Development of a Statistical Model for the Prediction of benign paroxysmal positional vertigo (BPPV) Diagnosis

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***Abstract*-Objective: This study aimed to improve the diagnosis of vertigo in emergency settings by developing a questionnaire-based predictive model combined with traditional clinical practices. The study sought to identify key symptoms and diagnostic tools associated with vertigo, with a focus on evaluating the relationship between dizziness and other symptoms, including headaches.**

Methods: A cross-sectional, questionnaire-based study was conducted over two years at the Emergency Department and Department of ENT at Max Superspecialty Hospital, Dehradun, India. Patients aged 18 and older who presented with vertigo as their primary complaint were included. Clinical evaluations, including history, vital signs, and ENT referrals, were conducted. A detailed questionnaire was administered to eligible patients to capture specific vertigo-related symptoms, and the responses were analyzed using logistic regression for predictive analysis. Diagnostic investigations such as Vestibular Evoked Magnetic Potential (VEMP), CT scans, MRI, and Dix-Hallpike tests were performed.

Results: The analysis of 271 reported cases reveals that the majority of patients presented with symptoms related to balance and spatial orientation. Dizziness was the most common complaint, accounting for 30.3% of cases, followed by visual vertigo (27.7%), giddiness (12.2%), and benign paroxysmal positional vertigo (BPPV) (11.1%). Together, these symptoms constituted over 80% of all cases, indicating a strong predominance of vestibular or balance-related issues. Less common symptoms included motion sensitivity (5.9%), traumatic brain injury (3.0%), syncope (2.6%), and tinnitus (1.8%). Rare diagnoses such as stroke, TIA, vestibular neuritis, and various ear-related conditions were each reported in 0.4% to 0.7% of cases.

Conclusion: The study demonstrated the utility of combining clinical evaluations with a symptom-based questionnaire to improve the diagnosis of vertigo in emergency settings. Findings regarding the association between dizziness and headaches, particularly light sensitivity and prolonged dizziness, emphasize the importance of considering both vestibular and neurological causes in diagnosis. The study supports the use of a multifaceted approach to enhance diagnostic accuracy and management of vestibular disorders.

I. INTRODUCTION

Vertigo is a common presentation to emergency room (ER) with patients having a variety of signs and symptoms. The etiology can be peripheral like such as benign paroxysmal positional vertigo (BPPV), Ménière disease , acute labrynthitis and vestibular neuritis or central like ischemic or hemorrhagic strokes, particularly involving the cerebellum or vertebrobasilar system or tumors, particularly those arising from the cerebellopontine angle. A dizziness study reports 27% of subjects with dizziness changed jobs, 50% had reduced efficiency at work, and 57% had a disruption in their social life. Another study found a 12-fold increase in the odds of falling – a higher risk among older individuals – and 10% of falls result in major and severe injuries including death. Unfortunately, misdiagnosis of vestibular disorders is common, inefficient, and ridden with patient frustration and dissatisfaction.

Large population-based studies revealed that 15–20% of healthy adults have suffered from dizziness yearly and the complaints annually account for about 5.6 million clinic visit in the United States [1,2], wherein BPPV was estimated the most frequent vestibular disease with an overall lifetime prevalence of 2.4% [**3**]. We concerned the majority of patients with BPPV visit either an emergency room or a primary care practice before they are referred to a neurotology specialist, wherein 65% of these patients undergo unnecessary diagnostic procedures, such as radiographic examination, even though the examination of nystagmus is critical to diagnose BPPV [**4**]. In addition, inappropriate treatment due to delay of diagnosis lead to a higher risk of falling or reduced physical activity in daily life [5]. Thus, given the notable prevalence, inappropriate interventions in patients with BPPV could be the leading cause financial burden of heath care system.

In recent years, machine-learning algorithms have been used to develop innovative diagnostic systems for medical image analysis [6]. For instance, the Inception V3 model (Google LLC, Menlo Park, California, USA) uses a mixed neural network of sub-convolutional neural network (CNN) structures to predict severity in cases of diabetic retinopathy, performing as well as human experts [7]. Interestingly, promising results have also been obtained by using deep learning to annotate scenes or detect spatiotemporal differences within videos [8], suggesting that deep-learning algorithms may be able to classify nystagmus patterns with spatiotemporal characteristics. Therefore, we hypothesized the diagnostic support system using machine leaning would be helpful when interpreting eye movements with spatiotemporal characteristics.

Benign paroxysmal positional vertigo (BPPV) is an otologic pathologic condition defined as a sensation of spinning triggered by changes in head position relative to gravity and caused by an entrapment of fragmented endolymph debris most commonly in the posterior semicircular canal. To differentiate BPPV from other origins of dizziness, e.g., stroke, require expert otological training and access to advance diagnostic and radiological investigations magnetic resonance imaging (MRI) computed tomography (CT) electronystagmography (ENG), videonystagmography (VNG), vestibular evoked magnetic potential (VEMP), audiogram, tilt test , rotator chair, dix- halpike maneuver , head impulse test etc. Patient verbal description of the quality of dizziness tend to be unclear, inconsistent and unreliable and physician dependence on clinical feature like timing and associated symptom might predispose them to misdiagnosis. In the face of such diagnostic challenge, and in the era of efficiency and cost reduction a simple, inexpensive and accurate questionnaire-base diagnostic algorithm.

As the diagnosis is dependent on high clinical acumen and costly investigations, a lot number of cases stay undiagnosed and thus creating a need for advanced predictive analysis.A predictive analysis model works by giving a questionnaire based on key elements of history to the patient at the time of triaging The data is then used for descriptive analyses and predictive model building. Results of this study may be generalized to practice management for allocating resources and improving efficiency of patient evaluation.

II. REVIEW OF LITERATURE

Friedland DR et al [9] conducted a study highlights the potential benefits of using a pre-encounter intake questionnaire to predict vestibular diagnoses, such as benign paroxysmal positional vertigo (BPPV), Meniere disease, and vestibular migraine, before a clinical evaluation. Vestibular disorders are often complex, requiring additional clinic time and clinical resources for diagnosis. By analyzing 414 new patient intake questionnaires and medical records, the researchers developed statistical models to predict common vestibular disorders. The study found that ear-related disorders made up 48% of diagnoses, while neurologic conditions accounted for 37%. BPPV, Meniere disease, and vestibular migraine together comprised 69% of diagnoses. The model showed that BPPV could be predicted with four variables, yielding a sensitivity of 79% and specificity of 65%, Meniere disease with five variables (sensitivity 81%, specificity 85%), and vestibular migraine with four variables (sensitivity 76%, specificity 59%). These findings suggest that a pre-encounter questionnaire could help triage patients, improving clinical efficiency by allowing for better resource allocation and faster intervention. Further refinement of the questionnaire could make it even more efficient, potentially reducing its length or enabling a more streamlined screening process.

Britt CJ et al 2018 conducted a study aimed to evaluate a statistical algorithm, based on a validated questionnaire, for diagnosing Benign Paroxysmal Positional Vertigo (BPPV) in a busy tertiary care setting. BPPV, a condition causing a sensation of spinning due to changes in head position, is often difficult to diagnose without specialized otologic training. The complexity of diagnosing BPPV inspired the creation of a questionnaire-based algorithm to assist in determining a vestibular diagnosis and treatment options. The retrospective case series included 200 patients who visited the Department of Otolaryngology-Head and Neck Surgery at Johns Hopkins University for initial vertigo symptoms between September and December 2016. The study assessed the use of the questionnaire and its ability to differentiate patients with dizziness. The linear predictor (LP) value calculated from the questionnaire was used to assess the diagnosis of BPPV. Of the 200 patient visits, 106 had the necessary information to calculate the LP value and had a confirmed diagnosis. An LP value of 0.2 or greater showed a sensitivity of 0.75 and a specificity of 1.0 for diagnosing BPPV, with a positive predictive value of 1.0 and a negative predictive value of 0.96. BPPV patients had a significantly different LP value compared to non-BPPV patients (odds ratio 5.92). The study concluded that this algorithm is efficient for diagnosing BPPV in a clinical care setting, providing a valuable tool to streamline the diagnostic process for dizziness and improve patient care.

Lim EC et al 2019 [10] This study explores the use of machine learning to assist in diagnosing benign paroxysmal positional vertigo (BPPV) by interpreting nystagmus, a common symptom in patients with dizziness. Diagnosing BPPV is challenging, particularly in primary care or emergency room settings where the accurate interpretation of eye movements is crucial. The researchers collected 91,778 annotated nystagmus videos from 3,467 patients and transformed them into grid images for training a deep-learning model. Upon validating the model with 5,354 videos, the results revealed high sensitivity and specificity for classifying horizontal, vertical, and torsional nystagmus, as well as for localizing the affected canal. With sensitivity rates ranging from 78% to 91% and specificity from 80% to 92%, the model demonstrated strong diagnostic capabilities. These findings suggest that the machine-learning model could significantly improve the clinical diagnosis of BPPV, offering a reliable tool for practitioners, especially in settings with limited access to specialized expertise.

Gwon O et al 2022 conducted a study aimed to develop a filtering and diagnostic assistive algorithm for distinguishing different types of Benign Paroxysmal Positional Vertigo (BPPV) using raw nystagmus images and Principal Component Analysis (PCA). Fifteen video clips of clinical data, including 13 BPPV cases with typical nystagmus patterns and two normal cases, were preprocessed through thresholding, morphology operations, noise filtering, and center point extraction. The PCA was applied to analyze multiple data clusters in a single frame, focusing on the horizontal and vertical components of the main vector in patients with canalolithiasis of the lateral semicircular canal (LSCC) and the posterior semicircular canal (PSCC). After preprocessing, clear data on the fast and slow phases of nystagmus were obtained. The results revealed distinct patterns for different types of BPPV: normal patients showed a round shape of clustered dots, LSCC patients had an elongated horizontal shape, and PSCC patients exhibited an oval shape in the (x, y) coordinates. Statistically, the horizontal component values of the main vector differed significantly between LSCC and PSCC BPPV (102.08±20.11 mm vs. 32.36±12.52 mm; $p=0.0012$), and the horizontal-to-vertical component ratio also showed a significant difference (16.11±10.74 mm vs. 2.61±1.07 mm; $p=0.0023$). The study concluded that the use of a simulated imaginary pupil without background noise could be an effective monitoring tool to assist clinicians in identifying the type of BPPV, offering valuable diagnostic support for clinical decision-making.

Yu F et al 2024 conducted a study aimed to develop and validate a questionnaire-based machine learning model for predicting the diagnosis of vertigo, with the goal of improving the efficiency of diagnosing vestibular disorders. Over a period from August 2019 to March 2021, patients presenting with vertigo at seven tertiary referral centers participated in this multicenter prospective study. The patients completed a diagnostic questionnaire, and those who received only one final diagnosis for their primary complaint were included for model development and validation. The study used data from patients enrolled before February 1, 2021, for modeling and cross-validation, while data from later participants were used for external validation. A total of 1,693 patients were enrolled, with a response rate of 96.2%. The median age was 51 years, and 58.5% were female. Among the enrolled patients, 928 were used for model development, and 113 for external validation. The patients were classified into five diagnostic categories, and nine machine learning methods were compared. The recalibrated light gradient boosting machine model achieved the best performance, with an area under the curve (AUC) of 0.937 in cross-validation and 0.954 in external validation, demonstrating its high accuracy in predicting vestibular disorders. The study concluded that this machine learning model can assist in decision-making in ENT and vertigo clinics, offering a valuable tool for improving diagnostic efficiency. Further studies with larger sample sizes and neurologist involvement will help assess the model's robustness and generalizability.

Tang B et al 2024 conducted a study aimed to identify predictive factors for the recurrence of Benign Paroxysmal Positional Vertigo (BPPV) in middle-aged and elderly patients and to develop a nomogram to estimate the risk of recurrence. BPPV, the most common cause of peripheral vertigo, has a high recurrence rate, particularly among older populations, and significantly affects quality of life. The study involved 582 participants aged 45 and older, selected from the electronic medical records system of the First Hospital of Changsha between March 2021 and March 2024. Participants were randomly divided into a training group (70%, $n = 407$) and a validation group (30%, $n = 175$). Using LASSO binomial regression, key predictive factors for BPPV recurrence were identified, including older age, higher levels of uric acid (UA) and homocysteine (HCY), diabetes, migraine, anxiety, and insomnia. A nomogram based on these predictors was developed to calculate the recurrence risk. The model demonstrated strong performance, with an area under the receiver operating characteristic curve (AUC) of 0.8974 in the training group and 0.8829 in the validation group. Calibration curves showed good agreement between predicted and actual recurrence probabilities, and decision curve analysis confirmed the clinical utility of the nomogram. In conclusion, the nomogram is a useful tool for predicting the likelihood of BPPV recurrence in middle-aged and elderly patients, helping clinicians make more informed treatment decisions to reduce recurrence rates.

III. AIMS AND OBJECTIVES

AIMS

- To develop a Statistical Model for the Prediction of Common benign paroxysmal positional vertigo (BPPV) Diagnosis

OBJECTIVE

Primary Objective

- To diagnose patients of BPPV with the help of a questionnaire based statistical model.

Secondary Objective

- *To minimize investigations and cost burden of patients presenting to ED with BPPV.*
- To prevent delay in diagnosis of BPPV

IV. MATERIAL AND METHODS

STUDY AREA

The study area Emergency Department and Department of ENT Max Superspecialty Hospital, Dehradun, Uttarakhand, India.

DURATION OF STUDY: 2 years

STUDY DESIGN:

Cross sectional questionnaire based study based on logistic regression analysis

STUDY POPULATION

- *Patients satisfying the following inclusion criteria and not having any of the exclusion criteria will be taken up for the study.*

Inclusion Criteria

- *All consecutive above 18 years of age of both gender patients presenting to ED with chief complaints of vertigo who willing to sign the consent form*

Exclusion Criteria

- *Patient who refuse to give consent to participate in study*

DATA COLLECTION AND ANALYSIS PLAN

DATA COLLECTION METHOD

A two prong approach of data collection method will be taken

All patient who will present to ED with symptoms of vertigo was evaluated in the usual manner. Patients will be triaged by a primary ED physician. The necessary history, vitals and examination findings was recorded. The necessary investigations and ENT referral will be taken as per the protocol. The classical approach of BPPV diagnosis with dix-hallpike, ENT referral and VNG test was continued.

All patients who present to ED with symptoms or vertigo and meet the inclusion criteria will be given a questionnaire under the supervision of primary physician. The response from the questionnaire will be analysed statistically for predictive analysis and linear progression.

QUESTIONNAIRE

Ref Taiwo F. Benign Paroxysmal Positional Vertigo Predictive Diagnosis from Patient Facing Survey; 2020; https://epublications.marquette.edu/theses_open/638

Symptoms section	
Although you may experience many of the listed sensations, what is the single mostnoticeable part of your dizziness?	Multiplechoice
Has your [dizziness] occurred once or more than once?	Once/More
With your [dizziness], have you had nausea and/or vomiting?	Y/N
During your [dizziness], have you ever had double vision?	Y/N
During your [dizziness], have you ever had blurry vision?	Y/N
Duration section	
Is your [dizziness] currently with you 24 hours a day, never stopping?	Y/N

Does your [dizziness] last seconds to 1 minute?	Y/N
Does your [dizziness] last about one hour?	Y/N
Does your [dizziness] last hours but less than 12 hours?	Y/N
Does your [dizziness] last 1 day or longer?	Y/N

Table 3-1 (contd.): Survey Question Details

Triggers section	
Is your [dizziness] typically made worse or triggered by lying down or rolling in bed?	Y/N
Is your [dizziness] typically made worse or triggered by automobile rides?	Y/N
Is your [dizziness] typically made worse or triggered by loud sounds?	Y/N
Is your [dizziness] typically made worse or triggered by sitting up or standing up?	Y/N
Is your [dizziness] typically made worse or triggered by walking on uneven ground?	Y/N
Is your [dizziness] typically made worse or triggered by supermarket aisles, malls, ortunnels?	Y/N
Is your [dizziness] typically made worse or triggered by turning your head while walking?	Y/N
Is your [dizziness] typically made worse or triggered by driving a car at night?	Y/N
Is your [dizziness] typically made worse or triggered by reaching or bending?	Y/N
Ear section	
Do you have ringing or other noise in your ears (tinnitus)?	Y/N
Do you have pain in your ears?	Y/N
Do you get frequent ear infections?	Y/N

Headache section	
Have you had a total of 5 or more bad headaches in your lifetime?	Y/N
Have you ever had a headache that throbs or pulses?	Y/N
Have you ever had nausea or vomiting with a headache?	Y/N
Have you ever had increased sensitivity to light with a headache?	Y/N
Have you ever had increased sensitivity to sounds with a headache?	Y/N
Have you ever had your [dizziness] associated with a headache?	Y/N
History section	
Have you had a hip or knee replacement?	Y/N

STATISTICAL ANALYSIS

- Study Design: Cross-Sectional
- Prevalence of BPPV= 10.37%
- Effect size= 0.37
- Type 1 Error (α)=0.05
- Type 2 Error (β)=0.2
- Power of test (1-β)=0.8
- Confidence Interval at 95%
- Rejection or Drop rate= 10%
- Calculated sample size n=271
- Sample size after adjusting for drop rate n'=298
- Rounding of to get sample size of 300 participant

ETHICAL CONSIDERTIONS

This protocol and the informed consent document, any subsequent modifications will be reviewed and approved by the thesis committee responsible for the oversight of the study.

INFORMED CONSENT FORMS

Informed consent about participation in research will be obtained from the patients.

PARTICIPANT CONFIDENTIALLY

Any data forms, forms, reports and other records that leave the site will be identified only by a participant identification number (participant ID) to maintain confidentially. All records was kept locked in a file cabinet. All computer entry and networking Program will be done using PIDs only. Information will not be released without written consent of the participant, except as necessary for monitoring by IEC and any regulatory authority.

V. OBSERVATION AND RESULTS

Table 1 Symptoms of Present

Symptoms	No. of cases	Percentage
DIZZINESS	82	30.3%
Visual vertigo	75	27.7%
GIDDINESS	33	12.2%
BPPV	30	11.1%
Motion sensitivity	16	5.9%
Trumatic Brain injury	8	3.0%
SYNCOPE	7	2.6%
TINNITUS	5	1.8%
TIA	2	0.7%
VERTIGO	2	0.7%
ACUTE STROKE	1	0.4%
BOTH EAR SOUND	1	0.4%
LEFT CSOM	1	0.4%
MIGRAIN	1	0.4%
OTITIS MEDIA	1	0.4%
PONTINE STROKE	1	0.4%
POSTERIOR STROKE	1	0.4%
RIGHT EAR PAIN	1	0.4%
STROKE	1	0.4%
VESTIBULAR	1	0.4%
VESTIBULAR NEURITIS	1	0.4%
Total	271	100.0%

The analysis of 271 reported cases reveals that the majority of patients presented with symptoms related to balance and spatial orientation. Dizziness was the most common complaint, accounting for 30.3% of cases, followed by visual vertigo (27.7%), giddiness (12.2%), and benign paroxysmal positional vertigo (BPPV) (11.1%). Together, these symptoms constituted over 80% of all cases, indicating a strong predominance of vestibular or balance-related issues. Less common symptoms included motion sensitivity (5.9%), traumatic brain injury (3.0%), syncope (2.6%), and tinnitus (1.8%). Rare diagnoses such as stroke, TIA, vestibular neuritis, and various ear-related conditions were each reported in 0.4% to 0.7% of cases.

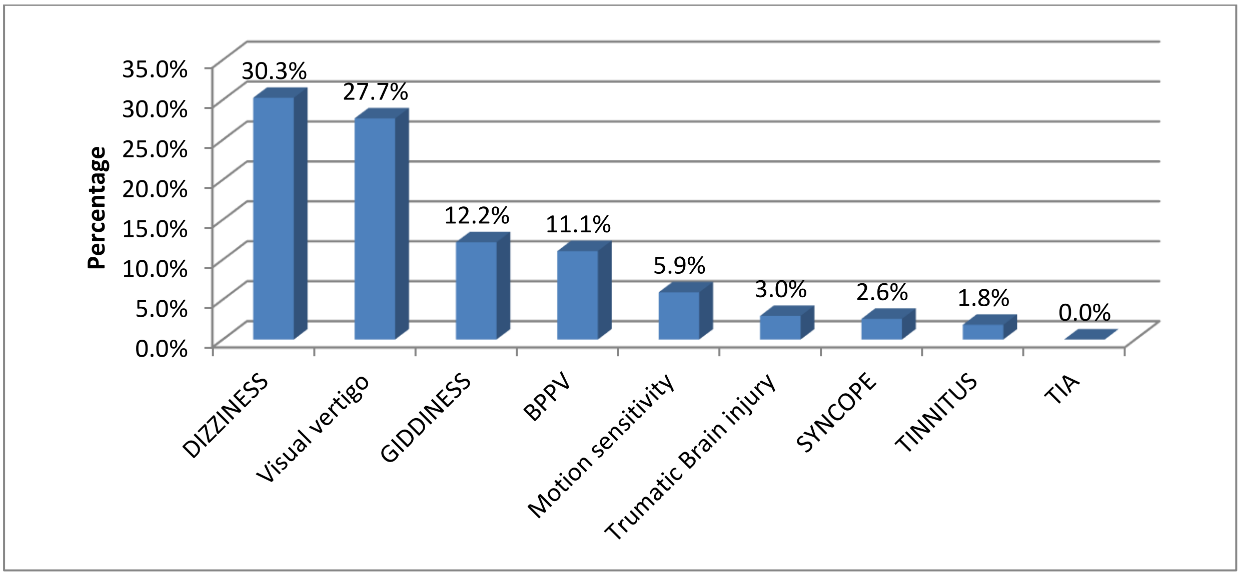

Figure 1: Symptoms of Present

Table 2: Age Group Distribution

Age Group	No. of Cases	Percentage
< 30	18	6.6%
31-60	114	42.1%
> 60	139	51.3%
Total	271	100.0%

This table shows the distribution of patients by age group. The majority of cases (51.3%) are in the age group over 60, followed by patients between 31-60 years (42.1%), and the smallest group is under 30 years (6.6%).

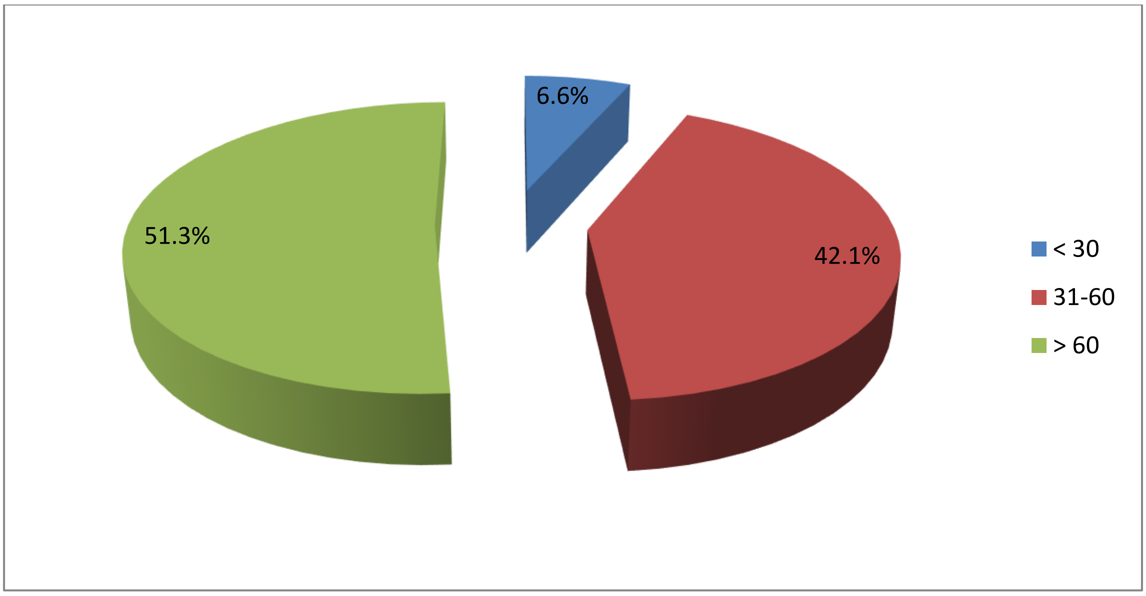

Figure 2: **Age Group Distribution**

Table 3: Gender Distribution

Gender	No. of Cases	Percentage
Female (F)	**124**	**45.8%**
Male (M)	**147**	**54.2%**
Total	**271**	**100.0%**

This table displays the gender distribution of patients. Males constitute 54.2% (147 cases) of the total, while females make up 45.8% (124 cases).

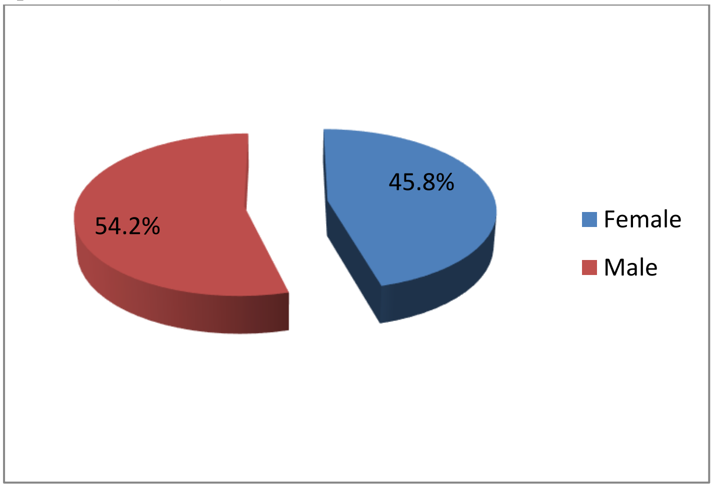

Figure 3: Gender Distribution

Table 4: Dizziness Questions

Question	No. of Cases	Percentage
Has your dizziness occurred once or more than once?	225	83.0%
Have you had nausea and/or vomiting with your dizziness?	115	42.4%
Have you ever had double vision with your dizziness?	92	33.9%
Have you ever had blurry vision with your dizziness?	94	34.7%
Is your dizziness currently with you 24 hours a day, never stopping?	124	45.8%
Does your dizziness last seconds to 1 minute?	147	54.2%
Does your dizziness last about one hour?	141	52.0%
Does your dizziness last hours but less than 12 hours?	136	50.2%
Does your dizziness last 1 day or longer?	89	32.8%

This table summarizes various characteristics of dizziness as reported by the patients. It reveals the frequency of symptoms, such as nausea/vomiting, double vision, and blurry vision. A significant percentage of patients reported that their dizziness lasts seconds to one minute (54.2%), while some reported dizziness lasting longer periods, such as hours (50.2%) or one day or longer (32.8%).

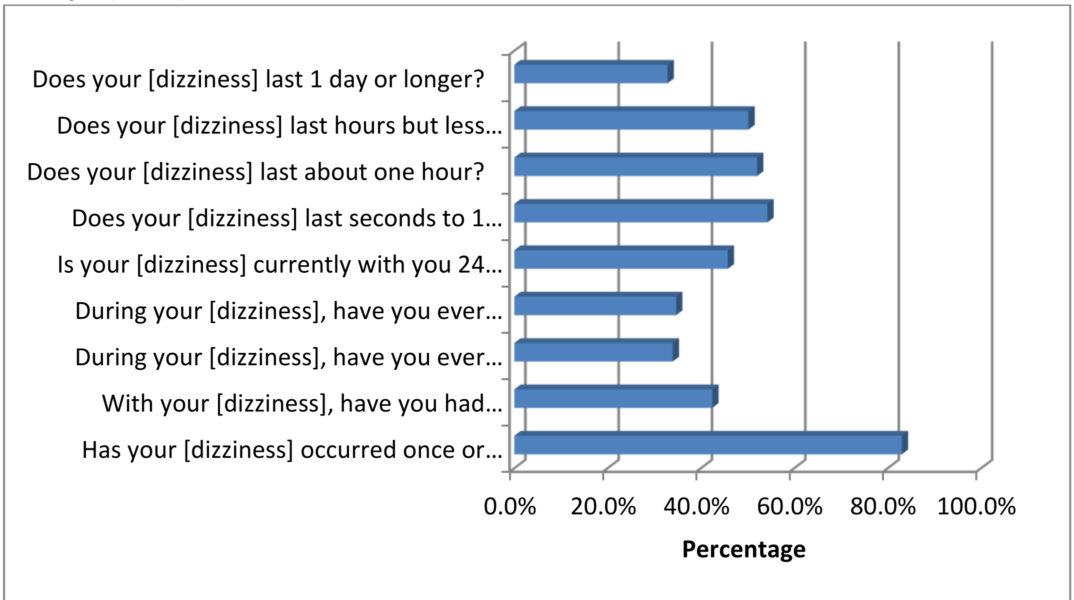

Figure 4: Dizziness Questions

Table 5: Triggers Section

Question	No. of Cases	Percentage
Dizziness worsened by lying down or rolling in bed?	144	53.1%
Dizziness worsened by automobile rides?	155	57.2%
Dizziness worsened by loud sounds?	122	45.0%
Dizziness worsened by sitting or standing up?	154	56.8%
Dizziness worsened by walking on uneven ground?	154	56.8%
Dizziness worsened by supermarkets, malls, or tunnels?	147	54.2%
Dizziness worsened by turning head while walking?	131	48.3%
Dizziness worsened by driving at night?	157	57.9%
Dizziness worsened by reaching or bending?	132	48.7%

This table identifies different triggers that worsen dizziness. The most common triggers were automobile rides (57.2%), driving at night (57.9%), and dizziness worsened by sitting or standing up (56.8%). Other triggers include loud sounds, walking on uneven ground, and reaching or bending.

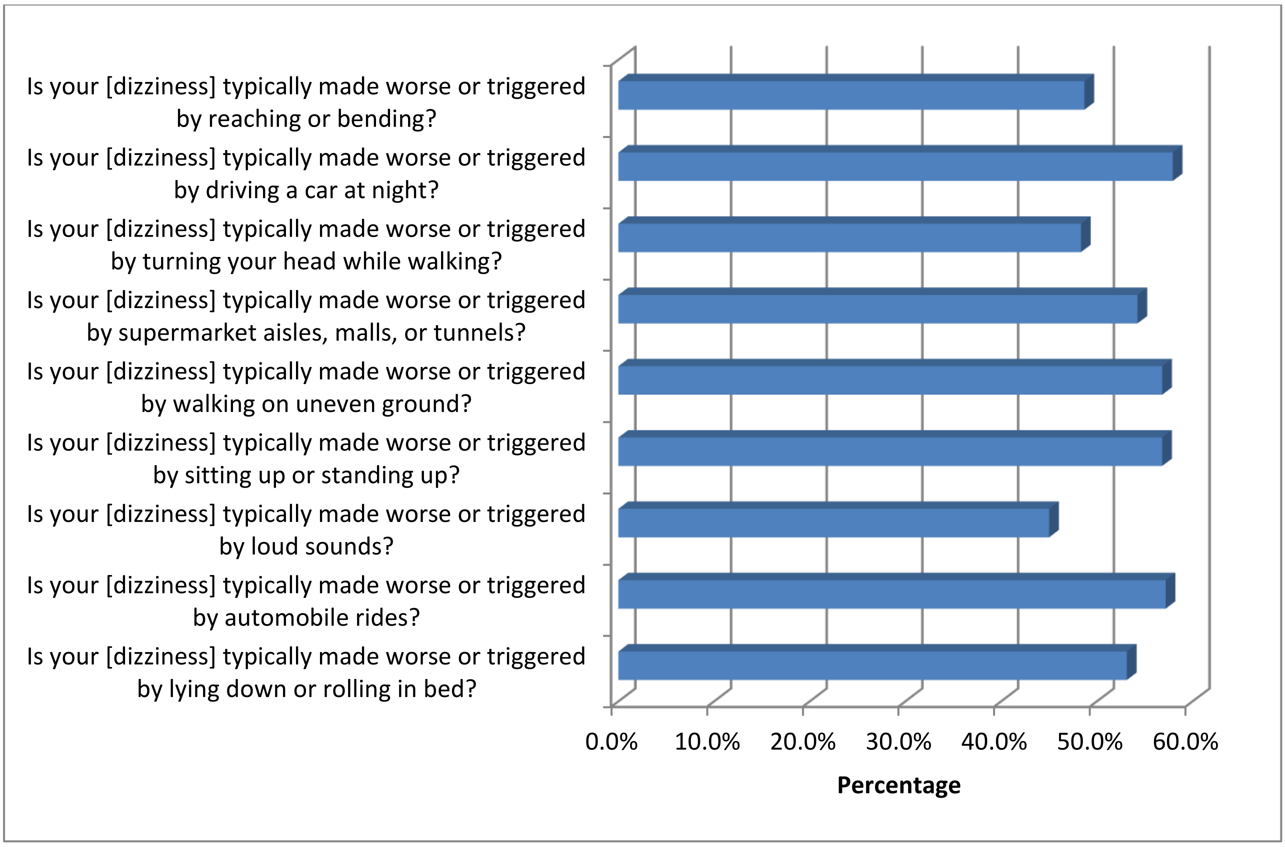

Figure 5: Triggers Section

Table 6: Triggers Frequency

No. of Triggers	No. of Cases	Percentage
0	2	0.7%
1	5	1.8%
2	13	4.8%
3	32	11.8%
4	72	26.6%
5	56	20.7%
6	54	19.9%
7	22	8.1%
8	12	4.4%
9	3	1.1%
Total	271	100.0%

This table shows how many different triggers each patient experienced. The majority of patients reported experiencing between 4 and 6 different triggers, with 26.6% experiencing four triggers and 20.7% experiencing five triggers.

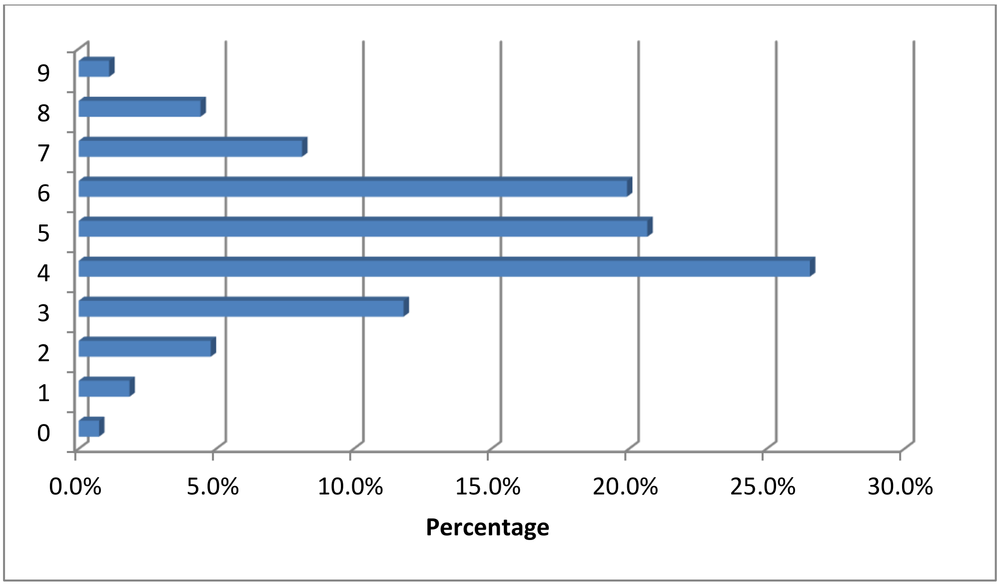

Figure 6: **Triggers Frequency**

Table 7: Ear Section

Question	No. of Cases	Percentage
Ringing or other noise in ears (tinnitus)?	**129**	**47.6%**
Pain in ears?	**152**	**56.1%**
Frequent ear infections?	**131**	**48.3%**

This section identifies ear-related issues reported by patients. Pain in the ears was the most common complaint, with 56.1% of patients reporting it. Tinnitus (47.6%) and frequent ear infections (48.3%) were also commonly reported.

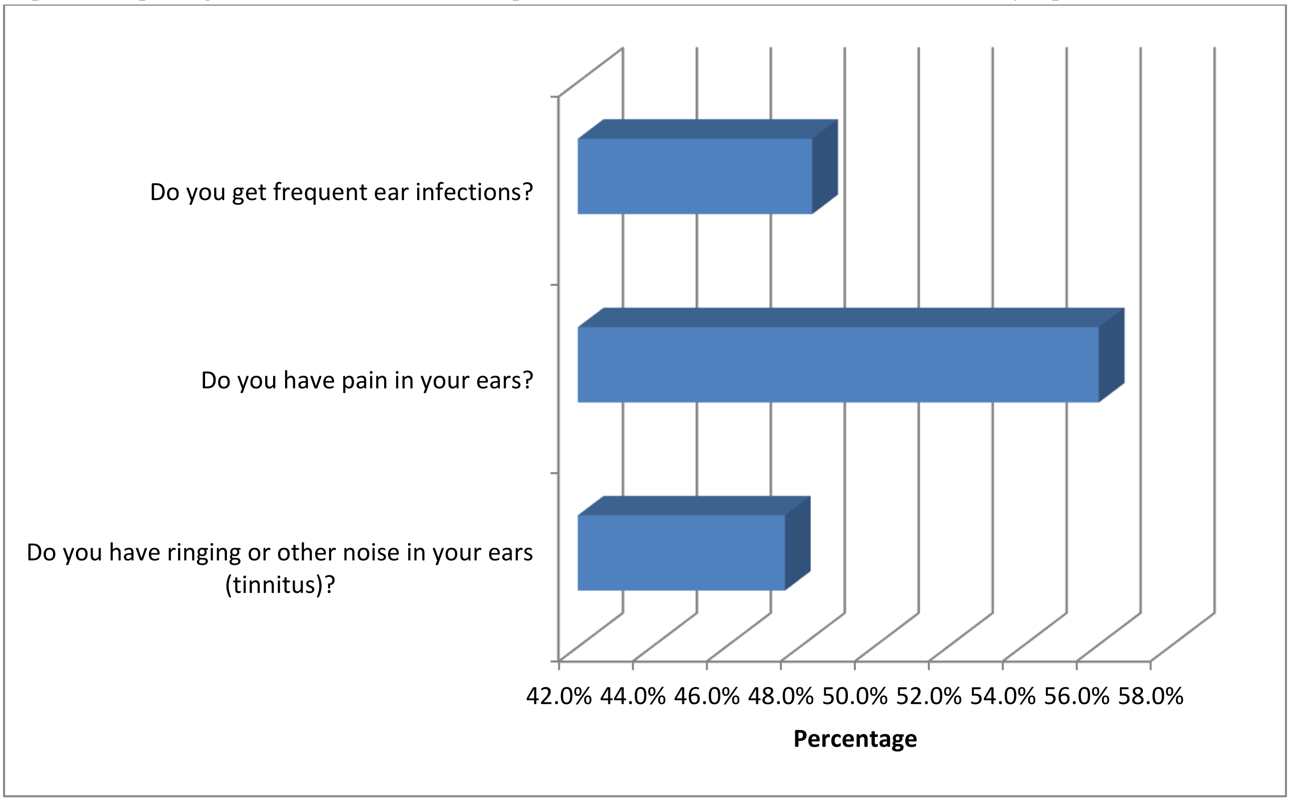

Figure 7: **Ear Section**

Table 8: Ear Frequency

No. of Ear Issues	No. of Cases	Percentage
0	35	12.9%
1	105	38.7%
2	86	31.7%
3	45	16.6%
Total	271	100.0%

This table shows how many ear-related issues patients reported. Most patients (38.7%) reported having one ear-related issue, while 31.7% reported two issues, and 16.6% reported three issues.

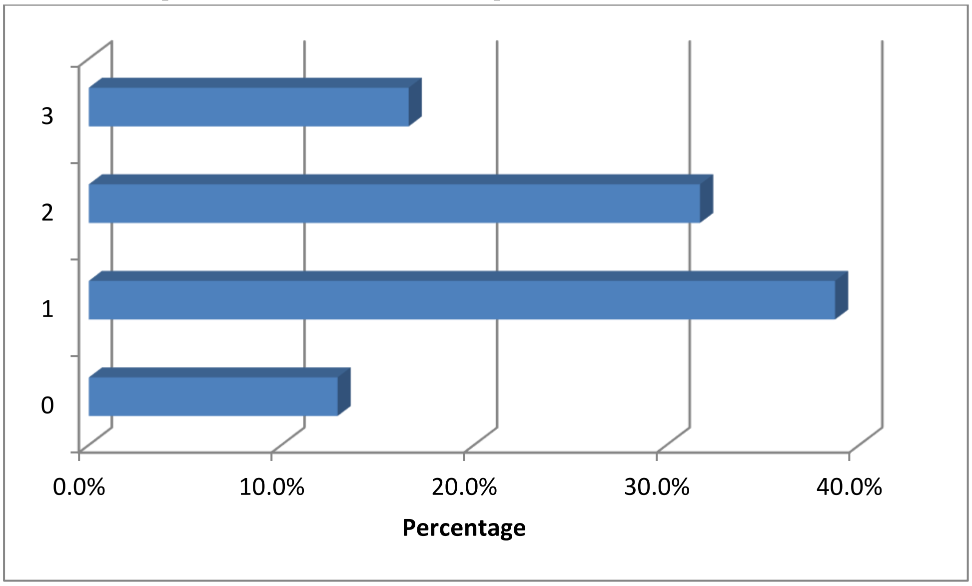

Figure 8: **Ear Frequency**

Table 9: Headache Section

Question	No. of Cases	Percentage
Have you had 5 or more bad headaches in your lifetime?	93	34.3%
Have you had a headache that throbs or pulses?	116	42.8%
Have you had nausea or vomiting with a headache?	118	43.5%
Have you had increased sensitivity to light with a headache?	139	51.3%
Have you had increased sensitivity to sounds with a headache?	97	35.8%
Have you had dizziness associated with a headache?	127	46.9%

Table describes the relationship between headaches and dizziness. A significant number of patients (51.3%) reported increased sensitivity to light during headaches. Additionally, dizziness associated with headaches was reported by 46.9% of patients.

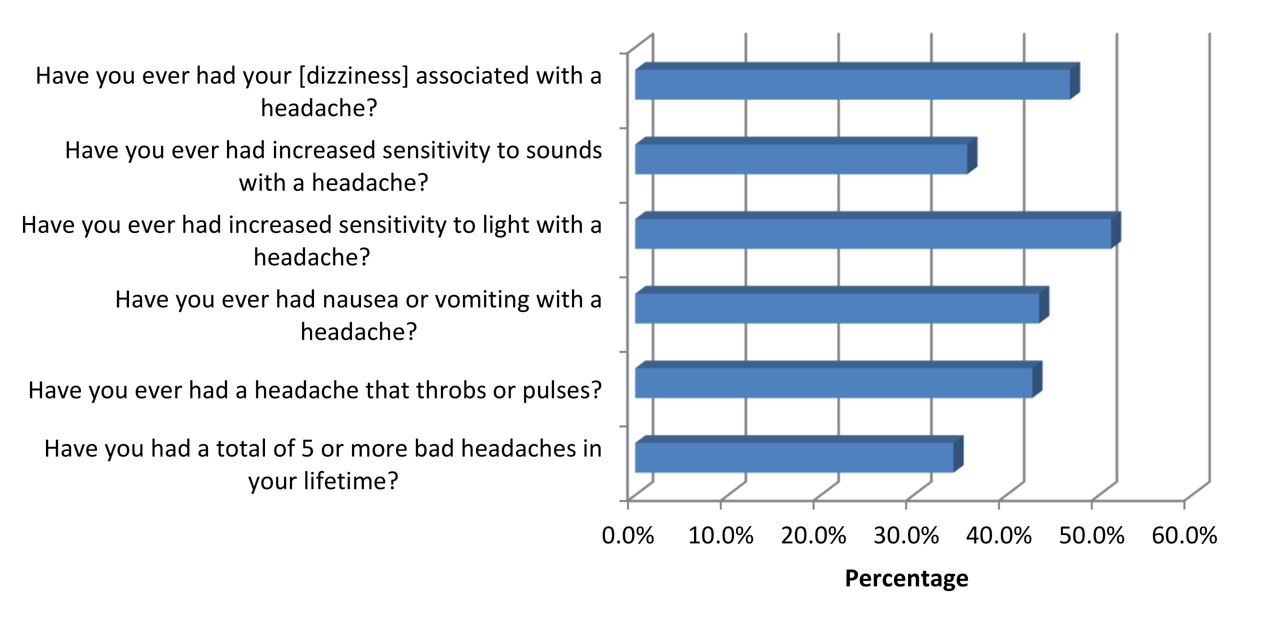

Figure 9: Headache Section

Table 10: Headache Frequency

No. of Headaches	No. of Cases	Percentage
0	21	7.7%
1	35	12.9%
2	67	24.7%
3	87	32.1%
4	47	17.3%
5	12	4.4%
6	2	0.7%
Total	271	100.0%

This table shows how many times patients have experienced headaches. The majority of patients (32.1%) reported experiencing headaches three times, followed by 24.7% who reported two instances of headaches.

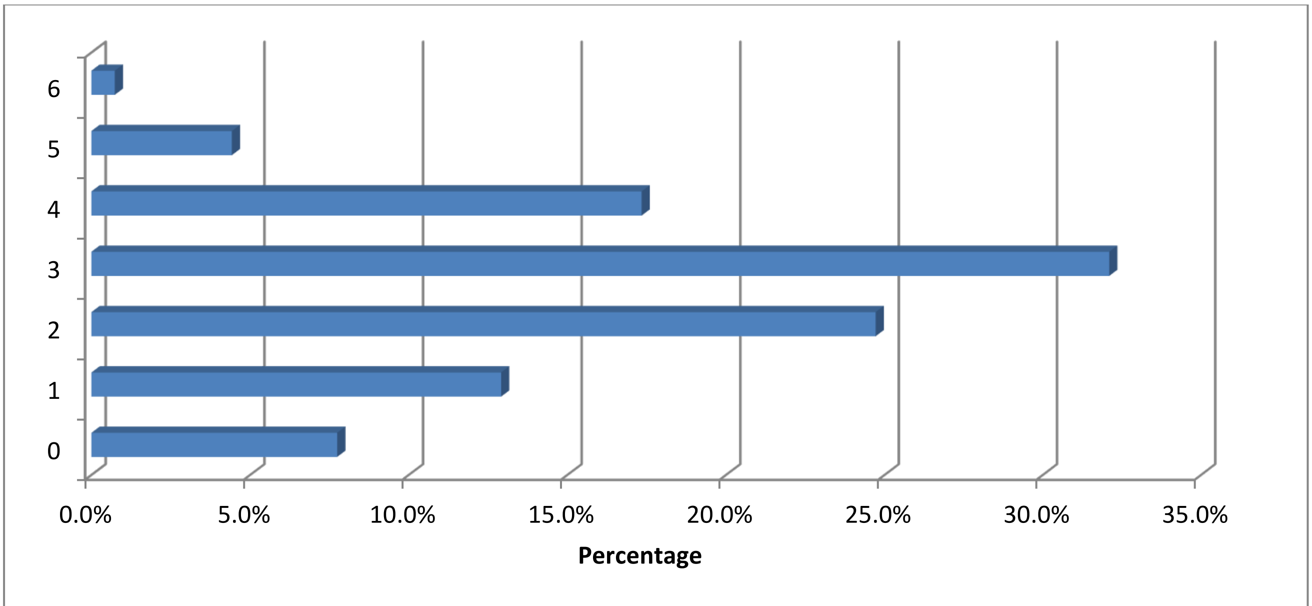

Figure 10: **Headache Frequency**

Table 11: Investigations

Investigation	No. of Cases	Percentage
Magnetic Resonance Imaging (MRI)	150	55.4%
Computed Tomography (CT)	151	55.7%
Electronystagmography (ENG)	148	54.6%
Audiogram	135	49.8%
Dix-Hallpike Test	132	48.7%
Vestibular Evoked Magnetic Potential	154	56.8%

This table shows the types of diagnostic investigations conducted. The most common tests performed were Vestibular Evoked Magnetic Potential (56.8%) and CT scans (55.7%). Other tests like MRI (55.4%) and ENG (54.6%) were also widely used.

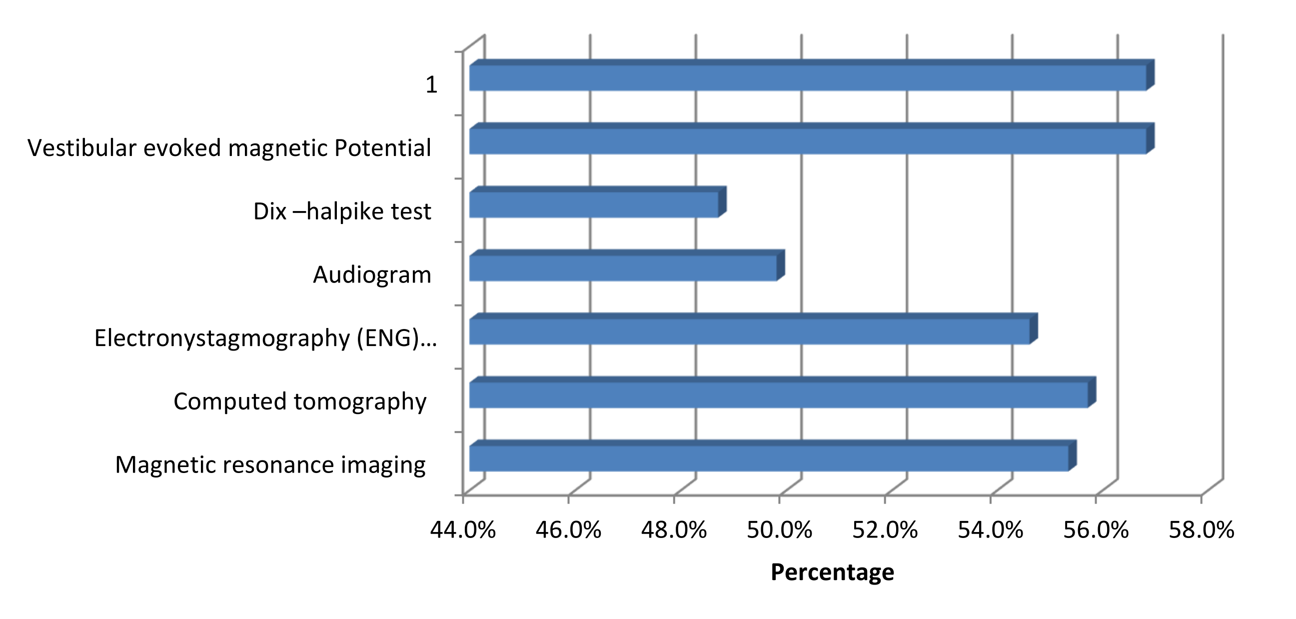

Figure 11: : Investigations

VI. DISCUSSION

The study was conducted over two years at the Emergency Department (ED) and the Department of ENT at Max Superspecialty Hospital in Dehradun, Uttarakhand, India. The design was a cross-sectional, questionnaire-based study that employed logistic regression analysis to examine the predictive factors associated with vertigo diagnoses.

The study population included patients over the age of 18 who presented to the ED with vertigo as their chief complaint, provided they met the inclusion criteria and consented to participate. Patients who refused consent were excluded. Data collection was carried out in two phases. The first phase involved the standard clinical evaluation of patients, where triage was conducted by a primary ED physician, including the collection of history, vitals, and examination findings, along with necessary investigations such as ENT referrals and VNG tests. The second phase involved administering a questionnaire to eligible patients, designed to capture detailed information about their vertigo symptoms. The responses from this questionnaire were analyzed using statistical methods to assess potential predictive factors and assist in the diagnosis of vertigo.

The overall aim of the study was to improve the efficiency and accuracy of diagnosing vertigo in a busy emergency setting by combining traditional clinical practices with a questionnaire-based predictive model.

The analysis of 271 reported cases reveals that the majority of patients presented with symptoms related to balance and spatial orientation. Dizziness was the most common complaint, accounting for 30.3% of cases, followed by visual vertigo (27.7%), giddiness (12.2%), and benign paroxysmal positional vertigo (BPPV) (11.1%). Together, these symptoms constituted over 80% of all cases, indicating a strong predominance of vestibular or balance-related issues. Less common symptoms included motion sensitivity (5.9%), traumatic brain injury (3.0%), syncope (2.6%), and tinnitus (1.8%). Rare diagnoses such as stroke, TIA, vestibular neuritis, and various ear-related conditions were each reported in 0.4% to 0.7% of cases.

Several other conditions, including stroke, migraine, vestibular neuritis, and otitis media, were observed in just one or two patients, reflecting their relative rarity in this cohort. This is in line with previous studies that have explored the prevalence and commonality of BPPV and other vestibular disorders, particularly in the context of emergency department visits.[15]

The types of diagnostic investigations conducted in the study were similar to those described in the literature. The most common tests performed were Vestibular Evoked Magnetic Potential (56.8%) and CT scans (55.7%). Other tests like MRI (55.4%) and ENG (54.6%) were also widely used, consistent with the diagnostic protocols suggested in other research (Yu F 2022) [13].

In Presents studies the relationship between headaches and dizziness among patients in the study. A significant proportion of patients (51.3%) reported experiencing increased sensitivity to light during headaches. This is consistent with common clinical findings where light sensitivity, or photophobia, often accompanies severe headaches such as migraines. Furthermore, 46.9% of the patients also reported that their dizziness was associated with their headaches, indicating a possible overlap between headache and vestibular symptoms. These findings suggest that the presence of headaches, particularly with photophobia, could be an important clinical feature to consider when diagnosing dizziness, particularly in conditions like vestibular migraine or other vestibular disorders associated with headaches. This connection highlights the need for comprehensive evaluation and a potential link between neurological and vestibular symptoms in patients presenting with dizziness.

Another relevant study by Furman et al. (2003) examined patients with vestibular migraine and found a similar prevalence of dizziness associated with headaches, where nearly half of the participants reported such symptoms. However, the current study's findings may be broader, considering the wide range of vestibular disorders included, and suggests that the overlap between dizziness and headache is not limited to migraine alone but may extend to other conditions like BPPV or visual vertigo.[16]

Additionally, studies by Shen Y[17] also emphasize the need for distinguishing vestibular disorders in patients who present with both dizziness and headache symptoms. These findings align with the current study's approach to evaluating both symptoms concurrently for better diagnostic accuracy and treatment planning.

In summary, the current study’s findings are in line with the broader body of research on the connection between headaches and dizziness, particularly in terms of light sensitivity and dizziness occurring alongside headaches. The evidence from previous studies confirms the importance of considering the dual symptomatology of headache and dizziness in clinical assessments of vestibular disorders.

This table highlights the different characteristics of dizziness as reported by the patients, revealing the diversity of experiences in terms of symptom duration and associated manifestations. A substantial number of patients (54.2%) reported that their dizziness lasted for only seconds to one minute, which is typical of benign conditions like Benign Paroxysmal Positional Vertigo (BPPV), where the vertigo episodes are brief and triggered by certain head movements. However, a significant portion of patients (50.2%) experienced dizziness that lasted for hours but less than 12 hours, which could suggest more complex vestibular or neurological issues, such as vestibular neuritis or vestibular migraine. Furthermore, 32.8% of patients reported that their dizziness persisted for a day or longer, which might be indicative of chronic vestibular disorders or other underlying conditions, such as Meniere’s disease.

Additionally, the table shows the presence of associated symptoms such as nausea and vomiting (42.4%), double vision (33.9%), and blurry vision (34.7%), which are often associated with vestibular disorders and may point toward more serious conditions like vestibular migraine or central vestibular pathology. These symptoms are significant as they can aid in differentiating between peripheral and central causes of dizziness. Previous studies have also highlighted the relationship between dizziness duration and severity, as well as the associated symptoms, to improve diagnostic accuracy and identify the underlying etiology of dizziness. [16]

Summary:

The study, conducted over two years at the Emergency Department (ED) and the Department of ENT at Max Superspecialty Hospital, Dehradun, Uttarakhand, India, aimed to improve the accuracy and efficiency of diagnosing vertigo through a combination of clinical evaluation and a questionnaire-based predictive model. The study included 271 patients who presented with

vertigo as their chief complaint, and data collection occurred in two phases: a standard clinical evaluation followed by a detailed questionnaire. Key findings indicated that the most common symptoms observed were dizziness (32.1%), visual vertigo (27.7%), and giddiness (12.2%). A variety of other conditions such as BPPV, Tinnitus, and TIA were also noted, though they were less frequent. Diagnostic investigations, including Vestibular Evoked Magnetic Potential (56.8%), CT scans (55.7%), and MRI (55.4%), were widely performed, reflecting the clinical protocols in diagnosing vertigo.

The study also examined the relationship between dizziness and headaches, finding that 51.3% of patients reported light sensitivity during headaches, with 46.9% noting a connection between their dizziness and headaches. This finding is consistent with research on vestibular migraine and other vestibular disorders associated with headaches. The symptoms of dizziness varied in duration, with many patients experiencing dizziness lasting from seconds to a minute (54.2%), while others had symptoms lasting for hours or days. The presence of associated symptoms like nausea, vomiting, double vision, and blurry vision were noted, which can help differentiate between peripheral and central causes of dizziness.

VII. LIMITATIONS OF THE STUDY

Despite the valuable insights gained, this study has several limitations. Firstly, it was conducted at a single tertiary care center in Dehradun, which may limit the generalizability of the findings to other geographic locations or healthcare settings.

VIII. CONCLUSION

This study reinforces the importance of comprehensive evaluation in diagnosing vertigo, particularly in emergency settings. It highlights the relevance of combining traditional diagnostic methods with a structured questionnaire-based approach to improve diagnostic accuracy. The findings align with previous research on the connection between dizziness and headaches, particularly in conditions like vestibular migraine, and emphasize the need for further investigation into the overlap between vestibular and neurological symptoms. Overall, the study suggests that a multifaceted approach to diagnosing vertigo, incorporating both clinical assessment and symptom-based questionnaires, can enhance diagnostic efficiency and lead to better management of patients with vestibular disorders.

IX. FUTURE DIRECTIONS

Future research should aim to address these limitations through multi-center studies involving a larger and more diverse population to enhance external validity. A longitudinal study design would allow for follow-up assessments to evaluate the progression of symptoms, treatment responses, and patient outcomes. Including detailed patient histories, comorbidity profiles, and medication use could provide a more comprehensive understanding of vertigo etiologies.

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APPENDIX

QUESTIONNAIRE

No	Age	Sex	**Symptoms section**	
			Although you may experience many of the listed sensations, what is the single mostnoticeable part of your dizziness?	Multiplechoice
			Has your [dizziness] occurred once or more than once?	Once/More
			With your [dizziness], have you had nausea and/or vomiting?	Y/N
			During your [dizziness], have you ever had double vision?	Y/N
			During your [dizziness], have you ever had blurry vision?	Y/N
			Describe Dizziness in it rotational/spinning of head surrounding or just visual blackout.	Y/N
			Hard of Hearing in it more during attack of vertigo which is the first symptoms finding Hard of hearing /Vertigo	Y/N
			Duration section	
			Is your [dizziness] currently with you 24 hours a day, never stopping?	Y/N
			Does your [dizziness] last seconds to 1 minute?	Y/N
			Does your [dizziness] last about one hour?	Y/N
			Does your [dizziness] last hours but less than 12 hours?	Y/N
			Does your [dizziness] last 1 day or longer?	Y/N

Table 3-1 (contd.): Survey Question Details

No	Age	Sex	**Triggers section**	
			Is your [dizziness] typically made worse or triggered by lying down or rolling in bed?	Y/N
			Is your [dizziness] typically made worse or triggered by automobile rides?	Y/N
			Is your [dizziness] typically made worse or triggered by loud sounds?	Y/N
			Is your [dizziness] typically made worse or triggered by sitting up or standing up?	Y/N
			Is your [dizziness] typically made worse or triggered by walking on uneven ground?	Y/N
			Is your [dizziness] typically made worse or triggered by supermarket aisles, malls, ortunnels?	Y/N
			Is your [dizziness] typically made worse or triggered by turning your head while walking?	Y/N
			Is your [dizziness] typically made worse or triggered by driving a car at night?	Y/N
			Is your [dizziness] typically made worse or triggered by reaching or bending?	Y/N
No	**Age**	**Sex**	**Ear section**	
			Do you have ringing or other noise in your ears (tinnitus)?	Y/N

			Do you have pain in your ears?	Y/N
			Do you get frequent ear infections?	Y/N

No	Age	Sex	**Headache section**	
			Have you had a total of 5 or more bad headaches in your lifetime?	Y/N
			Have you ever had a headache that throbs or pulses?	Y/N
			Have you ever had nausea or vomiting with a headache?	Y/N
			Have you ever had increased sensitivity to light with a headache?	Y/N
			Have you ever had increased sensitivity to sounds with a headache?	Y/N
			Have you ever had your [dizziness] associated with a headache?	Y/N
			History section	
			Have you had a hip or knee replacement?	Y/N