

# Auditory and Vestibular Research

## Prevalence and Factors Associated with Benign Paroxysmal Positional Vertigo and Falls in Hajj: A Cross-Sectional Study

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### Highlights

- BPPV prevalence in Hajj was low, likely due to younger participant demographics
- Falls were uncommon and not strongly linked to BPPV in this setting
- Bowing during praying was the main trigger associated with BPPV

### Abstract

**Background and aim:** Benign paroxysmal positional vertigo (BPPV) is a common vestibular disorder, typically affecting older adults, and is a recognized cause of vertigo and falls. The physically demanding conditions of Hajj may increase dizziness and fall risk, yet BPPV has not been studied in this mass-gathering context. This study aimed to estimate the self-reported prevalence of BPPV and falls among Hajj pilgrims, and to explore self-reported triggers of dizziness.

**Methods:** A cross-sectional survey was conducted during Hajj 2022–2023 using a validated Arabic questionnaire adapted from published BPPV screeners. Diagnosis of probable BPPV was based solely on self-reported responses to two screening items (brief vertigo episodes <1 minute provoked by specific positional changes). The questionnaire also assessed demographics, comorbidities, falls, and self-reported triggers of dizziness during religious activities.

**Results:** Of 183 respondents, 144 were eligible for analysis (mean age = 36.8 years; range = 16–72). Overall, 22.2% (95% CI: 15.7%–29.9%), reported dizziness, but only 1.4% (95% CI: 0.2%–4.9%) met the self-reported criteria for probable BPPV. The incidence of falls during Hajj was 2.1% (95% CI: 0.4%–6.0%), with no significant association with BPPV. Bowing during prayer was the only religious activity significantly associated with BPPV, although this was based on just two BPPV-positive cases.

**Conclusion:** The prevalence of BPPV was low in this predominantly young sample, limiting generalizability to the wider pilgrim population, which usually includes many older adults. Findings highlight the need for age-diverse, clinically confirmed studies to better understand vestibular health risks during Hajj.

**Keywords:** Benign paroxysmal positional vertigo, vertigo, dizziness, falls, hajj pilgrims

### Introduction

Benign paroxysmal positional vertigo (BPPV) is a leading cause of vertigo, accounting for approximately 20% of moderate to severe dizziness episodes with an overall prevalence of 3.4% in those over 60 [1, 2]. It is characterized by brief, sudden episodes of vertigo (spinning), often accompanied by nausea, vomiting, and balance disturbances, typically triggered by changes in head position [3, 4]. The condition results from the displacement of calcium carbonate crystals (otoconia) from the utricle into the semicircular canals—most commonly the posterior canal [5]. This misplacement disrupts normal vestibular function, leading to abnormal vestibulo-ocular responses and nystagmus.

BPPV affects about 2.4% of individuals over their lifetime, with prevalence increasing significantly amongst the older adults [1]. In Saudi Arabia, however, cross-sectional surveys have reported higher prevalence rates among comparatively younger cohorts—6.2% among attendees at King Saud Medical City in Riyadh [6] and 6.9% in a community-based survey across different regions in Saudi Arabia [7].

Although not life-threatening, BPPV can substantially affect quality of life, increasing the risk of falls, particularly among older adults [8]. Despite being highly treatable with **canalith repositioning maneuvers**, it is often misdiagnosed, leading to unnecessary diagnostic procedures and inefficient use of healthcare resources. Accurate diagnosis and effective management are therefore essential to alleviate symptoms, prevent falls, and reduce healthcare burden [8, 9].

Several risk factors contribute to the onset and recurrence of BPPV. Aging is strongly associated with this condition, as degeneration of the otoconial membrane partly explains its higher prevalence in older adults [10]. Trauma, head injuries, and comorbid vestibular disorders such as Ménière's disease further increase susceptibility [11]. Metabolic factors, including vitamin D deficiency have also been implicated [12]. Environmental and lifestyle factors, such as dehydration and prolonged certain head positions, may exacerbate symptoms by altering inner ear dynamics and blood flow [13, 14].

Hajj, the annual pilgrimage ritual of the Islamic faith, involves physically demanding conditions where people with a wide range of chronic illness often experience heat exhaustion, prolonged standing, bowing, and frequent head movements that may trigger or worsen BPPV symptoms [15, 16]. The crowded settings further increase the risk of falls, making it imperative to address vestibular health in this population. Previous research has emphasized the importance of screening for BPPV to improve diagnostic accuracy and reduce fall risk [10]. Despite this, current Saudi studies have been limited to hospital- or community-based surveys, and none have investigated BPPV in the context of mass gatherings where environmental and physical stressors are particularly pronounced [16].

Therefore, the aim of this study was to investigate the self-reported prevalence of BPPV and fall incidents among individuals in Makkah during the Hajj pilgrimage period.

## Method

### Study design and instrument

This cross-sectional study followed Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines to estimate the prevalence of BPPV and falls among participants in Hajj 2022-2023 using a validated Arabic questionnaire.

The questionnaire was adapted from previously published symptom-based BPPV screeners [4, 5], which emphasize two key diagnostic indicators: brief vertigo episodes lasting less than one minute and positional triggers such as lying down and rolling in bed. Additional items were incorporated to capture Hajj-specific risk contexts (e.g., dizziness during Tawaf, bowing, or Tasleem) as well as medical history (migraine, diabetes, hypertension, vitamin D deficiency, osteoporosis, and head trauma). The questionnaire was reviewed by a panel of two audiology experts for content validity and was pilot-tested on six senior audiology students to ensure face validity and accessibility. The final version consisted of four sections: 1) demographics and lifestyle, 2) medical history, 3) dizziness and BPPV-related symptoms, and 4) Hajj-specific triggers and healthcare utilization. The final questionnaire was distributed via Google Forms. The questionnaire included demographic information, health status, questions on BPPV screening, and incidents of falls. The questionnaire took approximately 10 minutes to complete.

### Participants and Recruitment

The study recruited a convenience sample of individuals who performed Hajj in 2022 and 2023. Data was collected through sharing the questionnaire via Hajj related social media (e.g. LinkedIn and X), WhatsApp groups managed by Hajj campaign organizers, and in-person administration of the questionnaire at the emergency

department of a major governmental hospital in Makkah (Al-Noor Hospital). Data were collected exclusively during the Hajj period, when participants were actively performing rituals. Arabic-speaking adults located in Makkah during Hajj of 2022 and 2023 were eligible. Participants who reported dizziness and/or falls were analyzed for specific vestibular outcomes. Individuals with vertebral artery stenosis or cervical spine dysfunction and/or diagnosed/treated for a stroke during Hajj were excluded from the study.

### **Ethical Considerations**

The study was reviewed and approved by the Institutional Review Board (IRB) of the Ministry of Health in Saudi Arabia (IRB number: H-02-K-076-0522-721), following the International Council for Harmonization (ICH) Good Clinical Practice (GCP) guidelines.

### **Sample size estimation and key variables**

Using a 95% confidence interval and a 5% margin of error, the estimated sample size ranged from 36 to 116 participants. This range was based on previous studies reporting a 2.4% lifetime prevalence of BPPV in adults and an 8% prevalence among patients with moderate to severe dizziness [1].

The outcomes of this study were the prevalence of BPPV and incidence of falls during Hajj 2022-2023. There are three independent factors in this study namely, demographics (age and gender), religious activities, and comorbid medical conditions. Confounders potentially influencing results include fatigue, hydration status, ambient temperature.

### **Statistical analysis**

Descriptive statistics were used to calculate the prevalence BPPV and falls among the participants. Odds ratios with 95% confidence intervals were calculated to identify risk factors associated with BPPV and falls. Correlation analysis was performed to assess associations between the variables. Group comparisons were conducted using the Mann-Whitney U test. Subgroup analyses explored variations in dizziness and BPPV across gender, age groups, and ritual activities and served to explore potential confounders. Missing data was not encountered, as the questionnaire required complete responses. Statistical analysis was conducted using SPSS version 29 [17].

## **Results**

### **Participants and demographics**

Overall, 183 individuals responded to the questionnaire; 39 of these were excluded as they had not participated in the Hajj of 2022 or 2023 as data collection was conducted during Hajj season rather than the after actual event. The total number of participants included in the analysis was 144 (Figure 1). **Table 1** presents their demographic information. The majority were female (60%), and they predominantly resided in the Kingdom of Saudi Arabia (KSA) (92%), mostly in the Makkah region (68.8%) with only a minority (8%) of international participants.

The average age of the participants was 36.8 years, ranging from 16 to 72 years. The male participants had an average age of 34.8 years (range: 16-65 years). The average age for females was 38.1 years (range: 20-72 years). Hence, the female participants were, on average, older than the male participants. Nonetheless, the Mann-Whitney U test revealed no statistically significant difference between the two groups ( $U = 2840.50$ ,  $Z = 1.48$ ,  $p = .140$ ,  $N = 144$ ).

### **Prevalence of benign paroxysmal positional vertigo**

Overall, as shown in Figure 1, 22.2% (95% CI: 15.7%–29.9%), of the participants reported some sort of dizziness (**Table 2**). However, based on the study's diagnostic criteria [1, 5] relying on the *duration* of the attacks and the *triggering* position, the prevalence of BPPV amongst the participants was 1.4% (95% CI: 0.2%–4.9%) none of them received a medical diagnosis (Figure 2) (**Table 3**).

### **Triggering religious positions during Hajj**

To investigate the potential triggering positions during Hajj, the religious activities as reported by individuals experiencing vertigo were examined. Bowing was identified as the most common trigger and was

significantly associated with BPPV (in both identified BPPV-positives participants). Other activities were not associated with BPPV, as presented in **Table 4**.

### **Age and gender effects in positive cases**

Self-reported BPPV was identified in a 30 and 41 years old, male and female respectively. When participants' ages were divided into two categories, below and above 40, the incidence of dizziness in participants aged below 40 was 25.8% (n=24), while the incidence of dizziness in participants aged above 40 was 15.7% (n=8). Interestingly, these findings indicate that dizziness was more common amongst participants under the age of 40.

In terms of gender, the results showed no significant difference between male and female as both genders were represented equally in the BPPV-positive cases (**Table 5**). However, the results revealed a significant difference between males and females in when participants reported the general term “dizziness” (Fisher Exact < 0.001) with a small to moderate association (Cramer’s V =0.296, p <0.001. Females had a 6.3 times higher risk of reporting “dizziness” than males (OR = 6.3 (CI 95 = 2.1 – 19.1)).

### **Medical conditions associated with dizziness**

Correlation analysis between reported medical conditions and BPPV revealed no significant relationship within the current sample. The medical histories of those participants who reported the general term “dizziness” were evaluated. Vitamin D deficiency was the most reported condition amongst participants, accounting for 78% (n=25) of the reported cases, followed by migraine (41%, n=13), diabetes (38%, n=12), and hypertension (28%, n=9).

### **Benign paroxysmal positional vertigo and falls**

Spearman’s correlation analysis revealed no statistically significant correlation between BPPV and falls during Hajj (rs = .156, p = .062, 95% CI [-.013, .316]) and the Pearson Chi-Square ( $X^2$ ) test indicated that there was no statistically significant association,  $\chi^2$  (1, N = 144) = 3.502, p = .124. Although two of the three recorded falls were reported by participants who also complained of dizziness, neither occurrence met the diagnostic criteria for BPPV. Even though the reported attacks were less than one minute (**Table 4**), the triggering positions were standing after sitting up and fatigue. In this sample, the incidence of falls during Hajj was 2.1% (95% CI: 0.4%–6.0%).

### **Discussion**

This study assessed the self-reported prevalence of BPPV and fall incidents among participants in Makkah Saudi Arabia during the Hajj pilgrimage period. Our study found a 1.4% prevalence of BPPV among participants, identified based on recurrent brief dizziness episodes lasting less than 60 seconds and triggered by positional changes such as lying down and rolling in bed. This prevalence is lower than previously reported rates, which globally range from 2.4% to 8% in patients with dizziness [1] and regionally range from 6.2% to 6.9% [6, 7]. The lower prevalence of BPPV in our cohort compared with prior reports may partly reflect the younger age profile of our sample, as age-related degeneration is a well-established risk factor. Due to COVID-19 restrictions, elderly pilgrims over 60 were underrepresented, which likely contributed to the lower prevalence observed. This is consistent with evidence showing that BPPV prevalence is nearly seven times higher in people over 60 compared to those aged 18–39 [1].

While the mean age of our cohort aligns with previous Saudi studies [6,7] (which also report averages under 40), the demographic skew, together with the limited power for subgroup analyses, may explain why our estimates differ from both regional and international reports. Variations in diagnostic criteria across studies, ranging from reliance on partially sensitive screening questions [6] to prior history of BPPV [7], may further complicate direct comparisons. Although clinical manoeuvres were not applied in this study, we used a validated questionnaire, which may have led to stricter case identification.

Although not specific to BPPV, a key finding in this study was the significantly higher incidence of dizziness among females compared to males (OR = 6.3, p < 0.001). This observation is consistent with prior reports of higher dizziness prevalence among women [18]. However, this should be interpreted as an association rather than a causal effect, given our cross-sectional design.

Interestingly, participants under the age of 40 reported more dizziness than older participants, which contrasts with previous studies linking dizziness primarily to aging [10]. This inconsistency may reflect age-related resilience to dizziness [19] or the influence of contextual factors specific to Hajj, such as fatigue or heat

exhaustion [15]. Since these variables were not directly measured in our study, their role remains uncertain. Future prospective research should examine these health and environmental factors more systematically to clarify their contribution to dizziness and BPPV during Hajj. This unexpected pattern warrants further investigation in age-stratified cohort

We initially hypothesized that the demanding environment of Hajj and frequent religious activities such as bowing, circumambulation (Tawaf), and prolonged looking up during supplication might increase vestibular stress and exacerbate BPPV symptoms. In our study, only bowing during prayer was statistically associated with BPPV; however, this finding was based on just two BPPV-positive cases and should therefore be interpreted with caution. More broadly, dizziness episodes were commonly reported during religious activities but were not specific to BPPV, suggesting that other confounders may underlie these symptoms. Although the study did not establish a strong overall link between Hajj-related activities and BPPV, the association observed between bowing during prayer and vertigo symptoms suggests that certain head positions may transiently provoke dizziness in susceptible individuals. Therefore, it is recommended that healthcare providers and Hajj health teams raise awareness among pilgrims with a history of vertigo or balance disorders about the potential effects of repeated head flexion during bowing. Preventive measures may include teaching slower, more controlled movements when changing posture, encouraging brief pauses between standing and bowing, and advising individuals with known BPPV to consult healthcare professionals before travel for possible vestibular rehabilitation or positional manoeuvre guidance. On-site medical teams should also be trained to recognize and manage vertigo episodes promptly, ensuring both safety and continuity of pilgrimage.

It is important to note that none of the participants who were identified as BPPV-positive had received a formal medical diagnosis. This highlights a critical gap in vestibular healthcare access and awareness. The costs to the healthcare system and the indirect costs of BPPV are also significant. It is estimated that arriving at a diagnosis of BPPV can cost approximately \$2,000, and that more than 65% of patients with this condition undergo potentially unnecessary diagnostic testing or therapeutic interventions before receiving appropriate care [9]. Improving early recognition and access to targeted vestibular assessment, particularly in mass-gathering contexts such as Hajj, could help reduce both the clinical burden on patients and the economic burden on health systems

A key strength of this study is its focus on a specific and unique population, Hajj pilgrims, where the younger age profile provided insight into vestibular symptoms under demanding environmental conditions. The use of a cross-sectional design and a validated Arabic questionnaire added methodological rigor. Nevertheless, several limitations must also be acknowledged. The sampling strategy attracted younger and more technologically engaged pilgrims, and COVID-19 restrictions further limited participation of elderly pilgrims, who are at higher risk of BPPV. Reliance on self-reported symptoms may have introduced recall bias, while the absence of direct measures for potential confounders such as hydration status, fatigue, and environmental stressors limited the ability to fully interpret dizziness triggers. In addition, most responses were obtained from residents of Makkah, which reduces the generalizability of the findings to the broader pilgrim population. Although the final sample exceeded the minimum size required for prevalence estimates, subgroup analyses were underpowered and should be interpreted with caution. These limitations highlight the need for future studies with controlled sampling strategies, objective diagnostic tools, and inclusion of more age-diverse cohorts to better understand vestibular health in mass-gathering contexts

Falls, both prior to and during Hajj, were relatively uncommon in our sample, with only 2.1% of participants reporting a fall. Most pilgrims also expressed little concern about falling, suggesting a generally low perceived risk. Taken together with the low prevalence of BPPV, these findings are reassuring, indicating that the majority of dizziness episodes experienced during the 2022 and 2023 Hajj seasons were transient and manageable. Nonetheless, even a small number of falls in a mass-gathering context can have significant health and safety consequences. Therefore, targeted attention should be directed toward individuals with a history of falls or heightened fall concerns to ensure preventive strategies and timely support.

Given the limitations and findings of this study, future research should pursue several directions. Longitudinal designs following pilgrims across the Hajj period could provide more accurate estimates of BPPV prevalence and dizziness-related falls. Incorporating objective vestibular assessments, such as the Dix–Hallpike manoeuvre would enhance diagnostic accuracy and help differentiate BPPV from other causes of vertigo. In addition, larger, age-diverse cohorts and multicentre sampling would improve generalizability and inform evidence-based health strategies to better support pilgrims at risk of vestibular dysfunction. A larger dataset would also allow for the application of advanced statistical methods, including multivariable and logistic regression analyses, which were not feasible in the present study due to the small number of BPPV-positive and fall cases.

Consequently, subgroup and multivariable associations could not be reliably assessed, underscoring the need for adequately powered future studies to enable more robust statistical modelling.

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**Conflict of Interest:** The authors declare no conflicts of interest related to this work.

### Authors' Contributions

HR: Study design, acquisition of data, statistical analysis, interpretation of the results, and drafting and editing the manuscript; AA: Study design, acquisition of data, and critical revision of the manuscript; AS: acquisition of data, revision of the manuscript; RA: Study design, interpretation of the results, and critical revision of the manuscript

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**Table 1.** Participants' demographic information. Chi-squared goodness-of-fit was used to examine the deviation of the sample from an equal distribution. Significantly higher than expected sample distributions are written in bold numbers.

Demographic		N (%)	$\chi^2$ GOF
Gender	Male	57 (39.9)	6.25*
	Female	<b>87 (60.4)</b>	
Visitors Lives in KSA	No	12 (8.3)	150.03**
	Yes	<b>132 (91.7)</b>	
Regions in KSA	Makkah Al-Mukarramah	<b>99 (68.8)</b>	100.00**
	Al-Madinah Al-Munawwarah	5 (3.5)	
	Riyadh	15 (10.4)	
	Eastern Province	7 (4.9)	
	Al-Qassim	2 (1.4)	
	Hail	1 (0.7)	
	Jazan	1(0.7)	
	Najran	1 (0.7)	
	Al-Baha	1 (0.7)	

$\chi^2$  GOF: Chi-squared goodness-of-fit;

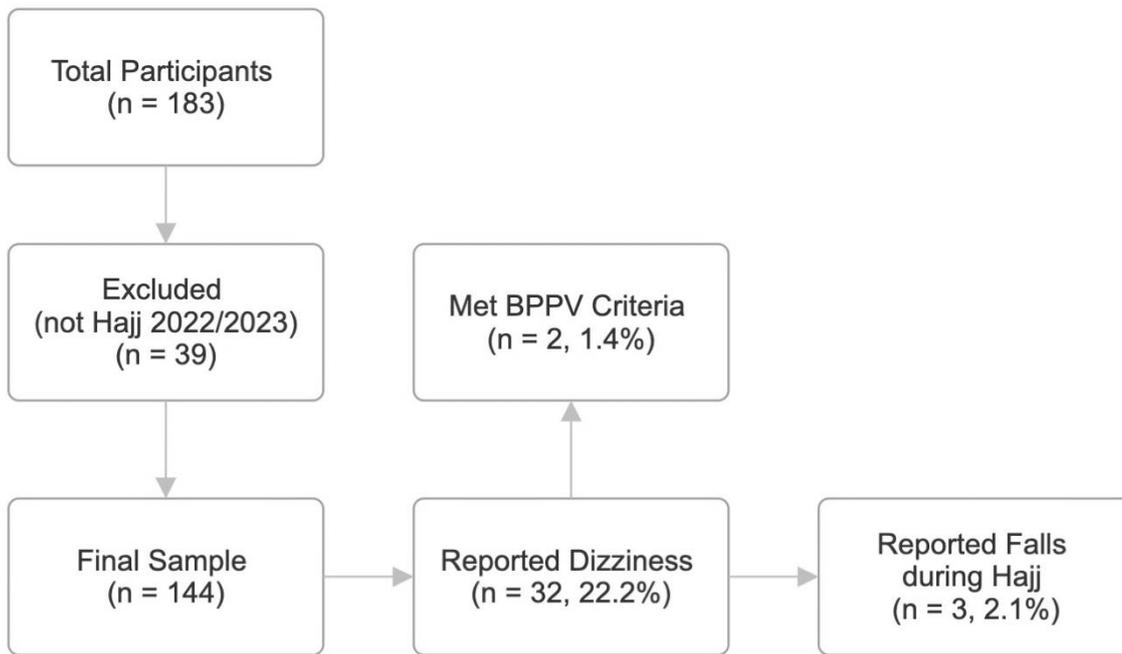
\* Significant at <0.05 level; \*\* significant at <0.01 level.

**Table 2.** Self-reported dizziness symptoms, triggers, and related factors among participants. Most episodes lasted less than one minute with recurrence most often reported as "rarely" Common positional triggers and emotional and functional impacts were also reported.

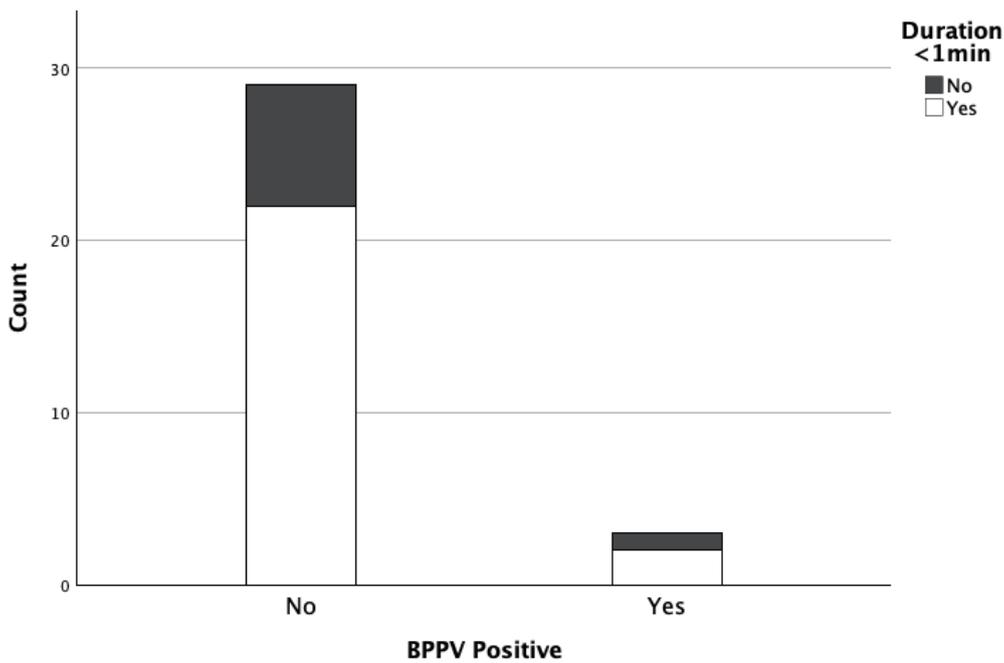
Symptoms, triggers and related factors		Reported Yes; N (%)
Dizziness	General	32 (22.2%)
	Vertigo	11 (34%)
	Unsteadiness	11 (34%)
	Lightheadedness	5 (16%)
	blurred vision	1 (3%)
	Fainting	3 (9%)
	Fatigue	1 (3%)
Duration < 1 m		24 (75%)
Recurrence	Rarely	19 (59%)
	Once a day	6 (19%)
	Once a week	2 (6%)
	Once a month	5 (16%)
Rolling in Bed		1 (3%)
Bending Over		5 (16%)
Standing Up		21 (66%)
Looking Up		5 (16%)
Lying in bed		2 (6%)
Fainting		2 (6%)
Other		3 (9%)
Dizzy with anxiety	Sometimes	21 (66%)
	Most of the time	2 (6%)
Dizziness with handicap	Sometimes	12 (38%)
	Most of the time	6 (19%)
Diagnosis		4 (13%)
Cured		4 (13%)

**Table 3.** Positions triggering dizziness and the number of people diagnosed and treated. The count of participants with Benign Paroxysmal Positional Vertigo-positive diagnosis is shown in bold.

Position	Overall	Duration < 1 m	
		No	Yes
Rolling in bed	1	0	1
Lying in bed	2	1	1
Looking Up	5	1	4
Bending Over	5	1	4
Standing up	21	7	16
Diagnosis	4	1	3
Cured	4	0	4



**Figure 1:** Flow diagram summarizing participant recruitment, exclusions, and diagnostic classification from initial respondents through dizziness reports, benign paroxysmal positional vertigo-positive cases, and falls.



**Figure 2.** Distribution of Benign Paroxysmal Positional Vertigo (BPPV)-positive cases by duration of attacks.

**Table 4.** Religious activities that may provoke vertigo are listed; bowing position is shown in bold, as it demonstrated a statistically significant association.

Events Provokes Vertigo	Overall (%)	Duration < 1m		Fisher's Exact (P)	BPPV Positive
		NO	YES		
<b>Bowing</b>	11 (34)	0	11	0.03*	2
Standing in Arafa	3 (9)	2	1	0.15	0
Standing in Muzdalefa	1 (3)	0	1	1.00	0
Circumambulation (Tawaf)	10 (31)	4	6	0.22	0
Ablution	3 (9)	1	2	1.00	0
Concluding prayer (Tasleem)	2 (6)	0	2	1.00	0
Looking up supplication	4 (13)	0	4	0.56	0
Working in a crowd	2 (6)	0	2	1.00	0

**Table 5.** Settings that may provoke vertigo lasting less than one minute are listed. Positions triggering Benign Paroxysmal Positional Vertigo (BPPV), categorized by gender, are shown in bold.

Triggering Position	Duration < 1m	
	Gender	
	Male	Female
<b>Rolling in bed</b>	1	0
<b>Lying in bed</b>	0	1
Looking up	0	4
Bending over	0	4
Fainting	0	1
Standing up	1	15