Vaccination of children against COVID-19: the experience in Latin America

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The Coronavirus Disease 2019 (COVID-19) caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) has spread globally, becoming a long-lasting pandemic [1–3]. As is so often the case for infectious diseases, vulnerable communities are likely to demonstrate the worse effects and this holds true for COVID-19 in Latin America [4].

Early in the pandemic, it was believed that COVID-19 did not significantly affect children. However, since the first confirmed pediatric case of COVID-19 was reported in Shenzhen, China, many cases have been reported and studied in pediatric patients [5]. It is now known that COVID-19 can affect children of all ages [6–9]. Although in many settings children usually have a lower risk of exposure and are tested less frequently than adults, the incidence in some countries in children is similar to that in adults [10].

During the surveillance in several countries, children typically account for up to 16% of laboratory-confirmed cases or even more, depending on the vaccinated groups. For example, in the United States, total childhood cases of COVID-19 reported since the beginning of the pandemic were 12.7 million cases, accounting for 19.0% of all cases [11].

In early reports of the disease in children, most cases resulted from exposure to SARS-CoV-2 within the home from contact with an adult carrier [7, 12, 13]. However, social gatherings with people outside the home and meeting other children at play activities were also associated with the transmission of the virus [14]. In addition, transmission related to health care and school attendance has also been reported [15–18].

COVID-19 infection mainly targets older people with comorbidities; children infected with SARS-CoV-2 have similar symptoms as adults; however, they have a milder course of illness and a better prognosis than adults, requiring less hospital admission [19, 20]. The primary infection characteristics in pediatric patients are fever and cough; diarrhoea, vomiting, nasal congestion, and fatigue may be found in a lesser proportion [21]. Forty-two per cent of the cases could generate an asymptomatic clinical picture, and 3% require hospitalisation [22]. Multisystem Inflammatory Syndrome in Children (MIS-C) is a severe complication of exposure to SARS-CoV-2 viruses, which may require admission to intensive care, mechanical ventilation, and cardiorespiratory support. However, it rarely leads to death [23, 24]. This clinical syndrome is characterised by fever, systemic inflammation, and multisystem involvement, most commonly abdominal and cardiac, apparently driven by an uncontrolled immune response [24, 25].

Immunisation is the most effective public health strategy against the SARS-CoV-2 pandemic [26]. Vaccines protect children and reduce the spread of disease to families and communities; given the lower risk of severe COVID-19 in young children, vaccine safety is paramount, monitored by the Centers for Disease Control and Prevention and other national or regional agencies [27].

Early in the pandemic, there was a compelling need to quickly develop vaccines in less than a year to prevent the
viral spread and save lives [28]. The COVID-19 vaccine is necessary to achieve herd immunity and is essential to mitigate the spread of the pandemic [29].

Currently, there are 9 vaccines with greater than 50% efficacy against symptomatic COVID-19 in adults: with 96% we have NVX-CoV2373 (Novavax, USA), with 95% BNT162b2 (Pfizer/BioNTech, USA & Germany), with 94.1% mRNA-1273 (Moderna, USA), with 92% Sputnik V (Gamaleya, Russia), 63.09% AZD1222 (Oxford/AstraZeneca), 79% BBIBP-CorV (Sinopharm, China), 77.8% Covaxin (Barat Biotech, India), 66.9% Ad26. CoV.S “Janssen” (Johnson & Johnson, USA) and with 50.4% CoronaVac (Sinovac, China) [30, 31].

More than 1698 million doses have been administered in the Americas, completing with a complete immunisation schedule for more than 672 million people. The countries with the highest percentage of complete schemes per-100 inhabitants are the Cayman Islands (94.65%), Puerto Rico (92.09%), Chile (89.93%), Cuba (87.34%) Saba Island (81.27%). The most widely used vaccines in the continent were from Pfizer/BioNTech, Moderna, and Sinovac laboratories [32].

The impact of COVID-19 on the education, health, and well-being of the pediatric population has been significant. Because of this, immunisation coverage against COVID-19 in this population is necessary [33]. Although vaccination in children and adolescents is essential to reduce infection and transmission of the virus from the vaccinated to the susceptible person, in many countries, it is necessary to restore the stability of the educational system, mental and emotional health, and for their parents, due to the severe labour, economic and social problems caused by the closure of schools [33].

Despite the significant advances achieved with the various types of vaccines, only a few vaccines against COVID-19 have completed clinical trials in children (Table 1) and there are a further 28 underway [34]. Thus, the Pfizer/BioNTech vaccine is the first COVID-19 vaccine to be licensed for emergency use in children aged 5 to 17 years in the United States [35].

Some vaccines not yet approved by regulatory agencies such as the U.S. Federal Drugs Administration (FDA) or the WHO are being applied in some Latin American countries; for example, Chile approved the Sinovac COVID-19 vaccine for children over 6 years. El Salvador licensed COVID-19 vaccination for children aged 6 to 11 years. Argentina is vaccinating children as young as three years old with the Sinopharm COVID-19 vaccine. Ecuador’s vaccination includes children as young as six years old with the Sinovac vaccine. Colombia offers COVID-19 vaccines from AstraZeneca, Moderna, Sinopharm, and Johnson & Johnson for children 12 years and older. Finally, Costa Rica is vaccinating from 12 years of age [42].

The distribution of vaccines against COVID-19 in Latin America is unevenly distributed. For example, Argentina has more than 16.6 million doses administered, Chile more than 7.2 million, and Ecuador more than 6.7 million. Most countries have started vaccination at 5 years of age. The most widely used vaccine in the region is the Pfizer/BioNTech vaccine (Fig. 1).

COVID-19 vaccines have proven effective and safe, demonstrating their effectiveness in reducing symptomatic disease, hospitalisations, and deaths; however, there are significant challenges, including approval by regulatory systems, and vaccine availability in all countries. In addition, there is still a lack of data on the efficacy of COVID-19 vaccines administered as a third (booster) dose, with some studies reporting that the booster dose increases the antibody and neutralising response, providing additional protection against SARS-CoV-2 infection for vaccines [43, 44].

It is very likely that, as the vaccination program progresses in the countries of Latin America, the target population will be modified to include the pediatric population which has been ignored in most countries, causing an increase in the incidence of infection in this population. It can be hoped that increased vaccination in the paediatric population will reverse this trend.

| Preliminary efficacy (%) | Phase | Vaccine | Laboratory | Type | Age group (years) | References |
|--------------------------|-------|---------|------------|------|------------------|------------|
| 100.0                    | 3     | BNT162b2 | Pfizer/BioNTech | mRNA | 12–15            | [36]       |
| 90.7                     | 2–3   | BNT162b2 | Pfizer/BioNTech | mRNA | 5–11             | [37]       |
| 100.0                    | 1–2   | BBIBP-CorV | Sinopharm | Inactivated virus | 3–17 | [38]       |
| 98.0                     | 2     | CTII-nCoV | Cansino | Non-replicant Viral Vector | 6–17 | [39]       |
| 96.0                     | 1–2   | CoronaVac | Sinovac | Inactivated virus | 3–17 | [40]       |
| 98.8                     | 2–3   | mRNA-1273 | Moderna | mRNA | 12–17            | [41]       |
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Authors’ contributions
AJR-M, DAL-F, and LR conceived the idea for the manuscript and conducted the search for information. AJR-M, DAL-F, and LR drafted the initial version of the manuscript. DAL-F and LR designed the tables and graphs used in the manuscript. AJR-M, TDM, and HL critically reviewed the manuscript. All authors read and approved the final manuscript.

Declarations
Competing interests
Tim McHugh and Hakan Leblebicioglu are the Editors-in-Chief of Annals of Clinical Microbiology and Antimicrobials. Alfonso J. Rodriguez-Morales is the Deputy Editor-in-Chief of Annals of Clinical Microbiology and Antimicrobials.

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References
1. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395:497. https://doi.org/10.1016/S0140-6736(20)30183-5.
2. Singh S, McNab C, Olsson RM, Bristol N, Nolan C, Bergstrom E, et al. How an outbreak became a pandemic: a chronological analysis of crucial

Fig. 1 COVID-19 vaccines doses administered in children and adolescents in Latin America. Only countries with public data on vaccination in children and adolescents are included. Updated March 8, 2021
junctures and international obligations in the early months of the COVID-19 pandemic. Lancet. 2021. https://doi.org/10.1016/S0140-6736(21)01897-3.

3. Valencia DN. Brief review on COVID-19: the 2020 pandemic caused by SARS-CoV-2. Cureus. 2020. https://doi.org/10.7759/CUREUS.7886.

4. Wang MY, Zhao R, Gao LJ, Gao XF, Wang DP, Gao JM. SARS-CoV-2: structure, biology, and structure-based therapeutics development. Front Cell Infect Microbiol. 2020. https://doi.org/10.3389/FCELL.2020.587269.

5. Chen ZM, Fu JF, Qiu CH, Chen YH, Hua CZ, Li FB, et al. Diagnosis and treatment recommendations for pediatric respiratory infection caused by the 2019 novel coronavirus. World J Pediatr. 2020;26:4–6. https://doi.org/10.1007/s12519-020-00345-5.

6. Wei M, Yuan J, Liu Y, Fu T, Yu X, Zhang ZJ. Novel coronavirus infection in hospitalised infants under 1 year of age in China. JAMA. 2020;323:1313–4. https://doi.org/10.1001/JAMA.2020.2131.

7. Blaak S, Gierke R, Hughes M, McNamara LA, Pilishvili T, Skoff T. Coronavirus disease 2019 in children—United States, February 12–April 2 2020. MMWR. 2020;69:422–6. https://doi.org/10.15585/mmwr.mm6914e4.

8. Zimmermann P, Curtis N. Coronavirus infections in children including COVID-19: an overview of the epidemiology, clinical features, diagnosis, treatment and prevention options in children. Pediatr Infect Dis J. 2020;39:355–68. https://doi.org/10.1097/INF.0000000000002680.

9. de Lisignan S, Dorward J, Jones A, Akinyemi O, Amirthalingam G, et al. Risk factors for SARS-CoV-2 among patients in the Oxford Royal College of general practitioners research and surveillance centre primary care network: a cross-sectional study. Lancet Infect Dis. 2020;20:1034–42. https://doi.org/10.1016/S1473-3099(20)30371-6.

10. Boggs J, Martin LM, Kim SS, Kirmse BM, Haynie L, McGraw S, et al. Incidence rates, household infection risk, and clinical characteristics of SARS-CoV-2 infection among children and adults in Utah and New York City, New York. JAMA Pediatr. 2021. https://doi.org/10.1001/jamapediatrics.2021.4217.

11. American Academy of Pediatrics. Children and COVID-19: state-level data report 2021. https://www.aap.org/en/pages/2019-novel-coronavirus-coVID-19-infections/children-and-covid-19-state-level-data-report/.

12. Loureiro J, Pitollo C, Bonanni M, Ferrari ME, Pusillo A, Nocerino A, et al. SARS-CoV-2 infection in children and newborns: a systematic review. Eur J Pediatr. 2020;179:1025–9. https://doi.org/10.1007/s00431-020-03684-7.

13. Posfay-Barbe KM, Wagner N, Gauthey M, Moussaou D, Loemy N, Diana A, et al. COVID-19 in children and the dynamics of infection in families. Pediatrics. 2020. https://doi.org/10.1542/peds.2020-1576.

14. Hobbis CV, Martin LM, Kim SS, Kirmse BM, Haynie L, McGraw S, et al. Factors associated with positive SARS-CoV-2 test results in outpatient health facilities and emergency departments among children and adolescents aged 2020. MMWR. 2020;69:1925–9. https://doi.org/10.18585/mmwr.mmw6905.e3.

15. Schwierzeck V, König JC, Kühn J, Mellmann A, Coerea-Martinez CL, Omran H, et al. First reported nosocomial outbreak of severe acute respiratory syndrome coronavirus 2 in a pediatric dialysis unit. Clin Infect Dis. 2020;21:265–70. https://doi.org/10.1093/cid/ciaa491.

16. Krass P, Zimbrick-Rogers C, Iheagwara C, Ford CA, Calderoni M. COVID-19 outbreak among adolescents at an inpatient behavioral health hospital. Pediatr Infect Dis J. 2020;39:355–68. https://doi.org/10.1097/INF.0000000000002680.

17. Hobbs CV, Martin LM, Kim SS, Kirmse BM, Haynie L, McGraw S, et al. COVID-19 in children and the dynamics of infection in families. Pediatrics. 2020. https://doi.org/10.1542/peds.2020-1576.

18. Hobbis CV, Martin LM, Kim SS, Kirmse BM, Haynie L, McGraw S, et al. Factors associated with positive SARS-CoV-2 test results in outpatient health facilities and emergency departments among children and adolescents aged. MMWR. 2020;69:1925–9. https://doi.org/10.18585/mmwr.mmw6905.e3.

19. Schwierzeck V, König JC, Kühn J, Mellmann A, Coerea-Martinez CL, Omran H, et al. First reported nosocomial outbreak of severe acute respiratory syndrome coronavirus 2 in a pediatric dialysis unit. Clin Infect Dis. 2021;72:265–70. https://doi.org/10.1093/CID/CIAA491.

20. Macartney K, Quinn HE, Pilibury AJ, Kiora A, Deng L, Winkler N, et al. Transmission of SARS-CoV-2 in Australian educational settings: a prospective cohort study. Lancet Child Adolesc Health. 2020;4:807–10. https://doi.org/10.1016/S2532-4462(20)30251-0.

21. Ludvigsson JF. Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. Acta Paediatr. 2020;109:1088–95. https://doi.org/10.1111/APP.15270.

22. Lee PI, Hu YL, Chen PY, Huang YC, Hsieh PR. Are children less susceptible to COVID-19? Microb Immunol Infect. 2020;53:371. https://doi.org/10.1016/j.mji.2020.02.011.
participants aged ≥6 years: a randomised, double-blind, placebo-controlled, phase 2b trial. Clin Infect Dis. 2021. https://doi.org/10.1093/CID/CIAA845.

40. Han B, Song Y, Li C, Yang W, Ma Q, Jiang Z, et al. Safety, tolerability, and immunogenicity of an inactivated SARS-CoV-2 vaccine (CoronaVac) in healthy children and adolescents: a double-blind, randomised, controlled, phase 1/2 clinical trial. Lancet Infect Dis. 2021. https://doi.org/10.1016/S1473-3099(21)00319-4.

41. Ali K, Berman G, Zhou H, Deng W, Faughnan V, Coronado-Voges M, et al. Evaluation of mRNA-1273 SARS-CoV-2 vaccine in adolescents. N Engl J Med. 2021. https://doi.org/10.1056/NEJMoa21109522.

42. REUTERS. Factbox: countries vaccinating children against COVID-19 | Reuters 2021. https://www.reuters.com/business/healthcare-pharma/healthcare-pharma/countries-vaccinating-children-against-covid-19-2021-06-29/. Accessed 8 Mar 2022.

43. Saciuik Y, Kertes J, Shamir Stein N, Ekka ZA. Effectiveness of a third dose of BNT162b2 mRNA vaccine. J Infect Dis. 2022;225:30–3. https://doi.org/10.1093/INFDIS/JIAB556.

44. Munro APS, Janani L, Cornelius V, Aley PK, Babbage G, Baxter D, et al. Safety and immunogenicity of seven COVID-19 vaccines as a third dose (booster) following two doses of ChAdOx1 nCoV-19 or BNT162b2 in the UK (COV-BOOST): a blinded, multicentre, randomised, controlled, phase 2 trial. Lancet. 2021;398:2258–76. https://doi.org/10.1016/S0140-6736(21)02717-3.

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