

Exploring nutritional supplement use for countering respiratory tract infections through an X (formerly Twitter)-based survey

Rajeev K. Singla^{a,1}, Himel Mondal^{b,1}, Shailja Singla^{a,c}, Ronita De^c, Sahar Behzad^d, Mihnea-Alexandru Găman^{e,f}, Siva Sai Chandragiri^g, Merisa Cenanic^h, Jayanta Kumar Patraⁱ, Jennifer R. Depew^j, Hemanth Kumar Boyina^k, Abdulkadir Yusif Maigoro^l, Soojin Lee^l, Omar M. Atrooz^m, Gitishree Dasⁱ, Fabien Schultz^{fn,n}, Emad Mohamed Abdallah^{o,fo}, Hitesh Chopra^p, Jamil Ahmad^q, Rupesh K. Gautam^{a,r}, Sourav S. Patnaik^s, Bey Hing Goh^{t,u,v}, Smith B. Babiaka^w, Sharad Vats^x, Michael P. Okoh^{a,y}, Atallah F. Ahmed^{z,aa}, Ankit Kumar Dubey^{a,c}, Ronan Lordan^{ab}, Parasuraman Aiya Subramani^{ac}, Amit Kumar Singh^{ad}, José M. Alvarez-Suarez^{ae}, Dinesh Kumar Chellappan^{af}, Shravan Kumar Paswan^{ag}, Prabhakar Semwal^{ah}, Johra Khan^{ai}, Sadeeq Sheshe^{aj}, Neeraj Kumar Sethiya^{ak}, Tomasz M. Karpiński^{al}, Muhammad Riaz^{am}, Zahra Emam-Djomeh^{an}, Girish Kumar Gupta^{ao}, Reecha Madaan^{fp}, Suresh Kumar^{ap}, Neeraj Choudhary^{aq}, Salvatore Parisi^{ar}, Harald Willschke^{as,at}, Vasil Pirgozliev^{au}, Rehab A. Rayan^{av}, Valentin Ritschl^{aw,ax}, Shaikat Mondal^{ay}, Gokhan Zengin^{az}, Pritt Verma^{ba}, Bhupinder Kapoor^{bb}, Monica Gulati^{bb}, Gareeballah Osman Adam Balla^{bc}, Dan Khoa Le^{bd}, Valeria Pittalà^{be}, Amr El-Demerdash^{bf,bg}, Garba M. Khalid^{bh}, Jesus Simal-Gandara^{bi}, Qushmua E. Alzahrani^{bj}, Gian Luigi Russo^{bk}, Kiran R. Kharat^{bl}, Anupam Bishayee^{bm}, Dongdong Wang^{bn}, Ilkay Erdogan Orhan^{bo,bp}, Hammad Ullah^{bq}, Michael Heinrich^{br}, Bikash Baral^{bs}, Nikolay T. Tzvetkov^{bt}, Andy Wai Kan Yeung^{bu}, João M.L. Dias-Ferreira^{bv}, Scarlett Perez Olea^{bw}, Yugal Kishore Mohanta^{bx,by}, Azazahemad A. Kureshi^{bz}, Claudiu T. Supuran^{ca}, Neeraj Rani^{cb}, Rohit Gundamaraju^{cc}, Eoghan Joseph Mulholland^{cd,ce}, Sara Di Lonardo^{cf}, Albena T. Dinkova-Kostova^{cg}, Elena González-Burgos^{ch}, Lucian Hritcu^{ci}, Pravin Badhe^{cj,ck,cl}, Abhilasha Singh^{cm}, Fuad Al-Rimawi^{cn}, Antoni Sureda^{co,cp,cq}, Rambod Abiri^{cr,cs}, Nady Braidy^{ct}, Lorenz Kapral^{as}, A.N. Abdullahi^{cu}, Christian Delfino Villanueva Medina^{cv}, Helen Sheridan^{cw,fq}, Massimo Lucarini^{cx}, Alessandra Durazzo^{cx}, Francesca Giampieri^{cy}, Davide Barreca^{cz}, Witkowska Anna Maria^{da}, José Carlos Andrade^{db}, Carmela Fimognari^{dc}, Faizan Akram^{dd}, Aleksei Tikhonov^{de}, Maurizio Battino^{df,dg,dh}, Akolade R. Oladipupo^{di}

Abbreviations: COVID-19, Coronavirus disease 2019; MERS, Middle East respiratory syndrome; NAC, N-acetyl cysteine; NER, Named-Entity Recognition; NLP, Natural Language Processing; NLTK, Natural Language Toolkit; QDA, Qualitative Data Analysis; SARS, Severe acute respiratory syndrome; URTIs, Upper respiratory tract infections; VADER, Valence Aware Dictionary and sEntiment Reasoner; WHO, World Health Organization.

* Corresponding author at: Department of Critical Care Medicine and Institutes for Systems Genetics, Frontiers Science Center for Disease-related Molecular Network, West China Hospital, Sichuan University, Chengdu, China.

** Corresponding author at: Ludwig Boltzmann Institute Digital Health and Patient Safety, Medical University of Vienna, Spitalgasse 23, 1090 Vienna, Austria.

E-mail addresses: atanas.atanasov@lbg.ac.at (A.G. Atanasov), bairong.shen@scu.edu.cn (B. Shen).

<https://doi.org/10.1016/j.crbiot.2025.100282>

Received 9 May 2024; Received in revised form 17 March 2025; Accepted 7 April 2025

Available online 15 April 2025

2590-2628/© 2025 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Mila Emerald^{dj}, Thomas Efferth^{dk}, Said Amrani^{dl}, Javier Echeverría^{dm}, Anna Maria Louka^{dn}, Surya Kant Tripathi^{do}, Bernd L. Fiebich^{dp}, Nour Eddine Es-Safi^{dq}, Shafaat Yar Khan^{dr}, Vivek P. Chavda^{ds}, Muhammad Asim Masoom Zubair^{dt}, Samrina Hussain^{du}, Muhammad Fasih Ur Rahman^{dv}, Joy Odimegwu^{dw}, Jaroslaw Olav Horbanczuk^{dx}, Hari Prasad Devkota^{dy}, Alejandro Cifuentes^{dz}, Rupinder Sodhi^{ea}, Antonello Santini^{eb}, Ourlad Alzeus G. Tantengco^{ec}, Sandeep Ramchandra Pai^{ed}, Ananda Kumar Chettupalli^{ee}, Sebastian Granica^{ef}, Nikola M. Stojanović^{eg}, Devesh Tewari^{eh}, Vineet Mittal^{ei}, Vandana Garg^{ei}, Mohammad Akhlaquer Rahman^{ej}, Rajan Logesh^{ek}, Ioana Berindan-Neagoe^{el}, Rohit Sharma^{em}, Artur Józwick^{en}, Maima Matin^{en}, Emil D. Parvanov^{as, eo}, Nina Strzałkowska^{en}, Farhan Bin Matin^{ep}, Olena Litvinova^{eq, as}, Jivko Stoyanov^{er}, Monika Michalczuk^{es}, Bogumila Zima-Kulisiewicz^{en}, Okyaz Eminaga^{et}, Awanish Mishra^{eu}, Nishat Jahan^{ev}, Joanna Benz^{ew}, Tanuj Joshi^{ex}, Aman Upaganlawar^{ey}, Kiran Patni^{ez}, Aleksandra Zielińska^{fa}, Dalibor Hrg^{fb, fc}, Artur Stolarczyk^{fd}, Olga Adamska^{fe}, George Perry^{ff}, Michał Ławiński^{en, fg}, Agnieszka Kamińska^{fh}, Mario Štefanović^{fi}, Bodrun Naher Siddiquea^{fj}, Sara Frazzini^{fk}, Luciana Rossi^{fk}, Marek Wiczorek^{fl}, Michel Edwar Mickael^{en}, Leif-Alexander Garbeⁿ, Atanas G. Atanasov^{as, en, fm, **}, Bairong Shen^{a, *}

^a Department of Critical Care Medicine and Institutes for Systems Genetics, Frontiers Science Center for Disease-related Molecular Network, West China Hospital, Sichuan University, Chengdu, China

^b Department of Physiology, All India Institute of Medical Sciences, Deoghar, Jharkhand, India

^c iGlobal Research and Publishing Foundation, New Delhi, India

^d Evidence-based Phytotherapy and Complementary Medicine Research Center, Alborz University of Medical Sciences, Karaj, Iran

^e Department of Hematology, Center for Clinical and Basic Research (CCBR Clinic), Bucharest, Romania

^f Department of Cellular and Molecular Pathology, Stefan S. Nicolau Institute of Virology, Romanian Academy, Bucharest, Romania

^g Department of Pathology, University of Oklahoma Health Sciences Center, Oklahoma City, OK, USA

^h Independent Researcher, Sarajevo, Bosnia and Herzegovina

ⁱ Research Institute of Integrative Life Sciences, Dongguk University-Seoul, Goyang-Si, Republic of Korea

^j Independent Researcher, USA

^k University Institute of Pharma Sciences, Chandigarh University, Mohali 140413, Punjab, India

^l Department of Microbiology and Molecular Biology, College of Bioscience and Biotechnology, Chungnam National University, Daejeon 34134, Republic of Korea

^m Department of Biological Sciences, Mutah University, Jordan

ⁿ Ethnopharmacology & Zoopharmacognosy Research Group, Department of Agriculture and Food Sciences, Neubrandenburg University of Applied Sciences, Germany

^o Department of Biology, College of Science, Qassim University, Buraydah 51452, Saudi Arabia

^p Department of Biosciences, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Chennai 602105 Tamil Nadu, India

^q Department of Human Nutrition, The University of Agriculture Peshawar, Khyber Pakhtunkhwa, 25120, Pakistan

^r Department of Pharmacology, Indore Institute of Pharmacy, IIST Campus, Rau, Indore 453331 (M.P.), India

^s The University of Texas Southwestern Medical Center, Dallas, TX, USA

^t Sunway Biofunctional Molecules Discovery Centre (SBMDC), School of Medical and Life Sciences, Sunway University, Sunway City 47500, Malaysia

^u Biofunctional Molecule Exploratory (BMEX) Research Group, School of Pharmacy, Monash University Malaysia, Bandar Sunway 47500, Malaysia

^v College of Pharmaceutical Sciences, Zhejiang University, 866 Yuhangtang Road, Hangzhou 310058, China

^w Department of Chemistry, Faculty of Science, University of Buea, P.O. Box 63, Buea, Cameroon

^x Department of Bioscience and Biotechnology, Banasthali Vidyapith, Rajasthan, India

^y Department of Medical Biochemistry, Faculty of Basic Medical Sciences, College of Health Sciences, University of Abuja, P.M.B 117 FCT, Abuja, Nigeria

^z Department of Pharmacognosy, College of Pharmacy, King Saud University, Riyadh 11451, Saudi Arabia

^{aa} Department of Pharmacognosy, Faculty of Pharmacy, Mansoura University, Mansoura 35516, Egypt

^{ab} Institute for Translational Medicine and Therapeutics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA 19104, USA

^{ac} Thünen Institute for Fisheries Ecology, Herwigstraße 31, 27572 Bremerhaven, Germany

^{ad} Department of Botany, B. M. K. Govt. Girls College Balod, (Hemchand Yadav University), 491226 Chhattisgarh, India

^{ae} Departamento de Ingeniería en Alimentos, Colegio de Ciencias e Ingenierías, Universidad San Francisco de Quito, Ecuador

^{af} Department of Life Sciences, School of Pharmacy, International Medical University, Bukit Jalil 57000, Kuala Lumpur, Malaysia

^{ag} Amity Institute of Pharmacy, Amity University Uttar Pradesh, Lucknow Campus, Lucknow 226010, India

^{ah} Department of Life Sciences, Graphic Era Deemed to be University, Dehradun, UK, India

^{ai} Department of Medical Laboratory Sciences, College of Applied Medical Sciences, Majmaah University, 11952 Al Majmaah, Saudi Arabia

^{aj} Department of Biochemistry, Kano University of Science & Technology, Nigeria

^{ak} Faculty of Pharmacy, School of Pharmaceutical and Populations Health Informatics, DIT University, Dehradun, Uttarakhand 248009, India

^{al} Chair and Department of Medical Microbiology, Poznań University of Medical Sciences, Rokietnicka 10, 60-806 Poznań, Poland

^{am} Department of Pharmacy, Shaheed Benazir Bhutto University, Sheringal, Pakistan

^{an} Transfer Properties Laboratory (TPL), Department of Food Science, Technology and Engineering, University of Tehran, Iran

^{ao} Department of Pharmaceutical Chemistry, Sri Sai College of Pharmacy, Badhani, Pathankot 145001 Punjab, India

^{ap} Department of Pharmaceutical Sciences and Drug Research, Punjabi University, Patiala, India

^{aq} School of Pharmacy, GNA University, Phagwara, Punjab, India

^{ar} Lourdes Matha Institute of Hotel Management and Catering Technology, India

^{as} Ludwig Boltzmann Institute Digital Health and Patient Safety, Medical University of Vienna, Spitalgasse 23, 1090 Vienna, Austria

^{at} Department of Anaesthesia, Intensive Care Medicine and Pain Medicine, Medical University Vienna, Vienna, Austria

^{au} Harper Adams University, Newport, Shropshire TF10 8ND, United Kingdom

^{av} Department of Epidemiology, High Institute of Public Health, Alexandria University, Egypt

^{aw} Section for Outcomes Research, Center for Medical Statistics, Informatics, and Intelligent Systems, Medical University of Vienna, Vienna, Austria

^{ax} Ludwig Boltzmann Institute for Arthritis and Rehabilitation, Vienna, Austria

- ^{ay} Department of Physiology, Raiganj Govt. Medical College and Hospital, WB, India
- ^{az} Department of Biology, Science Faculty, Selcuk University, Konya, Turkey
- ^{ba} Goel Institute of Pharmacy and Sciences, Lucknow, India
- ^{bb} School of Pharmaceutical Sciences, Lovely Professional University, Phagwara, Punjab, India
- ^{bc} Department of Veterinary Medicine and Surgery, Sudan University of Science and Technology, Khartoum-North 11311, Khartoum, Sudan
- ^{bd} Independent Researcher, Berlin, Germany
- ^{be} Department of Drug and Health Science, University of Catania, Catania 95125, Italy
- ^{bf} Metabolic Biology & Biological Chemistry Department, John Innes Centre, Norwich Research Park, Norwich NR4 7UH, United Kingdom
- ^{bg} Organic Chemistry Division, Chemistry Department, Faculty of Science, Mansoura University, Mansoura 35516, Egypt
- ^{bh} Department of Chemical and Pharmaceutical Sciences, Kingston University London, Kingston Upon Thames, Surrey, KT1 2EE, United Kingdom
- ^{bi} Universidad de Vigo, Nutrition and Bromatology Group, Analytical Chemistry and Food Science Department, Faculty of Science, E32004 Ourense, Spain
- ^{bj} Department of Pharmacy/Nursing Medicine Health and Environment, University of the Region of Joinville (UNIVILLE) Brazil, Sana Catarina, Joinville, Brazil
- ^{bk} National Research Council, Institute of Food Sciences, 83100, Avellino, Italy
- ^{bl} V.G. Vaze College (Autonomous), Mulund, Mumbai 400081, India
- ^{bm} College of Osteopathic Medicine, Lake Erie College of Osteopathic Medicine, Bradenton, FL 34211, USA
- ^{bn} Centre for Metabolism, Obesity, and Diabetes Research, Department of Medicine, McMaster University, 1280 Main Street West, Hamilton, ON L8S 4K1, Canada
- ^{bo} Department of Pharmacognosy, Faculty of Pharmacy, Lokman Hekim University, 06510 Ankara, Türkiye
- ^{bp} Turkish Academy of Sciences (TÜBA), Vedat Dalokay Cad., No. 112, 06670 Ankara, Türkiye
- ^{bq} Department of Pharmacy, University of Naples Federico II, 80131 Naples, Italy
- ^{br} Pharmacognosy and Phytotherapy, United Kingdom
- ^{bs} Institute of Biological Resources, Kathmandu, Nepal
- ^{bt} Department of Biochemical Pharmacology and Drug Design, Institute of Molecular Biology "Roumen Tsanev", Bulgarian Academy of Sciences, Bulgaria
- ^{bu} Oral and Maxillofacial Radiology, Applied Oral Sciences and Community Dental Care, Faculty of Dentistry, University of Hong Kong, Hong Kong, China
- ^{bv} Faculty of Medicine, University of Porto, Alameda Prof. Hernâni Monteiro, Porto 4200-319, Portugal
- ^{bw} Universidad Autónoma de Guerrero, Mexico
- ^{bx} Nano-biotechnology and Translational Knowledge Laboratory, Department of Applied Biology, School of Biological Sciences, University of Science and Technology Meghalaya (USTM), Techno City, 9th Mile, Baridua, Ri-Bhoi 793101 Meghalaya, India
- ^{by} Centre for Herbal Pharmacology and Environmental Sustainability, Chettinad Hospital and Research Institute, Chettinad Academy of Research and Education, kelambakkam 603103 Tamil Nadu, India
- ^{bz} Department of Chemistry, Sardar Vallabhbhai National Institute of Technology, Surat, India
- ^{ca} University of Florence, Neurofarba Department, Sezione di Chimica Farmaceutica, Via Ugo Schiff 6, 50019 Sesto Fiorentino (Florence), Italy
- ^{cb} Department of Pharmaceutical Sciences, Chaudhary Bansi Lal University, Bhiwani, India
- ^{cc} ER stress and Mucosal Immunology Team, School of Health Sciences, University of Tasmania, Launceston, Tasmania, Australia
- ^{cd} Gastrointestinal Stem Cell Biology Laboratory, Wellcome Trust Centre for Human Genetics, University of Oxford, Oxford, United Kingdom
- ^{ce} Somerville College, University of Oxford, Oxford, United Kingdom
- ^{cf} Research Institute on Terrestrial Ecosystems-National Research Council (IRET-CNR), Via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy
- ^{cg} Division of Cellular and Systems Medicine, University of Dundee School of Medicine, Dundee, United Kingdom
- ^{ch} Department of Pharmacology, Pharmacognosy and Botany, University Complutense of Madrid, Spain
- ^{ci} Department of Biology, Alexandru Ioan Cuza University of Iasi, Bd. Carol I, No. 11, Iasi 700506, Romania
- ^{cj} Swalife Foundation India
- ^{ck} Swalife Biotech Ltd, Ireland
- ^{cl} Sinhgad College of Pharmacy, Vadgaon (BK), Pune 411041, India
- ^{cm} MGH/Harvard Medical School, USA
- ^{cn} Chemistry Department, Faculty of Science and Technology, Al-Quds University, P.O. Box 20002, Jerusalem, Palestine
- ^{co} Research Group in Community Nutrition and Oxidative Stress (NUCOX), University of Balearic Islands, 07122 Palma de Mallorca, Spain
- ^{cp} CIBER Fisiopatología de la Obesidad y Nutrición (CIBEROBN), Instituto de Salud Carlos III (ISCIII), 28029 Madrid, Spain
- ^{cq} Health Research Institute of Balearic Islands (IdISBa), 07120 Palma de Mallorca, Spain
- ^{cr} Department of Forestry Science and Biodiversity, Faculty of Forestry and Environment, Universiti Putra Malaysia, Seri Kembangan 43400, Malaysia
- ^{cs} Department of Plant Agriculture, University of Guelph, Guelph, ON N1G 2W1, Canada
- ^{ct} Centre for Healthy Brain Ageing, School of Psychiatry, University of New South Wales, Sydney, Australia
- ^{cu} Kano University of Science and Technology, Wudil, Nigeria
- ^{cv} Universidad de la Ciénega del Estado de Michoacán de Ocampo, Licenciatura en Genómica alimentaria, Mexico
- ^{cw} NatPro Centre. School of Pharmacy and Pharmaceutical Sciences. Trinity College Dublin, Dublin 4, Ireland
- ^{cx} CREA-Research Centre for Food and Nutrition, Via Ardeatina, 546, 00178 Rome, Italy
- ^{cy} Research Group on Food, Nutritional Biochemistry and Health, Universidad Europea del Atlántico, Santander, Spain
- ^{cz} Department of Chemical, Biological, Pharmaceutical and Environmental Sciences, Università degli Studi di Messina, Messina, Italy
- ^{da} Department of Food Biotechnology, Medical University of Białystok, Poland
- ^{db} TOXRUN – Toxicology Research Unit, University Institute of Health Sciences – CESPU (IUCS-CESPU), 4585-116 Gandra PRD, Portugal
- ^{dc} Dept. For Life Quality Studies, University of Bologna, Italy
- ^{dd} Department of Pharmaceuticals, Faculty of Pharmacy, The Islamia University of Bahawalpur Pakistan
- ^{de} Gustave Roussy, France
- ^{df} International Joint Research Laboratory of Intelligent Agriculture and Agri-products Processing, Jiangsu University, Zhenjiang, China
- ^{dg} Research Group on Foods, Nutritional Biochemistry and Health, Universidad Europea del Atlántico, Isabel Torres, 21, 39011 Santander, Spain
- ^{dh} Department of Clinical Sciences, Polytechnic University of Marche, Ancona 60131, Italy
- ^{di} Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Lagos, Nigeria
- ^{dj} PHYTOCEUTICALS International, Canada
- ^{dk} Department of Pharmaceutical Biology, Institute of Pharmaceutical and Biomedical Sciences, Johannes Gutenberg University, Mainz, Germany
- ^{dl} Laboratoire de Biologie et de Physiologie des Organismes, Faculté des Sciences Biologiques, Université des Sciences et de la Technologie Houari Boumediène, BP 32 El Alia, Alger 16 111 Algeria
- ^{dmm} Departamento de Ciencias del Ambiente, Facultad de Química y Biología, Universidad de Santiago de Chile, Chile
- ^{dn} General Hospital of Corfu, University of Thessaly, Greece
- ^{do} Lineberger Comprehensive Cancer Center, University of North Carolina at Chapel Hill, NC-27514, USA
- ^{dp} Neuroimmunology and Neurochemistry Research Group, Department of Psychiatry and Psychotherapy, Medical Center-University of Freiburg, Faculty of Medicine, Freiburg, Germany
- ^{dq} Mohammed V University in Rabat, LPCMIO, Materials Science Center (MSC), Ecole Normale Supérieure, Rabat, Morocco
- ^{dr} Department of Zoology, Government College University Lahore, Pakistan
- ^{ds} Department of Pharmaceuticals and Pharmaceutical Technology, L M College of Pharmacy, Ahmedabad, Gujarat, India
- ^{dt} Department of Pharmaceuticals, the Islamia University of Bahawalpur, Pakistan
- ^{du} Department of Drug Design & Pharmacology, University of Copenhagen, Denmark
- ^{dv} Faculty of Pharmacy, The Islamia University of Bahawalpur, Pakistan

- ^{dw} Department of Pharmacognosy, Faculty of Pharmacy, University of Lagos, Nigeria
- ^{dx} Institute of Genetics and Animal Biotechnology of the Polish Academy of Sciences, ul. Postępu 36A, Magdalenka, Jastrzebiec 05-552, Poland
- ^{dy} Graduate School of Pharmaceutical Sciences, Kumamoto University, Kumamoto, Japan
- ^{dz} Foodomics Lab, CIAL, CSIC, Madrid, Spain
- ^{ea} Chandigarh College of Pharmacy, Landran, Mohali, India
- ^{eb} Department of Pharmacy, University of Napoli Federico II, Via D. Montesano 49, 80131 Napoli Italy
- ^{ec} Department of Physiology, College of Medicine, University of the Philippines Manila, Manila, Philippines
- ^{ed} Department of Botany, Rayat Shikshan Sanstha's, Dada Patil Mahavidyalaya, Karjat, Dist. Ahmednagar, Maharashtra 414402, India
- ^{ee} Center for Nanomedicine, Dept. of Pharmaceutics, Anurag University, Ghatkesar, Hyderabad, India
- ^{ef} Microbiota Lab, Department of Biology and Pharmacognosy, Medical University of Warsaw, Poland
- ^{eg} Department of Physiology, Faculty of Medicine, University of Niš, Niš, Serbia
- ^{eh} Department of Pharmacognosy and Phytochemistry, School of Pharmaceutical Sciences, Delhi Pharmaceutical Sciences and Research University, New Delhi 110017, India
- ^{ei} Department of Pharmaceutical Sciences, Maharshi Dayanand University, Rohtak 124001 Haryana, India
- ^{ej} Department of Pharmaceutics and Industrial Pharmacy, College of Pharmacy, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia
- ^{ek} Department of Pharmacognosy, SRM College of Pharmacy, SRM Institute of Science and Technology, Kattankulathur 603203, Tamil Nadu, India
- ^{el} Research Center for Functional Genomics, Biomedicine and Translational Medicine, "Iuliu Hatieganu" University of Medicine and Pharmacy, 400337 Cluj-Napoca, Romania
- ^{em} Department of Rasa Shastra and Bhaishajya Kalpana, Faculty of Ayurveda, Institute of Medical Sciences, Banaras Hindu University, Varanasi 221005 Uttar Pradesh, India
- ^{en} Institute of Genetics and Animal Biotechnology of the Polish Academy of Sciences, Jastrzebiec 05-552 Magdalenka, Poland
- ^{eo} Department of Translational Stem Cell Biology, Research Institute of the Medical University of Varna, Varna, Bulgaria
- ^{ep} Department of Pharmacy, East West University, Aftabnagar, Dhaka, Bangladesh
- ^{eq} National University of Pharmacy of the Ministry of Health of Ukraine, Kharkiv, Ukraine
- ^{er} Swiss Paraplegic Research, Nottwil, Switzerland
- ^{es} Department of Animal Breeding, Institute of Animal Sciences, Warsaw University of Life Sciences - SGGW, Ciszewskiego 8 St., 02-786 Warsaw, Poland
- ^{et} AI VOBIS, Palo Alto, USA
- ^{eu} Department of Pharmacology and Toxicology, National Institute of Pharmaceutical Education and Research (NIPER) - Guwahati, Changsari, Kamrup, Assam 781101, India
- ^{ev} Department of Pharmacy, University of Asia Pacific, 74/A, Green Road, Farmgate Dhaka - 1205, Bangladesh
- ^{ew} Longevity Center, Belwederska 9, 00-761 Warszawa, Poland
- ^{ex} Department of Pharmaceutical Sciences, Bhimtal, Kumaun University (Nainital), Uttarakhand, India
- ^{ey} SNJB's SSDJ College of Pharmacy, Chandwad, Nashik, India
- ^{ez} School of Allied Sciences, Graphic Era Hill University, Bhimtal Campus, Uttarakhand, India
- ^{fa} Department of Biotechnology, Institute of Natural Fibres and Medicinal Plants, National Research Institute, Wojska Polskiego 71B, 60-630 Poznań, Poland
- ^{fb} Hrg Scientific, Croatia
- ^{fc} Artificial Intelligence and Innovation in Healthcare Lab, AI2H Laboratory, Croatia
- ^{fd} Department of Orthopaedics and Rehabilitation, Medical University of Warsaw, 61 Zwirki i Wigury St., 02-091 Warsaw, Poland
- ^{fe} Department of Ophthalmology, Collegium Medicum, Cardinal Stefan Wyszyński University in Warsaw, 5 Dewajtis St., 01-815 Warsaw, Poland
- ^{ff} Department of Neuroscience, Development and Regenerative Biology, University of Texas at San Antonio, USA
- ^{fg} Department of General, Gastroenterologic and Oncologic Surgery, Medical University of Warsaw 02-097 Warsaw, Poland
- ^{fh} Faculty of Medicine, Collegium Medicum, Cardinal Stefan Wyszyński University, 01-815 Warsaw, Poland
- ^{fi} University Hospital Center Sestre Milosrdnice, University Department of Chemistry, Vinogradska cesta 29, 10000 Zagreb, Croatia
- ^{fj} Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia
- ^{fk} Department of Veterinary Medicine and Animal Sciences – DIVAS, University of Milan, Via dell'Università 6, 26900 Lodi, Italy
- ^{fl} Department of Neurobiology, Faculty of Biology and Environmental Protection, University of Lodz, 141/143 Pomorska street, 90-236 Lodz, Poland
- ^{fm} Laboratory of Natural Products and Medicinal Chemistry (LNPMC), Center for Global Health Research, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Thandalam, Chennai, India
- ^{fn} Ethnopharmacology and Zoopharmacognosy, Bernhard Nocht Institute for Tropical Medicine, Germany
- ^{fo} Faculty of Health and Life Sciences, INTI International University, Persiaran Perdana BBN, Putra Nilai, 71800 Nilai, Negeri Sembilan, Malaysia
- ^{fp} Adesh college of Pharmacy, NH 1, Mohri, Shahabad, Kurukshetra, Haryana 136135, India
- ^{fq} Faculty of Pharmacy, Biruni University, Istanbul, TR-34015, Türkiye

ARTICLE INFO

Keywords:
Phytomedicine
Respiratory tract infections
Bacteria
COVID-19
Nutritional supplements
X (formerly Twitter)

ABSTRACT

Background: Respiratory tract infections are a common health issue, driving interest in preventive strategies like nutritional supplements, while evidence on their usage and effectiveness remains limited. In this context, social media platforms, particularly X (formerly Twitter), provide a unique opportunity to gather large-scale public health-related data.

Objectives: In this study, we aimed to survey participants' uses and opinions on nutritional supplements in prevention or treatment of respiratory tract infections, by using X.

Methods: A survey was conducted between 1st and 15th December 2022. A single open-ended question "Which are the best dietary supplements to counteract respiratory infections?" was asked. One week after the start of the survey, a poll was posted to get more relevant information and boost the survey's reach. Total endorsements were calculated for each tweet posted as the total sum of replies, retweets, and likes.

Results: The open-ended question received a total of 118 retweets, 39 quotes, and 371 likes, while the poll received 56 retweets, 13 quotes, and 67 likes. A total of 495 replies, 2,251 retweets, 5,118 likes, and 148 quotes were received for the question and its related tweets. Vitamin D (1,607 endorsements), zinc (1,347 endorsements), vitamin C (803 endorsements), magnesium (694 endorsements), and honey (661 endorsements) were the nutritional supplements that received most endorsements.

Conclusion: Various foods, drinks, and natural ingredients have been suggested as potentially helpful for counteracting respiratory infections. Approximately half of respondents indicated using such supplements for

¹ Both authors have contributed equally and are to be treated as first authors.

themselves. The result of this study supports the idea that the X platform can be used as an effective survey tool to study global health-related behaviours and trends.

Introduction

Respiratory tract infections are a common ailment affecting people of all ages. They cause discomfort and inconvenience and can lead to serious complications, especially in vulnerable populations such as the elderly and immunocompromised individuals (Saleri & Ryan, 2019). Being a very common type of infection and generally with very favorable prognosis, patients may not seek medical help in mild cases and often treat themselves with various modalities of treatment, including home remedies and food supplements (Thota et al., 2020). Several previous studies have found that nutritional supplements like garlic, vitamin D, zinc acetate, and others may be beneficial or have potential benefits in preventing respiratory infections (Abioye et al., 2021; Camargo et al., 2021; Mrityunjaya et al., 2020; Murni et al., 2021; Nantz et al., 2012; Prasad et al., 2008; Trivillin et al., 2022). Over the course of the last two decades, there have been four significant outbreaks of viral infectious diseases, namely Severe Acute Respiratory Syndrome (SARS), Influenza H1N1 (Swine Flu), Middle East Respiratory Syndrome (MERS), and Coronavirus Disease 2019 (COVID-19), resulting in a substantial global mortality toll reaching hundreds of thousands of individuals. These diseases share a common clinical presentation characterized by initial respiratory tract infections affecting both the upper and lower respiratory system (Lombardi et al., 2020).

A respiratory tract infection is a term used to describe any infectious disease affecting either the upper or lower respiratory tract. Upper respiratory tract infections (URTIs) encompass various conditions such as the common cold, laryngitis, pharyngitis/tonsillitis, acute rhinitis, acute rhinosinusitis, and acute otitis media (Heikkinen & Ruuskanen, 2006; Shahan et al., 2019). On the other hand, lower respiratory tract infections comprise ailments like acute bronchitis, bronchiolitis, pneumonia, and tracheitis. In primary care settings, antibiotics are frequently prescribed for both adults and children with respiratory tract infections (Dasaraju & Liu, 1996; Guidelines, 2008).

Natural products offer significant potential as antimicrobial agents due to their diverse chemical structures and bioactive compounds (Raina et al., 2023; Sharma et al., 2023; Singla De, et al., 2023). Echinacea, Cistus, green tea, *Panax quinquefolius*, *Pelargonium sidoides*, *Cyclamen europaeum*, and garlic are only few examples of traditional natural remedies that have been employed since ancient times to alleviate symptoms associated with acute respiratory infections (Langeder et al., 2020).

Nowadays, the integrated approach of study and research networking represents a great challenge (Singla, et al., 2023). Social media has become a valuable tool for health research and communication. Health-related surveys can be conducted on social media platforms like X (formerly Twitter), Facebook, and Instagram. Such surveys can reach a wide range of individuals, including those for whom it may be challenging to get through traditional research methods (Chen & Wang, 2021). However, social media research in the healthcare context has some limitations too. For example, the population reached through social media may not be representative of the general population, and self-reported data may be subject to bias (Ventola, 2014). Additionally, social media survey participants may be more likely to have specific characteristics, such as higher levels of education and income (Thackeray et al., 2013). Despite these limitations, social media can be a valuable tool for conducting health-related surveys, providing a novel approach to gather information about health behaviours, attitudes, and knowledge (S. Mondal et al., 2022; Prieto et al., 2014; Zhou et al., 2018). Along the same lines, crowdsourcing, the process of obtaining ideas or information from a large group of people, has become a popular method for gathering information and generating innovative ideas. Social media

platforms, such as X, have emerged as powerful tools for crowdsourcing, providing a vast and diverse range of perspectives and ideas. In the field of health, crowdsourcing from social media platforms has the potential to provide valuable insights and generate new ideas for addressing various health-related issues (Alvaro et al., 2015; H. Mondal et al., 2022; Singla De, et al., 2023). Nevertheless, although social media platforms like X allow for large-scale, real-time data collection, their use particularly in epidemiological research is limited by factors such as self-reported data, the absence of detailed demographic and clinical information, and the potential for response bias. These limitations necessitate caution in interpreting findings and underscore the need for complementary methods to validate results.

In this study, the use of X as a method for gathering information and opinions on nutritional supplements used to prevent and treat respiratory infections is explored. This methodology allows for a large-scale data collection, providing a diverse range of perspectives and real-time insights. It demonstrates the potential of social media platforms for research purposes.

Materials and methods

Type and setting

The present study represented a mixed-method survey study conducted on X, a social media platform with limited text capacity *per post*. The study was conducted from December 1 to December 15, 2022.

Data collection

This study involved the collection of both qualitative and quantitative data with question and poll, respectively. The question and poll with the dates of posting are shown in Fig. 1. The open-ended question collected qualitative textual data, and the poll collected the total responses in “yes” and “no” votes. In addition, retweets, likes, and quotes

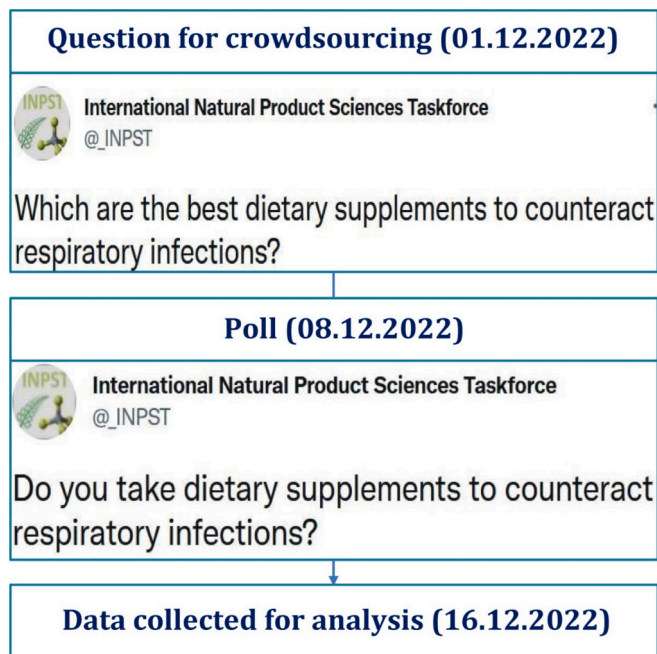


Fig. 1. The survey question and poll with dates of posting on X.

were collected in numbers.

The crowdsourcing survey was done with a single open-ended question: “Which are the best dietary supplements to counteract respiratory infections?”. The tweet with the indicated question was posted from the X handle of the International Natural Products Sciences Taskforce (https://twitter.com/_JNPST), which had 7,857 followers at the time of posting. After one week, a poll was posted on the same thread to get a closed opinion and boost the tweet’s reach. The poll was conducted with the question, “Do you take dietary supplements to counteract respiratory infections?” with “yes” and “no” response options.

For calculating endorsements, we considered each tweet suggesting a specific supplement as one endorsement. If a single tweet included multiple recommendations, each one was recorded and counted separately. For example, in Fig. 2, the displayed representative tweet contains two recommendations (vitamin D and magnesium). If there were X number of retweets, and Y is the number of likes of this tweet, then the total endorsement for each recommended item was calculated as 1 + X + Y.

Importantly, the survey aimed to collect general opinions and self-reported behaviors rather than comprehensive clinical data. Gathering data on variables such as participants’ health conditions, pregnancy status, or duration of supplement use were beyond the scope of this exploratory study.

Data analysis

The text responses were collected from X and cleaned from irrelevant inputs. For instance, tweets with only emojis, appraising or thanking were excluded and not evaluated further. The replies posted in languages other than English were translated to English with the help of Google Translate (<https://translate.google.co.in>) in “Detect language” mode, in order to automatically detects the input language, and converts to English.

The final textual data were first used to generate a word cloud (carried out at <https://www.freewordcloudgenerator.com>) after removing the following words, i.e., dietary, supplement, counteract, respiratory, tract, infection, following, thank, especially, just, work, treatment, symptoms, please, mg, beneficial, review, research, study, meta-analysis, yes, risk, say, high, people, concluded, help, upper, effective, prevent, recommended, effects, use, think, and found. The described filtering was performed to reduce the bulk of less relevant words for the analysis.

The data were further presented according to the occurrence frequency in tabular form. Directly quoted texts were used to represent the result. Qualitative Data Analysis (QDA) Miner Lite was used for the qualitative data analysis of the data collected from the current X-based

survey. QDA Miner Lite is a well-recognized tool for qualitative and quantitative data analysis (Bayked et al., 2022; Kurnianto et al., 2023; Mekashaw Bayked et al., 2022; Singla, Joon, et al., 2023). QDA Miner Lite was chosen for its ability to efficiently organize, code, and analyze textual data. This tool allowed the authors to identify patterns, themes, and sentiments within the user responses collected from X. Its intuitive interface and essential analytical features made it well-suited for handling the open-ended textual data, fulfilling the need for an accessible yet robust software solution for this exploratory study. The collected tweets were analyzed to identify patterns of endorsement for specific supplements. The authors applied reasoning to synthesize the most relevant and representative examples from the range of options provided by users. The resulting representative statements are included in Table 1 to illustrate the endorsements and highlight user opinions.

Further, the literature search was performed in PubMed on 11.06.2023 and the following search terms were utilized (applying a strategy involving a combination of keywords present in titles/abstracts of papers and Medical Subject Headings (MeSH) terms): (dietary supplement [Title/Abstract] OR Vitamin[Title/Abstract] OR Zinc[Title/Abstract] OR Magnesium[Title/Abstract] OR honey[Title/Abstract] OR ginger[Title/Abstract] OR Garlic[Title/Abstract] OR Turmeric[Title/Abstract] OR probiotic[Title/Abstract] OR Green tea[Title/Abstract] OR elderberry[Title/Abstract] OR flavonoid[Title/Abstract] OR lemon [Title/Abstract] OR basil[Title/Abstract] OR pepper[Title/Abstract]) AND (respiratory infection[MESH]). PubMed data was extracted and

Table 1

Top 20 endorsed nutritional supplements to prevent or treat respiratory infections. Quoted text from X was not curated for grammatical improvement. The specific quoted statements are based on the authors’ synthesis reflecting the user-recommendations from the analyzed tweets, representing the most commonly endorsed supplements.

Item	Endorsements	Quoted text example
Vitamin D	1,607	“I take vitamin D with magnesium and I believe it works well better than flu shot”
Zinc	1,347	“Vitamins and zinc may be beneficial dietary supplements to counteract respiratory infections”
Vitamin C	803	“when I have respiratory infections, I take vitamin C (sodium ascorbate)...”
Magnesium	694	“I take vitamin d with magnesium and I believe it works well better than flu shot”
Honey	661	“I usually prefer to take ginger, black pepper, mulethi, tulsi and honey”
Ginger	637	“I usually take ginger”
NAC*	552	“I know the official position, but NAC works for me”
Garlic	472	“I found chewing up raw garlic cloves was the best remedy for the painful sore throat”
Turmeric	450	“the powdered turmeric with luke warm water is very effective”
Probiotics	368	“Probiotics protect against various diseases, including respiratory infections”
Green tea	355	“green tea consumption is effective in the prophylaxis of influenza infections”
Elderberry	322	“Supplementation with elderberry was found to substantially reduce upper respiratory symptoms”
Flavonoids	319	“flavonoid quercetin can ameliorate COVID-19 infection and symptoms”
Multivitamins	284	“I think multivitamin with vitamin C as supplement is best”
Vitamin/s B	276	“I think vitamin B12 is also helpful”
Lemon	227	“Taking lemon juice daily might improve immunity against common cold”
Black seed oil	223	“take black seed oil”
Basil	212	“Holi Basil (Tulsi) is an Indian herb utilised for different diseases. The extracts from this plant is used for common cold or respiratory infection”
Pepper	205	“Traditionally, pepper is good for that as well”

* NAC: N-acetyl cysteine; COVID-19: Coronavirus disease 2019; Mulethi: Licorice; Tulsi: Holy basil.

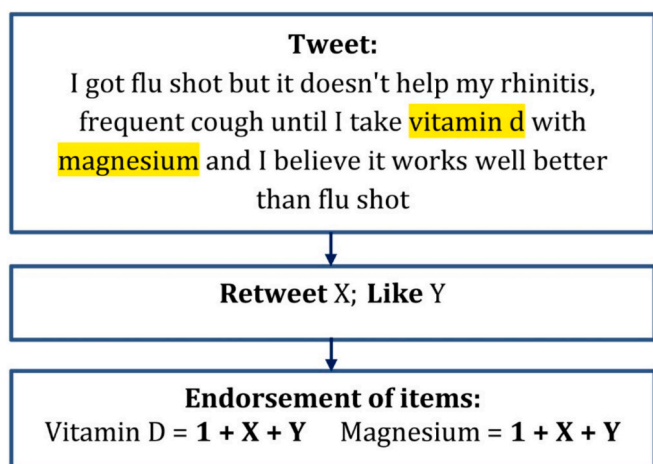


Fig. 2. Calculation of endorsements from a tweet.

imported for further analysis in VOSviewer, a tool used for bibliometric analysis (Cai et al., 2023; Chai et al., 2023; Su et al., 2023; Vaishya et al., 2023; Wang et al., 2023; Zielinska et al., 2023). VOSviewer extracts key terms from titles and abstracts and visualizes co-occurrence networks based on their frequency and relationships within the analysed data. Terms are grouped into clusters, with the strength of connections between terms represented by the thickness of lines and proximity of nodes. For this study, we input relevant PubMed search results (N = 5,298 articles) and generated keyword and MeSH term co-occurrence maps. A minimum occurrence threshold was set at five to ensure robust and meaningful relationships. The algorithm prioritizes terms based on their relevance and link strength, allowing for the identification of prominent research themes related to dietary supplements and respiratory infections. The minimum occurrence threshold in VOSviewer was set at five to achieve a balance between inclusiveness and relevance. This value was chosen to ensure that frequently occurring terms were captured while minimizing the inclusion of infrequent terms that could introduce noise. Similar thresholds have been commonly used in bibliometric analyses, with values typically ranging from 3 to 10 depending on dataset size and research objectives. Given the exploratory nature of our study and the dataset size (5,298 articles), this threshold was deemed appropriate to generate a meaningful co-occurrence network without compromising interpretability.

The poll result was presented in percentage and evaluated statistically by the binomial two-tailed test where a $p < 0.05$ was considered statistically significant. The test was conducted in GraphPad Prism 7.00 for Windows (GraphPad Software, Inc., USA).

Natural Language Processing (NLP) data analysis tasks – sentiment analysis and Named-Entity Recognition (NER) of entity types “chemical” and “disease” – were performed with the Natural Language Toolkit (NLTK) and ScispaCy libraries in Python (Bird et al., 2009; Neumann et al., 2019). NLTK VADER (Valence Aware Dictionary and sEntiment Reasoner) classifier is a lexicon and rule-based sentiment analyser specifically attuned to sentiments expressed in social media. It’s mainstream model for sentiment analysis frequently used in companies and academia. The lexicon dictionary contains around 7,500 sentiment features specifically used in social media. Words not listed in the dictionary are scored as “0: Neutral”. After cleaning text from URLs, hashtags, and mentions, text was tokenized and lemmatized, and compound scores were derived with NLTK VADER into the normalized range –1 to 1. Classification into “Positive”, “Negative” and “Neutral” was performed with the default rule. NER entity types “chemical” and “disease” were derived with a large pre-trained model of biomedical text. A spaCy NER model `en_ner_bc5cdr_md` (F1 = 84.23%) trained on the BC5CDR (BioCreative V Chemical Disease Relation) corpus is used for identification of entity types “chemical” and “disease”. The BC5CDR corpus consists of 1,500 PubMed articles with 4,409 annotated chemicals, 5,818 diseases, and 3,116 chemical-disease interactions. Entity type “chemical” as supplement have been cross-checked with derived sentiment classes.

The selection of visualization methods, including word clouds and term maps, was guided by their ability to effectively summarize and communicate key findings in an intuitive and accessible manner. Word clouds offer a straightforward representation of frequently mentioned terms, making it easier to identify dominant themes at a glance. Term maps, as generated through VOSviewer, provide a structured depiction of keyword relationships, allowing for the recognition of research clusters and co-occurrence patterns. These approaches align with standard bibliometric and text-mining methodologies, ensuring that the presented data remains interpretable to a broad audience while maintaining analytical rigor, and striking a balance between readability and meaningful representation, which is of particular importance given the exploratory nature of this study.

Results

We have successfully conducted a crowdsourcing survey in 15 days on X, yielding 118 retweets, 39 quotes, and 371 likes on the open-ended question. In addition, 56 retweets, 13 quotes, and 67 likes of the poll were received. A total of 495 replies, 2,251 retweets, 5,118 likes, and 148 quotes were generated on all thread tweets.

Altogether, the thread’s tweets contained a total of 9,021 words from the user’s inputs. After removing common and terms not useful for the research intended, we generated a word cloud, shown in Fig. 3. The top 10 words were: vitamin (specifically, vitamin D and vitamin C were frequently mentioned; see also Table 1), zinc, honey, garlic, ginger, N-acetyl cysteine (NAC), magnesium, and tea.

Users from around the world indicated that they were using or suggesting various nutritional supplements alone or in combination to counteract/ combat respiratory infections. Cumulatively, 14,737 endorsements were received, with the top 20 items contributing to 67.95% of the endorsements. The top 20 recommended nutritional supplements to prevent or treat respiratory infections and their respective numbers of endorsements are shown in Table 1.

The poll received 56 retweets, 13 quotes, and 67 likes. A total of 307 votes were obtained, with 166 (54.07%) in agreement and 141 (45.93%) in disagreement votes on the question, “Do you take dietary supplements to counteract respiratory infections?” Hence, about half of the users take dietary supplements to counteract respiratory infections (binomial two-tailed test, $p = 0.17$).

NLP sentiment analysis with NLTK VADER reveals that most responses had positive (50.3%) or neutral (41.9%) sentiment, with only minor negative (7.8%) sentiments received. User device type distribution follows an equal tendency across all three sentiment classes, with most devices being Web App, Android and iOS. Cross-checking of derived “chemical” NERs and sentiments, associates five most endorsed nutritional supplements, vitamin D, zinc, vitamin C, magnesium and honey, predominantly into positive and neutral sentiments.

We further explored PubMed for the available scientific literature on the obtained X-based recommendations using the search terms “dietary supplement, vitamin, zinc, magnesium, honey, ginger, garlic, turmeric, probiotics, green tea, elderberry, flavonoid, lemon, basil, pepper, and respiratory infection.” The indicated search yielded 5,298 results as of June 11, 2023. On processing the PubMed results in VOSviewer, these 5,298 articles resulted in 10,423 keywords, and 1,671 keywords were being repeated in a minimum of 5 publications. The top 15 key terms are given in Table 2. Network interactions between these 1,671 keywords are visualized in Fig. 4. However, when we processed it as per the MeSH terms, we found 5,239 MeSH keywords in those 5,298 articles, and there were 1,374 MeSH terms that minimally occurred five times. The top 15 MeSH key terms are given in Table 2. The obtained data (Table 2) further hint at emphasizing vitamin D uptake in the scientific literature related to respiratory tract infections. Network interactions among the identified 1,374 MeSH terms are visualized in Fig. 5. The association of ascorbic acid, flavonoids, flavones, riboflavin, glycine, and ginger with various respiratory tract infections like tuberculosis, pneumonia, COVID-19, and others, was also evident (Fig. 4). At the same time, examination of the MeSH key terms indicated a strong association of dietary supplements such as vitamin D, curcumin, flavonoids, *Lactobacillus*, magnesium, and ergocalciferol with ailments related to the respiratory tract.

Discussion

Findings from the current study highlight the effectiveness of the social media platform, X, for researching to gather insights and opinions from a large and diverse population. The research also indicates the role of different nutritional supplements that are popularly used for preventing and combating respiratory infections. The remedies identified in this study, including vitamins, minerals, and natural products, align

wider population, which can be reflected in the study results (Guidi et al., 2021; Vicente, 2023). Additionally, X messages have a limited character count, which can lead to oversimplification during discussions of complex topics. Furthermore, recent changes in X due to its ownership change have led to modification of some regulations and practices, which might have implications for the replicability of the outcomes received from our work in future studies (Lordan & Devkota, 2023). X data may also, in general be subject to noise, such as interference from spam or fake accounts, which can negatively impact the validity of the study's results. To counteract the latter limitation, our study relied on manual screening and evaluation of all shared tweets. Another limitation that should be mentioned that while the survey collected international data, was conducted using an English-language survey question. Querying X users with survey questions posted in other languages might provide further insights reflecting different views and experiences. Since X posts are publicly visible, a factor that might peer pressure effects influencing responses should also be considered (with users potentially more likely to give comments that conform to the views of their peers and their online communities). Last but not least, taking into account the need of scientific substantiation of effectiveness of interventions targeting respiratory infections, surveys of experiences in general have constrains related to influencing factors such as cultural traditions or personal beliefs that can result in placebo effects (Finniss et al., 2010). NLP related sentiment classifier such as NLTK VADER can misclassify sentiments due to not being domain-specific. While NLP techniques offer an interesting direction for large data analysis tasks, they warrant developing and benchmarking supervised, self-learning, and deep learning domain-specific sentiment classifiers for highest accuracies. In respect to the potential effectiveness of the recommended supplements, this study is limited by the self-reported nature of data, lack of demographic and clinical variables, potential response bias, and the representativeness of the X user base. The findings should be interpreted as exploratory and hypothesis-generating rather than definitive.

Taking into consideration that the study's reliance on self-reported data from X limits the ability to account for critical demographic and clinical factors, such as participants' age, health status, or duration of supplement use, future studies could integrate more detailed survey questions or combine social media data with traditional epidemiological methods to address these gaps. Thus, despite the outlined limitations, the findings highlight emerging trends and public perceptions, offering a foundation for more rigorous follow-up studies.

Conclusion

The X survey conducted in this study yielded valuable insights into the utilization and perceptions of nutritional supplements and home remedies in combating respiratory infections. This novel approach complements traditional survey methods and provides a unique perspective on public opinions and behaviours. The substantial engagement observed in response to the open-ended question and poll indicated a notable level of interest in the subject matter. The identification of common themes and sentiment analysis provide a nuanced understanding of the public discourse. Findings demonstrated that a significant proportion of individuals worldwide employ or recommend various vitamins, minerals, food components, teas (with or without specific additives), herbs, and other home remedies to counteract respiratory infections. The poll component of the study revealed that slightly over half of the respondents employ nutritional supplements for this purpose. These findings have implications for healthcare professionals, policymakers, and the development of evidence-based recommendations to prevent respiratory infections. Additionally, they can inform the creation of future public health messaging and campaigns aimed at enhancing respiratory health. Further research is warranted to assess the safety and efficacy of the frequently utilized supplements and home remedies in combating respiratory infections. While this study highlights the potential of social media platforms for gathering health-

related insights, it is exploratory in nature and future research should also integrate more robust methodologies to address limitations and provide a comprehensive understanding of public health behaviors.

Funding

This work was supported by the Sichuan Science and Technology Program (Grant Nos. 2025YFHZ0213 and 2024YFHZ0205) and the National Natural Science Foundation of China (Grant No. 32270690).

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: [Authors A.G. Atanasov, Dongdong Wang, Maurizio Battino, Anupam Bishayee, Alejandro Cifuentes, Thomas Efferth, Ilkay Erdogan Orhan, Michael Heinrich, and Gian Luigi Russo are Editorial Board Members of Current Research in Biotechnology but did not participate in the editorial handling and did not have information for the peer-review process of this work].

Data availability

Data will be made available on request.

References

- Abioye, A.I., Bromage, S., Fawzi, W., 2021. Effect of micronutrient supplements on influenza and other respiratory tract infections among adults: a systematic review and meta-analysis. *BMJ Glob. Health* 6 (1). <https://doi.org/10.1136/bmjgh-2020-003176>.
- Al-Azzawi, M.A., AboZaid, M.M.N., Ibrahim, R.A.L., Sakr, M.A., 2020. Therapeutic effects of black seed oil supplementation on chronic obstructive pulmonary disease patients: a randomized controlled double blind clinical trial. *Heliyon* 6 (8), e04711. <https://doi.org/10.1016/j.heliyon.2020.e04711>.
- Alvaro, N., Conway, M., Doan, S., Lofi, C., Overington, J., Collier, N., 2015. Crowdsourcing Twitter annotations to identify first-hand experiences of prescription drug use. *J Biomed Inform* 58, 280–287. <https://doi.org/10.1016/j.jbi.2015.11.004>.
- Aminian, A.R., Mohebbati, R., Boskabady, M.H., 2022. The effect of *Ocimum basilicum* L. and its main ingredients on respiratory disorders: an experimental, preclinical, and clinical review. *Front. Pharmacol.* 12. <https://doi.org/10.3389/fphar.2021.805391>.
- Anibasa, F.O., Abuba, T., Dankyau, M., 2022. Effect of honey on cough symptoms in children with upper respiratory tract infection: a randomised controlled trial. *West Afr J Med* 39 (9), 928–934. <https://www.ncbi.nlm.nih.gov/pubmed/36126325>.
- Anitua, E., Tierno, R., Alkhraisat, M.H., 2022. Current opinion on the role of vitamin D supplementation in respiratory infections and asthma/COPD exacerbations: a need to establish publication guidelines for overcoming the unpublished data. *Clin. Nutr.* 41 (3), 755–777. <https://doi.org/10.1016/j.clnu.2022.01.029>.
- Arunachalam, K., Sasidharan, S.P., Yang, X., 2022. A concise review of mushrooms antiviral and immunomodulatory properties that may combat against COVID-19. *Food Chem. Adv.* 1. <https://doi.org/10.1016/j.focha.2022.100023>.
- Babaei, F., Nassiri-Asl, M., Hosseinzadeh, H., 2020. Curcumin (a constituent of turmeric): new treatment option against COVID-19. *Food Sci Nutr* 8 (10), 5215–5227. <https://doi.org/10.1002/fsn3.1858>.
- Bayked, E.M., Workneh, B.D., Kahissay, M.H., 2022. Sufferings of its consequences; patients with Type 2 diabetes mellitus in North-East Ethiopia. A Qualitative Investigation. *Heliyon* 8 (2), e08871. <https://doi.org/10.1016/j.heliyon.2022.e08871>.
- Bird, S., Klein, E., Loper, E., 2009. *Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit* Vol. %6.
- Butt, M.S., Pasha, I., Sultan, M.T., Randhawa, M.A., Saeed, F., Ahmed, W., 2013. Black pepper and health claims: a comprehensive treatise. *Crit. Rev. Food Sci. Nutr.* 53 (9), 875–886. <https://doi.org/10.1080/10408398.2011.571799>.
- Cai, H., Sha, S., Zhang, Q., Si, T.L., Liu, Y.F., Zheng, W.Y., Su, Z., Cheung, T., Ungvari, G. S., Teo, A.R., Kato, T.A., Ng, C.H., Xiang, Y.T., 2023. Hikikomori: a perspective from bibliometric analysis. *Psychiatry Clin Neurosci.* <https://doi.org/10.1111/pcn.13573>.
- Calverley, P., Rogliani, P., Papi, A., 2020. Safety of N-Acetylcysteine at high doses in chronic respiratory diseases: a review. *Drug Saf.* 44 (3), 273–290. <https://doi.org/10.1007/s40264-020-01026-y>.
- Camargo, C.A., Toop, L., Sluyter, J., Lawes, C.M.M., Waayer, D., Khaw, K.-T., Martineau, A.R., Scragg, R., 2021. Effect of monthly Vitamin D supplementation on preventing exacerbations of asthma or chronic obstructive pulmonary disease in older adults: post hoc analysis of a randomized controlled trial. *Nutrients* 13 (2). <https://doi.org/10.3390/nu13020521>.
- Chai, R., Ye, Z., Wu, Q., Xue, W., Shi, S., Du, Y., Wu, H., Wei, Y., Hu, Y., 2023. Circadian rhythm in cardiovascular diseases: a bibliometric analysis of the past, present, and future. *Eur J Med Res* 28 (1), 194. <https://doi.org/10.1186/s40001-023-01158-8>.

- Chang, J.S., Wang, K.C., Yeh, C.F., Shieh, D.E., Chiang, L.C., 2013. Fresh ginger (Zingiber officinale) has anti-viral activity against human respiratory syncytial virus in human respiratory tract cell lines. *J Ethnopharmacol* 145 (1), 146–151. <https://doi.org/10.1016/j.jep.2012.10.043>.
- Chen, J., Wang, Y., 2021. Social media use for health purposes: systematic review. *J. Med. Internet Res.* 23 (5). <https://doi.org/10.2196/17917>.
- Chen, J., Zhang, C., Xia, Q., Liu, D., Tan, X., Li, Y., Cao, Y., 2020. Treatment with subcritical water-hydrolyzed citrus pectin ameliorated cyclophosphamide-induced immunosuppression and modulated gut microbiota composition in ICR mice. *Molecules* 25 (6). <https://doi.org/10.3390/molecules25061302>.
- Choo, E.K., Ranney, M.L., Chan, T.M., Trueger, N.S., Walsh, A.E., Tegtmeyer, K., McNamara, S.O., Choi, R.Y., Carroll, C.L., 2015. Twitter as a tool for communication and knowledge exchange in academic medicine: A guide for skeptics and novices. *Med Teach* 37 (5), 411–416. <https://doi.org/10.3109/0142159X.2014.993371>.
- Cristofori, F., Dargenio, V.N., Dargenio, C., Miniello, V.L., Barone, M., Francavilla, R., 2021. Anti-inflammatory and immunomodulatory effects of probiotics in gut inflammation: a door to the body. *Front. Immunol.* 12. <https://doi.org/10.3389/fimmu.2021.578386>.
- Darbandi, A., Asadi, A., Ghanavati, R., Affirad, R., Darb Emamie, A., Kakanj, M., Talebi, M., 2021. The effect of probiotics on respiratory tract infection with special emphasis on COVID-19: Systemic review 2010-20. *Int J Infect Dis* 105, 91–104. <https://doi.org/10.1016/j.ijid.2021.02.011>.
- Dasaraju, P. V., & Liu, C. (1996). Infections of the Respiratory System. In S. Baron (Ed.), *Medical Microbiology* (4th ed.). <https://www.ncbi.nlm.nih.gov/pubmed/21413304>.
- de Oliveira, J.R., Antunes, B.S., do Nascimento, G.O., Kawall, J.C.d.S., Oliveira, J.V.B., Silva, K.G.d.S., Costa, M.A.d.T., Oliveira, C.R., 2022. Antiviral activity of medicinal plant-derived products against SARS-CoV-2. *Exp. Biol. Med.* 247 (20), 1797–1809. <https://doi.org/10.1177/15353702221108915>.
- Dhar, S., Bhattacharjee, P., 2021. Promising role of curcumin against viral diseases emphasizing COVID-19 management: a review on the mechanistic insights with reference to host-pathogen interaction and immunomodulation. *J. Funct. Foods* 82. <https://doi.org/10.1016/j.jff.2021.104503>.
- Eftekhar, N., Moghimi, A., Mohammadian Roshan, N., Saadat, S., Boskabady, M.H., 2019. Immunomodulatory and anti-inflammatory effects of hydro-ethanolic extract of *Ocimum basilicum* leaves and its effect on lung pathological changes in an ovalbumin-induced rat model of asthma. *BMC Complement. Altern. Med.* 19 (1). <https://doi.org/10.1186/s12906-019-2765-4>.
- Emran, T.B., Eva, T.A., Zehravi, M., Islam, F., Khan, J., Kareemulla, S., Arjun, U., Balakrishnan, A., Taru, P.P., Nainu, F., Salim, E., Rab, S.O., Nafady, M.H., Wilairatana, P., Park, M.N., Kim, B., 2024. Polyphenols as therapeutics in respiratory diseases: moving from preclinical evidence to potential clinical applications. *Int J Biol Sci* 20 (8), 3236–3256. <https://doi.org/10.7150/ijbs.93875>.
- Eussen, S.R., Verhagen, H., Klungel, O.H., Garssen, J., van Loveren, H., van Kranen, H.J., Rempelberg, C.J., 2011. Functional foods and dietary supplements: products at the interface between pharma and nutrition. *Eur J Pharmacol* 668 (Suppl 1), S2–S9. <https://doi.org/10.1016/j.ejphar.2011.07.008>.
- Finniss, D.G., Kaptchuk, T.J., Miller, F., Benedetti, F., 2010. Biological, clinical, and ethical advances of placebo effects. *Lancet* 375 (9715), 686–695. [https://doi.org/10.1016/s0140-6736\(09\)61706-2](https://doi.org/10.1016/s0140-6736(09)61706-2).
- Gammoh, N., Rink, L., 2017. Zinc in Infection and Inflammation. *Nutrients* 9 (6). <https://doi.org/10.3390/nu9060624>.
- Ganmaa, D., Enkhmaa, D., Nasantogtokh, E., Sukhbaatar, S., Tumur-Ochir, K.E., Manson, J.E., 2021. Vitamin D, respiratory infections, and chronic disease: review of meta-analyses and randomized clinical trials. *J. Intern. Med.* 291 (2), 141–164. <https://doi.org/10.1111/joim.13399>.
- Goldman, P., 2001. Herbal medicines today and the roots of modern pharmacology. *Ann Intern Med* 135 (8 Pt 1), 594–600. https://doi.org/10.7326/0003-4819-135-8-part_1-200110160-00010.
- Goncalves, B., Sanchez, D., 2014. Crowdsourcing dialect characterization through Twitter. *PLoS One* 9 (11), e112074. <https://doi.org/10.1371/journal.pone.0112074>.
- Guidelines, N. C. (2008). Respiratory Tract Infections - Antibiotic Prescribing. In *Respiratory Tract Infections - Antibiotic Prescribing: Prescribing of Antibiotics for Self-Limiting Respiratory Tract Infections in Adults and Children in Primary Care*. <https://www.ncbi.nlm.nih.gov/pubmed/21698847>.
- Guidi, B., Gaisbauer, F., Pournaki, A., Banisch, S., Olbrich, E., 2021. Ideological differences in engagement in public debate on Twitter. *PLoS One* 16 (3). <https://doi.org/10.1371/journal.pone.0249241>.
- Guppy, M.P.B., Mickan, S.M., Del Mar, C.B., Thorning, S., Rack, A., 2011. Advising patients to increase fluid intake for treating acute respiratory infections. *Cochrane Database Syst. Rev.* <https://doi.org/10.1002/14651858.CD004419.pub3>.
- Harris, J.K., Mart, A., Moreland-Russell, S., Caburnay, C.A., 2015. Diabetes topics associated with engagement on Twitter. *Prev Chronic Dis* 12, E62. <https://doi.org/10.5888/pcd12.140402>.
- Hawkins, J., Baker, C., Cherry, L., Dunne, E., 2019. Black elderberry (*Sambucus nigra*) supplementation effectively treats upper respiratory symptoms: a meta-analysis of randomized, controlled clinical trials. *Complement. Ther. Med.* 42, 361–365. <https://doi.org/10.1016/j.ctim.2018.12.004>.
- Heikkinen, T., & Ruuskanen, O. (2006). Upper Respiratory Tract Infection. In *Encyclopedia of Respiratory Medicine* (pp. 385-388). Doi:10.1016/b0-12-370879-6/00416-6.
- Hemila, H., 2003. Vitamin C, respiratory infections and the immune system. *Trends Immunol* 24 (11), 579–580. <https://doi.org/10.1016/j.it.2003.09.004>.
- Holford, P., Carr, A.C., Jovic, T.H., Ali, S.R., Whitaker, I.S., Marik, P.E., Smith, A.D., 2020. Vitamin C—an adjunctive therapy for respiratory infection, sepsis and COVID-19. *Nutrients* 12 (12). <https://doi.org/10.3390/nu12123760>.
- Hughes, D.A., Norton, R., 2009. Vitamin D and respiratory health. *Clin. Exp. Immunol.* 158 (1), 20–25. <https://doi.org/10.1111/j.1365-2249.2009.04001.x>.
- Hunter, J., Arentz, S., Goldenberg, J., Yang, G., Beardley, J., Myers, S.P., Mertz, D., Leeder, S., 2021. Zinc for the prevention or treatment of acute viral respiratory tract infections in adults: a rapid systematic review and meta-analysis of randomised controlled trials. *BMJ Open* 11 (11), e047474. <https://doi.org/10.1136/bmjopen-2020-047474>.
- Im, H., Huh, J., 2017. Does health information in mass media help or hurt patients? investigation of potential negative influence of mass media health information on patients' beliefs and medication regimen adherence. *J. Health Commun.* 22 (3), 214–222. <https://doi.org/10.1080/10810730.2016.1261970>.
- Innocent, E., Marealle, A.I., Imming, P., Moeller, L., 2022. An annotated inventory of traditional medicinal plants traditionally used for the treatment of respiratory bacterial infections. *Plants (base)* 11 (7). <https://doi.org/10.3390/plants11070931>.
- Jarosz, M., Olbert, M., Wyszogrodzka, G., Mlyniec, K., Librowski, T., 2017. Antioxidant and anti-inflammatory effects of zinc Zinc-dependent NF-κB signaling. *Inflammopharmacology* 25 (1), 11–24. <https://doi.org/10.1007/s10787-017-0309-4>.
- Jolliffe, D.A., Camargo Jr., C.A., Sluyter, J.D., Aglipay, M., Aloia, J.F., Ganmaa, D., Bergman, P., Bischoff-Ferrari, H.A., Borzutzky, A., Damsgaard, C.T., Dubnov-Raz, G., Esposito, S., Gilham, C., Ginde, A.A., Golan-Tripto, I., Goodall, E.C., Grant, C.C., Griffiths, C.J., Hibbs, A.M., Martineau, A.R., 2021. Vitamin D supplementation to prevent acute respiratory infections: a systematic review and meta-analysis of aggregate data from randomised controlled trials. *Lancet Diabetes Endocrinol* 9 (5), 276–292. [https://doi.org/10.1016/S2213-8587\(21\)00051-6](https://doi.org/10.1016/S2213-8587(21)00051-6).
- Khare, R., Good, B.M., Leaman, R., Su, A.I., Lu, Z., 2016. Crowdsourcing in biomedicine: challenges and opportunities. *Brief Bioinform* 17 (1), 23–32. <https://doi.org/10.1093/bib/bbv021>.
- Kiselova-Kaneva, Y., Nashar, M., Roussev, B., Salim, A., Hristova, M., Olczyk, P., Komosinska-Vasve, K., Dincheva, I., Badjakov, I., Galunska, B., Ivanova, D., 2023. *Sambucus ebulus* (Elderberry) fruits modulate inflammation and complement system activity in humans. *Int. J. Mol. Sci.* 24 (10). <https://doi.org/10.3390/ijms24108714>.
- Koshak, A.E., Koshak, E.A., Mobeireek, A.F., Badawi, M.A., Wali, S.O., Malibary, H.M., Atwah, A.F., Alhamdan, M.M., Almalki, R.A., Madani, T.A., 2020. Nigella sativa supplementation to treat symptomatic mild COVID-19: a structured summary of a protocol for a randomised, controlled, clinical trial. *Trials* 21 (1). <https://doi.org/10.1186/s13063-020-04647-x>.
- Krawitz, C., Mraheil, M.A., Stein, M., Imirzalioglu, C., Domann, E., Pleschka, S., Hain, T., 2011. Inhibitory activity of a standardized elderberry liquid extract against clinically-relevant human respiratory bacterial pathogens and influenza A and B viruses. *BMC Complement. Altern. Med.* 11 (1). <https://doi.org/10.1186/1472-6882-11-16>.
- Kulyar, M.F.e.A., Li, R., Mehmood, K., Waqas, M., Li, K., Li, J., 2021. Potential influence of Nigella sativa (Black cumin) in reinforcing immune system: a hope to decelerate the COVID-19 pandemic. *Phytomedicine* 85. <https://doi.org/10.1016/j.phymed.2020.153277>.
- Kurnianto, A.A., Khatatbeh, H., Premusz, V., Nemeskeri, Z., Agoston, I., 2023. Managing disabled workers due to occupational accidents in Indonesia: a case study on return to work program. *BMC Public Health* 23 (1), 943. <https://doi.org/10.1186/s12889-023-15930-2>.
- La Fata, G., Weber, P., Mohajeri, M.H., 2017. Probiotics and the Gut Immune System: indirect regulation. *Probiotics Antimicrob. Proteins* 10 (1), 11–21. <https://doi.org/10.1007/s12602-017-9322-6>.
- Langeder, J., Grienne, U., Chen, Y., Kirchmair, J., Schmidtkne, M., Röllinger, J.M., 2020. Natural products against acute respiratory infections: strategies and lessons learned. *J. Ethnopharmacol.* 248. <https://doi.org/10.1016/j.jep.2019.112298>.
- Li, F.S., Weng, J.K., 2017. Demystifying traditional herbal medicine with modern approach. *Nat Plants* 3, 17109. <https://doi.org/10.1038/nplants.2017.109>.
- Lim, S.-L., Mohamed, S., 2016. Functional food and dietary supplements for lung health. *Trends Food Sci. Technol.* 57, 74–82. <https://doi.org/10.1016/j.tifs.2016.08.006>.
- Lombardi, A.F., Afshahi, A.M., Gupta, A., Gholamrezaezhad, A., 2020. Severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), influenza, and COVID-19, beyond the lungs: a review article. *Radiol. Med.* 126 (4), 561–569. <https://doi.org/10.1007/s11547-020-01311-x>.
- Lordan, R., Devkota, H.P., 2023. Turbulence at Twitter with leadership change: implications for health research and science communication. *Exploration of Digital Health Technologies* 4–10. <https://doi.org/10.37349/edht.2023.00002>.
- Luan, R., Ding, D., Xue, Q., Li, H., Wang, Y., Yang, J., 2022. Protective role of zinc in the pathogenesis of respiratory diseases. *Eur. J. Clin. Nutr.* 77 (4), 427–435. <https://doi.org/10.1038/s41430-022-01191-6>.
- Lucas, S., Kumar, D.S., Leach, D.M.J., Phillips, D.A.C., 2020. Complementary and alternative medicine use in Australian children with acute respiratory tract infection - A cross-sectional survey of parents. *Complement. Ther. Clin. Pract.* 39. <https://doi.org/10.1016/j.ctcp.2020.101171>.
- Mahboubi, M., 2018. Natural therapeutic approach of Nigella sativa (Black seed) fixed oil in management of Sinusitis. *Integrative Medicine Research* 7 (1), 27–32. <https://doi.org/10.1016/j.imr.2018.01.005>.
- Mahboubi, M., 2020. *Sambucus nigra* (black elder) as alternative treatment for cold and flu. *Adv. Tradit. Med.* 21 (3), 405–414. <https://doi.org/10.1007/s13596-020-00469-z>.
- Mandal, M.D., Mandal, S., 2011. Honey: its medicinal property and antibacterial activity. *Asian Pac. J. Trop. Biomed.* 1 (2), 154–160. [https://doi.org/10.1016/s2221-1691\(11\)60016-6](https://doi.org/10.1016/s2221-1691(11)60016-6).
- Manna, S., Chowdhury, T., Chakraborty, R., Mandal, S.M., 2020. Probiotics-derived peptides and their immunomodulatory molecules can play a preventive role against viral diseases including COVID-19. *Probiotics Antimicrob. Proteins* 13 (3), 611–623. <https://doi.org/10.1007/s12602-020-09727-7>.

- Martineau, A.R., Jolliffe, D.A., Greenberg, L., Aloia, J.F., Bergman, P., Dubnov-Raz, G., Esposito, S., Ganmaa, D., Ginde, A.A., Goodall, E.C., Grant, C.C., Janssens, W., Jensen, M.E., Kerley, C.P., Laaksi, I., Manaseki-Holland, S., Mauger, D., Murdoch, D.R., Neale, R., Hooper, R.L., 2019. Vitamin D supplementation to prevent acute respiratory infections: individual participant data meta-analysis. *Health Technol Assess* 23 (2), 1–44. <https://doi.org/10.3310/hta23020>.
- Matin, M., Hrg, D., Litvinova, O., Lysek-Gladyńska, M., Wierzbicka, A., Horbanczuk, J. O., Jozwik, A., Atanasov, A.G., 2024. The global patent landscape of functional food innovation. *Nat Biotechnol* 42 (10), 1493–1497. <https://doi.org/10.1038/s41587-024-02410-0>.
- Maywald, M., Rink, L., 2022. Zinc in human health and infectious diseases. *Biomolecules* 12 (12). <https://doi.org/10.3390/biom12121748>.
- Mekashaw Bayked, E., Haile Kahissay, M., Demeke Workneh, B., 2022. The “Life-World” trip of type 2 diabetes patients with allopathic treatment options: a triangulated qualitative investigation. *Ann Med* 54 (1), 2714–2724. <https://doi.org/10.1080/07853890.2022.2122552>.
- Mellon, J., Prosser, C., 2017. Twitter and Facebook are not representative of the general population: political attitudes and demographics of British social media users. *Research & Politics* 4 (3). <https://doi.org/10.1177/2053168017720008>.
- Merheb, R., Abdel-Massih, R.M., Karam, M.C., 2019. Immunomodulatory effect of natural and modified Citrus pectin on cytokine levels in the spleen of BALB/c mice. *Int. J. Biol. Macromol.* 121, 1–5. <https://doi.org/10.1016/j.ijbiomac.2018.09.189>.
- Mocanu, M.L., Amariei, S., 2022. Elderberries—a source of bioactive compounds with antiviral action. *Plants* 11 (6). <https://doi.org/10.3390/plants11060740>.
- Mondal, H., Parvanov, E.D., Singla, R.K., Rayan, R.A., Nawaz, F.A., Ritschl, V., Eibensteiner, F., Siva Sai, C., Cenovic, M., Devkota, H.P., Hribersek, M., De, R., Klager, E., Klecka-Pulker, M., Volk-Kernstock, S., Khalid, G.M., Lordan, R., Gaman, M.A., Shen, B., Atanasov, A.G., 2022a. Twitter-based crowdsourcing: What kind of measures can help to end the COVID-19 pandemic faster? *Front Med (lausanne)* 9, 961360. <https://doi.org/10.3389/fmed.2022.961360>.
- Mondal, S., Modak, P.K., Selim, M., Mondal, H., Baidya, C., Hribersek, M., Singla, R.K., Shen, B., Atanasov, A.G., 2022b. Twitter poll as a medium for questionnaire-based health survey: an experience of a pilot study on the preference of systems of medicine for various health conditions. *Cureus* 14 (9), e28767. <https://doi.org/10.7759/cureus.28767>.
- Mrityunjaya, M., Pavithra, V., Neelam, R., Janhavi, P., Halami, P.M., Ravindra, P.V., 2020. Immune-boosting, antioxidant and anti-inflammatory food supplements targeting pathogenesis of COVID-19. *Front. Immunol.* 11. <https://doi.org/10.3389/fimmu.2020.570122>.
- Murni, I.K., Prawirohartono, E.P., Triasih, R., 2021. Potential role of vitamins and zinc on acute respiratory infections including Covid-19. *Global Pediatric Health* 8. <https://doi.org/10.1177/2333794x211021739>.
- Nantz, M.P., Rowe, C.A., Muller, C.E., Creasy, R.A., Stanilka, J.M., Percival, S.S., 2012. Supplementation with aged garlic extract improves both NK and $\gamma\delta$ T cell function and reduces the severity of cold and flu symptoms: a randomized, double-blind, placebo-controlled nutrition intervention. *Clin. Nutr.* 31 (3), 337–344. <https://doi.org/10.1016/j.clnu.2011.11.019>.
- Neumann, M., King, D., Beltagy, I., & Ammar, W. (2019). *ScispaCy: Fast and Robust Models for Biomedical Natural Language Processing* Proceedings of the 18th BioNLP Workshop and Shared Task.
- Organization, G. W. H. (2021). *World Health Organization Model List of Essential Medicines – 22nd List, 2021*. World Health Organization. Retrieved 22.11.2023 from <https://iri.s.who.int/bitstream/handle/10665/345533/WHO-MHP-HPS-EML-2021.02-eng.pdf?sequence=1>.
- Ozen, M., Kocabas Sandal, G., Dinleyici, E.C., 2014. Probiotics for the prevention of pediatric upper respiratory tract infections: a systematic review. *Expert Opin. Biol. Ther.* 15 (1), 9–20. <https://doi.org/10.1517/14712598.2015.980233>.
- Pagano, E., Souto, E.B., Durazzo, A., Sharifi-Rad, J., Lucarini, M., Souto, S.B., Salehi, B., Zam, W., Montanaro, V., Lucarillo, G., Izzo, A.A., Santini, A., Romano, B., 2020. Ginger (Zingiber officinale Roscoe) as a nutraceutical: focus on the metabolic, analgesic, and anti-inflammatory effects. *Phytother. Res.* 35 (5), 2403–2417. <https://doi.org/10.1002/ptr.6964>.
- Park, J.-H., Lee, Y., Choi, M., Park, E., 2023. The role of some vitamins in respiratory-related viral infections: a narrative review. *Clinical Nutrition Research* 12 (1). <https://doi.org/10.7762/cnr.2023.12.1.77>.
- Pecora, F., Persico, F., Argentiero, A., Neglia, C., Esposito, S., 2020. The role of micronutrients in support of the immune response against viral infections. *Nutrients* 12 (10). <https://doi.org/10.3390/nu12103198>.
- Pouramini, A., Asgary, S., 2022. The pros and cons of using elderberry (Sambucus nigra) for prevention and treatment of COVID-19. *Advanced Biomedical Research* 11 (1). <https://doi.org/10.4103/abr.abr.146.21>.
- Prasad, A.S., 2014. Zinc: an antioxidant and anti-inflammatory agent: Role of zinc in degenerative disorders of aging. *J. Trace Elem. Med Biol.* 28 (4), 364–371. <https://doi.org/10.1016/j.jtemb.2014.07.019>.
- Prasad, A.S., Beck, F.W.J., Bao, B., Snell, D., Fitzgerald, J.T., 2008. Duration and severity of symptoms and levels of plasma interleukin-1 receptor antagonist, soluble tumor necrosis factor receptor, and adhesion molecules in patients with common cold treated with zinc acetate. *J Infect Dis* 197 (6), 795–802. <https://doi.org/10.1086/528803>.
- Prieto, V.M., Matos, S., Alvarez, M., Cacheda, F., Oliveira, J.L., 2014. Twitter: a good place to detect health conditions. *PLoS One* 9 (1), e86191. <https://doi.org/10.1371/journal.pone.0086191>.
- Raina, K., Chaudhary, A., Sharma, P., Sharma, R., Bhardwaj, K., Kumar, P., Kabra, A., Thakur, S., Chaudhary, A., Prajapati, M., Prajapati, P.K., Singla, R.K., Sharma, R., 2023. Phytochemical profiling and biological activities of *Diplazium esculentum* (Retz.) Sw.: an edible vegetable fern. *Drug Metabolism and Personalized Therapy*. <https://doi.org/10.1515/dmpt-2023-0035>.
- Rawangkan, A., Kengkla, K., Kanchanasurakit, S., Duangjai, A., Saokaew, S., 2021. Anti-influenza with green tea catechins: a systematic review and meta-analysis. *Molecules* 26 (13). <https://doi.org/10.3390/molecules26134014>.
- Saastamoinen, M., Sarkijarvi, S., Hyypya, S., 2019. Garlic (Allium Sativum) supplementation improves respiratory health but has increased risk of lower hematologic values in horses. *Animals (basel)* 9 (1). <https://doi.org/10.3390/ani9010013>.
- Sadowska, A.M., Verbraecken, J., Darquennes, K., Backer, W.A.D., 2006. Role of N-acetylcysteine in the management of COPD. *Int. J. COPD* 1 (4), 425–434. <https://doi.org/10.2147/copd.2006.1.4.425>.
- Said, S.A., Abdulbaset, A., El-Kholy, A.A., Beskales, O., Sabri, N.A., 2022. The effect of *Nigella sativa* and vitamin D3 supplementation on the clinical outcome in COVID-19 patients: a randomized controlled clinical trial. *Front. Pharmacol.* 13. <https://doi.org/10.3389/fphar.2022.1011522>.
- Saleri, N., & Ryan, E. T. (2019). Respiratory Infections. In *Travel Medicine* (pp. 527-537). Doi:10.1016/b978-0-323-54696-6.00059-8.
- Schloss, J., Leach, M., Brown, D., Hannan, N., Kendall-Reed, P., Steel, A., 2020. The effects of N-acetyl cysteine on acute viral respiratory infections in humans: a rapid review. *Adv Integr Med* 7 (4), 232–239. <https://doi.org/10.1016/j.aimed.2020.07.006>.
- Schön, C., Mödinger, Y., Krüger, F., Doebis, C., Pischel, I., Bonnländer, B., 2021. A new high-quality elderberry plant extract exerts antiviral and immunomodulatory effects in vitro and ex vivo. *Food Agric. Immunol.* 32 (1), 650–662. <https://doi.org/10.1080/09540105.2021.1978941>.
- Shahan, B., Barstow, C., Mahowald, M., 2019. Respiratory conditions: upper respiratory tract infections. *FP Essent* 486, 11–18. <https://www.ncbi.nlm.nih.gov/pubmed/31710453>.
- Sharma, R., Singla, R.K., Kumar, D., Sharma, P., Kumar, L., Kaur, N., Dhawan, R.K., Sharma, S., Dua, K., 2023. Phytochemistry and polypharmacological potential of *colebrookea oppositifolia* smith. *Curr. Top. Med. Chem.* 23 (5), 334–348. <https://doi.org/10.2174/1568026623666221202112414>.
- Singla, R.K., De, R., Efferth, T., Mezzetti, B., Sahab Uddin, M., Sanusi, Ntie-Kang, F., Wang, D., Schultz, F., Kharat, K.R., Devkota, H.P., Battino, M., Sur, D., Lordan, R., Patnaik, S.S., Tsagkaris, C., Sai, C.S., Tripathi, S.K., Gaman, M.A., Shen, B., 2023a. The International Natural Product Sciences Taskforce (INPST) and the power of Twitter networking exemplified through #INPST hashtag analysis. *Phytomedicine* 108, 154520. <https://doi.org/10.1016/j.phymed.2022.154520>.
- Singla, R.K., Joon, S., Sinha, B., Kamal, M.A., Simal-Gandara, J., Xiao, J., Shen, B., 2023b. Current trends in natural products for the treatment and management of dementia: Computational to clinical studies. *Neurosci Biobehav Rev* 147, 105106. <https://doi.org/10.1016/j.neubiorev.2023.105106>.
- Su, Y., Ruan, Z., Li, S., Li, Z., Chang, T., 2023. Emerging trends and research foci of neuromyelitis optica spectrum disorder: a 20-year bibliometric analysis. *Front Immunol* 14, 1177127. <https://doi.org/10.3389/fimmu.2023.1177127>.
- Takeuchi, H., Takahashi-Muto, C., Nagase, M., Kassai, M., Tanaka-Yachi, R., Kiyose, C., 2020. Anti-inflammatory effects of extracts of sweet basil (*Ocimum basilicum* L.) on a Co-culture of 3T3-L1 adipocytes and RAW264.7 macrophages. *J. Oleo Sci.* 69 (5), 487–493. <https://doi.org/10.5650/jos.ess19321>.
- Tang, C.F., Ding, H., Jiao, R.Q., Wu, X.X., Kong, L.D., 2020. Possibility of magnesium supplementation for supportive treatment in patients with COVID-19. *Eur J Pharmacol* 886, 173546. <https://doi.org/10.1016/j.ejphar.2020.173546>.
- Thackeray, R., Crookston, B.T., West, J.H., 2013. Correlates of health-related social media use among adults. *J Med Internet Res* 15 (1), e21.
- Thaggard, S., Reid, S., Chan, A.H.Y., White, C., Fraser, L., Arroll, B.A., Best, E., Whittaker, R., Wells, S., Thomas, M.G., Ritchie, S.R., 2023. Whānau Māori and Pacific peoples’ knowledge, perceptions, expectations and solutions regarding antibiotic treatment of upper respiratory tract infections: a qualitative study. *BMC Infect Dis.* 23 (1). <https://doi.org/10.1186/s12879-023-08431-5>.
- Thimmulappa, R.K., Mudnakudu-Nagaraju, K.K., Shivamallu, C., Subramaniam, K.J.T., Radhakrishnan, A., Bhojraj, S., Kuppusamy, G., 2021. Antiviral and immunomodulatory activity of curcumin: a case for prophylactic therapy for COVID-19. *Heliyon* 7 (2). <https://doi.org/10.1016/j.heliyon.2021.e06350>.
- Thota, S.M., Balan, V., Sivaramakrishnan, V., 2020. Natural products as home-based prophylactic and symptom management agents in the setting of COVID-19. *Phytother. Res.* 34 (12), 3148–3167. <https://doi.org/10.1002/ptr.6794>.
- Trivillin, A., Zanella, S., Castaldo, R.J., Prati, F., Zanonato, S., Carraro, S., Ferraro, V.A., 2022. Early oral nutritional supplements in the prevention of wheezing, asthma, and respiratory infections. *Front. Pediatr.* 10. <https://doi.org/10.3389/fped.2022.866868>.
- Uddin, M.S., Millat, M.S., Baral, P.K., Ferdous, M., Uddin, M.G., Sarwar, M.S., Islam, M. S., 2021. The protective role of vitamin C in the management of COVID-19: a review. *J. Egypt. Public Health Assoc.* 96 (1). <https://doi.org/10.1186/s42506-021-00095-w>.
- Vaishya, R., Gupta, B.M., Mamdapur, G.M.N., Vaish, A., Migliorini, F., 2023. Scientometric analysis of highly cited papers on avascular necrosis of the femoral head from 1991 to 2022. *J Orthop Traumatol* 24 (1), 27. <https://doi.org/10.1186/s10195-023-00709-3>.
- Ventola, C.L., 2014. Social media and health care professionals: benefits, risks, and best practices. *P T* 39 (7), 491–520. <https://www.ncbi.nlm.nih.gov/pubmed/25083128>.
- Vicente, P., 2023. Sampling Twitter users for social science research: evidence from a systematic review of the literature. *Qual. Quant.* 57 (6), 5449–5489. <https://doi.org/10.1007/s11335-023-01615-w>.
- Vlieg-Boerstra, B., de Jong, N., Meyer, R., Agostoni, C., De Cosmi, V., Grimshaw, K., Milani, G.P., Muraro, A., Oude Elberink, H., Pali-Scholl, I., Roduit, C., Sasaki, M., Skypala, I., Sokolowska, M., van Splunter, M., Untersmayr, E., Venter, C.,

- O'Mahony, L., Nwaru, B.I., 2022. Nutrient supplementation for prevention of viral respiratory tract infections in healthy subjects: A systematic review and meta-analysis. *Allergy* 77 (5), 1373–1388. <https://doi.org/10.1111/all.15136>.
- Wang, J., Rani, N., Jakhar, S., Redhu, R., Kumar, S., Kumar, S., Kumar, S., Devi, B., Simal-Gandara, J., Shen, B., Singla, R.K., 2023. *Opuntia ficus-indica* (L.) Mill. - anticancer properties and phytochemicals: current trends and future perspectives. *Front. Plant Sci.* 14. <https://doi.org/10.3389/fpls.2023.1236123>.
- Wessels, I., Fischer, H.J., Rink, L., 2021. Dietary and physiological effects of zinc on the immune system. *Annu. Rev. Nutr.* 41 (1), 133–175. <https://doi.org/10.1146/annurev-nutr-122019-120635>.
- Weyh, C., Krüger, K., Peeling, P., Castell, L., 2022. The role of minerals in the optimal functioning of the immune system. *Nutrients* 14 (3). <https://doi.org/10.3390/nu14030644>.
- Wieland, L.S., Piechotta, V., Feinberg, T., Ludeman, E., Hutton, B., Kanji, S., Seely, D., Garritty, C., 2021. Elderberry for prevention and treatment of viral respiratory illnesses: a systematic review. *BMC Complement Med Ther* 21 (1), 112. <https://doi.org/10.1186/s12906-021-03283-5>.
- York, T., de Wet, H., van Vuuren, S.F., 2011. Plants used for treating respiratory infections in rural Maputaland, KwaZulu-Natal, South Africa. *J Ethnopharmacol* 135 (3), 696–710. <https://doi.org/10.1016/j.jep.2011.03.072>.
- Yuan, L., Zhong, Z.-C., Liu, Y., 2020. Structural characterisation and immunomodulatory activity of a neutral polysaccharide from *Sambucus adnata* Wall. *Int. J. Biol. Macromol.* 154, 1400–1407. <https://doi.org/10.1016/j.ijbiomac.2019.11.021>.
- Zhang, Q., Ju, Y., Ma, Y., Wang, T., 2018. N-acetylcysteine improves oxidative stress and inflammatory response in patients with community acquired pneumonia. *Medicine* 97 (45). <https://doi.org/10.1097/md.00000000000013087>.
- Zhang, Z., Hao, M., Zhang, X., He, Y., Chen, X., Taylor, E.W., Zhang, J., 2023. Potential of green tea EGCG in neutralizing SARS-CoV-2 Omicron variant with greater tropism toward the upper respiratory tract. *Trends Food Sci. Technol.* 132, 40–53. <https://doi.org/10.1016/j.tifs.2022.12.012>.
- Zhao, Y., Dong, B.R., Hao, Q., 2022. Probiotics for preventing acute upper respiratory tract infections. *Cochrane Database Syst. Rev.* 2022 (8). <https://doi.org/10.1002/14651858.CD006895.pub4>.
- Zhou, L., Zhang, D., Yang, C., Wang, Y., 2018. Harnessing social media for health information management. *Electron Commer Res Appl* 27, 139–151. <https://doi.org/10.1016/j.elerap.2017.12.003>.
- Zielinska, A., Karczewski, J., Eder, P., Kolanowski, T., Szalata, M., Wielgus, K., Szalata, M., Kim, D., Shin, S.R., Slomski, R., Souto, E.B., 2023. Scaffolds for drug delivery and tissue engineering: the role of genetics. *J Control Release* 359, 207–223. <https://doi.org/10.1016/j.jconrel.2023.05.042>.
- Živanović, S., Pavlović, D., Stojanović, N., Veljković, M., 2019. Attitudes to and prevalence of bee product usage in pediatric pulmonology patients. *European Journal of Integrative Medicine* 27, 1–6. <https://doi.org/10.1016/j.eujim.2019.02.001>.