

# **NATIONAL JOURNAL OF MEDICAL AND ALLIED SCIENCES**

**Volume 12, Issue 2, Pages 1-14, July - December 2023**

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## National Journal of Medical and Allied Sciences

[ISSN Online: 2319 – 6335, Print: 2393 – 9192|Editorial |Open Access]

Website:-www.njmsonline.org

### GLOBAL PERSPECTIVES ON TRAUMATIC BRAIN INJURY: PREVENTION, MANAGEMENT, AND POLICY RECOMMENDATIONS

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Traumatic Brain Injury (TBI) remains a significant global public health challenge, with the burden of disability and death steadily rising across regions [1]. Annually, approximately 69 million individuals (95% CI: 64–74 million) suffer from TBI of all causes, with the highest incidences observed in Southeast Asia and the Western Pacific [2]. Globally, falls were the leading cause of TBI in 2021, followed by road injuries, interpersonal violence, and exposure to mechanical forces. Head injuries resulting from road traffic collisions are especially prevalent, and the proportion of TBIs attributable to such incidents is markedly higher in low- and middle-income countries [3, 4].

In high-income nations, the incidence of TBI due to road traffic accidents has decreased, attributable to effective preventive measures such as legislation, improved infrastructure, vehicle safety standards, and helmet use [5]. The United Nations Decade of Action for Road Safety (2011–2020) sought to halve traffic-related deaths—currently estimated at around 1.3 million—by implementing comprehensive strategies including road safety management, safer vehicles, informed road user behavior, and enhanced post-crash response systems [6]. Achieving these ambitious targets necessitates heightened awareness among policymakers and the

public to support effective prevention programs and improve patient care.

Accurate epidemiological data are essential for designing targeted interventions; such information underpins the development and deployment of strategies aimed at reducing TBI incidence and severity [7]. Vulnerable populations, especially children and adolescents, are at heightened risk, often experiencing concussions or mild TBIs that can have enduring effects on cognition, language, learning, behavior, and emotional health. While most recover fully within days or weeks, a subset may develop prolonged or severe symptoms [8].

Despite advances, misconceptions about TBI persist among healthcare providers, which can impede optimal care. Addressing the global TBI burden requires a comprehensive approach that includes strengthening prevention strategies, enhancing clinical management, and raising awareness among healthcare professionals and the public.

To effectively combat the global TBI burden, the following actions are essential:

1. **Strengthen Data Systems:** Develop comprehensive, standardized surveillance systems worldwide to

monitor TBI incidence, causes, and outcomes, facilitating informed decision-making.

2. Enhance Prevention Strategies: Enforce and promote road safety laws, increase helmet and seatbelt use, and implement fall prevention programs, especially targeting vulnerable groups like children and the elderly.

3. Increase Public Awareness: Launch educational campaigns to dispel myths about TBI, emphasizing prevention, early detection, and timely treatment.

4. Improve Healthcare Capacity: Train healthcare providers in best practices for diagnosis, management, and rehabilitation of TBI patients across all settings.

5. Expand Access to Care: Invest in trauma and rehabilitation services, particularly in low-resource settings, to ensure prompt and effective treatment.

6. Support Research and Innovation: Promote research to develop improved diagnostic tools, treatments, and prevention methods tailored to various settings.

7. Foster Multisectoral Collaboration: Encourage partnerships among governments, health agencies, communities, and international organizations to coordinate and sustain TBI prevention and care initiatives.

Implementing these recommendations can lead to significant reductions in TBI-related morbidity and mortality, ultimately saving lives and improving outcomes for millions worldwide.

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Conflicts of Interest: Nil Source of Funding: Nil

**Citation: Mahmood SE. Global Perspectives on Traumatic Brain Injury: Prevention, Management, and Policy Recommendations. National Journal of Medical and Allied Sciences 2023; 12(2): 1-2**

Date of Submission: 03-07-2023

Date of Acceptance: 20-07-2023



## National Journal of Medical and Allied Sciences

[ISSN Online: 2319 – 6335, Print: 2393 – 9192|Review article |Open Access]

Website:-www.njmonline.org

### ENSURING THE RIGHT TO HEALTH OF VULNERABLE GROUPS: AN ANALYSIS OF INDIA'S CONSTITUTIONAL FRAMEWORK

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#### ABSTRACT

The right to health is an essential component of human well-being and is intricately connected to the realisation of other fundamental rights. This paper analyses the constitutional framework in India, focusing on the protection of the right to health for vulnerable groups such as women, children, workers, persons with disabilities, and individuals with HIV/AIDS. It examines key constitutional provisions, including Article 21, which guarantees the right to life and has been judicially interpreted to encompass the right to health. The analysis also highlights significant judicial precedents that have expanded the scope of health rights, underscoring the State's obligation to safeguard these rights for Vulnerable groups. Despite these advancements, the analysis identifies gaps in legislative measures and challenges in implementation that hinder equitable access to healthcare. It concludes by suggesting recommendations to strengthen constitutional protections, address implementation barriers, and align India's health governance with the Sustainable Development Goal of ensuring health and well-being for all.

**Keywords:** Right to Health, Vulnerable Groups, Sustainable Development, Constitutional Framework, Fundamental Rights

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#### INTRODUCTION

The 2030 Agenda for Sustainable Development emphasizes the transformative principle of "Leaving No One Behind," which necessitates focused efforts to address the needs of populations characterised by heightened vulnerability to poor health and restricted healthcare access [1]. These vulnerable groups face substantial disparities in life expectancy

and healthcare availability and its utilisation, along with elevated health challenges, including morbidity and mortality. In this context, specific populations, such as women, children, workers, persons with disabilities, and individuals living with HIV/AIDS, often struggle to have their right to health adequately protected [2].

Vulnerability in health signifies a heightened susceptibility to adverse health outcomes arising from various factors, including age, gender, socioeconomic status, or specific health conditions. It is often a consequence of systemic inequalities that limit access to essential healthcare services and determinants of health, such as clean water, adequate nutrition, and safe living conditions. In the Indian context, vulnerable groups face a unique set of challenges [3]. Women, for instance, encounter gender-based discrimination that restricts their access to healthcare, while children are often at risk due to inadequate nutrition and healthcare facilities. Workers may face occupational health hazards without adequate safeguards, and persons with disabilities often encounter institutional neglect. Individuals living with HIV/AIDS frequently suffer from societal stigma and discrimination, further aggravating their health vulnerabilities.

Constitutional protections play a pivotal role in addressing these disparities and safeguarding the right to health. Article 21 of the Indian Constitution, which guarantees the fundamental right to life, has been judicially interpreted to encompass the right to health, recognizing its indispensability for a life of dignity. Furthermore, the Directive Principles of State Policy, such as Articles 39(e), 42, and 47, provide a framework for state action to promote public health, secure just and humane working conditions, and improve nutrition and living standards. While these principles are non-justiciable, they serve as guiding values for policymaking and governance.

Prioritising the health rights of vulnerable groups is essential to achieving Sustainable Development Goal 3, which aims to ensure healthy lives and

promote well-being for all. By addressing the structural inequities that hinder access to healthcare, India can move closer to realising its constitutional ideals and fulfilling its global commitments to health equity and inclusivity. This article examines the constitutional and judicial mechanisms that protect the right to health for vulnerable groups, shedding light on successes, gaps, and pathways for reform.

## Analysis of Constitutional Framework

India's Constitution provides a comprehensive framework for the protection and promotion of the right to health, drawing upon both enforceable fundamental rights and non-justiciable Directive Principles of State Policy. Together, these provisions underscore the State's commitment to ensuring health equity and addressing the needs of vulnerable groups.

The fundamental rights guaranteed under the Constitution play a crucial role in safeguarding public health. Article 21, which enshrines the right to life, has been expansively interpreted by Indian courts to include the right to health. Judicial pronouncements have consistently emphasised that the State's obligation to preserve and promote public health is integral to the right to life, encompassing access to medical care, a clean and safe environment, and adequate nutrition. This interpretation underscores that health is an essential precondition for a life of dignity. Additionally, Articles 14 and 15, which guarantee equality before the law and prohibit discrimination based on factors such as gender, caste, religion, or any other, have been instrumental in dismantling barriers to healthcare access for marginalised populations. These provisions foster an inclusive approach to

health services, ensuring that no individual is denied care based on their social identity.

In addition to fundamental rights, the Directive Principles of State Policy further guide the State's responsibilities towards health. Article 39(e) mandates the State to safeguard the health and strength of workers, protecting them from conditions that could be detrimental to their well-being. This provision emphasises the need for humane work environments and policies that address occupational health hazards. Article 42, which requires the provision of maternity relief, highlights the State's obligation to ensure the health of women, particularly during vulnerable periods such as pregnancy and childbirth. Similarly, Article 47 imposes a duty on the State to raise nutrition levels, improve public health, and prohibit the consumption of harmful substances, reinforcing the need for holistic public health measures.

Moreover, Indian Constitution empowers local governance structures through provisions like Article 243G, which allows Panchayats to implement health-related schemes within their jurisdiction. The Eleventh Schedule of the Constitution lists health and sanitation, drinking water, family welfare, and women and child development as key areas within the jurisdiction of Panchayats. This decentralisation of health governance is critical for addressing local health needs and ensuring that vulnerable groups have access to essential services.

These constitutional provisions collectively form the foundation for protecting and advancing the right to health in India. Through judicial interpretations and legislative actions, the framework aims to address health disparities and

promote the well-being of all citizens, with a particular focus on vulnerable groups.

## Judicial Interpretations

The Indian judiciary has played a critical role in interpreting the Constitution to expand the scope of the right to health, particularly under Article 21. Through landmark judgments, the courts have recognized health as an integral part of the right to life and personal liberty, contributing to the broader constitutional objective of ensuring equitable access to healthcare, especially for vulnerable groups.

The recognition of health as a fundamental right is evident in several landmark judgments. In *Vincent Panikurlangara v. Union of India* (1987) [4], the Supreme Court held that public health is an essential component of Article 21, emphasising the State's obligation to maintain and improve public health systems. The Court observed that the failure to ensure public health violates the constitutional right to life, placing an undue burden on individuals, particularly those from marginalised sections. Similarly, in *Consumer Education and Research Center v. Union of India* (1995) [5], the Supreme Court reinforced that the right to health is an important aspect of the right to life and dignity under Article 21. It highlighted the State's duty to ensure access to healthcare facilities and safeguard workers' health through appropriate policies and programs. This judgement extended the interpretation of life to include a life of dignity, where health is fundamental to personal well-being and human development.

Several judgments have focused specifically on the protection of vulnerable groups' health rights. In *Bandhua Mukti Morcha v. Union of India* (1984)

[6], the Court addressed the plight of bonded labourers, emphasising that the right to live with dignity, as guaranteed by Article 21, includes access to healthcare. The judgement connected health rights with Directive Principles, such as Articles 39(e) and 42, mandating the State to address health inequities in the workforce. Similarly, in *Paschim Banga Khet Mazdoor Samity v. State of West Bengal (1996)* [7], the Court ruled that the denial of immediate medical treatment by government hospitals violates the right to life under Article 21. It emphasised the State's obligation to establish an adequate healthcare system capable of addressing emergencies, particularly for vulnerable and rural populations who may not have alternative access to medical care.

These judgments have been instrumental in reinforcing the right to health as an integral part of the right to life, particularly for society's most vulnerable sections. Through these decisions, the judiciary has expanded constitutional protections and held the State accountable for addressing systemic gaps in healthcare access and delivery.

Further, several important judgments have illustrated the practical applications of the right to health in various contexts. For instance, in *Union of India v. Mool Chand Khairati Ram Trust* [8], the Supreme Court emphasised that access to life-saving drugs is a fundamental right under Article 21. The Court directed the government to ensure that intellectual property laws, including patents on medicines, do not obstruct access to affordable healthcare. This case highlighted the State's duty to balance public health needs with global trade obligations. Additionally, in *M.C. Mehta v. Union of India (1987)* [9], the Court recognized the right to

a clean and safe environment as part of the right to health. The case, which dealt with industrial pollution, saw the Court direct industries to adopt safety measures to protect public health. This judgement connected environmental protection with health rights, linking Article 21 with Article 48A, which mandates the State to improve and protect the environment.

These judicial interpretations collectively demonstrate the proactive role the judiciary has played in advancing the right to health in India. By interpreting constitutional provisions expansively and addressing systemic inequities, these judgments have significantly contributed to the evolution of health jurisprudence, ensuring that the State remains accountable for upholding the health and well-being of its citizens.

## Challenges and Gaps

Despite progressive judicial interpretations and constitutional provisions, significant challenges and gaps persist in ensuring equitable access to healthcare in India. These challenges, spanning legislative, implementation, and socioeconomic domains, continue to hinder the realisation of the right to health, particularly for vulnerable groups.

One of the primary legislative challenges is the absence of explicit recognition of the right to health in the Indian Constitution. While judicial interpretations have expanded the scope of Article 21 to include the right to health, the Constitution does not formally recognize it as a standalone fundamental right. This lack of clear, explicit recognition limits the potential for direct enforcement and comprehensive legislative action that could more effectively address health

inequities. The absence of a specific legal provision creates a gap in the healthcare system, leaving the issue of health rights vulnerable to inconsistencies in enforcement and insufficient policy initiatives. A parallel can be drawn with the right to education, which was judicially recognized as part of Article 21 in cases like *Mohini Jain v. State of Karnataka* [10] and *Unni Krishnan v. State of Andhra Pradesh* [11]. Despite this recognition, the addition of Article 21A through a constitutional amendment was necessary to provide a more concrete legal framework and facilitate the enactment of comprehensive legislation like the *Right to Education Act, 2009*, ensuring enforceability and systemic reforms. Similarly, while the judiciary has acknowledged the right to health under Article 21, its formal recognition as a standalone fundamental right could strengthen India's legal and institutional framework, enabling targeted policies and legislation to address inequities and establish healthcare as a legally enforceable obligation.

Healthcare infrastructure in India, especially in rural and marginalised areas, remains underdeveloped [12]. Vulnerable groups such as women, children, and persons with disabilities often face significant barriers in accessing basic health facilities. The inadequacy of healthcare services in these areas leads to disparities in health outcomes, with many marginalised populations unable to obtain even basic medical care. This systemic shortcoming contributes to widening health inequities, particularly in less developed regions where the availability of healthcare resources and skilled personnel is severely limited.

In addition to legislative and infrastructural gaps, implementation challenges also persist, particularly

regarding the application of judicial directives. Although there have been landmark rulings emphasising the right to health, the enforcement of these judgments is uneven across states. Administrative inefficiencies, lack of resources, and insufficient political will contribute to this disparity [13]. As a result, many vulnerable populations remain underserved, and the full potential of judicial interventions is not realised in practice. The uneven application of judicial directives aggravates existing health inequities, leaving significant portions of the population without access to essential services.

Discrimination within healthcare systems further compounds the challenges to achieving equitable access. Persons with disabilities and individuals living with HIV/AIDS often face stigma and marginalisation in healthcare settings, which results in delayed or inadequate treatment [14]. This discrimination leads to worsened health outcomes for already vulnerable populations and deepens systemic health disparities. The failure of healthcare providers to ensure equal treatment for all individuals undermines the constitutional guarantee of health equity and perpetuates social exclusion.

On the socioeconomic front, India faces significant barriers in healthcare access, primarily due to high out-of-pocket expenditure. India has one of the highest rates of out-of-pocket expenditure on healthcare in the world, which disproportionately affects marginalised populations [15]. The financial burden of healthcare services prevents many vulnerable individuals from seeking necessary medical treatment. This economic barrier aggravates health inequities and contributes to the continuation of health disparities between



socioeconomic groups. Additionally, many vulnerable populations remain unaware of their legal rights to healthcare under the Indian Constitution and various welfare schemes. This lack of awareness prevents individuals from seeking judicial remedies or advocating for their rights when they are denied healthcare services. Legal literacy among marginalised groups is essential to empower them to demand the healthcare services they are entitled to, as enshrined in the Constitution.

## CONCLUSION

India's constitutional framework, supported by progressive judicial interpretations, has significantly advanced the recognition of the right to health as an integral part of the right to life under Article 21. Judicial interventions have underscored the State's responsibility to provide equitable healthcare, protect vulnerable groups, and uphold the health and dignity of all citizens. However, challenges such as legislative gaps, uneven policy implementation, and inadequate healthcare infrastructure continue to impede the full realization of these constitutional commitments.

To address these shortcomings, enacting comprehensive legislation that explicitly recognizes the right to health as a fundamental right is essential. Such legislation should clearly delineate the State's obligations, establish accountability mechanisms, and safeguard the rights of vulnerable groups. Simultaneously, improving healthcare infrastructure—particularly in marginalized areas—is crucial. This includes targeted investments in primary healthcare centers, mobile health units, emergency services, and healthcare technology. Public awareness campaigns should be prioritized to educate citizens, especially vulnerable groups,

about their health rights and available welfare schemes. Collaboration with civil society organizations can further empower individuals to seek remedies for rights violations.

Aligning national health policies with Sustainable Development Goal 3 is critical for promoting inclusivity and equity. This requires reducing out-of-pocket healthcare expenditures, improving access to essential medicines, and addressing social determinants of health such as nutrition, clean water, and sanitation. By implementing these measures, India can bridge the gaps in its healthcare system, protect the health rights of vulnerable groups, and fulfill its constitutional and international obligations. Equitable healthcare is not just a legal mandate but a moral imperative for promoting a just and inclusive society.

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**Citation: Asdaque SS, Hasan A. Ensuring the Right to Health of Vulnerable Groups: An Analysis of India's Constitutional Framework. National Journal of Medical and Allied Sciences 2023; 12(2): 3-9**

Conflicts of Interest: Nil Source of Funding: Nil

Date of Acceptance: 15-08-2023

Date of Submission: 01-06-2023



## National Journal of Medical and Allied Sciences

[ISSN Online: 2319 – 6335, Print: 2393 – 9192|Short Communication |Open Access]

### FROM LUSH PONDS TO DECREASED PLATELET COUNTS- DENGUE SEROTYPES DURING THE COVID-19 PANDEMIC IN FIROZABAD, UTTAR PRADESH

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#### ABSTRACT

Dengue is a major arboviral disease caused by four primary serotypes of the Dengue virus (DENV-1 to DENV-4), with recent reports of a fifth serotype (DENV-5). Transmitted mainly by *Aedes aegypti* mosquitoes breeding in freshwater habitats, dengue infection can range from mild febrile illness to severe complications like hemorrhagic fever and shock, often associated with thrombocytopenia. Globally, dengue cases have increased exponentially, with India reporting over 1.93 lakh cases in 2021.

This study, the first from Firozabad district, Uttar Pradesh, investigates circulating dengue serotypes following the Coronavirus disease 2019 (COVID-19) pandemic. Between June and September 2021, 25 NS1-positive samples were analyzed via RT-PCR, revealing a 92% dengue positivity rate. DENV-2 was the predominant serotype (69.56%), followed by DENV-3 (13.04%), with some cases of mixed infections involving DENV-2 & DENV-3 and DENV-1 & DENV-3. Environmental factors like temperature and rainfall influence dengue transmission, which may be further affected by climate change and urbanization.

Understanding prevalent serotypes is crucial for clinical management, outbreak prediction, vector control, and vaccine development. Continuous surveillance post-pandemic is vital for effective dengue control strategies in the region.

**Key words:** Dengue virus, Serotypes, Post-COVID-19 surveillance, Uttar Pradesh

#### INTRODUCTION

Dengue, the arboviral disease, poses a significant global health threat. The Dengue virus, belonging to the Flaviviridae family is widely distributed throughout the tropics and subtropics. To date four serotypes have been identified: Dengue virus serotype 1 (DENV-1), DENV-2, DENV-3 and

DENV-4. These serotypes are genetically related but antigenically distinct causing Dengue infection in humans.<sup>[1]</sup> Recently, a fifth serotype, DENV-5, was isolated in 2013 and is known to follow the sylvatic cycle.<sup>[2]</sup> The primary vector for the Dengue virus is the *Aedes aegypti* mosquito which is known

to survive and multiply in fresh water; natural and artificial water holding sites like tree holes, ponds, domestic water containers, earthen pots, drums, tyres etc. being the preferred breeding sites.<sup>[3,4]</sup> A study conducted in Delhi reported that the Dengue infection rose in the months following rainfall rising highest in September and October.<sup>[5]</sup> Dengue virus transmission generally leads to a mild, self-limiting febrile illness and the most common symptoms are high fever, headache, body aches, joint pain, nausea, vomiting and rash. However, the complications can lead to Dengue haemorrhagic fever or dengue shock syndrome which may cause damage of lymphatic system and blood vessels, epistaxis, ecchymosis, haemorrhage, bleeding from the gums, hepatomegaly and circulatory system failure. Thrombocytopenia is a very common clinical manifestation in dengue infection. The Dengue virus can directly or indirectly damage bone marrow progenitor cells, reducing the proliferative ability of haematopoietic cells.<sup>[6]</sup> Thrombocytopenia may result from either decreased bone marrow cell production or accelerated platelet breakdown and clearance from the peripheral circulation.<sup>[7]</sup>

There has been an incessant rise in the Dengue cases worldwide in the recent decades, wherein, the WHO reported 5,05,430 cases in 2000 which increased to 5.2 million in 2019, with the highest number of dengue cases recorded in 2023.<sup>[8]</sup> Outbreaks of the four dengue virus serotypes have been increasingly reported in the tropics and subtropics, mostly in Asia, South America and the Caribbean.

Several virus serotypes have been detected cocirculating in the hyperendemic regions of Southeast Asia and the Pacific.<sup>[9]</sup> In India more than 100,000 cases of dengue infection are reported annually and in 2021 more than 1.93 lakh cases were documented, maximum being from the states of Uttar Pradesh and Punjab.<sup>[10]</sup> The Dengue serotypes which have generally progressed from a common ancestor are considered as the causative agent of essentially identical illness spectrum in the humans, due to Dengue selecting distinct receptors based on cell types and virus strains.<sup>[11]</sup> DENV-2 and DENV-3 have been associated with more serious disorders especially during secondary infections, while DENV-1 and DENV-4 are associated with less severe illness.<sup>[12]</sup> As per the "antibody-dependent enhancement" (ADE) theory, the antibodies from a previous dengue infection can enhance the entry of the virus into cells during a subsequent infection with a different serotype which attributes to difference in severity.<sup>[13]</sup>

## MATERIAL AND METHODS

This is the first study from Firozabad district of Uttar Pradesh, India, to report on the prevalence of different Dengue virus serotypes circulating within the local population, especially following the surge of COVID-19. During the period from June to

September 2021, immediately after the second wave of the COVID-19 pandemic, the Department of Microbiology at Autonomous State Medical College, Firozabad, serotyped 25 Dengue NS1-reactive samples using conventional RT-PCR, alongside RT-PCR testing for the COVID-19 virus.

## RESULTS

Out of these, twenty three (92%) cases were confirmed of dengue virus. None were COVID-19 positive. In this study DENV-1, DENV-2 and DENV-3 serotypes were identified. Maximum cases, sixteen (69.56%) were of serotype DENV-2, followed by three (13.04%) cases infected with DENV-3 serotype. Mixed infection with DENV-2 & DENV-3 serotypes was seen in three (13.04%) cases and one case (4.34%) was mixed infection with serotypes DENV-1 and DENV-3.

**Table 1: Distribution of Dengue Virus Serotypes and Co-infections Among Confirmed Cases**

Parameter	Number of Cases (n=23)	Percentage (%)
Total dengue-confirmed cases	23	92%
COVID-19 positive cases	0	0%
Dengue Serotype Distribution		
DENV-2	16	69.56%
DENV-3	3	13.04%
Mixed Serotype Infections		
DENV-2 & DENV-3	3	13.04%
DENV-1 & DENV-3	1	4.34%

## DISCUSSION

Our study was in concordance with results from Rajasthan where 60% cases were infected with DENV-2 or DENV-3 serotypes.<sup>[14]</sup> However, another study conducted in Southeastern Andhra Pradesh found predominantly DENV-2 serotype followed by DENV-4.<sup>[15]</sup> Yung et al also reported DENV-2 as the most prevalent serotype in Singapore.<sup>[16]</sup>

The interaction between dengue virus, the host and the environment is dynamic. The rise in rural-urban migration or urbanization increases the likelihood of genetic changes leading to diversity in virus population. The environmental factors like increase in temperature and rainfall are predictors of Dengue incidence and the vector control should be implemented at least two months prior to disease progression.<sup>[5]</sup> However, the erratic changes in the environment due to global warming pose a threat to the change in dynamics of Dengue ecology by increasing vector ranges, broadening the duration of vector activity and having a domino effect on the vectors' infectious period as vectors might adapt to new environments and climate.<sup>[17]</sup>

## CONCLUSION

Dengue virus serotyping is crucial to assess the severity of the infection, guiding efficient

management of the patients. It helps in understanding the risk of secondary infections particularly when caused by different serotypes than the prior infection. Besides, it helps in monitoring outbreaks and strategizing targeted vector controls. Additionally, it aids in understanding the dengue virus evolution and vaccine development. Furthermore, understanding how environmental changes influence dengue transmission dynamics is vital for predicting and mitigating future outbreaks.

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**Citation Tuli L, Shariq M. From Lush Ponds To Decreased Platelet Counts- Dengue Serotypes During The COVID-19 Pandemic In Firozabad, Uttar Pradesh. National Journal of Medical and Allied Sciences 2023; 12(2):10-14**

Date of Acceptance: 29-05-2023

Date of Submission: 23-04-2023

Conflicts of Interest: Nil Source of Funding: Nil