

When the mosquito bites: A cross-sectional study of regional gaps in awareness and preparedness for West Nile Virus in Slovakia

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ABSTRACT

Background: West Nile Virus (WNV) represents an emerging public health concern in Slovakia due to climatic changes and the expansion of invasive mosquito species. This study examined demographic and regional differences in knowledge, attitudes, and preventive practices related to WNV among Slovak residents.

Methods: A structured online questionnaire was completed by 368 participants from diverse backgrounds. Data were analyzed using analysis of variance (ANOVA) to assess the influence of gender, age, education, residence, employment status, regional affiliation, and time spent outdoors on selected WNV-related indicators.

Results: Significant differences were observed primarily for gender, age, and region. Gender was associated with differences in factual knowledge, subjective feeling of threat, and repellent use. Age was significantly related to knowledge levels, while regional affiliation influenced knowledge, perceived threat, and selected protective behaviors. In contrast, educational attainment, type of residence, employment status, and time spent outdoors did not demonstrate statistically significant effects.

Discussion and Conclusions: The findings indicate variability in WNV-related awareness and selected preventive behaviors across certain demographic and geographic subgroups. As an exploratory assessment based on non-probability sampling, the study provides preliminary evidence that may inform future large-scale, representative investigations and context-sensitive public health communication strategies in Slovakia.

Key words: West Nile Virus, public health awareness, mosquito-borne diseases, preventive behavior, Slovakia, mosquito bites



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Introduction

Mosquito-borne diseases represent a growing public health burden in Europe, with their spread being accelerated by climate change—particularly rising temperatures, as well as by globalization and the expansion of invasive mosquito species (1–3). West Nile virus (WNV) is among the most widespread mosquito-borne arboviruses and is a leading cause of arboviral encephalitis globally (4). The ecology of WNV is primarily based on an enzootic transmission cycle involving avian reservoir hosts and mosquitoes of the *Culex* genus. In Central European conditions, the primary biological vectors are *Culex pipiens* and *Culex modestus*. The biotypes *Cx. pipiens pipiens* (ornithophilic) and *Cx. pipiens molestus* (mammalophilic) play a key role in facilitating transmission from birds to humans, with their hybrids feeding on both host groups and potentially enabling so-called bridge transmission from animals to humans (5). Transmission occurs mainly through horizontal transfer via the bite of an infected mosquito; however, vertical transmission has also been documented in mosquitoes, contributing to the virus's persistence under unfavorable environmental conditions (6,7). Migratory birds play a critical role in introducing the virus into Europe, and in temperate regions, the virus can persist through the winter in overwintering mosquito populations (8). Slovakia is located along major migratory routes between Africa and Europe, which increases the likelihood of WNV introduction and local circulation (9). Although no major WNV outbreaks have been reported in Slovakia, the presence of the virus has been confirmed through virus isolation, molecular detection, and serological findings in reservoir and host species, indicating sporadic occurrence (10). The invasive species *Aedes albopictus* has already been detected in Slovakia and is capable of overwintering, thereby increasing the potential for transmission of various arboviruses, including WNV, and contributing to a shifting vector landscape (11). Climatic and environmental factors significantly influence transmission dynamics. Warmer spring and summer temperatures accelerate mosquito development, shorten the extrinsic incubation period of the virus, and increase mosquito activity, all of which elevate transmission risk (5, 12). Urban and

agricultural environments provide abundant breeding sites and increase human exposure to vectors, while rainfall extremes and droughts alter the availability of stagnant water and thus affect mosquito reproduction (13–16). Clinical diagnosis of WNV primarily relies on serological testing for IgM antibodies confirmed by plaque reduction neutralization tests (PRNT), and in specific cases, RNA detection via RT-PCR. WNV infection is a notifiable disease (6, 17–20). Since 2024, mosquito populations in Slovakia have been monitored for the presence of WNV through a nationwide surveillance program implemented by regional public health authorities in collaboration with the Biomedical Research Center of the Slovak Academy of Sciences. This program employs honey-soaked cards placed in specialized traps designed to attract gravid female mosquitoes. The captured samples enable ongoing virological analysis and early identification of potential public health risks (21, 22). The aim of this exploratory study is to provide an initial assessment of population awareness, risk perception, and preventive practices related to WNV in the Slovak context. Given the confirmed presence of WNV in Slovakia (9) and the growing risk of its spread due to climate change and the expansion of invasive mosquito species, this study focuses on assessing the level of knowledge, attitudes, and practices among the Slovak population toward this emerging public health threat. The Knowledge–Attitudes–Practices (KAP) framework is widely used in public health research, particularly in studies investigating awareness and behavioral responses to infectious and vector-borne diseases, as it enables structured evaluation of cognitive, perceptual, and behavioral dimensions (42).

Methods

The aim of the study was to identify sociodemographic and geographic factors that influence the level of awareness, risk perception, and willingness of the population to adopt preventive measures. Emphasis was placed on comparing communities living in different environmental conditions, based on the assumption that higher exposure to mosquitoes or the direct occurrence of WNV in a region may affect residents' behavior and attitudes.

Recruitment and sampling strategy

Participants were recruited using a voluntary, non-probability convenience sampling approach. The questionnaire was distributed electronically via social media platforms, university mailing lists, and regional online community groups during two data collection phases (March 1–April 10, 2025 and January 1–February 15, 2026). The second phase of data collection was conducted to increase the sample size and improve the robustness of subgroup analyses and to complement the age structure. The survey instrument remained identical across both phases, and the datasets were combined for analysis, as no structural modifications were introduced. Participation was anonymous and no financial incentives were provided. The survey link could be shared further by participants, resulting in partial snowball dissemination. Inclusion criteria required respondents to be residents of Slovakia. Given the exploratory aim of the study and the objective to capture regional variation in awareness and preparedness, the online survey format was selected as an efficient method to reach geographically dispersed populations. Although this approach does not ensure full population representativeness, it allows identification of patterns and associations across demographic and regional subgroups. Data collection was carried out using a structured online questionnaire consisting of 94 items. The introductory section of the questionnaire informed respondents about the purpose of the research, estimated time required to complete it, and assurances regarding anonymity and confidentiality. The demographic variables assessed included gender, age, education, employment status, type of residence (urban/rural), region of Slovakia, and the respondents' subjective perception of mosquito activity in their area. The questionnaire employed a combination of question types, including closed-ended, multiple-choice, and Likert scale questions. A standard 5-point Likert scale was used, ranging from "strongly agree" to "strongly disagree," with a neutral "I don't know" option at the midpoint. For behavior frequency, a 5-point scale from "never" to "always" was used. Attitudinal items included scales such as "not serious at all" to "very serious," "not afraid at all" to "very afraid," "very unlikely" to "very likely," "not confident at all" to "very

confident," and "never" to "always," as well as "definitely not" to "definitely yes." The questionnaire was constructed by selecting and adapting relevant items from previously validated instruments used in studies on vector-borne infections (23–26). The Knowledge–Attitudes–Practices framework was adopted as it represents a widely applied model in public health research for assessing awareness, risk perception, and preventive behavior related to infectious diseases. Items were contextually modified to reflect the epidemiological situation in Slovakia and the characteristics of West Nile Virus. The internal consistency of scale-based items was assessed using Cronbach's alpha ($\alpha = .85$), indicating high reliability.

Respondents

GENDER AND AGE

The research sample consisted of a total of 368 respondents who participated in the questionnaire survey. The questionnaire was distributed electronically in order to reach the broadest possible spectrum of the population from various parts of Slovakia, regardless of age, gender, or place of residence. In terms of gender, there was a significantly higher proportion of women, who made up approximately 71% of the sample. Men were represented to a lesser extent, accounting for 28% of the total number of respondents. The age distribution of respondents was diverse. The most numerous group consisted of young people aged 18 to 24 (26%), reflecting a high level of engagement among the youngest adult population. The second most represented group were respondents aged 25 to 34 (15%), 35 to 44 (11%), followed by those aged 45 to 54 (20%). In contrast, the least represented were adolescents under the age of 18 (1%), seniors over 60 (14%), and those aged 55 to 59 (10%). This indicates that the sample was predominantly composed of young and active individuals, which is typical for online surveys.

EDUCATION

The majority of respondents had completed secondary education with a school-leaving examination (43.9%). University graduates represented a

substantial proportion of the sample, including first-cycle (23.98%) and second-cycle degrees (22.07%), while doctoral education accounted for 2.99%. Lower educational levels were less represented, including secondary education without graduation (4.63%) and primary education (2.45%). Overall, the sample was relatively well educated, with nearly half holding a university degree.

EMPLOYMENT STATUS

Most respondents were employed full-time (52.59%), followed by students (30.52%). Smaller groups included retirees (9.54%), part-time employees (4.09%), unemployed individuals (2.45%), and persons with disabilities (0.82%). The sample therefore consisted predominantly of economically active individuals and students.

PLACE OF RESIDENCE

A slightly higher proportion of respondents lived in urban areas (57.49%), while 42.51% resided in rural areas. This indicates a moderate predominance of city inhabitants in the sample.

In terms of regional distribution, the largest groups of respondents came from the Žilina Region (24.80%) and the Prešov Region (23.71%). Other represented regions included the Trnava (12.26%), Bratislava (11.72%), Košice (10.63%), Trenčín (7.36%), and Nitra Regions (6.27%). The smallest proportion of respondents was from the Banská Bystrica Region (3.27%). Overall, the sample covered all Slovak regions, although with uneven representation. Overall, it can be stated that the research sample was diverse in terms of demographic characteristics, with a predominance of younger, more educated respondents from both urban and rural areas. The demographic structure of the sample reflects the characteristics typical of online survey participation, with a predominance of younger respondents.

Statistical analysis

Prior to the main analyses, distributional assumptions were evaluated. Although formal tests of

normality can be overly sensitive in large samples, the data were considered suitable for parametric procedures given the sample size ($n=368$) and the robustness of ANOVA to moderate departures from normality. Group differences were examined using analysis of variance (ANOVA). The effects of the following sociodemographic variables were analyzed: gender, age, education level, type of residence (urban/rural), region of Slovakia, and employment status. These variables were examined in relation to knowledge about West Nile virus (WNV), perceived threat, repellent use, implementation of preventive measures, interest in public awareness campaigns, and willingness to take personal responsibility. Statistical significance was set at $\alpha = .05$.

Results

The analysis of variance revealed that most sociodemographic variables had limited influence on the examined WNV-related indicators. Significant effects were identified primarily for gender, age, and region, while education, residence, time spent outdoors, and employment showed no statistically significant associations in the majority of cases. Gender demonstrated a significant effect on several variables. Men showed significantly higher knowledge about WNV, while women reported a higher subjective feeling of threat. Gender differences were also highly significant in repellent use, with one gender reporting more frequent use. However, no significant gender differences were observed in perceived threat of WNV, willingness to take individual action, or implementation of general and specific preventive measures. Educational attainment did not show statistically significant differences across any of the examined variables. Perception of threat, knowledge levels, behavioral intentions, and preventive practices were comparable across educational categories. Place of residence (urban vs. rural) was not associated with any statistically significant differences in knowledge, perception, or preventive behavior. Age showed a highly significant association with knowledge about WNV, indicating variability in factual awareness across age groups. However, age did not significantly influence threat perception, willingness to act, or preventive practices. Time spent

outdoors did not demonstrate statistically significant effects on any of the examined outcomes. Regional differences emerged as one of the strongest determinants. Highly significant differences were identified in knowledge about WNV, subjective feeling of threat, and repellent use. No significant regional variation was observed in overall perceived threat, willingness to take individual action, or implementation of preventive measures. Employment status did not significantly influence any of the analyzed variables. Overall, the findings indicate that knowledge and selected behavioral responses (particularly repellent use) vary primarily according to gender, age, and regional background, whereas other sociodemographic characteristics appear to have minimal impact (Table 1).

Discussion

As an exploratory cross-sectional survey based on convenience sampling, the present study provides preliminary insights rather than definitive population-level estimates. The findings should therefore be interpreted within the methodological constraints of the study design.

The cumulative analysis revealed that gender was one of the variables associated with significant differences in selected WNV-related indicators. Significant gender effects were identified for knowledge about WNV, subjective feeling of threat, and repellent use, whereas no differences were observed in perceived threat of WNV as a general public health issue, willingness to take individual action, or implementation of general and specific preventive measures. These findings partially align with previous research indicating gender-related differences in health risk perception and engagement in preventive behavior (28–34). Women are often described as more sensitive to health threats (28,29), while gender-specific patterns in health information seeking and preventive engagement have also been documented (30,31,33). However, the absence of gender differences in several behavioral indicators suggests that knowledge and subjective perception do not necessarily translate into consistent differences in practical implementation, which is consistent with findings reported by Pogreba-Brown et al. (46). At the

same time, other studies have reported stronger gender effects on preventive compliance (34), indicating that such associations may be context-dependent. In contrast, educational attainment did not demonstrate statistically significant associations with any of the examined WNV-related variables in the present analysis. This finding supports studies suggesting that formal education level is not always directly associated with risk perception or preventive engagement (35). However, other research has documented positive effects of higher education on health literacy and preventive health behaviors (36–38), indicating that the influence of education may vary depending on the specific health context and population characteristics. Employment status also showed no statistically significant associations across the analyzed indicators. This result contrasts with findings from other public health contexts, where occupational background has influenced knowledge, attitudes, and practices (39). The lack of occupational differences in the present study may reflect relatively homogeneous exposure patterns within the sample. Age was significantly associated with knowledge about WNV but did not influence perceived threat, willingness to act, or preventive behavior. Previous research has shown mixed findings regarding age-related differences in risk perception and preventive practices (40,41). While some studies report higher threat perception among older individuals (40), others identify age-related variation in protective behaviors such as repellent use (41). The present findings suggest that age may influence factual awareness more than behavioral implementation. Place of residence (urban vs. rural) and time spent outdoors were not significantly associated with the examined WNV-related outcomes. Although exposure-related factors are often considered important determinants of mosquito-borne disease risk perception (42,45), the current results indicate that subjective awareness and preventive engagement may not differ substantially between residential environments or varying levels of outdoor activity within this sample. Regional affiliation emerged as one of the strongest determinants, with significant differences observed in knowledge about WNV, subjective feeling of threat, and repellent use. No regional variation was identified in general threat perception or broader preventive implementation. Regional variability in vector

Table 1. ANOVA results for the effect of sociodemographic variables on WNV-related indicators

Variable	Gender		Educational attainment		Residence		Age		Time spent outdoors		Regional differences		Employment	
	F value	Significants	F value	significants	F value	significants	F value	significants	F value	significants	F value	significants	F value	significants
Perception of WNV as a threat	.28	NS	.81	NS	1.17	NS	1.69	NS	.32	NS	1.59	NS	.53	NS
Knowledge about WNV	10.08	**	1.60	NS	.12	NS	5.31	**	1.08	NS	6.36	**	1.96	NS
Subjective feeling of threat	5.67	*	0.64	NS	.01	NS	.65	NS	.01	NS	4.01	**	.90	NS
Willingness to take individual action	1.18	NS	1.13	NS	.33	NS	1.81	NS	.88	NS	1.83	NS	2.07	NS
Implementation of preventive measures (general)	2.42	NS	0.98	NS	.10	NS	.90	NS	.02	NS	.72	NS	.68	NS
Use of repellents	6.72	**	1.20	NS	.10	NS	1.53	NS	.08	NS	4.26	**	1.69	NS
Implementation of specific measures (e.g., removing standing water)	.86	NS	.61	NS	.30	NS	.38	NS	.00	NS	1.63	NS	0.84	NS

Note: Statistical significance was defined as * $p < .05$ and ** $p < .01$; NS indicates non-significant results ($p \geq .05$).

ecology and environmental conditions has been documented in previous research (43–45), and such ecological heterogeneity may contribute to differences in awareness and selected protective behaviors. However, the present findings do not allow conclusions regarding specific regional hierarchies and should be interpreted as evidence of variability rather than directional dominance. Overall, the results suggest that variability in WNV-related awareness and selected preventive behaviors is primarily associated with gender, age (in relation to knowledge), and regional background, whereas education, employment status, residence type, and time spent outdoors appear to exert limited influence within this sample. These findings highlight the complexity of factors shaping public engagement with mosquito-borne disease prevention and underscore the need for context-sensitive communication strategies.

Conclusion

This exploratory study provides preliminary insights into public awareness, perceptions, and preventive behaviors related to West Nile Virus (WNV) in Slovakia. Although statistically significant differences were identified across selected demographic and geographic variables, the findings should be interpreted with caution due to the non-probability sampling design and uneven demographic structure of the sample. The results contribute an initial analytical framework that may inform future large-scale and more representative investigations of WNV-related awareness and preparedness in Slovakia. Significant associations were observed primarily for gender, age (in relation to knowledge), and regional affiliation. Gender differences were identified in knowledge, subjective feeling of threat, and repellent use, while age was associated with differences in factual awareness. Regional variability emerged as an important factor influencing knowledge, perceived threat, and selected protective behaviors. In contrast, educational attainment, employment status, type of residence, and time spent outdoors did not demonstrate statistically significant effects in the present analysis. These findings suggest that variability in awareness and selected preventive behaviors may be shaped more strongly by contextual and

demographic characteristics than by formal education or occupational background. Tailored communication strategies addressing regional and gender-related variability may enhance public engagement and preparedness. However, given the exploratory nature of the study and the sampling strategy, conclusions should be interpreted cautiously. Several limitations must be acknowledged. The use of an online survey may have introduced sampling bias, potentially favoring younger and more digitally active participants. Self-reported data are also subject to social desirability and recall bias. In addition, the age distribution of the sample was uneven, with limited representation in certain age categories. The study did not assess longitudinal behavioral changes or actual infection incidence. Future research should involve larger and more representative samples, incorporate longitudinal designs, and examine psychological and environmental determinants of preventive behavior. Integration of spatial epidemiological data and entomological monitoring may further strengthen the understanding of regional risk dynamics and support evidence-based public health interventions.

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Informed consent: All participants were informed about the purpose of the study, the confidentiality of the data, and the voluntary nature of their participation before completing the questionnaire. Continuing to complete the questionnaire was considered having provided informed consent.

Authors' contributions: IL, AM, NC and VP collected field data. IL and AM drafted the first manuscript. VP critically revised the manuscript. All authors revised, read and approved the final version of the manuscript.

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ideas. The authors remain fully responsible for the integrity and accuracy of the manuscript.

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