



## Original Research

# The rocky road to freedom: number of countries transited during defection and risk of metabolic syndrome among North Korean Refugees in South Korea

D.W. Lee <sup>a, b</sup>, H.S. Lee <sup>c</sup>, S.G. Kim <sup>d, e</sup>, K.J. Kim <sup>d, \*\*</sup>, S.J. Jung <sup>a, f, g, h, \*</sup><sup>a</sup> Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, 03722, Republic of Korea<sup>b</sup> Institute of Health Services Research, Yonsei University, Seoul, 03722, Republic of Korea<sup>c</sup> Research Investment for Global Health Technology Fund Foundation, Seoul, 03145, Republic of Korea<sup>d</sup> Division of Endocrinology and Metabolism, Department of Internal Medicine, Korea University College of Medicine, Seoul, 02841, Republic of Korea<sup>e</sup> Department of Healthcare and Medicine for Unified Korea, Korea University College of Medicine, Seoul, 02842, Republic of Korea<sup>f</sup> Department of Public Health, Graduate School, Yonsei University, Seoul, 03722, Republic of Korea<sup>g</sup> Center for Global Health, Massachusetts General Hospital, Boston, MA, 02114, USA<sup>h</sup> Harvard Center for Population and Developmental Studies, Cambridge, MA, 02138, USA

## ARTICLE INFO

## Article history:

Received 24 November 2022

Received in revised form

22 May 2023

Accepted 15 June 2023

Available online 23 July 2023

## Keywords:

North Korean Refugees

Defection

Traumatic experience

Metabolic syndrome

Mental health

Physical health

## ABSTRACT

**Objectives:** North Korean Refugees (NKR) undergo defection, and this has been shown to impact their current health status in South Korea. However, little is understood about how the defection process is related to metabolic syndrome (MetS). This study regarded the defection process to be a quasi-measurement of traumatic experience and investigated whether defection was a risk factor for MetS among NKRs living in South Korea.

**Study design:** This cross-sectional study obtained data from the Korea University Anam Hospital in Seoul. NKRs (N = 847) voluntarily completed questionnaires and underwent at least one medical examination between October 2008 and July 2021.

**Methods:** Multivariable logistic regression models were used to evaluate whether the number of countries transited by NKRs was associated with MetS by controlling for covariates.

**Results:** The prevalence of MetS among male and female NKRs in South Korea was 12.3% and 13.3%, respectively. The highest prevalence of MetS (33.4%) was among NKRs who had transited two countries. The number of months in transit countries (mean: 49.9 ± 51.7) and period of residence in South Korea (mean: 40.9 ± 40.9 months) were also considered. NKRs who transited three countries had a higher probability of MetS (odds ratio [OR] 2.660, 95% confidence interval [CI] 1.161–6.097) than those who travelled directly to South Korea. NKRs who transited three countries and had only resided in South Korea for a short period had a higher probability of MetS (OR 3.424, 95% CI 1.149–10.208) than those who have lived in South Korea for a longer period.

**Conclusions:** Considering the social vulnerability of NKRs and consequential health problems, there is an urgent need for appropriate support from the government and society.

© 2023 The Authors. Published by Elsevier Ltd on behalf of The Royal Society for Public Health. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Introduction

Since the outbreak of the Korean War on 25 June 1950, people in North Korea have chosen to flee to South Korea for a variety of reasons. Initially, most people left North Korea for political purposes. However, in the late 1970s, South Korea had a dramatic economic growth, and the economic disparity between the two nations widened significantly. As a result, South Korea enjoyed sustained economic prosperity, whereas North Korea faced chronic economic difficulties. Consequently, the motivation

\* Corresponding author. Department of Preventive Medicine, Yonsei University College of Medicine, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea. Tel.: +82 2 2228 1573, fax: +82 2 392 8133.

\*\* Corresponding author. Division of Endocrinology and Metabolism, Department of Internal Medicine, Korea University College of Medicine, 73, Goryeodae-ro, Seongbuk-gu, Seoul 02841, Republic of Korea. Tel.: +82 2 2286 1125.

E-mail addresses: [jins0707@korea.ac.kr](mailto:jins0707@korea.ac.kr) (K.J. Kim), [sunjaejung@yuhs.ac](mailto:sunjaejung@yuhs.ac) (S.J. Jung).

behind North Korean Refugees (NKR) leaving their homeland shifted from political reasons to economic crisis. This shift triggered a large exodus of North Korean people to South Korea in pursuit of a better life. As of December 2021, the cumulative number of NKRs living in South Korea was 33,815. However, this figure does not include those who have left North Korea but are currently in transit in China or other Asian countries while trying to reach South Korea.<sup>1</sup> Most NKRs travel to neighbouring countries, such as China, Thailand, Laos, Vietnam, Mongolia, Cambodia and others, to receive assistance from the South Korean government and missionary organisations before entering South Korea.<sup>1</sup>

The process of defection from North Korea involves substantial risk, with the possibility of imprisonment in a political prison camp or even public execution.<sup>2</sup> NKRs are exposed to extreme stress due to the persistent fear of being tracked by Chinese authorities or the North Korean secret police operating in China; this level of stress remains until they receive help from the South Korean government or find a way into the country.<sup>3</sup> As a result, the physical and mental health of NKRs can deteriorate due to difficulties of securing basic necessities (e.g. food, water and shelter) to survive in the transit countries. These unique experiences of NKRs can lead to trauma, potentially manifesting as health conditions.<sup>4–7</sup> It has been shown that drastic changes in the sociocultural environments of immigrants or refugees can result in trauma, which subsequently negatively impacts their mental and physical health over time.<sup>8–10</sup>

Individuals experiencing psychological stress and mental health disorders have a higher mortality rate compared with the general population.<sup>11</sup> In particular, post-traumatic stress disorder (PTSD) has been linked with various chronic diseases, such as cardiovascular and metabolic diseases.<sup>12,13</sup> This correlation can be explained by a pathogenic process in which PTSD disrupts disease outcomes by altering the hypothalamic-pituitary-adrenal and sympathetic-adrenal-medullary stress axes.<sup>14</sup>

Studies suggest that the extreme stress of defection can traumatise NKRs, increasing their risk of developing chronic diseases due to a number of factors.<sup>15</sup> Previous research has demonstrated that endocrine disorders can be attributed to hormonal disturbances due to traumatic experiences.<sup>16</sup> Moreover, substantial research has indicated that traumatic experiences are closely associated with metabolic syndrome (MetS), which may predispose an individual to a high risk of developing cardiovascular disease (CVD) and type 2 diabetes mellitus.<sup>6,12,13,17,18</sup>

This study hypothesises that the risk of MetS in NKRs will vary depending on the severity of the trauma experienced during the defection process. It is expected that significant lifestyle and dietary changes in South Korea could lead to health problems, particularly metabolic issues that are known to be closely linked to such changes. The degree of difficulty in adaptation to their new environment is likely to be dependent on the level of stress experienced during defection and is expected to be proportional to the number of countries transited and the duration from defection until arrival in South Korea. In this study, the number of transited countries and the duration from defection to arrival in South Korea were used as proxy measurements to assess the degree of the traumatic event.

This study aimed to investigate whether the risk of MetS varies depending on the number of countries transited by NKRs and whether this association differs as a result of the duration from defection to arrival in South Korea, the period of residence in South Korea, sex and age. Lastly, this study also attempted to identify which MetS components have the strongest association with stressful defection experiences.

## Methods

### Data source and study population

The NORNS (North Korean Refugee health in South Korea) study aimed to examine the health and medical status of North Koreans who defected to live in South Korea. It included two phases, with an interval of 3.5 years from the first phase. However, since the follow-up is still ongoing, only 229 (21.6%) individuals were included in phase 2. The present research is a cross-sectional study conducted with the data obtained from the NORNS study. The NORNS study was established to evaluate diverse aspects of medical status and health determinants. The health questionnaire consisted of six domains: (1) demographic and migration information; (2) disease history; (3) mental health; (4) health-related lifestyle; (5) female reproductive health; and (6) socio-cultural adaptation.<sup>19</sup> The NORNS study has been described in detail elsewhere<sup>19</sup> and can be accessed for more information.

From an initial study population of 1059 participants who voluntarily underwent at least one medical examination between October 2008 and July 2021, 212 individuals were excluded because of missing information (age,  $n = 1$ ; body mass index [BMI],  $n = 1$ ; the period from defection until arrival,  $n = 53$ ; components of MetS,  $n = 69$ ; and 20-item Center for Epidemiologic Studies Depression Scale [CES-D-20],  $n = 88$ ).

Lifestyle variables accounted for almost 20% of missing values (alcohol drinking frequency,  $n = 152$ ; days of exercise,  $n = 173$ ). As lifestyle is known to be a major factor impacting the risk of MetS, multiple imputation, based on multivariate normal distribution, was used. It has been previously established that approximately 20% of missing values are acceptable for multiple imputation.<sup>20</sup> Accordingly, a total of 847 participants remained in the final study population (see [Appendix 1](#) in the supplementary material). This study followed the Strengthening the Reporting of Observational Studies in Epidemiology reporting guideline<sup>21</sup> (see [Appendix 2](#) in the supplementary material).

### Measures

All study participants visited the Korea University Anam Hospital located in Seoul. Participants were required to fast from midnight the day before the survey. The questionnaire took about 30 min to complete and was followed by a medical examination. The questionnaire consisted of the following sections: (1) demographic characteristics, (2) disease history, (3) mental health, (4) health-related lifestyle, and (5) women-specific conditions. The medical examination included (1) anthropometric measurements, (2) blood pressure, (3) test for atherosclerosis, and (4) biochemical measurements. To enhance the quality and validity of the questionnaire, participants were able to communicate with an in-person North Korean (defected) doctor regarding the content of the questionnaire. A more detailed description of the measurements has been previously reported.<sup>19</sup>

### Outcome: MetS

MetS was defined using the modified National Cholesterol Education Program Adult Treatment Panel III criteria by using the Asian cut-off values for waist circumference. Waist circumference varies between ethnicities and is associated with the prevalence of MetS among different ethnic groups.<sup>22–24</sup> A participant was considered to have MetS when three or more of the following five criteria were met: (1) waist circumference (men  $\geq 90$  cm and women  $\geq 85$  cm), (2) high triglyceride  $\geq 150$  mg/dL, (3) high-density lipoprotein cholesterol (HDL-C; men  $< 40$  mg/dL and women  $< 50$  mg/dL), (4) hypertension  $\geq 130/85$  mm Hg, and (5) high fasting glucose  $\geq 100$  mg/dL.

**Exposure: traumatic experiences of NKR during defection**

NKRs face poverty, political imprisonment and life-threatening situations if arrested by the police during defection.<sup>3</sup> Furthermore, prolonged insecurity because of their continued illegal status in a third country is particularly traumatic.<sup>25</sup> NKRs often transit multiple countries, and these refugees are more likely to be exposed to traumatic experiences than those who arrive directly in South Korea. Accordingly, the number of transit countries and the period from defection until arrival in South Korea were used as quasi-measurements to determine the extent of exposure of NKRs to traumatic experiences.

**Covariates**

As an important postsettlement factor, the period of residence in South Korea was considered as the moderating factor of the association between traumatic experiences during defection and MetS. In a previous study, the prevalence of mental health disorders in NKRs differed according to their duration of residence in South Korea and may have been impacted by better adaptation to a new environment over a period.<sup>26</sup> Sex, age and average monthly household income have been shown to be associated with MetS and were therefore controlled for during analysis of results in the present study.<sup>27,28</sup> In addition, pack-year of smoking, current alcohol drinking frequency ('Never had in last one year', 'Once or

less in a month', '1–4 times a month', '2–3 times a week' or '4 or more times a week') and days of vigorous-intensity exercise per week were considered as lifestyle factors. These lifestyle factors, including dietary intake, have been well-established as factors associated with the risk of MetS.<sup>29,30</sup>

A body of research has indicated that MetS could be considered as a common denominator for numerous diseases. Therefore, this study included the following comorbidities: hyperlipidaemia, stroke, myocardial infarction, angina pectoris and diabetes. Participants were categorised as having '0', '1' or '2 or more' comorbidities. CES-D-20 score (<16 = 'none/minimal'; 16–20 = 'mild'; 21–25 = 'moderate'; and >25 = 'severe') was also included as a covariate based on previous research, which showed that depressive symptoms were related to an increased risk of MetS.<sup>31,32</sup> BMI was included as a continuous variable because it is a major anthropometric factor of the current metabolic status of participants.<sup>33</sup> Total cholesterol was also included as a continuous variable, as it has been widely used for MetS risk assessment.<sup>34,35</sup>

**Statistical analyses**

Following statistical guideline, Chi-squared tests and *t*-tests were used to examine the general characteristics of the study

**Table 1**  
Characteristics of the study population.

Characteristics	Total (n = 847)		Metabolic syndrome <sup>a</sup>			
			Yes (n = 111)		No (n = 731)	
	N or mean	% or SD	N or mean	% or SD	N or mean	% or SD
<b>Number of transit countries, mean ± SD</b>	1.4	±1.0	1.4	±1.0	1.5	±0.9
3	117	(13.8%)	21	(18.9%)	96	(13.0%)
2	283	(33.4%)	33	(29.7%)	250	(34.0%)
1	278	(32.8%)	43	(38.7%)	235	(31.9%)
0 (arrived directly)	169	(20.0%)	14	(12.6%)	155	(21.1%)
Period from defection to arrival in South Korea (months), mean ± SD	49.9	±51.7	46.2	±52.0	50.4	±51.7
Period of residence in South Korea (months), mean ± SD	40.9	±40.9	48.7	±44.2	39.7	±40.3
Sex (women), n (%)	682	(80.5%)	91	(82.0%)	591	(86.7%)
Age (years), mean ± SD	42.3	±11.9	53.6	±13.0	40.6	±10.8
<b>Average monthly household income (10,000₩), mean ± SD</b>	97.7	±78.4	85.9	±72.5	99.8	±79.3
>100	148	(17.5%)	30	(27.0%)	118	(16.0%)
50–100	184	(21.7%)	32	(28.8%)	152	(20.7%)
<50	251	(29.6%)	24	(21.6%)	227	(30.8%)
Not answered	264	(31.2%)	25	(22.5%)	239	(32.5%)
Pack-year of smoking, mean ± SD	1.4	±5.7	1.7	±7.9	1.4	±5.3
<b>Alcohol drinking frequency<sup>b</sup></b>						
Never had in last 1 year	241	(28.5%)	42	(37.8%)	199	(27.0%)
Once or less in a month	166	(19.6%)	19	(17.1%)	147	(20.0%)
1–4 times a month	311	(36.7%)	35	(31.5%)	276	(37.5%)
2–3 times a week	86	(10.2%)	11	(9.9%)	75	(10.2%)
≥4 times a week	43	(5.1%)	4	(3.6%)	39	(5.3%)
Days of vigorous-intensity exercise (per week) <sup>b</sup>	1.1	±1.8	1.3	±2.0	1.1	±1.7
<b>CES-D-20 score, mean ± SD</b>	25.2	±8.1	25.9	±7.8	25.1	±8.1
None/minimal (<16)	89	(10.5%)	9	(8.1%)	80	(10.9%)
Mild (16–20)	167	(19.7%)	14	(12.6%)	153	(20.8%)
Moderate (21–25)	225	(26.6%)	38	(34.2%)	187	(25.4%)
Severe (>25)	366	(43.2%)	50	(45.0%)	316	(42.9%)
Body mass index (kg/m <sup>2</sup> ), mean ± SD	23.0	±6.0	26.1	±6.9	22.5	±5.7
Total cholesterol (mmol/L), mean ± SD	176.2	±37.3	192.1	±39.8	173.9	±36.4
<b>Number of comorbidities<sup>c</sup></b>						
0	720	(85.0%)	69	(62.2%)	651	(88.5%)
1	94	(11.1%)	26	(23.4%)	68	(9.2%)
≥2	33	(3.9%)	16	(14.4%)	17	(2.3%)

CES-D-20, 20-item Center for Epidemiologic Studies Depression Scale; SD, standard deviation.

<sup>a</sup> A participant was considered to have MetS when three or more of the following five criteria were met: (1) waist circumference (men ≥90 cm, women ≥85 cm); (2) high triglyceride ≥150 mg/dL; (3) high-density lipoprotein cholesterol (men <40 mg/dL and women <50 mg/dL); (4) hypertension ≥130/85 mm Hg; and (5) high fasting glucose ≥100 mg/dL.

<sup>b</sup> Multiple imputation was implemented for missing values.

<sup>c</sup> Hyperlipidaemia, stroke, myocardial infarction, angina pectoris and diabetes were considered as comorbidities.

population.<sup>36</sup> Frequencies and relative percentages were calculated for the categorical variables. Mean and standard deviation values were calculated for the continuous variables. Multivariable logistic regression analysis was used to estimate the odds ratios (ORs) and 95% confidence intervals (CIs). To select an optimal model, the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and  $-2 \log$  likelihood, the most prevalent model selection criteria, were used.<sup>37</sup> A lower AIC, BIC or  $-2 \log$  likelihood score indicated a better fit compared with the other candidate models. The crude model estimated the bivariate association between the number of transit countries and MetS. Model 1 was additionally adjusted for period of defection and residence in South Korea from the Crude Model. Model 2 was additionally adjusted for sex, age and monthly household income from Model 1. Model 3 was additionally adjusted for lifestyle factors and health status from Model 2. The

results showed that Model 3 had the best goodness-of-fit, including all of the foregoing covariates. Subgroup analyses were also performed for the period from defection until arrival in South Korea, the duration of residence in South Korea, sex and age group. In addition, this study also identified which components of MetS were most correlated with the exposures. All the statistical tests were two tailed, and a  $P$ -value of  $<0.05$  was considered to be significant. The analyses were performed using SAS version 9.4 software (Cary, NC).

### Ethical approval

Approval of the study was obtained from the Institutional Review Board of Korea University Medical Center (approval number: ED08023), and all participants provided written informed consent.

**Table 2**  
Odds ratio for metabolic syndrome and number of transit countries.

Characteristic	Metabolic syndrome <sup>a</sup>							
	Crude model		Model 1 <sup>b</sup>		Model 2 <sup>b</sup>		Model 3 <sup>b</sup>	
	aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI
<b>Number of transit countries</b>								
3	<b>2.42</b>	<b>(1.17–5.00)</b>	<b>2.43</b>	<b>(1.18–5.02)</b>	<b>2.79</b>	<b>(1.28–6.08)</b>	<b>2.66</b>	<b>(1.16–6.10)</b>
2	1.46	(0.76–2.83)	1.40	(0.73–2.71)	1.52	(0.75–3.10)	1.32	(0.57–3.04)
1	2.03	(1.07–3.84)	1.90	(1.00–3.60)	1.84	(0.91–3.69)	1.65	(0.75–3.64)
0 (arrived directly)	1.00		1.00		1.00		1.00	
<i>P for trend</i>	0.097		0.093		0.043		0.078	
Period from defection to arrival in South Korea (per month)			1.00	(0.99–1.00)	1.00	(0.99–1.00)	1.00	(0.99–1.00)
Period of residence in South Korea (per month)			1.01	(1.00–1.01)	1.00	(1.00–1.01)	1.00	(1.00–1.01)
<b>Sex</b>								
Men					1.00		1.00	
Women					1.59	(0.87–2.90)	1.57	(0.73–3.37)
<b>Age (years)</b>					1.09	(1.07–1.11)	1.07	(1.04–1.10)
<b>Average monthly household income, 10,000₩</b>								
>100					1.39	(0.75–2.58)	1.60	(0.83–3.10)
50–100					0.86	(0.44–1.72)	1.03	(0.46–2.29)
<50					0.82	(0.42–1.60)	0.96	(0.45–2.06)
Not answered					1.00		1.00	
Pack-year of smoking							1.01	(0.97–1.06)
<b>Alcohol drinking frequency<sup>c</sup></b>								
Never had in last 1 year							1.00	
Once or less in a month							0.73	(0.38–1.39)
1–4 times a month							0.97	(0.54–1.72)
2–3 times a week							1.18	(0.52–2.68)
≥4 times a week							0.72	(0.17–3.06)
Days of vigorous-intensity exercise (a week) <sup>c</sup>							0.97	(0.85–1.11)
<b>CES-D-20 score (0–60)</b>								
None/minimal (<16)							1.00	
Mild (16–20)							0.98	(0.38–2.54)
Moderate (21–25)							1.62	(0.67–3.92)
Severe (>25)							1.58	(0.71–3.54)
Body mass index (kg/m <sup>2</sup> )							1.12	(0.72–1.74)
Total cholesterol (mmol/L)							1.01	(1.00–1.01)
<b>Number of comorbidities<sup>d</sup></b>								
0							1.00	
1							1.57	(0.72–3.41)
≥2							3.08	(1.16–8.18)
<b>Model fitness</b>								
AIC	657.99		656.95		560.35		550.43	
BIC	676.95		685.40		612.51		664.23	
$-2 \log$ Likelihood	649.99		644.95		538.35		502.43	

AIC, Akaike Information Criterion; aOR, adjusted odds ratio; BIC, Bayesian Information Criterion; CES-D-20, 20-item Center for Epidemiologic Studies Depression Scale; CI, confidence interval; TSH, thyroid-stimulating hormone.

<sup>a</sup> A participant was considered to have MetS when three or more of the following five criteria were met: (1) waist circumference (men  $\geq 90$  cm and women  $\geq 85$  cm), (2) high triglyceride  $\geq 150$  mg/dL, (3) high-density lipoprotein cholesterol (men  $< 40$  mg/dL, women  $< 50$  mg/dL), (4) hypertension  $\geq 130/85$  mm Hg, and (5) high fasting glucose  $\geq 100$  mg/dL.

<sup>b</sup> Model 1, adjusted for defection-related characteristics; Model 2, adjusted for Model 1 and sociodemographic characteristics; Model 3, adjusted for Model 2 and health-related characteristics.

<sup>c</sup> Multiple imputation was implemented for missing values.

<sup>d</sup> Hyperlipidaemia, stroke, myocardial infarction, angina pectoris and diabetes were considered as comorbidities.

## Results

Characteristics of the 847 NKR participants living in South Korea are presented in Table 1. The study population included 682 (80.5%) women, and the mean age of participants was 42.3 ( $\pm 11.9$ ) years. Only 117 participants (13.8%) had defected to South Korea by transiting three countries. The mean period from defection until arrival in South Korea was 49.99 ( $\pm 51.7$ ) months, and the mean duration of residence in South Korea was 40.9 ( $\pm 40.9$ ) months. In total, 111 NKRs (13.1%) had MetS. There was a different distribution for those with and without MetS according to their age, sex, income, health-related characteristics (pack-year of smoking, alcohol drinking frequency, days of vigorous-intensity exercise, depressive symptoms, BMI, total cholesterol and number of comorbidities), defection process (number of transit countries, period from defection to arrival in South Korea) and period of residence in South Korea.

Table 2 summarises the associations between the number of transit countries during the defection process and MetS in different models, sequentially adjusted by the other covariates. Compared with NKRs who arrived directly in South Korea, those who transited a greater number of countries had a higher OR for MetS with marginal tendency ( $P$  for trend  $< 0.078$ , Model 3). There was a significant association between the number of transit countries and MetS with an adjusted OR (aOR: 2.66, 95% CI: 1.16–6.10) in Model 3. Older age (aOR: 1.069, 95% CI: 1.043–1.096) and two for more comorbidities (aOR: 3.075, 95% CI: 1.156–8.183) had significant associations with MetS.

Table 3 presents the results of the stratified analysis for the association between traumatic experiences during defection and MetS by defection period before arrival in South Korea (above and below the median number of months), residence period in South Korea (above and below the median number of months), sex and age group (above and below the median age). The association between the number of transit countries and MetS increased for NKRs who had a longer period of defection ( $> 32.4$  months), albeit a marginal statistical significance (transited three countries: aOR: 4.86, 95% CI: 0.89–26.60; two countries: aOR: 4.47, 95% CI: 0.91–22.02). Furthermore, for NKRs who had a longer period of defection, the higher the number of transited countries, the more likely they were to have MetS ( $P$  for trend = 0.031). However, the association between traumatic experiences during defection and MetS was stronger for NKRs who had settled in South Korea for a shorter period (aOR: 3.42, 95% CI: 1.15–10.21). Any noticeable differences in the association between traumatic experiences during

defection and MetS were not observed based on sex because there was no statistical significance, although men had a higher likelihood of MetS. NKRs aged  $> 41$  (median) years also had a higher association between the number of transit countries and MetS (aOR: 3.14, 95% CI: 1.16–8.56).

MetS component-specific association with number of transit countries is shown in Fig. 1. Among the five components of MetS, elevated fasting plasma glucose had a significant association when NKRs transited one or three (but not two) countries on their way to South Korea.

## Discussion

The primary objective of this study was to investigate the empirical association between traumatic experiences during defection and MetS among NKRs. The degree of traumatic experiences was measured by the number of countries NKRs transited and the period of defection. The study revealed that a higher number of transit countries had a significant association with the prevalence of MetS; this result was consistent across different analytical models. Furthermore, the association was found to be stronger if NKRs had a longer duration of defection, a shorter duration of residence in South Korea and if NKRs were older. Among the components of MetS, a higher fasting glucose level showed a stronger association with traumatic experiences during defection. These findings align with previous studies that have indicated an increased risk of metabolic diseases among military veterans or refugees who have experienced traumatic events.<sup>12,13,17,38</sup>

As a result of the defection process and the related traumatic experiences, NKRs exhibit a higher prevalence of physical and mental health problems before their arrival in South Korea.<sup>3,4,19</sup> Furthermore, their health status and socio-economic status are significantly lower compared with the South Korean population.<sup>1,6,19</sup> These characteristics of the NKR population are similar to those of other vulnerable minority groups, including military veterans or refugees from other countries, who have experienced severe traumatic events. Considering the substantial evidence indicating a higher risk of MetS in such vulnerable populations, it can be concluded that there is a significant association between trauma and the development of MetS. Previous research has established that trauma contributes to deteriorating health conditions, with stress being implicated as the primary pathogenic factor, particularly impacting metabolic diseases.<sup>17,18,39</sup> From a behavioural psychology perspective, stressful experiences render

**Table 3**

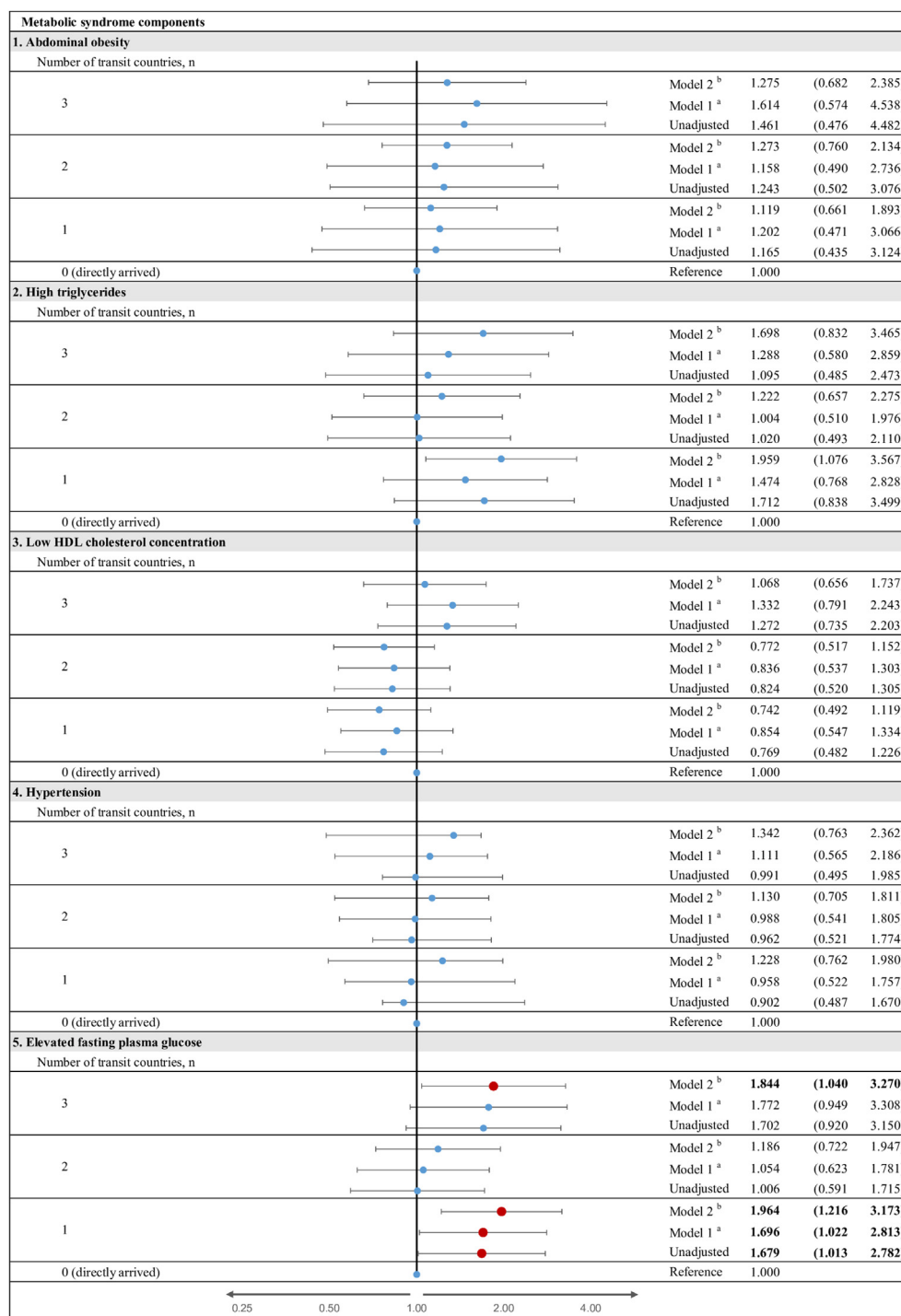
Odds ratio for metabolic syndrome and the number of transit countries, stratified by median groups of period from defection to arrival in South Korea, period of residence in South Korea, sex and age group.

Characteristics	n	Number of transit countries							<i>P</i> for trend
		3		2		1		0 (arrived directly)	
		aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	
<b>Period from defection to arrival in South Korea (months)</b>									
Median or below ( $\leq 32.43$ )	426	3.30	(0.92–11.82)	0.54	(0.17–1.70)	1.71	(0.57–5.16)	1.00	0.405
Above median ( $> 32.43$ )	421	4.86	(0.89–26.60)	4.47	(0.91–22.02)	3.15	(0.66–14.94)	1.00	<b>0.031</b>
<b>Period of residence in South Korea (months)</b>									
Median or below ( $\leq 25.56$ )	424	<b>3.42</b>	<b>(1.15–10.21)</b>	1.25	(0.43–3.57)	2.26	(0.76–6.76)	1.00	0.147
Above median ( $> 25.56$ )	423	2.70	(0.80–9.14)	1.56	(0.51–4.78)	1.40	(0.48–4.10)	1.00	0.122
<b>Sex</b>									
Men	165	5.14	(0.57–46.38)	0.88	(0.09–8.67)	3.91	(0.46–33.48)	1.00	0.490
Women	682	<b>2.65</b>	<b>(1.05–6.69)</b>	1.52	(0.57–4.04)	1.63	(0.65–4.10)	1.00	0.080
<b>Age group (years)</b>									
Median or below ( $\leq 41$ )	443	1.56	(0.22–11.20)	1.71	(0.33–8.73)	1.91	(0.38–9.47)	1.00	0.751
Above median ( $> 41$ )	404	<b>3.14</b>	<b>(1.16–8.56)</b>	1.18	(0.41–3.36)	1.62	(0.62–4.21)	1.00	0.093

aOR, adjusted odds ratio; CI, confidence interval.

Adjusted for period from defection to arrival in South Korea, period of residence in South Korea, sex, age, average monthly household income, pack-year of smoking, alcohol drinking frequency, days of vigorous-intensity exercise, 20-item Center for Epidemiologic Studies Depression Scale score, body mass index, total cholesterol and number of comorbidities.





**Fig. 1.** Odds ratio for each component of metabolic syndrome and the number of transit countries. (a) Adjusted for sociodemographic characteristics, anthropometric measurements, biochemical measurements, disease status. (b) Adjusted for Model 1 and other components of metabolic syndrome. A participant was considered to have MetS when three or more of the following five criteria were met: (1) waist circumference (men  $\geq 90$  cm, women  $\geq 85$  cm); (2) high triglyceride  $\geq 150$  mg/dL; (3) high-density lipoprotein cholesterol (men  $< 40$  mg/dL, women  $< 50$  mg/dL); (4) hypertension  $\geq 130/85$  mm Hg; and (5) high fasting glucose  $\geq 100$  mg/dL.

individuals more susceptible to chronic distress, which can lead to unhealthy habits and lifestyle choices, such as poor diet and sedentary behaviours, ultimately increasing the risk of diseases such as MetS and cardiovascular disease.<sup>39</sup> On a biochemical level, chronic stress induced by traumatic experiences can trigger overeating, simultaneous elevation of cortisol, insulin and fat angiogenesis, as well as suppression of certain anabolic hormones, all of which can contribute to metabolic dysfunction.<sup>18,40</sup>

Non-adherence to prescribed medication or self-medication among NKR is a significant issue in the management of metabolic diseases. The NKR population often holds different perspectives and values regarding medical treatment, making it challenging for healthcare providers to effectively address their needs.<sup>41,42</sup> In addition, NKRs' experience of living in other countries for several months or years before relocating to South Korea has led to a reliance on self-medication.<sup>41</sup> The difficulty in medication treatment among NKRs

could exacerbate the association between traumatic experiences during defection and an increased risk of MetS.

Overall, previous studies have consistently identified unhealthy lifestyles and diets as prominent risk factors for MetS. Therefore, it is crucial to provide appropriate support programmes for cultural adaptation and nutrition education for NKR. This study observed that NKRs who had been residing in South Korea for a shorter period exhibited a stronger correlation between traumatic experiences and the development of MetS. This may be because of the fact that NKRs who have gone through multiple countries and have not yet fully adapted to South Korea (due to a shorter period of adjustment) are more prone to adopting unhealthy lifestyles, such as poor dietary habits and non-compliance with medical treatment, leading to metabolic problems. In other words, the association between the extent of traumatic experiences and MetS implies not only a health problem but also, from a broader perspective, difficulties in adaptation that NKRs face in relation to South Korean society and lifestyle.

This study has several limitations. First, the NORNS data are non-representative of all NKRs living in South Korea, as it initially recruited NKRs aged  $\geq 30$  years residing in Seoul, the capital city of South Korea. In addition, no statistical sampling methods were used for the study participants, which may introduce a selection bias in the findings related to health. However, it has been reported that approximately one-third of the NKR population resides in Seoul.<sup>19</sup> Second, with the exceptions of medical examinations for anthropometric measurements, blood pressure, atherosclerosis and various biochemical measurements, the other data were self-reported. As a result, there may be a recall bias in certain major variables that heavily rely on memory, such as periods of defection. Third, there were no questions that specifically captured the type and severity of traumas experienced by NKRs, or their medication status. Fourth, certain analyses could not be combined because of the small size of the study population. Consequently, subgroup analysis was used by categorising the groups based on median values. In addition, data on thyroid-stimulating hormone and free thyroxine 4 could not be included because of a large number of missing values. However, this study attempted to analyse the maximum possible number of study participants by using multiple imputation for several lifestyle variables. Fifth, because the study had a cross-sectional design, it was not possible to infer causal relationships. Nonetheless, it is important to emphasise that the findings of this study provide meaningful evidence regarding the trauma experienced by NKRs and its persistence, even after their arrival in South Korea, as well as its negative impact on their metabolism. Future studies would benefit from longitudinal data with a sufficiently large study population to confirm the causal mechanisms linking traumatic experiences to previously identified or newly revealed health problems.

#### *Policy implications*

In general, it is crucial to prioritise policy interventions for vulnerable population groups. Considering that NKRs in South Korea belong to a socio-economically vulnerable population, it is necessary to enable them to lead a normal social life as valued members of society. In particular, adequate social support from the government and society is needed to provide continuous opportunities for their adaptation to the unfamiliar environment in South Korea. The policy implications of this study are significant, as it highlights that the psychological stress experienced during the process of defection among NKRs could potentially lead to metabolic health problems, which can have a significant impact on disease burden and quality of life. Therefore, it may be necessary to consider providing appropriate mental and healthcare support to NKRs during their adaptation to life in South Korea.

#### *Conclusions*

The number of countries transited by NKRs during the defection process and the duration of their transit were considered as quasi-measurements of traumatic experience, and they were found to be associated with the probability of MetS. Further studies are required to validate the association between chronic stress and MetS while also exploring the potential biological pathways linking migration and MetS. In addition, considering the social vulnerability of NKRs and its impact on health problems, it is crucial to provide appropriate support from the government and society.

#### *Author statements*

##### *Ethical approval*

Approval of the study was obtained from the Institutional Review Board of Korea University Medical Center (approval number: ED08023), and all participants provided written informed consent.

##### *Funding*

S.J.J. and D.W.L. are supported by the SongAm Memorial Research Fund (grant number is not applicable) through Yonsei University College of Medicine and National Research Foundation of Korea grant funded by the Ministry of Science and ICT (grant number 2020R1C1C1003502).

##### *Competing interests*

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

##### *Data availability*

The data sets generated during and/or analysed during the present study are available from the corresponding authors on reasonable request.

##### *Author contributions*

D.W.L. contributed to conceptualisation, methodology, data curation, formal analysis, investigation, visualisation and writing, reviewing, and editing the article. H.S.L. reviewed and edited the article. S.G.K. contributed to resources and conceptualisation. K.J.K. contributed to project administration, supervision, conceptualisation and reviewing and editing the article. S.J.J. contributed to project administration, supervision, conceptualisation, methodology, reviewing and editing the article and funding acquisition.

##### *Acknowledgements*

The authors would like to acknowledge the North Korean refugees who participated in the North Korea Refugee Health in South Korea (NORNS) study, as well as the medical doctors, nurses and volunteers who contributed to the health examinations of these refugees.

#### **Appendix A. Supplementary data**

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2023.06.019>.

## References

- Ministry of Unification. *Statistics of North Korean defectors entering South Korea*. 2022.
- Haggard S, Noland M. *Repression and punishment in North Korea: survey of prison camp experiences*. 2009.
- Jeon W, Hong C, Lee C, Kim DK, Han M, Min S. Correlation between traumatic events and posttraumatic stress disorder among North Korean defectors in South Korea. *J Trauma Stress* 2005;**18**:147–54.
- Song B-A, Yoo S-Y, Kang H-Y, Byeon S-H, Shin S-H, Hwang E-J, et al. Post-traumatic stress disorder, depression, and heart-rate variability among North Korean defectors. *Psychiat Invest* 2011;**8**:297.
- Jeon WT, Eom JS, Min SK. A 7-year follow-up study on the mental health of North Korean defectors in South Korea. *J Trauma Stress* 2013;**26**:158–64.
- Kim YJ, Lee YH, Lee YJ, Kim KJ, An JH, Kim NH, et al. Prevalence of metabolic syndrome and its related factors among North Korean refugees in South Korea: a cross-sectional study. *BMJ Open* 2016;**6**:e010849.
- Jo EJ, Cho HM, Choi EJ. Influence of trauma experiences and social adjustment on health-related quality of life in North Korean defectors. *J Korean Acad Community Health Nurs* 2018;**29**:488–98.
- Marshall GN, Schell TL, Elliott MN, Berthold SM, Chun C-A. Mental health of Cambodian refugees 2 decades after resettlement in the United States. *JAMA* 2005;**294**:571–9.
- Westermeyer J, Vang TF, Neider J. Migration and mental health among Hmong refugees: association of pre- and postmigration with self-rating scales. *J Nerv Ment Dis* 1983;**171**(2):92–6.
- Hollifield M, Warner TD, Lian N, Krakow B, Jenkins JH, Kesler J, et al. Measuring trauma and health status in refugees: a critical review. *JAMA* 2002;**288**: 611–21.
- Robinson KL, McBeth J, Macfarlane GJ. Psychological distress and premature mortality in the general Population: a prospective study. *Ann Epidemiol* 2004;**14**:467–72.
- Ahmadi N, Hajsadeghi F, Mirshakarlo HB, Budoff M, Yehuda R, Ebrahimi R. Post-traumatic stress disorder, coronary atherosclerosis, and mortality. *Am J Cardiol* 2011;**108**:29–33.
- Dedert EA, Calhoun PS, Watkins LL, Sherwood A, Beckham JC. Posttraumatic stress disorder, cardiovascular, and metabolic disease: a review of the evidence. *Ann Behav Med* 2010;**39**:61–78.
- Boscarino JA. Posttraumatic stress disorder and physical illness: results from clinical and epidemiologic studies. *Ann N Y Acad Sci* 2004;**1032**:141–53.
- Alonzo AA. The experience of chronic illness and post-traumatic stress disorder: the consequences of cumulative adversity. *Soc Sci Med* 2000;**50**:1475–84.
- Pervanidou P, Chrousos GP. Neuroendocrinology of post-traumatic stress disorder. *Prog Brain Res* 2010;**182**:149–60.
- Wolf EJ, Bovin MJ, Green JD, Mitchell KS, Stoop TB, Barretto KM, et al. Longitudinal associations between post-traumatic stress disorder and metabolic syndrome severity. *Psychol Med* 2016;**46**:2215–26.
- Epel ES. Psychological and metabolic stress: a recipe for accelerated cellular aging? *Hormones (Basel)* 2009;**8**:7–22.
- Lee YH, Lee WJ, Kim YJ, Cho MJ, Kim JH, Lee YJ, et al. North Korean refugee health in South Korea (NORNS) study: study design and methods. *BMC Publ Health* 2012;**12**:1–7.
- de Goeij MC, van Diepen M, Jager KJ, Tripepi G, Zoccali C, Dekker FW. Multiple imputation: dealing with missing data. *Nephrol Dial Transplant* 2013;**28**: 2415–20.
- The strengthening the reporting of observational studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med* 2007;**147**:573–7.
- Expert Panel on Detection E. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *JAMA* 2001;**285**:2486.
- Lee SY, Park HS, Kim DJ, Han JH, Kim SM, Cho GJ, et al. Appropriate waist circumference cutoff points for central obesity in Korean adults. *Diabet Res Clin Pract* 2007;**75**:72–80.
- Hong AR, Lim S. Clinical characteristics of metabolic syndrome in Korea, and its comparison with other Asian countries. *J Diabet Investig* 2015;**6**:508–15.
- Noh J-W, Lee SH. Trauma history and mental health of North Korean defectors. *Curr Behav Neurosci Rep* 2020;**7**:250–7.
- Lee Y, Lee M, Park S. Mental health status of North Korean refugees in South Korea and risk and protective factors: a 10-year review of the literature. *Eur J Psychotraumatol* 2017;**8**:1369833.
- Park MJ, Yun KE, Lee GE, Cho HJ, Park HS. A cross-sectional study of socio-economic status and the metabolic syndrome in Korean adults. *Ann Epidemiol* 2007;**17**:320–6.
- Dallongeville J, Cottel D, Ferrières J, Arveiler D, Bingham A, Ruidavets JB, et al. Household income is associated with the risk of metabolic syndrome in a sex-specific manner. *Diabetes Care* 2005;**28**:409–15.
- Park HS, Oh SW, Cho S-I, Choi WH, Kim YS. The metabolic syndrome and associated lifestyle factors among South Korean adults. *Int J Epidemiol* 2004;**33**: 328–36.
- Yamaoka K, Tango T. Effects of lifestyle modification on metabolic syndrome: a systematic review and meta-analysis. *BMC Med* 2012;**10**:1–10.
- Pan A, Keum N, Okereke OI, Sun Q, Kivimaki M, Rubin RR, et al. Bidirectional association between depression and metabolic syndrome: a systematic review and meta-analysis of epidemiological studies. *Diabetes Care* 2012;**35**:1171–80.
- Dunbar JA, Reddy P, Davis-Lameloise N, Philpot B, Laatikainen T, Kilkkinen A, et al. Depression: an important comorbidity with metabolic syndrome in a general population. *Diabetes Care* 2008;**31**:2368–73.
- Meigs JB, Wilson PW, Fox CS, Vasan RS, Nathan DM, Sullivan LM, et al. Body mass index, metabolic syndrome, and risk of type 2 diabetes or cardiovascular disease. *J Clin Endocrinol Metabol* 2006;**91**:2906–12.
- Chu S-Y, Jung J-H, Park M-J, Kim S-H. Risk assessment of metabolic syndrome in adolescents using the triglyceride/high-density lipoprotein cholesterol ratio and the total cholesterol/high-density lipoprotein cholesterol ratio. *Ann Pediatr Endocrinol Metabol* 2019;**24**:41.
- Klein BE, Klein R, Lee KE. Components of the metabolic syndrome and risk of cardiovascular disease and diabetes in Beaver Dam. *Diabetes Care* 2002;**25**: 1790–4.
- Lee SW. Methods for testing statistical differences between groups in medical research: statistical standard and guideline of Life Cycle Committee. *Life Cycle* 2022;**2**.
- Burnham KP, Anderson DR. Multimodel inference: understanding AIC and BIC in model selection. *Socio Methods Res* 2004;**33**:261–304.
- Rosenbaum S, Stubbs B, Ward PB, Steel Z, Lederman O, Vancampfort D. The prevalence and risk of metabolic syndrome and its components among people with posttraumatic stress disorder: a systematic review and meta-analysis. *Metabolism* 2015;**64**:926–33.
- Vitaliano PP, Scanlan JM, Zhang J, Savage MV, Hirsch IB, Siegler IC. A path model of chronic stress, the metabolic syndrome, and coronary heart disease. *Psychosom Med* 2002;**64**:418–35.
- Kuo LE, Kitlinska JB, Tilan JU, Li L, Baker SB, Johnson MD, et al. Neuropeptide Y acts directly in the periphery on fat tissue and mediates stress-induced obesity and metabolic syndrome. *Nat Med* 2007;**13**:803–11.
- Hong SJ. Not at all effective: differences in views on the causes of prescription non-adherence between North Korean defectors and medical providers in South Korea. *J Immigr Minority Health* 2015;**17**:867–84.
- Lee H, Robinson C, Kim J, McKee M, Cha J. Health and healthcare in North Korea: a retrospective study among defectors. *Conflict Health* 2020;**14**: 1–8.