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Influence of Seasonal Changes on Emergency Transports for Vertigo/Dizziness: A Study Based on Emergency Triage and Weather Factors

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Background: We investigated the association between the number of patients presenting to an emergency room (ER) with vertigo/dizziness (V/D) and seasonal variations, monthly trends, and weather factors.

Methods: We retrospectively investigated age, sex, cause of V/D, emergency triage level (Japan Triage and Acuity Scale), month, and seasonality among patients with V/D transported to the ER of Nippon Medical School between October 2014 and September 2017. We examined weather data, including monthly average precipitation and humidity, with respect to the number of patients with V/D.

Results: Among 706 patients with V/D, 481 presented with vertigo and 225 with dizziness. The mean age was 59±18 years and 66% were female. Regarding triage level, emergent (level 2) and urgent (level 3) cases accounted for 86% of cases and were more frequent in June-September ($p=0.012$). Regarding seasonality, 158 (22%), 195 (28%), 183 (26%), and 170 (24%) patients presented in spring, summer, autumn, and winter, respectively ($p=0.744$). The monthly number of V/D emergency transports tended to be higher between June and October and was significantly associated with average temperature ($r=0.648$, $p=0.023$), precipitation ($r=0.655$, $p=0.021$), humidity ($r=0.676$, $p=0.016$), and vapor pressure ($r=0.648$, $p=0.023$).

Conclusions: Although no apparent seasonality was observed in the monthly number of V/D-related emergency transports, the emergency triage level increased from the rainy season to early autumn. The monthly number of V/D cases transported by emergency services was significantly associated with average temperature, precipitation, humidity, and vapor pressure. These findings could inform public health policy and increase emergency preparedness. (J Nippon Med Sch 2025; 92: 268–278)

Key words: dizziness, emergency department, seasonality, vertigo, weather variation

Introduction

Vertigo/dizziness (V/D) is a common condition requiring ambulance transport[1]. A previous study reported that 11.0% to 13.7% of patients in an emergency room (ER) presented with vertigo/dizziness (V/D) as the chief complaint[2,3]. Most causes of V/D (57.7-72.9%) have a peripheral origin[4,5]. However, other major causes include emergency conditions such as cerebrovascular events, cardiovascular events, hypertension, drug-related complications, and infectious diseases[6–10], which are cross-disciplinary conditions and must be diagnosed upon hospital arrival.

V/D is associated with several risk factors, including weather conditions, medical history, and lifestyle habits[11–13]. Various problems in daily life, including mental stress, depression, and poor sleep quality, also contribute

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to V/D[14–16]. Weather conditions such as temperature, humidity, and atmospheric pressure are often influenced by seasonal changes and affect physical and mental health. In addition to influencing the autonomic nervous system[17], weather factors may worsen V/D symptoms because of their potential associations with V/D[18]. The effects of weather and climate in East Asia, especially Japan, cannot be ignored. Although studies have assessed the relationship between seasons and a number of medical conditions[19–23], evidence regarding the association between the seasons and V/D in the ER is limited. Thus, the influence of seasonal changes on V/D incidence rates in emergency settings, particularly in relation to environmental factors, remains unclear. The relationship of seasonality with Meniere's disease, benign paroxysmal positional vertigo (BPPV), and vestibular neuritis (VN) has been investigated[24–27]; however, these studies did not show a clear, consistent pattern of seasonality. Therefore, a theoretical explanation of how seasonal variations affect the occurrence of V/D is important, and analyzing weather conditions as an environmental factor may further our understanding. We hypothesized that the number of cases of emergency transport for V/D would differ by season.

Our ER, operated by the Department of Emergency and General Medicine and Health Science at Nippon Medical School Hospital, is located in the central area of Tokyo's 23 special wards. It mainly accepts ambulance visits (excluding critically ill patients) and manages an average of 2,840 patients per year transported by ambulance (2015-2017). The monthly/seasonal incidence of V/D is a novel research topic, and healthcare providers would benefit from investigating the monthly or seasonal incidence of V/D by using an emergency triage system that utilizes the Japan Triage and Acuity Scale (JTAS), which is based on symptoms and vital signs. This study aimed to systematically clarify monthly and seasonal patterns in ambulance-transported patients with V/D and to investigate potential associations between these patterns and meteorological factors. Seasonal variations and weather conditions provide important insights for improving emergency medical services, developing policies, and guiding future research. Specifically, understanding how weather conditions in a given season can increase the demand for emergency medical services would aid in developing strategies for improving future emergency medical systems.

Materials and Methods

Study Population, Inclusion Criteria, and Comparative Elements

We retrospectively analyzed data from the electronic medical records of patients transported to our ER between October 2014 and September 2017. We included emergency patients aged ≥18 years who had a primary complaint of V/D. In accordance with a previously reported classification system, we classified the origin of V/D as central and non-central for evaluation[28]. We compared age, sex, origin of V/D (central or non-central), emergency triage level (using the JTAS), monthly or seasonal number of emergency transports, and outcomes (hospitalized or not) in relation to meteorological factors.

Diagnostic and Exclusion Criteria

The main diagnoses were defined by using the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10) codes from the electronic medical records. We selected ICD-10 diagnostic keywords with V/D or their causative diseases, such as BPPV, VN, Meniere's disease, sudden deafness, and cerebral infarction/hemorrhage (including brainstem, cerebellar, and pontine infarction/hemorrhage and Wallenberg syndrome). The final diagnosis was based on findings from brain computed tomography or brain magnetic resonance imaging, an otolaryngologic examination by otolaryngologists, or the judgement of emergency doctors or general practitioners evaluating clinical symptoms and findings. V/D caused by cerebral infarction or hemorrhage was classified as central V/D, whereas non-central V/D was classified based on the assessment of peripheral V/D symptoms and exclusion of central origin. The classification of central and non-central V/D was performed with reference to previous research[28].

We excluded patients with V/D who presented with loss of consciousness, weakness, vagal reflexes, and other systematic symptoms that attending physicians determined to be unsuitable for inclusion. In addition, patients with V/D that could not be classified as either vertigo or dizziness were excluded. The decision to admit the patient to hospital was made by the clinician on the basis of V/D severity, significant disruption of personal activities, need for follow-up observation, and presence of central vertigo or a high possibility of central vertigo after CT and MRI imaging studies.

Triage Classification

Triage was classified using the JTAS, which comprises five categories (level 1, resuscitation; level 2, emergent; level 3, urgent; level 4, less urgent; and level 5, non-

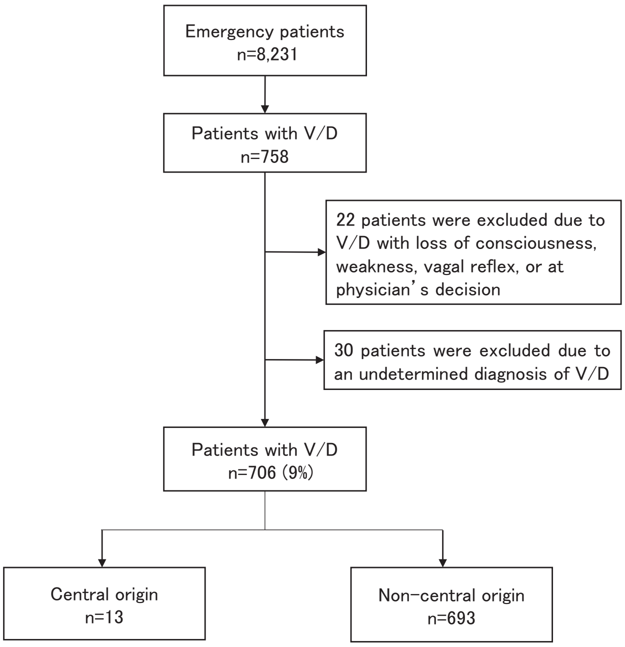


Fig. 1 Flowchart of study enrollment
V/D, vertigo/dizziness

urgent). Classifications were determined by a triage nurse on the basis of the severity of symptoms, vital signs such as blood pressure, and other relevant factors.

Meteorological Data Collection

Weather data such as monthly average precipitation and humidity in Tokyo City (Tokyo Observatory located in Chiyoda Ward) were obtained from the Japan Meteorological Agency website[29]. We analyzed the monthly average temperature, maximum temperature, minimum temperature, average precipitation, average humidity, average daylight hours, average daylight rate, average vapor pressure, minimum relative humidity, and average local pressure.

Seasonal Classification

Seasons were categorized as spring (March−May), summer (June−August), autumn (September−November), and winter (December−February), in accordance with the Japan Meteorological Agency classification[30].

Geographical and Environmental Context

Tokyo is located in East Asia between the subarctic and subtropical zones and has a relatively mild climate throughout the year. The rainy season occurs between June and July and is affected by typhoons from summer to autumn.

Nippon Medical School Hospital is located at latitude 35°43′15″ north and longitude 139°45′32″ east at 19 m above sea level, on relatively flat ground with no surrounding steep mountains. Therefore, it is not greatly affected by geographical features such as mountains and variations in sea level.

Statistical Analysis

We performed Fisher's exact test to identify significant differences in the distribution of patients according to month and season throughout the year. The normality of the distribution of continuous data was assessed using the Shapiro-Wilk test. Because many continuous data were not normally distributed, all continuous data were assessed using the Mann-Whitney U test. The relationship between weather factors and the number of V/D cases was assessed using the chi-square test and Spearman's rank correlation coefficients.

Statistical analyses were independently performed at the Japan Institute of Statistical Technology (Tokyo, Japan) using SPSS Statistics 26 (IBM Corporation, Armonk, NY, USA). Statistical significance was set at $p<0.05$ (two-tailed).

Statement of Ethics

This study was approved by the Ethics Committee of Nippon Medical School Hospital (approval number: R1-09-1203). In this study, we used an opt-out approach that allowed participants to decline participation without the need for explicit informed consent documentation, in accordance with the Ethical Guidelines for Life-science and Medical Research Involving Human Subjects.

Results

Baseline Characteristics of Patients

Among 8,231 patients transported to the ER of Nippon Medical School Hospital between October 2014 and September 2017, 758 (9%) reported V/D as their chief complaint; 22 patients were excluded because of loss of consciousness, weakness, vagal reflexes, and the physician's decision, and 30 patients were excluded because vertigo and dizziness could not be distinguished. Therefore, data from 706 (9%) patients were analyzed (**Fig. 1**). The mean age of the participants was 59±18 years, and 464 (66%) were female. **Table 1** shows the baseline characteristics of the study participants.

Among the 706 patients with V/D, vertigo was observed in 481 (68%) patients and dizziness in 225 (32%). Most cases were non-central (n=693 [98%]). Thirteen patients with V/D (2%) had critical conditions of central origin (cerebral infarction [n=8] and cerebral hemorrhage [n=5]). Seventy-nine (11%) patients with non-central V/D were diagnosed as having inner ear disease by otolaryngologists (BPPV [n=36], Meniere's disease [n=17], sudden hearing loss [n=14], and VN [n=12]). The triage JTAS

Table 1 Characteristics of participants with vertigo/dizziness

		V/D n =706		Non-central n = 693		Central n = 13		p-value [b)]
Female sex	n (%)	464	(66)	461	(67)	3	(23)	0.002**
Vertigo	n (%)	481	(68)	475	(69)	6	(46)	0.129
Dizziness	n (%)	225	(32)	218	(31)	7	(54)	
Age (years) [a)]	Mean ± SD	59 ± 18		59 ± 18		70 ± 9		0.033*
Age ≥ 65 years	n (%)	330	(47)	320	(46)	10	(77)	0.046*
Systolic BP (mmHg) [a)]	Mean ± SD	149 ± 27		149 ± 27		159 ± 23		0.177
Diastolic BP (mmHg) [a)]	Mean ± SD	85 ± 16		85 ± 16		90 ± 11		0.181†
Hypertension	n (%)	233	(33)	228	(33)	5	(38)	0.767
Hypertension or BP ≥ 140/90 mmHg	n (%)	456	(65)	445	(64)	11	(85)	0.153
Dyslipidemia	n (%)	93	(13)	91	(13)	2	(15)	0.685
DM	n (%)	50	(7)	48	(7)	2	(15)	0.233
Mental illness	n (%)	63	(9)	62	(9)	1	(8)	1
Antihypertensive drugs	n (%)	161	(23)	159	(23)	2	(15)	0.743
Oral diabetes medicine	n (%)	31	(4)	29	(4)	2	(15)	0.108
Insulin usage	n (%)	10	(1)	9	(1)	1	(8)	0.171
Triage level								
Resuscitation (Level 1)	n (%)	0	(0)	0	(0)	0	(0)	<0.001**
Emergent (Level 2)	n (%)	21	(3)	17	(2)	4	(31)	
Urgent (Level 3)	n (%)	589	(83)	580	(84)	9	(69)	
Less urgent (Level 4)	n (%)	91	(13)	91	(13)	0	(0)	
Non-urgent (Level 5)	n (%)	5	(1)	5	(1)	0	(0)	
Emergent and urgent (Levels 2-3)	n (%)	610	(86)	597	(86)	13	(100)	0.234
Less urgent and non-urgent (Levels 4-5)	n (%)	96	(14)	96	(14)	0	(0)	
Hospitalization	n (%)	59	(8)	47	(7)	12	(92)	<0.001**

V/D, vertigo/dizziness; BP, blood pressure; DM, diabetes mellitus; SD, standard deviation

[a)] Mann-Whitney U test

[b)] Fisher's exact test (except age, systolic BP, and diastolic BP)

* p<0.05

** p<0.01

†Missing data: four cases

categories were emergent (level 2, n=21; 3%), urgent (level 3, n=589; 83%), less urgent (level 4, n=91; 13%), and non-urgent (level 5, n=5; 1%), and 610 (86%) patients were assigned a triage level of urgent or emergent.

The characteristics of patients with V/D were classified according to the presence or absence of V/D of central origin. The mean blood pressure values were 149±27/85±16 mmHg and 159±23/90±11 mmHg in patients with V/D of non-central and central origins, respectively (p=0.177 and 0.181, respectively). Patients with V/D of central origin were more likely to have a history of hypertension or blood pressure ≥140/90 mmHg at the time of their visit (n=11 [85%]), as compared with those with a non-central origin (n=445 [64%]), although the difference was not significant (p=0.153). More women than men had V/D of central origin (p=0.002). Central V/D was significantly more common in patients aged ≥65 years than in those aged <65 years (n=10 [77%]) (p=0.046). Fifty-nine patients required hospitalization; the triage level was classified as emergent (level 2) in 7 (12%), urgent (level 3) in 50 (85%), less urgent (level 4) in 2 (3%), and non-urgent (level 5) in 0 (0%) patients. The proportion of emergent/urgent (EG/UG) cases among patients with V/D who were hospitalized was significantly higher (p=0.016). Hospitalizations for central vertigo were significantly more frequent (p<0.001).

Seasonality and the Number of Patients with V/D

There was no significant difference in the number of V/D cases in relation to season (spring, n=158 [22%]; summer, n=195 [28%]; autumn, n=183 [26%]; and winter, n=170 [24%]) (p=0.744) (**Table 2**); however, incidence tended to be higher in summer/autumn than in spring/winter. When we classified V/D origin as non-central and central, there was no significant difference in seasonality (p=0.195). Regarding hospitalization, 59 (8%) patients were hospitalized, and a significantly higher proportion of patients were hospitalized in spring (p=0.041); however, there was no significant difference in hospitalization according to month (p=0.068). During the study period, 67 (9%) patients presented with V/D in July; 65 (9%) in September; and 64 (9%) in June, August, and October. There was no significant difference in V/D incidence in relation to month (p=0.750); however, monthly incidence tended to be higher from the rainy season to mid-autumn. In contrast, the incidences of inner ear disease, BPPV, Meniere's disease, sudden hearing loss, or VN did not significantly differ in relation to season or month (**Supplementary Table 1**: https://doi.org/10.1272/jnms.JNMS.2025_92-308). Furthermore, no significant differences in relation to season or month were observed between patients with non-central and inner ear diseases (both p=1.0).

Seasonality and the Triage Level of Patients with V/D

There were significant differences in the distribution of triage classifications over the 12 months (p=0.028) (**Table 3**, **Fig. 2**). The proportion of EG/UG cases was higher in June－September than in other months, whereas that of less emergent/non-emergent (LE/NE) cases was higher in November, February, October, and March (p=0.011). When the two triage level categories were merged (EG/UG versus LE/NE), EG/UG cases were significantly more frequent in June－September than in the other months (p=0.012) (**Fig. 3**). Higher triage classifications were observed during the rainy season to early autumn, approximately aligning with the peak period of case incidence.

Weather Factors and the Number of Patients with V/D

Monthly trends in weather factors, such as average temperature, precipitation, and humidity, during the study period are shown in **Supplementary Fig. 1** (https://doi.org/10.1272/jnms.JNMS.2025_92-308). These trends were consistent with precipitation levels. Therefore, we investigated the association between V/D and monthly weather factors, such as temperature, precipitation, and humidity. Spearman's rank correlation test showed that the number of monthly cases diagnosed as V/D was significantly correlated with average temperature (r=0.648, p=0.023), maximum temperature (r=0.648, p=0.023), minimum temperature (r=0.648, p=0.023), precipitation (r=0.655, p=0.021), humidity (r=0.676, p=0.016), vapor pressure (r=0.648, p=0.023), and average daylight rate (r=−0.725, p=0.008) (**Table 4**). In rank correlation, the three temperature factors showed the same results. No significant seasonal or monthly variations were found in the number of V/D cases; therefore, we assessed the relationship with weather factors by analyzing V/D cases as a single group. Although V/D was associated with a range of conditions, including inner ear disorders, the analysis revealed significant associations between V/D and specific weather conditions.

Discussion

We found that the number of emergency transport cases for V/D did not significantly differ in relation to season in a mild, humid climate. However, the monthly number of patients with V/D was correlated with triage level and weather factors. This study provides insights into the impact of seasonal variations and weather factors on V/D incidence, most importantly that EG/UG triage-level cases were more frequent during particular periods. A Brazilian study of seasonal variation reported that vertigo was more frequent in late winter and spring, whereas dizziness peaked in the summer months, and that these seasonal patterns were potentially influenced by weather factors such as temperature, humidity, and precipitation[31]. In contrast, a Portuguese study noted an increase in the incidence of vertigo in summer and autumn[32]. In Portugal, summer temperatures are milder, typically ranging from 20°C to 25°C[33], with less frequent rainfall[31,33] and lower humidity than in Brazil, which may explain observed differences in seasonal patterns of vertigo and dizziness. Therefore, seasonal variations in V/D differ by country[3,31,32,34], and weather factors and geographic and climatological differences may have influenced the results.

Regarding the pathophysiology of V/D, low atmospheric pressure in summer may aggravate endolymphatic hydrops[35], with associations reported with blood pressure variability[36], upper respiratory infection[37], and air pollution[38]; however, the underlying pathophysiology remains unclear[31]. Future studies should analyze the direct effects of weather on V/D incidence in different regions.

In the present study, the number of patients hospital-

Table 2 Seasonal and monthly variation in V/D cases

	Season				Total	p-value a)
	Spring n (%)	Summer n (%)	Autumn n (%)	Winter n (%)		
Total emergency transportation	1,940 (24)	2,149 (26)	2,115 (26)	2,027 (25)	8,231	
V/D	158 (22)	195 (28)	183 (26)	170 (24)	706	0.744 b)
Vertigo	111 (23)	131 (27)	120 (25)	119 (25)	481	0.747
Dizziness	47 (21)	64 (28)	63 (28)	51 (23)	225	
Female sex	101 (22)	135 (29)	115 (25)	113 (24)	464	0.570
Age ≥ 65 years	68 (21)	89 (27)	88 (27)	85 (26)	330	0.610
Causes of V/D						
Central	4 (31)	2 (15)	6 (46)	1 (8)	13	0.195
Non-central	154 (22)	193 (28)	177 (26)	169 (24)	693	
Hospitalization	19 (32)	8 (14)	17 (29)	15 (25)	59	0.041*

	Month												Total	p-value a)
	Mar n (%)	Apr n (%)	May n (%)	Jun n (%)	Jul n (%)	Aug n (%)	Sep n (%)	Oct n (%)	Nov n (%)	Dec n (%)	Jan n (%)	Feb n (%)		
Total emergency transportation	690 (8)	618 (8)	632 (8)	661 (8)	756 (9)	732 (9)	657 (8)	749 (9)	709 (9)	735 (9)	662 (8)	630 (8)	8,231	
V/D	60 (8)	47 (7)	51 (7)	64 (9)	67 (9)	64 (9)	65 (9)	64 (9)	54 (8)	58 (8)	49 (7)	63 (9)	706	0.750 b)
Vertigo	39 (8)	32 (7)	40 (8)	43 (9)	49 (10)	39 (8)	43 (9)	40 (8)	37 (8)	33 (7)	39 (8)	47 (10)	481	0.251
Dizziness	21 (9)	15 (7)	11 (5)	21 (9)	18 (8)	25 (11)	22 (10)	24 (11)	17 (8)	25 (11)	10 (4)	16 (7)	225	
Female sex	43 (9)	32 (7)	26 (6)	44 (9)	47 (10)	44 (9)	39 (8)	42 (9)	34 (7)	36 (8)	31 (7)	46 (10)	464	0.534
Age ≥ 65 years	23 (7)	24 (7)	21 (6)	33 (10)	23 (7)	33 (10)	30 (9)	32 (10)	26 (8)	25 (8)	22 (7)	38 (12)	330	0.271
Causes of V/D														
Central	2 (15)	2 (15)	0 (0)	1 (8)	0 (0)	1 (8)	3 (23)	2 (15)	1 (8)	0 (0)	0 (0)	1 (8)	13	0.540
Non-central	58 (8)	45 (6)	51 (7)	63 (9)	67 (10)	63 (9)	62 (9)	62 (9)	53 (8)	58 (8)	49 (7)	62 (9)	693	
Hospitalization	7 (12)	7 (12)	5 (8)	1 (2)	3 (5)	4 (7)	4 (7)	11 (19)	2 (3)	6 (10)	3 (5)	6 (10)	59	0.068

V/D, vertigo/dizziness; Mar, March; Apr, April; Jun, June; Jul, July; Aug, August; Sep, September; Oct, October; Nov, November; Dec, December; Jan, January; Feb, February

a) Fisher's exact test

b) P-values indicate differences in frequency distribution for total emergency transportation

*p<0.05

Table 3 Seasonal variation, monthly variation, and triage level in patients with vertigo/dizziness

	Season					
	Spring	Summer	Autumn	Winter	Total	p-value [a)]
	n (%)	n (%)	n (%)	n (%)		
Triage level						
Resuscitation (Level 1)	0 (0)	0 (0)	0 (0)	0 (0)	0	
Emergent (Level 2)	6 (29)	5 (24)	6 (29)	4 (19)	21	
Urgent (Level 3)	133 (23)	170 (29)	145 (25)	141 (24)	589	0.736
Less urgent (Level 4)	18 (20)	19 (21)	30 (33)	24 (26)	91	
Non-urgent (Level 5)	1 (20)	1 (20)	2 (40)	1 (20)	5	
Emergent and urgent (Levels 2-3)	139 (23)	175 (29)	151 (25)	145 (24)	610	0.197
Less urgent and non-urgent (Levels 4-5)	19 (20)	20 (21)	32 (33)	25 (26)	96	

	Month													
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total	p-value [a)]
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)		
Triage level														
Resuscitation (Level 1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0	
Emergent (Level 2)	1 (5)	0 (0)	5 (24)	0 (0)	1 (5)	4 (19)	3 (14)	2 (10)	1 (5)	3 (14)	1 (5)	0 (0)	21	
Urgent (Level 3)	48 (8)	42 (7)	43 (7)	57 (10)	59 (10)	54 (9)	58 (10)	49 (8)	38 (6)	49 (8)	43 (7)	49 (8)	589	0.028*
Less urgent (Level 4)	10 (11)	5 (5)	3 (3)	6 (7)	7 (8)	6 (7)	4 (4)	12 (13)	14 (15)	6 (7)	5 (5)	13 (14)	91	
Non-urgent (Level 5)	1 (20)	0 (0)	0 (0)	1 (20)	0 (0)	0 (0)	0 (0)	1 (20)	1 (20)	0 (0)	0 (0)	1 (20)	5	
Emergent and urgent (Levels 2-3)	49 (8)	42 (7)	48 (8)	57 (9)	60 (10)	58 (10)	61 (10)	51 (8)	39 (6)	52 (9)	44 (7)	49 (8)	610	0.011*
Less urgent and non-urgent (Levels 4-5)	11 (11)	5 (5)	3 (3)	7 (7)	7 (7)	6 (6)	4 (4)	13 (14)	15 (16)	6 (6)	5 (5)	14 (15)	96	

V/D, vertigo/dizziness; Mar, March; Apr, April; Jun, June; Jul, July; Aug, August; Sep, September; Oct, October; Nov, November; Dec, December; Jan, January; Feb, February

[a)] Fisher's exact test

* p<0.05

ized for V/D was higher in spring, although the underlying cause could not be identified. The monthly incidence of V/D tended to increase from the rainy season to mid-autumn. In addition, significantly more cases were classified as EG/UG than LE/NE during triage, particularly in June – September. A study of patients in Tokyo with Meniere's disease reported that vertigo episodes were more frequent during the rainy season, summer, and winter, which partially supports the present findings[39]. Further, 31% and 69% of cases of central V/D were level 2 (emergency) and level 3 (urgent), respectively, which are high levels of emergency. Triage deci-

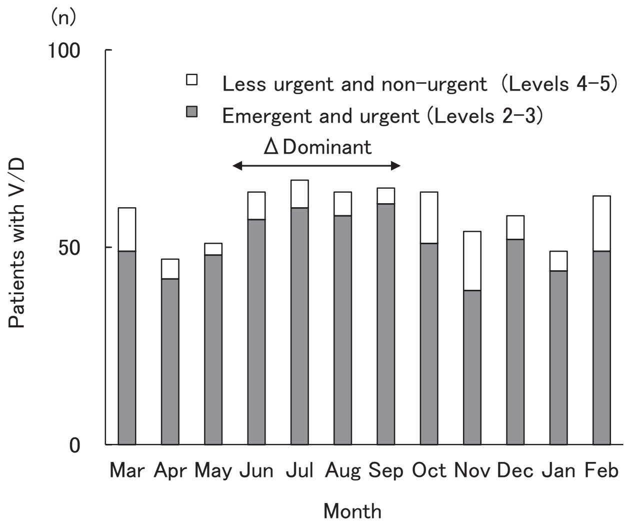
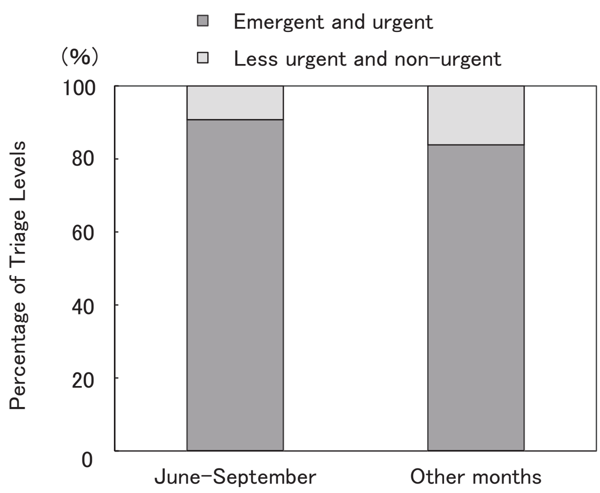


Fig. 2 Monthly numbers of patients with vertigo/dizziness, by emergency triage level
V/D, vertigo/dizziness; Mar, March; Apr, April; Jun, June; Jul, July; Aug, August; Sep, September; Oct, October; Nov, November; Dec, December; Jan, January; Feb, February

sions were based on the severity of symptoms, particularly abnormal vital signs such as extreme blood pressure fluctuations. In the case of central V/D, mean systolic blood pressure was as high as 159 mmHg, which may have affected the triage level.

During the rainy season and early autumn, when the number of patients with V/D and emergency transport rates are higher, caution should be exercised during emergency transport. The observed increase during these periods may increase strain on the emergency medical system, warranting the need for strategies to address this potential surge in demand during the rainy season and early autumn.

In Tokyo, the rainy season usually spans the months of June and July, while typhoons hit between August and October. The average monthly rainfall, humidity, and temperature values in Tokyo[29] were consistent throughout the investigation period (**Supplementary Fig. 1**). The number of patients with V/D was significantly positively correlated with precipitation, humidity, and temperature. Previous reports found that vertigo was associated with humidity and precipitation and that dizziness was associated with atmospheric pressure, average temperature,



		June–September n = 260		Other months n = 446		p-value[a)]
Emergent and urgent (Levels 2–3)	n (%)	236	(91)	374	(84)	0.012*
Less urgent and non-urgent (Levels 4–5)	n (%)	24	(9)	72	(16)	

a) Fisher' s exact test
*$p < 0.05$

Fig. 3 Triage levels and numbers of vertigo/dizziness cases, by period (June–September vs. other months)
To observe change in vertigo/dizziness incidence and associated triage levels, the analysis classified time of year as June–September and other months.

Table 4 Monthly variation in weather factors and number of patients presenting with vertigo/dizziness

Month		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	r [a]	p-value [b]
Patients with V/D	n	60	47	51	64	67	64	65	64	54	58	49	63		
	(%)	(9)	(7)	(7)	(9)	(10)	(9)	(9)	(9)	(8)	(8)	(7)	(9)		
Average temperature (°C)		9.6	14.9	20.4	22.2	26.3	26.7	23.3	18.7	13.2	8.3	5.9	6.6	0.648	0.023*
Maximum temperature (°C)		14.6	19.8	25.6	26.4	30.5	30.8	27.0	22.8	16.9	12.7	10.6	11.6	0.648	0.023*
Minimum temperature (°C)		5.4	10.5	16.1	18.7	23.1	23.7	20.4	15.4	10.0	4.4	1.8	2.5	0.648	0.023*
Average precipitation (mm)		94.2	123.7	91.5	158.8	132.3	219.7	333.3	179.3	125.7	76.2	67.8	44.8	0.655	0.021*
Average humidity (%)		59.3	68.0	66.7	74.3	79.3	79.7	81.3	68.3	69.3	57.0	53.3	54.7	0.676	0.016*
Average daylight hours (h)		182.1	165.8	220.8	145.1	171.5	125.9	105.7	145.4	128.9	180.3	203.4	173.6	−0.535	0.073
Average daylight rate (%)		49.7	42.3	50.7	33.7	38.7	30.3	28.0	41.7	42.0	59.7	65.7	56.7	−0.725	0.008**
Average vapor pressure (hPa)		7.1	11.5	15.7	19.6	26.9	27.8	23.1	14.9	10.7	6.4	4.9	5.4	0.648	0.023*
Minimum relative humidity (%)		12.0	19.7	14.7	20.0	41.0	40.0	31.0	26.3	22.0	21.0	14.0	15.0	0.704	0.011*
Average local pressure (hPa)		1,014	1,012	1,009	1,006	1,007	1,005	1,010	1,014	1,016	1,014	1,013	1,013	−0.401	0.196

V/D, vertigo/dizziness; Mar, March; Apr, April; Jun, June; Jul, July; Aug, August; Sep, September; Oct, October; Nov, November; Dec, December; Jan, January; Feb, February

[a] Correlation coefficient

[b] Spearman's rank correlation

* $p<0.05$, ** $p<0.01$

and rainfall[31]. Moreover, atmospheric pressure and humidity were associated with the incidence of Meniere's disease[40], which is triggered by the effect of air pressure in the inner ear[41]. The labyrinthine fluid in the inner ear and fluid regulation in the labyrinth may be affected by weather conditions, thus causing condition[31]. Although other mechanisms may be involved, this is the first study to demonstrate a causal relationship between V/D and factors such as precipitation, humidity, and temperature in a humid subtropical climate. However, there is insufficient evidence regarding the pathophysiology of humidity and the occurrence of V/D. No significant seasonal variation was observed in peripheral V/D. Additionally, there was no significant difference between non-central and inner ear diseases, suggesting that unknown weather-related factors may affect both conditions similarly. Approximately 5% of patients are admitted to the emergency department with acute dizziness due to acute cerebrovascular events[42]. In our study, 2% of patients had V/D of central origin (62% had cerebral infarction and 38% had cerebral hemorrhage); however, there was no significant seasonal difference.

Limitations

Our study has limitations. First, it was conducted at a single ER, and regional and facility selection bias is a concern. Multicenter studies may be required to address regional bias. Second, electronic medical records were searched based on ICD-10 diagnostic codes; thus, risk factors such as mental illness, drug-induced symptoms, and cardiovascular diseases including hypertension or hypotension could not be eliminated. In addition, this study focused only on emergency transport patients; inclusion of walk-in patients might have yielded different results. Third, because patients with V/D and symptoms such as paralysis or dysarthria are transported to stroke care units, in accordance with the prehospital stroke transport system, the number of patients with V/D of central origin might have been underestimated. Moreover, there was a small number of patients with V/D of central origin (13 cases). Therefore, given the specificity and rarity of this condition, the present results might not be applicable to the general population or populations in other regions. The statistical power may also be insufficient, which decreases the probability of finding a true effect or association, thus increasing both the likelihood that important effects or associations may be missed and susceptibility to chance effects and external factors. Fourth, to identify patients with central V/D, we referred to a classification used in a previous study[28] and evaluated two groups: central V/D and non-central V/D without central V/D. In our study, only 11% of patients were diagnosed as having inner ear diseases. The remaining 89% may have included cases that were not diagnosed with inner ear V/D or were not assessed by an otolaryngologist. Fifth, this study used average values for weather conditions during each month of the study period. This approach incorporated weather data from days on which V/D events did not occur. Finally, meteorological conditions and seasonal variations can change because of environmental factors such as global warming and air pollution. Therefore, further long-term studies are required.

Conclusions

Although no association between season and V/D was observed in this study, emergency triage levels among patients with V/D were higher during the rainy season and early autumn. To our knowledge, this is the first study to report emergency triage and seasonal variations in V/D, thus providing valuable information for emergency medical services and public health. In addition, the monthly number of V/D cases transported by emergency services was significantly associated with average temperature, precipitation, humidity, and vapor pressure. This emphasizes the need for further studies of the specific impacts of these weather factors on V/D.

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