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# VISUAL SNOW SYNDROME PREVALENCE AMONG YOUNG ADULTS IN THE RUSSIAN FEDERATION: A RESEARCH PERSPECTIVE

**Ekaterina Muravikova[1,2], Alexey Sustretov[1,2], Karina Berezhnaya[3], Daniil Kokorev[1,2], Timur Syunyakov[3] & Arseny Gayduk[1,3,4]**

[1]*Samara State Medical University, Samara, Russia*

[2]*Professional Center for Education and Research in Genetic and Laboratory Technologies, Samara State Medical University, Samara, Russia*

[3]*International Centre for Education and Research in Neuropsychiatry (ICERN), Samara State Medical University, Samara, Russia*

[4]*Research Institute for Healthcare Organization and Medical Management of Moscow Healthcare Department, Moscow, Russia*

## SUMMARY

***Background:*** *Visual snow syndrome (VSS) is a poorly understood neurological condition of unclear etiology, characterized by visual and non-visual symptoms that reduce quality of life. The objective of our study was to estimate the prevalence of young adults with visual snow in Russia.*

***Materials and methods:*** *We conducted an online survey among 1,177 respondents over the age of 18 residing in Russia. The questionnaire was based on MIDAS, HIT-6, ICHD-3, GAD-7, CES-D.*

***Results:*** *A total of 1085 individuals, divided into three groups: 48 participants with Visual Snow Syndrome (VSS), 36 participants with visual snow symptoms (VS), and 1001 participants without visual snow (control group). Tinnitus ($p<0.001$) and paresthesia ($p<0.001$) were more common in participants with VSS compared to the control group. VSS group also reported mood disorders more frequently than those in the other groups (29.2% VSS, 13.9% VS, 7.0% control, $p<0.001$). Additionally, VSS group exhibited more elevated anxiety levels on the GAD-7 scale compared to the other groups ($p=0.005$), suggesting a weak association between anxiety and VSS.*

***Conclusions:*** *Diagnosed migraine, tinnitus, concentration problems, paresthesia, and verified psychiatric conditions were significantly more prevalent in the VSS group in our study. Tinnitus was significantly more frequent in the VS group. Diagnosed conditions across all ICD-10 classes were more frequently identified in the VSS group, with the strongest associations (moderate) found with ICD-10 codes: F80-F89 and F60-F69. Additionally ICD-10 codes F30-F39 were more frequently found in the VS group compared to the control group. Our study revealed that nearly all individuals with VSS in our sample (89.6%) had experienced symptoms for as long as they can remember. The prevalence of VS symptoms in Russia is 7.7% (6.2-9.3%) and VSS is 4.4% (3.2-5.7%).*

***Key words:*** *visual snow syndrome – visual disturbance – tinnitus – anxiety – mood impairment*

***Abbreviations:*** *BFEP – blue field entoptic phenomenon; CES-D – Center for epidemiological studies depression scale; GAD-7 – Generalized anxiety disorder 7-item; HIT-6 – Headache Impact Test; ICD-10 – International Classification of Diseases; ICHD-3 – International Classification of Headache Disorders; MIDAS – Migraine Disability Assessment; MMSS – The Mizan Meta-Memory and Meta-Concentration Scale for Students; SD – standard deviations; VS – visual snow; VSS – visual snow syndrome*

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## INTRODUCTION

Visual snow syndrome (VSS) is a poorly understood neurological condition of unclear etiology, characterized by visual and non-visual symptoms that reduce quality of life. According to a study on the identifying VSS among people from the UK, 2.2% of the population reported this pathological condition (Kondziella et al. 2020). And this means that up to 200 million people worldwide affected by this syndrome. As a result, researchers' interest in VSS has increased in recent years.

The condition was first described in 1995 by Liu G.T. et al. in 10 patients with diagnosed migraine (Liu et al. 1995), the term itself was proposed in 2013 (Simpson et al. 2013), and the criteria for the syndrome were formulated in 2017-2018 (International Classification of Headache Disorders 2013), as presented in Table 1.

The criteria for determining VSS include only visual symptoms, but in addition to these, non-visual symptoms are often observed within the syndrome, such as tinnitus, dizziness, irritability, and concentration problems (Schankin et al. 2014, van Dongen et al. 2019, Yildiz et al. 2019, Schankin et al. 2020, Yoo et al. 2020). Many authors also noted a higher frequency of diagnosed migraine, anxiety and mood impairments in the population of patients with VSS compared to the population of individuals without this syndrome (Schankin et al. 2014, Kondziella et al. 2020, Puledda et al. 2020c).

**Table 1.** Diagnostic criteria of the VSS

| |
|---|
| Dynamic, continuous, tiny dots across the entire visual field, persisting for >3 months<br>Patients compare visual snow to television static ("television snow"). The dots are usually black or grey on a white background and grey or white on a black background, but also reported are transparent dots, white flashing dots and coloured dots. |
| Additional visual symptoms of at least two of the following four types: |
| Palinopsia may be visual after-images and/or trailing of moving objects. Visual after-images are different from retinal after-images, which occur only after staring at a high-contrast image and are in complementary colour. |
| Enhanced entoptic phenomena, arising from the structure of the visual system itself, include excessive floaters in both eyes, excessive blue field entoptic phenomenon (uncountable little grey/white/black dots or rings shooting over the visual field of both eyes when looking at homogeneous bright surfaces such as the blue sky), self-lighting of the eye (coloured waves or clouds perceived when closing the eyes in the dark) and spontaneous photopsia (bright flashes of light). |
| Photophobia |
| Impaired night vision (nyctalopia) |
| Symptoms are not consistent with typical migraine visual aura |
| Symptoms are not better accounted for by another disorder<br>Normal ophthalmology tests (corrected visual acuity, dilated-pupil fundoscopy, visual field examination and electroretinography) and no intake of psychotropic drugs. |

VSS typically manifests in young adults between 20-25 years old (Bessero et al. 2014, Schankin et al. 2014, van Dongen et al. 2019, Puledda et al. 2020a, Schankin et al. 2020, Viana et al. 2020). However, around 40% of patients affected by this condition since childhood and cannot recall seeing differently (Puledda et al. 2020a,c, Solly et al. 2020). According to most studies, there is no correlation with gender (Schankin et al. 2014, Puledda et al. 2020c, Viana et al. 2020).

There are many ophtalmological, neurological and psychiatric conditions which may cause VS, such as: hallucinogen persisting perception disorder (Puledda et al. 2020c, Fraser 2022), ophthalmic migraine (Yoo et al. 2020, Fraser 2022), posterior vitreous detachment, age-related macular degeneration (Fraser et al. 2022), Creutzfeldt-Jakob disease (Patel et al. 2021), Charles Bonnet syndrome (Fraser 2022, Unal-Cevik 2022), retinal tear, birdshot chorioretinopathy, retinitis pigmentosa and other retinopathy forms (Fraser et al. 2022). Thus, a thorough and comprehensive examination of the patient is necessary to differentiate VSS from the abovementioned conditions.

For comprehensive examination in terms of differential diagnosis physicians and researchers use: saccade and anti-saccade tasks (Solly et al. 2020, Strik et al. 2023), pupillary light reflex test (Yoo et al. 2020), random visual evoked potentials (Luna et al. 2018, Yildiz et al. 2019), magnetic resonance imaging (diffusion tensor imaging) (Puledda et al. 2020a,b, Strik et al. 2022, 2023, Michels et al. 2021), magnetoencephalography (Hepschke et al. 2022).

Despite the increased interest in studying the physiological basis of VSS, only a few scientific groups consider this syndrome dynamically. Currently, there is no data on complete loss of vision in VSS. The use of medication for VSS may include benzodiazepines, lamotrigine, topiramate, and acetazolamide, but data on their effects on VSS are quite controversial, and the relative benefit of these drugs is uncertain (van Dongen et al. 2019, Puledda et al. 2022). VSS may be observed in patients with affective or other psychiatric disorders and migraines, and at the same time, pharmacological treatement of this conditions may worsen VSS symptoms (for example amitriptyline and citalopram) (van Dongen et al. 2019, Puledda et al. 2022).

In addition to pharmacological symptom management for VSS, researchers try to apply transcranial magnetic stimulation and tinted lenses. However, the current studies to date have been characterized by low representativeness and objective monitoring of therapeutic outcomes has proven to be challenging (van Dongen et al. 2019, Puledda et al. 2022, Unal-Cevik 2022, Fraser 2022). To determine if treatment leads to any functional changes, it has been suggested to use saccade and anti-saccade tasks (Fraser et al. 2022, Ciuffreda et al. 2023).

In terms of insufficient data on different aspects of VSS, our primary objective was to estimate the prevalence of young adults with visual snow in Russia, including the prevalence of people satisfy the criteria for visual snow syndrome.

## MATERIALS AND METHODS

Between November 14 and December 31, 2023, we conducted a survey among 1,177 respondents over the age of 18 residing in Russia. Some respondents were excluded based on the following criteria: a) withdrawal from participation at any stage of the survey; b) age restrictions: younger than 18 years or older than 30 years.

The survey was administered online using Google Forms. The questionnaire comprised four sections: the first section included socio-demographic data (gender, age); the second section contained questions specifically

related to VSS, including presence, duration of symptoms, and possible causes; the third section focused on the most commonly associated condition, migraine; and the fourth section addressed other comorbid conditions (cardiological, neurological, psychiatric disorders). The VSS section was modeled after previous studies (Schankin et al. 2014, Eren et al. 2020, Kondziella et al. 2020, Puledda et al. 2020c) and included images to help participants better understand the various visual symptoms. The section on headaches and migraines was based on the MIDAS and HIT-6 questionnaires, with an additional question about the duration of headaches to distinguish participants experiencing headaches lasting more than four hours. This division was chosen to identify respondents with moderate or severe tension headaches or migraines, based on data from the ICHD-3 (International Headache Society 2013, Kondziella et al. 2020). In the section on comorbid conditions, participants were asked to report any diagnoses given by a cardiologist, neurologist, or psychiatrist. Additionally, all participants without psychiatric diagnoses completed the GAD-7 (Generalized Anxiety Disorder 7-item) and CES-D (Center for Epidemiological Studies Depression Scale) questionnaires to assess anxiety and depression. Scores above 9 on the GAD-7 were considered indicative of high anxiety, and scores above 23 on the CES-D were considered indicative of mood impairment.

Approval for the study was initially granted by the Ethics Committee at Samara State Medical University.

Based on previous research (Kondziella et al. 2020, Puledda et al. 2020c), we anticipated dividing the resulting sample into three groups: people with VSS, those with only VS, and those without these conditions. The VSS group included individuals who met all the criteria for VSS according to the ICHD-3 (Table 1). The VS group comprised individuals with VS symptoms who did not meet one or more of the criteria: the presence of two or more additional visual symptoms, and the absence of other ophthalmological or neurological conditions explaining the visual snow. The remaining participants (absence of VS or presence for less than three months) constituted the control comparison group. The inclusion criteria for each group are detailed in Figure 1.

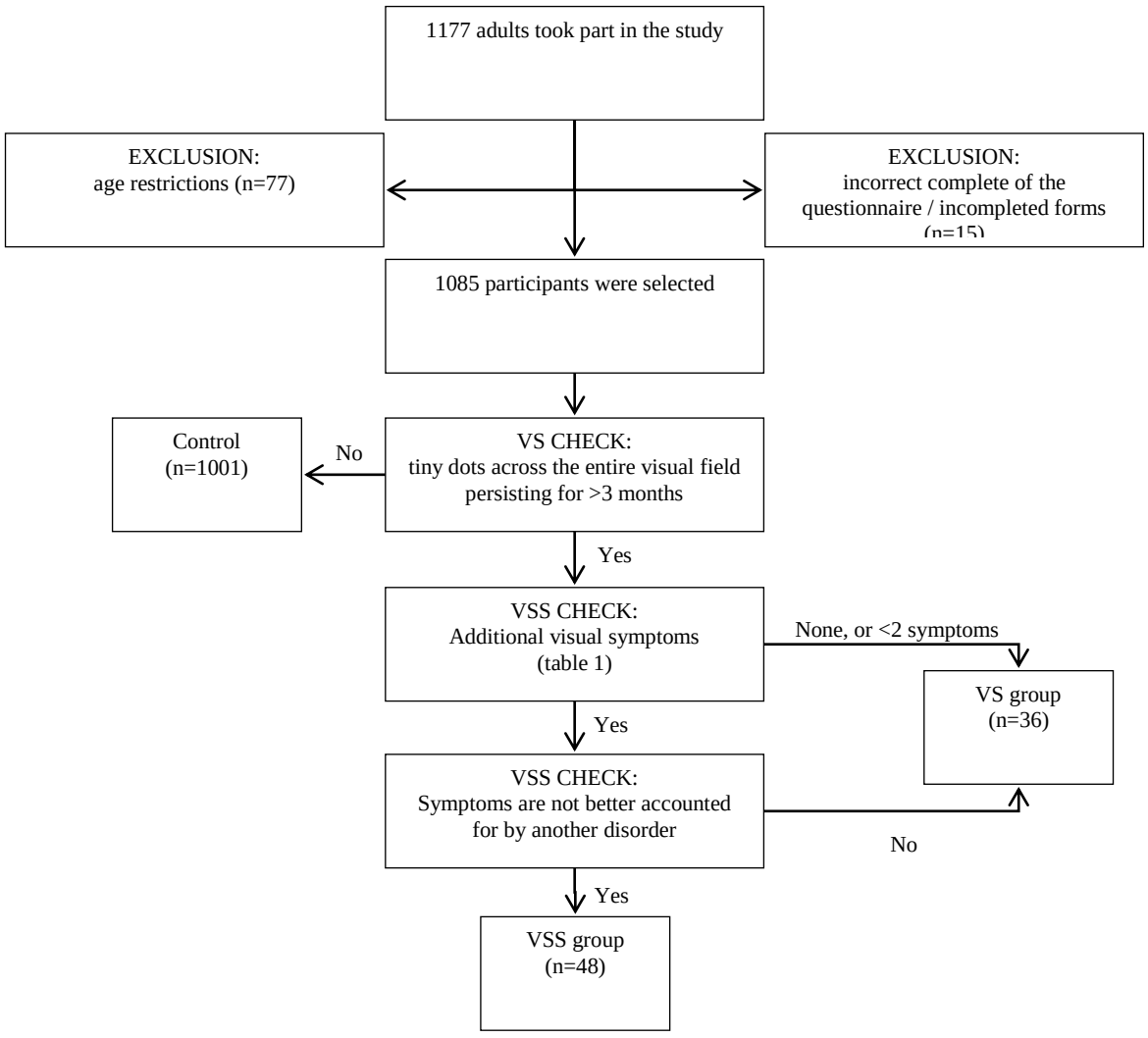


**Figure 1.** Study design

Descriptive statistics were used to describe the demographic characteristics of the study participants. For continuous variables, mean values (Mean) and standard deviations (SD) were provided, while frequencies and percentages were reported for categorical variables.

To analyze the differences in the frequency of characteristics among the three groups and to assess pairwise differences between the groups, we applied Pearson's chi-squared test ($\chi^2$). Post-hoc analysis and identification of differences between specific pairs of groups were conducted using Pearson's $\chi^2$ test. Cramér's V was used to evaluate the strength of association between categorical variables. For all tests, a P-value of less than 0.05 was considered statistically significant.

## RESULTS

Demographic characteristics, prevalence of visual snow syndrome (VSS), and comorbid conditions are presented in Table 2. Results of pairwise comparisons are shown in Table 3.

### Demographic characteristics and prevalence of visual snow syndrome

A total of 1085 individuals participated in the study, divided into three groups. The first group consisted of 48 participants diagnosed with visual snow syndrome (VSS), the second group included 36 participants with visual symptoms but not meeting the full criteria for VSS (VS group), and the third group comprised 1001 participants without any visual symptoms (control).

The majority of participants in all groups were female: 66.7% in the VSS group, 58.3% in the VS group, and 77.0% in the control group. The gender distribution differed significantly between the groups ($\chi^2$=9.011, df=2, p=0.011, V=0.091), indicating a weak association between gender and group classification. Pairwise comparisons revealed that the proportion of females was significantly higher in the control group compared to the VS group ($\chi^2$=6.727, df=1, p=0.009). The mean age of participants was similar across all groups: 21.6 years in the VSS group, 20.9 years in the VS group, and 21.3 years in the control group.

### Visual symptoms

Participants with VSS reported a higher prevalence of various visual symptoms compared to other groups. The most common symptoms in the VSS group were blue field entoptic phenomenon (BFEP, 79.2%), photopsia (56.3%), nyctalopia (56.3%), colored swirls with closed eyes (52.1%), and floaters (52.1%). In the VS group, the most frequently reported symptoms were BFEP (63.9%) and floaters (44.4%). In the control group, the most common symptom was floaters (27.8%).

Significant differences were found between groups in the frequency of visual symptoms such as trailing moving objects ($\chi^2$=26.669, df=2, p<0.001, V=0.157), afterimages ($\chi^2$=42.118, df=2, p<0.001, V=0.197), floaters ($\chi^2$=17.102, df=2, p<0.001, V=0.126), BFEP ($\chi^2$=25.731, df=2, p<0.001, V=0.154), diplopia ($\chi^2$=14.340, df=2, p=0.001, V=0.115), spontaneous photopsia ($\chi^2$=23.475, df=2, p<0.001, V=0.147), colored swirls with closed eyes ($\chi^2$=24.524, df=2, p<0.001, V=0.150), photophobia ($\chi^2$=489.758, df=2, p<0.001, V=0.672), and night blindness ($\chi^2$=28.824, df=2, p<0.001, V=0.163). The V values indicate that the association between group and these symptoms ranges from weak to moderate, with the strongest association observed with photophobia. Specifically, all these symptoms were significantly more frequent in participants with VSS compared to the control group. Pairwise comparisons showed that trailing moving objects ($\chi^2$=8.750, df=1, p=0.003) and afterimages ($\chi^2$=10.480, df=1, p=0.001) were more common in the VSS group than in the VS group. Additionally, participants in the VS group reported floaters (44.4%), diplopia (13.9%), and colored swirls with closed eyes (38.9%) more frequently than control group participants (p<0.05 in all cases).

### Non-visual symptoms

Participants with VSS also reported a higher prevalence of non-visual symptoms compared to other groups. The most common symptoms in the VSS group were tinnitus (68.8%), concentration problems (60.4%), and tremor (29.2%). In the VS group, the most frequently reported symptoms were tinnitus (52.8%) and concentration problems (50.0%). Control group participants most commonly did not report any non-visual symptoms (37.0%).

Tinnitus ($\chi^2$=34.933, df=2, p<0.001, V=0.179) and paresthesia ($\chi^2$=18.105, df=2, p<0.001, V=0.129) were significantly more common in participants with VSS compared to the control group. The V values indicate that the association between group and these symptoms ranges from weak to moderate. Additionally, concentration problems were more common in the VSS group (60.4%) compared to the control group (41.5%, $\chi^2$=6.744, df=1, p=0.009). The absence of non-visual symptoms was more characteristic of the control group than for the VSS ($\chi^2$=9.964, df=1, p=0.002) and VS groups ($\chi^2$=3.260, df=1, p=0.071).

### Mental health aspects

Participants in the VSS group reported mood disturbances more frequently compared to the other groups (29.2% in the VSS group, 13.9% in the VS group, and 7.0% in the Control group, $\chi^2$=31.507, df=2, p<0.001, V=0.170), indicating a moderate association between the presence of VSS and psychiatric diagnoses.

**Table 2.** Demographics, comorbid conditions, and characteristics of symptom onset across three groups

| Variable | VSS (n=48) | VS group (n=36) | Control (n=1001) | Total (N=1085) | Statistics |
|---|---|---|---|---|---|
| Gender | | | | | |
| Female | 32 (66.7%) | 21 (58.3%) | 771 (77.0%) | 824 (75.9%) | $\chi^2$=9.011, df=2, p=0.011, V=0.091 |
| Male | 16 (33.3%) | 15 (41.7%) | 230 (23.0%) | 261 (24.1%) | |
| Age (average) | 21.6 | 20.9 | 21.3 | | |
| Visual snow | | | | | |
| Since childhood | 44 (91.7%) | 33 (91.7%) | - | 77 (7.1%) | $\chi^2$=0.000, df=1, p=1.000, V=0.000 |
| Sudden onset of symptoms | 4 (8.3%) | 3 (8.3%) | - | 7 (0.6%) | $\chi^2$=0.000, df=1, p=1.000, V=0.000 |
| Age at symptom onset | 20.5 | 16.5 | - | | |
| Visual symptoms - Palinopsia | | | | | |
| Trailing moving objects | 13 (27.1%) | 1 (2.8%) | 71 (7.1%) | 85 (7.8%) | $\chi^2$=26.669, df=2, p=0.000, V=0.157 |
| Afterimages | 17 (35.4%) | 2 (5.6%) | 80 (8.0%) | 99 (9.1%) | $\chi^2$=42.118, df=2, p=0.000, V=0.197 |
| Visual symptoms -Entoptic phenomena | | | | | |
| Floaters | 25 (52.1%) | 16 (44.4%) | 278 (27.8%) | 319 (29.4%) | $\chi^2$=17.102, df=2, p=0.000, V=0.126 |
| BFEP | 38 (79.2%) | 23 (63.9%) | 450 (45.0%) | 511 (47.1%) | $\chi^2$=25.731, df=2, p=0.000, V=0.154 |
| Diplopia | 8 (16.7%) | 5 (13.9%) | 53 (5.3%) | 66 (6.1%) | $\chi^2$=14.340, df=2, p=0.001, V=0.115 |
| Flashes (spontaneous photopsia) | 16 (33.3%) | 5 (13.9%) | 105 (10.5%) | 126 (11.6%) | $\chi^2$=23.475, df=2, p=0.000, V=0.147 |
| Coloured swirls with eyes closed | 25 (52.1%) | 14 (38.9%) | 231 (23.1%) | 270 (24.9%) | $\chi^2$=24.524, df=2, p=0.000, V=0.150 |
| Photophobia | 27 (56.3%) | 3 (8.3%) | 3 (0.3%) | 33 (3.0%) | $\chi^2$=489.758, df=2, p=0.000, V=0.672 |
| Nightblindness | 27 (56.3%) | 5 (13.9%) | 235 (23.5%) | 267 (24.6%) | $\chi^2$=28.824, df=2, p=0.000, V=0.163 |
| None | - | 5 (13.9%) | 231 (23.1%) | 236 (21.8%) | $\chi^2$=15.684, df=2, p=0.000, V=0.120 |
| Non-visual symptoms | | | | | |
| Tinnitus | 33 (68.8%) | 19 (52.8%) | 313 (31.3%) | 365 (33.6%) | $\chi^2$=34.933, df=2, p=0.000, V=0.179 |
| Paraesthesia | 10 (20.8%) | 3 (8.3%) | 56 (5.6%) | 69 (6.4%) | $\chi^2$=18.105, df=2, p=0.000, V=0.129 |
| Concentration problems | 29 (60.4%) | 18 (50.0%) | 415 (41.5%) | 462 (42.6%) | $\chi^2$=7.572, df=2, p=0.023, V=0.084 |
| Tremors | 14 (29.2%) | 5 (13.9%) | 152 (15.2%) | 166 (15.3%) | $\chi^2$=6.843, df=2, p=0.033, V=0.079 |
| Dizziness | 16 (33.3%) | 7 (19.4%) | 211 (21.1%) | 234 (21.6%) | $\chi^2$=4.165, df=2, p=0.125, V=0.062 |
| None | 7 (14.6%) | 8 (22.2%) | 370 (37.0%) | 385 (35.5%) | $\chi^2$=12.882, df=2, p=0.002, V=0.109 |
| Headache, migraine and aura | | | | | |
| Headache without diagnosis | 11 (22.9%) | 8 (22.2%) | 136 (13.6%) | 155 (14.3%) | $\chi^2$=5.172, df=2, p=0.075, V=0.069 |
| With visual aura | 5 (10.4%) | 3 (8.3%) | 41 (4.1%) | 49 (4.5%) | $\chi^2$=5.502, df=2, p=0.064, V=0.071 |
| Migraine | 8 (16.7%) | 3 (8.3%) | 74 (7.4%) | 85 (7.8%) | $\chi^2$=5.469, df=2, p=0.065, V=0.071 |
| With visual aura | 4 (8.3%) | 1 (2.8%) | 41 (4.1%) | 46 (4.2%) | $\chi^2$=2.222, df=2, p=0.329, V=0.045 |
| Mood impairments | | | | | |
| With diagnosis | 14 (29.2%) | 5 (13.9%) | 70 (7.0%) | 89 (8.2%) | $\chi^2$=31.507, df=2, p=0.000, V=0.170 |
| Mood (affective) disorders (F30-F39) | 7 (14.6%) | 5 (13.9%) | 56 (5.6%) | 68 (6.3%) | $\chi^2$=9.982, df=2, p=0.007, V=0.096 |
| Neurotic, stress-related and somatoform disorders (F40-F48) | 5 (10.4%) | 0 (0.0%) | 19 (1.9%) | 24 (2.2%) | $\chi^2$=16.208, df=2, p=0.000, V=0.122 |
| Disorders of adult personality and behavior (F60-F69) | 5 (10.4%) | 0 (0.0%) | 13 (1.3%) | 18 (1.7%) | $\chi^2$=23.969, df=2, p=0.000, V=0.149 |
| Disorders of psychological development (F80-F89) | 3 (6.3%) | 0 (0.0%) | 4 (0.4%) | 7 (0.6%) | $\chi^2$=24.699, df=2, p=0.000, V=0.151 |
| Other | 3 (6.3%) | 0 (0.0%) | 6 (0.6%) | 9 (0.8%) | $\chi^2$=18.090, df=2, p=0.000, V=0.129 |
| GAD-7 | | | | | |
| Score 0-9 | 18 (37.5%) | 21 (58.3%) | 710 (71.0%) | 749 (69.0%) | $\chi^2$=10.521, df=2, p=0.005, V=0.103 |
| Score 10-21 | 16 (33.3%) | 10 (27.8%) | 221 (22.1%) | 26 (2.4%) | |
| CES-D | | | | | |
| Score 0-23 | 20 (41.7%) | 21 (58.3%) | 680 (68.0%) | 721 (66.5%) | $\chi^2$=3.663, df=2, p=0.160, V=0.061 |
| Score 24-60 | 14 (29.2%) | 10 (27.8%) | 251 (25.1%) | 275 (25.3%) | |

**Table 3.** Results of statistical pairwise comparison of 3 groups

| Variable | VSS vs. VS | VSS vs. Control | VS vs. Control |
|---|---|---|---|
| Gender | | | |
| Female | $\chi^2$=0.614, df=1, p=0.433 | $\chi^2$=2.737, df=1, p=0.098 | $\chi^2$=6.727, df=1, p=0.009 |
| Male | $\chi^2$=0.614, df=1, p=0.433 | $\chi^2$=2.737, df=1, p=0.098 | $\chi^2$=6.727, df=1, p=0.009 |
| Visual snow | | | |
| Since childhood | $\chi^2$=0.000, df=1, p=1.000 | - | - |
| Sudden onset of symptoms | $\chi^2$=0.000, df=1, p=1.000 | - | - |
| Visual symptoms - Palinopsia | | | |
| Trailing moving objects | $\chi^2$=8.750, df=1, p=0.003 | $\chi^2$=24.848, df=1, p=0.000 | $\chi^2$=1.001, df=1, p=0.317 |
| Afterimages | $\chi^2$=10.480, df=1, p=0.001 | $\chi^2$=41.051, df=1, p=0.000 | $\chi^2$=0.283, df=1, p=0.595 |
| Visual symptoms - Entoptic phenomena | | | |
| Floaters | $\chi^2$=0.480, df=1, p=0.488 | $\chi^2$=13.179, df=1, p=0.000 | $\chi^2$=4.755, df=1, p=0.029 |
| BFEP | $\chi^2$=2.415, df=1, p=0.120 | $\chi^2$=21.548, df=1, p=0.000 | $\chi^2$=5.022, df=1, p=0.025 |
| Diplopia | $\chi^2$=0.121, df=1, p=0.728 | $\chi^2$=10.815, df=1, p=0.001 | $\chi^2$=4.861, df=1, p=0.027 |
| Flashes (spontaneous photopsia) | $\chi^2$=4.148, df=1, p=0.042 | $\chi^2$=23.424, df=1, p=0.000 | $\chi^2$=0.423, df=1, p=0.515 |
| Coloured swirls with eyes closed | $\chi^2$=1.440, df=1, p=0.230 | $\chi^2$=20.889, df=1, p=0.000 | $\chi^2$=4.815, df=1, p=0.028 |
| Photophobia | $\chi^2$=20.572, df=1, p=0.000 | $\chi^2$=516.131, df=1, p=0.000 | $\chi^2$=38.988, df=1, p=0.000 |
| Nightblindness | $\chi^2$=15.653, df=1, p=0.000 | $\chi^2$=26.255, df=1, p=0.000 | $\chi^2$=1.796, df=1, p=0.180 |
| Non-visual symptoms | | | |
| Tinnitus | $\chi^2$=2.225, df=1, p=0.136 | $\chi^2$=29.110, df=1, p=0.000 | $\chi^2$=7.386, df=1, p=0.007 |
| Paraesthesia | $\chi^2$=2.457, df=1, p=0.117 | $\chi^2$=18.041, df=1, p=0.000 | $\chi^2$=0.486, df=1, p=0.486 |
| Concentration problems | $\chi^2$=0.906, df=1, p=0.341 | $\chi^2$=6.744, df=1, p=0.009 | $\chi^2$=1.042, df=1, p=0.307 |
| Tremors | $\chi^2$=2.743, df=1, p=0.098 | $\chi^2$=6.722, df=1, p=0.010 | $\chi^2$=0.045, df=1, p=0.831 |
| Dizziness | $\chi^2$=1.996, df=1, p=0.158 | $\chi^2$=4.056, df=1, p=0.044 | $\chi^2$=0.056, df=1, p=0.813 |
| Headache, migraine and aura | | | |
| Headache without diagnosis | $\chi^2$=0.006, df=1, p=0.940 | $\chi^2$=3.309, df=1, p=0.069 | $\chi^2$=2.167, df=1, p=0.141 |
| With visual aura | $\chi^2$=0.104, df=1, p=0.748 | $\chi^2$=4.364, df=1, p=0.037 | $\chi^2$=1.536, df=1, p=0.215 |
| Migraine | $\chi^2$=1.255, df=1, p=0.263 | $\chi^2$=5.467, df=1, p=0.019 | $\chi^2$=0.045, df=1, p=0.832 |
| With visual aura | $\chi^2$=1.134, df=1, p=0.287 | $\chi^2$=2.003, df=1, p=0.157 | $\chi^2$=0.155, df=1, p=0.693 |
| Mood impairments | | | |
| With diagnosis | $\chi^2$=2.743, df=1, p=0.098 | $\chi^2$=30.572, df=1, p=0.000 | $\chi^2$=2.463, df=1, p=0.117 |
| Mood (affective) disorders (F30-F39) | $\chi^2$=0.008, df=1, p=0.928 | $\chi^2$=6.556, df=1, p=0.010 | $\chi^2$=4.318, df=1, p=0.038 |
| Neurotic, stress-related and somatoform disorders (F40-F48) | $\chi^2$=3.987, df=1, p=0.046 | $\chi^2$=14.868, df=1, p=0.000 | $\chi^2$=0.696, df=1, p=0.404 |
| Disorders of adult personality and behavior (F60-F69) | $\chi^2$=3.987, df=1, p=0.046 | $\chi^2$=22.580, df=1, p=0.000 | $\chi^2$=0.473, df=1, p=0.491 |
| Disorders of psychological development (F80-F89) | $\chi^2$=2.333, df=1, p=0.127 | $\chi^2$=23.651, df=1, p=0.000 | $\chi^2$=0.144, df=1, p=0.704 |
| Other | $\chi^2$=2.333, df=1, p=0.127 | $\chi^2$=17.193, df=1, p=0.000 | $\chi^2$=0.217, df=1, p=0.641 |
| GAD-7 | | | |
| Score 0-9 | $\chi^2$=3.590, df=1, p=0.058 | $\chi^2$=24.103, df=1, p=0.000 | $\chi^2$=2.650, df=1, p=0.104 |
| Score 10-21 | $\chi^2$=0.297, df=1, p=0.586 | $\chi^2$=3.318, df=1, p=0.069 | $\chi^2$=0.652, df=1, p=0.419 |
| CES-D | | | |
| Score 0-23 | $\chi^2$=2.287, df=1, p=0.130 | $\chi^2$=14.233, df=1, p=0.000 | $\chi^2$=1.462, df=1, p=0.227 |
| Score 24-60 | $\chi^2$=0.019, df=1, p=0.889 | $\chi^2$=0.406, df=1, p=0.524 | $\chi^2$=0.135, df=1, p=0.714 |

Specifically, the prevalence of affective disorders ($\chi^2$=6.556, df=1, p=0.010), neurotic, stress-related, and somatoform disorders ($\chi^2$=14.868, df=1, p<0.001), personality and behavioral disorders in adults ($\chi^2$=22.580, df=1, p<0.001), developmental disorders ($\chi^2$=23.651, df=1, p<0.001), and other mental disorders ($\chi^2$=17.193, df=1, p<0.001) were significantly higher in the VSS group compared to the control group. Additionally, a higher proportion of participants in the VSS group exhibited elevated anxiety levels on the GAD-7 scale compared to the other groups ($\chi^2$=10.521, df=2, p=0.005, V=0.103), suggesting a weak association between anxiety and VSS.

## DISCUSSION

In examining a sample of young adults, we found that the prevalence of individuals in this age group with symptoms meeting the criteria for VSS was 4.4% (95% CI, ±1.59). This is higher than the prevalence reported by previous researchers who described VSS in the general UK population but not in a specific age group (Kondziella et al. 2020 (2.2%; 95% CI, 1.4–3.3). As demonstrated in one study (Costa et al. 2022), text-based surveys tend to identify fewer individuals with VS, and the use of graphic simulations may have been more effective in drawing attention to the fact that visual snow is "permanently or usually there". Unlike previous surveys (Schankin et al. 2014, Kondziella et al. 2020, Puledda et al. 2020c), our questionnaire included examples of various visual phenomena, which might explain the higher estimated prevalence of VSS in our findings.

We limited our study to individuals aged 18 to 30 years because this age group is least susceptible to acquired ophthalmologic (Klein & Klein 2013) and neurologic (Shastin et al. 2021) conditions. Additionally, our study not only examines the VSS group but also includes a group with only VS. This approach is justified by the presumed association between the mechanisms underlying VS as a symptom and conditions such as tinnitus and migraine aura (Puledda et al. 2020c).

The average age at the onset of the first symptoms among VSS participants (20.5±) was somewhat higher than in some studies (13 years (Puledda et al. 2020c), 10.5 years (Kondziella et al. 2020) and lower than in others (21 years (Schankin et al. 2014), 26.1 years (Mehta et al. 2021). These differences can be attributed to the selection of relatively young respondents and specific counting methods, as individuals who reported "as long as they can remember" were excluded. Furthermore, 89.6% of respondents with VSS indicated the duration of their symptoms as "as long as they can remember", which is twice as high as reported in previous studies (Schankin et al. 2014, Costa et al. 2022, Kondziella et al. 2020, Puledda et al. 2020c).

Our findings regarding the prevalence of untreated headache and diagnosed migraine (39.6%) differ somewhat from previous reports (59.0% (Schankin et al. 2014), 69.0-70.0% (Viana et al. 2020), 54.5% (Kondziella et al. 2020). This discrepancy can be attributed to the fact that other researchers did not use scales to assess migraine and its duration in their surveys. In the VSS sample, untreated headache and diagnosed migraine were 1.96 times more common than in the control group. Diagnosed migraine was significantly more prevalent in the VSS group ($\chi^2$=5.467, df=1, p=0.019).

The proportion of participants with tinnitus (68.8%) is generally consistent with other studies (75.0% (Puledda et al. 2020c), 62.0% (Schankin et al. 2014), 70.0% (Viana et al. 2020), 59.1% (Kondziella et al. 2020). Both VS ($\chi^2$=7.386, df=1, p=0.007) and VSS ($\chi^2$=29.110, df=1, p=0.000) were associated with a significantly higher prevalence of tinnitus, with a moderate correlation between VSS and tinnitus. These findings may support previous hypotheses suggesting closely related mechanisms between tinnitus and migraine and VSS. Earlier hypotheses on the origin of VSS (Fraser 2022) propose that VSS may result from a sensory processing dysfunction leading to incorrect sensory perception (Puledda et al. 2018).

Concentration problems, paresthesia, tremor, and dizziness were also examined in our study, albeit rather superficially. We did not use the MMSS (The Mizan Meta-Memory and Meta-Concentration Scale for Students) for additional assessment of concentration problems. Our data indicate that concentration problems were 1.46 times more common in the VSS sample than in the control group, which is consistent with previous findings (Schankin et al. 2014). The differences between the control and VSS groups are statistically significant, with a weak correlation between VSS and concentration problems ($\chi^2$=6.744, df=1, p=0.009).

Paresthesia and tremor have been previously studied by only a few groups (Solly et al. 2020, Strik et al. 2023, Lauschke et al. 2016, Hepschke et al. 2022, Strik et al. 2023). However, due to differences in study aims and methods, direct comparison of results is not feasible. In the case of paresthesia, the difference from the control group is 3.71 times ($\chi^2$=18.041, df=1, p=0.000), and for tremor, it is 1.92 times ($\chi^2$=6.722, df=1, p=0.010), with moderate and weak correlations, respectively. Previous data on dizziness (15% (Mehta et al. 2021) differ from our 33.3%, which may be due to different research methods. In the VSS group, this condition was significantly more common than in the control group ($\chi^2$=4.056, df=1, p=0.044).

Participants identified with anxiety based on the GAD-7 scale and mood impairments on the CES-D scale constituted 33.3% and 29.2%, respectively, which are higher than those reported in previous research (Schankin et al. 2014). This discrepancy can be attributed to our use of lower threshold values on the GAD-7 and a different scale for assessing depression. However, no statistically significant correlation was found between VSS and depression or anxiety as diagnosed by these questionnaires.

Clinically diagnosed psychiatric conditions were significantly more frequent in the VSS group, showing a moderate correlation ($\chi^2$=30.572, df=1, p=0.000). Participants with VSS were significantly more likely to have conditions across all blocks according to the ICD-10, with the strongest correlations (moderate)

observed for disorders of psychological development (F80-F89) ($\chi^2$=23.651, df=1, p=0.000) and disorders of adult personality and behavior (F60-F69) ($\chi^2$=22.580, df=1, p=0.000). Additionally, participants with mood (affective) disorders (F30-F39) were more common in the VS group compared to the control group ($\chi^2$=4.318, df=1, p=0.038).

At the time of our study, the prevalence of VSS in Russia had not been extensively studied. Prior to 2023, mentions of VS were limited to its presence as a symptom of hallucinogen persisting perception disorder (Vinnikova et al. 2019 Scheidegger et al. 2021a Scheidegger et al. 2021b). However, in 2023, Russian research teams published two original studies and two literature reviews on the topic (Bogoslavskaya & Lebedeva 2023, Kamaeva 2023, Naumova et al. 2023, Nikitina 2023). Given the difficulty in differentiating VSS from other conditions (low severity), VSS is not yet included in the ICD-10, leading to low awareness among specialists. The progression of VSS symptoms remains a significant issue. Currently, it is unclear whether VSS is correctly diagnosed in Russia. More research on VSS is necessary to better understand the nature of this condition and to develop treatment protocols or symptom management strategies.

## CONCLUSIONS

The prevalence of VS symptoms in Russia is 7.7% (6.2-9.3%) and VSS is 4.4% (3.2-5.7%). Our study revealed that nearly all individuals with VSS in our sample (89.6%) had experienced symptoms for as long as they can remember. Similar to previous researchers, we found correlations between VSS and the presence of tinnitus and headache with tinnitus. Notably, none of the respondents had ever sought medical help specifically for VSS. Our study revealed that nearly all individuals with VSS in our sample had experienced symptoms for as long as they can remember. The prevalence data on VSS can help determine the percentage of the population that may need assistance for this condition and can be used in further research.

### Limitations

Online studies have limitations that should be acknowledged. Firstly, complex clinical notions cannot be fully implemented in a survey form. We used plain language to inquire about visual phenomena and showed representative visual material. Reports of participants were not validated by personal interviews. Secondly, like a previous web-based surveys, we were unable to fully exclude relevant ophthalmological disorders in people with visual snow syndrome. Third, as our data represent the young adult Russian population, the prevalence of visual snow syndrome in other groups remains unknown and our results cannot be extrapolated to other regions of the world. Also, we tested for associations with headache, tinnitus and mood impairment, but this does not exclude the possibility that other, still unidentified, conditions might be of even greater importance or that we missed confounders. Finally, our questionnaire regarding headache and mood disorders was not designed to inquire about all necessary ICD-10 criteria for these conditions, but instead we used a more inclusive approach to identify people with a high likelihood of having a primary headache disorder (including migraine aura) and mood impairment because we were not interested in headache or mood impairment per se but rather in these conditions as possible predictors for VSS.

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### *Contribution of individual authors:*

Ekaterina Muravikova, Alexey Sustretov & Arseny Gayduk have composed the primary idea and specified the hypothesis, have designed a questionnaire.

Daniil Kokorev has been responsible for data collection.

Ekaterina Muravikova & Timur Syunyakov conducted an analysis of data.

Ekaterina Muravikova have been responsible for the literature data collection and wrote the first draft of the manuscript.

Ekaterina Muravikova, Alexey Sustretov, Daniil Kokorev & Arseny Gayduk managed the research documents formalization, detailed manuscript editing and revision, preparation of the manuscript and gave their final approval of the manuscript for submission.

Alexey Sustretov & Arseny Gayduk have made decision to publish.

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*Correspondence:*
*Arseny J. Gayduk, MD*
*International Centre for Education and Research in Neuropsychiatry (ICERN),*
*Samara State Medical University*
*18 Gagarina Street, 443079 Samara, Russia*
*E-mail: a.j.gayduk@samsmu.ru*