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Travel Frequency, Duration, and Heavy Smoking as Independent Predictors of Hypertension Among Travelers: A Cross-Sectional Study in Indonesian Port Transit Areas

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A B S T R A C T

Hypertension is a major cardiovascular risk factor, yet its determinants in highly mobile maritime populations are underexplored. This study aimed to identify independent predictors of hypertension among travelers at the Port of Ampana, Indonesia. A cross-sectional study was conducted (January–March 2026) involving 287 travelers. Blood pressure was measured digitally, and structured interviews captured demographic, lifestyle, and travel-related data. Hypertension prevalence was 40.1%. Independent predictors included heavy smoking (OR=2.374), travel duration (OR=2.134), travel frequency (OR=2.097), family history (OR=2.095), and age (OR=1.073). Rest patterns were not significant (p=0.277). Modifiable travel-related factors and smoking are key predictors, highlighting an urgent need for port-based screening, smoking cessation, and targeted health promotion in this vulnerable population.

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INTRODUCTION

Hypertension is one of the most significant global public health challenges due to its significant contribution to increased morbidity and mortality due to cardiovascular disease. Based on data from the World Health Organization (WHO), it is estimated that by 2024 there will be around 1.4 billion adults aged 30-79 years in the world who suffer from hypertension, equivalent to about 33% of the total adult population, with two-thirds of them in low- and middle-income countries (WHO, 2025). Hypertension also contributes to more than 10.8 million deaths each year, making it the leading cause of premature death worldwide. This circumstance suggests that hypertension is not only an individual clinical problem, but also an epidemiological burden that increases the rate of pain, disability, and death from complications such as stroke, coronary heart disease, kidney failure, and heart failure (WHO, 2025). The WHO (2021) notes that about 46% of people with hypertension in the world do not know that they have this disease, and only 21% have well-controlled blood pressure, so active screening and early detection in at-risk groups are essential.

Hypertension in Indonesia is still a major health problem with a high prevalence. Data from the Ministry of Health of the Republic of Indonesia shows that the prevalence of hypertension based on blood pressure measurement results in the population aged ≥18 years increased from 25.8% in 2007 to 34.1% in Riskesdas 2018, while the Indonesian Health Survey in 2023 reported a prevalence of hypertension of 30.8% (Ministry of Health of the Republic of Indonesia, SKI, 2023). Hypertension ranks fourth among the deadliest diseases in Indonesia, and Riskesdas data in 2018 shows that hypertension, diabetes mellitus, cancer, stroke, and chronic kidney disease are non-communicable diseases (NCDs) that are increasing every year (Ministry of Health of the Republic of Indonesia, 2018). In Central Sulawesi Province, there are 2,365,637 people with hypertension, but only 81,365 people (3%) receive health services according to standards, indicating that the coverage of hypertension services is still low despite the high burden of the disease (Central Sulawesi Provincial Health Office, 2024). However, public awareness of routine blood pressure checks is still low, and this phenomenon shows the need for active screening and early detection in at-risk groups, including high-mobility populations such as travelers (Ministry of Health of the Republic of Indonesia, 2024).

The group of individuals involved in travel—including crew members, passengers, transportation workers, and people with high mobility—is a vulnerable group to hypertension due to a variety of specific risk factors inherent in travel activities. Prolonged travel activities, high travel frequency, time zone changes, shift work, lack of rest time, and travel stress can disrupt the body's circadian rhythm and increase the work of the sympathetic nervous system, contributing to an increase in blood pressure (Costelo & Gums, 2021). In addition, tourists often experience irregular diets, eating foods high in salt and fat, lack of physical activity, and sleep disturbances, which cumulatively increase the risk of hypertension and cardiovascular complications (Vasconselos et al., 2021). Risk factors for hypertension are generally divided into two large groups, namely modifiable factors (unhealthy diet, lack of physical activity, tobacco and alcohol consumption, obesity) and non-modifiable factors (family history, age >65 years, and comorbidities such as diabetes or kidney disease) (WHO, 2022; Nelwan, 2022; Nurhaedah & Utama, 2018; Ardiani et al., 2015).

More specifically, the travel history factor has important relevance in the context of travelers' health. Long-distance travel, especially with long duration or high frequency, has been shown to affect the prevalence of hypertension and the stability of blood pressure control during travel (Gultawatvichai et al., 2023). Hours worked per week, especially in ship crews, can lead to physiological and psychological stress, dehydration, and sleep disturbances (Sagaro et al., 2023). Meanwhile, poor rest patterns due to shifted working hours or limited rest time play an important role in increasing blood pressure through hormonal and metabolic disorder mechanisms (Gamboa-Madeira et al., 2021). The combination of these factors makes travelers a group with a typical hypertension risk and is often overlooked in national health surveys. In the context of the Ampana work area, the Poso Class II Health Quarantine Center (HQC) noted that throughout 2024 160 travelers with hypertension were found, and in the January-September 2025 period 105 cases were found, with an additional 22 cases in the 2025 Eid al-Fitr special situation period (HQC Poso, 2025). The number of travelers in this region has also increased significantly, from 5,975 people in September 2024 to 8,169 people in September 2025, or an increase of 34.74% (HQC Poso, 2025). The high mobility of the population, especially fishermen, boat crews, and business actors who travel between islands with regular intensity, as well as limited rest facilities and changes in consumption patterns during the trip, have the potential to affect blood pressure and physiological balance of travelers.

Although hypertension has been widely researched in Indonesia, studies that specifically highlight the relationship between travel history (frequency and duration), rest patterns, and lifestyle (especially smoking behavior) and the incidence of hypertension in travelers at port and airport entrances is still very limited. This is an important research gap to fill, considering that the traveler population has the potential to become a vector of non-communicable diseases that have not been optimally monitored in health surveillance systems. In addition, the Poso Class II Health Quarantine Center has the main task and function to prevent the entry of diseases and health risk factors through entrances such as ports and airports (Permenkes Number 10 of 2023), so this research also supports the strategic function of HQC in expanding the scope of epidemiological surveillance from infectious diseases to non-communicable diseases. in line with the One Health paradigm.

Based on the background description, this study aims to analyze the relationship between travel history (frequency and duration), rest patterns, and lifestyle (smoking behavior and travel stress) and the incidence of hypertension in travelers in HQC Class II Poso Ampana Work Area, by controlling for confounding factors such as age and family history of hypertension. In particular, this study aims to identify whether travel frequency, travel duration, heavy smoking behavior are independent predictors of hypertension incidence in the population of travelers in the transit area of the port of Ampana, Indonesia.

LITERATURE REVIEW

Frequency of Travel and Incidence of Hypertension

Some studies show that the frequency and duration of travel are significantly associated with an increased risk of hypertension. Research shows that high travel and mobility activities are associated with changes in blood pressure as well as an increased risk of hypertension. Travel activities that are carried out continuously can lead to reduced rest time and recovery of the body, increasing the risk of cardiovascular disorders. In addition, long-term exposure to travel stress can also affect blood pressure stability in individuals with high travel frequency (Fishbein et al 2021; Sagaro et al. 2023; Byambasukh et al., 2020). High travel frequency can also lead to sleep pattern disruption and chronic fatigue due to a lack of recovery time. Prolonged travel can also increase fatigue and circadian rhythm disturbances due to reduced resting quality. The condition is known to be associated with increased blood pressure and hypertension as found in shift workers (Gamboa-Madeira et al., 2021).

H1: Travel frequency affects the incidence of hypertension in travelers at the Poso Class II Health Quarantine Center, Ampana Work Area.

Duration of Travel and incidence of hypertension

Some studies on transportation workers show that long commutes (e.g., drive/service hours >8–12 hours or sea rotations of days) are associated with an increased incidence of undiagnosed hypertension and the incidence of acute cardiovascular symptoms on the trip. Mechanistic review states that prolonged exposure modulates sympathetic and hormonal responses (Costello, et al., 2021). While the high frequency of travel, despite the short distance, creates an accumulation of stress and an inability to establish a stable healthy living routine (eating, resting, exercising). The absence of this routine, which is also reflected in poor work patterns and work stress, significantly increases the incidence of hypertension in workers. Research conducted by Hystad and Eid also on working conditions in the maritime sector shows that duration *at sea* is a factor that significantly affects the level of fatigue of seafarers. In the study, it was found that the longer a crew member was at sea, the higher the rate of burnout reported, especially in a sample of offshore re-supply vessel workers. This indicates that long commutes serve as chronic stressors due to prolonged exposure to an isolated and limited work environment." (Midu, et,al. 2024; Hystad et al., 2016).

H2: The length of the trip affects the incidence of hypertension in travelers at the Poso Class II Health Quarantine Center in the Ampana Work Area.

Rest patterns and incidence of hypertension

One of the main factors that make travelers vulnerable is disruption to rest or sleep patterns. Sleep time in travelers is often fragmented, reduced, and of poor quality because they have to adapt to non-ideal sleeping conditions (in vehicles, rest areas, or temporary lodging). Chronic sleep deprivation not only causes fatigue, but physiologically has been shown to trigger dysregulation of stress hormones and increase the activity of the sympathetic nervous system, which is a key mechanism in the development of hypertension. Growing scientific evidence also points to the important role of circadian rhythms, sleep disturbances, and shift work on the pathogenesis and control of blood pressure. The mechanism involves disruption of the biological clock, activation of the sympathetic nervous system, dysregulation of hormones (cortisol, melatonin), as well as changes in vascular function. A review of circadian clocks and blood pressure (Costello & Gumz, 2021) and a review of circadian disruption (Fishbein et al., 2021) stated that sleep pattern disruption/sleep irregularities were related to nocturnal blood pressure non-dipping patterns, blood pressure variability, and increased risk of hypertension findings that were relevant for traveler populations who frequently experience jet-lag or sleep disturbances due to shift work. (Costello & Gumz, 2021; Fishbein et al., 2021).

H3: Rest patterns affect the incidence of hypertension in travelers at the Poso Class II Health Quarantine Center, Ampana Work Area.

Smoking and the incidence of hypertension

The study was conducted on crew members at the port of Bungku where those who are moderate and heavy smokers have a 2.51 times higher risk of developing hypertension compared to crew members who are light smokers after being controlled by age and family history with hypertension (Asrun, et, al., 2023). The same thing is also found where smoking habits can affect the incidence of type I hypertension (Meylin, et al., 2019). Another observational study conducted on crew members found the prevalence of obesity, smoking, repetitive work stress, social isolation, and travel fatigue correlated with higher blood pressure indicators. It is also related to limited onboard food options and long work schedules (Sagaro et al., 2023).

H4: Smoking habits affect the incidence of hypertension in travelers at the Poso Class II Health Quarantine Center, Ampana Work Area.

Family history and incidence of hypertension

Family history or genetic factors can affect blood pressure regulation through sodium regulation mechanisms, renin-angiotensin-aldosterone system activity, and blood vessel sensitivity to vasoconstriction stimuli of the Indonesian Ministry of Health, explaining that a person with a family history of hypertension has a higher chance of experiencing an increase in blood pressure at a younger age. (Ministry of Health of the Republic of Indonesia, 2019). Research results by Marpaung et, al (2025) It also showed that family history had a significant relationship with the incidence of hypertension in adult patients at Kalooran Amurang General Hospital with values of p=0.003 and OR=4.296. The study explained that respondents who had a family history of hypertension were at about 4.3 times greater risk of developing hypertension than respondents without a family history of hypertension. These findings reinforce that genetic factors and family lifestyle play an important role in increasing a person's blood pressure. (Marpaung, et al., 2025).

H5: Family history affects the incidence of hypertension in travelers at the Poso Class II Health Quarantine Center, Ampana Work Area.

Age and incidence of hypertension

Age is one of the risk factors for hypertension that cannot be changed. The older a person gets, the more the risk of hypertension will increase due to physiological changes in the cardiovascular system, such as decreased elasticity of blood vessels, increased peripheral resistance, and progressive atherosclerosis processes. This condition causes blood pressure to tend to increase in the adult to elderly age group of the Ministry of Health of the Republic of Indonesia, stating that the prevalence of hypertension increases with age and is more commonly found in the age group of ≥40 years. In travelers and crew members, increasing age can also aggravate the body's adaptation to work fatigue, irregular sleep patterns, and travel stress that contributes to increased blood pressure. Research shows that adults and the elderly have a higher risk of hypertension than young age groups because the compensatory ability of blood vessels and heart function has gradually decreased (Ministry of Health of the Republic of Indonesia, 2019).

H6: Age affects the incidence of hypertension in travelers at the Poso Class II Health Quarantine Center, Ampana Work Area.

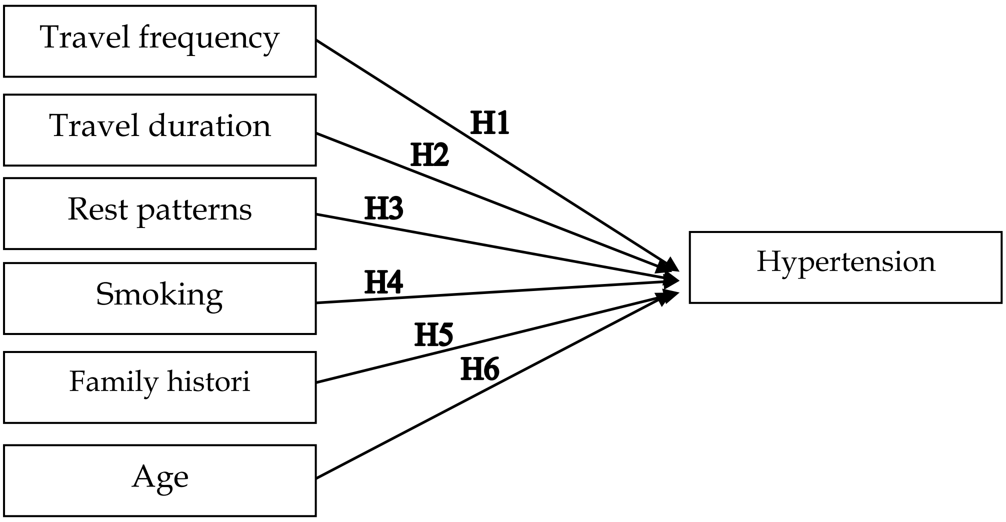

Figure 1. Conceptual Framework

METHODOLOGY

Study Design and Setting

The study used a quantitative analytical observational design with a cross-sectional approach to assess the relationship between travel-related exposure, rest patterns and lifestyle factors, and the prevalence of hypertension among travelers. The research was conducted at Ampana Port, under the working area of the Poso Class II Health Quarantine Center, Central Sulawesi, Indonesia. This location was strategically chosen because of its status as a major transit point for inter-island maritime tourists, with an increase in tourist volume of 34.7% from September 2024 to September 2025. The data collection lasted for three months, from January to March 2026.

Population and Study Sampling

The target population consisted of all travelers registered at Ampana Port during the study period, with a total of 8,169 individuals. Sample sizes were calculated using the Lemeshow formula for a limited population, with a 95% confidence interval (Z=1.96), an assumed prevalence of hypertension of 50% (p=0.5), and a margin of error of 6%. An additional 10% was added for potential non-response, resulting in a final sample of 287 respondents.

The non-probability consecutive sampling technique was used due to the dynamic nature of the traveler population0P and the absence of a complete sampling framework. All travellers present at the port during the data collection who meet the eligibility criteria are invited to participate until the required sample size is reached.

Inclusion criteria: Travelers are ≥18 years old, present at Ampana Port during the study period, and willing to provide a signed consent. Exclusion criteria: Individuals who are currently on regular antihypertensive medications.

Research Procedure

Research Instruments and Variables

The main instruments are a structured questionnaire developed through a multi-step adaptation of the WHO STEPwise approach, the Indonesian Basic Health Research questionnaire, the Ministry of Health's screening module, and the Pittsburgh Sleep Quality Index. The questionnaire has been pre-tested for validity and reliability, with Cronbach's Alpha coefficient ranging from 0.711 to 0.889, indicating good internal consistency.

Dependent variables - Hypertension: Defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg based on an average of two measurements, or a previous doctor's diagnosis or history of antihypertensive medication use.

Independent variable - Travel History: Travel frequency is assessed by a 5-item Likert scale, dichotomy based on median scores (17) to "High Frequency" (>17) and "Low Frequency" (≤17). The duration of the trip was assessed on a 5-item Likert scale, a dichotomy based on the median (15) being "Long Duration" (>15) and "Short Duration" (≤15). Rest Pattern: Rated on a 4-item Likert scale, categorized as "Good" (≤13) or "Poor" (>13) based on the median. Lifestyle Factors: Smoking behaviors are categorized as "Non-smokers", "Light/Medium smokers", or "Heavy smokers" based on intensity scores. Travel stress is measured on a Likert scale of 4 items categorized as "Low", "Medium", or "High".

Confounding variables Age (continuous and categorized at a median of 36 years), sex, and family history of hypertension.

Statistical Analysis

Data is processed using SPSS version 30.0. Univariate analysis describes the frequency and percentage distribution of all variables. Bivariate analysis uses the Chi-square test to examine the rough association between each independent variable and hypertension, with the Fisher's Exact test applied when the expected cell frequency is <5. A Gross Odds Ratio (OR) to a 95% Confidence Interval (CI) was calculated, with p<0.05 considered significant.

Multivariate analysis using binary logistic regression using the Backward Likelihood Ratio method. All variables with p<0.25 in the bivariate analysis were included as candidates, while age and family history were forced into the model as control variables. Model suitability was assessed using the Omnibus Test, Hosmer-Lemeshow Test, and Nagelkerke R-square. Adjusted Odds Ratio (aOR) to 95% CI reported.

Ethical Considerations

This study adheres to the Helsinki Declaration. Ethical approval was obtained from the Health Research Ethics Committee of R.S. R.D. Kandou (No. 038/EA/KEPK-KANDOU/I/2026, January 29, 2026).

RESEARCH RESULT

Characteristics of Participants (Univariate Analysis)

Table 1. Distribution of Participant Characteristics and Study Variables (n=287)

Variable	Categories	n	%
Age (years)	SD ± Red	37.98 ± 14.33	
	Median (Min-Max)	36 (18-78)	
Gender	Male	207	72.1
	Women	80	27.9
Education	Elementary (Elementary/Junior High)	40	13.9
	Secondary (High School/Vocational School)	148	51.6
	Higher (Diploma / S1 / S2 / S3)	99	34.5
Family History of Hypertension	Yes	74	25.8
	No	213	74.2
Frequency of Travel	Height	142	49.5
	Low	145	50.5
Duration of the trip	Length	140	48.8
	Short	147	51.2
Rest Patterns	Poor	136	47.4
	Good	151	52.6
Smoking Behavior	Non-smokers	152	53.0
	Light/Medium Smokers	80	27.9
	Heavy Smokers	55	19.2
Travel Stress	Low	84	29.3
	Medium	109	38.0
	Height	94	32.8
Hypertension	Yes	115	40.1
	Yes	172	59.9

The average age of respondents was 37.98 ± 14.33 years (mean 36 years, range 18–78 years). The majority were men (207, 72.1%), while female respondents consisted of 80 (27.9%). Most of the respondents had secondary education (high school/vocational) (148, 51.6%), followed by higher education (99, 34.5%) and primary education (40, 13.9%). Family history of hypertension was reported by 74 respondents (25.8%).

Regarding travel history, 142 respondents (49.5%) had a high frequency of travel, while 145 (50.5%) had a low frequency. For travel duration, 140 respondents (48.8%) experienced a long travel duration, and 147 (51.2%) had a short duration. Rest patterns were classified as good in 151 respondents (52.6%) and bad in 136 (47.4%). Regarding lifestyle factors, 152 respondents (53.0%) were non-smokers, 80 (27.9%) were light/moderate smokers, and 55 (19.2%) were heavy smokers. Travel stress levels were distributed as low at 84 (29.3%), moderate at 109 (38.0%), and high at 94 (32.8%) respondents. Hypertension was identified in 115 respondents (40.1%), while 172 (59.9%) normotens.

Bivariate Analysis

Table 2. Bivariate Association between Independent Variables and Hypertension

Variable	Categories	Hypertension		*p-value*	Raw GOLD (95% CI)
		Ya n (%)	No n (%)		
Frequency of Travel	Height	70 (49.3)	72 (50.7)	**0.002**	**2.160 (1.335–3.497)**
	Low	45 (31.0)	100 (69.0)		1,000 (references)
Duration of the trip	Length	68 (48.6)	72 (51.4)	**0.004**	**2.009 (1.244–3.246)**
	Short	47 (32.0)	100 (68.0)		1,000 (references)
Rest Patterns	Poor	59 (43.4)	77 (56.6)	0.277	1.300 (0.810–2.087)
	Good	56 (37.1)	95 (62.9)		1,000 (references)
Smoking Behavior	Heavy Smokers	32 (58.2)	23 (41.8)	**0.009**	**2.385 (1.272–4.474)**
	Light/Medium	27 (33.8)	53 (66.3)		0.873 (0.495–1.542)
	Non-smokers	56 (36.8)	96 (63.2)		1,000 (references)
Travel Stress	Height	45 (47.9)	49 (52.1)	**0.040**	**2.167 (1.168–4.023)**
	Medium	45 (41.3)	64 (58.7)		1.659 (0.908–3.034)
	Low	25 (29.8)	59 (70.2)		1,000 (references)
Age	>36 Years	82	58	**<0.001**	**4.884 (2.924–8.158)**

		(58.6)	(41.4)		
	≤36 Years	33 (22.4)	114 (77.6)		1,000 (references)
Gender	Male	79 (38.2)	128 (61.8)	0.289	0.754 (0.448–1.272)
	Women	36 (45.0)	44 (55.0)		1,000 (references)
Family History	Yes	40 (54.1)	34 (45.9)	**0.004**	**2.165 (1.266–3.703)**
	Yes	75 (35.2)	138 (64.8)		1,000 (references)

Bivariate analysis using the Chi-square test revealed that travel frequency (p=0.002), travel duration (p=0.004), smoking behavior (p=0.009), travel stress (p=0.040), age (p<0.001), and family history of hypertension (p=0.004) were significantly associated with hypertension. Rest patterns (p = 0.277) and sex (p = 0.289) showed no significant relationship.

1. **Travel Frequency:** High-frequency travelers had a 2.16-fold higher chance of hypertension compared to low-frequency travelers (OR: 2,160; 95% CI: 1,335–3,497).
2. **Duration of Trip:** Long-term travelers have about twice the likelihood of hypertension compared to short-term travelers (OR: 2,009; 95% CI: 1,244–3,246).
3. **Smoking Behavior:** Heavy smokers had a 2.39-fold higher chance of hypertension compared to non-smokers (OR: 2,385; 95% CI: 1,272–4,474). Light/moderate smokers showed no significant increased risk (OR: 0.873; 95% CI: 0.495–1.542).
4. **Travel Stress:** Travelers with high stress had a 2.17 times higher likelihood of hypertension compared to travelers with low stress (OR: 2,167; 95% CI: 1,168–4,023).
5. **Age:** Older travellers (>36 years) had almost 5 times a higher chance of hypertension compared to younger travellers (OR: 4,884; 95% CI: 2,924–8,158).
6. **Family History:** Travelers with a family history of hypertension had a 2.17-fold higher chance of hypertension compared to those without it (OR: 2,165; 95% CI: 1,266–3,703).

Multivariate Analysis

Variables with p<0.25 in bivariate analysis were included in binary logistic regression using the Backward Likelihood Ratio method: frequency of trips, duration of trips, smoking behaviors, travel stress, age, and family history. Rest patterns (p=0.277) and sex (p=0.289) were excluded. The final model showed a good match (Omnibus Test p<0.001, Hosmer-Lemeshow p=0.431, Nagelkerke R^2=0.346).

Table 3. Final Multivariate Model: Independent Predictors of Hypertension

Variable	Categories	B	p-value	Customized OR
Frequency of Travel	Height	0.740	**0.016**	**2.097**
	Low (ref)			1.000
Duration of the trip	Length	0.758	**0.016**	**2.134**
	Short (reference)			1.000
Smoking Behavior			**0.015**	
	Heavy Smokers	0.864	**0.020**	**2.374**
	Light/Medium	-0.276	0.434	0.759
	Non-smokers (ref)			1.000
Age	Sustainable	0.071	**<0.001**	**1.073**
Family History	Yes	0.740	**0.028**	**2.095**
	No (reference)			1.000

After adjusting for confounders, five factors remain significant independent predictors of hypertension:

1. **Travel Frequency:** High travel frequency is significantly associated with hypertension (OR: 2.097; 95% CI: 1.147–3.833; p=0.016). Respondents with high travel frequencies had about twice the likelihood of hypertension compared to those with low frequencies, after controlling for other variables.
2. **Travel Duration:** Long travel duration remained a significant independent predictor (OR: 2.134; 95% CI: 1.150–3.960; p=0.016). Long-term travelers had a 2.13 times higher chance of hypertension than those with short duration.
3. **Smoking Behaviors:** Heavy smoking remains significantly associated with hypertension (OR: 2.374; 95% CI: 1.148–4.908; p=0.020). Heavy smokers have almost 2.4 times higher odds of hypertension compared to non-smokers. Light/moderate smoking was insignificant (OR: 0.759; 95% CI: 0.380–1.515; p=0.434).
4. **Age:** Age was a strong predictor (OR: 1.073; 95% CI: 1.050–1.097; p<0.001), suggesting that each additional year increased the likelihood of hypertension by 7.3%.
5. **Family History:** A family history of hypertension is significantly associated with hypertension (OR: 2.095; 95% CI: 1.084–4.049; p=0.028). Travelers with a family history have about twice the likelihood of hypertension compared to those who don't.
6. **Travel stress:** Although significant in bivariate analysis, travel stress was not maintained as an independent predictor in the final multivariate model after controlling for other variables.
7. Among modifiable risk factors, **heavy smoking** accounted for the greatest risk (OR = 2.374), followed by **duration of trips** (OR = 2.134) and **frequency of trips** (OR = 2.097). This model explains about 34.6% of the variance in hypertension incidence (Nagelkerke R^2 = 0.346).

DISCUSSION

Travel Frequency as an Independent Predictor of Hypertension

One of the most significant findings of the study is a strong independent association between high travel frequency and hypertension. After adjusting for age, family history, and other triggers, high-frequency travelers were more than twice as likely to have hypertension compared to those with low-frequency (aOR: 2,097; 95% CI: 1,147–3,833; p=0.016). This association remains strong in multivariate models, confirming that frequent travel is not just a proxy for other risk factors but an independent contributor to increased blood pressure.

The physiological mechanisms underlying these associations are diverse. Frequent travel causes recurrent disruptions of the circadian rhythm, which regulates various cardiovascular processes including blood pressure, heart rate, and hormonal secretions (Costello & Gumz, 2021). Each trip involves exposure to physical stress such as prolonged sitting, vibrations, noise, and environmental changes, which cumulatively activate the sympathetic nervous system and trigger the release of stress hormones including cortisol and adrenaline. This hormonal response induces vasoconstriction, increases cardiac output, and increases peripheral vascular resistance, leading to a sustained increase in blood pressure over time (Vyas et al., 2021).

In addition, high-frequency travelers experience recurrent sleep disturbances and reduced opportunities for physiological recovery. The inability to establish a stable sleep-wake pattern and regular meal times contribute to metabolic dysregulation and endothelial dysfunction, both of which are precursors to hypertension. Fishbein, Knutson, and Zee (2021) showed that recurrent circadian disorders in highly mobile worker populations are associated with increased cardiometabolic risk markers, including increased blood pressure, regardless of other lifestyle factors. Our findings corroborate this evidence and extend it specifically to maritime travellers in the Indonesian port environment.

The consistency of our results with previous research reinforces the credibility of this association. Byambasukh et al. (2020) found that high travel and mobility were associated with changes in blood pressure and an increased risk of hypertension among adults in the Lifelines Cohort Study. Similarly, Vyas et al. (2021) reported that high work-related mobility and sustained exposure to work stress are associated with an increased risk of hypertension among workers in the transportation and travel sectors. These parallel findings across a range of geographic and occupational contexts suggest that travel frequency is a universally relevant hypertension risk factor that requires attention in occupational health and travel medicine.

Duration of Journey as an Independent Predictor of Hypertension

Long travel duration emerged as another significant independent predictor of hypertension, with travellers reporting extended travel time having more than twice the likelihood of hypertension compared to those with shorter durations (aOR: 2.134; 95% CI: 1.150–3.960; p=0.016). Bivariate analyses revealed a dose-response relationship, with the prevalence of hypertension increasing from 32.0% among short-term travelers to 48.6% among long-term travelers (OR: 2,009; 95% CI: 1,244–3,246). This gradient shows that the duration of travel exposure is directly correlated with the risk of hypertension.

The pathophysiological mechanisms linking prolonged travel duration to hypertension are well established in the literature. Long periods of immobility during travel reduce venous return, disrupt peripheral circulation, and increase fluid retention, all of which can increase blood pressure. Additionally, prolonged exposure to the maritime environment—including ship vibrations, engine noise, weather fluctuations, and limited habitat—creates chronic stress states that activate the sympathetic nervous system (Oldenburg et al., 2019). This environmental stress, combined with irregular eating schedules, limited physical activity, and limited opportunities for rest during long trips, creates a cumulative physiological load that manifests as high blood pressure.

Our findings are strongly in line with the findings of Gultawatvichai et al. (2023), who suggest that stress, jet lag, lack of sleep, and fatigue during travel significantly affect blood pressure stability among international travelers. The authors emphasize that many international travelers have undiagnosed hypertension, underscoring the importance of blood pressure screening at transit points. The similarity of our findings in domestic maritime settings to those observed in international air travel suggests that the physiological effects of prolonged travel are consistent across different modes and contexts of transport.

The relationship between long travel duration and hypertension is further supported by occupational health research in the maritime sector. Cui et al. (2025), in a health screening of more than 10,000 seafarers, found that occupational predictors including frequency and duration of trips were closely related to electrocardiography disorders and hypertension. The authors describe the maritime environment as a "high-stress" area that requires specialized preventive health interventions. Hystad and Eid al-Fitr (2016) also reported that duration at sea was positively correlated with accumulated fatigue among seafarers, with total time spent in a high-stress environment remaining a strong predictor of decreased sleep quality and cardiovascular tension.

Consistency of our findings with travel medicine and occupational health literature suggests that duration of travel is a strong predictor of hypertension across a wide range of populations and settings. This has important implications for health surveillance at ports, as travellers with longer travel times can benefit from targeted blood pressure screening and health education interventions.

Rest Patterns and Their Insignificant Relationship with Hypertension

Contrary to our initial hypothesis, resting patterns were not significantly associated with hypertension in either bivariate ($p = 0.277$) or multivariate analyses. Although respondents with poor rest patterns had a higher proportion of hypertension (43.4%) compared to those with good rest patterns (37.1%), this difference was not statistically significant. An odds ratio of 1,300 (95% CI: 0.810–2.087) indicates a non-significant tendency toward increased risk.

Several factors could explain this unexpected finding. First, the rest pattern measurements in this study may not capture the full complexity of sleep quality and quantity. The questionnaire assessed general rest patterns over detailed sleep parameters such as total sleep duration, sleep efficiency, sleep latency, or frequency of nocturnal awakening. The Pittsburgh Sleep Quality Index (PSQI), which provides a more comprehensive assessment of sleep quality, is not used as the primary instrument, potentially limiting our ability to detect subtle but clinically meaningful associations (Rahma Hidayah, 2025).

Second, the unique characteristics of the study population may have weakened the relationship between rest patterns and hypertension. Maritime tourists, especially crew members, often work in shift systems and have adapted to irregular sleep schedules. Ramadhani et al. (2022) found that shift workers in maritime environments may develop physiological adaptations to irregular rest patterns over time, potentially reducing the impact detected on blood pressure in cross-sectional studies. This adaptation phenomenon may explain why resting patterns did not emerge as a significant predictor in our predominantly maritime-based samples.

Third, the effect of rest patterns on hypertension may have been overshadowed by stronger effects of other travel-related factors. Our multivariate model shows that travel frequency, duration of travel, smoking behavior, age, and family history all have a stronger and more consistent association with hypertension. It is possible that rest patterns exert their effects through these other variables—for example, frequent and prolonged commutes inherently interfere with rest patterns, making it difficult to isolate independent contributions from rest quality.

Our findings differ from those of Angreini and Fayasari (2019), who found a significant association between sleep quality and blood pressure among shift workers ($p<0.05$). However, those differences may reflect differences in the study population, with their study involving general shift workers rather than highly mobile maritime travelers in our study. The different results underscore the importance of considering population-specific factors when interpreting the relationship between sleep-related variables and cardiovascular outcomes.

Heavy Smoking as the Strongest Risk Factor That Can Be Modified

Heavy smoking emerged as the strongest modifiable independent predictor of hypertension in our study, with heavy smokers having nearly 2.4 times higher odds of hypertension compared to non-smokers (aOR: 2,374; 95% CI: 1,148-4,908; p = 0.020). Bivariate analysis showed a clear gradient, with a prevalence of hypertension of 58.2% among heavy smokers compared to 33.8% among mild/moderate smokers and 36.8% among non-smokers. Notably, light/moderate smoking was not significantly associated with hypertension (aOR: 0.759; 95% CI: 0.380–1.515; p=0.434), suggesting a threshold effect in which only heavy smoking posed a significant cardiovascular risk.

The biological mechanisms linking smoking to hypertension are well characterized. Nicotine stimulates the release of catecholamines, which leads to the activation of the sympathetic nervous system, increased heart rate, and peripheral vasoconstriction (WHO, 2021). Carbon monoxide binds to hemoglobin, reducing oxygen delivery and triggering increased cardiac throughput compensation. Chronic exposure to these toxins induces endothelial dysfunction, arterial stiffness, and oxidative stress, all of which contribute to a sustained increase in blood pressure (Rahman et al., 2025). The dose-response relationship observed in our study—where only heavy smoking achieved statistical significance—was consistent with the cumulative nature of this pathological process.

Our findings are consistent with previous research on seafarers and transport workers. Asrun et al. (2023) found that moderate and heavy smokers among crew members had a 2.51 times higher risk of hypertension than light smokers after controlling for age and family history. The authors attribute this increased risk to the maritime environment, which is characterized by high mobility, work stress, fatigue, and unhealthy lifestyle patterns that promote smoking behavior. Sagaro et al. (2023) also report that smoking is one of the most commonly identified cardiovascular risk factors among seafarers, alongside unhealthy diets and obesity.

The strong association between heavy smoking and hypertension has important implications for workplace health interventions. Smoking is a modifiable risk factor, and smoking cessation programs are a cost-effective strategy to reduce the burden of hypertension in the mobile population. Given the high prevalence of smoking observed in our study (47.0% of respondents were current smokers, with 19.2% being heavy smokers), maritime and port authorities should consider implementing comprehensive tobacco control policies, including health education, access to nicotine replacement therapy, and a smoke-free workplace environment.

Travel Stress: From Bivariate Significance to Multivariate Non-Significance

Travel stress was significantly associated with hypertension in a bivariate analysis ($p = 0.040$), with high-stress travelers having more than twice the likelihood of hypertension compared to those with low stress (crude OR: 2.167; 95% CI: 1.168–4.023). However, in multivariate models, travel stress was not maintained as a significant independent predictor after controlling for other variables. This attenuation suggests that the effects of travel stress on hypertension are largely mediated through other factors, particularly travel frequency, travel duration, and age.

The conceptual difference between travel stress and other travel-related variables is important for interpretation. Travel stress represents the subjective experience of psychological and physical strain during travel, while travel frequency and duration are objective measures of travel exposure. It makes sense that travel stress serves as a pathway through which frequent, prolonged travel exerts its effects on blood pressure—individuals who travel more frequently and for longer durations experience greater cumulative stress, which in turn contributes to hypertension. When frequency and duration of travel are included in multivariate models, the specific contribution of subjective stress can be captured in part by these objective exposure measures.

The findings that travel stress is significant at the bivariate level are consistent with previous research. Maulitya et al. (2025) show that prolonged and intensive travel is associated with stress and increased blood pressure. Asrun et al. (2023) found that maritime working conditions and psychological stress during voyages contribute to an increased risk of hypertension among crew members. Oldenburg et al. (2019) reported that seafarers experience high work stress due to isolation, irregular sleep patterns, and environmental demands, all of which affect cardiovascular health. Sagaro et al. (2023) emphasize that seafarers face high job demands, safety responsibilities, extreme weather exposure, and limited rest, which leads to chronic stress, sympathetic activation, and hormonal dysregulation.

The insignificance of travel stress in our multivariate model does not diminish its clinical relevance. Instead, it suggests that interventions targeting hypertension in mobile populations must address objective travel exposure and subjective stress experiences. A comprehensive approach that reduces the frequency and duration of trips where possible, while also providing stress management resources and psychological support, is likely to be most effective.

Age and Family History as Non-Modifiable Risk Factors

Consistent with established epidemiological knowledge, age was strongly associated with hypertension in our study. Each year of additional age increases the likelihood of hypertension by 7.3% (aOR: 1,073; 95% CI: 1,050–1,097; p<0.001). Respondents over the age of 36 had nearly five times the likelihood of hypertension than younger respondents (crude OR: 4,884; 95% CI: 2,924–8,158). Age was the strongest predictor in bivariate and multivariate analyses, accounting for the largest variance in the model.

The physiological basis for age-related hypertension is well established. Old age is associated with progressive arterial stiffness, decreased endothelial function, decreased vascular adherence, and increased peripheral vascular resistance (Mills, Stefanescu, & He, 2020). These structural and functional changes are driven by cumulative oxidative stress, chronic low-level inflammation, and the gradual loss of elastin fibers in the artery walls. The progressive nature of these changes explains why the prevalence of hypertension increases with age globally, including in Indonesia where SKI 2023 reported a higher prevalence of hypertension among older age groups.

Family history of hypertension is also a significant independent predictor, with affected individuals having twice the likelihood of hypertension (aOR: 2.095; 95% CI: 1.084–4.049; p=0.028). Genetic factors influence blood pressure regulation through various mechanisms, including sodium homeostasis, renin-angiotensin-aldosterone system activity, and vascular sensitivity to vasoconstrictors (Ministry of Health of the Republic of Indonesia, 2019). Marpaung et al. (2025) also found that family history was significantly associated with hypertension (OR: 4.296; p = 0.003) among adult patients, reinforcing the role of genetic predisposition.

Although age and family history cannot be modified, their identification as strong risk factors has important clinical implications. Older and family history travelers represent high-risk groups who would benefit from more frequent blood pressure screening, early detection, and immediate management. Port health authorities should prioritize these individuals for preventative interventions, recognizing that their genetic and age-related vulnerabilities can be amplified by travel-related stress.

Multivariate Models and Relative Contributions

Our final multivariate model includes five independent predictors of hypertension: frequency of trips, duration of trips, heavy smoking, age, and family history. This model shows a good match (Hosmer-Lemeshow $p = 0.431$) and explains 34.6% of the variance in hypertension incidence (Nagelkerke $R^2 = 0.346$). Among modifiable risk factors, heavy smoking accounted for the greatest risk (aOR: 2,374), followed by duration of trips (aOR: 2,134) and frequency of trips (aOR: 2,097). The magnitude of the comparable opportunity ratio suggests that all three are clinically meaningful and actionable intervention targets.

The retention of three travel-related variables—frequency, duration, and smoking—in the final model highlights the unique constellation of risk factors that the moving population faces. Tourists are not only exposed to conventional cardiovascular risk factors such as smoking but also job-specific hazards associated with mobility and travel exposure. This dual risk burden underscores the need for integrated surveillance programs and health interventions at transit points.

The exclusion of travel stress from the final model, regardless of its bivariate significance, suggests that the effect is mediated through other variables. This pattern is consistent with complex causal pathways in which subjective stress acts as an intermediate variable between objective course exposure and hypertension outcomes. Future research that utilizes longitudinal design and modeling of structural equations may help explain this mechanistic pathway.

Limitations and Implications of the Study

Some limitations should be considered when interpreting our findings. First, cross-sectional design precludes causal inference; While we observe strong associations, we cannot definitively establish temporal relationships or causalities. Second, some variables rely on self-reports through questionnaires, which has the potential to introduce memory bias, especially for travel history and rest patterns. Third, the study was conducted in a single port location, limiting generalizations to other settings and travel populations. Fourth, we did not measure other potentially important variables such as dietary sodium intake, physical activity levels, body mass index, and alcohol consumption, which may contribute to unexplained variance in hypertension events.

Despite these limitations, our research has important implications for clinical practice, occupational health, and health policy. At the clinical level, blood pressure screening should be prioritized for travelers with high travel frequency, long travel duration, heavy smoking, older age, and a family history of hypertension. At the occupational health level, maritime and transportation companies must implement comprehensive wellness programs that address smoking cessation, travel schedule optimization, and stress management. At the policy level, port health authorities such as the Poso Class II Port Health Office must expand the scope of surveillance from infectious diseases to non-communicable diseases, in line with the One Health paradigm and strategic functions outlined in the Minister of Health Regulation Number 10 of 2023.

CONCLUSIONS AND RECOMMENDATIONS

This study shows that travel frequency, trip duration, and heavy smoking are significant independent predictors of hypertension among travelers in Indonesian port transit areas, after controlling for age and family history. The high prevalence of hypertension of 40.1% in this population underscores the vulnerability of the mobile group to cardiovascular disease. Rest patterns are not significantly associated with hypertension, possibly due to limitations in population-specific measurements and adaptations. Among modifiable risk factors, heavy smoking accounts for the greatest risk, followed by the duration of trips and frequency of trips. These findings highlight the need for targeted screening, health promotion, and policy interventions at port transit points to address the dual burden of conventional and travel-related cardiovascular risk factors in mobile populations.

ADVANCED RESEARCH

Future research with longitudinal designs, comprehensive sleep assessment instruments, and multi-site sampling is needed to further elucidate this relationship and inform evidence-based interventions.

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