

Influence of physicians' seniority on head computed tomography use for patients with isolated vertigo/dizziness

Ming-Ta Tsai^{1,*}, Kung-Pin Chang^{2,*},
Jyun-Bin Huang¹, Shih-Yu Cheng¹,
Chang-Yen Chiang¹ and Fu-Jen Cheng^{1,†} 

Abstract

Objective: Vertigo/dizziness is a common reason for emergency department (ED) visits. Emergency physicians (EPs) must distinguish patients with dizziness/vertigo owing to serious central nervous system (CNS) disorders. We aimed to evaluate the association between physician seniority and use of head computed tomography (CT) and ED length of stay (LOS) in patients presenting to the ED with isolated dizziness/vertigo.

Methods: This retrospective cohort study included adult patients with non-traumatic dizziness/vertigo in the ED. EPs were categorized according to seniority: junior (less than 6 years' clinical experience), intermediate (7–12 years), and senior (≥ 12 years).

Results: Among 2589 patients with isolated dizziness/vertigo, 460 (17.8%) received brain CT; 46 (1.78%) had CNS disorder as a final diagnosis. Junior and intermediate EPs ordered more CT examinations than senior EPs: (odds ratio [OR] = 1.329, 95% confidence interval [CI]: 1.002–1.769 and OR = 1.531, 95% CI: 1.178–2.001, respectively). Patients treated by junior and intermediate EPs had lower patient ED LOS (OR = –0.432, 95% CI: –0.887 to 0.024 and OR = –0.436, 95% CI: –0.862 to –0.011).

Conclusions: We revealed different judgment strategies among senior, intermediate, and junior EPs. Senior EPs ordered fewer CT examinations for patients with isolated vertigo/dizziness but had longer patient LOS.

*These authors contributed equally to this work" would also be added to the paper.

†Present address: No. 347, Haodong Rd., Sanmin Dist., Kaohsiung City 807

Corresponding author:

Fu-Jen Cheng, Department of Emergency Medicine, Kaohsiung Chang Gung Memorial Hospital, Chang Gung University College of Medicine, No. 123, Dapi Rd., Niasong Township, Kaohsiung County 833.
Email: a0953283092@yahoo.com.tw

¹Department of Emergency Medicine, Kaohsiung Chang Gung Memorial Hospital, Chang Gung University College of Medicine, No. 123, Dapi Rd., Niasong Township, Kaohsiung County 833

²Department of Emergency Medicine, Kaohsiung Municipal Ta-Tung Hospital, No. 68, Zhonghua 3rd Rd., Qianjin Dist., Kaohsiung City 801



Keywords

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Introduction

Dizziness and vertigo are difficult conditions to manage and constitute nearly 4% of primary complaints seen among patients in the emergency department (ED) in the United States (US).^{1,2} Although the reasons for dizziness/vertigo are mostly benign, potentially life-threatening conditions must be considered in the differential diagnosis because, in the absence of other simultaneous neurologic symptoms, isolated dizziness can be the main presentation of ischemic or hemorrhagic stroke, especially cerebellar or brain stem infarction.^{3,4} Emergency physicians (EPs) face the challenge of identifying the small number of patients with serious central nervous system (CNS) disorders among all patients that present with dizziness/vertigo to the ED. Previous studies have shown that only 0.6% to 2.8% of patients with dizziness/vertigo had lesions originating in the CNS.^{5,6} Non-contrast brain computed tomography (CT) is the most routinely used brain imaging modality in the ED;⁷ however, CT has low sensitivity in patients with posterior fossa stroke.⁸ Magnetic resonance imaging (MRI), combined with diffusion-weighted imaging techniques, is considered the right choice for visualizing the posterior fossa,⁸ but these are more time consuming and expensive than CT and are not 100% sensitive.⁹ Taking into consideration the risks arising from misdiagnosis, such as potentially critical illness and legal challenges, EPs may lower the analysis threshold for brain imaging to

manage situations with low probability but high morbidity. In fact, there has been a large increase in the use of CT imaging for patients in the ED with dizziness: in the US alone, CT use rose from 9.4% to 39.4% in these patients during 1995 to 2011, together with increasing medical costs.² However, unnecessary head CT examinations may increase the length of stay (LOS) in the ED,¹⁰ medical costs,¹¹ and exposure to radiation, which is a potential carcinogen.¹²

Previous studies have demonstrated that different EPs have different strategies with respect to the use of head CT,¹³ and that the seniority of EPs might impact their decision-making.¹⁴ Most senior EPs have been found to have the lowest discharge rates¹⁴ and best quality of care, assessed in terms of mortality and fewer 72-hour returns to the ED.¹⁵ Only a limited number of studies have investigated the connection between physician seniority and the tendency to order head CT for patients with isolated dizziness/vertigo in the ED, where these complaints are encountered daily. Thus, in the present study, we aimed to assess how the seniority of the treating physician is associated with the use of head CT and with ED LOS among patients presenting with isolated dizziness/vertigo in the ED.

Methods

Study design and population

This was a retrospective study in which we analyzed data collected between 1 February

2016 and 31 August 2016 at an urban tertiary hospital that serves approximately 72,000 adult patients in the ED each year. We obtained data from ED databases for non-trauma patients (age >17 years) who came to the ED and were given a main diagnosis of dizziness or vertigo, according to International Classifications of Diseases, Tenth Revision (ICD-10) codes (vertigo, code H81.3 and dizziness, code R42). The definition of isolated dizziness/vertigo referred to patients with a major complaint of dizziness or vertigo and no evidence of stroke. Patients were identified by reviewing their electronic medical charts. We excluded patients with new neurological deficits identified during examination of the cerebellar function or cranial nerve, or altered muscle strength or sensing. We defined dizziness/vertigo with a CNS origin as a new finding on CT scan of the brain that could lead to dizziness/vertigo, or confirmed using brain MRI or other examination, and according to diagnosis by a neurologist at hospital discharge.

This study was approved by our hospital's institutional review board (approval number: 201600764B0) and was conducted in accordance with the tenets of the Declaration of Helsinki. Formal consent from participants was not required for this type of retrospective study.

Physician seniority

EPs were divided into three groups according to experience, as follows: junior physicians (≤ 6 years of experience), intermediate physicians (7–12 years of experience), and senior physicians (>12 years of experience). When the cut-off points were changed to 5 years and 10 years, the groupings were similar. Because EPs worked continuously from the time they finish training, calendar differences and those owing to cohort effects were minimal. During the study period, there were 29 EPs in our ED.

All 29 EPs included in the study were blinded to the protocol and design of this study. EPs had completed their training at an accredited teaching hospital, i.e., a 4-year residency program in emergency medicine developed by the Taiwan Society of Emergency Medicine. No EPs participating in this study had a record as a defendant in a medical lawsuit during the 5 years prior to this study. In practice, although residents help in the evaluation of patients in our ED, final decisions with regard to patient admission and CT examination scheduling are only made by EPs. Neurologists were consulted after CT examination in patients with stroke onset <3 hours or major stroke, for the evaluation of recombinant tissue plasminogen activator injection or the need of transfer to the intensive care unit. The opinion of consulting neurologists did not affect decisions regarding ordering of CT scans. To ensure that ordering tests is not profit-motivated, EPs are paid on the basis of the number of working hours and not the number of examinations ordered.

Variables and outcome measures

Information about sex, age, triage grading, and risk factors for diabetes, hypertension, ischemic stroke, and previous records of coronary artery disease, transient ischemic attack (TIA)/stroke, atrial fibrillation, hypercholesterolemia, as well as current status of smoking and alcohol consumption¹⁶ was collected from patients' medical records. Data for final diagnoses by a neurologist of dizziness/vertigo owing to a CNS event at discharge, ED LOS, and patient disposition were compiled as well. The primary outcome was the frequency of ordering a brain CT during evaluation of patients with vertigo/dizziness in the ED; the secondary outcomes were ED LOS and hospital admission.

Statistical analysis

Descriptive analyses of the independent variables in this study are shown as frequency and percentage or mean \pm standard deviation. Analysis of the independent variables was performed using the chi-square test (χ^2), Student *t*-test, and/or Mann–Whitney U test, as appropriate. The relationship between seniority group and CT use was determined using logistic regression analysis; odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Linear regression analysis was conducted to evaluate the relationship between physician seniority and ED LOS.

We considered *p*-values < 0.05 to indicate statistical significance. All statistical analyses were performed using IBM SPSS version 25.0 (IBM Corp, Armonk, NY, USA).

Results

According to EPs' experience level, there were 10 junior physicians (≤ 6 years' experience), 9 intermediate physicians (7–12 years' experience) and 10 senior physicians

(> 12 years' experience) included in our study.

Clinical and demographic characteristics of patients

A total of 2660 patients presented to the ED with a primary diagnosis of dizziness or vertigo during the study period. We excluded 71 patients with a new neurologic deficit, as documented in their medical chart or on CT examination performed at another hospital. The remaining 2589 patients were enrolled in the study. These patients were examined by the 29 EPs; the median number of patients treated by each EP was 87 (interquartile range = 69.5–113.5). Patients' demographic characteristics (age, sex, and triage grading) and risk factors for cerebral vascular accident were stratified according to the seniority group that provided care (Table 1). The clinical and demographic characteristics showed no significant difference among groups. Overall, 46 (1.78%) patients received a final diagnosis by a neurologist at discharge of vertigo/dizziness with CNS origin. Thirty-five (1.35%)

Table 1. Demographic characteristics of 2589 patients who presented to the emergency department (ED) with isolated dizziness/vertigo, according to emergency physician seniority (V) in years.

Demographic characteristics of patients in the ED	$>V12$ N = 677	V7–V12 N = 1092	$\leq V6$ N = 820	<i>p</i>
Age	59.4 \pm 16.9	58.4 \pm 17.0	58.0 \pm 16.9	0.127
Male sex	254	438	316	0.533
Hypertension	289	438	360	0.229
Coronary artery disease	50	70	42	0.191
Diabetes	137	210	164	0.853
Previous transient ischemic attack/stroke	48	73	70	0.292
Current smoker	11	22	14	0.805
Hypercholesterolemia	67	107	65	0.295
Atrial fibrillation	19	25	22	0.765
Heavy alcohol consumption	10	11	10	0.676
Triage urgent (triage I and II)	17	31	19	0.61
Mean arterial pressure during triage (mm Hg)	108.5 \pm 19.3	107.8 \pm 19.9	107.5 \pm 18.5	0.61
Final diagnosis of central origin	9	19	18	0.448

Values in the table are number or mean \pm standard deviation, unless otherwise noted.

patients had ischemic lesions, including vertebrobasilar insufficiency and cerebral infarction. Five (0.19%) patients had hemorrhagic lesions; four (0.15%) had brain mass lesions, including aneurysm, meningioma, and malignant tumor; one (0.04%) patient had sinus thrombosis; and one (0.04%) patient had vasculitis. Among these patients, 29 were diagnosed using CT scan, 16 with MRI after admission, and 1 (vasculitis) with another examination. In total, 43 patients returned to the ER within 72 hours during the study period. Four of these patients had a final diagnosis of CNS disorder; one patient was treated by the senior EP group, another was treated by the intermediate group, and the remaining two patients were treated by the junior EP group. There was no significant difference with respect to ED return within 72 hours or missing diagnosis of CNS origin at the first visit.

Association between CT use and patient characteristics

Results of univariate analysis (Table 2) demonstrated that EPs tended to order

brain CT scans for the following patients: older patients ($p < 0.001$) and those with higher mean arterial pressure during triage ($p = 0.001$), diabetes ($p = 0.003$), hypertension ($p < 0.001$), hypercholesterolemia ($p = 0.010$), previous TIA/stroke ($p < 0.001$), atrial fibrillation ($p = 0.007$), and urgent triage status ($p = 0.003$). Patients who underwent CT examination had higher rates of hospitalization ($p < 0.001$) and longer ED LOS ($p < 0.001$).

Association between decision-making and physician seniority

As shown in Figure 1 and Table 3, compared with intermediate and junior EPs, senior EPs tended to order head CTs for isolated cases of vertigo/dizziness less frequently (19.8%, 17.6%, and 14.6%, respectively; $p = 0.022$). However, patients who were attended by senior EPs had longer ED LOS than those treated by intermediate and junior EPs (6.7 ± 9.4 hours, 5.3 ± 6.9 hours, and 5.3 ± 8.7 hours, respectively; $p = 0.001$). The admission rates did not

Table 2. Demographic characteristics of patients in the emergency department (ED) with dizziness/vertigo and with or without computed tomography (CT) scan.

Demographic characteristics of patients in the ED	N = 460	N = 2129	p
	CT exam (+)	CT exam (-)	
Age	62.9 ± 16.0	57.9 ± 17.0	<0.001
Male sex	194	814	0.116
Hypertension	227	860	<0.001
Coronary artery disease	34	128	0.268
Diabetes	114	397	0.003
Previous transient ischemic attack/stroke	62	140	<0.001
Current smoker	8	39	0.893
Hypercholesterolemia	57	182	0.010
Atrial fibrillation	20	46	0.007
Heavy alcohol consumption	4	27	0.476
Triage urgent (triage I and II)	21	46	0.003
Mean arterial pressure during triage (mm Hg)	110.7 ± 20.3	107.3 ± 19.0	0.001
ED length of stay (hours)	8.85 ± 11.3	4.9 ± 7.2	<0.001
Admission	81	48	<0.001

Values in the table are number or mean ± standard deviation, unless otherwise noted.

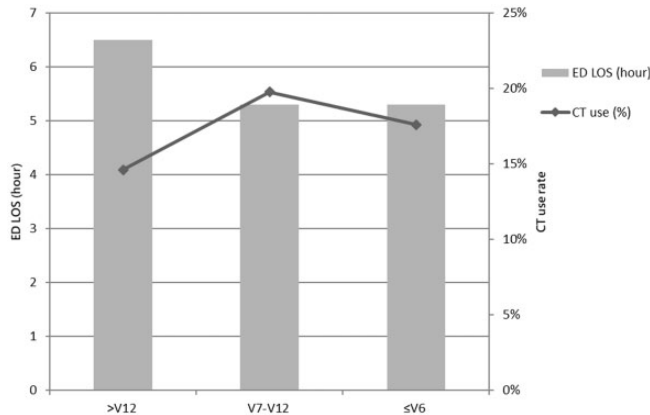


Figure 1. Rate of brain computed tomography (CT) scan use and patient length of stay (LOS) in the emergency department (ED), by physician seniority (V) in years.

Table 3. Variation in computed tomography (CT) scan use rate, hospital admission rate, and emergency department length of stay (ED LOS) by physician seniority (V) in years.

	CT use (n/rate)		Admission		ED LOS	
	N = 460	p	N = 121	p	Hours	p
Seniority		0.022		0.351		0.001
>V12 (600 patients)	99 (14.6%)		29		6.7 ± 9.4	
V7–V12 (965 patients)	216 (19.8%)		59		5.3 ± 6.9	
≤V6 (726 patients)	145 (17.6%)		33		5.3 ± 8.7	

Values in the table are number (percentage) or mean ± standard deviation, unless otherwise noted.

significantly differ based on the seniority groups.

Scatter plots presenting EP seniority in comparison with CT rates and ED LOS are shown in Figure 2a and 2b. We calculated Pearson's correlation coefficients for EP seniority, CT rates, and ED LOS. EP seniority was negatively correlated with the CT use rate ($r = -0.102$) and moderately correlated with ED LOS ($r = 0.520$, $p = 0.004$).

In multivariate logistic regression analysis, we observed a significant relationship between the seniority of the EP and head CT use, after adjusting for patient-level confounding factors such as risk factors for ischemic stroke (Table 4). Junior and

intermediate EPs were more likely to order CT examinations than senior EPs (OR = 1.329, 95% CI: 1.002–1.769 and OR = 1.531, 95% CI: 1.178–2.001, respectively). Linear regression analysis showed shorter ED LOS among junior and intermediate EPs (OR = -0.432, 95% CI: -0.887–0.024 and OR = -0.436, 95% CI: -0.862–-0.011, respectively). The hospital admission rate (OR = 1.271, 95% CI: 0.821–2.002 and OR = 0.943, 95% CI: 0.574–1.557, respectively) and final diagnosis of CNS origin (OR = 1.375, 95% CI: 0.631–3.228 and OR = 1.803, 95% CI: 0.818–4.267, respectively) did not significantly differ between groups with higher and lower seniority.

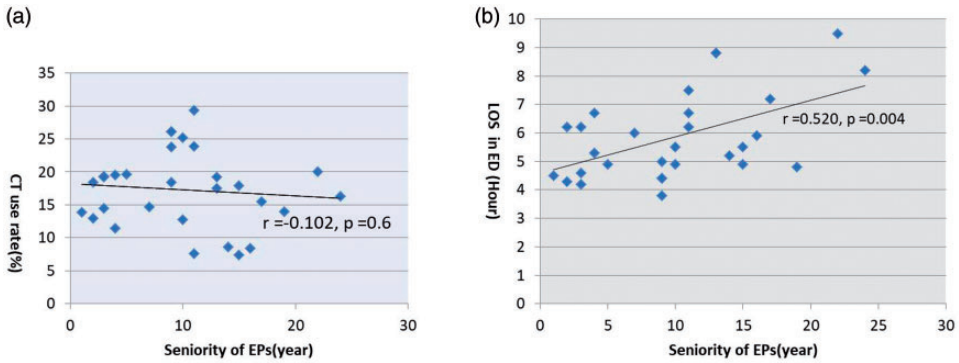


Figure 2a. (a) Scatter plot for rate of brain computed tomography (CT) scan use and emergency physician (EP) seniority. (b) Scatter plot for patient length of stay (LOS) in the emergency department (ED) and emergency physician (EP) seniority.

Table 4. Multivariate analysis after adjustment for patient-level confounding factors.^a

	OR	95% CI for EXP(B)		p
		Lower	Upper	
CT use				
>V12	1.000			
V7–V12	1.531	1.178	2.001	0.001*
≤V6	1.329	1.002	1.769	0.048*
ED LOS				
>V12	0.000			
V7–V12	−0.436	−0.862	−0.011	0.045
≤V6	−0.432	−0.887	0.024	0.063
Hospital admission				
>V12	1.000			
V7–V12	1.271	0.821	2.002	0.285
≤V6	0.943	0.574	1.557	0.819
Final diagnosis of CNS origin				
>V12	1.000			
V7–V12	1.375	0.631	3.228	0.430
≤V6	1.803	0.818	4.267	0.146

^aAdjusted for age, mean arterial pressure, triage status, diabetes, hypertension, hypercholesterolemia, previous transient ischemic attack/stroke, and atrial fibrillation.

OR, odds ratio; CI, confidence interval; CT, computed tomography; ED LOS, emergency department length of stay; CNS, central nervous system; V, physician seniority in years.

Discussion

In this study, we found a statistically significant relationship between head CT use and seniority of the attending EP. Senior EPs tended to order fewer CT examinations than junior and intermediate EPs for

patients with dizziness/vertigo; however, patients of senior EPs had longer ED LOS.

Despite the limited diagnostic value of CT imaging for patients with vertigo,⁸ there was a 169% increase in the proportion of patients who underwent CT scans from

1995 to 2004, following presentation to the ED with dizziness.¹⁷ However, during the same period, the rate of CNS-related diagnosis of these patients decreased by 62%.¹⁸ Another study showed that increasing CT scan and MRI use is related to rising annual costs in EDs in the US.² In 2011, the frequency of neuroimaging was calculated to be 39.9% (39.4% CT, 2.3% MRI), with a median cost of USD 1004 per ED visit owing to dizziness. In the present study, we found that intermediate and junior EPs tended to order more head CT exams, without increasing the diagnosis rate of dizziness/vertigo of CNS origin. These results suggest that some EPs might arrange a head CT for patients who have a lower probability of a CNS disorder. Another study showed that 48% of patients with dizziness or vertigo received a head CT scan and 0.74% of patients had clinically important abnormal findings; the average cost was USD 1220 per CT scan and USD 164,700 for per clinically important abnormal finding.¹¹

Compared with the above studies,^{2,11} the percentage of patients with dizziness/vertigo who received a brain CT in our study was lower. One explanation for our findings might be that more patients with minor symptoms visit the ED for reasons of convenience owing to the low personal health care costs in Taiwan; nearly 100% of Taiwanese people are insured by Taiwan National Health Care Insurance coverage, under which the cost of visiting the ED and obtaining medical services is equivalent to USD 25. Earlier studies have demonstrated that patients covered by health insurance are likely to visit the ED more frequently for non-urgent causes,^{19,20} this may result in underestimation of the proportion of patients who are seriously ill and require neuroimaging studies.

EPs have a distinct responsibility in ruling out potentially serious illness among unfamiliar patients in a demanding

and stressful environment. Most physicians (93%) working in high-risk specialties state that they engage in defensive medical decision making; this is reflected in the radiologic tests ordered by 63% of EPs in situations where there is no clinical need.²¹ In this study, junior and intermediate EPs had 1.577 and 1.355 times the odds of ordering a CT scan, in comparison with senior EPs. CT is an efficient tool for EPs to exclude numerous acute CNS events, including tumor and hemorrhage. For patients with suspected central vertigo, CT is usually the first tool used to differentiate ischemic or hemorrhagic lesion. Increasing the use rate of CT seems to be a worldwide trend;² however, increasing the use of CT scans is related to increasing health care costs. MRIs are another examination of choice, with higher sensitivities than CTs in patients with acute stroke;⁹ however, MRIs are more expensive and time-consuming.¹¹ Some studies have demonstrated that neurologic examinations, such as head impulse tests and risk scores for acute stroke, might help EPs to make accurate diagnoses,^{22,23} however, as yet, no reliable guideline exists that can be applied in the investigated patient population. Thus, establishing a trustworthy guideline would enhance the diagnosis rate of central vertigo and would reduce the costs of unnecessary imaging studies.

Only a small proportion of patients who presented to the ED with dizziness as a major complaint received a final diagnosis of a CNS event. A population-based study conducted in Texas in the US among 1666 mostly Mexican American patients who presented to the ED with dizziness found an incidence of TIA or stroke of 3.2%; this rate was only 0.7% in patients without neurologic signs and older than 44 years of age. It should be noted that only acute cerebrovascular disorders were assessed in that study.¹⁶ In another study of 907 patients experiencing dizziness who were admitted

to the ED, 49 (5%) had serious neurologic disorders.²⁴ That study did not exclude patients with focal neurological findings. In our study, 46 (1.78%) patients with isolated dizziness/vertigo were finally diagnosed with dizziness/vertigo owing to a CNS disorder. The percentage of patients with central dizziness/vertigo in our study was higher than that reported by Kerber et al.¹⁶ and lower than that reported by Navi et al.²⁴ This difference may be owing to differences in the study groups, designs, and methods.

Previous research findings have shown that EPs diverge considerably in their clinical practice with respect to ordering imaging studies for patients with dizziness/vertigo.^{13–15,25,26} Prevedello et al. demonstrated that EPs differ considerably in their use of head CT.¹³ Pines et al. revealed a significant association among EPs who were reluctant to take risks, and higher admission rates and excessive use of cardiac biomarkers in patients presenting with chest pain.²⁷ In a single-center study by Wu et al. among 18,953 adult non-trauma patients in the ED, a survey of admission or discharge decision-making showed that senior EPs tended to have lower discharge rates than junior EPs.¹⁴ In a multicenter study, Li et al. found that the best quality of care (lowest mortality, fewest 72-hour returns) together with a longer ED LOS for adult non-trauma patients, was associated with senior EPs.¹⁵ Our study confirmed the impact of EP seniority on patient management. We found that senior EPs ordered fewer CT scans than intermediate and junior EPs, but the patient LOS was longer than that for patients treated by intermediate and junior EPs. This suggested that senior EPs might prolong the stay in the ED, to observe the patient for any clinical changes and to make definitive and pertinent decisions regarding CT use. Conversely, prolonged ED LOS might exacerbate ED overcrowding. Based on our

findings, in our ED with approximately 3900 visits for dizziness/vertigo per year, patients remain in the ED for approximately 1092 to 1864 more hours (annual total) if they are treated by senior EPs. ED overcrowding is associated with increased medical errors,²⁸ increased short-term mortality,²⁹ and transmission of infectious diseases.³⁰ Compared with senior EPs, intermediate and junior EPs tended to order more CT scans but the patient ED LOS was shorter, which was in line with findings from a previous study.³¹ Li et al. conducted a study including five EDs and found that patients with neurologic disorders who underwent CT scans had shorter ED LOS if they were admitted to a general ward, admitted and discharged from an observation room, or admitted to the intensive care unit.³¹ These results suggest that a CT scan facilitates decision-making based on patient admission/discharge. Additionally, those findings might further explain our results. In the present study, we observed different strategies in decision-making among senior, intermediate, and junior EPs. Further research is needed to ascertain the reasons underlying our results. Additionally, further efforts are needed to advance reliable and practical recommendations for the use of CT in patients who present to the ED with dizziness/vertigo and to minimize the differences in practice among EPs.

Limitations

This study has several limitations. The relatively small number of EPs at a single institution and the retrospective nature of the study may limit its generalization to other institutions and hospitals. Our study results also do not take into account the gap between different-level hospitals in urban versus rural locations. Additionally, there were limitations in the assignment of ICD-10 codes for diagnoses. It is possible that

patients with a main problem of dizziness were missing from our review owing to the inclusion criteria being stipulated according to ICD-10 diagnosis codes R42 (dizziness) and H81.3 (vertigo). It is possible that the statistical power of between-group analyses may have been limited in this study owing to the limited number of patients with CNS disorders. The present study was carried out in only one country and may not be applicable to other countries with different laws and regulations. Decision-making among EPs may differ when faced with the possibility of legal disputes. The different national or personal health insurance systems in different countries may also impact policies regarding costly examinations.

Conclusion

This study revealed different judgment strategies regarding CT use among senior, intermediate, and junior EPs. Compared with intermediate (7–12 years' experience) and junior EPs (<6 years), senior EPs (>12 years) tended to order fewer brain CT examinations for patients with isolated vertigo/dizziness. Lower rates of CT use were associated with reduced medical costs but also with slightly longer ED LOS, which may increase ED overcrowding. The rates of admission and final diagnosis of dizziness/vertigo owing to a CNS event did not differ significantly among the different seniority groups. Further studies are required to advance reliable and practical recommendations for the use of CT in patients who present to the ED with dizziness/vertigo and to minimize the differences in practice among EPs.

Availability of data

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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ORCID iD

Fu-Jen Cheng  <https://orcid.org/0000-0003-1960-2274>

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