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VISUAL AND BRAINSTEM EVOKED POTENTIALS: A RETROSPECTIVE CROSS-SECTIONAL AUDIT FROM A TERTIARY CARE HOSPITAL IN PAKISTAN

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ABSTRACT

Background and Objective:

Visual and brainstem auditory evoked potentials (VEPs and BAEPs) are standard techniques for evaluating the integrity of visual and auditory pathways respectively. The objective of our audit study was to assess demographic trends, referral indications, and electrophysiological outcomes of patients undergoing VEP and BAEP testing in a tertiary care neurophysiology laboratory in Pakistan.

Methods:

A retrospective, cross-sectional audit was conducted of 952 patient records (VEP, n=219; BAEP, n=733) over a three-year period from neurophysiology laboratory of Aga Khan University Hospital. Demographic characteristics, clinical referral indications, and electrophysiological findings were collected. Standard ACNS guidelines were used for all recordings. Statistical analysis was descriptive, with categorical variables expressed as frequencies and percentages.

Results:

In the VEP cohort (51.1% female; 48.9% male), the 1-10-year age group underwent a VEP most commonly. The predominant referral indication was visual loss with optic neuropathy (52.5%), and bilateral optic pathway dysfunction (42.3%) was the most frequently seen abnormality. The BAEP cohort was also predominantly in the 1-10-year age group. Primary referral indications were delayed speech development (42.7%) and hearing loss (26.6%); peripheral auditory pathway dysfunction (53.2%) was the most common abnormal finding.

Conclusion:

Our study demonstrates the primary utility of VEPs and BAEPs in evaluating pediatric and young adult populations for optic neuropathy and peripheral auditory dysfunction, respectively. These data underscore the critical role of evoked potential testing in the early diagnosis and management of visual and auditory pathway disorders, supporting its integration into standard diagnostic protocols.

Keywords: Evoked Potentials; Visual Evoked Potentials; Brainstem Auditory Evoked Response; Neurophysiology; Pakistan

INTRODUCTION

Evoked potentials (EPs) are standard neurophysiological techniques that objectively quantify the functional integrity of sensory pathways by recording electrical responses to predefined sensory stimuli. Among these, Visual Evoked Potentials (VEP) and Brainstem Auditory Evoked Potentials (BAEP) are cornerstones for diagnosing abnormalities in the auditory/visual pathways. VEP records the electrical activity in the visual cortex following visual stimulation and primarily assesses the optic pathway, providing critical data in disorders such as optic neuritis, multiple sclerosis (MS), and compressive lesions.[1,2] Conversely, routine BAEPs evaluate the auditory pathway mainly from the cochlea to the inferior colliculus, proving indispensable in the workup of hearing loss and brain stem pathology. [3,4] In demyelinating diseases like MS, EPs can detect sub-clinical lesions and serve as biomarkers of disease burden.[5] The utility of these tests is underscored by their non-invasive nature, reproducibility,

and high sensitivity to dysfunction within their respective sensory systems.

Despite their well-established role in neurological diagnosis and management, the demographic and clinical patterns of VEP and BAEP referrals and findings in Pakistan are not well-documented. Therefore, our study aimed to provide a comprehensive overview of the demographic characteristics, referral indications, and electrophysiological outcomes for patients undergoing VEP and BAEP testing at a major tertiary care center in Pakistan.

METHODS

We conducted a retrospective, cross-sectional audit of all VEP and BAEP studies performed at the neurophysiology laboratory of the Aga Khan University hospital, Karachi, Pakistan, from January 1, 2022, to December 31, 2024. This study was exempted from the need of approval from the institutional review board of the university.

The study cohort included all consecutive patients referred for VEP or BAEP testing during the study period. We extracted data from our neurophysiology registry. Patients were excluded if their medical records were incomplete (e.g., missing demographic data or referral indication) or if the electrophysiological study was deemed technically inadequate by the supervising neurophysiologist.

Data were collected using a structured proforma. Variables included patient age, sex, clinical referral indication, and the final electrophysiological diagnosis (categorized as normal or abnormal, with specification of the abnormal pathway). All tests were performed by trained technologists under the direct supervision of fellowship-trained neurophysiologists.

VEP and BAEP recordings were performed in accordance with the latest published guidelines of the American Clinical Neurophysiology Society.

VEP: Pattern-reversal VEPs were obtained using checkerboard pattern reversal and goggle stimulation methods with standardized protocol. The active electrode was placed at Oz (mid-occipital) with reference to Fz (mid-frontal) and additional electrodes at RO (right occipital), LO (left occipital) and bilateral ear/mastoid (A1/A2). The ground electrode was placed at the vertex area.[6] VEPs were analyzed for P100 latency (our laboratory normative <116ms), interocular latency difference (difference of >6ms considered significant) and amplitudes (difference of >50% significant for axonal injury).

BAEP: BAEPs were elicited using monaural click stimuli through headphones. Contralateral white noise masking was applied. Responses were recorded between the ipsilateral earlobe (Ai) and the vertex (Cz). Absolute latencies of waves I, III, and V, as well as interpeak latencies (I-III, III-V, I-V), were measured using rarefaction, condensation and alternating methods and maximum 105 DbSL were used for hearing threshold.[7]

BAEP interpretation primarily relies on three factors: absolute latencies, interpeak latencies (IPLs), and interaural latency differences. Prolongation of absolute latencies of Waves I, III and V localize the lesion to various points along the auditory pathway: Prolongation of Wave I latency indicates peripheral auditory dysfunction (e.g., cochlear nerve involvement, hearing loss); prolongation of Wave III latency points to an abnormality at the lower pons level; prolongation Wave V latency localizes to a dysfunction at the upper brainstem.

Prolongation of Interpeak Latencies (IPLs) further refines localization, where a prolonged I–III interval suggests pathology between the auditory nerve and lower pons, a prolonged III–V interval indicates involvement between the pons and midbrain, and an increased I–V interval reflects a more diffuse brainstem conduction delay.

Interaural latency differences, particularly a Wave V difference greater than 0.3–0.4 ms, are suggestive of retrocochlear pathology. In addition, patterns such as uniformly prolonged absolute latencies with preserved interpeak latencies are typically seen in conductive hearing loss, while selective prolongation of interpeak latencies is more indicative of central or demyelinating brainstem disorders.[8]

Data were analyzed using SPSS Statistics, Version 19.0 (IBM Corp.). Descriptive statistics were used to summarize demographic and clinical variables, expressed as frequencies and percentages.

RESULTS

During the three-year study period, 1,138 evoked potential studies were performed (265 VEP; 873 BAEP). One-hundred-eighty-six studies (46 VEP and 140 BAEP) were excluded due to incomplete data, a final cohort of 952 studies was analyzed (219 VEP; 733 BAEP) (Figure 1)

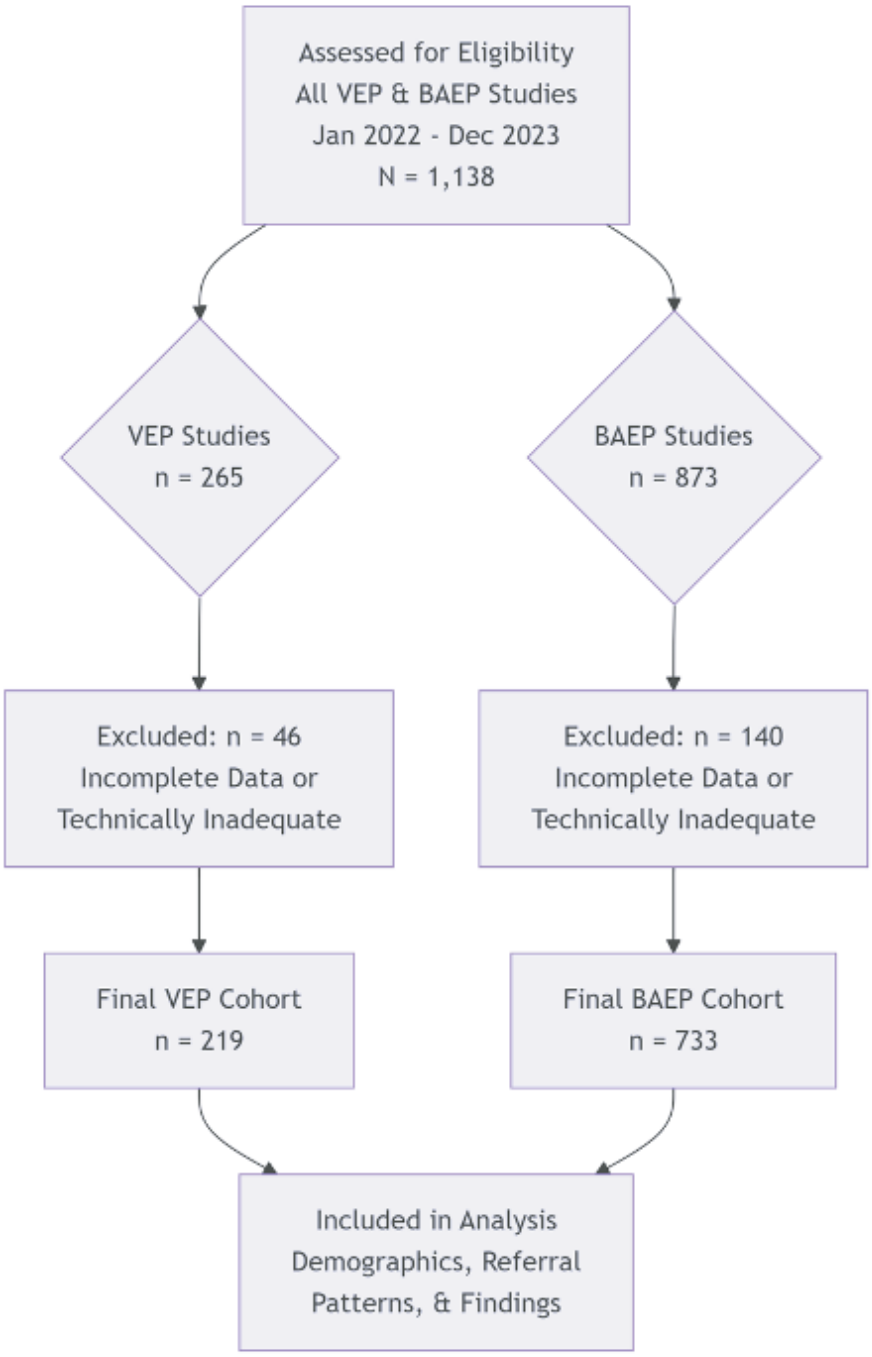

Figure 1: Flow diagram of study participants

Visual Evoked Potentials (VEP):
The VEP cohort (n=219) demonstrated a near-equal sex distribution (112 [51.1%] female; 107 [48.9%] male). The age distribution was broad, with the highest proportion of patients in the 1-10 year age group (55 [25.1%]), followed by the 21-30 year (36 [16.4%]) and 31-40 year (31 [14.2%]) groups (figure 2).

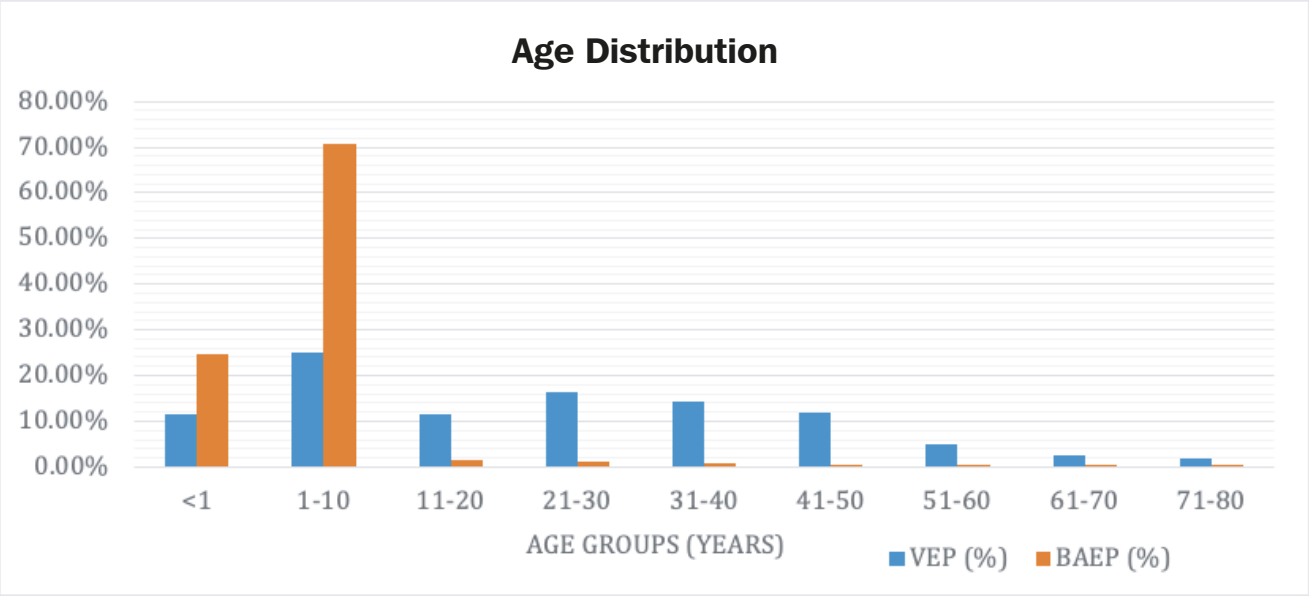

Figure 2: Age distribution for each test type (in percentages). VEP, visual evoked potential (in blue); BAEP, brainstem auditory evoked potential (in orange).

Figure 3 demonstrates the reasons of VEP referrals and their results.

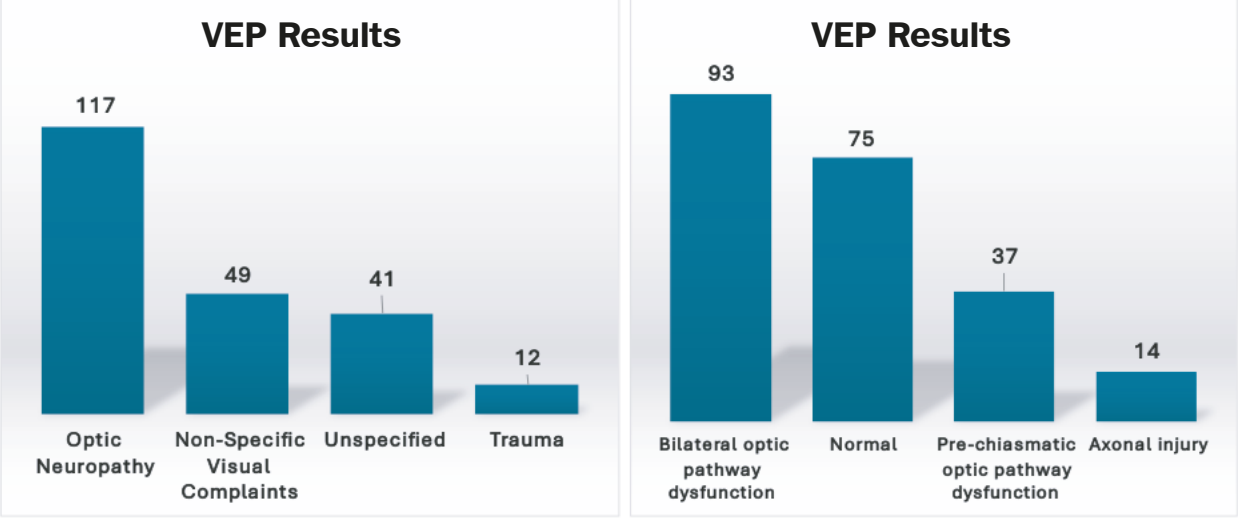

Figure 3A. Indications for Visual Evoked Potential (VEP) testing, with optic neuropathy as the most common referral reason. Figure 3B. VEP findings, showing frequencies of bilateral and pre-chiasmatic pathway dysfunction, normal studies, and axonal injury.

Brainstem Auditory Evoked Potentials (BAEP):
The demographics of the BAEP group has been presented in Figure 2 . The referral indications and their results are shown in Figure 4.

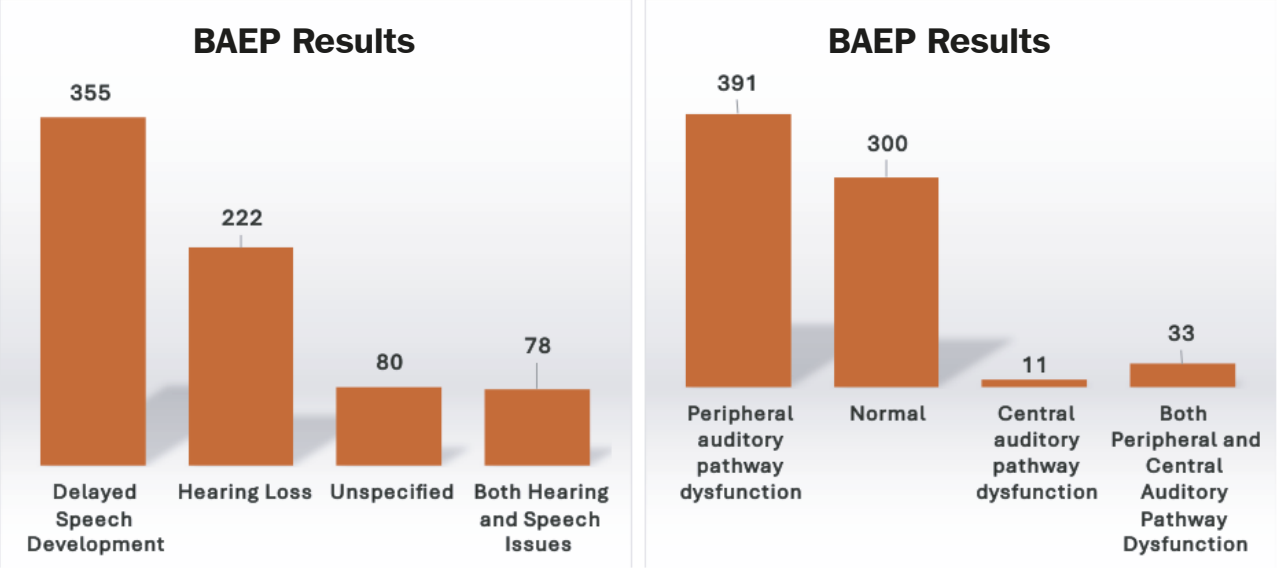

Figure 4A. Indications for Brainstem Auditory Evoked Potential (BAEP) testing, predominantly delayed speech development and hearing loss. Figure 4B. BAEP results, including peripheral and central pathway abnormalities and normal responses.

DISCUSSION

Our study highlights demographic trends and diagnostic outcomes of VEP and BAEP testing in a tertiary neurophysiology setting, providing novel population-level data from Pakistan. The observed near-equal sex distribution in the VEP cohort contrasts with the pronounced male predominance in BAEP testing, a finding that likely reflects the established higher prevalence of developmental conditions such as speech delay among male children, which constituted nearly half of all BAEP referrals.[9]

The predominance of optic neuropathy as the primary indication for VEP referral aligns with established literature, where demyelinating and ischemic etiologies are leading causes of visual pathway dysfunction.[10] The high frequency of bilateral optic pathway abnormalities identified in our cohort highlights the utility of VEP in detecting chronic or progressive disorders that may not be immediately apparent on neuroimaging, reinforcing its role as a first-line diagnostic tool when clinical suspicion is high and magnetic resonance imaging findings are inconclusive.

The overwhelming pediatric predominance in BAEP testing highlights its critical role in evaluating childhood hearing and speech development. The high yield of peripheral auditory pathway dysfunction (53.2% of all BAEP studies) is consistent with prior audits identifying conductive and cochlear pathologies as major contributors.[11] The precision of BAEP in localizing lesions within the auditory pathway renders it indispensable for initial diagnosis, rehabilitation planning, and surgical decision-making in pediatric audiology.

The parallel interpretation of VEP and BAEP results underscores their complementary roles in functional neurodiagnostics. Both modalities provide objective, quantifiable measures of sensory pathway integrity. These detect subclinical demyelination, axonal loss, and synaptic dysfunction. Their utility extends beyond diagnosis to include monitoring disease progression, evaluating treatment response, and prognosticating functional outcomes in conditions such as multiple sclerosis, posterior fossa surgeries, and neurodevelopmental disorders.[12,13]

Our study has several limitations. Its retrospective, single-center design may affect the generalizability of findings. Furthermore, incomplete data for certain demographic and clinical variables may introduce selection bias. Although pattern reversal (checkerboard) stimulation was the standard protocol for most visual evoked potential (VEP) recordings, goggle-based stimulation was used in a small subset of uncooperative or non-fixating patients; however, the exact distribution between these two stimulation methods was not systematically documented. Moreover, the study did not include a stratified analysis based on age or gender, which may have provided additional insights into demographic variations in abnormal findings and referral patterns. Despite these limitations, this audit provides foundational insights that can inform clinical practice and public health strategy in similar resource-limited settings. Future prospective, multi-center studies are warranted to establish national normative data and to further validate the diagnostic and prognostic utility of evoked potentials in our population.

CONCLUSION

Our study establishes the essential roles of VEP and BAEP in diagnosing sensory pathway disorders, with a pronounced impact on pediatric neurodevelopmental care. The high diagnostic yield supports the integration of these electrophysiological tools into standard neurologic practice in Pakistan to enhance early detection, guide intervention, and improve patient outcomes.

REFERENCES

1. Kothari R, Vemparala SS, Shafy SM, Wanjari M, Sangoi L, Sangoi R. Visual evoked potentials among Indian patients with optic nerve disorders. Bioinformation. 2024 Oct 31;20(10):1266–1270. doi:10.6026/9732063002001266.
2. Chiappa KH. Evoked Potentials in Clinical Medicine. 3rd ed. Philadelphia: Lippincott-Raven; 1997.
3. Hall JW. New Handbook of Auditory Evoked Respons es. Pearson Education; 2007.
4. Musiek FE, Lee WW. Auditory evoked potentials in normal and disordered populations. In: Handbook of Clinical Audiology. 7th ed. 2015.
5. Lascano AM, Lalive PH, Hardmeier M, Fuhr P, Seeck M. Clinical evoked potentials in neurology: a review of techniques and indications. J Neurol Neurosurg Psychiatry. 2017 Aug;88(8):688-696. doi: 10.1136/-jnnp-2016-314791.
6. American Clinical Neurophysiology Society. Guideline 9B: Guidelines on visual evoked potentials. J Clin Neurophysiol. 2006 Apr;23(2):138–156. doi:10.1097/00004691-200604000-00011. Erratum in: J Clin Neurophysiol. 2006 Aug;23(4):281.
7. American Clinical Neurophysiology Society. Guideline 9C: Guidelines on short-latency auditory evoked potentials. J Clin Neurophysiol. 2006 Apr;23(2):157–167. doi:10.1097/00004691-200604000-00012.
8. Yamada T, Meng E. Practical guide for clinical neurophysiologic testing: EEG. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2017.
9. Diler Durgut B, Tekin E. Speech and Language Delay in Children: Child Neurology Experience. *J Behçet Uz Child Hosp*. 2024;14(3):135-140. doi:10.4274/jbuch.galenos.2024.96992.
10. Khamraeva GKh, Kamilov KhM, Kasimova MS.

Diagnostic value of the visual evoked potential investigation in optic neuritis. Int J Biomed. 2015;5(3):147-150. doi:10.21103/Article5(3)_OA7.
11. Habib SS, Husain A, Omar SA, Al Drees AM. Brainstem auditory evoked potentials and electrocochleographic findings in patients with idiopathic sudden sensorineural hearing loss. J Coll Physicians Surg Pak. 2011 Jul;21(7):415-9.
12. Kaya Tutar N, Ömerhoca S, Söylemez E, Adatepe T, Kale İçen N. The Role of Visual Evoked Potentials in the Differential Diagnosis of Demyelinating Diseases. Turk J Neurol. 2021;27:366-70.
13. Kálmánchey R, Avila A, Symon L. The use of brainstem auditory evoked potentials during posterior fossa surgery as a monitor of brainstem function. Acta Neurochir (Wien). 1986;82(3-4):128–136. doi:10.1007/BF01456373.

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Zuha Amin Alvi: Concept, Design, Data collection, manuscript writing
Sundus Mehtab Shafee: Data collection, data analysis manuscript writing
Zahra Talib Shah; Data collection, data analysis, Manuscript writing
Dureshahwar Kanwar; Data interpretation, manuscript revision
Sajid Hameed; Data collection, data analysis, manuscript writing, manuscript revision

All the authors have approved the final version to be published and agree to be accountable for all aspects of the work.