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ORIGINAL ARTICLE

Diagnostic yield and cost-effectiveness of head CT scans for dizziness and related complaints in the emergency department

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ABSTRACT

Background: Dizziness is a common yet diagnostically challenging complaint in emergency departments (EDs). Although head computed tomography (CT) is widely employed for its evaluation, evidence suggests that it offers limited diagnostic utility. The aim of this study was to evaluate the diagnostic effectiveness of CT scans for patients presenting with dizziness in the ED and to compare CT findings among patients presenting with dizziness, loss of consciousness, and syncope.

Methods: This retrospective, single-center study analyzed electronic medical records of 305 patients who underwent head CT scans at Daryiah Hospital, Riyadh, in 2024. The collected data included patient demographics, clinical presentation, CT findings, and associated costs. Statistical analyses were conducted to assess predictors of abnormal CT results and the financial implications of CT utilization. Of the 305 CT scans performed, 96% yielded normal findings, while only 4% revealed abnormalities.

Results: No statistically significant associations were observed between abnormal CT findings and patient age, sex, or prior medical history. Among patients presenting with dizziness, vertigo, loss of consciousness, or syncope, the diagnostic yield remained uniformly low. Logistic regression analysis confirmed the poor predictive value of clinical variables for detecting abnormal CT outcomes. The cost per abnormal diagnosis was estimated at SAR 26,980.88, underscoring the financial burden associated with low-yield imaging. A projected 20% reduction in CT utilization could result in annual savings of approximately SAR 70,150.

Conclusion: Head CT scans demonstrate a low diagnostic yield in evaluating dizziness-related complaints in the ED and are associated with high costs and limited clinical benefit. These findings support the adoption of more selective imaging protocols that emphasize thorough clinical examination and the use of alternative imaging modalities, such as magnetic resonance imaging, in high-risk cases to enhance diagnostic accuracy and cost-effectiveness.

Keywords: Dizziness, computed tomography, emergency department, diagnostic yield, cost-effectiveness, MRI, syncope, vertigo.

Introduction

Dizziness describes a subjective sensation of unsteadiness or imbalance. Saccomano [1] classified it into syncope, vertigo, and disequilibrium, each reflecting different underlying mechanisms. Neuhauser [2] reported that dizziness affects up to 20% of adults, with women three times more likely to be affected. Edlow and Newman-Toker [3] emphasized that careful physical examination is central to distinguishing

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peripheral vestibular disorders from serious central causes. Although most acute vestibular syndromes arise from vestibular neuritis, a minority are stroke-related, and specialized eye movement assessments outperform early brain imaging in detecting these events.

In episodic vestibular syndromes, benign paroxysmal positional vertigo is the most common cause and can be confirmed and treated through bedside maneuvers. Edlow also noted the limitations of neuroimaging, reinforcing reliance on clinical evaluation to improve diagnostic accuracy and avoid unnecessary testing [3]. Despite this, neuroimaging, particularly computed tomography (CT), remains widely used, even though its diagnostic performance in dizziness is poor. Many vestibular disorders are non-imaging conditions, and central lesions are relatively uncommon. CT has low sensitivity for posterior fossa strokes [16% compared with 83% for magnetic resonance imaging (MRI)], although early MRI may also miss small infarcts [4]. Current guidelines recommend MRI for suspected central etiologies and temporal bone CT for selected peripheral conditions.

Evidence consistently shows that CT provides limited diagnostic value in dizziness. Multiple studies report that over 90% of CT scans are normal, with abnormalities detected in only 6%-15% of cases [5,6]. MRI demonstrates better performance, especially for ischemic stroke. Accordingly, routine CT use in patients without neurological deficits may not be justified. More selective imaging strategies are recommended to reduce radiation exposure and healthcare costs [5,6].

Large-scale analyses further highlight extensive and often non-targeted neuroimaging use. Adams et al. [7] showed that 20% of patients undergo imaging within 6 months of presentation, with CT used in 92% of cases at initial evaluation. Utilization was influenced by age, comorbidities, race, and care setting, with MRI accounting for most imaging expenditures [7]. The authors called for early interventions to reduce unnecessary CT scans and strengthen appropriate MRI use [7].

Cost-effectiveness studies support similar conclusions. Tu et al. [8] demonstrated that specialized MRI provides the greatest diagnostic value and highest quality-adjusted life years, whereas non-contrast CT offers the lowest utility. MRI-based approaches also improve stroke detection and long-term outcomes at a more favorable cost [8]. Recent price-transparency policies, starting in 2019 and expanded in 2021, require hospitals to publish imaging prices to promote competition, though they may inadvertently increase patient-driven imaging demand [9,10]. Initiatives such as Choosing Wisely remain essential to guide evidence-based imaging decisions [11].

Overall, CT continues to be the most frequently used imaging modality for dizziness despite its low diagnostic yield, financial burden, and radiation risks [3,7,9]. While CT is valuable in specific situations, unnecessary routine use persists. This study, therefore, assesses CT's diagnostic effectiveness, cost-efficiency, radiation considerations, and appropriate clinical indications to support a more selective, evidence-based approach to evaluating dizziness.

Methodology

This study used a retrospective observational design. It relied on secondary data extracted from electronic medical records. The records were from patients who presented to the emergency department (ED) at Dariyah Hospital, Riyadh, during 2024. All patients who underwent CT scans for the evaluation of dizziness, loss of consciousness (LOC), or syncope within this period were included. This ensured complete coverage of the eligible population without applying a sampling technique. The study population consisted of all cases meeting these criteria. Only records with complete clinical and imaging data were considered.

Patients were excluded if they had incomplete medical files. They were also excluded if they did not undergo CT imaging. Additionally, those with a recent history (within 3 months) of acute stroke, head trauma, or intracranial hemorrhage were excluded. Individuals with a chronic history of brain insults were included if they met the primary presentation criteria.

Data were retrieved from electronic medical records. These included CT findings, MRI follow-up results when available, demographic information, clinical presentation, and documented medical history. Follow-up MRI was ordered only when clinically indicated. It was not uniformly obtained for all patients. Data extraction was performed by trained research staff. A second investigator reviewed the data to ensure accuracy and completeness. Missing or inconsistent entries were excluded and not imputed. The analysis assessed diagnostic outcomes, differences in CT findings across presenting complaints, and patterns in imaging utilization.

Both descriptive and inferential statistical analyses were conducted. Descriptive statistics included frequencies, percentages, means, and standard deviations. Inferential analysis included chi-square tests to assess associations between categorical variables. Logistic regression was used to evaluate predictors of abnormal CT findings. A p-value of < 0.05 was considered statistically significant. Statistical analyses were performed using SPSS software.

The study also incorporated a cost analysis. This evaluated the financial implications of CT utilization in cases presenting with dizziness, LOC, or syncope. It included the direct cost of imaging and the estimated physician time associated with CT interpretation.

Ethical standards were maintained throughout. This was in accordance with institutional and national

guidelines. No direct patient contact occurred. All data were anonymized and handled confidentially. Ethical approval for the study was obtained from the Riyadh Third Health Cluster Institutional Review Board (IRB Log No: 25-14-R3).

Results

A total of 305 patients met the inclusion criteria. The mean age was 50.13 years (SD = 17.34; range 14–107 years) (Table 1). Females represented 56.4% (*n* = 172) of the cohort, and males 43.6% (*n* = 133) (Table 2). Dizziness was the most common presenting symptom (69%), followed by vertigo (14%), LOC (10%), and syncope (8%) (Table 2), with the distribution of presentations stratified by gender shown in Table 3.

Of all CT scans, 96% (*n* = 292) were normal, and 4% (*n* = 13) demonstrated abnormalities (Table 2). Abnormal findings occurred in 4.7% of patients without medical history and 2.1% with medical history, with no significant association (p = 0.416) (Table 4). Similarly, abnormal findings were more frequent among males (6%) than females (2.9%); however, the association between gender and CT result was not significant (p = 0.183) (Table 5).

Across clinical presentations, abnormal CT findings were recorded in dizziness (3.8%), LOC (6.9%), and syncope (8.7%), while none were observed in vertigo cases; these differences were not statistically significant (p = 0.517) (Table 3). Logistic regression showed no significant predictors of abnormal CT results, with age, gender, and medical history explaining little variance (Table 8), and this was further supported by the Wald test (Table 9).

Table 1. *Age distribution of the study population (N = 305), including mean, variability, and observed range.*

Statistic	Value
Valid (*n*)	305
Mean	50.128
Standard deviation (SD)	17.34
Minimum	14
Maximum	107

Table 2. *Distribution of clinical presentations, gender, CT findings, and history of medical conditions among the study population.*

Variable	Level	Count	Proportion
History	Vertigo	43	14%
	Dizziness	210	69%
	Loss of consciousness (LOC)	29	10%
	Syncope	23	8%
Gender	Female (F)	172	56%
	Male (M)	133	44%
Findings	Normal	292	96%
	Abnormal	13	4%
History of prior medical condition (Yes\No)	No	257	84%
	Yes	48	16%

Notes: Percentages are based on total sample size (*N* = 305).

Table 3. *Distribution of clinical presentations stratified by gender.*

Complaint	Females (F)	%	Males (M)	%	Total
Vertigo	28	65%	15	35%	43
Dizziness	118	56%	92	44%	210
LOC	15	52%	14	48%	29
Syncope	11	48%	12	52%	23
Total	172	56%	133	44%	305

Notes: Percentages represent within-gender distributions.

Cost analysis showed that the total direct imaging cost for 305 CT scans was SAR 305,000. Physician time contributed an additional SAR 45,751.5, bringing the total expenditure to SAR 350,751.5. With only 13 abnormal findings, the cost per abnormal diagnosis was SAR 26,980.88 (Table 7).

These results confirm that CT imaging has a low diagnostic yield in dizziness-related presentations and underscore the importance of selective, evidence-based imaging strategies.

Table 4. *Association between patient medical history and CT findings using chi-square analysis.*

History	Normal	Abnormal	Total
No	245	12	257
Yes	47	1	48
Total	292	13	305

Table 5. *Chi-square test for the association between patient medical history and CT findings.*

Chi-squared tests			
Statistic	**Value**	**df**	***p*-value**
X^2	0.663	1	0.416
N	305		

Table 6. *Association between gender and CT findings using chi-square analysis.*

CT Findings	Female (F)	Male (M)	Total (*n*)
Normal	167	125	292
Abnormal	5	8	13
Total	172	133	305

Table 7. *Chi-square test for the association between gender and CT findings.*

Chi-squared tests			
Statistic	**Value**	**df**	***p*-value**
X^2	1.776	1	0.183
N	305		

Notes: A *p*-value based on a chi-square test for association.

Discussion

Abnormal findings on head CT scans performed in the ED for dizziness-related presentations were identified in only 4% of cases, aligning with prior evidence demonstrating the limited diagnostic utility of CT in this context. Lawhn-Heath et al. [12] reported a similarly low abnormality rate of 2.2%, with MRI detecting additional abnormalities in 16% of patients. Although MRI follow-up was not routinely performed in our study, this trend is consistent with findings from Alawneh [5], who observed a 15% rate of positive CT results but likewise emphasized MRI's superior diagnostic accuracy. Collectively, these studies highlight the clear diagnostic advantage of MRI over CT in evaluating suspected central causes of dizziness.

In our analysis, abnormal CT findings were slightly more common among patients without a significant medical history (4.7%) compared to those with comorbidities (2.1%), although this difference was not statistically significant (p = 0.416). Masood [6] similarly reported that despite 43.5% of patients having at least one comorbidity, clinically meaningful CT abnormalities remained uncommon. These results suggest that comorbidities do not reliably predict abnormal CT outcomes and reinforce the need for more specific clinical criteria to guide CT utilization in ED settings.

The logistic regression model showed that age, gender, and medical history did not significantly predict abnormal CT results, consistent with broader analyses such as the MedInsight review, which found that more than half of CT scans ordered for dizziness are non-value-adding due to non-specific clinical indicators [13]. Since dizziness is frequently benign and rarely caused by CT-detectable pathology - especially in the absence of focal deficits - routine CT adds limited diagnostic value.

Cost implications further underscore these findings. Wasay et al. [14] reported a diagnostic yield of 0% among 200 patients who underwent CT imaging at a total cost of USD 60,000. Adjusted for inflation, this exceeds USD 110,000 (SAR ~412,500). In our study, the cost per abnormal diagnosis was SAR 26,980.88. These results highlight the inefficiency of routine CT use in low-risk presentations and support the need for improved imaging stewardship.

Table 8. *Logistic regression model predicting abnormal CT findings based on age, gender, and medical history.*

Model	Deviance	AIC	BIC	df	□□□	p	McFadden R□	Nagelkerke R□	Tjur R□	Cox & Snell R□
M_0	107.477	109.477	113.198	304			0		0	
M_1	104.687	112.687	127.568	301	2.791	0.425	0.026	0.031	0.011	0.009

Table 9. *Wald test for logistic regression model predicting abnormal CT findings.*

Wald test						
Predictor	**Estimate (β)**	**Standard Error (SE)**	**Z**	**Wald**	**df**	***p*-value**
Intercept (M_0)	-3.112	0.283	-10.978	120.518	1	
Intercept (M_1)	-3.763	0.998	-3.771	14.222	1	
Gender (Male)	0.796	0.585	1.361	1.851	1	
History (Yes)	-0.996	1.097	-0.908	0.824	1	
Age	0.007	0.018	0.397	0.157	1	

Note. Findings: Abnormal CT results were coded as the reference class 1.

Table 10. *Cost-benefit analysis of CT utilization among patients presenting with dizziness-related complaints.*

Category	Value
Total CT scans performed	305.0
Cost per CT scan (SAR)	1,000.0
Total cost of CT scans (SAR)	305,000.0
Total physician time (HOURS)	101.67
Physician cost per 20 minutes (SAR)	150.0
Total physician cost (SAR)	45,751.5
Total cost (CT + physician) (SAR)	350,751.5
Cost of normal scans (SAR)	292,000.0
Cost of abnormal scans (SAR)	13,000.0
Cost per abnormal diagnosis (SAR)	26,980.88

A projected 20% reduction in CT utilization would yield estimated savings of SAR 70,150, combining reduced imaging expenditure and decreased physician time. This demonstrates the financial advantage of selective imaging strategies that prioritize clinical evaluation and reserve CT for high-risk presentations - consistent with recommendations advocating for evidence-based pathways to reduce unnecessary imaging while maintaining patient safety.

Overall, this study confirms the low diagnostic yield of CT imaging (4%) in patients presenting with dizziness, consistent with previous research demonstrating the limited role of CT and the higher sensitivity of MRI in detecting central causes. The absence of significant associations between abnormalities and demographic or clinical history variables further supports selective imaging rather than routine scanning.

Several limitations should be noted. The analysis was confined to a single year, which may affect generalizability across time. MRI follow-up was not routinely performed, limiting the ability to compare CT and MRI outcomes directly. Additionally, the dataset did not include detailed symptom characterization or duration, which could have provided more granular predictors of imaging utility.

Based on the findings, CT scanning should be reserved for patients with focal neurological deficits or high-risk features suggestive of intracranial pathology. Incorporating structured bedside assessment tools may further improve decision-making. When clinically appropriate and available, MRI should be prioritized given its superior sensitivity. Healthcare systems are encouraged to develop policies that reduce low-value imaging and strengthen monitoring of CT utilization to support cost-effective, evidence-based, and patient-centered practice.

List of Abbreviations

AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CT	Computed tomography
CTA	Computed tomography angiography
ED	Emergency department
IRB	Institutional Review Board
LOC	Loss of consciousness
MRI	Magnetic resonance imaging
QALYs	Quality-adjusted life years
SAR	Saudi Riyal
SD	Standard deviation
SE	Standard error

Conflict of interest

The authors declare that they have no conflicts of interest regarding the publication of this case report.

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Consent to participate

All authors have read and approved the final manuscript and consent to participate in this study.

Ethical approval

Ethical approval for this study was obtained on April 22, 2025, from the Riyadh Third Health Cluster Institutional Review Board (IRB Log No: 25-14-R3).

Authors' contributions

All authors contributed to the study conception, data collection, and manuscript preparation. Alaa Jadidi led the data analysis and critically reviewed the final manuscript. All authors participated in the interpretation of the findings and approved the final version for submission.

Declaration of generative AI and AI-Assisted technologies in the writing process

The authors used Grammarly and ChatGPT to support grammar correction and preliminary language refinement. The manuscript subsequently underwent professional language editing. All authors reviewed the content thoroughly and take full responsibility for the integrity and accuracy of the final version.

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