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Review

The Actual Situation of Covid-19 Infection at High Altitudes in Perú

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Abstract

This study aimed to reveal the evolution and characteristics of the COVID-19 pandemic in high-altitude areas of Perú. An observational, descriptive, retrospective and longitudinal study based on information from the Peruvian Ministry of Health, COVID-19 Situational Room, warning from the National Epidemiology Center, Prevention and Disease Control, and the Panamerican Health Organization (PAHO) was conducted to analyze the occurrence of the COVID-19 pandemic in Perú from the beginning of the pandemic until March 7, 2022. In this period, 31,635,319 people were examined, 3,637,529 were infected, and 213,551 died from the disease, with a lethality index of 5.87%. Perú is now the country most affected by the pandemic in South America. The data showed heterogeneity in prevalence across the country, with higher altitudes having lower prevalence than coastal and jungle areas, which was related to climatic circumstances and social factors. The situation was complicated by the severe spread of the pandemia, which caused a surge in demand for health services and intensive care units, loss of workplaces and increased levels of poverty. A notable result was a decrease in the prevalence and mortality of the COVID-19 pandemic at high altitudes in Perú compared to the coastal and jungle areas.

Keywords

SARS-CoV-2; pandemic; high altitude; Perú; 2020-2022

1. Introduction

According to the last census in 2017, 34,08% of Peruvians live above 2000 meters above sea level (masl) [1], an environment characterized by low air and oxygen partial pressures, hypoxia, lower environmental temperatures and humidity, high solar irradiation, high rainfall. Based on previous in-depth studies and our own experience, it is now known that normal high-altitude dwellers have adapted to high altitude through physiological changes and thus developed other characteristics associated with sea-level dwellers [2, 3].

Regarding the effects of high-altitude hypoxia on humans, three different situations need to be distinguished: first, the acute exposition to the high altitude of people who climb from sea level to high altitude [4]; second, the acclimatization of high-altitude dwellers born or live at high altitude for a long time without any limitations [5], and finally, the process of adaptation through genetic changes in people who have lived at high altitude for a long time, depending on the time lived at high altitude [2, 6].

The most essential biological phenomenon related to human acclimatization to high altitude is the decrease in the partial pressure of inhaled oxygen due to the decrease in barometric pressure, which is inversely proportional to the increase in altitude, while the amount of oxygen remains constant at 20,93% [2].

Geographically, Perú is divided into 3 main regions: the coastal, the highland, and the jungle, and administratively into 24 departments or states, 196 provinces, and 1896 districts. Coastal departments extend from Tumbes to Tacna and are considered the coast departments by their boundaries with the Pacific Ocean. The high-altitude departments are located in the Andes, and the Jungle departments are in the Peruvian Jungle on the oriental side of the Andes [1]. The COVID-19 outbreak began in Wuhan, China in December 2019 [7]. The first case in Perú was reported on March 6, 2020 [8], and the first death occurred in March and has since expanded throughout the country, with Ucayali being the last department to report an infection in March 2020. On 15th March, it was declared a curfew.

2. Methods

This is an observational, descriptive, retrospective, and longitudinal study based on the information obtained from the Peruvian Ministry of Health, COVID-19 Situational Room, warnings from the National Epidemiology Center, Prevention and Disease Control, and the Panamerican Health Organization (PAHO), compiled and analyzed the COVID-19 pandemic in Perú from its inception to July 6, 2022 [9].

The evolution of the pandemic is summarized in Figure 1.

Figure 1 Evolution of the COVID-19 pandemic in Perú. Source: National Center of Epidemiology, Prevention, and Control of Diseases, Ministry of Health, Perú, 2020 [10].

3. Results

The evolution of COVID-19 from the beginning to the present has particular characteristics that are worthy of analysis. The data in Table 1 showed that Perú is now the country with the highest mortality per million population rate in South America, and the second in lethality percentage. Table 2 describes the information for the coastal departments, which have the highest morbidity rates in Perú. Table 3 describes information for high-altitude departments, where the prevalence was lower than in other regions. Table 4 describes the data for the Jungle departments. Table 5 shows the comparison of the three regions.

Table 1 Morbidity and mortality in South American countries during COVID-19 pandemic, ranked by Mortality/Million. (Venezuela data seems questionable). Source: Datosmacro.expasion.com [11].

Place	N° of cases	N° of deaths	% Lethality	Mortality/Million
Perú	3,640,061	213,551	5,87	6,403,35
Brazil	32,535,927	672,033	2,06	3,143,97
Chile	4,035,779	58,631	1,45	3,052,67
Argentina	9,394,326	129,109	1,37	2,818,44
Colombia	6,175,181	14,070	2,26	2,743,83
Paraguay	660,841	18,944	2,87	2,583,16
Uruguay	962,251	7,499	8,13	2,109,23
Ecuador	913,798	35,745	3,91	1,998,33
Bolivia	931,955	21,985	2,35	1,856,09
Venezuela	527,074	5,735	1,08	199,86

Table 2 described the incidence and mortality of COVID-19 in the coastal departments of Perú, and the data showed that the prevalence in coastal areas was the highest in Perú.

Table 2 Morbidity and mortality of COVID-19 in the coastal departments of Perú.

COAST	N° of samples	N° of cases	N° of Deaths	% lethality
Tumbes	188,726	27,685	1,697	6.13
Piura	1,052,270	159,351	13,118	8.23
Lambayeque	761,129	106,454	9,251	7.35
La Libertad	1,129,741	148,027	10,881	7.35
Ancash	996,561	131,917	7,205	5.46
Callao	1,161,515	148,524	10,532	7.09
Lima Metropolitan	14,662,950	1,542,694	85,707	5.56
Lima Region	951,654	117,778	7,759	6.59
Ica	688,637	104,681	8,955	8.55
Arequipa	2,468,781	222,436	10,364	4.66
Moquegua	575,113	50,004	1,638	3.26
Tacna	366,452	54,472	2,148	3.94
Total	25,003,529	2,814,023	169,255	74.17
Mean	2,083,627.4	234,501.9	14,104.6	6.2

COVID-19 morbidity and mortality in high-altitude departments were shown in Table 3, where the results indicated a lower incidence than in other regions in Perú.

Table 3 Morbidity and mortality of COVID-19 in high altitude departments of Perú.

HIGH ALTITUDE	N°of samples	N° of cases	N° of deaths	% lethality
Cajamarca	800,593	96,560	4,788	4.54
Huánuco	403,744	52,476	2,898	5.52
Huancavelica	241,355	25,927	1,278	4.93
Ayacucho	306,874	48,421	2,338	4.38
Apurimac	318,909	39,272	1,642	4.18
Cusco	1,052,567	119,933	5,190	4.33
Puno	530,792	66,668	4,824	7.24
Pasco	429,525	24,322	1,104	4.56
Total	3,111,792	473,579	23,752	39.68
Mean	444541.7	59197.4	2,969.0	5.0

Morbidity and mortality of COVID-19 in the Peruvian jungle areas were presented in Table 4.

Table 4 Morbidity and mortality of COVID-19 in the Peruvian jungle departments.

JUNGLE	N° of samples	N° of cases	N° of deaths	% lethality
Amazonas	233,934	44,441	1348	3.03
San Martín	342,589	61,937	3,173	5.12

Loreto	397,914	58,069	4,394	7.57
Ucayali	235,522	39,666	3,270	8.24
Madre de Dios	124,710	17,948	859	4.79
Total	1,334,669	222,061	13,044	4.79
Mean	266,933.8	44,412.2	2,608.8	5.75

A comparison of the incidence and lethality of COVID-19 in the above three regions was shown in Table 5.

Table 5 COVID-19 morbidity and mortality in Perú by altitude.

Place	N° of samples	N° of Cases	N° of deaths	% Lethality
Coastal	25,003,325,529	2,814,023	169,255	6.18*
High altitude	3,111,792	473,579	23,752	5.02*
Jungle	1,334,669	222,061	13,044	5.75
Perú	28,128,990	3,640,061	182,534	5.87

* Comparison of prevalence of covid-19 in the 3 regions and the total in Perú

The data in this paper demonstrated that the number of COVID-19 infections and deaths in Perú was not only high but also has the highest mortality rate in the South American countries [9-11]. An outstanding fact is that the prevalence varies across the main territory regions, with high-altitude departments having lower rates than coastal and jungle areas [12].

The COVID-19 epidemic began in Wuhan, China in December 2019 and quickly expanded globally [7]. The first case in Perú was registered in March 2020 [8], since then until March 7, 2022, 3,640,061 people were infected, 213,551 people died, for a lethality rate of 5.87%, and the mortality rate was 36.55 per million persons [9].

There is a controversy as to whether COVID-19 is less prevalent at high altitudes than at sea level. Woolcott and Bergman sustained that there is no better situation at high altitudes [13, 14] but was refuted by Zubieta-Calleja [15], nevertheless, Woolcott and Berman still insisted [16]. Millet et al. also suggested that altitude/hypoxia may be associated with elevated risk for patients with COVID-19 [14].In comparing the results from the Rocky Mounts and New York, more extensive studies have demonstrated that COVID-19 prevalence was lower at high altitudes than at lower altitudes in the Americas including the USA [17, 18].

In addition, many other studies have indicated that the COVID-19 pandemic is less prevalent at high altitudes than at lower altitudes [8, 19-22]. However, it is difficult to explain these divergences, which may be related to the number of cases, different social attitudes in front of the pandemic, health facilities, geographic differences, etc. [23-26].

At high altitudes in the Andes, like Perú [8, 20-26], Colombia [27], Ecuador [28, 29], Bolivia [30, 31], and Brazil [32], the prevalence of the COVID-19 pandemic is lower compared to lower altitudes [33]. There are also some very distant countries [34], such as Tibetan [35], China plateaus [25], India [36], and Saudi Arabia [37], which show the same situation.

There is now a wealth of information demonstrating that high altitude limits the prevalence of the COVID-19 pandemic, but the mechanisms underlying this phenomenon have not yet been elucidated.

It has been suggested that low barometric and partial oxygen pressures would cause a decrease in the average half-lifetime of the virus and/or a decrease in the regulation of the angiotensin-converting enzyme 2 (ACE2), the main SARS-CoV-2 virus receptor in human epithelial cells [38, 39]. but normal residents who have adapted to high altitudes, whose pathophysiological features have changed, can live unrestricted at high altitudes, has he developed resistance to the SARS-CoV-2 virus? Under some responses, the normal high-altitude dwellers experience increased erythrocytosis, higher hemoglobin, greater oxygen transport, and higher concentrations of erythropoietin in the blood [40]. Among critically ill patients treated in UCI, high-altitude residents have better outcomes than those at sea level [41, 42].

In addition, meteorological and geographic conditions [43], and low serum erythropoietin concentrations [40] are negative factors for contagiousness and lethality. High levels of social informality have had an important effect on the high prevalence of pandemics, not only in the absence of continuous hygiene advice, such as the use of masks, social distancing, and crowd avoidance but also implies the absence of protection and services provided by the state [41]. This has been evident in the most contagious places such as markets, informal employment, and transportation, as well as other forms of informality.

It is well known that the existence of comorbidities like obesity, diabetes, and arterial hypertension increases the grade of poor prognosis [43-46].

One important issue to consider is the situation of persons who need to return to high altitudes after COVID-19 healing due to work, travel, sports, and other reasons and develop acute disease, which might lead to confusion between the acute mountain sickness or Hurtado´s diseases [47, 48] and COVID-19 pulmonary inflammation. Therefore, it is also necessary to evaluate the pulmonary function afterward to detect the possibility of a functional restriction, which would be a risk for climbing to high altitudes [49].

The COVID-19 pandemic in Perú has brought serious consequences to health, society, and the economy. The prevalence was so high that it caused the collapse of the health system, making it necessary to improvise increase the number of hospitalization and ICU beds, and the utilization of new strategies to bring recovery patients back to high altitudes [50].

As shown in Figure 1, the evolution of the pandemic had 3 waves, and now it is very worrying that this could be the beginning of another wave. One explanation is the emergence of new virus variants that are insensitive to the actual vaccines [24, 51-56]. And Zubieta-Calleja and Zubieta-DeUrioste hypothesized 16 possible reasons that could explain the lower incidence of SARS-CoV-2 [57].

The limitations of this work are that the statistical indicators are relative and only referential, depending on the number of rapid and molecular tests performed and the presence of asymptomatic patients or those who do not go to health facilities without being diagnosed.

In conclusion, COVID-19 had a very high pandemic in Perú and has its own epidemiological characteristics due to its territorial diversity and social determinants, with data showing a lower prevalence, lethality, and mortality in the departments of the mountains than those in the jungle and coastal departments.

Author Contributions

FG-L has participated in the data recollection, manuscript drafting, critical review of manuscript, final aproval of manuscript, asume the responsability respect other aspects of manuscript.

Competing Interests

The autor declare that he dose't have any conflict of interest.

References

1. Instituto Nacional de Estadistica e Informatica. Perú: Crecimiento y distribución de la población 2017 [Internet]. Lima: Instituto Nacional de Estadistica e Informatica; 2018. Available from: https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1530/libro.pdf.
2. Tymko MM, Tremblay JC, Bailey DM, Green DJ, Ainslie PN. The impact of hypoxaemia on vascular function in lowlanders and high altitude indigenous populations. J Physiol. 2019; 597: 5759-5776.
3. Monge CM, Monge CC. High altitude diseases: Mechanism and management. Springfield: Thomas; 1966.
4. Pun M, Hartmann SE, Furian M, Dyck AM, Muralt L, Lichtblau M, et al. Effect of acute, subacute, and repeated exposure to high altitude (5050 m) on psychomotor vigilance. Front Physiol. 2018; 9: 677.
5. Villena J. Cambios Metabólicos en la hipoxia crónica. Acta Andina. 1994; 3: 83-112.
6. Beall CM. Adaptation to high altitude: Phenotypes and genotypes. Annu Rev Anthropol. 2014; 43: 251-272.
7. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. N Engl J Med. 2020; 382: 1199-1207.
8. Centro Nacional de Epidemiología, Prevención y Control de Enfermedades, MINSA. Alerta Epidemiológica, código AE 011-2020 [Internet]. Lima: Centro Nacional de Epidemiología; 2020. Available from: https://www.dge.gob.pe/portal/docs/alertas/2020/AE011.pdf.
9. Sala situacional Covid-19 Perú. Total de casos positivos por departmento [Internet]. Lima: El Centro Nacional de Epidemiología, Prevención y Control de Enfermedades; 2022. Available from: https://covid19.minsa.gob.pe/sala_situacional.asp.
10. National Center of Epidemiology, Prevention, and Control of Diseases, Ministry of Health, Perú [Internet]. Lima: National Center of Epidemiology, Prevention, and Control of Diseases, Ministry of Health; 2022. Available from: https://www.dge.gob.pe/porta Please check the detail of this reference whether it is correct lnuevo/.
11. Covid-19. 2022 [cited date 2022 July 13]. Available from: https://datosmacro.expansion.com/.
12. Arias-Reyes C, Zubieta-DeUrioste N, Poma-Machicao L, Aliaga-Raduan F, Carvajal-Rodriguez F, Dutschmann M, et al. Does the pathogenesis of SARS-CoV-2 virus decrease at high-altitude? Respir Physiol Neurobiol. 2020; 277: 103443.

13. Woolcott OO, Bergman RN. Mortality attributed to COVID-19 in high-altitude populations. High Alt Med Biol. 2020; 21: 409-416.
14. Millet GP, Debevec T, Brocherie F, Burtscher M, Burtscher J. Altitude and COVID-19: Friend or foe? A narrative review. Physiol Rep. 2021; 8: e14615.
15. Zubieta-Calleja G, Merino-Luna A, Zubieta-DeUrioste N, Armijo-Subieta NF, Soliz J, Arias-Reyes C, et al. Re: "Mortality attributed to COVID-19 in high-altitude populations" by Woolcott and Bergman. High Alt Med Biol. 2021; 22: 102-104.
16. Woolcott OO, Bergman RN. Response to Zubieta-Calleja et al., Re: "Mortality attributed to COVID-19 in high-altitude populations". High Alt Med Biol. 2021; 22: 109.
17. Stephens KE, Chernyavskiy P, Bruns DR. Impact of altitude on COVID-19 infection and death in the United States: A modeling and observational study. PLoS One. 2021; 16: e0245055.
18. Arias-Reyes C, Carvajal-Rodriguez F, Poma-Machicao L, Aliaga-Raduán F, Marques DA, Zubieta-DeUrioste N, et al. Decreased incidence, virus transmission capacity, and severity of COVID-19 at altitude on the American continent. PloS One. 2021; 16: e0237294.
19. Garmendia-Lorena F. La evolución y características de la pandemia de COVID-19 en el Perú. Diagnóstico. 2020; 59: 117-122.
20. Accinelli RA, Leon-Abarca JA. En la altura la COVID-19 es menos frecuente: La experiencia del Perú. Arch Broconeumol. 2020; 56: 760-761.
21. Thomson TM, Casas F, Guerrero HA, Figueroa-Mujíca R, Villafuerte FC, Machicado C. Potential protective effect from COVID-19 conferred by altitude: A longitudinal analysis in Peru during full lockdown. High Alt Med Biol. 2021; 22: 209-224.
22. Moreira-Soto A, Pachamora Diaz JM, González-Auza L, Merino Merino XJ, Schwalb A, Drosten C, et al. High SARS-CoV-2 Seroprevalence in Rural Peru, 2021: A cross-sectional population-based study. Msphere. 2021; 6: e00685-21.
23. Li HL, Yang BY, Liao K, Sun N, Liu YC, Ma RF, et al. A meta-analysis result: Uneven influences of season, geo-spatial scale and latitude on relationship between meteorological factors and the COVID-19 transmission. Environ Res. 2022; 212: 113297.
24. Chen H, Qin L, Wu S, Xu W, Gao R, Zhang X. Clinical characteristics and laboratory features of COVID-19 in high altitude areas: A retrospective cohort study. PloS One. 2021; 16: e0249964.
25. Song P, Han H, Feng H, Hui Y, Zhou T, Meng W, et al. High altitude Relieves transmission risks of COVID-19 through meteorological and environmental factors: Evidence from China. Environ Res. 2022; 212: 113214.
26. Hakami AR, Dobie G. Studying the effect of particulate matter as SARS-CoV-2 transmitters. J Public Health Res. 2022; 11. doi: 10.4081/jphr.2021.2521.
27. Rodriguez DR, Pinzon AM, Rubio Ch, Pinilla DI, Nino MJ, Diaz MA, et al. Clinical characteristics and mortality associated with COVID-19 at high altitude: A cohort of 5161 patients in Bogotá, Colombia. Int J Emerg Med. 2022; 5: 22.
28. Ortiz-Prado E, Fernandez Naranjo RP, Vasconez E, Simbaña-Rivera K, Correa-Sancho T, Lister A, et al. Analysis of excess mortality data at different altitudes during the COVID-19 outbreak in Ecuador. High Alt Med Biol. 2021; 22: 406-416.
29. Ortiz-Prado E, Simbaña-Rivera K, Fernandez-Naranjo R, Vásconez JE, Henriquez-Trujillo AR, Vallejo-Janeta AP, et al. SARS-CoV-2 viral load analysis at low and high altitude: A case study from Ecuador. Int J Environ Res Public Health. 2022; 19: 7945.

30. Ministerio-de-Comunicación. COVID-19 Bolivia. Gaceta oficial [Internet]. La Paz: Ministerio-de-Comunicación; 2020. Available from: https://www.comunicacion.gob.bo/?q=noticias.
31. Yao Y, Fu J, Liu J, Li L, Chen W, Meng Z, et al. Distribution, progression, and associated factors of refractive status of children in Lhasa, Tibet, after COVID-19 quarantine. Ophthalmic Res. 2022; 65: 321-327. doi: 10.1159/000522548.
32. Fernandes JS, da Silva RS, Silva AC, Villela DC, Mendonça VA, Lacerda AC. Altitude conditions seem to determine the evolution of COVID-19 in Brazil. Sci Rep. 2021; 11: 4402.
33. Simbaña-Rivera K, Jaramillo PR, Silva JV, Gómez-Barreno L, Campoverde AB, Novillo Cevallos JF, et al. High-altitude is associated with better short-term survival in critically ill COVID-19 patients admitted to the ICU. PloS One. 2022; 17: e0262423.
34. Wondimagegn D, Petros A, Asrat Y, Aklilu T, Estifanos AS, Addissie A, et al. COVID-19 in Ethiopia: A contextual approach to explaining its slow growth. J Glob Health. 2020; 10: 020369.
35. Lei Y, Huang X, SiLang B, Lan Y, Lu J, Zeng F. Clinical features of imported cases of coronavirus disease 2019 in Tibetan patients in the Plateau area. Medrxiv. 2020. doi: 10.1101/2020.03.09.20033126.
36. Chakraborty S, Das U, Rathore U, Sarkhel P. Are high-altitude residents more susceptible to Covid-19 in India? Findings and potential implications for research and policy. Int J Health Serv. 2022; 52: 455-469.
37. El Askary A, Almehmadi M, Halawi M, Ali Al Hajjiahmed A, Alenazi M, Sami R, et al. Clinical findings of COVID-19 patients at high and average altitudes in Saudi Arabia. Pak J Biol Sci. 2021; 24: 663-671.
38. del Valle-Mendoza J, Tarazona-Castro Y, Merino-Luna A, Carrillo-Ng H, Kym S, Aguilar-Luis MA, et al. Comparison of cytokines levels among COVID-19 patients living at sea level and high altitude. BMC Infect Dis. 2022; 22: 96.
39. Huamaní C, Velásquez L, Montes S, Mayanga-Herrera A, Bernabé-Ortiz A. SARS-CoV-2 seroprevalence in a high-altitude setting in Peru: Adult population-based cross-sectional study. PeerJ. 2021; 9: e12149.
40. Leon-Velarde F, Monge CC, Vidal A, Carcagno M, Criscuolo M, Bozzini CE. Serum immunoreactive erythropoietin in high altitude natives with and without excessive erythrocytosis. Exp Hematol. 1991; 19: 257-260.
41. Viruez-Soto A, López-Dávalos MM, Rada-Barrera G, Merino-Luna A, Molano-Franco D, Tinoco-Solorozano A, et al. Low serum erythropoietin levels are associated with fatal COVID-19 cases at 4,150 meters above sea level. Respir Physiol Neurobiol. 2021; 292: 103709.
42. Jibaja M, Roldan-Vasquez E, Rello J, Shen H, Maldonado N, Grunauer M, et al. Effect of high altitude on the survival of COVID-19 patients in intensive care unit: A cohort study. J Intensive Care. 2022; 37: 1265-1273.
43. Breevoort A, Carosso GA, Mostajo-Radji MA. High-altitude populations need special considerations for COVID-19. Nat Commun. 2020; 11: 3280.
44. Zubieta-Calleja G, Zubieta-DeUrioste N, Venkatesh T, Das KK, Soliz J. COVID-19 and pneumolysis simulating extreme high-altitude exposure with altered oxygen transport physiology; multiple diseases, and scarce need of ventilators: Andean Condor's-eye-view. Rev Recent Clin Trials. 2020; 15: 347-359.

45. Leon-Abarca JA, Portmann-Baracco A, Bryce-Alberti M, Ruiz-Sánchez C, Accinelli RA, Soliz J, et al. Diabetes increases the risk of COVID-19 in an altitude dependent manner: An analysis of 1,280,806 Mexican patients. Plos One. 2021; 16: e0255144.
46. Noyola DE, Hermosillo-Arredondo N, Ramírez-Juárez C, Werge-Sánchez A. Association between obesity and diabetes prevalence and COVID-19 mortality in Mexico: An ecological study. J Infect Dev Ctries. 2021; 15: 1396-1403.
47. Hurtado A. Aspectos patológicos de la vida en las grandes alturas. An Fac Med. 1956; 39: 957-976.
48. Lizárraga L. Soroche agudo y edema agudo de pulmón en la altitud. Lima: Faculty of Medicine, Universidad Nacional Mayor de San Marcos; 1954.
49. Ballaz SJ, Pulgar-Sánchez M, Chamorro K, Fernández-Moreira E, Ramírez H, Mora FX, et al. Common laboratory tests as indicators of COVID-19 severity on admission at high altitude: A single-center retrospective study in Quito (ECUADOR). Clin Chem Lab Med. 2021; 59: e326-e329.
50. Luks AM, Grissom CK. Return to high altitude after recovery from coronavirus disease 2019. High Alt Med Biol. 2021; 22: 119-127.
51. van Veelen MJ, Voegele A, Rauch S, Kaufmann M, Brugger H, Strapazzon G. COVID-19 pandemic in mountainous areas: Impact, mitigation strategies, and new technologies in search and rescue operations. High Alt Med Biol. 2021; 22: 335-341.
52. Srivastava S, Garg I, Bansal A, Kumar B. SARS-CoV-2 infection: Physiological and environmental gift factors at high altitude. Virusdisease. 2020; 31: 450-452.
53. Kim C, Yu J, Lee YG, Kim J, Bae S. Identifying behavior of long-distance virus transmission and mitigation performance from a COVID-19 outbreak of a daycare center. Environ Res. 2022; 212: 113318.
54. Joob B, Wiwanitkit V. COVID-19 lung injury and high altitude pulmonary edema. Med J Dr DY Patil Vidyapeeth. 2022; 15: 126.
55. Galindo JL, Lutz JR, Izquierdo MA, Parra K, Prieto LM, Carrillo JA. Characteristics and clinical course of adult inpatients with SARS-CoV-2 pneumonia at high altitude. Can Respir J. 2021; 2021: 5590879.
56. Strapazzon G, Hilty MP, Bouzat P, Pratali L, Brugger H, Rauch S. To compare the incomparable: COVID-19 pneumonia and high-altitude disease. Eur Respir J. 2020; 55: 2001362.
57. Zubieta-Calleja G, Zubieta-DeUrioste N. Sixteen possible scientific explanations in support of lower COVID-19 Case Fatality Rate at high altitudes. OSF Prepr. 2022. doi: 10.31219/osf.io/u5nyz.

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