Facial palsy as a manifestation of COVID-19: A systematic review of cases

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Abstract

Background and Aims: Facial palsy is a rare complication of the COVID-19 infection. Herein, we conducted a systematic review of all published cases of facial palsy post-COVID-19 infection in an attempt to educate the general population and medical practitioners regarding the likely occurrence of facial palsy in COVID-19 patients, its detection, effective treatment plan, and prognosis of the condition.

Methods: We searched PubMed, Google Scholar, and Directory of Open Access Journals (DOAJ) from December 1, 2019 to September 21, 2021.

Results: We included 49 studies bearing accounts of 75 cases who had facial palsy. The mean age of patients was 42.9 ± 19.59 years, with a male-to-female ratio of 8:7. The majority of the cases were reported from Brazil (n = 14), USA (n = 9), Turkey (n = 9), and Spain (n = 9). Noticeably, 30.14% of COVID-19 patients were diagnosed with Guillain-Barré syndrome. In total, 22.97% of patients complained of bilateral facial paralysis (n = 17), whereas ipsilateral paralysis was observed in 77.03% (n = 57). These were common complaints of Lagophthalmos, otalgia, facial drooping, dysarthria, and compromised forehead wrinkling. The treatment regimen mainly included the use of corticosteroids (n = 51) (69.86%), antivirals (n = 23) (31.51%), IVIG (n = 18) (24.66%), antibiotics (n = 13) (17.81%), antiretroviral (n = 9) (12.33%), and antimalarial (n = 8) (10.96%) medications. In all, 35.62% of patients (n = 26) adhered to a combination of antiviral and corticosteroid-based therapy. Positive treatment outcomes were observed in 83.58% (n = 56) of cases. In contrast, 10 patients (14.93%) showed nonsignificant recovery, out of which 3 (4.48%) died from the disease.

Conclusion: The association of facial palsy with COVID-19 is controversial and therefore requires further investigation and published work to confirm a causal relationship. However, physicians should not overlook the likelihood of facial palsy post-COVID-19 infection and treat it accordingly.

KEYWORDS
COVID-19, facial palsy, neurological symptoms, SARS-CoV-2, systematic review
1 | INTRODUCTION

On December 31, 2019, a novel coronavirus was first identified in Wuhan, China, after reports of multiple cases of pneumonia among its people.¹ This was the start of an outbreak that took the shape of a pandemic over a few months, owing to its rapid transmission through respiratory droplets. As of May 10, 2022, 6.53% of the world population (n = 515,748,861) has confirmed infection with COVID-19, while 1.21% of these have lost their lives to the complications of COVID-19.²

COVID-19 patients commonly complain of fever, fatigue, nasal congestion, myalgia, anosmia, dry cough, ageusia, hemoptysis, dyspnea, and so forth.³ Under more serious circumstances, COVID-19 can result in severe pneumonia, acute respiratory distress syndrome, sepsis, septic shock, multiple organ failure, and so forth.⁴ While these are some of the most widely reported complications of COVID-19 infection, other less common ones have also surfaced, for example, hemophagocytic lymphohistiocytosis (HLH), vasculitis, central retinal vein occlusion, and so forth.⁵–⁷ Similarly, facial palsy has emerged as an unusual yet interesting complication of COVID-19, whose pathophysiology is yet to be known.

Numerous case reports and series documenting facial palsy as a complication of COVID-19 have been published. In addition, some systematic reviews have discussed the association of facial palsy with COVID-19. However, none of these reviews collectively assessed all the cases of facial palsy secondary to COVID-19. For instance, Gupta et al.⁸ included only those cases in which facial palsy was an isolated neurological finding. Therefore, in our systematic review, we aim to develop a stronger evidence base by including all the cases of facial palsy secondary to COVID-19 that have been published to date. Moreover, we generated patient-level data by including case reports to thoroughly evaluate the patient characteristics and clinical course of facial palsy secondary to COVID-19. This will not only bridge the gap in literature but will also aid physicians in reaching a timely diagnosis and in devising treatment regimens that cater to the patients’ individual needs.

2 | METHODOLOGY

2.1 | Literature review

Our work aligns with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) checklist (Supporting Information: File S1).⁹ We searched PubMed, Google Scholar, and Directory of Open Access Journals (DOAJ) from December 1, 2019 to September 21, 2021 for published accounts of cases of facial palsy as a symptom of COVID-19. Search terms were combined using appropriate Boolean operators. Our search strategy included keywords/subject headings pertaining to COVID-19 (e.g., SARS-CoV-2 OR Coronavirus Disease 2019 OR COVID-19 OR severe acute respiratory syndrome coronavirus 2 OR coronavirus infection) and facial palsy (e.g., facial palsy OR facial weakness OR facial paresis OR bell's palsy). The Reference section of included studies was also checked for completeness’ sake. Please refer to our Supporting Information: File S1 for a detailed search strategy. Furthermore, this study is registered in the International prospective register of systematic reviews (PROSPERO) and holds the unique identifying number (UIN): CRD42022324693.¹⁰

2.2 | Inclusion and exclusion criteria

Our search criteria included all case reports, case series, editorials, correspondence, and retrospective cohorts on the topic of facial palsy following COVID-19 infection. Only work published in English and containing comprehensive detail of clinical presentation and progression of the condition in each patient was included in our systematic review. Studies bearing aggregate level data, language barriers, and incomplete detail of the condition were excluded from our study. The title, abstract, and full-text screening were completed in duplicate and independently by two reviewers (M.K. and A.S.). Disagreements regarding the inclusion of studies for data extraction were resolved by the senior author (A.K.).

2.3 | Data extraction

Duplicate work was removed after a final version of included literature was entered on excel sheets. We gathered available data on the origin of the reported case (country), date of publication, study type, relevant case within every included study, patient characteristics, age, sex, the status of Guillain-Barre syndrome (present or absent), affected side of the face, the onset of facial palsy, the test used for detection of COVID-19, features related to facial palsy, results of cerebrospinal fluid (CSF) analysis, COVID-19-related symptoms, other signs/symptoms, imaging results, treatment regimen and outcome of treatment. Due to a lack of uniformity in the assessment of facial symptoms between included studies, the percentage-wise prevalence of symptoms could not be calculated. Additionally, since follow-up time varied between studies, treatment follow-up results are not comparable. The terms "complete recovery," "partial recovery," "progressive improvement," and "significant improvement" were regarded as positive treatment outcomes by the author of this review.

2.4 | Quality assessment

The quality of included cases was assessed using Joanna Briggs institute’s critical appraisal tools.¹¹ Selected studies were examined for inclusion criteria, sample size, description of study participants, and setting. Two reviewers independently assessed the methodological quality of each paper. Quality assessments were done with different tools based on different study designs. Each tool was modified to provide a numeric score. Tools had 8 items for case reports and 10 for case series. Included case reports (n = 39) had a mean score of 6.385 ± 1.41 with scores ranging from 2 to 8.¹²–⁵⁰ 10 case series had a mean score of 5.60 ± 2.01, and scores ranged from 3 to 9.⁵¹–⁵⁹ The detailed results of the quality
assessments are provided in Supporting Information: File S1. The quality of our systematic review was assessed using AMSTAR 2 criteria.60 The level of compliance with AMSTAR 2 came out to be “low.” We could not conduct a meta-analysis because only case reports and case series were included in the analyses without quantitative data.

2.5 | Statistical analysis

This systematic review reported descriptive information using individual-level data of 75 cases from a total of 49 studies reported on facial palsy as a manifestation of COVID-19. The data focused on the date and country of publication, patient’s characteristics, detailed symptoms of facial palsy and COVID-19, the status of Guillain-Barré syndrome (present or absent), results of imaging and Cerebrospinal Fluid (CSF) analysis, treatment plan and its outcome. In addition, the continuous variable’s mean, median, and SD were calculated where possible.

3 | RESULTS

Our initial search provided 1408 results. After removing duplicate studies (N = 1006), 347 studies were screened individually by the two reviewers (M.K. and A.S.). Two hundred and sixteen studies were rejected after going through their titles and abstracts, while full-text versions of the remaining articles (N = 131) were opened to ascertain their relevance to the topic. Out of these, 82 were excluded for reporting aggregate-level data (N = 35), not being of the desired study type (N = 12), not being in English (N = 19), or for reporting insufficient data on medical manifestation (N = 16). Finally, 49 studies met our inclusion criteria and were, thus, included for systematic analysis (Figure 1).

3.1 | Patient characteristics

A total of 75 patients gathered from 49 studies who developed facial palsy due to COVID-19 [Table 1]. The mean age of patients was 42.91 ± 19.59 years, ranging from 15 months to 88 years. In addition, 40 out of 75 patients were males. At the same time, 35 were females, giving a slightly higher ratio of male to female sufferers (8:7). Highest number of cases were reported from Brazil (n = 14), followed by the USA (n = 9), Turkey (n = 9), and Spain (n = 7). Iran and Italy reported six cases each, whereas Singapore, Morocco, and France published accounts of three people each suffering from the condition. India, Egypt, and Japan reported two cases each. At the same time, Canada, Nepal, UK, Belgium, Qatar, Germany, Sweden, Norway, and Portugal each had one published account of a patient complaining of facial palsy due to COVID-19. It is noteworthy that 13 out of 62 patients

![Figure 1](Image)
| Author     | Country | Study type   | No of cases | Patient No. | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/ symptoms | Imaging | Treatment | Treatment outcome |
|------------|---------|--------------|-------------|-------------|-------------------------|----------|------------|----------------------|--------------------------------|---------------------------------|-------------|------------------------|---------------------|----------|-----------|-------------------|
| Lima et al. | Brazil  | Case series  | 8           | 1           | None                    | 43/F     | No         | Right               | Yes                            | Moderate (HB Grade 3)             | NS          | Mild symptoms          | Ipsilateral abducant nerve palsy | CT Scan normal | Oral corticosteroids | PR                |
|            |         |              |             | 2           | None                    | 25/F     | No         | Right               | Yes                            | Mild (HB Grade 2)                | NS          | Mild                   | None               | Brain MRI normal     | Oral corticosteroids + acyclovir | CR                |
|            |         |              |             | 3           | None                    | 33/F     | No         | Right               | Yes                            | Moderate (HB Grade 3)             | NS          | Mild                   | None               | NA                   | Oral corticosteroids + acyclovir | PR                |
|            |         |              |             | 4           | None                    | 26/F     | No         | Left (after 2-10 days for all Nos) | No                                    | Mild (HB Grade 2)                | NS          | Mild                   | MRI: left CN7 enhancement | Oral corticosteroids | CR                |
|            |         |              |             | 5           | None                    | 50/F     | No         | Left                | No                            | Moderate (HB Grade 3)             | Protein: mildly elevated; WBC: normal; SARS-CoV: negative | Mild | None                   | CT scan: normal | Oral corticosteroids | PR                |
|            |         |              |             | 6           | None                    | 38/F     | No         | Left                | No                            | Mild (HB Grade 2)                | NS          | Mild                   | None               | Brain MRI: normal     | Supportive (eye lubricant) | CR                |
|            |         |              |             | 7           | None                    | 39/F     | No         | Right               | No                            | Mild (HB Grade 2)                | NS          | Mild                   | None               | Brain MRI: normal     | Oral corticosteroids | CR                |
|            |         |              |             | 8           | None                    | 34/M     | No         | Left                | No                            | Mild (HB Grade 2)                | NS          | Mild                   | None               | Brain MRI: normal     | IV corticosteroids | CR                |
| Homma et al. | Japan  | Case report  | 1           | 1           | Smoker                  | 35/F     | No         | Right               | Yes                            | NA                              | NS          | Cough, malaise, sore throat, nausea, fever, right-sided aguesia of tongue and anosmia | None         | CT scan: multiple bilateral ground-glass opacities | Acetaminophen, Maoto, favipiravir, and inhaled Cidofovir (corticosteroid) | CR                |
| Author               | Country | Study type | No of cases | Patient No. | Patient characteristics | Age/Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome |
|----------------------|---------|------------|-------------|-------------|------------------------|---------|------------|---------------------|---------------------------------|-------------------------------|-------------|------------------------|----------------------|----------|------------|------------------------|
| Goh et al.           | Singapore | Case report | 1           | 1           | NA                     | 27/M    | No         | Left                | No (after 6 days)                | Left-sided otalgia             | NS          | Myalgia, cough, fever, dysguesia, left-sided throbbing headache, and conjunctival infection | None                 | None     | Oral corticosteroid, valacyclovir and Lopinavir/ritonavir | No significant improvement |
| Figueiredo et al.    | Portugal | Case report | 1           | 1           | Pregnant, 35/F         | 35/F    | No         | Left                | Yes                             | Involuntary drooling, left-side labial commissure deviation and ipsilateral lagophthalmos | NA          | None                   | None                 | None     | Corticosteroid therapy and eye hydration therapy | No significant improvement |
| Caamaño et al.       | Spain    | Case report | 1           | 1           | None                   | 61/M    | Yes        | Bilateral           | No (after 10 days)               | Involuntary drooling on his right facial commissure, unresponsive blink reflex on both eyes | Protein: mildly elevated; WBC: normal; SARS: CON: negative | Fever, cough, and pneumonia | None                 | Brain MRI: unremarkable; Chest X-ray: bilateral frosted glass pneumonia | Oral corticosteroid, antimalarial and Lopinavir/ritonavir |
| Muras et al.         | Spain    | Case report | 1           | 1           | None                   | 20/M    | No         | Bilateral           | No (after a week)                | NA                           | Protein: elevated; WBC: elevated; SARS: CON: negative | Fever, significant asthenia, headache, myalgia, nausea, headache, odynophagia and vomiting | EBV coinfection | Brain MRI: confirmed bilateral facial neuritis | Levofloxacin and oral corticosteroid CR |
| Manganotti et al.    | Italy    | Case series | 3           | 1           | NA                     | 72/M    | Yes        | Right               | No (after 18 days)                | Mild right sided lower face weakness | Protein: elevated; WBC: normal; SARS: negative | Fever, dyspnea, hyposmia, ageusia | Racid tetraparesis, hypothermia of | NA                   | IVIG cycle, antimalarial, oseltamivir, darunavir | NA |

(Continues)
| Author          | Country | Study type | No of cases | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/ symptoms | Imaging | Treatment | Treatment outcome |
|-----------------|---------|------------|-------------|-------------------------|----------|------------|----------------------|---------------------------------|---------------------------------|-------------|--------------------------|----------------------|----------|-----------|---------------------|
| Khaja et al.    | USA     | Case report | 1           | 1                       | HTN and asthma | 44/M       | Yes                  | Bilateral                       | No (after 3 days)                | Elevated; Protein: normal; WBC: normal; SARS-COV: negative | Fever, hypoxia, and ageusia | None                   | Chest X-ray: clear; MRI brain: unremarkable | IVIG | PR         |
| Sancho-Saldana et al. | Spain  | Case report | 1           | 1                       | None       | 56/F       | Yes                  | Bilateral                       | No (after 20 days)               | Elevated; Protein: normal; WBC: normal; SARS-COV: negative | Fever, dry cough, and dyspnea | Tetraparesis, lumbar pain, paraparesis in both hands and oropharyngeal weakness | Chest X-ray: lobar consolidation | Antimalarial, azithromycin, and IVIG | PR         |
| Author         | Country  | Study type       | No of cases | Patient No. | Patient characteristics                                                                 | Age / Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms  | Other signs/ symptoms | Imaging | Treatment                          | Treatment outcome |
|----------------|----------|------------------|-------------|-------------|-----------------------------------------------------------------------------------------|-----------|-------------|----------------------|----------------------------------|----------------------------------|-------------|-------------------------------|-----------------|---------|-----------------------------------|-------------------|
| Theophanous et al. | USA      | Case report | 1          | 1           | Prematurely born, multiple congenital abnormalities, asthma, and gastrostomy tube feeding | 6/M       | No          | Right                | Yes                              | Moderate severe (HB Grade 4) | NA          | None                           | Tachycardiac     | NA      | IV acyclovir, IVIG infusion, lubricating eye drops and IV corticosteroids | Significant improvement |
| Dahl et al.     | Norway   | Case report | 1          | 1           | Acute MI                                                                                | 37/M      | No          | Right                | No (after 18 days)                 | NA                  | Protein: elevated; IgG: normal; WBC: elevated | Fever, headache, dyspnea          | X-ray thorax: bilateral consolidations | IV furosemide and intermittently required low-dose nor-epinephrine | CR |
| Egilmez et al.  | Turkey   | Retrospective cohort | 8  | 1          | HTN, CHF                                                                                | 90/M      | No          | Left                 | Yes                              | Moderate severe (HB Grade 4) | NA          | Pneumonia                        | None                             | Thorax CT: Intense pneumonia with ground glass opacities | IV methylprednisolone and corticosteroids (dexamethasone and prednisolone) | PR |
|                |          |                  |             | 2          | None                                                                                   | 4/F       | No          | Left                 | No (after 7 days)                 | Moderate severe (HB Grade 4) | NA          | Cough and fever                  | None                              | Thorax CT: normal | Oral corticosteroid               | CR |
|                |          |                  |             | 3          | None                                                                                   | 17/F      | No          | Right                | Yes                              | Moderate (HB Grade 3)           | NA          | Cough, ageusia and anosmia        | None                             | Thorax CT: normal | Favipiravir and oral corticosteroid | CR |
|                |          |                  |             | 4          | HTN, DM                                                                                | 71/F      | No          | Right                | Yes                              | Moderate severe (HB Grade 4) | NA          | Fever, ageusia and anosmia        | None                             | Thorax CT: normal | Favipiravir and IV corticosteroid | CR |

(Continues)
| Author | Country | Study type | No of cases | Patient characteristics | Age/Sex | GB present | Affected side of face | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome |
|--------|---------|------------|-------------|-------------------------|---------|------------|---------------------|---------------------------------|------------|--------------------------|---------------------|---------|-----------|-----------------------|
| 5       | None    | 63/F       | No          | Left                    | Yes     | Moderate severe (HB Grade 4) | NA | Fever, myalgia, ageusia and anosmia | None | Thorax CT: Mild pneumonia with ground glass appearance | Favipiravir and oral corticosteroids | PR |
| 6       | None    | 60/F       | No          | Left                    | No (after 12 days) | Moderate severe (HB Grade 4) | NA | Fever, ageusia and anosmia | None | Thorax CT: normal | Favipiravir and oral corticosteroids | PR |
| 7       | HTN     | 65/F       | No          | Left                    | Yes     | Moderate (HB Grade 3) | NA | Ageusia and anosmia | None | Thorax CT: Mild pneumonia with ground glass opacities | IV corticosteroids | PR |
| 8       | HTN, OSA | 30/M       | No          | Left                    | No (after 9 days) | Moderate (HB Grade 3) | NA | ageusia and anosmia | None | Thorax CT: Mild pneumonia with ground glass appearance; brain MRI: normal | Favipiravir and oral corticosteroids (methylprednisolone and dexamethasone) | No improvement |

Engström et al. Sweden Case report 1 1 None 46/F No Left No (after 26 days) Tongue deviation to left, inability to wrinkle forehead and left lagophthalmos, drooping left corner of mouth, vocal cord paresis, left-sided paresis NA High fever, cough, dyspnea, dysphagia, and severe headaches None CT thorax: bilateral ground glass appearance, MRI brain: some edema in the parotid gland High-flow oxygen therapy, dalteparin, IV cefotaxime, oral and IV corticosteroids, and tear substitutes with watch bandages Significant improvement

Corrêa et al. Brazil Case series 4 1 None 25/F No Right No (after 2 weeks) Right-sided facial muscle weakness and right lagophthalmos NA Vertigo, mild dyspnea, and fever Stabismus in the right eye after right CN6 palsy None Brain MRI: restricted diffusion (right CN6 nucleus) and an Oral corticosteroids CR
| Author     | Country | Study type | No of cases | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome |
|------------|---------|------------|-------------|-------------------------|----------|------------|----------------------|----------------------------------|---------------------------------|-------------|------------------------|---------------------|---------|-----------|----------------------|
| Chan et al. | Canada  | Case report | 1           | None                    | 58/M     | Yes        | Bilateral           | Right                           | No (after 10 days)               | NA                | Mild fever and sore throat | None                | Brain MRI: | CR        | CR                   |
|            |         |            |             |                         |          |            |                     |                                  |                                 |                            |             |                        | CR                   |          |           |                      |
| Ozer et al. | Turkey  | Case report | 1           | 62/F                    | Left     | No         | No (after 2 days)   | Total paralysis (HB Grade 6)     | NA                              | NA                | Fatigue, chills, and myalgia | None                | Brain MRI: | Oral      | CR                   |
|            |         |            |             |                         |          |            |                     |                                  |                                 |                            |             |                        | corticosteroids     |          |           |                      |

(Continues)
| Author          | Country | Study type | No of cases | Patient No. | GB present | Age/Sex | Patient characteristics | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome |
|----------------|---------|------------|-------------|-------------|------------|---------|-------------------------|----------------------|-------------------------------|----------------------------------|------------------------|---------------------|----------|-----------|------------------|
| Neo et al.     | Singapore | Case series | 2           | 1           | NA         | 25/M    |                         | Left                 | Yes                           | Severe (HB Grade 5)            | None                   | None                | NA       | enoxaparin sodium |
| Mackenzie et al.| USA     | Case report | 1           | 1           | HTN, T2DM  | 39/F    | Bilateral              | No (after 20 days)   | NA                           | NA                               | NA                     | None                | NA       | oral corticosteroids, valaciclovir and given eye care advice |
| Bastola et al. | Nepal   | Case report | 1           | 1           | DM         | 48/M    | Left                   | No (after 4 days)     | Left-sided facial droop with inability to wink left forehead, raise left eyebrow and left lateral canthus | NA                           | Mild dry cough and hyposmia | None                | HRCT chest: ground-glass opacity in the right lower lobe | Regular insulin and other antidiabetic medications, tear plus drops for dry eyes, and IV corticosteroid |
| Hookham et al. | UK      | Case report | 1           | 1           | Childhood asthma and HTN | 17/M    | Right                  | No (after 1.5 months) | Right-sided facial droop with right-sided facial hypesthesia | NA                           | Fever, diaphoresis, vomiting, mild headache, intermittent right-sided chest pain, myalgia and pedal paresis | Pediatric inflammatory multisystem syndrome, tachycardia | Brain MRI: minimal increased enhancement of a segment right CN 7 | IV fluids, broad spectrum antibiotics, oral corticosteroids, tocilizumab |
| Author          | Country | Study type | No of cases | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/ symptoms | Imaging | Treatment | Treatment outcome |
|-----------------|---------|------------|-------------|-------------------------|----------|------------|----------------------|-------------------------------|---------------------------------|-------------|------------------------|----------------------|----------|-----------|-------------------|
| Khedr et al.    | Egypt   | Case report | 2           | None                    | 49/F     | Yes        | Left                 | No                           | Right-sided deviation of mouth and left lagophthalmos | NA          | Fever, dysphagia, and vomiting | Flaccid areflexic quadriplegia, hoarseness of voice, and an impaired cough reflex and stock and glove hypoesthesia | CT chest: bilateral ground-glass opacities | Plasmapheresis and IVIg | Progressive improvement |

| Kumar et al.    | India   | Case report | 1           | pregnant and PCOS       | 28/F     | No         | Right                | No                           | Inability to wrinkle right forehead and close right eye, left-sided deviation of mouth, numbness of the right side of the face and right-sided drooling | NA          | Fever, dysgeusia, and anosmia | Persistently high blood pressure (160/110), generalized weakness | NA          | Oral valacyclovir and oral corticosteroid, insulin (for steroid-induced DM) with physiotherapy and eye protective measures | CR          | (Continues) |
| Author         | Country | Study type | No of cases | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/ symptoms | Imaging | Treatment | Treatment outcome |
|----------------|---------|------------|-------------|------------------------|----------|------------|----------------------|-----------------------------------|---------------------------------|-------------|------------------------|---------------------|---------|-----------|-------------------|
| Aasfara et al. | Morocco | Case report | 1           | Pregnant               | 36/F     | Yes        | Bilateral           | Yes                               | Moderate severe (HB Grade 4)    | WBC: normal; protein: elevated; glucose: normal | vertigo, nausea, and vomiting | asymmetric numbness in the lower limbs and left fingers, right sensori-neural hearing loss, right vestibular areflexia and nystagmus | NA        | IV Ig and IV corticosteroids | CR of facial palsy. |
| Paybast et al. | Iran    | Case report | 1           | HTN                    | 38/M     | Yes        | Bilateral           | Yes                               | Bilateral facial droop, drooling, and slurred speech | glucose: normal; WBC: normal; protein: elevated | head ache, dysphagia, and mild dizziness | quadriparesis, decrease in all sensation modalities in four limbs affecting the distal parts up to ankle and elbow joints, tachycardia, blood pressure instability | NA        | Plasmapharesis and labetalol (for HTN) | No significant improvement |
| Bigaut et al.  | France  | Case report | 2           | None                   | 43/M     | Yes        | Right               | No                                | WBC: normal; protein: elevated | cough, anosmia, ageusia, and diarrhea | flaccid paraparesis, generalized areflexia, hypaesthesias, fore limb paresthesia, ataxia, myalgias in legs | chest CT: bilateral ground glass opacities; MRI: CN 3, 5, 6, 7, and 8 neuritis | IV Ig | Progressive improvement |
|                |         |            | 2            | Obesity                | 70/M     | Yes        | Left                | No                                | WBC: normal; protein: elevated | anosmia, ageusia, | flaccid tetraparesis | Chest CT: bilateral moderate | IV Ig and physiotherapy | No significant improvement |
| Author          | Country | Study type | No of cases | No of Patient | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results                  | COVID-19 related symptoms | Other signs/ symptoms | Imaging | Treatment | Treatment outcome |
|-----------------|---------|------------|-------------|---------------|-------------------------|----------|------------|-----------------------|-------------------------------|-------------------------------|-----------------------------|---------------------------|------------------------|----------|-----------|------------------|
| Ottaviani et al.| Italy   | Case report| 1           | 1             | Mild HTN               | 66/F     | NA         | left                  | Yes                           | NA                            | Protein: elevated; rest: normal | Acute fatigue, mild fever, and cough | Paraplegia, transient pruriginous dorsal rash, initial distal weakness in the upper limbs and diffuse areflexia | Lung CT: bilateral ground-glass opacities | IVIG, lopinavir/ritonavir and antimalarial | NA       |
| Casas et al.    | Spain   | Case report| 1           | 1             | vWB                     | 32/M     | No         | Left                  | No                           | Moderate severe (HB Grade 4) | Malaise, fever, dry cough, and headache | None                        | Brain MRI: asymmetric contrast uptake in a segment of Left CN7 | acetylsalicylic acid, metamizole, physiotherapy and ocular hydration | CR         |
| Hutchins et al. | USA     | Case report| 1           | 1             | HTN, pre-diabetes, Class I obesity | 21/M     | Yes        | Bilateral             | No                           | Dysarthria, hypogeusia, and facial numbness | Protein: mildly elevated; WBIC: normal; SARS-COV: negative | Fever, cough, dyspnea, diarrhea, nausea, headache, and sinonasal congestion, dizziness, hypogeusia | Tachycardic, bilateral lower extremity weakness, bilateral upper extremity paraesthesia, Grade 4/5 weakness in the deltoids and hip flexors bilaterally, diffuse areflexia | Chest X-ray: increased bilateral airspace opacities; brain MRI: abnormal bilateral enhancement of CN 6 and 7, alongside right CN 3 | Plasmapheresis | Nonsignificant improvement |
| Abolmaali et al.| Iran    | Case series| 3           | 1             | HTN                     | 88/F     | Yes        | Left                  | Yes                          | Left | Fatigue: low back and thigh pain, impaired proprioception | Quadruparesis, with a ground-glass pattern | CT: pneumonia with a ground-glass pattern | Plasmapheresis, intubation, corticosteroids, antimalarsal and lopinavir/ritonavir | No significant improvement | (Continues) |
| Author          | Country | Study type | No of cases | Patient No. | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome |
|----------------|---------|------------|-------------|-------------|------------------------|----------|------------|----------------------|-----------------------------------|----------------------------------|-------------|------------------------|---------------------|----------|-----------|----------------------|
| Oke et al.     | USA     | Case report| 1           | 1           | history of nephrolithiasis | 36/M     | No         | Right                | No                                | Moderate severe (HB Grade 4)     | NA          | Fever and body aches  | NA                  | Brain MRI: asymmetric enhancement of the right CN7 | Oral valacyclovir, corticosteroid, eye patch and artificial tears | Significant improvement |
| Derollez et al.| France  | Case report| 1           | 1           | Overweight             | 57/F     | NA         | Left                 | No                                | NA                               | NA          | NA (HB Grade 4)        | NA                  | Chest X-ray: infiltrates | Oral and corticosteroid, favipiravir, arbidol and NSAID | CR                     |
| Hasibi et al.  | Iran    | Case report| 1           | 1           | Class 1 obesity        | 52/M     | No         | Right                | No                                | Severe (HB Grade 5)              | NA          | Fever, malaise, dry cough, and anorexia | NA                  | CT: multiple peripheral ground glass opacities | Oral and corticosteroid, favipiravir, remdesivir, arbidol and NSAID | CR                     |
| Taouihar et al.| Morocco | Case report| 2           | 1           | DM, CML                | 39/M     | No         | Right                | Yes                               | Facial asymmetry, dysarthria, and difficulty chewing | NA          | Dyspnea                | NA                  | Azithromycin, zinc, vitamin C, oral corticosteroid, preventive anticoagulation | CR of facial palsy |
| Author          | Country | Study type      | No of cases | Patient No. | Gender | Age/Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome       |
|-----------------|---------|-----------------|-------------|-------------|--------|---------|-------------|-----------------------|----------------------------------|---------------------------------|--------------|-----------------------|---------------------|---------|-----------|------------------------|
| Kaplan et al.   | USA     | Case report    | 1           | 1           | DM     | 48/F    | No          | Left                  | No                               | Asymmetric forehead folds, dry eye, inability to raise the left eyebrow and left facial droop | NA          | Fever, chills, headaches, fatigue, myalgia, and weakness | None                  | CT: bilateral CN7 contrast enhancement | Oral corticosteroids, valacyclovir, and doxycycline | Significant improvement |
| Kerstens et al. | Belgium | Case report    | 1           | 1           | NA     | 27/M    | No          | Bilateral             | Yes                              | Severe (HB Grade 5)               | IgG: elevated; rest: normal | None                  | MRI: bilateral CN7 contrast enhancement | Valacyclovir, artificial tears and oral corticosteroids | CR                   |
| Kakumoto et al. | Japan   | Case report    | 1           | 1           | NA     | 22/M    | Yes         | Bilateral             | No                               | Dysarthria                       | Protein: elevated; rest: normal | Fever and dysphagia | Tetraparesis, hypotension of extremities, dysuria, inability to deflectate, dyschezia, sinus arrhythmia | Head MRI: bilateral CN7 contrast enhancement | IVIG, intubated and managed on a ventilator | CR                   |
| Al-Mashdali et al. | Qatar  | Case report    | 1           | 1           | Atrial septal defect | 21/M    | No          | Right                 | No                               | NA                              | NA          | Fever, cough, watery diarrhoea, vomiting, conjunctivitis, and abdominal pain | Acute myocarditis | CT: Bilateral ground-glass opacities and pleural effusion | IV corticosteroids and ocular lubricant | Significant improvement | (Continues) |
| Author         | Country | Study type | No of cases | No of patients | Patient characteristics | Age/sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome     |
|----------------|---------|------------|-------------|----------------|-------------------------|---------|------------|---------------------|-----------------------------------|---------------------------------|-------------|------------------------|----------------------|----------|-----------|------------------------|
| Judge et al.   | USA     | Case report| 1           | 1              | NA                     | 64/M    | No         | Bilateral          | No                                | Dysarthria and subjective facial paresthesia | WBC: elevated; protein: elevated; Glucose: normal | Cough, fever, and chills | None     | NA         | Progressive improvement |
| Tran et al.    | USA     | Case report| 1           | 1              | DM                     | 42/M    | Yes        | Right              | Yes                               | Right-sided hypesthesia, dysartrhia, diplopia, ptosis, and inability to raise eyebrows or smile | Protein: elevated; WBC: normal; glucose: elevated | None         | Right lower extremity weakness | None | NA         | NA                     |
| Silveira et al.| Brazil  | Case report| 1           | 1              | DM, HTN                | 65/M    | No         | Left               | Yes                               | Facial asymmetry, otalgia, and ophthalmo-plegia | NA          | Fever, dry cough, and dyspnea | Chest X-ray: bilateral infiltrates; CT: ground-glass opacities | IV corticosteroids, electrolyte replacement for hypokalemia, IVig, physical, occupational, and speech therapy | CR         | IV         | Death                  |
| Liberatore et al. | Italy | Case report| 1           | 1              | HTN and history of testicular seminoma | 49/M    | Yes        | Left               | No                               | NA                              | Glucose: normal; protein: slight elevation; WBC: normal | Fever, cough | Symmetric weakness in the upper limbs with flaccid tone, reduced tendon reflexes, and | Chest CT: multifocal ground-glass opacities; Brain MRI: compression of CN 2, 3, 4 and 6 | Antimalarial, lopinavir/ritonavir, and ceftriaxone | NA         | IV         | NA                     |
| Author          | Country | Study type | No of cases | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome |
|-----------------|---------|------------|-------------|-------------------------|----------|------------|----------------------|-----------------------------------|-------------------------------|-----------------------|---------------------|----------|-----------|-------------------|
| Shinde et al.   | India   | Case report | 1           | 1                       | 64/M     | No         | Right                | Yes                               | Severe (HB Grade 5)             | NA                   | None                 | Macular erythematous rash along zygomatic arch, maxillary and mandibular division of trigeminal nerve | Chest X-ray: normal | Eye care, acyclovir, corticosteroid, and methylcobalamin | PR       |
| Ochoa-Fernández et al. | Spain   | Case report | 1           | 1                       | 6/F      | No         | Left                 | Yes                               | Moderate (HB Grade 3)           | NA                   | None                 | None                 | NA                   | Eye protection and oral corticosteroids | CR       |
| Zain et al.     | USA     | Case report | 1           | 1                       | 2/F      | No         | Right                | Yes                               | Right lagophthalmos, ptosis, and drooping of corner of mouth, flattening of the nasolabial fold, dryness of the eye and tearing | Glucose: normal; protein: normal; WBC: normal | None                 | EBV coinfection and contact dermatitis | Brain MRI: abnormal enhancement of the canalicular segment of right CN7 | IV       | corticosteroids | CR       |

(Continues)
| Author          | Country | Study type | No of cases | Patient No. | Patient characteristics | Age/ Sex | GB present | Affected side of face | Facial palsy as first sign or not | Features related to facial palsy | CSF results | COVID-19 related symptoms | Other signs/symptoms | Imaging | Treatment | Treatment outcome |
|-----------------|---------|------------|-------------|-------------|-------------------------|----------|------------|----------------------|---------------------------------|---------------------------------|-------------|------------------------|---------------------|---------|-----------|---------------------|
| Ribeiro et al.  | Brazil  | Case report| 1           | 1           | None                    | 26/M     | No         | Right                | No (on 8th day from first onset of symptoms) | Right facial weakness            | NA          | Cough and fever        | None                | NA      | High-flow oxygen therapy | NA                  |
| González-Castro et al. | Spain | Case series | 2           | 1           | Obesity                | 40/F     | No         | Left                 | No (after 2nd day of ward admission) | Moderate (HB Grade 3)              | NA          | None                   | MRI: poorly defined contrast uptake in the left hemifacial/malar subcutaneous region | NA      | High-flow oxygen therapy | NA                  |
|                 |         |            |             |             | DM, smoker and Parkinson's disease patient | 65/M     | No         | Left                 | No                              | Moderate (HB Grade 3)              | NA          | None                   | NA                  | NA      | High-flow oxygen therapy | NA                  |
had hypertension (20.97%), 9 had diabetes mellitus (14.52%), and 3 of the women were pregnant (4.84%). Twenty-seven patients had no comorbid condition (43.55%), while no information was shared for 13 patients (17.33%).

### 3.2 | Symptom presentation

Noticably, 30.14% of the patients were diagnosed with Guillain-Barré Syndrome associated with COVID-19. Facial palsy was observed as an initial symptom in 26/74 (35.14%) patients. In all, 22.97% of patients complained of bilateral facial paralysis, whereas ipsilateral paralysis was observed in 77.03%. Out of this 77.03% of patients, left (n = 29) and right (n = 28) sided involvement was observed in an almost equal number of patients. In all, 76.47% of bilateral facial paralysis patients also had GBS. Varying intensity of facial paralysis was seen among the 75 COVID-19-inflicted patients. While some experienced only mild facial deficit, weakness, or hypesthesia of the face, others complained of complete facial paralysis (n = 1). Most people complained of moderate-severe facial dysfunction (n = 10) based on the House Brackmann scale. Among sufferers, Lagophthalmos, otalgia, facial drooping, dysarthria, and compromised forehead wrinkling were common complaints. Most patients witnessed mild to moderate COVID-19-specific symptoms. These included complaints of fever, fatigue, cough, ageusia, and headache.

### 3.3 | Diagnostic results

Polymerase chain reaction (PCR), reverse transcriptase (RT)-PCR, and serology were the most used tests to confirm COVID-19 infection among 75 individuals. CSF analysis was performed in only half (48%) of the patients. 55.56% of whom had elevated CSF protein levels. CSF SARS-CoV-2 result was negative in all (100%), while approximately 1 in every 7 patients (13.5%) had elevated WBC levels on CSF report. Moreover, some patients underwent radiologic imaging to reach a diagnosis. Common findings on chest X-ray, computer tomography (CT) thorax, and magnetic resonance imaging (MRI) brain included the presence of infiltrates/consolidations (50%), ground glass opacities (71.88%), and enhancement of CN 7 of the affected side (51.52%), respectively.

### 3.4 | Treatment regimen and disease prognosis

Data on treatment plans were shared for 73 (97.33%) out of 75 patients. Although every individual had a treatment plan tailored according to his age, comorbidities, severity of the condition, availability of resources, and so forth, a handful of overlapping medications were prescribed too. Treatment regimen mainly included the use of corticosteroids (69.86%), antivirals (31.51%), IVIG (24.66%), antibiotics (17.81%), antiretroviral (12.33%), and

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**Table 1** (Continued)

| Author          | Country | Study type      | No of cases | Patient characteristics | Age/ Sex | GB present | Patient No. | Affected side of face | features related to facial palsy as first sign or not | G8 present | Patient No. | No | Treatment outcome | Features related to facial palsy CSF results | Other signs related to COVID-19 | Imaging | Treatment | outcome |
|-----------------|---------|-----------------|-------------|-------------------------|----------|------------|-------------|-----------------------|-----------------------------------------------|------------|--------------|---|------------------|-----------------------------------------------|-----------------------------|----------|-----------|---------|
| Pelea et al.    | Germany | Case report     | 1           | HTN, hypothyroidosis    | 56/F     | Yes        | 1           | Bilateral            | No                                                             | Severe (HB Grade 5) | NA           | 1 | PR              | Protein: elevated; glucose: normal; WBC: elevated; SARS-CoV: negative | Fever, cough, and dypnea | Chest CT: leaky infiltrates in the right lower lobe | IVIG and Plasmapheresis | PR          |
| Karimi et al.   | Iran    | Letter to the editor | 1           | None                    | 60/M     | No         | 1           | Bilateral            | No                                                             | Right-sided facial nerve palsy, involving mouth, eye, and forehead | NA           | 1 | PR              | None                          | Chest CT: ground glass opacities | Remdesivir, corticosteroid, and oxygen therapy | NA          | PR          |

Abbreviations: CR, complete recovery; CT, computed tomography; IVIg, intravenous immunoglobulin; MRI, magnetic resonance imaging; NA, not applicable; PR, partial recovery.
antimalarial (10.96%) medications. Lopinavir/Ritonavir was the most readily prescribed antiretrovirals, whereas hydrochloroquine (100%) was the only antimalarial advised to patients. Three antivirals, namely, acyclovir, valacyclovir, and favipiravir, were predominantly administered to these patients. In total, 35.62% of patients (n = 26) adhered to a combination of antiviral-corticosteroid-based therapy. Furthermore, in some cases, eye care (19.18%) medications, for example, lubricants, artificial tears and watch bandages, and so forth, were also encouraged eye care. Physiotherapy (5.48%) and plasmapheresis (10.96%), though less common, were also a part of the treatment plan of some patients. The outcome of treatment was provided for 67 (89.33%) patients. Positive treatment outcomes were observed in 83.58% of cases. In contrast, 10 patients (14.93%) showed nonsignificant recovery, out of which 3 (4.48%) died from the disease.

4 | DISCUSSION

Systematic reviews have been conducted in the past that discussed the association of facial palsy with COVID-19. The reviews indirectly discussed facial palsy concerning COVID-19 by establishing the correlation of COVID-19 with GBS, while some only explored cases in which facial palsy was an isolated neurological finding. However, none of them collectively assessed all the cases of facial palsy secondary to COVID-19 regardless of associated conditions. Thus, we were able to collate a stronger evidence base to support our findings concerning facial palsy and COVID-19.

Cranial nerve involvement in GBS most commonly results in bilateral facial palsy, rarely unilateral involvement, and facial palsy mostly occurs in the early stage of the disease. The findings of our study corroborate this observation. Of the 17 patients who demonstrated bilateral facial nerve palsy, 13 (76.5%) had accompanying GBS. Thus, cases of bilateral facial palsy are mostly attributed to GBS.

4.1 | Pathophysiology

Pathomechanisms of nervous tissue involvement have been discussed in great detail in the literature. Some of these mechanisms have been highlighted in Figure 2. In our study, unilateral facial palsy patients demonstrated right and left side involvement in almost equal proportions. This shows that SARS-CoV-2 has an equivalent predilection for right and left facial nerves.

In clinical practice, various other viruses have been observed to be associated with facial palsy as well, which include echovirus, enterovirus, herpes simplex virus, Epstein-Barr virus, cytomegalovirus, human herpesvirus 6, human immunodeficiency virus, mumps, rubella, poliomyelitis, and varicella zoster virus. Thus, this further corroborates that a virus like SARS-CoV-2 could be behind the etiopathogenesis of facial palsy.

Classically, facial palsy is known to show a predominance in females, which is evident in the prevalence studies conducted. Moreover, a systematic review involving studies in which Bell’s palsy was the only major neurological manifestation in COVID-19 patients also showed a female preponderance. However, our study demonstrated a slightly high male preponderance. This is because our study included a significantly high number (30.14%) of patients with accompanying GBS, and previous reviews evaluating the relationship between COVID-19 and GBS have demonstrated a high male preponderance. In addition, approximately 21% of the patients had hypertension, and 14.5% demonstrated diabetes mellitus. This finding is corroborated by a study conducted in Korea which demonstrated that facial palsy was associated with age, gender, smoking status, alcohol drinking, history of hypertension, stroke, CVD, diabetes mellitus, total cholesterol level in the blood, and hearing loss through a univariable analysis.
Furthermore, Paolino and colleagues\(^7\),\(^7\) reported a greater frequency of arterial hypertension and lipid disorders in patients with Bell’s palsy than in controls. Moreover, a study showed that the risk of Bell’s palsy was increased in diabetes.\(^7\)\(^9\) Also, patients with underlying comorbidities such as DM, obesity, hypertension, respiratory distress, or advanced age are at higher risk of developing COVID-19.\(^8\)\(^0\) Thus, all these factors contribute to the findings of our study.

The treatment regimen mainly involved corticosteroids (69.86%), and 35.62% of patients adhered to a combination of antiviral–corticosteroid-based therapy. This finding corroborates a meta-analysis demonstrating significant benefits of treating Bell’s palsy with corticosteroids.\(^8\)\(^1\) Moreover, a network meta-analysis showed that combined therapy remains the best regimen for a good recovery outcome, supporting its use by a significant 35.62% of patients.\(^8\)\(^2\) However, only two patients used antivirals without corticosteroids to treat facial palsy. A systematic review supports this finding by demonstrating that corticosteroids alone were superior to antivirals alone in treating facial palsy. There was no clear benefit from antivirals alone over placebo.\(^8\)\(^3\) Our findings show that the successful regimens in treating facial palsy due to other etiologies are also effective in treating facial palsy secondary to COVID-19.

Positive treatment outcomes were observed in 83.58% of patients. This corroborates the effectiveness of the treatment regimens used in the case reports to treat facial palsy secondary to COVID-19. A favorable response to treatment has also been shown in other complications that arise secondary to COVID-19, such as central retinal vein occlusion.\(^7\) However, some complications, such as hypoxic encephalopathy, have also shown a poor prognosis.\(^8\)\(^4\) Thus, this highlights that many distinct complications can arise due to COVID-19 with differing pathogenesis and severity.

There were some limitations in our study. Due to lack of provision of pertinent analytical data, no meta-analysis could be conducted on the topic to confirm the relationship between COVID-19 and facial palsy. Our review only comprised of case reports/series in which a limited number of patients were assessed. Therefore, large-scale studies with more patients and longer follow-ups are warranted to reliably draw the correlation between COVID-19 and facial palsy. Moreover, studies in languages other than English were excluded from the analyses. Lastly, adequate representation of most countries was not seen in our review, which implies that many cases went unreported there, so they could not be included in our analyses. Despite the limitations, we tried to include all relevant cases to date and demonstrated an in-depth comparison of clinical, radiological, and diagnostic features of COVID-19 and concomitant facial palsy in our patient-level analyses.

5 | CONCLUSION

To the best of our knowledge, this is the most updated review of facial palsy cases following COVID-19 infection. Although our patient-level systematic review successfully collated published accounts of facial palsy cases post COVID-19 infection while theorizing the pathophysiology behind COVID-19 and subsequent onset of facial palsy, the likelihood of the association being purely coincidental cannot be overlooked. Therefore, large-scale studies are still warranted to thoroughly understand the association between COVID-19 and concomitant facial palsy. Systematic reviews involving studies with large sample sizes, such as retrospective cohorts, should be conducted, generating a large patient pool for analyses. This would allow us to develop a clearer understanding of patient characteristics and devise more effective treatment regimens that cater to the needs of individual patients.

AUTHOR CONTRIBUTIONS

Aiman Khurshid: Conceptualization, methodology, writing – original draft preparation, writing – review & editing. Maman Khurshid, Aruba Sohail, Imran Mansoor Raza, Muhammad Khubab Ahsan, Mir Umer Farooq Alam Shah, Anab Rehan Taseer, Abdulqadir J. Nashwan, Irfan Ullah: Data curation, writing – review & editing. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST

Abdulqadir J. Nashwan is an Editorial Board member of Health Science Reports and co-author of this article. He is excluded from editorial decision-making related to the acceptance of this article for publication in the journal. The remaining authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article and its Supporting Information.

TRANSPARENCY STATEMENT

The lead author Abdulqadir J. Nashwan affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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