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WSV2023 - The second meeting of the world society for virology: One health - One world - One virology

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ABSTRACT

The Second International Conference of the World Society for Virology (WSV), hosted by Riga Stradiņš University, was held in Riga, Latvia, on June 15–17th, 2023. It prominently highlighted the recent advancements in different disciplines of virology. The conference had fourteen keynote speakers covering diverse topics, including emerging virus pseudotypes, Zika virus vaccine development, herpesvirus capsid mobility, parvovirus invasion strategies, influenza in animals and birds, West Nile virus and Marburg virus ecology, as well as the latest update in animal vaccines. Discussions further explored SARS-CoV-2 RNA replicons as vaccine candidates, SARS-CoV-2 in humans and animals, and the significance of plant viruses in the 'One Health' paradigm. The presence of the presidents from three virology societies, namely the American, Indian, and Korean Societies for Virology, highlighted the event's significance. Additionally, past president of the American Society for Virology (ASV), formally declared the partnership between ASV and WSV during the conference.

1. Introduction

The World Society for Virology (WSV), founded in 2017, operates as a non-profit entity aiming to facilitate global connections among virologists without imposing restrictions, boundaries, or membership fees. Its primary objective is to establish a diverse network of virologists across different income brackets and geographic regions to promote interdisciplinary collaboration among researchers investigating virology of all disciplines (Abdel-Moneim et al., 2017, 2020). Presently, the WSV boasts a steadily increasing membership exceeding 1900 individuals from 92 countries across 6 continents. Its members include virologists at various career stages, ranging from eminent virology leaders in the field to early-career researchers and postgraduate students with an interest in virology. It holds its meetings biennially; online 2021, and Riga 2023

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Abdel-Moneim et al. (2020); Söderlund-Venermo et al. (2022); WSV, 2023).

The WSV has currently the Elsevier journal, *Virology*, serving as the society's official journal and *Tumour Virus Research* as an affiliated journal, and has forged memoranda of understanding with prominent institutions such as the International Vaccine Institute. Furthermore, it collaborates with an expanding array of virology societies, including those in America (ASV), Brazil, Canada, China, Colombia, Europe (European Society for Virology), Finland, India, Korea, Mexico, Morocco, Spain, and Sweden, as well as the Middle East, Eurasia, and Africa Influenza Stakeholders Network (ME'NA-ISN).

2. Highlights of the conference

The Second International Conference of WSV on the theme **"One Health – One World – One Virology"** took place in Riga, Latvia, and was graciously hosted by Riga Stradiņš University from June 15th to 17th, 2023. The proceedings commenced with an introductory remark from Ms. Agrita Kiopa, Vice-Rector for Science at Riga Stradiņš University, and Richard Kuhn, President of WSV. In the notable presence of Modra Murovska, WSV Council Member and Lead Researcher of the Institute of Microbiology and Virology at Riga Stradiņš University, as well as Maria Söderlund-Venermo, the President-Elect of WSV from Helsinki University, Finland, and Ahmed S. Abdel-Moneim, the founder of the World Society for Virology from Taif University, Saudi Arabia. The event received generous sponsorship from three Platinum sponsors (Leading Med, China; Diamedica, Latvia; and Takeda International), two Gold sponsors (Huvepharma and Boehringer Ingelheim), and four Silver sponsors (Spanish Society for Virology, Global One Health Community, Biotecha Latvia, and Live Riga). The sponsorship enabled reduced participation costs for scientists from low and medium-income countries, ensuring inclusivity and facilitating their attendance at the conference.

We were pleased and honored that a total of 14 esteemed Keynote speakers, all renowned experts in their respective fields, addressed many virology topics of global significance. In addition, virologists, representing 26 countries, presented 87 papers categorized into three main sessions under the overarching themes of 'One Health, One Virology', Human Virology, Animal Virology, and Plant Virology (WSV, 2023).

3. Day 1 - Session I | Zoonotic viruses

The first session was chaired by William C. Wilson, head of the WSV Training and Career Developing Committee, USDA, Arthropod-Borne Animal Diseases Research Unit, Manhattan, USA, and Marietjie Venter, WSV Vice President – Africa, Center for Emerging arbo and respiratory virus research, University of Pretoria, South Africa. The session discussed zoonotic viruses, One Health – One Virome, experimental and natural infection of sheep and mosquitoes with the phlebovirus Rift Valley fever virus, the importance of host factors during alphavirus replication, cellular tropism of Powassan virus and how tick-borne flavivirus NS5 antagonizes interferon signaling.

Keynote 1 by Janet Daly, from the University of Nottingham, UK, presented a very interesting talk about emerging viruses, emphasized a unified approach in virology using pseudotyped viruses (PVs) to study them. She explained how PVs have become essential tools in studying emerging RNA viruses, notably since the SARS-CoV-2 outbreak. She outlined strategies for developing PVs targeting members of *Orthomyxoviridae, Bunyaviridae,* and *Flaviviridae* families, comparing them with HIV and vesicular stomatitis virus systems. She demonstrated PVs' utility in investigating viral entry requirements and neutralizing antibody responses, and discussed remaining challenges in PV development and application.

Keynote 2 was given by Alessandra Scagliarini, from Alma Mater Studiorum, University of Bologna, Italy, who delivered an amazing talk about "ONE WORLD, ONE HEALTH … ONE VIROME". She discussed the complex mammalian virome, emphasizing its ecological significance and potential zoonotic risks. While the Global Virome Project aimed to unveil unknown viruses and prevent pandemics, debates arose regarding its efficacy and sustainability. Scagliarini advocated for a holistic approach considering human-animal interactions and environmental factors in zoonotic risk assessment, highlighting the importance of monitoring viromes in various ecosystems, including invertebrate vectors.

4. Day 1 - Session II | Flaviviruses

The second session on flaviviruses was chaired by Richard J. Kuhn, WSV President, the Trent and Judith Anderson Distinguished Professor in Science, at Purdue University, USA, and Shailendra K Saxena, WSV Head of Membership Review Committee, Vice Dean, Professor & Head at Centre for Advance Research (CFAR), King George's Medical University, Lucknow, India. The topics covered in this session included Zika virus vaccine development and structural studies of flavivirus-antibody interactions, North American tick-borne bandavirus and flavivirus, implications for flavivirus nucleocapsid core-envelope glycoprotein interactions, how metabolism controls virus-host interactions and pathogenesis, as well as the emergence of dengue virus in Nigeria.

Keynote 3 by Theodore C. Pierson, director of the *Vaccine Research Center at NIAID, USA*, discussed the urgent need for Zika virus (ZIKV) vaccine development, spurred by its designation as a Public Health Emergency of International Concern in 2016, due to associated birth defects and neurological complications. His team swiftly developed DNA vaccines, progressing to phase I and II clinical trials. Animal studies revealed nuances in vaccine efficacy, highlighting the importance of neutralizing antibodies and structural protein characteristics. Pierson emphasized the challenge of eliciting protective responses comparable to natural infection and proposed strategies to enhance vaccine effectiveness. Overall, the talk underscored the complexity of ZIKV vaccine development and the potential for accelerated progress to mitigate future outbreaks.

5. Day 1 - Session III | Human DNA viruses

This session was chaired by Maria Söderlund-Venermo, the President-Elect of WSV from Helsinki University, Finland, and Modra Murovska, WSV Council Member and Lead Researcher of the Institute of Microbiology and Virology at Riga Stradiņš University, Latvia. It included featured talks about herpesvirus capsid mobility, parvovirus invasion strategy, persistent parvovirus infection in human tissues, the association of cutavirus with skin lymphoma and parapsoriasis, and JC polyomavirus infection in human cells. Discussions also included the role of human papillomavirus vaccine, the presence of herpesviruses in hospitalized COVID-19 patients, and their involvement in myalgic encephalomyelitis/chronic fatigue syndrome development. Additionally, talks addressed the promotion of host B-cell migration by EBV infection.

Keynote 4 was given by Maija Vihinen-Ranta from the University of Jyväskylä, Finland, who delivered an intriguing presentation regarding the mobility of herpesvirus capsids within chromatin, elucidating virus-induced alterations in chromatin structure. By utilizing advanced microscopy and machine-learning techniques, her research illustrated how capsid movement was initially constrained by chromatin but became more permissive as the infection progressed. Live-cell imaging revealed sub-diffusive capsid motion with reduced diffusion coefficients in chromatin-rich areas, offering valuable insights into viral transport mechanisms within the nucleus and enhancing our understanding of virus-host interactions.

Keynote 5 by Carlos Ros from the University of Bern, Switzerland, delivered an exemplary presentation on the intricacies of receptor switching as a parvovirus invasion strategy. He highlighted the narrow tropism of human parvovirus B19 (B19V) and the mechanisms



Fig. 1. Group photo of the many of the attendees of the WSV2023 in front of the Riga Stradiņš University, Riga, Latvia.

governing its infection cycle. B19V initially binds to globoside receptors in the respiratory epithelium under acidic conditions before transitioning to target erythroid precursor cells (EPCs) in the bone marrow under neutral pH. This receptor switching facilitates precise cell targeting and intracellular trafficking, exemplifying an evolutionary adaptation for efficient virus entry and dissemination.

6. Day 2 - Session I | Influenza and coronaviruses

Chaired by Richard J. Kuhn, President of WSV from Purdue University, USA, and Ahmed S. Abdel-Moneim, WSV Founder and Professor at Taif University, Saudi Arabia, the inaugural plenary keynotes addressed influenza in animals and birds, including the threat posed by the clade 2.3.4.4B H5N1 avian influenza virus. Other discussions in this session covered topics such as the zoonotic potential of bat influenza-A like viruses, concurrent antibody detection in dromedary camels, coronavirus envelope proteins' interactions with host proteins, and mutations in SARS-COV-2 variants' structural proteins during cell culture propagation.

Keynote 6: Stacey Schultz-Cherry, from St Jude Children's Research Hospital, USA, highlighted in her remarkable presentation the persistent threat posed by influenza viruses, particularly strains like H5NX, to global human and animal health. These viruses exhibit an expanded host range, infecting various mammals, including foxes, coyotes, and marine mammals. Genetic alterations, notably in hemagglutinin receptor binding and fusion stability, facilitate interspecies transmission. Surveillance through risk assessment pipelines is essential to identify viruses with heightened potential for mammalian infections, and crucial for pandemic preparedness and managing zoonotic risks.

Keynote 7: Ashley C. Banyard, from the Department of Virology, Animal and Plant Health Agency (APHA-Weybridge), UK, demonstrated the escalating global spread of highly pathogenic avian influenza since 2020. The UK has witnessed over 320 confirmed cases in poultry premises, with significant impacts on wild bird populations and widespread declines. Spillover events into mammalian species raise concerns about these viruses as potential pandemic zoonotic threats. Research efforts aim to understand susceptibility, transmission, risk to commercial sectors, virus survival, impacts on wild birds, and human behaviors affecting virus spread. Collaborative studies seek to address knowledge gaps and enhance understanding for future assessments.

Stacey Schultz-Cherry, representing the ASV, officially announced the partnership between the ASV and the WSV. This partnership aims to foster cooperation among ASV and WSV members and virologists worldwide.

7. Day 2 - Session II| Animal viruses

The session was chaired by Yashpal Malik, WSV secretary, Dean, College of Biotechnology, GADVASU Ludhiana, Punjab, IVRI Izatnagar Bareilly, India, and Gisselle N. Medina WSV-Deputy of the training and career developing committee, Agricultural Research Service (ARS) at Plum Island Animal Disease Center (PIADC), Kansas, USA. The session included discussion about the role of West Nile virus as a bridge between Africa and Europe, the eradication and control of rinderpest and control of diseases in India, developing a BFDV vaccine candidate, and updates on African swine fever virus. Additionally, studies on porcine astrovirus infection in South Korea and the detection of neurotropic astroviruses in wild raccoon dogs were presented as well as the development of a reverse genetic system and infectious mouse model for Akabane virus.

Keynote 8: Giovanni Savini from the Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise Giuseppe Caporale, Teramo, Italy, highlighted West Nile virus (WNV) as a significant zoonotic arbovirus, causing neurological symptoms in humans and animals globally. It was demonstrated how Europe serves as a crucial resting area for migratory birds from Africa, facilitating the spread of WNV strains, particularly lineages 1 and 2. WNV Lineage 1 clade 1A likely originated in North and West Africa in the 1900s, while Lineage 2 strains trace back to South Africa in the 18th to 19th century. These strains move along migratory flyways, highlighting the critical role of bird species in WNV's *trans*-continental spread.

8. Day 2 - Session III | Emerging and re-emerging viral threats

The session, led by Angelika Krūmiņa, Department of Infectology, Riga Stradiņš University, Latvia, and Burtram C. Fielding, Molecular Biology and Virology Research Laboratory, University of the Western Cape, South Africa, included discussions about Marburg Virus ecology and transmission, CEPI's efforts in accelerating vaccine development against future pandemics, the impact of the COVID-19 pandemic on the diagnosis of West Nile virus infections in South Africa and resistance mechanisms of tick-borne encephalitis virus against human antibodies.

Keynote 9: Janusz T. Pawęska from the National Institute for Communicable Diseases (NICD), South Africa, provided an outstanding talk about exploring Marburg virus ecology, emphasizing its transmission mechanisms. While most filovirus cases stem from human-to-human transmission, initial spillover events occur during encounters with natural reservoirs or secondary hosts, often through hunting. Despite decades of research, filovirus reservoirs, particularly for ebola-viruses, remain elusive, with evidence pointing to bats. Investigations implicate the Egyptian rousette bat as the prime Marburg virus

reservoir, prompting discussions on experimental infections, shedding modes, and potential reservoir ecosystems.

9. Day 2 - Session IV | Diagnostics

This session was chaired by Matthew D. Moore, Treasurer-Elect of the WSV and affiliated with the University of Massachusetts, Amherst, USA, and Ingus Skadiņš, Vice-Dean, Faculty of Medicine, Riga Stradiņš University, Latvia. The session featured an invited lecture by Shirin Ashraf from the MRC-University of Glasgow Centre for Virus Research, UK. Ashraf discussed the application of deep sequencing at the zoonotic interface, revealing novel and high-consequence viruses. The use of next-generation sequencing and serology for detecting hemorrhagic fever viruses and emerging pathogens causing febrile illnesses in sub-Saharan Africa underscores the importance of enhanced surveillance and new diagnostic tools. Other presentations highlighted the significance of rapid detection methods for highly transmissible viral pathogens, including a novel virus concentration technique and a portable nanopore-based sensing platform. Overall, the session highlighted the role of innovative diagnostic tools in diagnostic virology.

This session was followed by a group photo (Fig. 1) and then a poster session, followed by Walk Tours in Old Riga or along Alberta Street with the famous Art Nouveau houses of Riga.

10. Day 2 - Poster session

The presentations covered a diverse range of topics related to virus research, spanning from insect viruses to the molecular mechanisms of virus attenuation and cross-species infection risks posed by bat coronaviruses. Noteworthy vaccine-related studies explored the immunotherapy of hepatitis C virus infection using a heterologous prime/boost vaccine and the development of antiviral treatments against SARS-CoV-2. Other studies delved into the detection and diversity of enteric viruses, the presence of herpesviruses in thyroid glands of patients with autoimmune thyroiditis, and the involvement of viral chemokine receptors in autoimmune diseases. Additionally, research on the prevalence of respiratory viruses among symptomatic individuals, innovative HIV-1 drug resistance testing, and the association between human papillomavirus infections and cancer pathways were also presented. These studies collectively highlighted the diverse strategies employed in virus research and the ongoing efforts to combat viral diseases through innovative diagnostic and therapeutic approaches.

11. Day 3 - Session I | Viral vaccines

This session was chaired by Udeni Balasuriya, Louisiana Animal Disease Diagnostic Laboratory, and Department of Pathobiological Sciences, Louisiana State University, USA, and Dario Di Luca, Università di Ferrara, Italia. The discussion included key topics on the unmet needs of animal vaccines, characterization of the Rift Valley fever vaccine RVAX-1, development of a recombinant dengue virus vaccine, and a baculoviral COVID-19 DNA vaccine. Talks also covered immune responses triggered by SARS-CoV-2 infection versus COVID-19 vaccines and the immunogenicity of the BBIBP-CorV (Sinopharm) COVID-19 vaccine in Morocco.

Keynote 10: Egbert Mundt from Boehringer Ingelheim Animal Health, France, provided a presentation about the unmet needs in animal vaccines and potential approaches to address them. Current vaccines are effective but face challenges such as cost-effectiveness, protection against antigenic variants, and rapid onset and long-lasting immunity. Biomathematical methods can help develop broad-spectrum antigens that induce cross-protective immunity by analyzing amino acid sequences. Early detection of disease outbreaks is crucial, and systems based on artificial intelligence can analyze vast amounts of data to identify and track outbreaks in real time. Boehringer Ingelheim Animal Health has partnered with LifeBit to establish such a system, demonstrating the feasibility of real-time outbreak identification and monitoring.

12. Day 3 - Session II | Viral intervention

This session, presided over by Valērija Groma from the Laboratory of Electron Microscopy at the Institute of Anatomy and Anthropology, Rīga Stradiņš University, Latvia, and Raj Kumar Singh from ICAR-Indian Veterinary Research Institute Uttar Pradesh, India, and President of the Indian Virological Society, encompassed discussions on various topics. These included the potential of SARS-CoV-2-derived RNA replicons as vaccine candidates, the characterization of flavivirus structure and infectivity post non-ionic detergent treatment, the inhibitory effects of Plantaricin NC8 αβ on flaviviruses and SARS-CoV-2, a novel approach for treating HPV-related cervical cancer using E6-siRNA in combination with oxaliplatin, and the introduction of an indirect co-culturing model system correlating lithium's anti-inflammatory properties with endothelial integrity in RVFV inoculated RAW 264.7 cells.

Keynote 11: Luis Enjuanes from the National Center for Biotechnology (CNB–CSIC), Spain, highlighted skillfully the development of SARS-CoV-2-derived RNA replicons as promising vaccine candidates. These propagation-deficient replicons, engineered based on successful models from MERS-CoV, demonstrated safety and efficacy in inducing strong immune responses in animal models. By deleting specific non-essential genes from the SARS-CoV-2 genome, including those affecting replication and attenuation, the replicons were designed to prevent reversion to virulence. Intranasal administration of these replicons expressing S proteins from both previous SARS-CoV-2 strains and the Omicron variant elicited robust humoral and cellular immune responses, providing full protection in mouse models with a single dose.

13. Day 3 - Session III| Plant viruses

The session, chaired by the past WSV President Anupam Varma from the Plant Virology Centre, Indian Agricultural Research Institute, New Delhi, India, and Selvarajan Ramasamy from ICAR-National Research Centre for Banana, Tiruchirappalli, India, included discussions on the potential role of plant viruses in the 'One Health' approach, exploring the connection between plant viruses and broader health considerations. The development of sensitive and innovative diagnostic kits for banana viruses, aiming to improve banana plant quality and enhance production in India.

Keynote 12: Anupam Varma discussed how plant viruses potentially play a role in the 'One Health' approach, despite not replicating in mammals. Their impact on human and animal health is through food scarcity caused by crop damage. The Global South is particularly vulnerable to plant virus epidemics, affecting staple crops. However, plant viruses also offer opportunities, such as expressing therapeutic proteins and contributing to phage therapy for bacterial diseases, highlighting their relevance to the 'One Health' program and the need for greater investment in their research and utilization.

14. Day 3 - Session IV| COVID-19 in humans and animals

The session was chaired by Yashpal Malik, WSV-Secretary, and Esmeralda Vizzi, Biología de Virus, IVIC, Caracas, Venezuela. Discussion focused on the public health implications of SARS-CoV-2 in animals. Talks on the comparative pathology of SARS-CoV-2 in various animals, the phenomenon of long COVID-19, morphological changes and decreased HLA-G expression in gestational COVID-19, and the role of SARS-CoV-2 isolation in cell cultures in improving patient management during hospitalization were presented.

Keyote 13: Udeni BR Balasuriya from the School of Veterinary Medicine and LADDL, Louisiana State University, USA, discussed the transmission of SARS-CoV-2 to various animal species, including pets, farmed animals like minks, and wildlife such as deer and big cats in the



Fig. 2. Closing Ceremony of the WSV2023 at the main hall of Riga Stradiņš University. From the left to the right: William Wilson, the head of the training and career developing committee, Ahmed Abdel-Moneim, WSV Founder, Modra Murovska, WSV-Council (conference co-chair), Maria Söderlund-Venermo, WSV President -Elect, and Richar J Kuhn, WSV- President (conference chair).

US. While there have been reported cases of animal infections, there is no significant evidence of animals transmitting the virus to humans. The presentation explores the implications of virus variants in animals for public health.

15. Day 3 - Session V | Viruses of human concern

The session was overseen by Zaiga Nora-Krūkle, Director and Lead Researcher of the Institute of Microbiology and Virology at Riga Stradiņš University, Latvia, and Sayed F. Abdelwahab, WSV Secretary-Elect, from the College of Pharmacy, Taif University, Saudi Arabia. The discussion encompassed the impact of HIV-1 B and C clades on neuroAIDS, the influence of enterovirus D68 VP3 D18E on capsid assembly, the consideration of hepatitis E virus as a neglected or emerging pathogen in Egypt, immunotherapy for hepatitis C virus infection using a heterologous prime/boost vaccine, and a network analysis examining potent signaling in COVID-19, MPOX, prostate cancer, and mental health.

Keynote 14: Shailendra K. Saxena demonstrated the effect of HIV-1 B and C clade Tat's effect on indoleamine dioxygenase (IDO) and serotonin transporter 5 (5-HTT) expressions on dendritic cells in order to understand neuroAIDS mechanisms. Their study found that HIV-1 clade B Tat upregulates IDO and down-regulates 5-HTT expressions, leading to reduced serotonin levels and increased kynurenine, possibly influencing HIV-associated neurocognitive disorders.

16. Closing ceremony

The conclusion of WSV2023 featured closing remarks by the President of WSV, expressing gratitude to speakers, attendees, sponsors, the local organizing committee, and the hosting institute (Fig. 2). Recognition was given to the top three oral and three poster presentations. Goodman Mulondo from the University of Cape Town, South Africa, Abubakr Omer from Örebro University, Sweden, and Eun-Jee Na from Jeonbuk National University, Jeonbuk, Republic of Korea, received gold, silver, and bronze awards for the best oral presentations, respectively. Meanwhile, Murisi Pedroza from the University of Guadalajara, Mexico, Amandine Chantharath from Institute Pasteur Paris, and Liba Sokolovska from Riga Stradins University, Latvia, received gold, silver, and bronze awards for the best poster presentations, respectively (Fig. 3). Additionally, acknowledgment was extended to Co-chair Modra Murovska and her team, including conference secretary Ms. Liga Hartpenga, for their exceptional efforts in running an outstanding meeting (Fig. 4). Proposals for the next WSV conference, WSV 2025, were received from the Czech Republic, India, Malaysia, and Morocco, with Malaysia's proposal finally selected to host WSV2025 from May 6 to 8, 2025 in Kuala Lumpur, Malaysia.

The WSV2023 conference highlighted the significant challenges in addressing emerging and re-emerging viruses, stressing on the necessity for collaborative action among virologists worldwide to mitigate the global threat of new pathogenic infections affecting humans, animals, and plants. The WSV founder urged the participants of the conference and members, to be the ambassadors of WSV in fostering a strong global network of virologists and academic societies. This collaboration is essential for engaging a majority of virologists worldwide in the WSV, facilitating more collaborative virology research for the betterment of

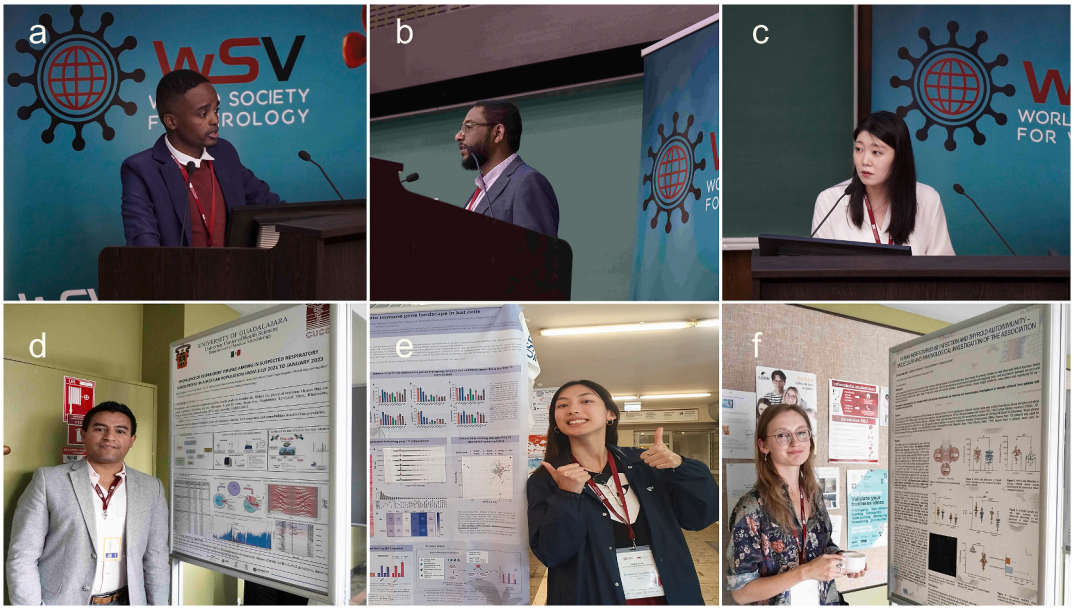

Fig. 3. Honoring of the best poster and best oral presentations in the WSV 2023. a) Goodman Mulondo (Gold award, oral presentation), b) Abubakr Omer (Silver award, oral presentation), c) Eun-Jee Na (Bronze award, oral presentation), d) Murisi Pedroza (Gold award, poster presentation), e) Amandine Chantharath (Silver award, poster presentation), and f) Liba Sokolovska (Bronze award, oral presentation).



Fig. 4. Honoring of the WSV2023 local organizers: Modra Murovska, head of the local committee and conference co-chair and Liga Hartpenga, conference secretary. From left to the right Richard Kuhn, Liga Hartpenga, Modra Murovska, William Wilson, Maria Söderlund-Venermo, and Ahmed Abdel-Moneim.

humanity and global well-being. WSV, alongside other national virology societies, possesses the potential to play a pivotal role in advancing this initiative.

CRediT authorship contribution statement

Ahmed S. Abdel-Moneim: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. **Modra Murovska:** Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. **Maria Söderlund-Venermo:** Conceptualization, Supervision, Writing – original draft, Writing – review & editing. **Vikram N. Vakharia:** Writing – original draft, Writing – review & editing. **William C. Wilson:** Conceptualization, Writing – original draft. **Douglas P. Gladue:** Conceptualization, Writing – original draft. **Matthew D. Moore:** Conceptualization, Validation. **Covadonga Alonso:** Conceptualization, Validation. **Sayed F. Abdelwahab:** Conceptualization, Validation. **Marietjie Venter:** Conceptualization, Validation. **Yashpal S. Malik:** Conceptualization, Validation. **Shi Zhengli:** Conceptualization, Methodology. **Shailendra K. Saxena:** Conceptualization, Validation. **Anupam Varma:** Conceptualization, Writing – review & editing. **Richard J. Kuhn:** Conceptualization, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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