensity.[17] In terms of drinking, Siegrist and Rödel, in their meta-analysis of 18 articles, investigated the association between work-related stress and alcohol consumption.[6] They indicated that most of the existing articles have used the JDC model to evaluate work stress, while few articles have used the ERI model. [6] Although previous study failed to determine the association between work-related stress and drinking [20], some European studies found that work-related stress contributed to chronic heavy drinking and alcohol addiction.[18,21-22]

Middle-aged and older workers in the Asian region are particularly vulnerable to work-related stress.[23,24] Meanwhile, Korea, Japan and other East Asian countries have longer working hours than western countries.[23] In 2007, the average working hours in Korea exceeded 2300, which is the highest among OECD member countries.[25] Japan has a similar situation and Okamoto (2019) mentioned that about 30% of male and 10% of female Japanese workers have long working hours in 2015.[26] Although the governmental minister in Japan has introduced a criterion to limit overtime work, no punishment has been made.[26] Because of this and lack of relevant policies and welfare systems guaranteeing the rights of employees in Asia, it is

predicted that work-related stress might have a more serious impact on employees in East Asian countries than in Western countries.[23,24]

Two developed countries with similar economic development patterns, Japan and Korea, have witnessed an increased rate of work-related deaths in the last three decades.[27,28] Since the early 1990s, the sudden death due to heavy workload became common in both countries.[23] Scholars mentioned in their study that East Asian people may have a similar pattern of stress coping.[24] Thus, investigating the factors associated with health behaviours and work stress could provide valuable information for designing appropriate public health strategies. Meanwhile, it may also provide experience for other countries that also face increasing work stress problems.

In Korea and Japan, evidence from the analysis of the relationships between work-related stress and health behaviours is limited.[29,30] Kawakami and Haratani pointed out that compared to some European countries, Japanese people felt less satisfied with their jobs, thereby making them vulnerable to work-related stress.[31] In a Korean cohort study, job security was negatively associated with smoking status among people aged 20-59.[32] Similarly, in a cross-sectional study conducted in Japan, a considerable number of nurses with high job strains depended on heavy smoking.[30]

Additionally, Japan and South Korea have some similarities when exploring the association between work stress and healthy behaviour; however, no literature has compared the two countries simultaneously. Several Japanese

and Korean studies found that a gender difference might exist in the association between work stress and various health outcomes.[2,29,31,33] Lack of intrinsic work rewards and uncertainty about the future contributed to unhealthy behaviours more seriously in males than in females.[33,34] Moreover, previous studies also found that age, gender, education level, marital status, occupational grade, socioeconomic status and working time might be covariates that need to be controlled for when studying the relationship between work-related stress and health behaviours in Korea and Japan.[2,31,32,35]

Research gaps in work stress and health behaviours

In summary, past Japanese and Korean work-stress research focused on the relationship between work-related stress and individual health behaviours in some specific occupations, but they had yet to look at several health behaviours in the same analysis in general population samples.[2,30,31] Thus, this paper focuses on the association between work stress and two unhealthy behaviours, current smoking status and heavy alcohol consumption, in Korea and Japan by using two well-known ageing datasets, the Korean Longitudinal Study of Aging (KLoSA) and Japanese Study of Aging and Retirement (JSTAR).[6,36] To focus on a potentially vulnerable population, the target population of this research is middle-aged and older workers aged 45 years and older in Korea and Japan.[37] The short form of ERI used in the KLoSA

and JSTAR datasets, previously used and partially validated by Siegrist *et al*, will be used to measure the ERI model.[13,37,38]

The study has three objectives: (1) to examine the association between ERI and health behaviours in KLoSA and JSTAR, (2) to investigate the potential interactions between ERI and gender, and (3) to compare results from Korea and Japan and to identify any potential differences in findings.

METHODS

Study design

The KLoSA and JSTAR databases are public data with open access.[36,39] The KLoSA study was based on the random selection of men and women aged 45-98 in South Korea, excluding Jeju Island. The baseline data were obtained in 2006, and Computer Assisted Personal Interviewing (CAPI) was employed to ask questions related to work stress and health behaviours. Because of the large number of missing outcome variables in the follow-up waves, it was decided that this study would focus on cross-sectional analysis using 2006 data (wave1).

The JSTAR survey was conducted by the Research Institute of Economy, Trade and Industry Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo.[36] This survey focused on men and women aged 50-78 in 2007. According to the JSTAR first results report, the data quality was evaluated by comparing the JSTAR database with the 2005 Japanese census

data. JSTAR has a high response rate in terms of the Japanese standard, however, JSTAR datasets have various limitations, such as changing the questionnaire between waves.[36] Because of this, some variables are missing in different waves. Siegrist *et al.* pointed out that JSTAR data were not of enough quality for the longitudinal analysis of work stress, as many people dropped out in later waves.[13] Hence, this project uses the baseline JSTAR data to perform cross-sectional analyses. The data from 5 cities (Adachi, Kanazawa, Shirakawa, Sendai, and Takikawa) were collected in 2007, with an additional two cities (Tosi and Naha) obtained in 2009.

Overall, as KLoSA is a much larger study and past literature suggests that it is of better quality than JSTAR.[36,39] the present study will mainly focus on Korean results. Japanese results will then be compared with Korean results. Both studies were approved by relevant ethical committees in both countries, and all participants signed informed consent for participation in the study.

Study sample

Figures 1 and *2* present the analytical sample selection in this study. Responders who worked at wave1 in KLoSA (N=3,478) or in JSTAR (N=1,504) without missing data were included in the analytical sample. A total of 482 participants were excluded from the analysis due to missing data, which accounted for 12.2% of the total workers in the Korean baseline sample. According to the same inclusion and exclusion criteria, approximately 53.5%

(N=1,504) of responders could be used from a Japanese sample. In summary, nearly 87.8% of the Korean eligible sample was analysed, while only approximately half of the eligible Japanese sample was included in the analysis. In order to test whether the potential bias caused by the missing values would influence the results, this study applied multiple imputation (MI) method for both datasets. The samples after imputation account for 91.24% of KLoSA (N=3613) and 81.59% of JSTAR (N=2292) respectively.

(please put Figure 1 here)

(please put Figure 2 here)

Patient and Public Involvement

No patient involved

MEASUREMENTS

ERI evaluation

The ERI, the exposure of this project, was measured with three questions in KLoSA and six questions in JSTAR. The original ERI questionnaire consists of 17 items, 6 of which measure “efforts”, and the remaining items measure “rewards”.[40] Because of the limitations of the existing data, only one item is available for evaluating the effort dimension, while two items are available for assessing the reward dimension (“ERI [1+2]”) in Korea. In Japan, two and four

questions were used to measure “efforts” and “rewards” (“ERI [2+4]”), respectively. In 2012, Siegrist *et al*. demonstrated in their study that the short version and the long version of the ERI model had similar properties.[13] Hence, the results from the analysis using the ERI (1+2) model will be directly comparable between KLoSA and JSTAR samples. Meanwhile, this project used the ERI (2+4) model in a Japanese sample to carry out the sensitivity analysis. [40]

Each item in the model was answered using a 4-point Likert scale. Higher scores indicate higher efforts, while lower scores reflect more work-related stress caused by lower occupational rewards. [40] The ER ratio is calculated by adding the score of the effort and then dividing the value by the total score of reward, adjusted for the different number of items (correction factor), which is 0.5 in the three-item ERI model and six-item ERI model. Then, the categorical ERI is obtained by dividing continuous ERI into tertiles.[13] Individual questions available in both datasets are shown in Table 1, with questions requiring reverse scoring marked with an asterisk.

Table 1 Questions related to ERI measurement

	KLoSA	JSTAR
Effort	*My job requires lots of physical effort.	*My current job involves physical labour.
	N/A	*I have a lot of work and always feel time pressure.
Reward	*I feel my job is secure.	Do you think it is likely that you could lose your current job for a reason other than retirement?
	*I am satisfied with current wage.	*Considering the effort I put in and the results I produce, I am satisfied with my current pay.
	N/A	*I receive appropriate evaluation on my work from co-workers.
	N/A	*When I have problems Doing my work, colleagues give me advice and help me.

* Reverse coding

Health behaviours

The main focus of the paper in terms of health behaviours is current smoking and drinking status. Used as a binary outcome in Korea, smoking was assessed by the question “Do you smoke cigarettes now?” Participants who answered “yes” to the question were classified as current smokers, and those whose response was “No” were considered non-smokers. In Japan, participants were asked, “Do you regularly use tobacco, or did you use it in the past?” Participants were given three options: (1) Yes, I smoke now; (2) I

smoked in the past, but I have quit; (3) No, I have never smoked regularly. To ensure comparability between the two countries and considering this paper mainly studies the current smoking situation, participants who chose Option (1) were regarded as current smokers, and those who selected (2) or (3) were classified as current non-smokers.

Drinking was used as a categorical outcome in the analysis. First, the weekly alcohol consumption was calculated by multiplying the weekly drinking frequency of different drinks by their alcohol content. Next, according to the criteria of different drinking levels among men and women, this research classified individuals in Korea and Japan into three groups: non-drinkers, moderate drinkers, and heavy drinkers.[31] Males who drank between 0~210 g alcohol per week (g/wk) were considered moderate drinkers, and those who consumed more than 210 g/wk were regarded as heavy drinkers. Similarly, females who drank approximately 0~140 g/wk and more than 140 g/wk were considered moderate drinkers and heavy drinkers, respectively.[41]

Covariates

All available covariates were categorised as demographic, social and socioeconomic, and work-related characteristics. The demographic variables included age and gender. Age was divided into 5-year age groups. The social variables included education and marital status. In each country, education was classified into four categories. Marital status was classified into five

categories (married, separated, divorced, widowed, and never married) in Korea but was only available in two categories (married/not married) in Japan. The work-related variables refer to the working position and weekly working hours. In both countries, the working position was classified as non-supervisor, supervisor and self-employed. Participants were asked “How many hours do you work per week on average?” to estimate weekly working hours.

Analytical strategy

This study employed the number (%) and mean (SD) for all variables of interest to describe the characteristics of the analytical sample. The associations between exposure (categorical ER-ratio) and outcomes (smoking and drinking) were examined in both countries separately. Given that smoking is a binary variable, logistic regression was used to explore the relationship between ERI and the prevalence of smoking, and odds ratios (ORs) were estimated. Multinomial logistic regression were used to evaluate the association between ERI and drinking. In both analyses, the associations between ERI and two outcomes were analysed in the same order of adjustment. For all the analyses, four adjusted models were fitted: (Model 1) adjusted for age; (Model 2) Model 1 + gender; (Model 3) Model 2 + education, marital status; and (Model 4) Model 3 + working position, working hours. Moreover, on the basis of model 4, this study used the samples after imputation for the additional analysis and presented results in Model 5.

To compare the KLoSA and JSTAR datasets, the analytical process of JSTAR had the same sequence of adjustments of the covariates as it did in Korea. As more ERI-related questions were available in JSTAR, this study used a shorter version (ERI 1+2, same as in Korea) to make available comparisons and a longer version of the ERI model (2+4) to perform the sensitivity analysis. Additionally, this study also used ERI as a continuous variable in the sensitivity analysis since the arbitrariness of setting thresholds might exist in the categorical ERI variable.

Considering that differences might be observed in the healthy behaviours of men and women, likelihood-ratio tests were performed to examine the interactions between ERI and gender. The goodness of fit indices of the regression models, including and excluding the corresponding interaction terms, were compared. (Supplementary Table 1 and Supplementary Table 2).

All the analyses mentioned above were conducted in STATA 16-MP.

RESULTS

Characteristics of samples in Korea and Japan

Table 2 describes both analytical samples. The mean age of respondents in the Korean sample was 55.6 years (SD=8.3 years), while that of the Japanese sample was 59.2 years (SD=6.1 years). More than half of the participants had at least a high school education in both Korea (53.3%) and Japan (70.1%). A large proportion of subjects (Korea 88.6%, Japan 83.4%) were married. In both

samples, men (Korea 15.6%, Japan 8.8%) have a larger proportion in the supervisory working position than women (Korea 3.0%, Japan 2.9%).

The prevalence of smoking was 32.2% in Korea and 30.7% in Japan. In both countries, the prevalence of smoking was higher among men (Korea: 44.5%; Japan: 39.9%) than among women (Korea: 3.6%; Japan: 13.7%). While the prevalence of male heavy drinkers was 21.1% in Korea and 43.0% in Japan, it was 3.2% in Korea and 12.9% in Japan among women.

Table 2 Characteristics of the cross-sectional sample in Korea and Japan

Variables	Korea	Japan
	Number(%)	Number(%)
Sample	3,478	1,504
Age		
years mean (SD)	55.6(8.3)	59.2(6.1)
45-49years	1,055(30.3)	N/A
50-54years	787(22.6)	392(26.1)
55-59years	596(17.1)	513(34.1)
60-64years	444(12.8)	296(19.7)
65-69years	358(10.3)	191(12.7)
>70years	238(6.8)	112(7.5)
Gender		
male	2,431(69.9)	977(65.0)
female	1,047(30.1)	527(35.0)
Education		
elementary	988(28.4)	330(21.9)
middle	635(18.3)	
vocational school	N/A	120(8.0)
high	1,281(36.8)	715(47.5)
college/university	574(16.5)	339(22.5)
Marital status		
married	3,080(88.6)	1,255(83.4)
separated	36(1.0)	N/A
divorced	90(2.6)	N/A
widowed	238(6.8)	N/A
never married	34(1.00)	249(16.6)
Working position		
non-supervisor	1,366(39.3)	994(66.1)
supervisor	409(11.8)	101(6.7)
self-employed	1,703(49.0)	409(27.2)
Working hour		
hours per week(SD)	48.5(18.3)	41.7(16.4)
Location		
Seoul	536(15.4)	N/A
other places	2,942(84.6)	N/A
ERI(1+2)	3,478	1,504
lowest tertile	1,611(46.3)	543(36.1)
middle tertile	1,001(28.8)	579(38.5)
upper tertile(ERI)	866(24.9)	382(25.4)
ERI(2+4)	N/A	1,504
lowest tertile	N/A	559(37.2)
middle tertile	N/A	447(29.7)
upper tertile(ERI)	N/A	498(33.1)

Smoking		
no	2,359(67.8)	1,042(69.3)
yes	1,119(32.2)	462(30.7)
Drinking		
grams per week(SD)	201.7(289.2)	169.7(242.5)
never	1,490(42.8)	553(36.8)
moderate	1,441(41.4)	460(30.6)
heavy	547(15.7)	491(32.7)

Evaluation of potential gender effect modification

In terms of the association between ERI and smoking, no statistically significant interactions by gender were found after adjusting for age, education and marital status, work position and weekly working hours constant ($p>0.05$). The p values for the likelihood-ratio tests were 0.20 and 0.82 in Korea and Japan, respectively. For drinking, after adjusting all the covariates, no statistically significant interaction was found; the p value was 0.82 in Korea and 0.19 in Japan. The complete results of gender-specific analyses were shown in Supplementary Table 1 and Supplementary Table 2. Although there was no statistically significant gender interaction, the results were different between men and women; for example, in Korea, the associations between work stress and health behaviours were much stronger in male than female.

ERI and health behaviours in Korea

Based on KLoSA dataset (2007), the results of different adjusted models for smoking and drinking are presented in Table 3.

Smoking

As shown in Table 3, all the results were statistically significant ($p<0.05$) among people who experienced the highest level of work stress (T3-high effort and low reward) compared to T1. After adjusting for age (Model 1), the OR (95% CI) represents the ERI effect estimates on smoking behaviour, where the OR of upper ERI was 1.45 (1.22-1.73). A considerable change in the effect estimates of the upper ERI group was observed after adjusting for gender (Model 2), and the OR (95% CI) was 1.81 (1.49-2.20). Further adjustment for social and work-related covariates reduced the effects of work stress but remained statistically significant (Models 3 and 4).

Drinking

The effect estimates of ERI on drinking are presented in the bottom part of Table 3. When comparing moderate-alcohol consumers to non-alcohol consumers, it was found that the OR (95% CI) of upper ERI compared to low ERI was 1.15 (0.93-1.42) in fully adjusted Model 4, although this association was not statistically significant ($p>0.05$). Statistically significant results were obtained when examining the association between the upper tertile of ERI and heavy drinking. The OR (95%CI) in Model 4 was 1.44 (1.09-1.90). Additionally, gender takes major accounts for the largest change in ORs in Model 2.

In addition, place of residence was taken into consideration. Participants were classified as living in the capital Seoul or elsewhere. The effect estimates

of ERI did not change when the residence variable was added into the regression models. The result of the likelihood ratio test showed that residence did not play a role in the association between ERI and smoking or between ERI and drinking when comparing the model with and without residence variable, as the p-values were 0.30 in Korea and 0.87 in Japan, respectively.

In model 5, after imputed missing values, the association between work stress and health behaviours presented similar results to the model which dropped missing values. In Korea, ERI was significantly associated with current smoking and heavy drinking behaviours with the OR (95%CI) were 1.51(1.22-1.86) and 1.29(1.05-1.59) respectively.

Table 3 ORs (95% CI) of the association between ERI (1+2) and current smoking and alcohol drinking in Korea

Korea	Model1		Model2		Model3		Model4		Model5	
ERI(tertiles)	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value
Smoking										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.07(0.90,1.27)	0.42	1.38(1.14,1.67)	0.001	1.23(1.01,1.50)	0.04	1.21(0.99,1.48)	0.06	1.25(1.02,1.52)	0.03
T3(upper-ERI)	1.45(1.22,1.73)	<0.001	1.81(1.49,2.20)	<0.001	1.48(1.20,1.83)	<0.001	1.45(1.17,1.80)	0.001	1.51(1.22,1.86)	<0.001
p for linear trend		<0.001		<0.001		<0.001		0.001		<0.001
Drinking										
non-drinker	1.00		1.00		1.00		1.00		1.00	
moderate drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.83(0.70,0.99)	0.04	0.99(0.82,1.19)	0.88	0.99(0.81,1.19)	0.88	1.00(0.83,1.22)	0.98	1.26(0.87,1.83)	0.23
T3(upper-ERI)	0.96(0.80,1.16)	0.69	1.11(0.91,1.36)	0.29	1.11(0.90,1.37)	0.32	1.15(0.93,1.42)	0.21	1.20(0.80,1.81)	0.38
p for linear trend		0.45		0.34		0.36		0.24		0.34
heavy drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.81(0.63,1.03)	0.08	1.01(0.78,1.31)	0.92	0.96(0.73,1.25)	0.75	0.94(0.72,1.23)	0.66	0.97(0.80,1.18)	0.79
T3(upper-ERI)	1.32(1.04,1.67)	0.02	1.60(1.24,2.07)	<0.001	1.45(1.10,1.91)	0.008	1.44(1.09,1.90)	0.01	1.29(1.05,1.59)	0.02
p for linear trend		0.07		0.001		0.01		0.02		0.03
N	3478		3478		3478		3478		3613	

Model1:Adjusted for age
Model2:Model1+gender
Model3:Model2+education, marital status
Model4:Model3+working position, working hours
Model5:Fully adjusted model(after MI)

ERI and health behaviours in Japan

In the ERI (1+2) model, the higher ERI group had a higher proportion of smoking individuals among Japanese people. Compared to the lowest tertile ERI group, the proportion of heavy drinkers in the upper tertile ERI group (31.1%) was slightly lower than the lowest tertile ERI group (35.3%).

Smoking

Table 4 shows the relationship between ERI and current smoking and alcohol drinking behaviours in Japan. To compare the results from Japan and Korea, the results also using the ERI (1+2) evaluation. The ORs (95% CI) of smoking for the upper tertile versus the lowest tertile of ER ratio were 1.50 (1.13-2.00) when adjusted for age (Model 1) and 1.56 (1.16-2.10) when additionally adjusted for gender (Model 2). The magnitude and strength of the association decreased when additionally adjusted for education and marital status. ERI remained associated with smoking in a similar way as in KLoSA. Moreover, the imputed Japanese sample present a stronger association between job stress and smoking after adjusted for all the covariates in Model 5.

Drinking

According to Table 4, the relationship between ERI categorised into tertiles and drinking in Japan was different from the trend seen in Korea. When comparing people in different ERI groups, people with higher work stress were less likely to drink. Moreover, when adjusted for additional covariates, work stress was not statistically associated with heavy drinking behaviour and the effect estimates of ERI on drinking did not change much (Model 3 and Model 4) even used the imputed data sample (Model 5).

Table 4 ORs (95% CI) of the association between ERI (1+2) and current smoking and alcohol drinking in Japan

Japan	Model1		Model2		Model3		Model4		Model5	
ERI (tertiles)	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	OR(95%CI)	OR(95%CI)	p value	OR(95%CI)	p value
Smoking(1+2)										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.31(1.01,1.70)	0.05	1.42(1.08,1.87)	0.01	1.33(1.01,1.75)	0.04	1.32(1.00,1.75)	0.05	1.27(1.00,1.61)	0.05
T3(upper-ERI)	1.50(1.13,2.00)	0.005	1.56(1.16,2.10)	0.004	1.36(1.00,1.85)	0.05	1.37(1.01,1.89)	0.05	1.41(1.09,1.82)	0.01
p for linear trend		0.004		0.003		0.04		0.04		0.01
Drinking(1+2)										
Non-drinker	1.00		1.00		1.00		1.00		1.00	
moderate drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.74(0.55,0.99)	0.04	0.74(0.55,1.00)	0.05	0.77(0.56,1.04)	0.09	0.76(0.56,1.04)	0.08	0.87(0.68,1.12)	0.29
T3(upper-ERI)	0.90(0.65,1.24)	0.50	0.85(0.61,1.18)	0.33	0.92(0.65,1.30)	0.63	0.91(0.64,1.29)	0.59	1.02(0.78,1.34)	0.89
p for linear trend		0.40		0.26		0.53		0.50		0.93
heavy drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.71(0.54,0.94)	0.02	0.71(0.52,0.97)	0.03	0.71(0.52,0.97)	0.03	0.71(0.52,0.97)	0.03	0.79(0.61,1.03)	0.08
T3(upper-ERI)	0.78(0.57,1.07)	0.12	0.72(0.51,1.02)	0.07	0.71(0.49,1.01)	0.06	0.71(0.50,1.02)	0.07	0.76(0.57,1.02)	0.07
p for linear trend		0.08		0.05		0.04		0.05		0.06
N	1504		1504		1504		1504		2292	

Model1:Adjusted for age
Model2:Model1+gender
Model3:Model2+education, marital status
Model4:Model3+working position, working hours
Model5:Fully adjusted model(after MI)

Sensitivity analysis

The results of sensitivity analysis are shown in Table 5 and Table 6. In Table 5, using the ERI (2+4) model, the prevalence of smoking was the highest in the middle tertile. No statistically significant differences between the top and bottom ERI tertiles were found when the ERI (2+4) was used (Model 4). However, the association between ERI(2+4) and smoking was found in the data imputed model 5, which was consistent with the results of the ERI(1+2) model. The OR of smoking was significantly increased in the middle ER ratio group (Model1-4).

In terms of drinking, the results of ERI (1+2) and ERI (2+4) evaluation presented a similar trend among moderate drinkers. Additionally, the ER ratios of the upper tertile (T3) in both ERI measurements had the widest range from 1.14 to 4 and from 0.93 to 3.20, respectively. The characteristics of the drinking prevalence of the ERI (2+4) version were similar to those of the ERI (1+2) version. Meanwhile, when comparing the imputed (Model 5) and unimputed model (Model 4), the associations between ERI and heavy drinking behaviours were consistent. Because the Japanese female data might not be reliable, this study also tested the gender-specific association between ERI and health behaviours (Supplementary Table 1 and Supplementary Table 2).[19]

In Table 6, when considered ERI as a continues variable, similar results were found. There was a statistically significant association between stress and smoking in both countries. No association was found between job stress and drinking in Japan.

Table 5 ORs (95% CI) of the association between ERI (2+4) and current smoking and alcohol drinking in Japan

Japan	Model1		Model2		Model3		Model4		Model5	
ERI (tertiles)	OR(95%CI)	P value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value
Smoking(2+4)										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.49(1.13,1.96)	0.004	1.71(1.28,2.28)	<0.001	1.62(1.21,2.17)	0.001	1.59(1.18,2.14)	0.002	1.33(1.05,1.68)	0.02
T3(upper-ERI)	1.30(0.99,1.70)	0.05	1.31(0.99,1.73)	0.06	1.21(0.91,1.61)	0.19	1.17(0.87,1.58)	0.29	1.40(1.08,1.82)	0.01
p for linear trend		0.05		0.05		0.19		0.29		0.01
Drinking(2+4)										
moderate drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.79(0.58,1.07)	0.13	0.83(0.60,1.14)	0.26	0.84(0.60,1.16)	0.28	0.85(0.61,1.17)	0.32	1.02(0.80,1.31)	0.86
T3(upper-ERI)	0.89(0.66,1.20)	0.45	0.84(0.62,1.15)	0.28	0.87(0.64,1.20)	0.41	0.89(0.64,1.23)	0.47	0.99(0.75,1.31)	0.94
p for linear trend		0.44		0.27		0.40		0.47		0.96
heavy drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.75(0.56,1.02)	0.07	0.82(0.59,1.14)	0.24	0.80(0.57,1.11)	0.18	0.80(0.57,1.12)	0.19	0.85(0.66,1.10)	0.23
T3(upper-ERI)	0.78(0.58,1.05)	0.10	0.72(0.52,0.99)	0.05	0.71(0.51,0.97)	0.04	0.71(0.51,0.99)	0.04	0.72(0.53,0.97)	0.03
p for linear trend		0.09		0.04		0.04		0.04		0.03
N	1504		1504		1504		1504		2292	

Model1:Adjusted for age
Model2:Model1+gender
Model3:Model2+education, marital status
Model4:Model3+working position, working hours
Model5:Fully adjusted model(after MI)

Table 6 ORs (95% CI) of the association between ERI (continues) and current smoking and alcohol drinking

	Model1		Model2		Model3		Model4	
ERI(continues)	**OR(95%CI)**	**P value**	**OR(95%CI)**	**p value**	**OR(95%CI)**	**p value**	**OR(95%CI)**	**p value**
Korea								
Smoking	1.23(1.12,1.35)	<0.001	1.40(1.26,1.56)	<0.001	1.26(1.12,1.41)	<0.001	1.24(1.11,1.39)	<0.001
Drinking								
moderate drinker	0.94(0.77,1.16)	0.57	1.05(0.85,1.30)	0.64	0.99(0.79,1.24)	0.92	1.00(0.80,1.25)	0.98
heavy drinker	1.00(0.91,1.11)	0.92	1.11(0.99,1.24)	0.07	1.07(0.96,1.21)	0.22	1.10(0.98,1.23)	0.12
Japan (1+2)								
Smoking	1.32(1.12,1.54)	0.001	1.32(1.12,1.56)	0.001	1.21(1.03,1.45)	0.03	1.23(1.03,1.46)	0.02
Drinking								
moderate drinker	1.05(0.88,1.25)	0.58	1.01(0.84,1.21)	0.91	1.06(0.88,1.28)	0.55	1.05(0.87,1.27)	0.60
heavy drinker	0.92(0.76,1.11)	0.38	0.87(0.72,1.07)	0.19	0.86(0.70,1.06)	0.17	0.87(0.71,1.08)	0.21

Model1:Adjusted for age
Model2:Model1+gender
Model3:Model2+education, marital status
Model4:Model3+working position, working hours

DISCUSSION

Main findings and comparison with previous studies

The results indicate that a higher ERI level was positively associated with a higher prevalence of smoking and heavy drinking among Korean workers. Moreover, it was also found that work-related stress was positively associated with smoking among Japanese people. ERI was, however, negatively associated with drinking in Japan. The Japanese results for alcohol consumption contradict some previous studies.[42–45] This might be because of the report bias and selection bias. Nonetheless, the effect estimates and direction of ERI were consistent with the results from previous research in non-Asian regions.[46,47] Moreover, the results from Japan also provide some evidence for the validity of the short version of the ERI. In both analyses of JSTAR, the results using ERI (1+2) and ERI (2+4) are mostly but not entirely similar.

This study also used the likelihood-ratio test to explore the potential interaction between ERI and gender factors. No gender interaction was found in Korea or Japan. However, the associations between ERI and health behaviours were significant among only men. This may be because only a few women in both datasets were smokers or heavy drinkers. In any case, this result was consistent with a previous US study that gender was not an effect modifier in the relationship between work-related stress and health behaviours.[48] Contrary to most previous observational and experimental studies conducted in Western countries.[12] This study found that work-related stress might be a protective factor against heavy drinking among Japanese workers and that this type of stress was not statistically significantly associated

with the outcomes among Japanese females. People with the highest ERI levels had low odds (OR<1) of becoming heavy drinkers in Japan. Moreover, no significant association existed between work stress and drinking by comparing moderate drinkers to non-drinkers in Japan. In Japan and Korea, the association between work-related stress and drinking was not similar. The following explanations account for the different results in Japan. First, occupational drinking subculture could contribute to job stress. The purpose of socialisation and career development could also make individuals more or less prone to heavy drinking.[49] In several Asian countries, such as Japan, drinking alcohol is considered an essential way of engaging in social interactions.[45,50,51] The difference in drinking patterns in both Japan and Korea accounts for the disparity in the results. Most drinkers in Japan are moderate drinkers, while those in Korea have a penchant to binge drinking.[52–54] Hence, in Japan, the influence of drinking culture tends to be greater than the impact of work-related stress. However, the subculture and culture norms represent difficult elements to control in the analysis.[49] One US study illustrated that even though work-related stress had more enormous effects on males' drinking behaviours than on females' drinking behaviours, the results were usually statistically significant. [48] With a sample size of 26,946 people, this US study could be used to detect the significant association between stress and drinking.[48]

Strengths and limitations of this study

This study utilised the ERI model to evaluate work stress levels and used two national based datasets to examine the association between work stress and

health behaviours in Korea and Japan. Comparing to JDC model, ERI model concentrated on personal component rather than job dimension.[55] In previous research, only a few studies applied the ERI model to explore the association between work stress and health behaviours.[19] Of those few studies, only a small percentage focused on Asian countries. Acquired from two reliable organisations (KEIS and RIETI), the baseline data of this study were collected nationally. These data provided a representative sample in Korea and a male sample group in Japan. Although the representation of Japanese females was not very good, it has been previously stated that JSTAR provides more useful information than other existing female-based studies because many other existing studies were based on only a limited geographic area or a specific occupation or age group.[54,56–58]

This study fills the gaps in the research regarding the association between Asian workers' stress and health behaviours. Moreover, the study sample in this project comprised the middle-aged and older adults over 45 years old, who were more sensitive to the experience of work-related stress than younger people.[59] Multinomial logistic regression was applied in this project to explore the association between work stress and health behaviours, thereby providing a better way to control various potential confounders simultaneously.

However, the results of this study still have several limitations. One limitation is the small sample size of JSTAR after the selection process with the inclusion and exclusion criteria and due to the data limitation sampling weights were not calculated in the study. Another limitation is the methodological considerations. Due to the self-reporting questions nature, the results could be influenced by reporting/recall bias.[60] The recall bias indicates that variation in personal

response tendencies existed but was difficult to control.[61] Apart from the possibility of causing outcome misclassification, it is highly likely that the effect estimates of work-related stress on smoking and drinking becomes underestimated.[62,63]

The third limitation is that the effect of residual confounding from other risk factors, for example, drinking subcultures was not taken into account because of the data limitations of the two datasets.[43] It might influence the association between stress and health behaviours, a behavioural pattern that may lead to under-estimation or over-estimation of the real ORs of the association.[46,64,65] Moreover, this study could not explore the causality between work stress and health behaviours since the cross-sectional study design.

Suggestion for further research

In future research, it is pertinent to identify other datasets in Korea and Japan, evaluate associations to see whether results are consistent within national boundaries, and investigate whether any study has better alcohol data of drinking patterns to test the ERI-drinking association.

Furthermore, longitudinal studies based on a larger sample size are recommended by taking more possible confounders under control to explore the causality and clarify the relationship between work-related stress and health behaviours.

CONCLUSION

Overall, after accounting for available covariates, it was found that a higher

work stress expressed by the ERI (1+2) version was positively associated with a higher prevalence of smoking and heavy drinking among senior workers over 45 years old in Korea but was negatively associated with the prevalence of heavy drinking in Japan. The results also indicated that the effects of work stress were not significantly modified by gender. Moreover, the ERI-smoking association was similar in Korea and Japan. The ERI-drinking association, however, was different in these two countries. This may because work stress was a risk factor in Korea but a protective factor in Japan. Based on these findings, this paper recommends that governments enhance the balance between extrinsic efforts and work rewards in Asian countries. Doing so may improve the health behaviours, particularly smoking behaviour, of workers and accelerate social and economic development.

DECLARATION

Ethics approval and consent to participate

The Korean Longitudinal Study of Ageing (KLoSA) received approval from the National Statistical Office (Approval number: 33602) and the Institutional Review Board (IRB) of the Korea National Institute for Ethics Policy. The JSTAR survey was conducted by the Research Institute of Economy, the Research Institute of Economy, Trade and Industry Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo, Japan. Data from KLoSA and JSTAR are publicly available with all data anonymized. This study also received approval for the secondary use of the KLoSA and JSTAR data. All methods in this study were carried out in accordance with the relevant guidelines and regulations. Since the KLoSA and JSTAR databases have been released to the public for scientific use and no experimental treatment was conducted on either human or animal subjects in this study, ethical approval was not required for the study.

Consent for publication

Not applicable.

Availability of data and materials

The KLoSA data that support the findings of this study are available from Korea Employment Information Service (KEIS), but restrictions apply to the availability of these data, which were used under licence for the current study

and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of KEIS.

The JSTAR data that support the findings of this study are available from the Research Institute of Economy, Trade and Industry (RIETI), but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of RIETI.

Competing interests

We have read and understood BMJ policy on declaration of interests and declare that we have no competing interests.

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Authors' contributions

TC and HP designed this study. TC wrote the first draft of the manuscript, prepared the analysis and interpreted the data. HP helped with the analysis. All authors were involved in writing the manuscript, gave critical comments on multiple versions, and approve its final version.

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Not applicable.

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Figure 1 Flow chart of the Korean cross-sectional study sample selection

Figure 2 Flow chart of the Japanese cross-sectional study sample selection

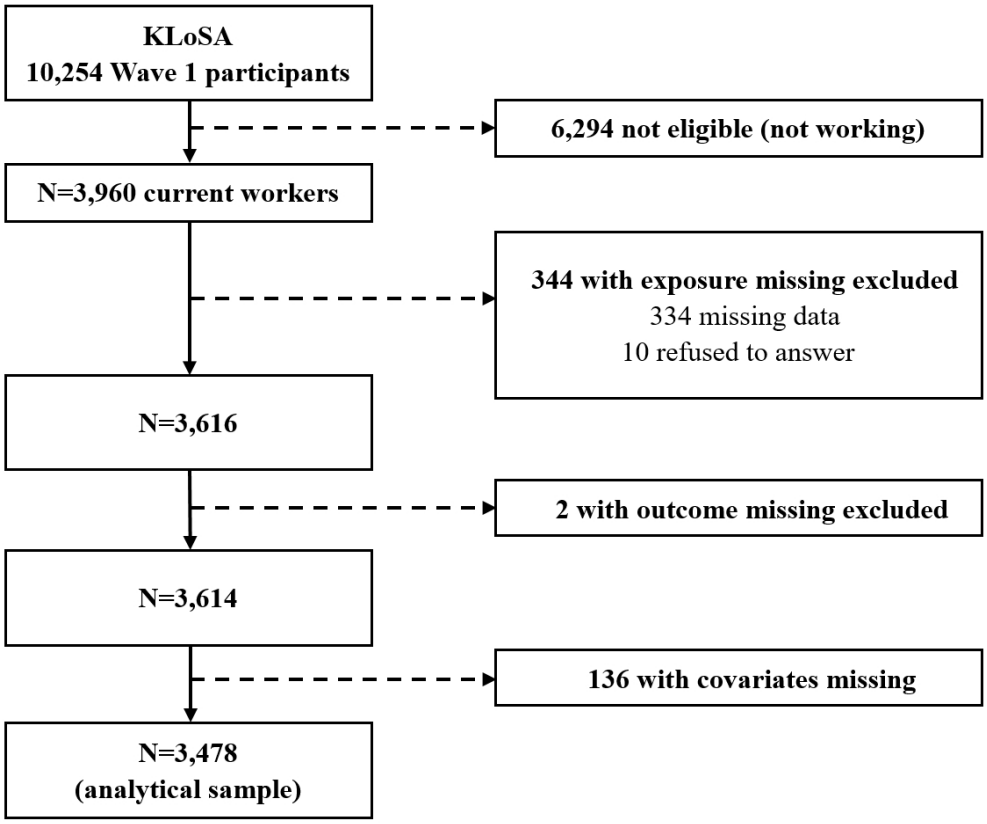

Figure 1 Flow chart of the Korean cross-sectional study sample selection

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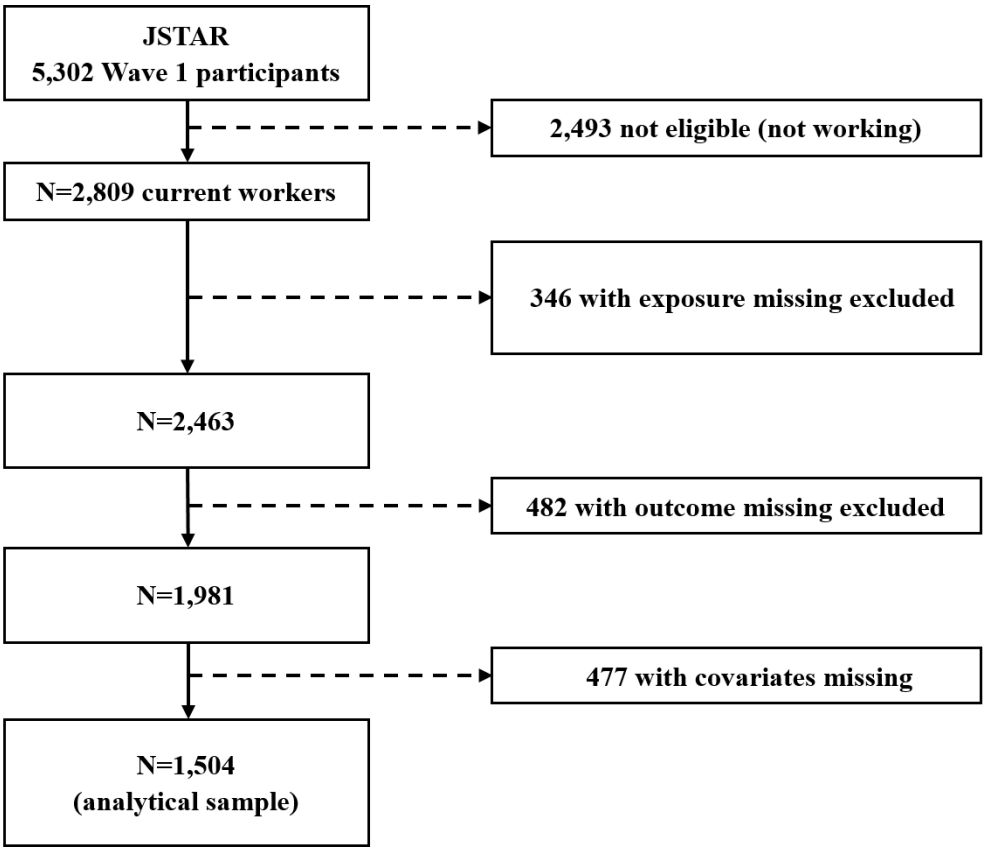

Figure 2 Flow chart of the Japanese cross-sectional study sample selection

302x260mm (96 x 96 DPI)

Supplementary Information

Additional file 1:

Supplemental Table 1. ORs (95% CI) of the association between Effort-reward Imbalance and current smokers by gender

	Model1				Model2				Model3			
	male		female		male		female		male		female	
ERI(tertiles)	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value
Korea												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.45(1.20,1.76)	<0.001	0.65(0.28,1.50)	0.31	1.26(1.03,1.55)	0.03	0.63(0.26,1.55)	0.32	1.29(1.05,1.58)	0.01	0.70(0.29,1.71)	0.44
T3(upper-ERI)	1.84(1.50,2.25)	<0.001	1.27(0.59,2.73)	0.54	1.49(1.19,1.85)	<0.001	1.03(0.44,2.42)	0.95	1.54(1.24,1.91)	<0.001	1.15(0.50,2.64)	0.75
p for linear trend		<0.001		0.64		<0.001		0.96		<0.001		0.75
N	2431		1047		2431		1047		2509		1104	
Japan(1+2)												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.44(1.0451.94)	0.02	1.34(0.73,2.46)	0.34	1.37(1.00,1.87)	0.05	1.23(0.65,2.30)	0.52	1.36(1.03,1.79)	0.03	1.07(0.66,1.73)	0.80
T3(upper-ERI)	1.62(1.16,2.27)	0.004	1.32(0.66,2.62)	0.43	1.52(1.06,2.17)	0.02	1.14(0.56,2.34)	0.72	1.58(1.17,2.14)	0.003	1.05(0.62,1.78)	0.85
p for linear trend		0.003		0.41		0.02		0.71		0.002		0.85
Japan(2+4)												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.49(1.10,2.01)	0.01	1.59(0.86.2,96)	0.14	1.41(1.03,1.93)	0.03	1.53(0.81,2.89)	0.19	1.33(1.02,1.74)	0.04	1.35(0.84,2.18)	0.21
T3(upper-ERI)	1.48(1.06,2.08)	0.02	1.33(0.69,2.55)	0.40	1.40(0.98,2.02)	0.07	1.13(0.58,2.21)	0.72	1.47(1.09,1.99)	0.01	1.32(0.76,2.28)	0.32
p for linear trend		0.01		0.39		0.05		0.73		0.01		0.29
N	977		527		977		527		1388		904	

Model1:Adjusted for age

Model2:Model1+ education, marital status, working position, working hours

Model3:Model1+ education, marital status, working position, working hours (after MI)

Supplemental Table 2. ORs (95% CI) of the association between Effort-reward Imbalance and drinking levels by gender

	Model1				Model2				Model3			
	male		female		male		female		male		female	
ERI(tertiles)	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value	OR(95%CI)	p value
Korea												
non-drinker(baseoutcome)	1.00		1.00		1.00		1.00		1.00		1.00	
moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.95(0.76,1.19)	0.66	1.06(0.76,1.47)	0.75	1.00(0.79,1.26)	0.98	1.05(0.74,1.50)	0.77	1.36(0.90,2.05)	0.14	1.00(0.33,3.06)	1.00
T3(upper-ERI)	1.09(0.86,1.38)	0.47	1.22(0.85,1.75)	0.29	1.20(0.92,1.55)	0.17	1.19(0.81,1.75)	0.39	1.26(0.80,2.00)	0.32	1.36(0.44,4.24)	0.59
p for linear trend		0.57		0.31		0.21		0.40		0.27		0.60
heavy drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.99(0.75,1.32)	0.97	0.97(0.43,2.18)	0.94	0.94(0.70,1.26)	0.68	1.01(0.43,2.39)	0.98	1.96(0.83,1.36)	0.62	0.89(0.64,1.23)	0.48
T3(upper-ERI)	1.63(1.23,2.16)	0.001	1.05(0.43,2.58)	0.92	1.53(1.13,2.08)	0.006	1.05(0.39,2.79)	0.92	1.42(1.09,1.86)	0.01	1.22(0.86,1.73)	0.26
p for linear trend		0.001		0.93		0.01		0.92		0.01		0.31
N	2431		1047		2431		1047		2509		1104	
Japan(1+2)												
moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.63(0.42,0.94)	0.03	0.89(0.55,1.45)	0.65	0.66(0.44,1.00)	0.05	0.92(0.56,1.49)	0.72	0.73(0.52,1.01)	0.06	1.07(0.72,1.60)	0.75
T3(upper-ERI)	0.63(0.40,0.97)	0.04	1.33(0.76,2.22)	0.34	0.66(0.41,1.05)	0.08	1.37(0.79,2.39)	0.27	0.89(0.62,1.27)	0.51	1.16(0.75,1.80)	0.51
p for linear trend		0.03		0.39		0.08		0.31		0.51		0.51
heavy drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.61(0.41,0.89)	0.01	0.94(0.51,1.73)	0.85	0.61(0.41,0.91)	0.02	0.97(0.52,1.82)	0.92	0.68(0.50,0.93)	0.02	1.12(0.65,1.94)	0.69
T3(upper-ERI)	0.56(0.36,0.85)	0.007	1.09(0.54,2.21)	0.82	0.54(0.35,0.85)	0.008	1.17(0.56,2.44)	0.68	0.68(0.48,0.96)	0.03	1.04(0.56,1.93)	0.91
p for linear trend		0.005		0.84		0.006		0.71		0.03		0.89

Japan(2+4)												
moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.80(0.54,1.20)	0.29	1.00(0.61,1.65)	0.99	0.84(0.55,1.27)	0.40	0.99(0.60,1.65)	0.97	0.95(0.69,1.31)	0.75	1.16(0.79,1.72)	0.45
T3(upper-ERI)	0.58(0.37,0.90)	0.02	1.23(0.74,2.03)	0.43	0.59(0.37,0.95)	0.03	1.32(0.78,2.22)	0.30	0.85(0.59,1.22)	0.37	1.22(0.77,1.93)	0.40
p for linear trend		0.02		0.43		0.03		0.31		0.37		0.37
heavy drinker												
T1(reference)	1.00				1.00				1.00		1.00	
T2(middle)	0.79(0.54,1.15)	0.22	0.89(0.48,1.65)	0.70	0.78(0.53,1.17)	0.23	0.89(0.48,1.68)	0.73	0.86(0.63,1.17)	0.34	0.78(0.46,1.32)	0.36
T3(upper-ERI)	0.56(0.37,0.85)	0.007	0.74(0.38,1.44)	0.38	0.54(0.35,0.85)	0.007	0.78(0.39,1.54)	0.47	0.66(0.47,0.94)	0.02	0.83(0.45,1.55)	0.57
p for linear trend		0.007		0.38		0.007		0.47		0.02		0.49
N	977		527		977		527		1388		904	

Model1:Adjusted for age

Model2:Model1+ education, marital status, working position, working hours

Model3:Model1+ education, marital status, working position, working hours (after MI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-9
Objectives	3	State specific objectives, including any prespecified hypotheses	9
Methods			
Study design	4	Present key elements of study design early in the paper	10-11
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	10-11
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	11
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	12-16
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	12-16
Bias	9	Describe any efforts to address potential sources of bias	29,31
Study size	10	Explain how the study size was arrived at	11-12
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	12-16
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	16
		(*b*) Describe any methods used to examine subgroups and interactions	16
		(*c*) Explain how missing data were addressed	11,16
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	11-12
		(*e*) Describe any sensitivity analyses	13,17,26
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	11
		(c) Consider use of a flow diagram	12
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	17-20
		(b) Indicate number of participants with missing data for each variable of interest	11
Outcome data	15*	Report numbers of outcome events or summary measures	17-20

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	20-28
		(*b*) Report category boundaries when continuous variables were categorized	12-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	16,20, 26-28
Discussion			
Key results	18	Summarise key results with reference to study objectives	29
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	30-32
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	30-32
Generalisability	21	Discuss the generalisability (external validity) of the study results	30-33
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	35

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The association between work stress and health behaviors in Korean and Japanese aging studies: a cross-sectional study

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The association between work stress and health behaviors in Korean and Japanese aging studies: a cross-sectional study

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Key words:

Work stress; Effort-reward Imbalance; Health Behavior; Smoking; Drinking

Word count: 4789

ABSTRACT

Objectives: Limited research has focused on the association between work stress and health behaviors in Asian countries. We aimed to explore the effect of work stress on two health behaviors among employees aged 45 years or above in two countries with aging populations, Korea and Japan.

Design: A cross-sectional study.

Setting: This secondary data analysis was conducted on baseline data from the Korean Longitudinal Study of Aging (KLoSA, 2006) and the Japanese Study of Aging and Retirement (JSTAR, 2007 & 2009).

Participants: Included in the analytical sample were 4,982 responders without missing data aged 45 years or older who reported work positions and hours (KLoSA n=3,478, JSTAR n=1,504). .

Main outcome measures: Work stress was represented by the short version of the effort-reward imbalance (ERI) model. We used logistic regression and multinomial logistic regression to investigate the association between work stress and smoking (binary current smoking) and between work stress and drinking (categorical volume of alcohol). Socioeconomic and work-related characteristics were taken into consideration, and we examined the potential interaction between ERI and gender.

Results: Work stress as measured by ERI ratio was significantly associated with both smoking and drinking in the KLoSA analysis; after the model was

fully adjusted, ORs (95% CI) were 1.45 (1.17-1.80) and 1.44 (1.09-1.90), respectively. In analysis of the data from JSTAR, the ERI ratio was associated with smoking (OR 1.37 (1.01-1.89)) but not with drinking. No statistically significant interaction was found between ERI and gender in any model (p-value of 0.82 in KLoSA data and 0.19 in JSTAR data).

Conclusions: Statistically significant associations were found between work stress and both smoking and drinking behaviors in Korea and between work stress and smoking in Japan. Government integration of effort-reward-balance programs and health promotion programs could effectively promote population health in these two Asian countries.

Strengths and limitations of this study

- This study is the first to use the ERI model to analyze work-related stress and health behaviors in Korea and Japan simultaneously.
- This study acquired baseline data from two reliable organizations (KEIS and RIETI), which provided representative samples from Korea and Japan.
- The results may be influenced by recall bias because both datasets consisted of self-reported questions.
- We were not able to test the effect of residual confounding, such as drinking subcultures, on the association between work stress and health behaviors due to the data limitations of the two datasets.

INTRODUCTION

In the last few decades, many public health studies have highlighted the necessity of studying unhealthy behaviors such as smoking, drinking, poor diet and sedentary lifestyles.[1,2] Scholars have observed that smoking, binge drinking, lack of exercise and poor diet contribute significantly to high levels of morbidity and mortality in both developed and developing countries.[1,3-4] Work stress as a potential risk factor associated with unhealthy behaviors has not been studied extensively.[5,6] Moderate work stress can motivate people to become more productive; however, excessive or unmanageable work stress may increase the risk of unhealthy behaviors.[7] A theoretical framework for the association between occupational stress and health behaviors can be found in Lazarus and Folkman (1984), who found that individuals respond to threatening events via primary and secondary appraisals.[8] While individuals engage in "primary appraisal" to evaluate potential threats, they use "secondary appraisal" to identify opportunities to prevent or reduce the detrimental consequences of stress.[8] We sought to examine whether health behaviors play an important role in this secondary appraisal process.[8]

Two models for work stress evaluation

Work stress has been shown to result from dissatisfaction with work or from lack of reward for work effort.[7] Two models widely used in many

epidemiological studies to evaluate the level of work stress are Karasek's Job Demand-Control (JDC) model[9–11] and Siegrist's Effort-Reward Imbalance (ERI) model[12–15]. The JDC model measures the magnitude of work-related stress from job demand and job control dimensions.[16] The model postulates that the most stressed people are those with high job demands combined with low work control.[17,18] In contrast, the core of the ERI model is the principle of the work contract and social reciprocity.[15] This model predicts that the combination of high effort and low reward significantly increase negative emotions and may lead to a high level of work stress.[19]

Reasons for studying the association between work stress and health behaviors in Korea and Japan

Most studies that examined the association between job stress and health behaviors have focused on European and North American countries, and only a few have focused on East Asian countries.[1,5] For example, a study from Finland adopted the ERI model to examine the relationship between work stress and smoking and found that highly stressed people were more likely to smoke.[2] A study from the United States, using the job strain model, produced a similar result and concluded that high-stress jobs were positively associated with smoking intensity.[17] In terms of drinking, Siegrist and Rödel, in their meta-analysis of 18 articles, investigated from the perspective of a Western lifestyle the association between work-related stress and alcohol

consumption.[6] They indicated that most of the articles used the JDC model to evaluate work stress, while few articles used the ERI model.[6] Although a study from Norway failed to determine the association between work-related stress and drinking,[20] some European studies found that work-related stress contributed to chronic heavy drinking and alcohol addiction.[18,21-22]

Nevertheless, middle-aged and older workers in Asia have been shown to be particularly vulnerable to work-related stress.[23,24] Further, Korea, Japan and other East Asian countries have longer working hours than Western countries.[23] In 2007, the average working hours in Korea exceeded 2300, which is the highest among OECD member countries.[25] Japan has a similar situation, and Okamoto (2019) mentioned that approximately 30% of male and 10% of female Japanese workers had long working hours in 2015.[26] Although the governmental minister in Japan has introduced a criterion to limit overtime work, no consequences have been established for overworking situations.[26] Based on these facts and the lack of relevant policies and welfare systems guaranteeing the rights of employees in Asia, it is predicted that work-related stress might have a more serious impact on employees in East Asian countries than in Western countries.[23,24]

It has been postulated that East Asian people of various countries may have similar patterns of coping with stress. [24] We know that two developed countries with similar economic development patterns, Japan and Korea, have witnessed an increased rate of work-related deaths in the last three

decades.[27,28] Since the early 1990s, sudden deaths due to heavy workloads have become common in both countries.[23] Thus, investigating the factors associated with health behaviors and work stress in Korea and Japan may provide valuable information for designing appropriate public health strategies. Further, this work may offer helpful experience for other countries that also face increasing problems related to work stress.

In Korea and Japan, evidence from the analysis of the relationships between work-related stress and health behaviors is limited.[29,30] Kawakami and Haratani pointed out that compared to some European countries, Japanese people felt less satisfied with their jobs, thereby making them vulnerable to work-related stress.[31] In a Korean cohort study, job security was negatively associated with smoking status among people aged 20-59.[32] Similarly, in a cross-sectional study conducted in Japan, a considerable number of nurses with high job strains depended on heavy smoking.[30]

Despite these similarities when exploring the association between work stress and healthy behavior in Korea and Japan, no literature has compared the two countries directly. Several Japanese and Korean studies found that a gender difference might exist in the association between work stress and various health outcomes.[2,29,31,33] Lack of intrinsic work rewards and uncertainty about the future contributed to unhealthy behaviors more seriously in males than in females.[33,34] Moreover, previous studies also found that age, gender, education level, marital status, occupational grade,

socioeconomic status and working time might be covariates that need to be controlled for when studying the relationship between work-related stress and health behaviors in Korea and Japan.[2,31,32,35]

Research gaps in work stress and health behaviors

In summary, past Japanese and Korean work-stress research focused on the relationship between work-related stress and individual health behaviors in some specific occupations, but not in general population samples.[2,30,31] Thus, this paper focuses on the association between work stress and two unhealthy behaviors, current smoking status and heavy alcohol consumption, in Korea and Japan by using two well-known aging datasets, the Korean Longitudinal Study of Aging (KLoSA) and Japanese Study of Aging and Retirement (JSTAR).[6,36] To focus on a potentially vulnerable population, the target population of this research is middle-aged and older workers, aged 45 years and above, in Korea and Japan.[37] The short form of ERI used in the KLoSA and JSTAR datasets, previously used and partially validated by Siegrist *et al.*, will be used to measure the ERI model.[13,37,38]

The study has three objectives: (1) to examine the association between ERI and health behaviors in KLoSA and JSTAR, (2) to investigate the potential interactions between ERI and gender, and (3) to compare results from Korea and Japan and to identify any potential differences in findings.

METHODS

Study design

The KLoSA and JSTAR databases are public data with open access.[36,39] The KLoSA study was based on the random selection of men and women aged 45-98 in South Korea, excluding Jeju Island. The baseline data were obtained in 2006, and computer-assisted personal interviewing (CAPI) was employed to ask questions related to work stress and health behaviors. Because of the large number of missing outcome variables in the follow-up waves, we decided to focus our study on cross-sectional analysis using 2006 data (wave 1).

The JSTAR survey was conducted by the Research Institute of Economy, Trade and Industry Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo.[36] This survey focused on men and women aged 50-78 in 2007. According to the JSTAR first results report, the data quality was evaluated by comparing the JSTAR database with the 2005 Japanese census data. JSTAR has a high response rate in terms of the Japanese standard; however, JSTAR datasets have various limitations, such as changing the questionnaire between waves.[36] Because of this, some variables are missing in different waves. Siegrist *et al.* pointed out that JSTAR data were not of sufficient quality for the longitudinal analysis of work stress, as many people dropped out in later waves.[13] Hence, our project uses the baseline JSTAR

data to perform cross-sectional analyses. The baseline data from 5 cities (Adachi, Kanazawa, Shirakawa, Sendai, and Takikawa) were collected in 2007, with an additional two cities (Tosi and Naha) obtained in 2009.

Because KLoSA is a much larger study and past literature suggests that it is of better quality than JSTAR,[36,39] the present study will focus mainly on Korean results. The Japanese results will then be compared with the Korean results. KLoSA and JSTAR were approved by relevant ethical committees in their respective countries, and all participants signed informed consent for participation in the study.

Study sample

Figures 1 and *2* present the analytical sample selection in this study. Responders in wave 1 of KLoSA (N=3,478) and JSTAR (N=1,504) who reported a working position and working hours and were not missing data were included in the analytical sample. A total of 482 participants were excluded from the analysis due to missing data, which accounted for 12.2% of the total workers in the Korean baseline sample. According to the same inclusion and exclusion criteria, approximately 53.5% (N=1,504) of responders could be used from a Japanese sample. In summary, nearly 87.8% of the eligible Korean sample was analyzed, while only approximately half of the eligible Japanese sample was included in the analysis. To test whether the potential bias caused by the missing values would influence the results, this study

applied the multiple imputation (MI) method for both datasets. The samples after imputation accounted for 91.24% of KLoSA (N=3613) and 81.59% of JSTAR (N=2292).

(please put Figure 1 here)

(please put Figure 2 here)

Patient and Public Involvement

No patients were involved in this study that used de-identified data**.**

MEASUREMENT

Effort-Reward Imbalance evaluation

ERI, the measure of work stress in this project, was measured with three questions in KLoSA and six questions in JSTAR. The ERI questionnaire used in those reports consisted of 17 items; 6 of the items measure “efforts” and the remainder measure “rewards.” [19] Because of limitations in the existing data from Korea, only one item was available for evaluating the effort dimension, while two items were available for assessing the reward dimension (“ERI [1+2]”). In data from Japan, two and four questions were used to measure “efforts” and “rewards” (“ERI [2+4]”), respectively. In 2012, Siegrist *et al*. demonstrated that the short and long versions of the ERI model had similar properties.[13] Hence, the results from the analysis using the ERI (1+2) model

will be directly comparable between KLoSA and JSTAR samples. Further, we used the ERI (2+4) model in a Japanese sample to carry out the sensitivity analysis. [40]

Responses to each item in the model used a 4-point Likert scale. A higher level of stress is indicated by higher scores on the effort scale and by lower scores on the reward scale.[40] The ERI ratio is calculated by adding the score of the effort and then dividing the value by the total score of reward, adjusted for the different number of items (correction factor), which is 0.5 in the three-item ERI model and six-item ERI model. Then, the categorical ERI is obtained by dividing the continuous ERI into tertiles.[13] Individual questions available in both datasets are shown in Table 1, with questions requiring reverse scoring marked with an asterisk.

Table 1 Questions related to ERI measurement

	KLoSA	JSTAR
Effort	*My job requires lots of physical effort.	*My current job involves physical labor.
	N/A	*I have a lot of work and always feel time pressure.
Reward	*I feel my job is secure.	*Do you think it is likely that you could lose your current job for a reason other than retirement?*
	*I am satisfied with current wage.	*Considering the effort I put in and the results I produce, I am satisfied with my current pay.
	N/A	*I receive appropriate evaluation on my work from coworkers.
	N/A	*When I have problems doing my work, colleagues give me advice and help me.

* Reverse coding

Health behaviors

The main health behaviors focused on this report are current smoking and drinking status. Measured as a binary outcome in the data from Korea, smoking was assessed by the question “Do you smoke cigarettes now?” Participants who answered “yes” were classified as current smokers, and those whose response was “No” were considered nonsmokers. The questionnaire in Japan asked, “Do you regularly use tobacco, or did you use it in the past?” Participants were given three options: (1) Yes, I smoke now; (2) I smoked in the past, but I have quit; (3) No, I have never smoked regularly. To ensure comparability between the two countries and considering that this paper mainly examines the current smoking variable, participants in Japan who chose Option (1) were regarded as current smokers, and those who selected (2) or (3) were classified as current nonsmokers.

Drinking was measured as a categorical outcome in the analysis. First, weekly alcohol consumption was calculated by multiplying the weekly drinking frequency of different drinks by their alcohol content. Next, according to the criteria of different drinking levels among men and women, we classified individuals in Korea and Japan into three groups: nondrinkers, moderate drinkers, and heavy drinkers.[31] Males who drank between 0~210 g alcohol per week (g/wk) were considered moderate drinkers, and those who consumed more than 210 g/wk were regarded as heavy drinkers. Similarly,

females who drank approximately 0~140 g/wk and more than 140 g/wk were considered moderate drinkers and heavy drinkers, respectively.[41]

Covariates

All available covariates were categorised as demographic, social and socioeconomic, and work-related characteristics. Demographic variables included age and sex. Age was divided into 5-year age groups. Social variables included education and marital status. In each country, education was classified into four categories. Marital status was classified into five categories (married, separated, divorced, widowed, and never married) in Korea but was available in only two categories (married/not married) in Japan. The work-related variables refer to working position and weekly working hours. In both countries, the working position was classified as nonsupervisor, supervisor and self-employed. Participants were asked “How many hours do you work per week on average?” to estimate weekly working hours.

Analytical strategy

This study employed the number (%) and mean (SD) for all variables of interest to describe the characteristics of the analytical sample. The associations between exposure (categorical ERI ratio) and outcomes (smoking and drinking) were examined in both countries separately. Given that smoking

is a binary variable, logistic regression was used to explore the relationship between ERI and the prevalence of smoking, and odds ratios (ORs) were estimated. Multinomial logistic regression was used to evaluate the association between ERI and drinking. In both analyses, the associations between ERI and two outcomes were analyzed in the same order of adjustment. For all the analyses, four adjusted models were fitted: (Model 1) adjusted for age; (Model 2) Model 1 + gender; (Model 3) Model 2 + education, marital status; and (Model 4) Model 3 + working position, working hours. Moreover, on the basis of model 4, we used the samples after imputation for the additional analysis and presented the results in Model 5.

To compare the KLoSA and JSTAR datasets, our analytical process of JSTAR data used the same sequence of adjustments of the covariates as used for KLoSA data. As more ERI-related questions were available in JSTAR, we used a shorter version (ERI 1+2, same as in Korea) to make available comparisons and a longer version of the ERI model (2+4) to perform the sensitivity analysis. Additionally, we used ERI as a continuous variable in the sensitivity analysis since the arbitrariness of setting thresholds might exist in the categorical ERI variable.

Considering that differences might be observed in the healthy behaviors of men and women, likelihood-ratio tests were performed to examine the interactions between ERI and gender. The goodness of fit indices of the regression models, including and excluding the corresponding interaction

terms, were compared. (Supplementary Table 1 and Supplementary Table 2).

All the analyses mentioned above were conducted in STATA 16-MP.

RESULTS

Characteristics of samples in Korea and Japan

Table 2 describes both analytical samples. The mean age of respondents in the Korean sample was 55.6 years (SD=8.3 years), while that of the Japanese sample was 59.2 years (SD=6.1 years). More than half of the participants had at least a high school education in both Korea (53.3%) and Japan (70.1%). A large proportion of subjects (Korea 88.6%, Japan 83.4%) were married. In both samples, the proportion of respondents in supervisory working positions was larger for men (Korea 15.6%, Japan 8.8%) than women (Korea 3.0%, Japan 2.9%).

The prevalence of smoking was 32.2% in Korea and 30.7% in Japan. In both countries, the prevalence of smoking was higher among men (Korea 44.5%, Japan 39.9%) than among women (Korea 3.6%, Japan 13.7%). The prevalence of male heavy drinkers was 21.1% in Korea and 43.0% in Japan; the prevalence of female heavy drinkers was 3.2% in Korea and 12.9% in Japan.

Table 2 Characteristics of the cross-sectional sample in Korea and Japan

Variables	Korea	Japan
	Number(%)	Number(%)
Sample	3,478	1,504
Age		
years mean (SD)	55.6(8.3)	59.2(6.1)
45-49years	1,055(30.3)	N/A
50-54years	787(22.6)	392(26.1)
55-59years	596(17.1)	513(34.1)
60-64years	444(12.8)	296(19.7)
65-69years	358(10.3)	191(12.7)
>70years	238(6.8)	112(7.5)
Gender		
male	2,431(69.9)	977(65.0)
female	1,047(30.1)	527(35.0)
Education		
elementary	988(28.4)	330(21.9)
middle	635(18.3)	
vocational school	N/A	120(8.0)
high	1,281(36.8)	715(47.5)
college/university	574(16.5)	339(22.5)
Marital status		
married	3,080(88.6)	1,255(83.4)
separated	36(1.0)	N/A
divorced	90(2.6)	N/A
widowed	238(6.8)	N/A
never married	34(1.00)	249(16.6)
Working position		
nonsupervisor	1,366(39.3)	994(66.1)
supervisor	409(11.8)	101(6.7)
self-employed	1,703(49.0)	409(27.2)
Working hour		
hours per week(SD)	48.5(18.3)	41.7(16.4)
Location		
Seoul	536(15.4)	N/A
other places	2,942(84.6)	N/A
ERI (1+2)	3,478	1,504
lowest tertile	1,611(46.3)	543(36.1)
middle tertile	1,001(28.8)	579(38.5)
upper tertile(ERI)	866(24.9)	382(25.4)
ERI (2+4)	N/A	1,504
lowest tertile	N/A	559(37.2)
middle tertile	N/A	447(29.7)
upper tertile(ERI)	N/A	498(33.1)

Smoking		
no	2,359(67.8)	1,042(69.3)
yes	1,119(32.2)	462(30.7)
Drinking		
grams per week(SD)	201.7(289.2)	169.7(242.5)
never	1,490(42.8)	553(36.8)
moderate	1,441(41.4)	460(30.6)
heavy	547(15.7)	491(32.7)

Evaluation of potential gender effect modification

In terms of the association between ERI and smoking, no statistically significant interactions by gender were found after adjusting for age, education marital status, work position and weekly working hours ($p>0.05$). The p-values for the likelihood-ratio tests were 0.20 and 0.82 in Korea and Japan, respectively. After adjusting for all the covariates, no statistically significant interaction was found; the p-value was 0.82 in Korea and 0.19 in Japan. The complete results of gender-specific analyses are shown in Supplementary Table 1 and Supplementary Table 2. Although there was no statistically significant gender interaction, the results were different between men and women; for example, in Korea, the associations between work stress and health behaviors were much stronger in males than females.

ERI and health behaviors in Korea

Based on the KLoSA dataset (2007), the results of different adjusted models for smoking and drinking are presented in Table 3.

Smoking

As shown in Table 3, all the results were statistically significant ($p<0.05$) among people who experienced the highest level of work stress (T3-high effort and low reward) compared to T1. After adjusting for age (Model 1), the OR (95% CI) represents the ERI effect estimates on smoking behavior, where the OR of upper ERI was 1.45 (1.22-1.73). A considerable change in the effect estimates of the upper ERI group was observed after adjusting for gender (Model 2), and the OR (95% CI) was 1.81 (1.49-2.20). Further adjustment for social and work-related covariates reduced the effects of work stress but remained statistically significant (Models 3 and 4).

Drinking

The effect estimates of ERI on drinking are presented in the bottom part of Table 3. When comparing moderate alcohol consumers to nonalcohol consumers, the OR (95% CI) of upper ERI compared to low ERI was 1.15 (0.93-1.42) in fully adjusted Model 4, although this association was not statistically significant ($p>0.05$). Statistically significant results were obtained when examining the association between the upper tertile of ERI and heavy drinking. The OR (95% CI) in Model 4 was 1.44 (1.09-1.90). Additionally, gender accounted for the largest change in ORs in Model 2.

In addition, place of residence was taken into consideration. In the data from Korea, participants were classified as living in the capital Seoul or elsewhere.

The effect estimates of ERI did not change when the residence variable was added into the regression models. The result of the likelihood ratio test showed that residence did not play a role in the association between ERI and smoking or between ERI and drinking when comparing the model with and without residence variable, as the p-values were 0.30 in Korea and 0.87 in Japan, respectively.

In model 5, after missing values were imputed, the association between work stress and health behaviors presented similar results to the model that dropped missing values. In Korea, ERI was significantly associated with current smoking and heavy drinking behaviors, with ORs (95% CI) of 1.51 (1.22-1.86) and 1.29 (1.05-1.59), respectively.

Table 3 ORs (95% CI) of the association between ERI (1+2) and current smoking and alcohol drinking in Korea

Korea	Model1		Model2		Model3		Model4		Model5	
ERI(tertiles)	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value
Smoking										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.07(0.90,1.27)	0.42	1.38(1.14,1.67)	0.001	1.23(1.01,1.50)	0.04	1.21(0.99,1.48)	0.06	1.25(1.02,1.52)	0.03
T3(upper-ERI)	1.45(1.22,1.73)	<0.001	1.81(1.49,2.20)	<0.001	1.48(1.20,1.83)	<0.001	1.45(1.17,1.80)	0.001	1.51(1.22,1.86)	<0.001
p for linear trend		<0.001		<0.001		<0.001		0.001		<0.001
Drinking										
nondrinker	1.00		1.00		1.00		1.00		1.00	
moderate drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.83(0.70,0.99)	0.04	0.99(0.82,1.19)	0.88	0.99(0.81,1.19)	0.88	1.00(0.83,1.22)	0.98	1.26(0.87,1.83)	0.23
T3(upper-ERI)	0.96(0.80,1.16)	0.69	1.11(0.91,1.36)	0.29	1.11(0.90,1.37)	0.32	1.15(0.93,1.42)	0.21	1.20(0.80,1.81)	0.38
p for linear trend		0.45		0.34		0.36		0.24		0.34
heavy drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.81(0.63,1.03)	0.08	1.01(0.78,1.31)	0.92	0.96(0.73,1.25)	0.75	0.94(0.72,1.23)	0.66	0.97(0.80,1.18)	0.79
T3(upper-ERI)	1.32(1.04,1.67)	0.02	1.60(1.24,2.07)	<0.001	1.45(1.10,1.91)	0.008	1.44(1.09,1.90)	0.01	1.29(1.05,1.59)	0.02
p for linear trend		0.07		0.001		0.01		0.02		0.03
N	3478		3478		3478		3478		3613	

Model1:Adjusted for age
Model2:Model1+gender
Model3:Model2+education, marital status
Model4:Model3+working position, working hours
Model5:Fully adjusted model (after MI)

ERI and health behaviors in Japan

In the data from Japan, using the ERI (1+2) model, the higher ERI group had a higher proportion of smoking individuals. Compared to the lowest tertile ERI group, the proportion of heavy drinkers in the upper tertile ERI group (31.1%) was slightly lower than that in the lowest tertile ERI group (35.3%).

Smoking

Table 4 shows the relationship between ERI and current smoking and alcohol drinking behaviors in Japan. To compare the results from Japan and Korea, the results also used the ERI (1+2) evaluation. The OR (95% CI) of smoking was 1.50 (1.13-2.00) when adjusted for age (Model 1) and was 1.56 (1.16-2.10) when additionally adjusted for sex (Model 2). The magnitude and strength of the association decreased when additionally adjusted for education and marital status. ERI in JSTAR remained associated with smoking in a similar way as in KLoSA. Moreover, the imputed Japanese sample presents a stronger association between job stress and smoking after adjusting for all the covariates in Model 5.

Drinking

According to Table 4, the relationship between the ERI categorized into tertiles and drinking in Japan was different from the trend seen in Korea. When comparing people in different ERI groups, people with higher work stress were less likely to drink. Moreover, when adjusted for additional covariates, work stress was not statistically associated with heavy drinking behavior, and the effect estimates of ERI on drinking did not change much (Model 3 and Model 4), even when the imputed data sample was used (Model 5).

Table 4 ORs (95% CI) of the association between ERI (1+2) and current smoking and alcohol drinking in Japan

Japan	Model1		Model2		Model3		Model4		Model5	
ERI (tertiles)	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	OR(95%CI)	OR(95%CI)	p-value	OR(95%CI)	p-value
Smoking(1+2)										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.31(1.01,1.70)	0.05	1.42(1.08,1.87)	0.01	1.33(1.01,1.75)	0.04	1.32(1.00,1.75)	0.05	1.27(1.00,1.61)	0.05
T3(upper-ERI)	1.50(1.13,2.00)	0.005	1.56(1.16,2.10)	0.004	1.36(1.00,1.85)	0.05	1.37(1.01,1.89)	0.05	1.41(1.09,1.82)	0.01
p for linear trend		0.004		0.003		0.04		0.04		0.01
Drinking(1+2)										
nondrinker	1.00		1.00		1.00		1.00		1.00	
moderate drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.74(0.55,0.99)	0.04	0.74(0.55,1.00)	0.05	0.77(0.56,1.04)	0.09	0.76(0.56,1.04)	0.08	0.87(0.68,1.12)	0.29
T3(upper-ERI)	0.90(0.65,1.24)	0.50	0.85(0.61,1.18)	0.33	0.92(0.65,1.30)	0.63	0.91(0.64,1.29)	0.59	1.02(0.78,1.34)	0.89
p for linear trend		0.40		0.26		0.53		0.50		0.93
heavy drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.71(0.54,0.94)	0.02	0.71(0.52,0.97)	0.03	0.71(0.52,0.97)	0.03	0.71(0.52,0.97)	0.03	0.79(0.61,1.03)	0.08
T3(upper-ERI)	0.78(0.57,1.07)	0.12	0.72(0.51,1.02)	0.07	0.71(0.49,1.01)	0.06	0.71(0.50,1.02)	0.07	0.76(0.57,1.02)	0.07
p for linear trend		0.08		0.05		0.04		0.05		0.06
N	1504		1504		1504		1504		2292	

Model1:Adjusted for age
Model2:Model1+gender
Model3:Model2+education, marital status
Model4:Model3+working position, working hours
Model5:Fully adjusted model (after MI)

Sensitivity analysis

The results of the sensitivity analysis are shown in Table 5 and Table 6. In Table 5, using the ERI (2+4) model, the prevalence of smoking was the highest in the middle tertile. No statistically significant differences between the top and bottom ERI tertiles were found when the ERI (2+4) was used (Model 4). However, the association between ERI (2+4) and smoking was found in the data imputed model 5, which was consistent with the results of the ERI (1+2) model. The OR of smoking was significantly increased in the middle ERI ratio group (Models 1-4).

In terms of drinking, the results of ERI (1+2) and ERI (2+4) evaluation presented a similar trend among moderate drinkers. Additionally, the ERI ratios of the upper tertile (T3) in both ERI measurements had the widest range from 1.14 to 4 and from 0.93 to 3.20, respectively. The characteristics of drinking prevalence in the ERI (2+4) version were similar to those in the ERI (1+2) version. Meanwhile, when comparing the imputed (Model 5) and unimputed (Model 4) models, the associations between ERI and heavy drinking behaviors were consistent. Because the female data from Japan might not be reliable, this study also tested the gender-specific association between ERI and health behaviors (Supplementary Table 1 and Supplementary Table 2).[19]

In Table 6, when considering ERI as a continuous variable, similar results were found. There was a statistically significant association between stress and smoking in both countries. No association was found between job stress and drinking in Japan.

Table 5 ORs (95% CI) of the association between ERI (2+4) and current smoking and alcohol drinking in Japan

Japan	Model1		Model2		Model3		Model4		Model5	
ERI (tertiles)	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value
Smoking(2+4)										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.49(1.13,1.96)	0.004	1.71(1.28,2.28)	<0.001	1.62(1.21,2.17)	0.001	1.59(1.18,2.14)	0.002	1.33(1.05,1.68)	0.02
T3(upper-ERI)	1.30(0.99,1.70)	0.05	1.31(0.99,1.73)	0.06	1.21(0.91,1.61)	0.19	1.17(0.87,1.58)	0.29	1.40(1.08,1.82)	0.01
p for linear trend		0.05		0.05		0.19		0.29		0.01
Drinking(2+4)										
moderate drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.79(0.58,1.07)	0.13	0.83(0.60,1.14)	0.26	0.84(0.60,1.16)	0.28	0.85(0.61,1.17)	0.32	1.02(0.80,1.31)	0.86
T3(upper-ERI)	0.89(0.66,1.20)	0.45	0.84(0.62,1.15)	0.28	0.87(0.64,1.20)	0.41	0.89(0.64,1.23)	0.47	0.99(0.75,1.31)	0.94
p for linear trend		0.44		0.27		0.40		0.47		0.96
heavy drinker										
T1(reference)	1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.75(0.56,1.02)	0.07	0.82(0.59,1.14)	0.24	0.80(0.57,1.11)	0.18	0.80(0.57,1.12)	0.19	0.85(0.66,1.10)	0.23
T3(upper-ERI)	0.78(0.58,1.05)	0.10	0.72(0.52,0.99)	0.05	0.71(0.51,0.97)	0.04	0.71(0.51,0.99)	0.04	0.72(0.53,0.97)	0.03
p for linear trend		0.09		0.04		0.04		0.04		0.03
N	1504		1504		1504		1504		2292	

Model1:Adjusted for age
Model2:Model1+gender
Model3:Model2+education, marital status
Model4:Model3+working position, working hours
Model5:Fully adjusted model (after MI)

Table 6 ORs (95% CI) of the association between ERI (continues) and current smoking and alcohol drinking

	Model1		Model2		Model3		Model4	
ERI(continues)	**OR(95%CI)**	**p-value**	**OR(95%CI)**	**p-value**	**OR(95%CI)**	**p-value**	**OR(95%CI)**	**p-value**
Korea								
Smoking	1.23(1.12,1.35)	<0.001	1.40(1.26,1.56)	<0.001	1.26(1.12,1.41)	<0.001	1.24(1.11,1.39)	<0.001
Drinking								
moderate drinker	0.94(0.77,1.16)	0.57	1.05(0.85,1.30)	0.64	0.99(0.79,1.24)	0.92	1.00(0.80,1.25)	0.98
heavy drinker	1.00(0.91,1.11)	0.92	1.11(0.99,1.24)	0.07	1.07(0.96,1.21)	0.22	1.10(0.98,1.23)	0.12
Japan (1+2)								
Smoking	1.32(1.12,1.54)	0.001	1.32(1.12,1.56)	0.001	1.21(1.03,1.45)	0.03	1.23(1.03,1.46)	0.02
Drinking								
moderate drinker	1.05(0.88,1.25)	0.58	1.01(0.84,1.21)	0.91	1.06(0.88,1.28)	0.55	1.05(0.87,1.27)	0.60
heavy drinker	0.92(0.76,1.11)	0.38	0.87(0.72,1.07)	0.19	0.86(0.70,1.06)	0.17	0.87(0.71,1.08)	0.21

Model1:Adjusted for age
Model2:Model1+gender
Model3:Model2+education, marital status
Model4:Model3+working position, working hours

DISCUSSION

Main findings and comparison with previous studies

Our results indicate that a higher ERI level was positively associated with a higher prevalence of smoking and heavy drinking among Korean workers and positively associated with a higher prevalence of smoking among Japanese workers. ERI was, however, negatively associated with the prevalence of drinking in Japan. The Japanese results for alcohol consumption contradict some previous studies.[42–45] This finding might be due to report bias and selection bias. Nonetheless, the effect estimates and direction of the ERI were consistent with results from previous research in non-Asian regions.[46,47] Moreover, the results from Japan also provide some evidence for the validity of the short version of the ERI. In both analyses of JSTAR, the results using ERI (1+2) and ERI (2+4) are mostly but not entirely similar.

This study also used the likelihood-ratio test to explore the potential interaction between ERI and gender factors. No gender interaction was found in Korea or Japan. However, the associations between ERI and health behaviors were significant only among men. Although this finding may be because few women in both datasets were smokers or heavy drinkers, the result is consistent with a previous US study showing that gender was not an effect modifier in the relationship between work-related stress and health behaviors,[48] a finding contrary to most previous observational and experimental studies conducted in Western countries.[12] Our study found that work-related stress might be a protective factor against heavy drinking among Japanese workers and that this type of stress was not statistically significantly associated with outcomes among Japanese females. People with the highest

ERI levels had low odds (OR<1) of becoming heavy drinkers in Japan. Moreover, no significant association existed between work stress and drinking by comparing moderate drinkers to nondrinkers in Japan.

Thus, in Japan and Korea the association between work-related stress and drinking was dissimilar. The following explanations may account for the different results in Japan. First, an occupational drinking subculture could contribute to job stress. The purposes of socialization and career development could also make individuals more or less prone to heavy drinking.[49] In several Asian countries, such as Japan, drinking alcohol is considered an essential way of engaging in social interactions.[45,50,51]

Differences in drinking patterns in Japan and Korea account for the disparity in the results. Most drinkers in Japan are moderate drinkers, while those in Korea are more likely to binge drink.[52–54] Hence, in Japan, the influence of drinking culture tends to be greater than the impact of work-related stress. Nevertheless, subculture and cultural norms are difficult elements to control in the analysis.[49] With a sample size of 26,946 people, one US study detected a statistically significant association between stress and drinking even though work-related stress had a much larger effect on male versus female drinking behaviors.[48]

Strengths and limitations of this study

This study utilized the ERI model to evaluate work stress levels and used two national-based datasets to examine the association between work stress and health behaviors in Korea and Japan. Compared to the JDC model, the ERI model concentrated on the personal component rather than the job

dimension.[55] In previous research, only a few studies have applied the ERI model to explore the association between work stress and health behaviors.[19] Of those few studies, only a small percentage focused on Asian countries. Acquired from two reliable organisations (KEIS and RIETI), the baseline data of this study were collected nationally. These data provided a representative sample in Korea and a male sample group in Japan. Although the representation of Japanese females was not ideal, it has been previously stated that JSTAR provides more useful information than other existing female-based studies because the latter were based on only a limited geographic area or a specific occupation or age group.[54,56–58]

This study fills research gaps regarding the association between Asian workers' stress and health behaviors. Moreover, the study sample in this project comprised middle-aged and older adults, 45 years of age and above, who may be more sensitive to the experience of work-related stress than younger people.[59] Multinomial logistic regression was applied in this project to explore the association between work stress and health behaviors, thereby providing a better way to control various potential confounders simultaneously.

However, the results of this study have several limitations. One limitation is the small sample size of JSTAR after the selection process with the inclusion and exclusion criteria; and, due to data limitation, sampling weights were not calculated in our study. From a methodological standpoint, the nature of the self-reported questions may influence the results through reporting/recall bias.[60] Recall bias indicates that variation in personal response tendencies existed but was difficult to control.[61] Apart from possibly causing outcome

misclassification, it is highly likely that the effect estimates of work-related stress on smoking and drinking are underestimated.[62,63]

A third limitation is that the effect of residual confounding from other risk factors, for example, drinking subcultures, was not taken into account because of data limitations of the two datasets.[43] Residual confounding might influence the association between stress and health behaviors, leading to underestimation or overestimation of the ORs of the association.[46,64,65] Moreover, due to the cross-sectional nature of the study design, the question of causality between work stress and health behaviors is not addressed at this time.

Suggestions for further research

In future research, it will be pertinent to identify other datasets in Korea and Japan to evaluate associations and determine whether the results are consistent within national boundaries, and to investigate whether any study has better data on drinking patterns to test the ERI-drinking association.

Furthermore, longitudinal studies based on a larger sample size are recommended to control for more possible confounders, to explore causality and to clarify the relationship between work-related stress and health behaviors.

CONCLUSION

Overall, after accounting for available covariates, our study found that higher work stress expressed by the ERI (1+2) version was positively associated with a higher prevalence of smoking and heavy drinking among senior workers 45

years of age and above in Korea, positively associated with a higher prevalence of smoking in Japan, but negatively associated with the prevalence of heavy drinking in Japan. The results indicated that the effects of work stress were not significantly modified by gender. The ERI-smoking association was similar in Korea and Japan. The ERI-drinking association, however, was different in these two countries. This discrepancy may be due to the action of work stress as a risk factor in Korea but as a protective factor in Japan. Based on these findings, we recommend that governments enhance the balance between extrinsic efforts and work rewards in Asian countries. Doing so may improve health behaviors, particularly smoking behavior, of workers and accelerate social and economic development.

DECLARATION

Ethics approval and consent to participate

The Korean Longitudinal Study of Aging (KLoSA) received approval from the National Statistical Office (Approval number: 33602) and the Institutional Review Board (IRB) of the Korea National Institute for Ethics Policy. The JSTAR survey was conducted by the Research Institute of Economy, the Research Institute of Economy, Trade and Industry Trade and Industry (RIETI), Hitotsubashi University, and the University of Tokyo, Japan. Data from KLoSA and JSTAR are publicly available with all data anonymized. This study also received approval for the secondary use of the KLoSA and JSTAR data. All methods in this study were carried out in accordance with the relevant guidelines and regulations. Since the KLoSA and JSTAR databases have been released to the public for scientific use and no experimental treatment was conducted on either human or animal subjects in this study, ethical approval was not required for the study.

Consent for publication

Not applicable.

Availability of data and materials

The KLoSA data that support the findings of this study are available from Korea Employment Information Service (KEIS), but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. Data are, however, available from the

authors upon reasonable request and with permission of KEIS.

The JSTAR data that support the findings of this study are available from the Research Institute of Economy, Trade and Industry (RIETI), but restrictions apply to the availability of these data, which were used under licence for the current study and are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of RIETI.

Competing interests

We have read and understood BMJ policy on declaration of interests and declare that we have no competing interests.

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Authors' contributions

TC and HP designed this study. JG and HP drafted the statistical analysis plan. TC wrote the first draft of the manuscript, prepared the analysis and interpreted the data. JG and BZ helped with the data management and HP helped with the analysis. All authors were involved in writing the manuscript, gave critical comments on multiple versions, and approved its final version.

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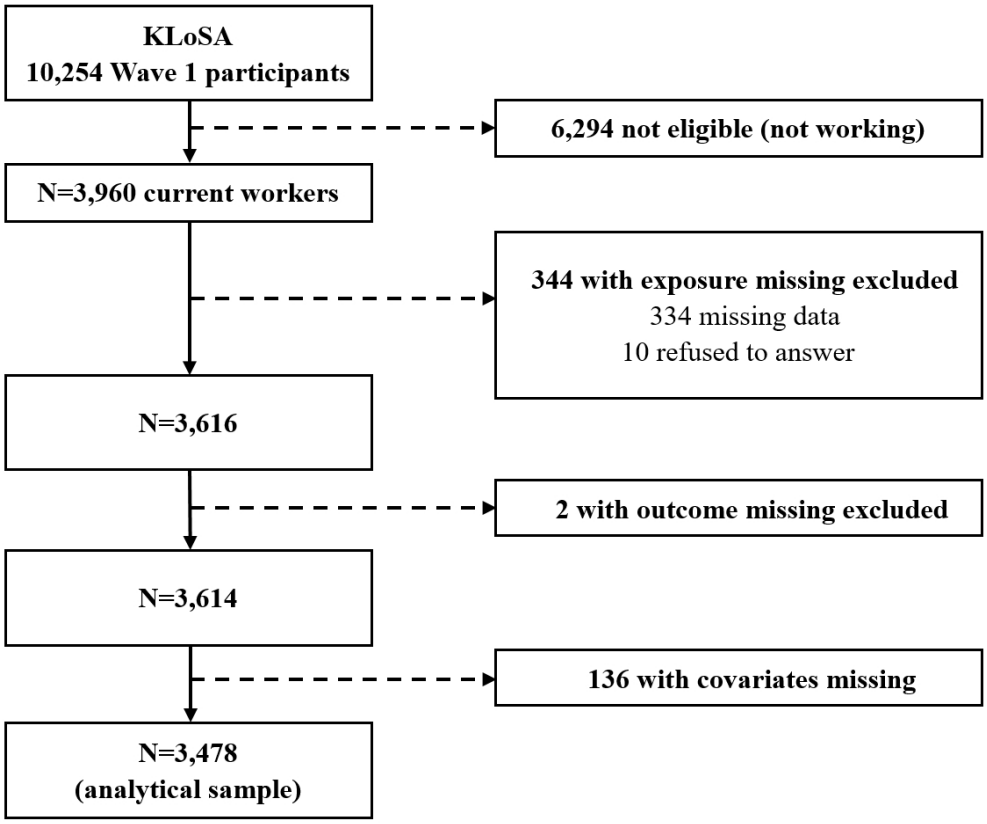
Figure 1 Flow chart of the Korean cross-sectional study sample selection

Figure 2 Flow chart of the Japanese cross-sectional study sample selection



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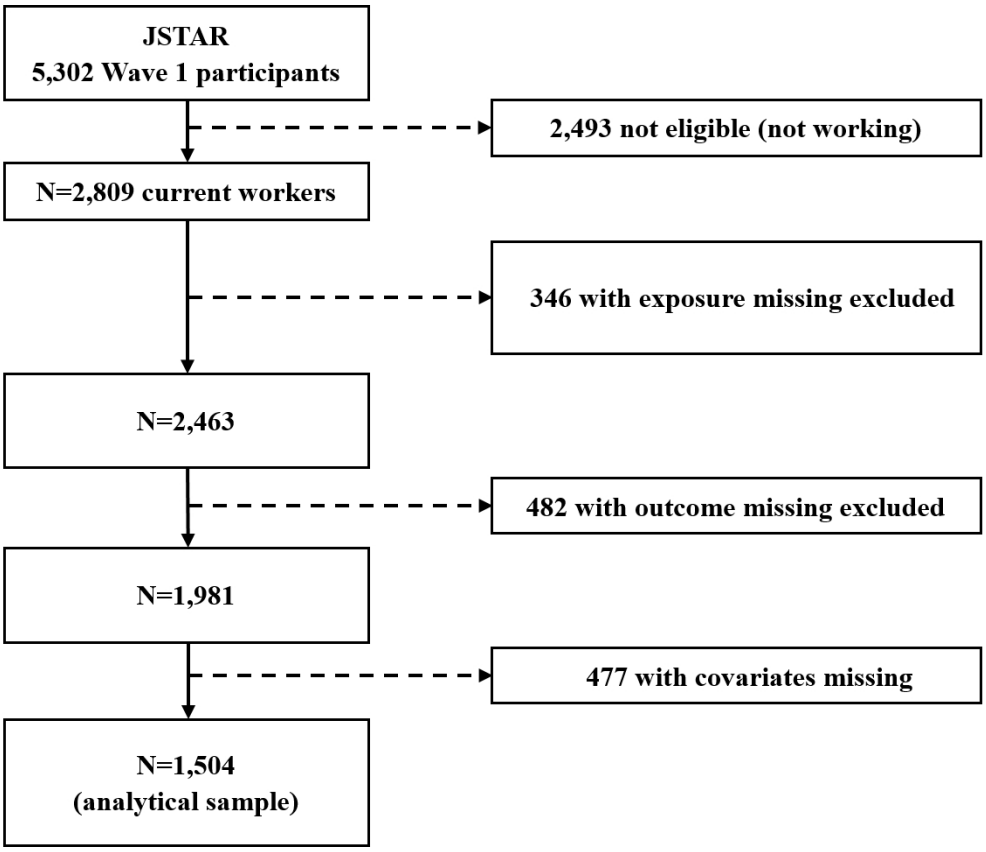

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Supplementary Information

Additional file 1:

Supplemental Table 1. ORs (95% CI) of the association between Effort-reward Imbalance and current smokers by gender

	Model1				Model2				Model3			
	male		female		male		female		male		female	
ERI(tertiles)	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value
Korea												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.45(1.20,1.76)	<0.001	0.65(0.28,1.50)	0.31	1.26(1.03,1.55)	0.03	0.63(0.26,1.55)	0.32	1.29(1.05,1.58)	0.01	0.70(0.29,1.71)	0.44
T3(upper-ERI)	1.84(1.50,2.25)	<0.001	1.27(0.59,2.73)	0.54	1.49(1.19,1.85)	<0.001	1.03(0.44,2.42)	0.95	1.54(1.24,1.91)	<0.001	1.15(0.50,2.64)	0.75
p for linear trend		<0.001		0.64		<0.001		0.96		<0.001		0.75
N	2431		1047		2431		1047		2509		1104	
Japan(1+2)												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.44(1.0451.94)	0.02	1.34(0.73,2.46)	0.34	1.37(1.00,1.87)	0.05	1.23(0.65,2.30)	0.52	1.36(1.03,1.79)	0.03	1.07(0.66,1.73)	0.80
T3(upper-ERI)	1.62(1.16,2.27)	0.004	1.32(0.66,2.62)	0.43	1.52(1.06,2.17)	0.02	1.14(0.56,2.34)	0.72	1.58(1.17,2.14)	0.003	1.05(0.62,1.78)	0.85
p for linear trend		0.003		0.41		0.02		0.71		0.002		0.85
Japan(2+4)												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	1.49(1.10,2.01)	0.01	1.59(0.86.2,96)	0.14	1.41(1.03,1.93)	0.03	1.53(0.81,2.89)	0.19	1.33(1.02,1.74)	0.04	1.35(0.84,2.18)	0.21
T3(upper-ERI)	1.48(1.06,2.08)	0.02	1.33(0.69,2.55)	0.40	1.40(0.98,2.02)	0.07	1.13(0.58,2.21)	0.72	1.47(1.09,1.99)	0.01	1.32(0.76,2.28)	0.32
p for linear trend		0.01		0.39		0.05		0.73		0.01		0.29
N	977		527		977		527		1388		904	

Model1:Adjusted for age

Model2:Model1+ education, marital status, working position, working hours

Model3:Model1+ education, marital status, working position, working hours (after MI)

Supplemental Table 2. ORs (95% CI) of the association between Effort-reward Imbalance and drinking levels by gender

	Model1				Model2				Model3			
	male		female		male		female		male		female	
ERI(tertiles)	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value	OR(95%CI)	p-value
Korea												
nondrinker(baseoutcome)	1.00		1.00		1.00		1.00		1.00		1.00	
moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.95(0.76,1.19)	0.66	1.06(0.76,1.47)	0.75	1.00(0.79,1.26)	0.98	1.05(0.74,1.50)	0.77	1.36(0.90,2.05)	0.14	1.00(0.33,3.06)	1.00
T3(upper-ERI)	1.09(0.86,1.38)	0.47	1.22(0.85,1.75)	0.29	1.20(0.92,1.55)	0.17	1.19(0.81,1.75)	0.39	1.26(0.80,2.00)	0.32	1.36(0.44,4.24)	0.59
p for linear trend		0.57		0.31		0.21		0.40		0.27		0.60
heavy drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.99(0.75,1.32)	0.97	0.97(0.43,2.18)	0.94	0.94(0.70,1.26)	0.68	1.01(0.43,2.39)	0.98	1.96(0.83,1.36)	0.62	0.89(0.64,1.23)	0.48
T3(upper-ERI)	1.63(1.23,2.16)	0.001	1.05(0.43,2.58)	0.92	1.53(1.13,2.08)	0.006	1.05(0.39,2.79)	0.92	1.42(1.09,1.86)	0.01	1.22(0.86,1.73)	0.26
p for linear trend		0.001		0.93		0.01		0.92		0.01		0.31
N	2431		1047		2431		1047		2509		1104	
Japan(1+2)												
moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.63(0.42,0.94)	0.03	0.89(0.55,1.45)	0.65	0.66(0.44,1.00)	0.05	0.92(0.56,1.49)	0.72	0.73(0.52,1.01)	0.06	1.07(0.72,1.60)	0.75
T3(upper-ERI)	0.63(0.40,0.97)	0.04	1.33(0.76,2.22)	0.34	0.66(0.41,1.05)	0.08	1.37(0.79,2.39)	0.27	0.89(0.62,1.27)	0.51	1.16(0.75,1.80)	0.51
p for linear trend		0.03		0.39		0.08		0.31		0.51		0.51
heavy drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.61(0.41,0.89)	0.01	0.94(0.51,1.73)	0.85	0.61(0.41,0.91)	0.02	0.97(0.52,1.82)	0.92	0.68(0.50,0.93)	0.02	1.12(0.65,1.94)	0.69
T3(upper-ERI)	0.56(0.36,0.85)	0.007	1.09(0.54,2.21)	0.82	0.54(0.35,0.85)	0.008	1.17(0.56,2.44)	0.68	0.68(0.48,0.96)	0.03	1.04(0.56,1.93)	0.91
p for linear trend		0.005		0.84		0.006		0.71		0.03		0.89

Japan(2+4)												
moderate drinker												
T1(reference)	1.00		1.00		1.00		1.00		1.00		1.00	
T2(middle)	0.80(0.54,1.20)	0.29	1.00(0.61,1.65)	0.99	0.84(0.55,1.27)	0.40	0.99(0.60,1.65)	0.97	0.95(0.69,1.31)	0.75	1.16(0.79,1.72)	0.45
T3(upper-ERI)	0.58(0.37,0.90)	0.02	1.23(0.74,2.03)	0.43	0.59(0.37,0.95)	0.03	1.32(0.78,2.22)	0.30	0.85(0.59,1.22)	0.37	1.22(0.77,1.93)	0.40
p for linear trend		0.02		0.43		0.03		0.31		0.37		0.37
heavy drinker												
T1(reference)	1.00				1.00				1.00		1.00	
T2(middle)	0.79(0.54,1.15)	0.22	0.89(0.48,1.65)	0.70	0.78(0.53,1.17)	0.23	0.89(0.48,1.68)	0.73	0.86(0.63,1.17)	0.34	0.78(0.46,1.32)	0.36
T3(upper-ERI)	0.56(0.37,0.85)	0.007	0.74(0.38,1.44)	0.38	0.54(0.35,0.85)	0.007	0.78(0.39,1.54)	0.47	0.66(0.47,0.94)	0.02	0.83(0.45,1.55)	0.57
p for linear trend		0.007		0.38		0.007		0.47		0.02		0.49
N	977		527		977		527		1388		904	

Model1:Adjusted for age

Model2:Model1+ education, marital status, working position, working hours

Model3:Model1+ education, marital status, working position, working hours (after MI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-8
Objectives	3	State specific objectives, including any prespecified hypotheses	8
Methods			
Study design	4	Present key elements of study design early in the paper	9-10
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	9-10
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	10-11
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11-14
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	11-14
Bias	9	Describe any efforts to address potential sources of bias	27,29
Study size	10	Explain how the study size was arrived at	10-11
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-14
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	14-15
		(*b*) Describe any methods used to examine subgroups and interactions	15
		(*c*) Explain how missing data were addressed	10,15
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	14-15
		(*e*) Describe any sensitivity analyses	11,15,24
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	11
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	16-18
		(b) Indicate number of participants with missing data for each variable of interest	10
Outcome data	15*	Report numbers of outcome events or summary measures	16-18

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	18-26
		(*b*) Report category boundaries when continuous variables were categorized	12-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	/
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11,15, 18,24
Discussion			
Key results	18	Summarise key results with reference to study objectives	27
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	28-30
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	28-30
Generalisability	21	Discuss the generalisability (external validity) of the study results	28-31
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	33

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.