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Inflammatory diseases
IFN- γ , TNF- α , IL-6, IL-17, IL-10, TGF- β

Filariae and their products

Leishmaniasis
Mono, Th1, NEUT, M Φ , NO, IFN- γ , TNF- α , IL-12, IL-17

Cerebral Malaria
IFN- γ , TNF- α , MONO, CTL, M Φ

Immune Evasion Strategy of Human Lymphatic Filariae: A Double-Edged Sword

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Department of Infectious Diseases, College of Veterinary Medicine, University of Georgia Athens, GA 30602-7387, USA

Interests: RNA viruses; respiratory viruses; epithelial cells; siRNA; CRISPR-Cas; host genes; innate immunity; adaptive immunity; anti-viral immunity

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[Website \(https://www.conted.ox.ac.uk/tutors/5696\)](https://www.conted.ox.ac.uk/tutors/5696) [SciProfiles \(https://sciprofiles.com/profile/712849\)](https://sciprofiles.com/profile/712849)

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2. Department for BioMedical Research, University of Bern, 3012 Bern, Switzerland

3. Nuffield Department of Medicine, The Jenner Institute, The Henry Wellcome Building for Molecular Physiology, University of Oxford, Oxford OX1 2JD, UK

Interests: therapeutic vaccines; non-communicable diseases; cancer; virus-like particles; antibody therapies; immunology; memory

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[Website \(https://smhs.gwu.edu/bukrinsky-lab/research\)](https://smhs.gwu.edu/bukrinsky-lab/research) [SciProfiles \(https://sciprofiles.com/profile/50561\)](https://sciprofiles.com/profile/50561)

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School of Medicine and Health Sciences, George Washington University, Washington, DC 20052, USA

Interests: HIV accessory genes; HIV-related lipid dysregulation; HIV-related mechanisms of inflammation; HIV-infected cells; anti-HIV compounds; HIV-1 translocation

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[Website \(https://publichealth.nyu.edu/index.php/faculty/ralph-diclemente\)](https://publichealth.nyu.edu/index.php/faculty/ralph-diclemente)

[SciProfiles \(https://sciprofiles.com/profile/959164\)](https://sciprofiles.com/profile/959164)

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School of Global Public Health, New York University, New York, NY 10012, USA

Interests: infectious disease; development of HIV and STD prevention programs; immunology; community interventions; diabetes; implementation science; influenza; psychology

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Interests: psoriasis; psoriatic arthritis; atopic dermatitis; immunopharmacology; skin biology; skin immune system; skin and internal

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Website1 (<https://www.researchgate.net/profile/Eduardo-Gomez-Casado>) **Website2** (<http://www.inia.es>)
SciProfiles (<https://sciprofiles.com/profile/915490>)

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Department of Biotechnology, INIA-CSIC, 28040 Madrid, Spain

Interests: viral immunology; innate immunity; adaptive immunity; adjuvants; vaccines; immune pathways; fish immunology; rhabdovirus; virus-host interaction; RNA virus; DNA virus

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Website (<https://primeinc.org/faculty-biography/prof-hans-peter-hartung-md-phd-frcp-1296>)
SciProfiles (<https://sciprofiles.com/profile/1764049>)

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Department of Neurology, Heinrich-Heine-University Düsseldorf, Germany and Brain and Mind Center, University of Sydney, Sydney, Australia

Interests: interferon; virus; immunology multiple sclerosis neuroimmunology

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Website1 (<http://amine-kamen.lab.mcgill.ca>) **Website2** (<https://www.mcgill.ca/bioengineering/people/faculty/amine-kamen>) **SciProfiles** (<https://sciprofiles.com/profile/904592>)

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Department of Bioengineering, McGill University, Montreal, QC H2X 1Y4, Canada

Interests: cell culture engineering; bioprocess optimization and scale-up; process analytical technologies and process control; viral vaccines manufacturing; viral vectors and nanoparticles for gene delivery and vaccination

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SciProfiles (<https://sciprofiles.com/profile/656887>)

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Interests: malaria; vaccines; immunology; genomics; helminthes and co-infection; malaria transmission; malaria drugs and diagnostics

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Website (<https://dspmi.uniroma1.it/node/6625>) **SciProfiles** (<https://sciprofiles.com/profile/57307>)

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Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal

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Website (<https://www.virology.umn.edu/bio/virology/hinh-ly>) **SciProfiles** (<https://sciprofiles.com/profile/112434>)

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Interests: hemorrhagic fever viruses; arenaviruses; Lassa fever; host-virus interactions; innate immunity; viral pathogenesis and host defense

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Website (<https://orcid.org/0000-0001-7084-0804>) **SciProfiles** (<https://sciprofiles.com/profile/1340>)

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2. Texas Biomedical Research Institute, San Antonio, TX 78245, USA

Interests: virology; vaccines; antivirals; influenza viruses; arenaviruses; Zika virus; coronavirus; SARS-CoV-2; COVID-19; innate immunity; adaptive immunity; interferon; virus-host interactions

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Website (<https://www6.angers-nantes.inra.fr/bioepar/Infos-pratiques/Annuaire/Fiches-des-membres-de-l-Unite/Meurens-Francois>) **SciProfiles** (<https://sciprofiles.com/profile/986648>)

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UMR 1300 INRAE/Oniris - Biology, Epidemiology and Risk Analysis in Animal Health (BIOEPAR), Nantes Atlantic National College of Veterinary Medicine - Oniris, 44200 Nantes, France

Interests: virology; veterinary microbiology; innate immune response; animal model; pig; vaccines; mucosal immunology; respiratory and intestinal infectious diseases

* Associate Editor

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Dr. Romain Paillot

Website (<https://www.ahtr.co.uk/sciprofiles/profile.cfm?stID=2830&refooter=1>)

SciProfiles (<https://sciprofiles.com/profile/76508>)

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Interests: equine infectious diseases; immunology; vaccination; equine influenza

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Website (<http://subreelab.umn.edu/people/subree-subramanian>). **SciProfiles** (<https://sciprofiles.com/profile/37647>).

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Department of Surgery, University of Minnesota, Minneapolis, MN, USA

Interests: colorectal cancer; tumor immunology; T cells; immune cells; microbiome

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Website (<https://medicine.nus.edu.sg/mbio/about-us/our-people/academic-staff/tan-yee-joo.html>).

SciProfiles (<https://sciprofiles.com/profile/11131>).

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Infectious Diseases Translational Research Programme and Department of Microbiology and Immunology, Yong Loo Lin School of Medicine, National University Health System, National University of Singapore, Singapore, Singapore

Interests: Characterization of newly emerged viruses and hepatitis viruses; Development of antibodies for diagnostic and therapeutic applications; Protein engineering

Prof. Dr. Artur Summerfield

Website (http://www.ivi.unibe.ch/ueber_uns/personen/prof_dr_summerfield_artur/index_ger.html)

SciProfiles (<https://sciprofiles.com/profile/789707>).

Section Associate Editor

Veterinary Immunology, Institute of Virology and Immunology, University of Bern Hochschulstrasse, 6, 3012 Bern, Switzerland

Interests: porcine and bovine mononuclear phagocytes; dendritic cells; viral pathogenesis; vaccines; virology

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Website (<https://vet.osu.edu/about-us/people/david-benfield>). **SciProfiles** (<https://sciprofiles.com/profile/829875>).

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Department of Animal Sciences, The Ohio State University, Wooster Campus, 1680 Madison Avenue, Wooster, OH 44691, USA

Interests: virology, immunology and pathogenesis of diseases in large and companion animals; emerging viruses; RNA viruses; diagnostic virology

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Website

(<https://www.uniroma3.it/en/persona/cHlrdGIURjQzbFA4NGFaZGdFZEVDaE40RUtHVnJwa0dwTGpRMnR5cIFGQT0=/ricerca/>)

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Laboratory of Molecular Virology and Antimicrobial Immunity, Roma Tre University, 00154 Rome, Italy

Interests: Interferons; retrovirus and HIV; virus-host interactions; viral immunoevasion; antiviral innate immunity

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Website (<http://www.mchanherson.org/depts/molecul/biology/bbaggawal.html>)

SciProfiles (<https://sciprofiles.com/profile/1032737>).

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Inflammation Research Center, San Diego, CA 92126, USA

Interests: cytokines; inflammation; nutraceuticals; chronic diseases; cancer medicine and immunology

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Website (<https://www.shebaonline.org/doctor/nancy-agmon-levin/>)

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Clinical Immunology, Angioedema and Allergy Unit, Center for Autoimmune Diseases, Sheba Medical Center, Tel-Hashomer 52621, Israel

Interests: immunology; lupus; allergy; angioedema; autoimmune diseases; food allergy; drugs allergy; respiratory allergy; immunotherapy; immune deficiency; antiphospholipid syndrome; atopic disorders

Dr. Randy A. Albrecht

★ (<https://recognition.webofscience.com/awards/highly-cited/2020/>) **Website1** (<https://profiles.mountsinai.org/randy-albrecht#about>) **Website2** (<https://www.linkedin.com/in/randy-albrecht-4a4953102/>)

SciProfiles (<https://sciprofiles.com/profile/430730>)

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Department of Microbiology, Global Health and Emerging Pathogens Institute, Icahn School of Medicine at Mount Sinai, New York, NY, USA

Interests: vaccines; mucosal immunity; respiratory viruses; pathogenesis; animal models; biocontainment

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Website1 (<http://agripa.org/profile/alonso>) **Website2** (<http://labviruscelula.agripa.org>)

SciProfiles (<https://sciprofiles.com/profile/106421>)

Editorial Board Member

Department of Biotechnology, Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA), 28040 Madrid, Spain

Interests: virus/host interactions and pathogenesis; anti-viral immune responses; innate immunity; targets for vaccines and antivirals design; nanoparticles; animal viruses; African swine fever virus

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Website (<https://www.hivresearch.org/our-scientists/carl-alling-md>)

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Laboratory of Adjuvant & Antigen Research, US Military HIV Research Program, Walter Reed Army Institute of Research, Silver Spring, MD 20910, USA

Interests: vaccines to HIV-1 infection, malaria, and addiction to drugs of abuse; Adjuvant

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Website (<https://www.univ-reims.fr/cardiovir>) **SciProfiles** (<https://sciprofiles.com/profile/1186418>)

Editorial Board Member

Department of Infections Cardiovasculaires virales et Inflammation en Pathologie Humaine (CARDIOVIR), Université de Reims Champagne-Ardenne, Reims, France

Interests: enterovirus; positive single-strand RNA; persistence; molecular mechanisms; virus-cell interaction; inflammation; immunity; escape to immune system

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Website1 (<https://www.vu.edu.au/research/vasso-apostolopoulos>) **Website2** (<https://www.linkedin.com/in/vasso-apostolopoulos-b85a91176/>) **Website3** (<https://www.facebook.com/professorvassoapostolopoulos>)

SciProfiles (<https://sciprofiles.com/profile/139297>)

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Institute for Health and Sport, Victoria University, Wellington, VIC 3101, Australia

Interests: cancer; autoimmunity; mental health; vaccines; exercise; infectious diseases; drugs; healthy aging; bioactives

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Website (<https://currents.plos.org/outbreaks/author/araisnih-go-jp/index.html>)

SciProfiles (<https://sciprofiles.com/profile/73122>)

Editorial Board Member

Infectious Disease Surveillance Center, National Institute of Infectious Diseases, Tokyo 162-8640, Japan

Interests: Japanese encephalitis vaccine; arbovirus infection; virus evolution; seroepidemiological survey; host-virus cophylogeny; and zoonotic diseases



Prof. Dr. Brigitte Autran

Website (https://www.ameli.fr/sites/default/files/references_du_professeur_brigitte_autran.pdf)

Editorial Board Member

Centre International de Recherche en Infectiologie, CIRI, Lyon, France

Interests: HIV; antiviral vaccines; vaccine immunity; vaccines against HIV and emerging viruses; immunity and immunotherapeutic approaches

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Website (<https://med.umn.edu/bio/lab-med-and-pathology-faculty/henry-balfour>)

SciProfiles (<https://sciprofiles.com/profile/2227684>)

Editorial Board Member

Department of Laboratory Medicine and Pathology, Department of Pediatrics, University of Minnesota Medical School, Minneapolis, MN 55455, USA

Interests: Epstein-Barr Virus (EBV); infectious mononucleosis; epidemiology of EBV infections; antiviral drugs; cytomegalovirus infections

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Go to page [1](#) [2](#) [3](#) [4](#) [5](#) [6](#) [7](#) [8](#) [9](#) [10](#) [11](#) [12](#) [13](#) [14](#)

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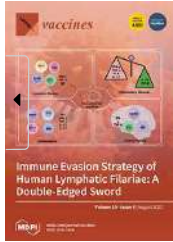
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[Abilash Valsala Gopalakrishnan \(https://sciprofiles.com/profile/2456209\)](#)

Vaccines 2022, 10(8), 1370; <https://doi.org/10.3390/vaccines10081370> (<https://doi.org/10.3390/vaccines10081370>) - 22 Aug 2022


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Abstract In recent history, immunotherapy has become a viable cancer therapeutic option. However, over many years, its tenets have changed, and it now comprises a range of cancer-focused immunotherapies. Clinical trials are currently looking into monotherapies or combinations of medicines that include immune checkpoint [...] [Read more](#).





(This article belongs to the Special Issue [Cancer Immunology Focus: Cellular & Molecular Immunology \(/journal/vaccines/special_issues/Cancer_Immunology_Focus\)](#).)

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SARS-CoV-2 Vaccine Uptake during Pregnancy in Regione Lombardia, Italy: A Population-Based Study of 122,942 Pregnant Women ((2076-393X/10/8/1369))by  Irene Cetin (<https://sciprofiles.com/profile/1476052>), Maria Mandalari (<https://sciprofiles.com/profile/author/NmR4MHdTTVBuZ0h0NIRVTy9JmKFIK3Y2Y0JTRytEZFBXOHpRK3NJb1IkMD0=>), Elena Cesari (<https://sciprofiles.com/profile/author/MkpzNEE5STFtMGpnMFZQZmFDL3BuT2VGKzZIZG9HVVFwQ3FKUKJYTnV4OD0=>), Catia Rosanna Borriello (<https://sciprofiles.com/profile/author/TjFDVVRNb0o5TittWmdMd0JIU0hka2RWVyt1N0ZuUnJmSnFaTVVWVE5FYm41NTFYazE3NDJQalo>) Michele Ercolanoni (<https://sciprofiles.com/profile/1687759>) and Giuseppe Preziosi (<https://sciprofiles.com/profile/author/V0IkN0VZaU56Z3p1MGZ4bDRYSHNDMWd1NE1vanVXdkZuZJScDdadC9UYz0=>)*Vaccines* 2022, 10(8), 1369; <https://doi.org/10.3390/vaccines10081369> (<https://doi.org/10.3390/vaccines10081369>) - 22 Aug 2022

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Abstract Italy has been one of the hardest hit countries in the European Union since the beginning of the SARS-CoV-2 pandemic, and Regione Lombardia (RL) has reported the largest number of cases in the country. This population-based retrospective study analyzed RL records of 122,942 [...] [Read more](#).(This article belongs to the Special Issue **COVID-19 Vaccination: Considerations for Public Health and Policy** ([/journal/vaccines/special_issues/covid_19_vaccination](#).)[/journal/vaccines/special_issues/covid_19_vaccination](#).)**Show Figures**[\(vaccines/vaccines-10-01369/article_deploy/html/images/vaccines-10-01369-g001-550.jpg\)](#) [\(vaccines/vaccines-10-01369/article_deploy/html/images/vaccines-10-01369-g002-550.jpg\)](#) [\(vaccines/vaccines-10-01369/article_deploy/html/images/vaccines-10-01369-g003-550.jpg\)](#)**Streptococcus pneumoniae Causing Invasive Diseases in Children and Adults in Central Thailand, 2012–2016** ((2076-393X/10/8/1368))by  Wanatpreeya Phongsamart (<https://sciprofiles.com/profile/author/UDh5SW5IM0NQU2lrQUUxV28zZHZA4UFidGVhcDVWeGtsS2p2TDdPTk40WT0=>), Somporn Srifeungfung (<https://sciprofiles.com/profile/author/ck9BU2tadDkwVONFV1orTHQ4M0JZbE4yRUFUTzVHU3N6ZUI6R1JhVzBnYz0=>), Tanittha Chatsuwan (<https://sciprofiles.com/profile/1937900>), Pimpha Rungnophakhun (<https://sciprofiles.com/profile/author/MEY1aTdUSkpPbUuWQVikSzRrZXdWSzICsmtvcEdXkYUxclduVm10T0xwYz0=>), Alan Maleesatharn (<https://sciprofiles.com/profile/2372644>) and  Kulkanya Chokephaibulkit (<https://sciprofiles.com/profile/1971025>),*Vaccines* 2022, 10(8), 1368; <https://doi.org/10.3390/vaccines10081368> (<https://doi.org/10.3390/vaccines10081368>) - 21 Aug 2022**Cited by** 1 ((2076-393X/10/8/1368#citedby)) | Viewed by 668**Abstract** Longitudinal data regarding the serotype distribution and antimicrobial susceptibility of *S. pneumoniae*-causing invasive pneumococcal disease (IPD) in developing countries are limited. Our aim was to monitor the antimicrobial susceptibility, serotype distribution, and serotype coverage rates of the pneumococcal conjugate vaccines (PCVs) and [...] [Read more](#).(This article belongs to the Section **Vaccines against Infectious Diseases** ([/journal/vaccines/sections/infectious_diseases](#)))**Show Figures**[\(vaccines/vaccines-10-01368/article_deploy/html/images/vaccines-10-01368-g001-550.jpg\)](#) [\(vaccines/vaccines-10-01368/article_deploy/html/images/vaccines-10-01368-g002-550.jpg\)](#) [\(vaccines/vaccines-10-01368/article_deploy/html/images/vaccines-10-01368-g003-550.jpg\)](#) [\(vaccines/vaccines-10-01368/article_deploy/html/images/vaccines-10-01368-g004-550.jpg\)](#)**Current Vaccine Platforms in Enhancing T-Cell Response** ((2076-393X/10/8/1367))by  Takehiro Ura (<https://sciprofiles.com/profile/author/cHpCRXJPOWZ1Qm10ZHB2azZaWEFCQIMrT2NMTIIGZFBaRHJOZEZVbGNPdz0=>), Masaki Takeuchi (<https://sciprofiles.com/profile/author/WjBOcTNKb09CRHJrbmlwaldZMFAvSi93OHNTjRjBJcnykVwKdVdmRIFDUT0=>), Tatsukata Kawagoe (<https://sciprofiles.com/profile/author/SmJwSmtoaUNObHdKa3dXM0ZQWQ1Z5aURSK2NKSjQvOG5kQkHajZwSDRHQT0=>), Nobuhisa Mizuki (<https://sciprofiles.com/profile/907319>), Kenji Okuda (<https://sciprofiles.com/profile/author/MTNMCTRaN2NOWW1WcnhwU3VLdWhyQkVyOXBFBh0NEt5ZS9qRmHLZnE0cz0=>) and Masaru Shimada (<https://sciprofiles.com/profile/75414>)*Vaccines* 2022, 10(8), 1367; <https://doi.org/10.3390/vaccines10081367> (<https://doi.org/10.3390/vaccines10081367>) - 21 Aug 2022

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Abstract The induction of T cell-mediated immunity is crucial in vaccine development. The most effective vaccine is likely to employ both cellular and humoral immune responses. The efficacy of a vaccine depends on T cells activated by antigen-presenting cells. T cells also play a [...] [Read more](#).(This article belongs to the Special Issue **B and T Cell-Mediated Immunity 2.0** ([/journal/vaccines/special_issues/B_T_Cell_Mediated_Immunity](#).)**Show Figures**[\(vaccines/vaccines-10-01367/article_deploy/html/images/vaccines-10-01367-g001-550.jpg\)](#)**Association of Reactogenicity with Immunogenicity of the ChAdOx1 nCoV-19 Vaccine in Patients Undergoing Hemodialysis** ((2076-393X/10/8/1366))by  Ting-Yun Lin (<https://sciprofiles.com/profile/author/b0JGNzJNcINLdWhiWGdq0tITDIweE5leWt4SFJIUKJwRWRtM0taelpzaz0=>), Nai-Kuan Hung (<https://sciprofiles.com/profile/author/ZmlZGR6Q3hqjdVsZndHRzVNQVlxamI5b3IxdjZkMGFTVE8waEQyTEdtaz0=>) and Szu-Chun Hung (<https://sciprofiles.com/profile/208427>).*Vaccines* 2022, 10(8), 1366; <https://doi.org/10.3390/vaccines10081366> (<https://doi.org/10.3390/vaccines10081366>) - 21 Aug 2022**Cited by** 3 ((2076-393X/10/8/1366#citedby)) | Viewed by 643**Abstract** The aim of our study was to determine whether local and systemic reactions following SARS-CoV-2 vaccination are predictive of immunogenicity in patients undergoing hemodialysis. We used an established questionnaire to survey 206 hemodialysis patients without prior SARS-CoV-2 infection regarding solicited local (pain, redness, [...]) [Read more](#).(This article belongs to the Special Issue **Antibody Response of Vaccines to SARS-CoV-2** ([/journal/vaccines/special_issues/vaccines_antibody](#)))

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Anti-SARS-CoV-2 Spike Antibody Titers and Neutralizing Antibodies in Vaccinated Rheumatoid Arthritis Patients (/2076-393X/10/8/1365)

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Shomi Oka (<https://sciprofiles.com/profile/author/ZHBjVFTS3NnRiZ3aWdxVE5QOVdyaUxaZFFHVmowd3J0OWpETGNrUCt5ND0=>),

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Nobuhiro Nagai (<https://sciprofiles.com/profile/author/K21rT3VDM010Qk94VDArSkhkU08rSUIyZWxvVFNaZGlgVhPZMGkyT2pKc1g3Qk11ZkRZcHRZUG52M0g0Z1>) and

Shigeto Tohma (<https://sciprofiles.com/profile/author/Rmt1aDhraGVZbWdrM3B3TGZSeWdPQIZxQllwdFI5ejVCSCtBS3RHR1R6Q1VjZzJsOCs2VGNebIREZzdJcW>)
Vaccines 2022, 10(8), 1365; <https://doi.org/10.3390/vaccines10081365> (<https://doi.org/10.3390/vaccines10081365>) - 21 Aug 2022

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Abstract Coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). A serological test is used to assess the efficacy of vaccination. It has been reported that anti-SARS-CoV-2 spike (S) and neutralizing antibody (Ab) levels are lower following vaccination in [...]. [Read more.](#)

(This article belongs to the Special Issue **Assessment of Post-COVID-19 Complications and Vaccination Efficacy** (/journal/vaccines/special_issues/epidemic_Vaccines))

Rapid Implementation of a Community–Academic Partnership Model to Promote COVID-19 Vaccine Equity within Racially and Ethnically Minoritized Communities (/2076-393X/10/8/1364)

by Jacinda C. Abdul-Mutakabbir (<https://sciprofiles.com/profile/1279683>),

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Vaccines 2022, 10(8), 1364; <https://doi.org/10.3390/vaccines10081364> (<https://doi.org/10.3390/vaccines10081364>) - 20 Aug 2022

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Abstract Coronavirus disease 2019 (COVID-19) has highlighted inequities in mortalities and associated illnesses among non-Hispanic Black and Hispanic/Latino individuals. Immunization against COVID-19 is critical to ending the pandemic, especially within racial and ethnically minoritized communities. However, vaccine hesitancy and institutional mistrust in these communities, [...]. [Read more.](#)

(This article belongs to the Special Issue **COVID-19 Vaccine Hesitancy: Correlates and Interventions** (/journal/vaccines/special_issues/COVID_Vaccine_Hesitancy))

Pre-Existing Comorbidities Diminish the Likelihood of Seropositivity after SARS-CoV-2 Vaccination (/2076-393X/10/8/1363)

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Aruni Bhatnagar (<https://sciprofiles.com/profile/author/OTJuWHIUaWxKVjZKVDyQW9nc1JmQkZmbVJHaDFYRysrM3lMa05tUGhCz0=>),

Vaccines 2022, 10(8), 1363; <https://doi.org/10.3390/vaccines10081363> (<https://doi.org/10.3390/vaccines10081363>) - 20 Aug 2022

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Abstract Background: The impact of chronic health conditions (CHCs) on serostatus post-severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) vaccination is unknown. Methods: We assessed serostatus post-SARS-CoV-2 vaccination among fully vaccinated adult residents of Jefferson County, Kentucky, USA, from April 2021 to August 2021. Serostatus [...]. [Read more.](#)

(This article belongs to the Special Issue **Research in Vaccine Epidemiology: Immunogenicity, Effectiveness, and Safety** (/journal/vaccines/special_issues/Vaccine_Epidemiology))

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COVID-19 Vaccine Effectiveness against Omicron Variant among Underage Subjects: The Veneto Region’s Experience (/2076-393X/10/8/1362)

by Silvia Cocchio (<https://sciprofiles.com/profile/1139652>), Federico Zabeo (<https://sciprofiles.com/profile/1857460>),

Giulia Tremolada (<https://sciprofiles.com/profile/author/Qm41UVZrR115dkNPQUFsR0ZPM0VZQXpXc2IRrnJrZ3hNRzZNam80REVmclczdkFRK2NDZTgyVThMds9>),

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Vaccines 2022, 10(8), 1358; <https://doi.org/10.3390/vaccines10081358> (<https://doi.org/10.3390/vaccines10081358>) - 19 Aug 2022



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Abstract Duck enteritis virus and *Pasteurella multocida* are major duck pathogens that induce duck plague and fowl cholera, respectively, in ducks and other waterfowl populations, leading to high levels of morbidity and mortality. Immunization with live attenuated DEV vaccine containing *P. multocida* outer membrane [...] [Read more](#). (This article belongs to the Special Issue [Immunology and Vaccines against Avian Infectious Diseases](#) ([/journal/vaccines/special_issues/Avian_Infectious](#)))

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Young Age, Female Sex, and No Comorbidities Are Risk Factors for Adverse Reactions after the Third Dose of BNT162b2 COVID-19 Vaccine against SARS-CoV-2: A Prospective Cohort Study in Japan ([/2076-393X/10/8/1357](#))

by Ryuta Urakawa (<https://sciprofiles.com/profile/2359649>), Emiko Tanaka Isomura (<https://sciprofiles.com/profile/2394995>),
Kazuhide Matsunaga (<https://sciprofiles.com/profile/2395557>) and
Kazumi Kubota (<https://sciprofiles.com/profile/author/cmd5RmNiajVMU0REdIq4bkJuSIBPNghvYVW5WkFoaXBITDg3bUIUL1R2QT0=>)
Vaccines 2022, 10(8), 1357; <https://doi.org/10.3390/vaccines10081357> (<https://doi.org/10.3390/vaccines10081357>) - 19 Aug 2022

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Abstract Background: This study compared the adverse events (AEs) of the second and third doses of BNT162b2, as well as investigated the impact of vaccine recipients' background and vaccination interval on the AEs of the third dose. Methods: We conducted a questionnaire survey of [...] [Read more](#). (This article belongs to the Special Issue [The Current Situation and Future Perspective of Vaccines against Infectious Diseases in Children and Women](#) ([/journal/vaccines/special_issues/K3S9034E1T](#)))

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Global Prevalence and Potential Influencing Factors of COVID-19 Vaccination Hesitancy: A Meta-Analysis ([/2076-393X/10/8/1356](#))

by Jonny Karunia Fajar (<https://sciprofiles.com/profile/1442020>), Malik Sallam (<https://sciprofiles.com/profile/663766>),
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Vaccines 2022, 10(8), 1356; <https://doi.org/10.3390/vaccines10081356> (<https://doi.org/10.3390/vaccines10081356>) - 19 Aug 2022

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Abstract Countries worldwide have deployed mass COVID-19 vaccination drives, but there are people who are hesitant to receive the vaccine. Studies assessing the factors associated with COVID-19 vaccination hesitancy are inconclusive. This study aimed to assess the global prevalence of COVID-19 vaccination hesitancy and [...] [Read more](#). (This article belongs to the Section [Vaccines and Society](#) ([/journal/vaccines/sections/Vaccines_Society](#)))

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The Role of Psychological Factors and Vaccine Conspiracy Beliefs in Influenza Vaccine Hesitancy and Uptake among Jordanian Healthcare Workers during the COVID-19 Pandemic ([/2076-393X/10/8/1355](#))

Malik Sallam (<https://sciprofiles.com/profile/663766>), Ramy Mohamed Ghazy (<https://sciprofiles.com/profile/2008636>),
Wahed AbSalhat (<https://sciprofiles.com/profile/author/RGspyaQmwaNEFLa2pXQJrTU94dnIQOTIIdXl3MVVKMEUZn2EXNXo4SIU1VT0=>),
Rahmoud AlMahzoum (<https://sciprofiles.com/profile/author/NldIdHFEUnQ5ZFRDa2JDeWtSeHpSRmVtVVRQaENTczdKbjFxFRfo0emtjOD0=>),
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Vaccines 2022, 10(8), 1273; <https://doi.org/10.3390/vaccines10081273> (<https://doi.org/10.3390/vaccines10081273>) - 07 Aug 2022

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Abstract The term hybrid immunity is used to denote the immunological status of vaccinated individuals with a history of natural infection. Reports of new SARS-CoV-2 variants of concern motivate continuous rethought and renewal of COVID-19 vaccination programs. We used a naturalistic case-control study design [...]. [Read more.](#)
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Immunotherapeutic Strategies for Head and Neck Squamous Cell Carcinoma (HNSCC): Current Perspectives and Future Prospects ([/2076-393X/10/8/1272](https://2076-393X/10/8/1272))

by [Lei Gao](https://sciprofiles.com/profile/2374281) (<https://sciprofiles.com/profile/2374281>), [Anqi Zhang](https://sciprofiles.com/profile/2374464) (<https://sciprofiles.com/profile/2374464>),
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Vaccines 2022, 10(8), 1272; <https://doi.org/10.3390/vaccines10081272> (<https://doi.org/10.3390/vaccines10081272>) - 07 Aug 2022

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Abstract Neoantigens are abnormal proteins produced by genetic mutations in somatic cells. Because tumour neoantigens are expressed only in tumour cells and have immunogenicity, they may represent specific targets for precision immunotherapy. With the reduction in sequencing cost, continuous advances in artificial intelligence technology [...]. [Read more.](#)

(This article belongs to the Special Issue **Tumor-Associated Antigens in Therapeutic Development** ([/journal/vaccines/special_issues/tumor_antigen](https://journal/vaccines/special_issues/tumor_antigen)))

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Are Fear of COVID-19 and Vaccine Hesitancy Associated with COVID-19 Vaccine Uptake? A Population-Based Online Survey in Nigeria ([/2076-393X/10/8/1271](https://2076-393X/10/8/1271))

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Vaccines 2022, 10(8), 1271; <https://doi.org/10.3390/vaccines10081271> (<https://doi.org/10.3390/vaccines10081271>) - 07 Aug 2022

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Abstract This study examined the association between COVID-19 and fear of contracting COVID-19 and reasons for vaccination refusal. A population-based online survey was conducted via social media in Nigeria using the Fear of COVID-19 scale and items related to vaccination refusal/hesitancy items. Individuals aged [...]. [Read more.](#)

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Attitudes toward Receiving COVID-19 Booster Dose in the Middle East and North Africa (MENA) Region: A Cross-Sectional Study of 3041 Fully Vaccinated Participants ([/2076-393X/10/8/1270](https://2076-393X/10/8/1270))

by [Mohamed Abouzid](https://sciprofiles.com/profile/1396126) (<https://sciprofiles.com/profile/1396126>), [Alhassan Ali Ahmed](https://sciprofiles.com/profile/1867907) (<https://sciprofiles.com/profile/1867907>),
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COVID-19 Vaccination Status among Pregnant and Postpartum Women—A Cross-Sectional Study on More Than 1000 Individuals (/2076-393X/10/8/1179)

by [Urszula Nowacka](#) (<https://sciprofiles.com/profile/1464559>), [Paulina Malarkiewicz](#) (<https://sciprofiles.com/profile/2016798>), [Janusz Sierdzinski](#) (<https://sciprofiles.com/profile/443490>), [Aleksandra Januszaniec](#) (<https://sciprofiles.com/profile/author/K1V1VnhicDg2M0NIMm93emFRVXdMM3N6OU1iZU51V2VHc0dQQUFEVTRVShYOVFOL0FIK0Rz>)

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Vaccines 2022, 10(8), 1179; <https://doi.org/10.3390/vaccines10081179> (<https://doi.org/10.3390/vaccines10081179>), - 25 Jul 2022

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Abstract Pregnancy is a well-known factor for vaccine hesitancy and immunization remains the most effective form of prevention against coronavirus disease (COVID-19) related complications. The objective was to estimate vaccine uptake and hesitancy rate, characteristics, and factors contributing to a decision-making process among pregnant [...]. [Read more.](#)

(This article belongs to the Special Issue [SARS-CoV-2 \(COVID-19\) Vaccination and Compliance/Hesitancy](#). (/journal/vaccines/special_issues/covid_stress/))

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DNA-Vaccine-Induced Immune Response Correlates with Lower Viral SARS-CoV-2 Titers in a Ferret Model (/2076-393X/10/8/1178)

by [Mirco Compagnone](#) (<https://sciprofiles.com/profile/2488428>), [Eleonora Pinto](#) (<https://sciprofiles.com/profile/2310414>), [Erika Salvatori](#) (<https://sciprofiles.com/profile/2334389>), [Lucia Lione](#) (<https://sciprofiles.com/profile/2310413>), [Antonella Conforti](#) (<https://sciprofiles.com/profile/author/TEs1ZVFCOXBPCForQUtmSmYvMjUjUN0Ti9KT3VxN3h6aUZReENueHRiZ0>), [Silvia Marchese](#) (<https://sciprofiles.com/profile/2343292>), [Micol Ravà](#) (<https://sciprofiles.com/profile/author/VGs5eTZL3d4SnBBNjVvRkJCbTVRNjdYeVpUvh0cVFCZJF2SIZJMKISOD0>), [Kathryn Ryan](#) (<https://sciprofiles.com/profile/author/b3V2ZTlnb0ZmeWNkbDl1MUxReXNkbZobmtzZnI5czAzNmprMDJ5R3dvYz0>), [Yper Hall](#) (<https://sciprofiles.com/profile/author/aC9Bc0E4ZjNoc004cGRJeU5QMWR3R0QwRTdrd2ora2J2M3o5RnFkc2dPTT0>), [Emma Rayner](#) (<https://sciprofiles.com/profile/author/YWxuSzBySG9xTke4OG5UWDZ1Uk5WK20vYnpZR3Y3Zm5ORINjcTAVMIQMMD0>), [Francisco J. Salguero](#) (<https://sciprofiles.com/profile/author/Qk5HUjQvVIIWN3JMQ3g0S1VvVwElwdVZsVVFDDZEp6N2VTMzU3TXdtM0ICRT0>), [Jemma Paterson](#) (<https://sciprofiles.com/profile/author/ZIYyV0UrZhdWTUroGVLZHBSTIY4N0Yvc21pMS9ZMGtsQ090MGNRSVhqZ0>), [Matteo Iannacone](#) (<https://sciprofiles.com/profile/author/a1kvZjIYXFGdGsvV3pIS3pOMWJ0WUNsYU56MTZyQVAVSIIWZXdmsnhTOD0>), [Raffaele De Francesco](#) (<https://sciprofiles.com/profile/1018727>), [Luigi Aurisicchio](#) (<https://sciprofiles.com/profile/2283716>) and [Fabio Palombo](#) (<https://sciprofiles.com/profile/2282765>)

Vaccines 2022, 10(8), 1178; <https://doi.org/10.3390/vaccines10081178> (<https://doi.org/10.3390/vaccines10081178>), - 25 Jul 2022

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Abstract The COVID-19 pandemic is entering a new era with the approval of many SARS-CoV-2 vaccines. In spite of the restoration of an almost normal way of life thanks to the immune protection elicited by these innovative vaccines, we are still facing high viral [...]. [Read more.](#)

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Protectivity of COVID-19 Vaccines and Its Relationship with Humoral Immune Response and Vaccination Strategy: A One-Year Cohort Study (/2076-393X/10/8/1177)

by [Ferdî Tanir](#) (<https://sciprofiles.com/profile/author/YmJzUjVUCXUdSZk0zb3NocHFZb3QwWIVlaDazM1VUNUI0a1BhZjI3MTdEVT0>), [Burak Mete](#) (<https://sciprofiles.com/profile/author/NFNuZk52QvDdbWRmR21telFic10QT09>), [Hakan Demirhindi](#) (<https://sciprofiles.com/profile/2068621>), [Ertan Kara](#) (<https://sciprofiles.com/profile/1831298>), [Ersin Nazlican](#) (<https://sciprofiles.com/profile/author/Q1YyT1RMNjExQWJ0YlFImMMyC5cXU5cZJb0JrbzM2NmtZWUgvr2o0c1hWYz0>), [Gülçin Dağlıoğlu](#) (<https://sciprofiles.com/profile/author/aHZ0OEImRTNheUyYa2FvcjZqNHJ2QVZhYUhxSWI5VWNmWWRTQTJrV1g4dz0>), [Filiz Kibar](#) (<https://sciprofiles.com/profile/author/cnFVVUydw93MnIsTEJkUmVsSVFCRHYvWUxhQVVD004Wi82VmczSnF6bz0>), [Salih Çetiner](#) (<https://sciprofiles.com/profile/2266727>) and [Ceren Kanat](#) (<https://sciprofiles.com/profile/author/UEIoV1RsY1pncmZ6cDJVY2RHa0FuSGR3T2VUTIN2VUdKdHdYSWhtcmN3UT0>)

Vaccines 2022, 10(8), 1177; <https://doi.org/10.3390/vaccines10081177> (<https://doi.org/10.3390/vaccines10081177>), - 25 Jul 2022

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Abstract This prospective cohort study aimed to evaluate the efficacy of COVID-19 vaccine schemes, homologous versus heterologous vaccine strategies, and vaccine-induced anti-S-RBD-IgG antibody response in preventing COVID-19 among 942 healthcare workers 1 year after vaccination with the inactivated and/or mRNA vaccines. All participants received [...]. [Read more.](#) Accept (/accept_cookies)



Review

Global Prevalence and Potential Influencing Factors of COVID-19 Vaccination Hesitancy: A Meta-Analysis

Jonny Karunia Fajar ¹, Malik Sallam ^{2,3,4,*}, Gatot Soegiarto ⁵, Yani Jane Sugiri ⁶, Muhammad Anshory ⁷, Laksmi Wulandari ⁸, Stephanie Astrid Puspitasari Kosasih ⁹, Muhammad Ilmawan ¹⁰, Kusnaeni Kusnaeni ¹¹, Muhammad Fikri ¹¹, Frilianty Putri ¹², Baitul Hamdi ¹³, Izza Dinalhaque Pranatasari ¹⁴, Lily Aina ¹⁵, Lailatul Maghfiroh ¹⁶, Fernanda Septi Ikhriandanti ¹⁷, Wa Ode Endiaverni ¹⁸, Krisna Wahyu Nugraha ¹⁸, Ory Wiranudirja ¹⁸, Sally Edinov ¹⁹, Ujang Hamdani ¹⁸, Lathifatul Rosyidah ¹⁸, Hanny Lubaba ¹⁸, Rinto Ariwibowo ¹⁸, Riska Andistyani ¹⁸, Ria Fitriani ²⁰, Miftahul Hasanah ²¹, Fardha Ad Durrun Nafis ²¹, Fredo Tamara ¹, Fitri Olga Latamu ¹, Hendrix Indra Kusuma ^{22,23,24}, Ali A. Rabaan ^{25,26,27}, Saad Alhumaid ²⁸, Abbas Al Mutair ^{29,30,31,32}, Mohammed Garout ³³, Muhammad A. Halwani ³⁴, Mubarak Alfaresi ^{35,36}, Reyouf Al Azmi ³⁷, Nada A. Alasiri ³⁸, Abeer N. Alshukairi ^{26,39}, Kuldeep Dhama ⁴⁰ and Harapan Harapan ^{22,41,42}



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- ¹ Brawijaya Internal Medicine Research Center, Department of Internal Medicine, Faculty of Medicine, Universitas Brawijaya, Malang 65145, Indonesia
- ² Department of Pathology, Microbiology and Forensic Medicine, School of Medicine, The University of Jordan, Amman 11942, Jordan
- ³ Department of Clinical Laboratories and Forensic Medicine, Jordan University Hospital, Amman 11942, Jordan
- ⁴ Department of Translational Medicine, Faculty of Medicine, Lund University, 22184 Malmö, Sweden
- ⁵ Division of Allergy and Immunology, Department of Internal Medicine, Faculty of Medicine, Universitas Airlangga, Surabaya 60286, Indonesia
- ⁶ Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Brawijaya, Malang 65145, Indonesia
- ⁷ Division of Allergy and Immunology, Department of Internal Medicine, Faculty of Medicine, Universitas Brawijaya, Malang 65145, Indonesia
- ⁸ Department of Pulmonology and Respiratory Medicine, Faculty of Medicine, Universitas Airlangga, Surabaya 60286, Indonesia
- ⁹ Faculty of Medicine, Universitas Brawijaya, Malang 65145, Indonesia
- ¹⁰ Department of Urology, Faculty of Medicine, Universitas Brawijaya, Malang 65145, Indonesia
- ¹¹ Faculty of Mathematics and Sciences, Institut Pertanian Bogor, Bogor 16680, Indonesia
- ¹² School of Veterinary Medicine and Biomedicine, Institut Pertanian Bogor, Bogor 16680, Indonesia
- ¹³ Faculty of Economy and Business, Universitas Airlangga, Surabaya 60286, Indonesia
- ¹⁴ Faculty of Public Health, Universitas Airlangga, Surabaya 60286, Indonesia
- ¹⁵ Faculty of Pharmacy, Universitas Airlangga, Surabaya 60286, Indonesia
- ¹⁶ Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya 60286, Indonesia
- ¹⁷ Faculty of Medicine, Universitas Airlangga, Surabaya 60286, Indonesia
- ¹⁸ Faculty of Economy and Business, Universitas Brawijaya, Malang 65145, Indonesia
- ¹⁹ Faculty of Economics and Business, Riau University, Pekanbaru 28293, Indonesia
- ²⁰ Faculty of Administrative Science, Universitas Brawijaya, Malang 65145, Indonesia
- ²¹ Faculty of Animal Science, Universitas Brawijaya, Malang 65145, Indonesia
- ²² Medical Research Unit, School of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia
- ²³ Faculty of Mathematics and Natural Sciences, Universitas Syiah Kuala, Darussalam, Banda Aceh 23111, Indonesia
- ²⁴ Faculty of Tarbiyah and Teacher Training, Universitas Islam Negeri Ar-Raniry, Banda Aceh 23111, Indonesia
- ²⁵ Molecular Diagnostic Laboratory, Johns Hopkins Aramco Healthcare, Dhahran 31311, Saudi Arabia
- ²⁶ College of Medicine, Alfaisal University, Riyadh 11533, Saudi Arabia
- ²⁷ Department of Public Health and Nutrition, The University of Haripur, Haripur 22610, Pakistan
- ²⁸ Administration of Pharmaceutical Care, Al-Ahsa Health Cluster, Ministry of Health, Al-Ahsa 31982, Saudi Arabia
- ²⁹ Research Center, Almoosa Specialist Hospital, Al Mubarrazs 36342, Saudi Arabia
- ³⁰ College of Nursing, Princess Norah Bint Abdulrahman University, Riyadh 11564, Saudi Arabia
- ³¹ School of Nursing, Wollongong University, Wollongong, NSW 2522, Australia
- ³² Nursing Department, Prince Sultan Military College of Health Sciences, Dhahran 33048, Saudi Arabia
- ³³ Department of Community Medicine and Health Care for Pilgrims, Faculty of Medicine, Umm Al-Qura University, Makkah 21955, Saudi Arabia

- ³⁴ Department of Medical Microbiology, Faculty of Medicine, Al Baha University, Al Baha 4781, Saudi Arabia
- ³⁵ Department of Pathology and Laboratory Medicine, Sheikh Khalifa General Hospital, Umm Al Quwain 499, United Arab Emirates
- ³⁶ Department of Pathology, College of Medicine, Mohammed Bin Rashid University of Medicine and Health Sciences, Dubai 505055, United Arab Emirates
- ³⁷ Infection Prevention and Control, Eastern Health Cluster, Dammam 32253, Saudi Arabia
- ³⁸ Scientific Advisory Council, InsanCare Group for Scientific Studies and Specialized Business Solutions, Riyadh 13313, Saudi Arabia
- ³⁹ Department of Medicine, King Faisal Specialist Hospital and Research Center, Jeddah 12713, Saudi Arabia
- ⁴⁰ Division of Pathology, ICAR–Indian Veterinary Research Institute, Izatnagar, Bareilly 243122, India
- ⁴¹ Tropical Disease Centre, School of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia
- ⁴² Department of Microbiology, School of Medicine, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia
- * Correspondence: malik.sallam@ju.edu.jo; Tel.: +962-79-184-5186

Abstract: Countries worldwide have deployed mass COVID-19 vaccination drives, but there are people who are hesitant to receive the vaccine. Studies assessing the factors associated with COVID-19 vaccination hesitancy are inconclusive. This study aimed to assess the global prevalence of COVID-19 vaccination hesitancy and determine the potential factors associated with such hesitancy. We performed an organized search for relevant articles in PubMed, Scopus, and Web of Science. Extraction of the required information was performed for each study. A single-arm meta-analysis was performed to determine the global prevalence of COVID-19 vaccination hesitancy; the potential factors related to vaccine hesitancy were analyzed using a Z-test. A total of 56 articles were included in our analysis. We found that the global prevalence of COVID-19 vaccination hesitancy was 25%. Being a woman, being a 50-year-old or younger, being single, being unemployed, living in a household with five or more individuals, having an educational attainment lower than an undergraduate degree, having a non-healthcare-related job and considering COVID-19 vaccines to be unsafe were associated with a higher risk of vaccination hesitancy. In contrast, living with children at home, maintaining physical distancing norms, having ever tested for COVID-19, and having a history of influenza vaccination in the past few years were associated with a lower risk of hesitancy to COVID-19 vaccination. Our study provides valuable information on COVID-19 vaccination hesitancy, and we recommend special interventions in the sub-populations with increased risk to reduce COVID-19 vaccine hesitancy.

Keywords: COVID-19; vaccination; hesitancy; acceptance; prevalence

1. Introduction

Coronavirus disease 2019 (COVID-19) vaccination has been progressing globally since the beginning of 2021. Several types of vaccines, including inactivated, vector-based, messenger ribonucleic acid (mRNA), and protein subunit vaccines, are being administered to recipients [1]. Since the vaccines became available, there have been expectations of the COVID-19 pandemic ending, considering that previous vaccination programs have been effective in managing several infectious diseases such as rubella, mumps, measles, and polio. These vaccination programs have been proven to improve global health and the economy [2,3]. However, the probability of failure of any vaccination program should be assessed. A study reported that the barriers to effective vaccination programs include inconvenient and limited clinic hours for immunization, inadequate access to healthcare, high vaccine administration fees, and vaccine hesitancy [4]. Of these factors, vaccine hesitancy is considered one of the most critical [5]. Individuals who are hesitant to be immunized have a tendency to spread incorrect information about vaccination, which may influence people close to them to reject vaccines as well [6].

Vaccine hesitancy is commonly observed in the case of new vaccines or vaccine candidates [7,8]. This phenomenon was reported in the case of malaria [9], dengue [10], and Ebola [11]. The factors contributing to vaccine hesitancy are complex and may include a lack of awareness regarding disease prevention and socioeconomic status [12,13]. This

phenomenon poses a dilemma to vaccine coverage. Moreover, governments—as the highest regulatory authority of any nation—seemingly do not provide special interventions to reduce hesitancy toward vaccination programs. It is observed in the guidelines on COVID-19 vaccination, that the primary recommendation only focused on dose allocation, outreach, delivery, and monitoring; there was no information on how to reduce COVID-19 vaccination hesitancy [14].

Regarding COVID-19 vaccination, several studies have been conducted to assess the prevalence of COVID-19 vaccine hesitancy and its associated predictors [7,8,15]. However, the findings were inconclusive with variability regarding the correlation between COVID-19 vaccine acceptance and the following: sociodemographic factors, vaccine confidence and trust regarding vaccine safety, complacency towards the disease, conspiracy beliefs towards COVID-19 vaccination and willingness to pay for the vaccine [7,16–21]. Therefore, a meta-analysis is necessary to determine the potential factors influencing COVID-19 vaccination hesitancy.

2. Materials and Methods

2.1. Study Design

During the period May–June 2022, we conducted a meta-analysis that followed the protocols of the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) [22,23]. In line with the purpose of our study, we first performed an organized search of PubMed, Scopus, and Web of Science and, subsequently, collected the required information to calculate the global prevalence of vaccine hesitancy and effect estimates of the potential influencing factors. The PRISMA checklist for this review is provided in (Supplementary Materials). Additionally, data used in this review are available in Figshare (<https://doi.org/10.6084/m9.figshare.20055539.v3>, accessed on 6 December 2022) [23].

2.2. Eligibility Criteria

We determined the eligibility criteria before conducting the organized search. An article was included in the analysis if the following inclusion criteria were met: (1) whether it assessed the prevalence of COVID-19 vaccination hesitancy or (2) identified potential factors influencing COVID-19 vaccination hesitancy. Reviews, commentaries, letters to the editor, grey literature, and double publications were excluded.

2.3. Search Strategy and Data Extraction

As of 25 May 2022, we performed an organized search of PubMed, Scopus, and Web of Science. Prior to the search for the main outcomes, the potential factors associated with COVID-19 vaccination hesitancy were determined. We used keywords from the following medical subject headings: “vaccine”, “vaccination”, or “immunization”; “COVID-19” or “coronavirus disease 2019”; “hesitancy” or “acceptance”. We limited the organized search to the English language. If we found any duplication, we included the studies with larger sample sizes. Furthermore, we also conducted an organized search of the reference lists of the relevant articles to obtain additional papers. Thereupon, the following information was collected from the selected articles: (1) first author name, (2) year of publication, (3) study design, (4) study period, (5) Newcastle–Ottawa scale (NOS), (6) the prevalence of COVID-19 vaccination hesitancy, and (7) event rate of potential factors associated with COVID-19 vaccination hesitancy. Two independent teams, led by JKF and SAPK, conducted the article search and data extraction. Prior to the systematic search, the kappa statistic was used to measure the agreement between the two investigators. If the kappa statistic was greater than the *p*-value, agreement was established.

2.4. Assessment of the Methodological Quality

All potential articles for inclusion in the study were assessed for quality using NOS [24]. The quality was considered high, moderate, or low if the score was 7–9, 4–6, or 0–3, respectively. Low-quality articles were excluded from the analysis. Using a pilot form, the

two independent teams, led by JKF and SAPK, conducted the NOS assessment, and any discrepancies were resolved through discussion.

2.5. Outcome Measures

The major outcomes were global prevalence and potential influencing factors of COVID-19 vaccination hesitancy. To identify the potential factors associated with vaccine hesitancy, we performed an initial organized search in PubMed, Scopus, and Web of Science. We identified the following potential factors: age group, gender, marital status, educational attainment, religion, employment status, healthcare-related job, socioeconomic status, urbanity, presence of children and elderly people at home, household size, and presence of family members with a medical background. Additionally, wearing masks, hand hygiene, compliance with physical distancing norms, smoking, history of chronic disease, personal history of COVID-19 diagnosis, COVID-19 diagnosis of a family member/friend, hospitalization due to COVID-19 among people in the same social circle, death owing to COVID-19 among people in the same social circle, safety conceptions about COVID-19 vaccines, and history of influenza vaccination in the past few years were also factors of interest.

2.6. Statistical Analysis

Before calculating the global prevalence of COVID-19 vaccination hesitancy and effect estimates of potential predictors of such hesitancy, we conducted an analysis of potential publication bias and heterogeneity among the studies. We analyzed the risk of publication bias using the Egger's test, with a p -value of <0.05 suggesting the existence of publication bias. Furthermore, we performed an analysis of heterogeneity among studies using the Q test, with a p -value of <0.10 indicating heterogeneity; thus, a random effects model was applied for data analysis—in cases where there was no heterogeneity, a fixed-effects model was used. A single-arm meta-analysis was performed using the dichotomous covariate method to calculate the event rate from each study to discern the global prevalence of COVID-19 vaccination hesitancy. The effect estimate was presented as the event rate. The analysis was performed using the R package (RStudio version 4.1.1, R Studio, Boston, MA, USA). The effect estimates of potential factors associated with COVID-19 vaccination hesitancy were outlined in a forest plot as a pooled odds ratio and 95% confidence interval (OR, 95% CI).

3. Results

3.1. Selection of Studies

We retrieved 4299 potential papers from the databases mentioned and 18 from the reference lists of related articles. Of these, 23 papers were excluded owing to duplication and 4219 papers with irrelevant subjects. Thus, 75 articles were included in the full-text review. Subsequently, six reviews and thirteen articles were excluded because of insufficient data. Eventually, a total of 56 articles were included in the final analysis to calculate the global prevalence and potential influencing factors in COVID-19 vaccination hesitancy [19,25–79]. The plotting of article selection in our study is presented in (Figure 1), and the characteristics of the included articles are listed in (Table 1).

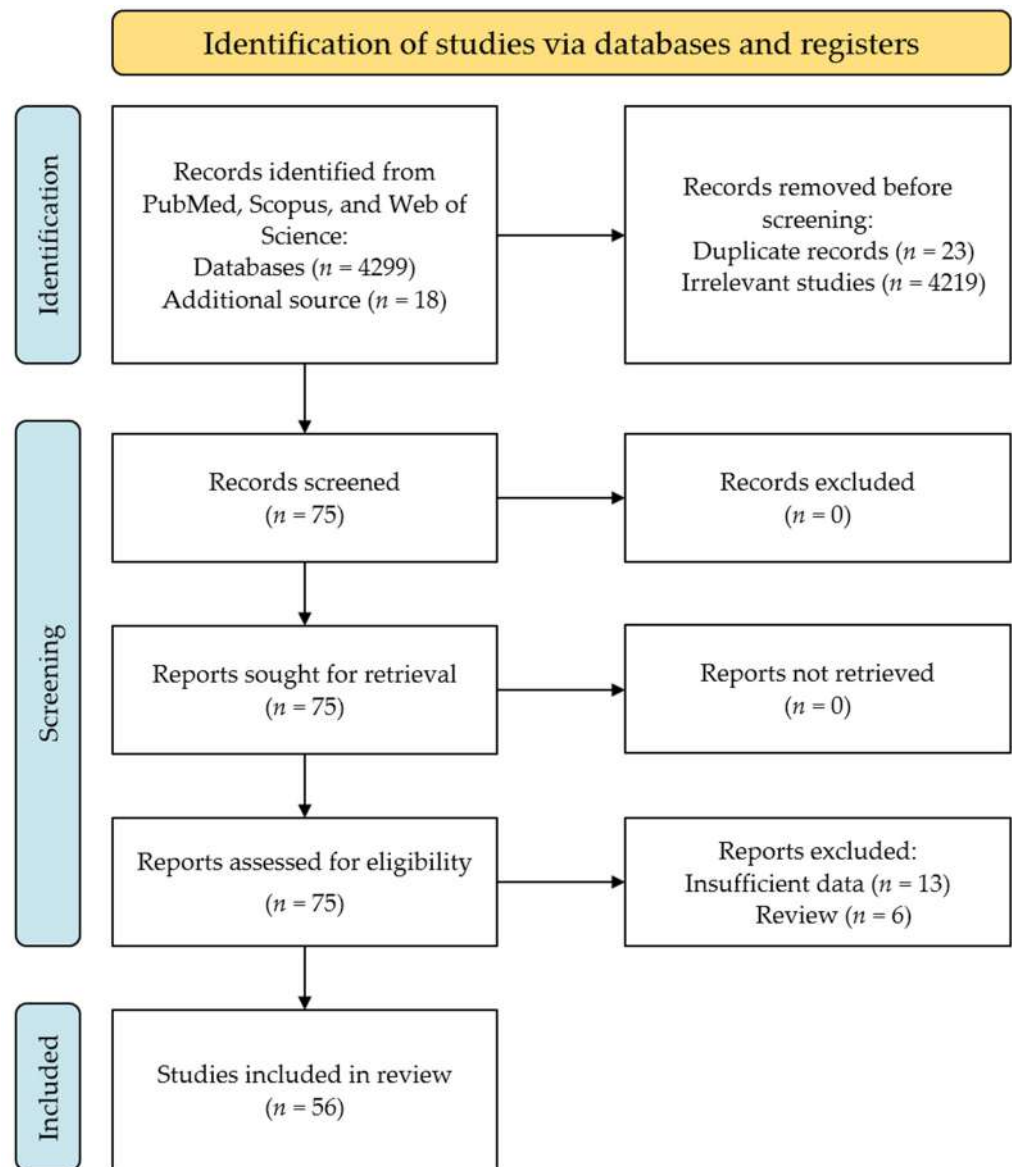


Figure 1. A flowchart of article selection in this review.

Table 1. Baseline characteristics of articles included in our analysis [19,25–79].

Author and Year	Country	Sample Size	Study Period	Population	Funding	NOS ¹
Aemro et al., 2021 [25]	Ethiopia	418	May–June 2021	Healthcare workers	No funding	5
Ali et al., 2021 [26]	Bangladesh	1134	January 2021	General population	No funding	6
Barry et al., 2021 [27]	Saudi Arabia	1512	November 2020	Healthcare workers	No funding	6
Bell et al., 2020 [28]	England	1252	April–May 2020	General population	London School of Hygiene and Tropical Medicine	6
Chen et al., 2021 [29]	China	2531	January 2021	General population	NA	7
Chudasama et al., 2022 [30]	Multinational	275	April–July 2021	Healthcare workers	NA	6

Table 1. Cont.

Author and Year	Country	Sample Size	Study Period	Population	Funding	NOS ¹
Detoc et al., 2020 [31]	France	3259	March–April 2020	General population	NA	5
Dong et al., 2020 [32]	China	1236	June–July 2020	General population	Chinese University of Hong Kong	6
Dror et al., 2020 [33]	Israel	1661	2020–2022	Healthcare workers	NA	5
Faasse et al., 2020 [34]	Australia	2232	March 2020	General population	UNSW Science Goldstar (2020)	5
Fisher et al., 2020 [35]	US	991	April 2020	General population	Agency for Healthcare Research and Quality	7
Goodwin et al., 2022 [36]	Multinational	3059	December 2020–January 2021	General population	Ariel University, JSPS KAKENSHI, Hungaria National Excellence Program	6
Habib et al., 2022 [37]	Saudi Arabia	1445	August–October 2021	Students	King Saud University	7
Bou Hamdan et al., 2021 [38]	Lebanon	758	May–June 2021	Students	No funding	7
Harapan et al., 2020 [39]	Indonesia	1359	March–April 2020	General population	No funding	6
Horiuchi et al., 2021 [40]	Japan	1200	May–June 2021	General population	No funding	7
Hossain et al., 2021 [41]	Bangladesh	1497	February 2021	General population	No funding	6
Huang et al., 2022 [42]	China	4227	January–March 2021	General population	National Health Commission of the People’s Republic of China	7
Ikiisik et al., 2021 [43]	Turkey	384	December 2020	General population	NA	7
Jabessa et al., 2022 [44]	Ethiopia	350	August–September 2021	General population	No funding	6
Jain et al., 2021 [45]	India	1068	February–March 2021	Students	No funding	6
Kelekar et al., 2021 [46]	US	408	September–December 2020	Students	NA	6
Khubchandani et al., 2021 [47]	US	1878	June 2020	General population	No funding	8
Koh et al., 2022 [48]	Singapore	528	May–June 2021	Healthcare workers	No funding	6
Kumar et al., 2021 [49]	Qatar	1414	October–November 2020	Healthcare workers	Qatar National Library	5
Lazarus et al., 2020 [50]	Multinational	13,426	June 2020	General population	City University of New York	6
Lee et al., 2022 [51]	South Korea	1016	January 2021	General population	No funding	6
Li et al., 2022 [52]	China	721	June 2021	Students	Xuzhou Medical University	7
Liddell et al., 2021 [53]	Australia	437	June 2021	General population	UNSW Sydney / Australian Red Cross	6
Lucia et al., 2021 [54]	US	167	NA	Students	No funding	5
Malik et al., 2020 [55]	US	672	May 2020	General population	Yale Institute for Global Health	8
Marzo et al., 2022 [56]	Multinational	5260	February–May 2021	General population	No funding	7
Mascarenhas et al., 2021 [57]	US	245	2020	Students	No funding	6

Table 1. Cont.

Author and Year	Country	Sample Size	Study Period	Population	Funding	NOS ¹
Mohammed et al., 2021 [58]	Ethiopia	614	March–July 2021	Healthcare workers	No funding	7
Mose et al., 2022 [59]	Ethiopia	420	March 2021	Students	No funding	6
Nery et al., 2022 [60]	Brazil	2537	November 2020–January 2021	General population	Brazilian Ministry of Health	8
Neumann-Böhme et al., 2020 [61]	Multinational	7664	April 2020	General population	European Union’s Horizon 2020 research and innovation programme	6
Ousseine et al., 2022 [62]	France	15,427	February–April 2021	General population	National Agency for Research on AIDS and Viral Hepatitis (ANRS)	6
Patwary et al., 2021 [19]	Bangladesh	543	July–August 2021	General population	No funding	6
Qunaibi et al., 2021 [63]	Multinational	36,220	January 2021	General population	No funding	7
Raja et al., 2022 [64]	Sudan	217	June–July 2021	Students	No funding	5
Reiter et al., 2020 [65]	US	2006	May 2020	General population	National Center for Advancing Translational Sciences	7
Rodríguez-Blanco et al., 2021 [66]	Spain	2494	November–December 2020	General population	No funding	6
Saied et al., 2021 [67]	Egypt	2133	January 2021	Students	NA	7
Salali et al., 2020 [68]	Multinational	5024	May 2020	General population	No funding	6
Schwarzinger et al., 2021 [69]	France	1942	July 2020	General population	French Public Health Agency	7
Shah et al., 2021 [70]	India	274	February 2021	Students	NA	7
Singh et al., 2021 [71]	Hong Kong	245	May 2021	General population	Tung Foundation	7
Tao et al., 2021 [72]	China	1392	November 2020	General population	National Key Research and Development Project of China	7
Tlale et al., 2022 [73]	Botswana	4952	February 2021	General population	No funding	6
Wang et al., 2020 [74]	Hong Kong	806	February–March 2020	Healthcare workers	No funding	6
Ward et al., 2020 [75]	France	5018	April 2020	General population	Agence Nationale de la Recherche and the CNRS	8
Wong et al., 2020 [76]	Malaysia	1159	April 2020	General population	Ministry of Education Malaysia	8
Wu et al., 2021 [77]	China	29,925	August 2021	General population	National Social Science Fund of China	7
Xu et al., 2021 [78]	China	5247	January 2021	Healthcare workers	Health Commission of Chongqing municipal, China	6
Yassin et al., 2022 [79]	Sudan	365	April 2021	Healthcare workers	NA	6

¹ NOS: Newcastle–Ottawa scale; all selected studies were based on a cross-sectional design.

3.2. Global Prevalence of COVID-19 Vaccination Hesitancy

To calculate the global prevalence of COVID-19 vaccination hesitancy, we included a total of 56 articles. Data analysis using the random effects model revealed that the global prevalence was 25% (event rate: 0.25; 95% CI: 0.19, 0.32; *p* Egger’s: 1.2710; *p* heterogeneity: <0.0001; *p* < 0.0001). The global prevalence of COVID-19 vaccination hesitancy is presented

in (Figure 2A). In sub-group analysis, we found that the prevalence of COVID-19 vaccination hesitancy in the general population (Figure 2B), healthcare workers (Figure 2C), and students (Figure 2D) was 25%, 26%, and 25%, respectively.

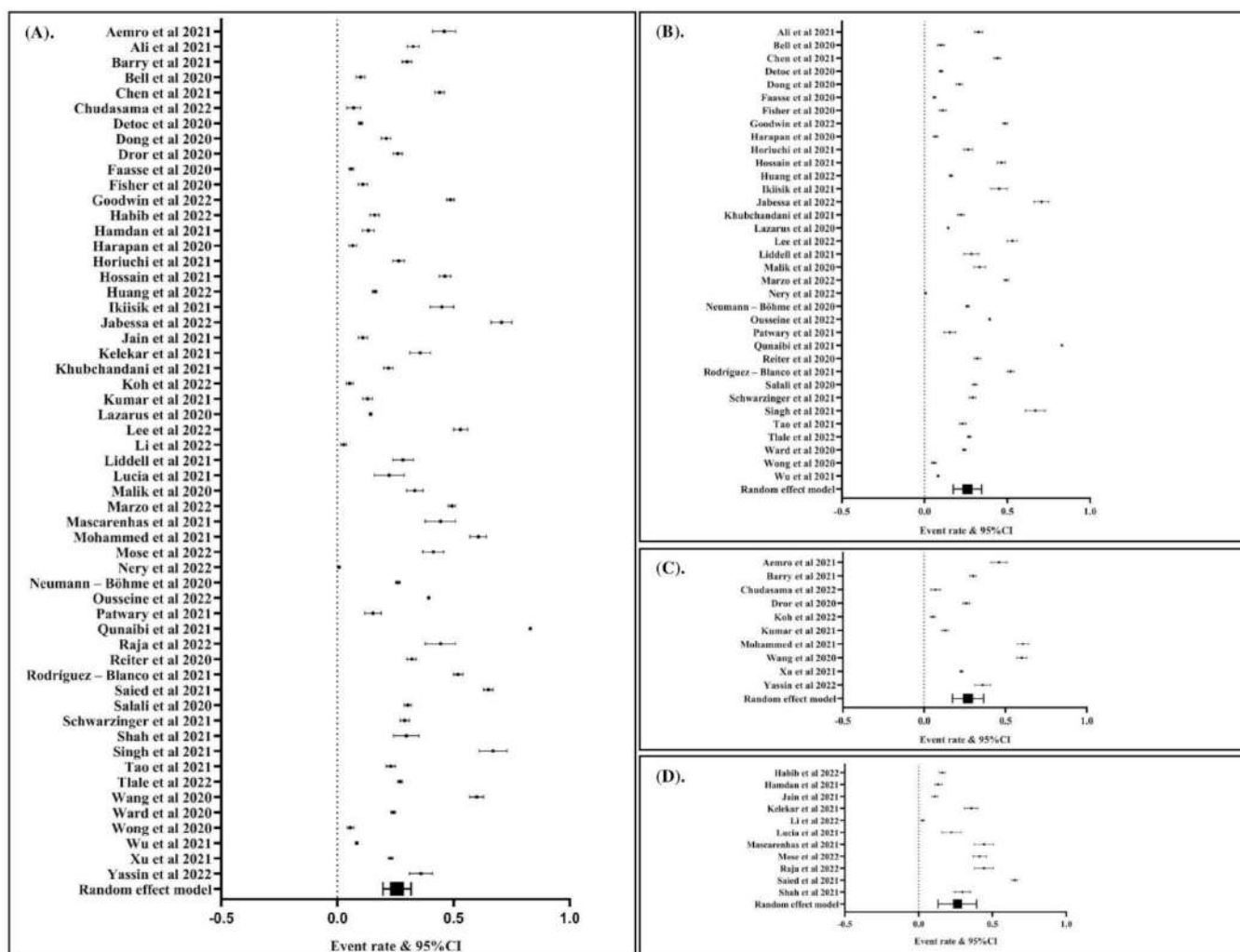


Figure 2. The global prevalence of hesitancy to COVID-19 vaccination (event rate: 0.25; 95% CI: 0.20, 0.32; p Egger: 1.2580; p heterogeneity: <0.0001; p : <0.0001) (A). The prevalence of hesitancy to COVID-19 vaccination among general population (event rate: 0.25; 95% CI: 0.18, 0.34; p Egger: 1.3090; p heterogeneity: <0.0001; p : <0.0001) (B). The prevalence of hesitancy to COVID-19 vaccination among healthcare workers (event rate: 0.26; 95% CI: 0.18, 0.37; p Egger: 0.7670; p heterogeneity: <0.0001; p : <0.0001) (C). The prevalence of hesitancy to COVID-19 vaccination among students (event rate: 0.25; 95% CI: 0.14, 0.40; p Egger: 1.2090; p heterogeneity: <0.0001; p : 0.0030) (D). The studies included are provided in the reference list [19,25–79].

3.3. Potential Factors Associated with COVID-19 Vaccination Hesitancy

The potential factors associated with COVID-19 vaccination hesitancy are summarized in (Table 2) and presented in (Figures 3–6). Our analysis revealed that out of 25 factors, 12 of them were associated with COVID-19 vaccine hesitancy. The following factors were associated with a higher risk of vaccination hesitancy: being a woman (compared to man) (Figure 3A), being ≤ 50 years old (compared to those older than 50 years) (Figure 3B), being single (compared to married individuals) (Figure 3C), being unemployed (compared to employed) (Figure 4A), living in a household with five or more individuals (compared to living in smaller households) (Figure 4B), having an educational attainment lower than an undergraduate degree (compared to those with an undergraduate degree or higher) (Figure 5A), having a non-healthcare-related job (compared to having a healthcare-related

job) (Figure 5B), and considering COVID-19 vaccines to be unsafe (compared to those who consider COVID-19 vaccines to be safe) (Figure 5C).

Table 2. The potential factors associated with the hesitancy to COVID-19 vaccination.

Covariates	Hesitancy/Total (n [%])	NS	<i>p</i> Egger	<i>p</i> Het	OR	95% CI	<i>p</i>
Age group (years)							
≤30	6568/14,356 [45.8]	16	0.2320	<0.0001	1.14	0.98–1.32	0.0870
31–40	5097/11,335 [45.0]	16	0.2360	<0.0001	1.09	0.94–1.26	0.2630
41–50	3034/6536 [46.4]	15	0.2730	<0.0001	0.88	0.74–1.06	0.1760
>50	2034/4677 [43.5]	13	0.2980	<0.0001	0.79	0.64–0.98	0.0290
Sex							
Male	8934/22,362 [40.0]	31	0.2840	<0.0001	0.76	0.67–0.85	<0.0001
Female	11,170/28,707 [38.9]	31	0.2840	<0.0001	1.32	1.17–1.49	<0.0001
Marital status							
Married	6888/20,496 [33.6]	17	0.1950	<0.0001	0.84	0.75–0.95	0.0040
Single	7173/18,764 [38.2]	17	0.1950	<0.0001	1.19	1.06–1.34	0.0040
Educational attainment							
<BSC	12,130/22,950 [52.9]	22	0.5260	<0.0001	1.30	1.03–1.65	0.0300
≥BSC	17,532/41,182 [42.6]	22	0.5260	<0.0001	0.77	0.61–0.97	0.0300
Religion							
Christian	1053/2124 [49.6]	5	<0.0001	0.4380	1.17	1.01–1.35	0.0340
Muslim	1265/3961 [31.9]	6	0.5110	<0.0001	1.39	0.85–2.26	0.1860
Hindu	16/129 [12.4]	2	1.5700	0.0710	0.28	0.02–3.40	0.3150
Employment							
Not working	1704/4455 [38.2]	10	0.1790	0.0090	1.20	1.02–1.42	0.0300
Working	5883/16,413 [35.8]	10	0.1790	0.0090	0.83	0.71–0.98	0.0300
Healthcare-related job	2886/8313 [34.7]	10	0.3340	<0.0001	0.68	0.52–0.89	0.0040
Socioeconomic status							
Low income	1320/2939 [44.9]	7	0.4840	<0.0001	1.31	0.88–1.94	0.1790
Middle income	1217/3220 [37.8]	7	1.2050	<0.0001	0.61	0.25–1.52	0.2900
High income	1427/2515 [56.7]	7	1.2860	<0.0001	1.28	0.49–3.38	0.6140
Urbanicity							
Urban	9192/28,583 [32.2]	15	0.4500	<0.0001	0.92	0.72–1.18	0.5070
Rural	3128/8338 [37.5]	15	0.4500	<0.0001	1.09	0.85–1.39	0.5070
Children at home	1207/4595 [26.3]	8	1.4040	<0.0001	0.37	0.14–0.99	0.0490
Aged people at home	456/1542 [29.6]	5	0.2760	0.0140	1.07	0.78–1.45	0.6920
Household number (n)							
≤2	930/3192 [29.1]	5	0.3900	<0.0001	0.94	0.64–1.36	0.7270
3–4	564/2067 [27.3]	5	0.2290	0.0110	0.89	0.69–1.14	0.3510
≥5	278/712 [39.0]	4	0.1680	0.1620	1.36	1.13–1.63	0.0010

Table 2. Cont.

Covariates	Hesitancy/Total (n [%])	NS	<i>p</i> Egger	<i>p</i> Het	OR	95% CI	<i>p</i>
Family members with medical backgrounds	464/1382 [33.6]	2	0.0410	0.3170	0.92	0.78–1.07	0.2770
Wearing masks all the time	1523/6606 [23.1]	6	0.5570	<0.0001	0.61	0.36–1.05	0.0720
Constantly washing hands	1209/4974 [24.3]	4	0.8900	<0.0001	0.45	0.18–1.16	0.0980
Keep physical distancing	213/745 [28.6]	3	0.8370	0.0010	0.23	0.08–0.65	0.0050
Smoker	665/2236 [29.7]	5	0.0590	0.3360	1.13	0.99–1.29	0.0610
History of chronic disease(s)	3828/8197 [46.7]	17	0.1840	<0.0001	0.91	0.80–1.03	0.1420
Ever tested for COVID-19	670/4430 [15.1]	6	0.4340	<0.0001	0.46	0.31–0.68	<0.0001
Personal history of COVID-19 diagnosis	4114/7733 [53.2]	15	0.6090	<0.0001	0.94	0.66–1.33	0.7150
Family member/friend ever diagnosed with COVID-19	1192/3759 [31.7]	7	0.2960	<0.0001	0.83	0.63–1.09	0.1730
Hospitalization due to COVID-19 among people in the same social circle	69/621 [11.1]	2	<0.0001	0.9770	0.57	0.37–0.88	0.0110
Death due to COVID-19 among people in the same social circle	63/537 [11.7]	3	<0.0001	0.9450	0.73	0.49–1.08	0.1160
COVID-19 vaccines are not safe	628/1595 [39.4]	6	0.7000	<0.0001	2.24	1.21–4.14	0.0100
Influenza vaccination in the past few years	3481/10,687 [32.6]	11	0.3460	<0.0001	0.46	0.36–0.58	<0.0001

OR: odds ratio; CI: confidence interval; NS: number of studies; *p* Het: *p* heterogeneity; BSC: Bachelor of Science.

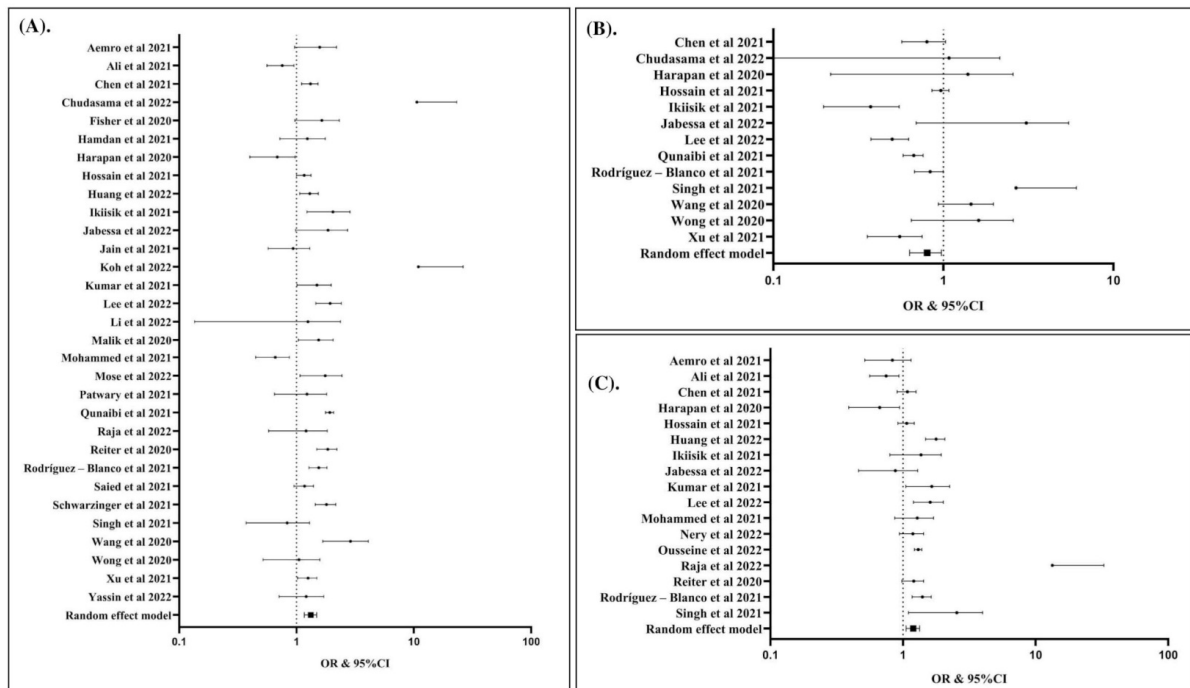


Figure 3. Female was associated with increased risk of hesitancy to COVID-19 vaccination compared to male (OR: 1.32; 95% CI: 1.17, 1.49; *p* Egger: 0.2840; *p* heterogeneity: <0.0001; *p*: <0.0001) (A). Individuals with age > 50 years was associated with lower risk of hesitancy to COVID-19 vaccination compared to individuals with age ≤ 50 years (OR: 0.79; 95% CI: 0.64, 0.98; *p* Egger: 0.2980; *p* Het: <0.0001; *p*: 0.0290) (B).

Single individuals had higher risk of hesitancy to COVID-19 vaccination than married individuals (OR: 1.19; 95% CI: 1.06, 1.34; *p* Egger: 0.1950; *p* heterogeneity: <0.0001; *p*: 0.0040) (C). The studies included are provided in the reference list [19,25–79].

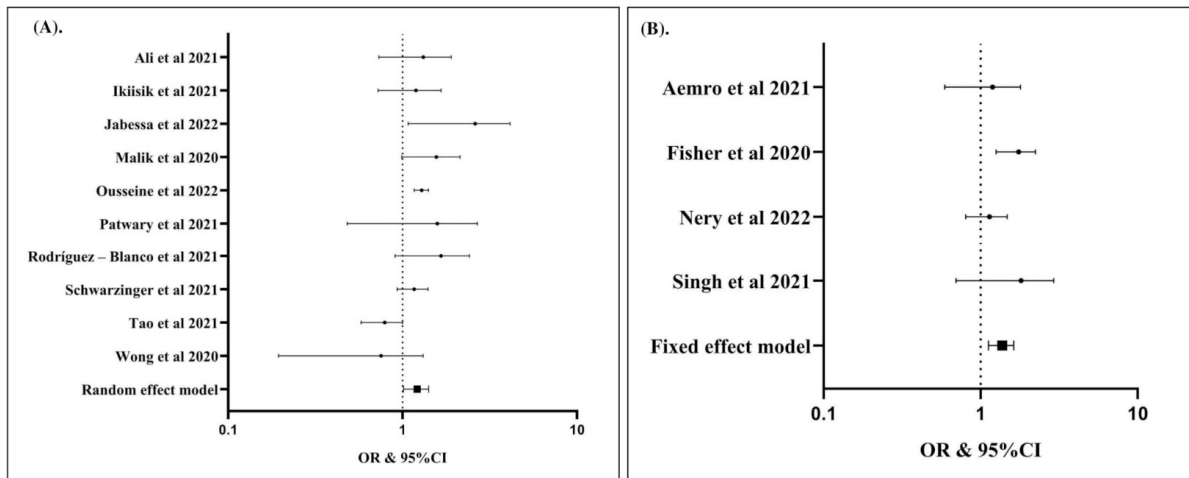


Figure 4. Unemployed individuals were associated with increased risk of hesitancy to COVID-19 vaccination compared to working individuals (OR: 1.20; 95% CI: 1.02, 1.42; *p* Egger: 0.1790; *p* heterogeneity: 0.0090; *p*: 0.0300) (A); individuals with household number ≥ 5 individuals had higher risk of hesitancy to COVID-19 vaccination (OR: 1.36; 95% CI: 1.13, 1.63; *p* Egger: 0.1680; *p* heterogeneity: 0.1620; *p*: 0.0010) (B). The studies included are provided in the reference list [19,25–79].

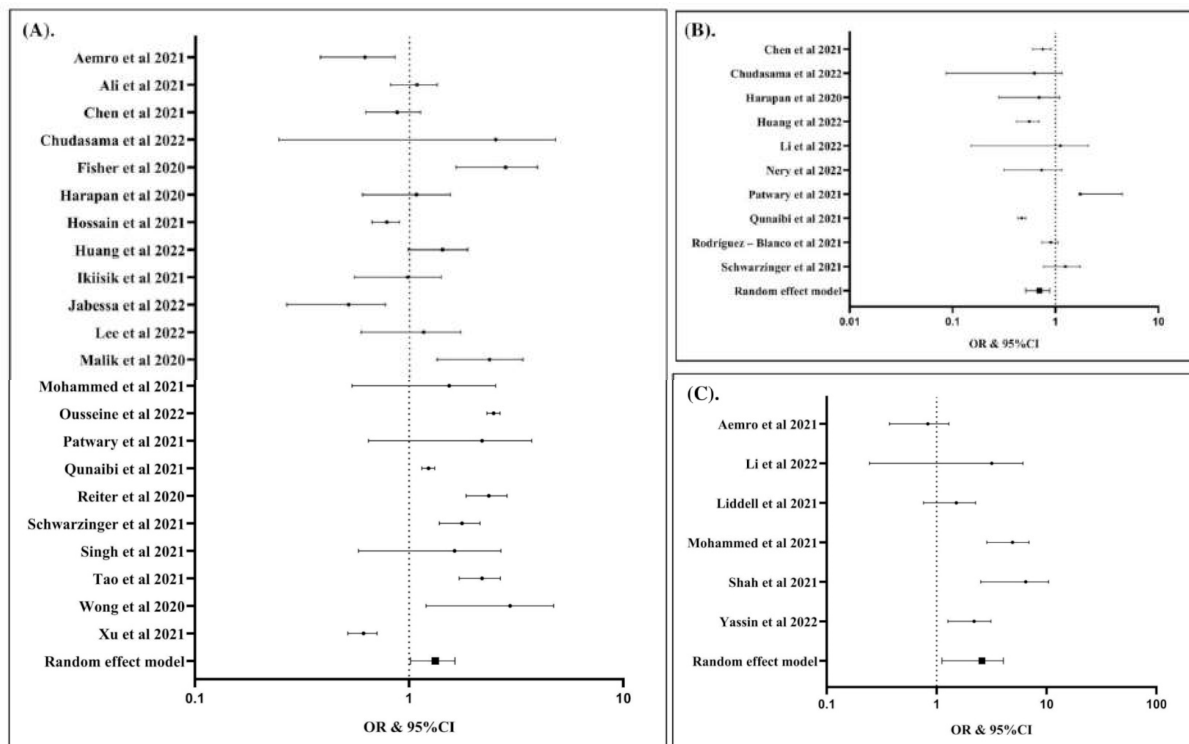


Figure 5. Individuals with the education levels < BSC had higher risk of hesitancy to COVID-19 vaccination than \geq BSC (OR: 1.30; 95% CI: 1.03, 1.65; *p* Egger: 0.5260; *p* heterogeneity: <0.0001; *p*: 0.0300) (A); individuals having the healthcare-related job had lower risk of hesitancy to COVID-19 vaccination (OR: 0.68; 95% CI: 0.52, 0.89; *p* Egger: 0.3340; *p* heterogeneity: <0.0001; *p*: 0.0040) (B); Individuals considering that COVID-19 vaccines are not safe had higher risk of hesitancy to COVID-19 vaccination (OR: 2.24; 95% CI: 1.21, 4.14; *p* Egger: 0.7000; *p* heterogeneity: <0.0001; *p*: 0.0100) (C). The studies included are provided in the reference list [19,25–79].

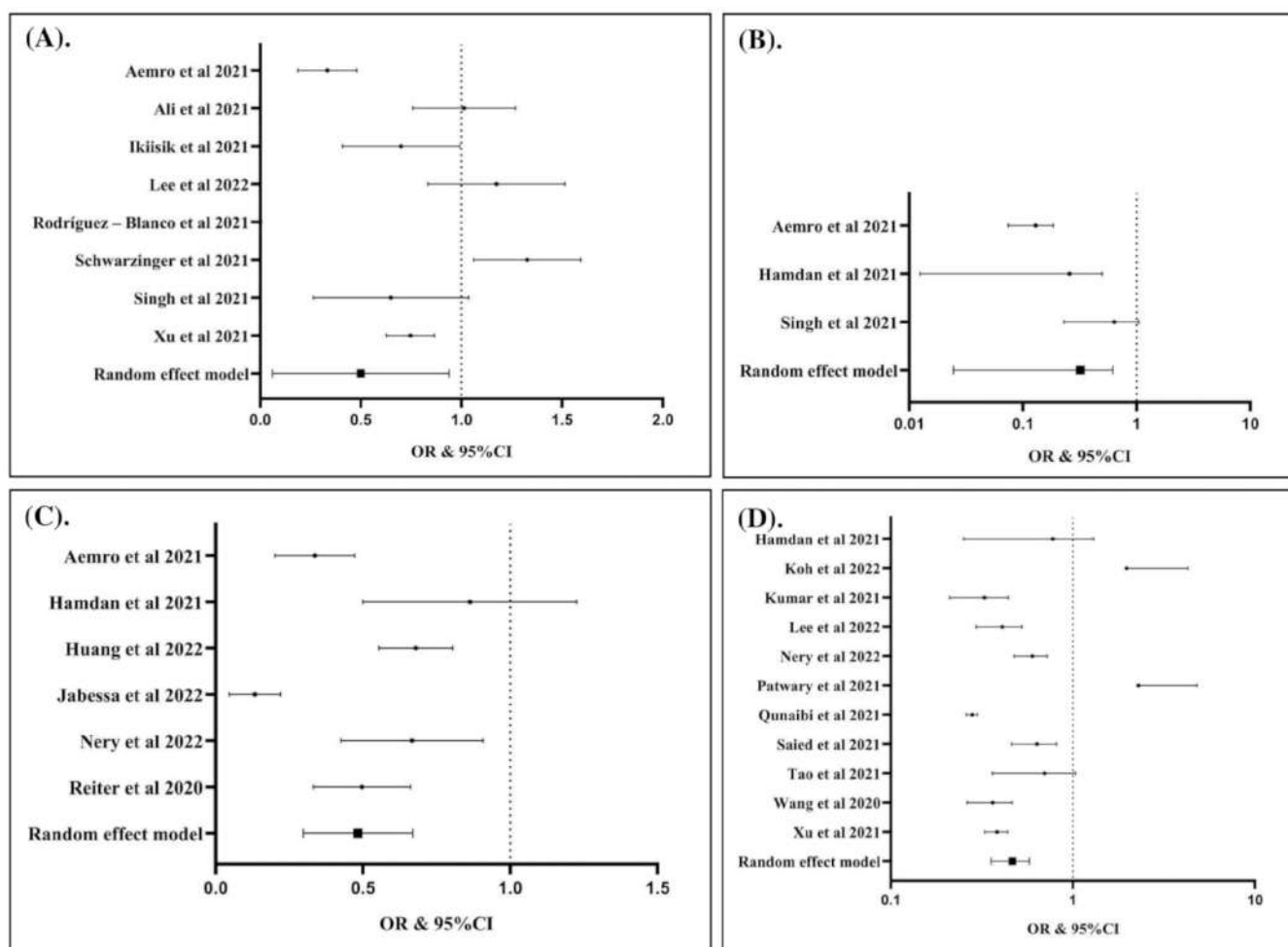


Figure 6. Individuals living with children in the home had lower risk of hesitancy to COVID-19 vaccination (OR: 0.37; 95% CI: 0.14, 0.99; p Egger: 1.4040; p heterogeneity: <0.0001; p : 0.0490) (A); individuals keeping physical distancing had lower risk of hesitancy to COVID-19 vaccination (OR: 0.23; 95% CI: 0.08, 0.65; p Egger: 0.8370; p heterogeneity: 0.0010; p : 0.0050) (B); individuals with history of COVID-19 test were associated with lower risk of hesitancy to COVID-19 vaccination (OR: 0.46; 95% CI: 0.31, 0.68; p Egger: 0.4340; p heterogeneity: <0.0001; p : <0.0001) (C); individuals with history of influenza vaccination in the past few years had lower risk of hesitancy to COVID-19 vaccination (OR: 0.46; 95% CI: 0.36, 0.58; p Egger: 0.3460; p heterogeneity: <0.0001; p : <0.0001) (D). The studies included are provided in the reference list [19,25–79].

In contrast, living with children at home (compared to having no child at home) (Figure 6A), maintaining physical distancing norms (compared to not following such norms) (Figure 6B), having ever tested for COVID-19 (compared to having never tested for COVID-19) (Figure 6C), and having a history of influenza vaccination in the past few years (compared to not having been vaccinated for influenza in the past few years) (Figure 6D) were associated with a lower risk of hesitancy to COVID-19 vaccination.

3.4. Source of Heterogeneity and Potential Publication Bias

Heterogeneity was not found for six variables (Christian religion, household size ≥ 5 individuals, family members with a medical background, smoking, hospitalization due to COVID-19 among people in the same social circle, and death owing to COVID-19 among people in the same social circle). Therefore, we used a fixed-effects model. Conversely, other variables were assessed using a random effects model. The Egger's test was used to assess potential bias among the studies. Our pooled analyses revealed a risk of publication bias for the following covariates: the Christian religion, family members with a medical background,

hospitalization due to COVID-19 among people in the same social circle, and death owing to COVID-19 among people in the same social circle (Table 2).

4. Discussion

Our study estimated the global prevalence of COVID-19 vaccination hesitancy at 25%. The current findings are consistent with those of previous meta-analyses, which estimated the prevalence of vaccine hesitancy in the general population at 26–42% [15,80–83]. In special populations, previous meta-analyses revealed that the hesitancy for COVID-19 vaccination was estimated at 24%, 27%, and 26% in multiple sclerosis patients, older people, and healthcare students, respectively [84–86]. Furthermore, hesitancy to receive a COVID-19 booster was reported at 21% in the general population [87]. Moreover, high rates of COVID-19 vaccine hesitancy were reported among the ethnic minorities in the UK [88]. Our estimate was in the range of extant literature. However, our study had a larger sample size, which might have provided a more accurate calculation. Moreover, in sub-group analysis, we also identified that the prevalence of COVID-19 vaccination hesitancy was 25%, 26%, and 25% in the general population, healthcare workers, and students, respectively. This study also identified the potential predictors of COVID-19 vaccine hesitancy, thereby providing more comprehensive evidence on this phenomenon.

The current study noted that the potential factors associated with COVID-19 vaccination hesitancy can be contextualized in terms of awareness, knowledge, and socioeconomic status. In the context of awareness of COVID-19 vaccination, we found that older people (>50 years), those living with children at home, individuals who have ever tested for COVID-19, and those with a history of influenza vaccination had a lower risk of COVID-19 vaccination hesitancy. In contrast, several factors, such as single marital status and unemployment, were associated with an increased risk of hesitancy toward COVID-19 vaccination.

The precise underlying factors contributing to COVID-19 vaccination hesitancy could not be defined clearly. However, some presumptions may explain these findings. Older individuals are more likely to suffer from one or more chronic diseases compared to younger people. In our previous investigation, we found that advanced age and comorbidity were associated with an increased risk of severity in COVID-19 patients [89]. Therefore, the possibility of an increased risk of severe COVID-19 might influence the awareness of such individuals and contribute to a lower risk of COVID-19 vaccination hesitancy in this group due to low levels of complacency [90].

Similarly, individuals living with children at home might be afraid of transmitting the virus to their children should they be infected with COVID-19. Therefore, it is reasonable that this group is less hesitant to receive COVID-19 vaccination. Interestingly, a similar impact was not observed in individuals living with elderly people at home. This ironic finding is supported by previous studies, which found that living with children was a crucial determinant of health-related behavior [91], whereas this was not the case for individuals living with elderly people [92].

Furthermore, individuals who have ever tested for COVID-19 and had a history of influenza vaccination might have had good practice in disease prevention. Disease screening and vaccination history have been shown to affect health behavior, which can possibly explain why this group is less averse to COVID-19 vaccination. Moreover, married individuals might engage in protective behavior toward their spouse; couples have mutual concern and might have a better life expectancy than single individuals. A previous study found that married individuals had better health behavior and a lower risk of mortality than single individuals [93]. Thus, single individuals might be more averse than married individuals to COVID-19 vaccination. This reason, in the context of poor health behavior, might also explain vaccine hesitancy in unemployed individuals.

Our study also found that individuals with lower educational levels and those who consider COVID-19 vaccines to be unsafe had a higher risk of COVID-19 vaccination hesitancy. In contrast, individuals with healthcare-related jobs had a lower risk of COVID-19 vaccination hesitancy. The association between higher educational levels,

knowledge of disease prevention, and vaccine acceptance or hesitancy has been widely investigated [16,94–96]. Individuals with higher educational levels and healthcare-related jobs might have adequate information on the global pandemic and consider vaccination to be a great step toward ending the pandemic, which can explain why this group had a lower risk of vaccine hesitancy. Our current findings are supported by previous studies in the context of dengue, Ebola, and monkeypox vaccines. Those studies also showed that knowledge of disease prevention and good health practices had a significant impact on the acceptance of vaccine candidates [97–101].

Although we could not elucidate the role of socioeconomic status in COVID-19 vaccination hesitancy in this study, we found that some factors related to socioeconomic status, such as unemployment and household size (≥ 5 individuals), were associated with COVID-19 vaccination hesitancy. Socioeconomic status has been proven to affect health-related behavior [102]. Individuals with a low socioeconomic status might lack knowledge of the pandemic and the role of vaccination in the pandemic. Moreover, individuals with a low socioeconomic status might also lack social interaction; therefore, they might lack adequate knowledge concerning disease prevention, which could contribute to COVID-19 vaccination hesitancy. Previous meta-analyses in this context did not assess the role of socioeconomic status in COVID-19 vaccination hesitancy. However, in other settings, such as in the case of dengue vaccines, socioeconomic status was found to affect vaccination acceptance [100].

To the best of our knowledge, this meta-analysis is the first comprehensive study to assess COVID-19 vaccination hesitancy worldwide. In sub-group analysis, our study identified similar prevalence rates of hesitancy to COVID-19 vaccination in the general population, healthcare workers, and students; suggesting that interventions to reduce the risk of COVID-19 vaccination hesitancy in those populations do not need to be differentiated. In addition to reporting the global prevalence, we also identified the potential factors associated with hesitancy to receive COVID-19 vaccination. Although the COVID-19 vaccination program targets the global population, some people have been hesitant to receive the vaccine. Our study identified the factors associated with such hesitancy, thereby shedding light on the populations that require special attention in order for the vaccination program to be successful. We recommend customized interventions and education for these special populations. A study suggested that customized effective, ethical, and evidence-based communication may be able to increase the acceptance of the COVID-19 vaccination [103]. This customized intervention was suggested to provide by community leaders and healthcare practitioners to establish the trust of COVID-19 vaccination [88]. Moreover, a recent study also reported that providing the population with reliable information regarding the COVID-19 pandemic and the COVID-19 vaccination was associated with the increased rate of vaccination acceptance among the Israeli parents [104]. On the other hand, while we have provided the valuable information on the factors associated with the risk COVID-19 vaccine hesitancy, it should be realized that the main factor driving individuals to be able to receive the vaccinations is the proven effectiveness and safety of vaccines in well-documented long-term studies. However, among those exhibiting COVID-19 vaccination hesitancy, there are people who outright refuse vaccination. Therefore, further studies should be performed with a focus on this group.

There are some potential limitations of our study. First, a meta-analysis is a methodological approach conducted by calculating the crude effect of the related factors to determine the evidence. However, the impact of potential confounding factors is difficult to evaluate. In the current study, potential confounding factors such as the types of COVID-19 vaccine, government regulations, source of information regarding COVID-19 vaccination, and environmental factors were not included; therefore, our findings should be interpreted carefully. We reported that considering the COVID-19 vaccine to be unsafe was one of the factors associated with increased risk of COVID-19 vaccination hesitancy. Considering that the different types of COVID-19 vaccine have different side effects; the factors of the type of vaccine might also govern the final findings. Moreover, the government

regulations in several countries have implemented COVID-19 vaccination as a condition of administration, and the regulations in each country may have differences; thereby, this circumstance may also affect the final findings of this study. Therefore, we reiterate the importance of the basic tenet in studying the phenomenon of vaccine hesitancy, which is the time, context, place, and type specificity. All these peculiarities need to be considered in the efforts aiming to fathom the determinants of vaccine hesitancy [105]. Second, our study involved a multi-national population, and the knowledge of disease prevention among people with similar socioeconomic status and educational level might vary in each region. Third, all the papers included in our study had an observational research design. Therefore, further studies including randomized controlled trials are required in order to obtain better levels of evidence.

5. Conclusions

Our study estimated the global prevalence of COVID-19 vaccination hesitancy at 25%. It also recommended special interventions to minimize COVID-19 vaccination hesitancy among unmarried individuals, women, people with low educational levels, the unemployed, people living in households with five or more individuals, and those who believe COVID-19 vaccines to be unsafe.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/vaccines10081356/s1>, Supplementary S1: PRISMA 2020 Checklist.

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