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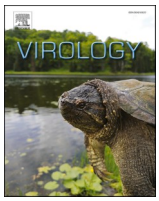

Meeting report: The 3rd international conference of the World Society for Virology (WSV 2025) - The Virosphere of Our Cellular World

A B S T R A C T

The 3rd International Conference of the World Society for Virology (WSV 2025) was held in May 6–8, 2025, in Kuala Lumpur, Malaysia. WSV2025 adopted the integrative theme "The Virosphere of Our Cellular World." This theme denotes the universal and intricate relationships between viruses and their cellular hosts across all domains of life. The conference attracted 291 participants from 27 countries, featuring a scientific program of 83 talks and numerous poster presentations spanning human, animal, plant, insect, and bacterial viruses at basic, clinical and applied levels. This report summarizes the program highlights, key scientific discussions, and significant outcomes of the conference, confirming the WSV's role as a unifying platform for the global virology community since its founding in 2017.

1. Introduction

The World Society for Virology (WSV) was established to transcend traditional boundaries between basic, medical, veterinary, plant, and microbial virology, fostering a collaborative, "One Health"-oriented approach to global viral challenges (Abdel-Moneim et al., 2017, 2020). The society's first international conference in 2021, held virtually, set a high standard for global dialogue on pandemic preparedness and response (Söderlund-Venermo et al., 2022). The second conference in 2023 further solidified this conceptual vision (Abdel-Moneim et al., 2024). The WSV2025 conference, hosted in-person in Kuala Lumpur in collaboration with the National Institute of Biotechnology Malaysia, marked a significant milestone as the society's first major physical gathering in the post-pandemic era. The chosen theme, "The Virosphere of Our Cellular World," provided a powerful, unifying lens to view virology. It emphasized that viruses are not merely pathogens but fundamental components of the biosphere, constantly shaping and being shaped by their cellular environments.

This perspective is critical for understanding viral evolution, emergence, pathogenesis, and utility, particularly when challenged with tropical emerging viruses and arboviruses. Malaysia's status as a megadiverse country provided a fitting backdrop for discussions on viral diversity and ecology. The conference was structured into eleven scientific sessions, meticulously designed to encourage cross-disciplinary dialogue and to explore the virosphere comprehensively, from molecular mechanisms to global ecological impacts. The scientific program was carefully organized into cohesive sessions that flowed seamlessly from fundamental viral biology to applied research and emerging viral threats.

1.1. Opening ceremony

The conference commenced under the distinguished patronage of the Honourable Mr. Chang Lih Kang, Minister of Science, Technology and Innovation (MOSTI). In his opening remarks, the Minister highlighted the indispensable role of science policy in building a resilient, knowledge-driven future founded on evidence, innovation, and international collaboration. He articulated a vision where scientific progress in virology, and indeed in all fields in virology, is nurtured by societies and governments that actively cultivate environments where research can thrive.

The ceremony featured welcoming addresses by Prof. Datuk Wira, Dr. Raha Abdul Rahim, Chief Executive Officer of the National Institutes of Biotechnology Malaysia (NIBM), Prof. Datin Paduka, Dr. Khatijah Yusoff, and Dr. Maria Söderlund-Venermo, President of the World Society for Virology. On behalf of the Society, Dr. Söderlund-Venermo presented a commemorative plaque to Minister Chang, recognizing his enduring commitment to advancing science and innovation in Malaysia (Fig. 1).

In her address, Dr. Söderlund-Venermo extended heartfelt gratitude to the Government of Malaysia, Ministry of Science, Technology and Innovation (MOSTI), and NIBM for their pivotal collaboration. She reflected on the inspiring journey of the WSV, founded in 2017 by Prof. Ahmed S. Abdel-Moneim, whose vision transformed an idea into a vibrant global community. She highlighted a cornerstone of the Society's ethos: maintaining a zero-fee membership model while not only enduring but also flourishing. This commitment, she noted, has enabled the Society to provide crucial financial support to scientists from developing countries, ensuring inclusive and equitable participation in the global scientific dialogue. She also expressed profound gratitude to the event's sponsors, whose generosity was instrumental and reflects a shared commitment to advancing virology through global solidarity.

Dr. Söderlund-Venermo emphasized that this spirit of openness defines the WSV's mission: to bridge scientific, cultural, and geographic divides and to empower virologists worldwide to confront infectious diseases through collaboration and innovation. She also acknowledged with deep appreciation the foundational contributions of Past Presidents Prof. Richard Kuhn and Prof. Anupam Varma, as well as the founder of WSV, Prof. Ahmed Abdel-Moneim (Fig. 1).

The conference opened with sessions dedicated to human and animal

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Fig. 1. Opening Ceremony. a) The ceremony being officially launched by Mr. Chang Lih Kang, Minister of the Ministry of Science, Technology and Innovation (MOSTI). b) Address by Prof. Maria Söderlund-Venermo, President of the World Society for Virology (WSV). c) Presentation of a commemorative plaque to Mr. Chang Lih Kang from the WSV President. d) (From right to left) Prof. Datuk Wira Dr. Raha Abdul Rahim, Chief Executive Officer of the National Institutes of Biotechnology Malaysia (NIBM); Prof. Ahmed S. Abdel-Moneim (WSV Founder); Prof. Richard J. Kuhn (WSV Past President); and Prof. Datin Paduka Dr. Khatijah Yusoff (Head of the Local Organizing Committee).

viruses of major concern, reflecting a continuous thread from previous WSV meetings on global virus epidemics (Abdel-Moneim et al., 2024; Söderlund-Venermo et al., 2022).

1.2. Day 1, session 1: Established and Re-emerging viral threats

Chaired by Richard Kuhn (WSV-Past President) and Ahmed Abdel-Moneim (WSV-Founder), this session provided a powerful overview of the global scientific response to high-consequence pathogens, spanning from molecular discovery to international preparedness. The session commenced with a keynote by Andrea Marzi (NIAID, NIH, USA), who highlighted the persistent threat of filoviruses. She presented groundbreaking progress in developing rapid-response countermeasures, demonstrating single-dose vaccines against both Sudan virus (SUDV) and Bundibugyo virus (BDBV) that elicit protective immunity in nonhuman primate models within just one week of administration. This theme of viral adaptation was further explored by Alessandra Scagliarini (University of Bologna, Italy), who provided crucial insights into the atypical 2022 monkey pox (MPOX) outbreak. Her work moved beyond surveillance bias in available sequence data to identify specific genomic regions, particularly within the viral replication complex, that are critical for understanding the virus' altered replication efficiency and adaptation to human populations.

A significant molecular breakthrough was presented in an invited talk by Ali Mirazimi (President of the Swedish Society for Virology), who identified the Low-Density Lipoprotein Receptor (LDLR) as a critical entry receptor for Crimean-Congo hemorrhagic fever virus. His definitive data showed that LDLR is essential for infection in human models and that its absence delays the disease progress *in vivo*. The data presented unveils a promising and previously unknown target for antiviral intervention. Complementing the focus on human infection, Rushika Perera (Colorado State University, USA) delivered an invited talk revealing how arboviruses like dengue, Zika, and chikungunya systematically rewire the metabolic landscape of their *Aedes aegypti* mosquito vector. These virus-induced alterations in key lipids and energy pathways were shown to be essential for establishing infection, identifying potential new targets for transmission-blocking strategies. Finally, the session highlighted the durability of immune responses and systemic preparedness. Li-Yen Chang (Universiti Malaya, Malaysia) reported that survivors of the 1998 Nipah virus outbreak retain durable antibody and memory B- and T- cell responses even after 25 years, providing a critical benchmark for future vaccine development. Concluding the session, Diana Stepanyan (ERINHA) outlined Europe's coordinated efforts through the ISIDORe and INTERCEPTOR initiatives, showcasing a structured framework for enhancing high-containment research, international collaboration, and rapid outbreak response (Suppl. 1).

1.3. Day 1, session 2: Clinical virology

The second session chaired by Maria Söderlund-Venermo (WSV President) and Syahrilnizam Abdullah (Malaysia Genome and Vaccine Institute), set a high scientific standard for the conference, featuring a series of talks that elegantly traversed the viral life cycle from initial infection to long-term disease. The session opened with a foundational keynote from Lawrence Banks (ICGEB, Italy), who detailed the molecular journey of human papilloma viruses from cellular entry to oncogenic transformation. This theme of intricate host-pathogen interaction was further explored by Carlos Ros (University of Bern, Switzerland), who presented a novel mechanism for parvovirus B19 tropism. His work revealed that the virus is shielded by host protease inhibitors, a sophisticated strategy that prevents premature receptor binding and ensures targeted infection of erythroid progenitor cells. Shifting to epidemiology and public health, Radha Kanta Ratho (President of the Indian Virological Society) provided a comprehensive analysis of the evolving landscape of respiratory viruses. His data illustrated a significant paradigm shift in respiratory synctial virus (RSV) circulation patterns post-COVID-19 and delineated key host-virus interactions, including specific autophagy-related pathways, that dictate disease severity in children. Complementing this, Ahd Ouladlahsen (President of the Moroccan Association of Infectious Pathology) presented critical data revealing a high prevalence of HPV, particularly high-risk genotypes, among women living with HIV-1 in Morocco, underscoring the

need for targeted screening programs. Finally, the session delved into the long-term consequences of viral infections. Maria F. Perdomo (University of Helsinki, Finland) compellingly argued for persistent DNA viruses as dynamic components of the human virome, linking specific Epstein-Barr virus variants to the pathogenesis of multiple sclerosis and lymphoma. This theme of long-term sequelae was powerfully reinforced by Chandran S. Abhinand (Institute of Advanced Virology, India), whose meta-analysis of COVID-19 patient proteomics identified significant molecular overlaps with neurodegenerative pathways, suggesting a potential link between SARS-CoV-2 infection and an increased susceptibility to future neurological complications (Suppl. 1).

1.4. Day 1, session 3: Veterinary viruses

This session, co-chaired by Colin Parrish (Past President of the American Society for Virology) and Aini Ideris (IMU University), showcased critical advancements in animal virology, spanning vaccine innovation, viral evolution, and the identification of emerging threats at the human-animal-environment interface. The session opened with a keynote from Bryan Charleston (Director of the Pirbright Institute, UK), who presented a transformative approach to foot-and-mouth disease virus (FMDV) control through next-generation vaccines. His work detailed engineered virus-like particles (VLPs) that offer superior stability and can be produced cost-effectively outside high-containment facilities, significantly enhancing their global accessibility. The "One Health" initiative was immediately reinforced by Abdul R. Omar (Universiti Putra Malaysia), who emphasized the persistent pandemic threat posed by evolving H5N1 and H9N2 avian influenza viruses, stressing the need for integrated surveillance at the poultry-human interface.

Colin Parrish (Past President of the American Society for Virology), delineated in his invited talk, the molecular underpinnings of the canine parvovirus (CPV) cross-species jump. He demonstrated how a minimal set of mutations altering receptor binding and immune evasion enabled a feline virus to spark a global pandemic in dogs. This theme of viral discovery was extended by Yashpal Malik (Indian Virological Society), who highlighted the identification of novel avian rotaviruses and porcine astroviruses, underscoring the vast, under-explored virosphere.

The focus then shifted to emerging reservoir hosts, with Rajesh Jacob (McMaster University, Canada) reporting the unexpected susceptibility of rabbits, Chinese hamsters, and certain bats to monkeypox virus, revealing potential new pathways for viral maintenance. Concurrently, Martia R. Tacharina (Universitas Airlangga, Indonesia) documented the prevalence of a flying fox gamma retrovirus (FFRV) in an endangered flying fox population, noting its distinct tissue tropism as a potential conservation threat. The session concluded with a series of innovative intervention strategies. Anusyah Rathakrishnan (Pirbright Institute, UK) presented a rationally attenuated African swine fever (ASF) vaccine candidate, the GΔIDKE strain, which demonstrated improved safety and robust protection in pigs following deletion of the interferon-inhibiting gene I267L. For aquaculture, Subha Bhassu (University of Malaya) proposed novel strategies to combat devastating shrimp viruses, including epigenetic modulation and HMGB1-targeted therapies to bolster innate immunity. Junfeng Xie (Sun Yat-sen University, China) elucidated a key immune evasion mechanism of nervous necrosis virus (NNV), where the viral capsid directly degrades host immune components to facilitate replication. Finally, in a striking example of applied virotherapy, Anjali Gowripalan (Australian National University, Australia) provided compelling evidence that oncolytic pox viruses can selectively target and destroy transmissible facial tumors in Tasmanian devils, offering a novel biological tool for wildlife conservation (Suppl.1).

1.5. Day 2, session 4: The epic evolution of viruses

This session, chaired by Marietjie Venter (WSV-President Elect) and Dr. Eddie Chia Suet Lin (Universiti Putra Malaysia), provided a profound exploration of the forces shaping viral evolution and emergence across diverse hosts and ecosystems. The session was opened with two pivotal keynote speakers that framed the scale of viral diversity. Edward Holmes (University of Sydney, Australia) detailed how the application of meta transcriptomics and artificial intelligence has uncovered tens of thousands of novel RNA viruses, effectively illuminating the dark matter of the global virosphere and reshaping our understanding of viral evolution and ecology. This was complemented by Sato Kei (University of Tokyo, Japan), who presented critical research on the dynamics of coronavirus infection and its spread within Asian wildlife reservoirs, highlighting the ongoing risk of zoonotic spillover. A consistent theme was the identification of specific drivers behind viral adaptation. Marietjie Venter demonstrated, through a comprehensive One Health study in South Africa, that wastewater, wildlife, and immunocompromised patients serve as key crucibles for the generation of new, highly mutated SARS-CoV-2 variants. Similarly, El-Sayed M. Abdelwhab (Friedrich-Loeffler-Institut, Germany) elucidated the multi-genic process by which low-pathogenic avian influenza viruses evolve into highly pathogenic forms, showing that mutations beyond the hemagglutinin gene collectively enhance virulence, immune evasion, and tissue tropism. The impact of environmental and ecological factors was further emphasized by Anupam Varma (WSV-Ex-President), who outlined how genetic recombination and efficient whitefly transmission, accelerated by climate change, are driving the rapid spread of plant viruses into new regions and crops. This theme of expanding threat landscapes was reinforced by Sing-Sin Sam (Universiti Malaya, Malaysia), who highlighted the silent spread of neglected Malaysian arboviruses like getah and tembusu viruses, which exhibit high exposure rates in animal populations and a demonstrated capacity to replicate in human cells. Finally, Hamza Ghammaz (National Center for Scientific and Technical Research, Morocco) provided a molecular perspective, identifying a high rate of spike gene mutations in circulating viruses that show significant interactions with the NSP5 protease, suggesting a potent co-evolutionary mechanism that fine-tunes viral fitness (Suppl. 2).

1.6. Day 2, session 5: Advancing diagnostics, therapeutics and vaccines

This session, chaired by Ali Mirazimi (President of the Swedish Society for Virology) and Mohd. Anuar Jonet (Malaysia Genome Institute), showcased cutting-edge advances in viral countermeasure development, spanning novel production platforms, structural insights, and innovative vaccine strategies. The session commenced with a keynote presentation by Janet Daly (Director of Wolfson Centre for Global Virus Research, UK), who demonstrated how transient expression systems in *Nicotiana benthamiana* can rapidly produce milligram quantities of recombinant viral proteins. This versatile platform has been successfully adopted for developing veterinary vaccines against influenza and orbiviruses, while also generating diagnostic antigens for hepaciviruses. Following this, Richard Kuhn (WSV-Past President) provided structural insights into flavivirus entry mechanisms, demonstrating how dengue virus utilizes both heparin as an attachment factor and DC-SIGN for viral entry through adjacent binding sites on its envelope protein, revealing potential targets for entry inhibitors.

Several presentations highlighted innovative vaccine approaches. Kyoko Tsukiyama-Kohara (Kagoshima University, Japan) developed immunocompetent mouse models expressing hepatitis C virus (HCV) proteins through a Cre/loxP system, demonstrating that heterologous prime/boost vaccination significantly reduced hepatic HCV core protein levels compared to homologous regimens. Christopher Broder (Uniformed Services University, USA) reported a thermostable, needle-free microneedle patch vaccine incorporating soluble Hendra virus G glycoprotein, which elicited robust, cross-protective immunity against both Hendra and Nipah viruses in ferrets.

Therapeutic development was presented by Shibo Jiang (Fudan University, China), who presented EK1 and its derivative EK1C4 as potent pan-coronavirus fusion inhibitors effective against all known

human coronaviruses and its variants, with a new long-acting oral candidate, XY4-C7, showing promise. Eddie C. S. Lin (Universiti Putra, Malaysia) described enhanced oncolytic activity through recombinant Newcastle disease virus engineered to express immunomodulatory genes or shRNA. The session also featured advances in surveillance and diagnostic technologies. Shirin Ashraf (MRC-University of Glasgow, UK) employed deep sequencing and serology to identify over 200 viral species, including novel pathogens, in human, vector, and animal populations in Uganda. Nur Izzati Zakaria (Universiti Putra, Malaysia) designed a high-affinity aptamer targeting rice tungro spherical virus capsid protein for diagnostic applications, while Nouhaila Elfellaki (Cadi Ayyad University, Morocco) validated an adsorption-elution method for efficient recovery of human adenoviruses from water sources. Finally, strategic initiatives were highlighted by Dory Kovacs (CEPI, UK), who presented the Coronavirus Vaccine Library of 26 prototype vaccines as part of CEPI's 100 Days Mission, enabling rapid vaccine adaptation during outbreaks. Complementary research by Nurhafiza Zainal (Universiti Malaya) identified host proteins HMGB1 and SIRT1 as potential targets for enhancing antiviral immunity against arboviruses (Suppl.2).

1.7. Day 2, session 6: SARS-CoV-2 and COVID-19

This session, chaired by Burtram Fielding (Stellenbosch University, South Africa) and Rozainanee Mohd Zain (Institute for Medical Research, Malaysia), provided critical insights into the complex pathogenesis of SARS-CoV-2, its long-term health consequences, and novel therapeutic strategies. A significant focus was placed on the mechanisms underlying long COVID and related chronic conditions. In an invited talk, Etheresia Pretorius (Stellenbosch University, South Africa) demonstrated that long COVID is characterized by persistent immune dysfunction and thrombo-inflammation, with lysis-resistant microclots serving as drivers of vascular damage and potential biomarkers for patient stratification. This theme was extended by Massimo Nunes (Stellenbosch University, South Africa), who revealed that ME/CFS patients exhibit a similar hypercoagulable status, with a five-fold increase in microclot burden and proteomic alterations in clotting pathways, suggesting shared vascular and endothelial dysfunction between these post-viral syndromes.

At the cellular level, Giuseppe Balistreri (University of Helsinki, Finland) revealed in his invited talk that SARS-CoV-2 can infect human neurons via an endosomal pathway dependent on cathepsin proteases, providing a potential mechanistic link to neurodegenerative processes. Further elucidating viral manipulation of host biology, Efstathios Giotis (University of Essex, UK) showed that SARS-CoV-2 variants differentially reprogram cellular metabolism, with delta increasing amino acid availability to support rapid replication, while Omicron BA.1 suppresses protein synthesis. Anna Shishova (The Russian Academy of Sciences) identified another key vulnerability, reporting that SARS-CoV-2 blocks the cellular Ire1-Xbp1 stress-defense pathway, unveiling a potential target for host-directed antiviral therapy.

Several other presentations addressed immune responses and viral evolution. Sayeh Ezzikouri (Pasteur Institute of Morocco) found that a two-dose regimen of BBIBP-CorV/Sinopharm, Covishield, or Pfizer/BioNTech vaccines elicited a stronger humoral immunity than a single or three-dose schedules. Florette Treurnicht (University of the Witwatersrand, South Africa), through analysis of 2618 South African genomes, confirmed Omicron dominance (48.6 %) and identified the characteristic V3G signal peptide mutation of the BA.4 subvariant. A notable finding from Rajesh Kumar (Indian Institute of Technology, Roorkee) indicated that SARS-CoV-2 spike antibodies cross-react with the HIV-1 Env gp41 region, though without demonstrating cross-neutralizing activity. Finally, promising interventional approaches were highlighted. Faezeh Ramezani (High Institute for Research and Education in Transfusion Medicine, Iran) presented clinical evidence that a wheat-derived Nutrition Bio-shield super-food significantly improved outcomes in ICU patients with COVID-19 acute respiratory distress (Suppl. 2).

1.8. Day 2, session 7: Food-borne and vector-borne viruses

This session was chaired by William Wilson (Kansas State University, USA) and Mary Jane Cardosa (MAb Explorations Sdn Bhd, Malaysia). Shailendra K. Saxena (King George's Medical University, India) identified curcumin to effectively block the Japanese encephalitis virus (JEV) NS5 protein and to modulate key host inflammatory pathways (IL-6, TNF-α, AKT1). Matthew D. Moore (University of Massachusetts, USA) developed portable, equipment-free methods to detect human noroviruses, combining bacterial and magnetic liquid-based virus concentration technologies along with work on nanopore and durable polymer nanoparticle sensors for efficient viral field detection. Sharifah S. Hassan (Monash University, Malayia) conducted a one-year study for dengue using a focus reduction plaque neutralization test ($FRNT_{70,90}$). A high infection rate (72–87 %) was reported, with 38 participants (20.7 %) showing antibodies against all four DENV serotypes. Felicity Burt (University of the Free State, South Africa), through surveillance of over 10,000 mosquitoes and selected tick pools, identified known pathogens like West Nile and Sindbis viruses, as well as novel viruses including a new tick orthoflavivirus, using multiplex RT-PCR and Oxford Nanopore sequencing. Daniel Ruzek (Masaryk University, Czech Republic) developed a novel fluorescent reporter virus (tGFP-TBEV) that enables real-time tracking of tick-borne encephalitis virus infection in neural tissues. Jo Ern Wong (Universiti Malaya) revealed that a non-epidemic Zika virus strain demonstrated more aggressive replication, and greater cellular damage in human cells than an epidemic strain. This shows a strain's epidemic potential is not solely dictated by its replication efficiency. Researchers from Cady Ayyad University-Morocco advanced foodborne virus detection methods. Hafid Jamal Eddine identified adenovirus, norovirus, and rotavirus in mussels, with rotavirus being the most prevalent. Salma Berrouch and Hibatallah Lachkar improved ISO-based protocols, enhancing viral RNA recovery and detection sensitivity in leafy greens and oysters.

1.9. Day 3, session 8: Latent and persistent human viral infections

This session, chaired by Kristine Yoder (The Ohio State University, USA) and Tan Wen Siang (Universiti Putra, Malaysia), highlighted transformative advances in combating persistent viral infections, spanning from clinical elimination campaigns to novel molecular interventions.

The session featured significant progress in HCV management. In her keynote, Rowena Bull (President of the Australian Society for Virology) reported that while specific HCV variants can induce broadly neutralizing antibodies across multiple individuals, their capacity to imprint these responses exhibits considerable variation. Abdelouaheb Benani (Pasteur Institute of Morocco) detailed how pan-genotypic direct-acting antivirals have revolutionized HCV treatment, enabling Egypt to achieve WHO gold-tier elimination status through treatment of 93 % of diagnosed patients. This clinical success was complemented in the invited talk by Rosaida Hj Md Said (Ministry of Health, Malaysia), who reported that Malaysia's national HCV program now treats approximately 75,500 adults with directly acting antivirals (DAAs), including the WHO-listed NS5A inhibitor Ravidasvir. Future directions anticipate novel therapeutic platforms including nanomedicine and CRISPR-based approaches.

A parallel focus examined herpes virus chromatin dynamics and therapeutic targeting. Michael Nevels (University of St-Andrews, UK), in his invited talk, established a model for nucleosome-based regulation of herpesvirus chromatin, demonstrating how this architecture controls viral transcription, replication, and genome packaging to determine infection outcomes. Maija Vihinen-Ranta (University of Jyväskylä, Finland) provided mechanistic insights, revealing that HSV-1 capsids preferentially localize within loosely packaged chromatin regions, with

infection-induced chromatin mobility enhancing capsid transport to the nuclear envelope.

The session also showcased innovative strategies for targeting latent viral reservoirs. In her invited talk, Emma Poole (Cambridge University, UK) presented dual approaches against human cytomegalovirus, combining epigenetic manipulation of the viral promoter either through kick and kill reactivation or lock and block silencing with targeted therapies including nanobodies and a US28-directed fusion protein to eliminate infected cells. Similarly, Kristine Yoder demonstrated the therapeutic potential of CRISPR/Cas9 genome editing against human T-lymphotropic virus type 1 (HTLV-1), showing that targeted disruption of the hbz gene significantly reduced tumor proliferation in murine models (Supp. 3).

1.10. Day 3, session 9: Plant viruses: Insights into disease Control and crop protection

This session, chaired by Stephan Winter (Leibniz Institute-DSMZ, Germany) and Rofina Yasmin Othman (Universiti Malaya), highlighted the transformative role of modern technologies in addressing the critical challenges posed by plant viruses to global food security. The session opened with a keynote address by Stephan Winter, who articulated how advanced genomics and artificial intelligence are fundamentally reshaping plant virology. He established these technologies as pivotal tools for novel virus discovery, predictive epidemic modeling, and the implementation of next-generation mitigation strategies, including RNA interference sprays and CRISPR-edited resistant crops.

This theme of technological innovation was powerfully reinforced in an invited talk by Virendra Kumar Baranwal (ICAR-Indian Agricultural Research Institute), who demonstrated the game-changing capacity of high-throughput sequencing (HTS) as a comprehensive surveillance tool. His work uncovered complex viromes in Indian grapevines, revealing multiple viruses and viroids that had previously eluded conventional diagnostics. The urgent need for such advanced approaches was underscored by Rofina Y. Othman, who emphasized that vital tropical crops face escalating threats from plant viruses, while current research and surveillance efforts remain critically inadequate. She compellingly argued for the immediate implementation of advanced surveillance technologies and integrated, eco-friendly control measures to safeguard food production. The session presenters further showcased the application of these technologies against specific devastating pathogens. Selvarajan Ramasamy (ICAR-National Research Centre for Banana, India) detailed the global threat of banana bunchy top virus (BBTV) and the development of sophisticated countermeasures, including RNAi and CRISPR-based strategies designed to target both the virus and its aphid vector. Similarly, Samar Sheat (Leibniz Institute-DSMZ, Germany) presented a comprehensive research program against cassava brown streak disease, combining the deployment of resistant cassava lines from South American germplasm with genomic and transcriptomic studies to elucidate key resistance genes and critical virus-host interactions (Suppl. 3).

1.11. Day 3, session 10: Bacteriophages shaping ecosystems and medicine

This session, chaired by Shailendra Saxena (King George's Medical University, India) and Adelene Song Ai Lian (Universiti Putra, Malaysia), showcased the transformative potential of bacteriophage therapy as a precise and sustainable alternative to conventional antibiotics across clinical, agricultural, and environmental settings. The session was opened with a keynote by Martha Clokie (University of Leicester, UK) who established phage therapy as a promising strategic alternative to antibiotics, particularly for targeting resistant bacteria while preserving beneficial microbiota. Her research demonstrated a precision medicine approach for urinary tract infections, systematically linking phage genomic data to phenotypic activity to guide therapeutic selection.

This clinical focus was further reinforced by Gopal Nath (Banaras Hindu University, India), who presented a remarkable case of successful phage therapy in a patient with septicemia caused by pan-drug-resistant *Klebsiella pneumoniae*. The targeted phage cocktail rapidly normalized critical infection markers despite the persistent challenge of a biofilm-coated implant, demonstrating the unique capability of phages to manage infections where traditional antibiotics would fail. Expanding beyond human medicine, Indrani Karunasagar (Nitte University, India), in an invited talk, emphasized the vital role of phages within the 'One Health' framework, highlighting their particular value in dynamic environments like aquaculture. Their high specificity enables targeted pathogen elimination without disrupting ecosystems or animal microbiomes, while their applications are increasingly extending to food and water safety. This theme was elegantly complemented by Swee Seong Tang (Universiti Malaya), who presented an innovative green biocontrol strategy using polymer-coated lytic bacteriophages against tilapia pathogens. The encapsulated phages demonstrated efficacy against both single and mixed infections while maintaining an excellent safety profile in fish immune response evaluations (Suppl. 3).

1.12. Day 3, session 11: Zoonotic viruses

This session, chaired by El-Sayed M. Abdelwhab (Friedrich-Loeffler-Institut, Germany) and Hair Bejo (Universiti Pertanian, Malaysia), provided a compelling journey into the origins of viral threats and our evolving defense mechanisms against them. The discussion was opened with a powerful keynote by Linfa Wang (Duke-NUS Medical School, Singapore), who framed the landscape of modern pandemics by highlighting that the most severe recent outbreaks: Nipah, Ebola, and SARS-CoV-2, all share a common origin in bats. He masterfully connected ecological drivers like climate change and wildlife trade to viral spillovers, outlining essential strategies to build better defenses at the human-animal interface. The session then zoomed in, on specific threats lurking at this interface in another keynote, where Sazaly Abu Bakar (Universiti Malaya) sounded the alarm on the silent spread of tick-borne diseases in Malaysia, where borderline exposure to the dangerous Crimean-Congo hemorrhagic fever virus in high-risk groups signals the urgent need for expanded surveillance. This theme of environmental disruption was echoed by William Wilson (Kansas State University, USA), who demonstrated how rising global trade and climate change are fueling the expansion of transboundary arboviruses, against which novel tools like CRISPR-Cas9 are being marshaled.

A fascinating deep dive into the biology of reservoir hosts followed. Arinjay Banerjee (University of British Columbia, Canada) and Mariia Bogacheva (University of Helsinki, Finland) independently revealed how bats have evolved sophisticated antiviral defenses, including a unique interferon-β system and a novel GBP1 motif in *Eptesicus fuscus* that provide broad, cross-species protection. These findings not only explain bat resilience but also unveil new avenues for therapeutic development. Complementing this, Kenny Voon (University of Nottingham, Malaysia) provided sobering data on the high prevalence of Pteropine orthoreoviruses in Malaysian bats and outpatients, highlighting a constant, simmering risk of spillover, particularly into swine populations. Finally, the session showed brilliant scientific countermeasures. Victoria S. Baryshnikova (Russian Academy of Sciences) presented an elegant diagnostic solution in a differential serological test for tick-borne encephalitis virus that achieves 100 % specificity against other flaviviruses. In a fascinating closing presentation, Fadi G. Alnaji (A*STAR, Singapore) demonstrated how defective viral genomes (DelVGs), once considered mere byproducts of infection, can be engineered into superior interfering agents capable of sabotaging wild-type influenza virus replication (Suppl. 3).

1.13. Poster sessions

The poster sessions, displayed throughout Day 1 and Day 2 of the



Fig. 2. Poster Session. Poster presenters discuss their research and interactions between reviewers and presenters during the poster evaluation.

conference, offered a panoramic view of a field in full momentum, with studies spanning continents, species, and molecular scales. Together, they revealed a community tackling viral threats through a unified One Health lens, bridging human, animal, plant, and environmental systems (Fig. 2).

1.14. Zoonotic and arboviral threats

Nowhere was this breadth more evident than in the studies of zoonotic and arboviral infections. Researchers from Malaysia, Finland, the United States, and India presented data on dengue, Japanese encephalitis, and newly identified tick-borne phenuiviruses and orthohantaviruses-pathogens that underscore the porous borders between ecosystems and populations. These efforts highlight the critical need for integrated surveillance networks that link local fieldwork to global early-warning systems.

1.15. Innovations in veterinary and aquaculture virology

Veterinary virology stood out as a pillar of innovation. Studies from Malaysia, Indonesia, and Peru shed new light on avian viruses, including the first detection of Japanese encephalitis virus in poultry, while UK groups unveiled a recombinant chimeric vaccine offering dual protection against infectious bursal disease virus and avian coronavirus. Similar translational ambition was evident in livestock research, where teams refined bioluminescent immunoassays to accelerate detection of bovine viral diarrhea and border disease viruses. In aquaculture, teams from Malaysia and Canada reported mRNA vaccine prototypes and antiviral compounds against tilapia lake virus and white spot syndrome virus, underscoring the rapid emergence of marine virology as a critical frontier for global food security.

1.16. Bacteriophage therapy and human virology

A striking theme was the maturation of bacteriophage therapy from a niche curiosity to a credible weapon against antimicrobial resistance. Studies showcased phage applications across humans, fish, and shrimp, offering a precision-based, ecologically sound alternative to antibiotics.

In human virology, research from Japan, Saudi Arabia, Oman, Egypt, and Finland updated the global picture of HCV elimination, while others traced the long-term immunogenetic footprint of SARS-CoV-2. The discovery-oriented edge of the discipline was on display in studies of human protoparvoviruses, including emerging evidence linking cutavirus to cutaneous T-cell lymphoma, a reminder that viral oncology remains a fertile ground for discovery.

1.17. Cross-cutting technological and ecological themes

Across all domains, technological innovation was a consistent thread. Posters described advances in mRNA vaccine platforms, nanobody-based therapeutics, and extracellular vesicle engineering, each signaling a future where precision virology meets molecular design. Complementing these were contributions from plant virologists in Nigeria and India confronting viruses that endanger staple crops, reinforcing that viral ecology is inseparable from global nutrition and stability. Taken together, the posters formed more than a snapshot; they represented a living map of modern virology. From bat-borne orthoreoviruses to aquaculture pathogens and phage-based therapeutics.

1.18. Conference concluding session

The conference culminated in a closing session that honored scientific distinction and underscored the power of international partnership in virology. The proceedings commenced with the presentation of the Best Poster Awards by WSV leadership, including Richard Kuhn, Marietjie Venter, and Maria Söderlund-Venermo. The top honor was conferred upon Muhammad Nur Adam Hatta (Universiti Malaya) for his investigation into the molecular dynamics of human SEPT5 protein interactions with H5 influenza A viruses, elucidating key mechanisms of viral neuropathogenesis. Second place was awarded to Yi Jing Yap (Universiti Malaya) for her insightful research on dengue virus-induced endothelial senescence. Third-place recognition was shared collectively by three exceptional research presentations: Cienna Buckner, (University of Helsinki, Finland) for their work on Puumala orthohantavirus immunity; Ziyin Cheah (Universiti Malaya) for innovative development of an extracellular vesicle-based dengue vaccine platform; and Razieh Sadat Banijamali (University of British Columbia, Canada) for advancing mesenchymal stromal cell-mediated delivery of oncolytic coxsackievirus B3 for cancer therapy (Fig. 3).

Following the awards ceremony, closing reflections were delivered



Fig. 3. Closing Ceremony. a) The closing ceremony panel (from right to left): Prof. Khatijah Yusoff (Head, LOC), Prof. Marietjie Venter (WSV President-Elect), Prof. Ahmed S. Abdel-Moneim (WSV Founder), Prof. Raha Abdul Rahim (CEO, NIBM), Prof. Maria Söderlund-Venermo (WSV President), Prof. Richard J. Kuhn (WSV Past President). b) Honoring the best poster presentation award winners. c) Prof. Maria Söderlund-Venermo presenting a token of appreciation to Prof. Raha Abdul Rahim. d) Prof. Richard Kuhn presenting a token of appreciation to Prof. Khatijah Yusoff.

by Raha Abdul Rahim (CEO of NIBM). The session included formal acknowledgments by WSV leadership of Raha Abdul Rahim and Khatijah Yusoff, recognizing their instrumental roles in the conference's success (Fig. 3). Marietjie Venter (WSV President-Elect) announced that the next WSV2027 conference will be in Rabat, Morocco in spring 2027, and invited everybody there. It was selected through a competitive process among several candidate nations.

WSV-Founder Ahmed S. Abdel-Moneim extended profound gratitude to Malaysia as the host nation, the NIBM as primary host institution, collaborating co-hosts, supporting sponsors, and all participants. The ceremony included special recognition of current president Maria Söderlund-Venermo and past presidents Anupam Varma and Richard Kuhn for their dedicated leadership in advancing the society's mission. Acknowledgment was also made of the Indian Virological Society as the WSV's inaugural partner society. He concluded that the WSV2027 in Morocco will coincide with the society's 10-year anniversary celebration. The meeting concluded formally at 6:00 p.m. with a commemorative photograph of the WSV Steering Committee and Malaysian Organizing Committee, marking both the successful conclusion of the current assembly and the promising future of global virology



Fig. 4. Pre-Conference Workshop. a) The workshop being officially opened by Prof. Ahmed S. Abdel-Moneim, alongside Dr. Azira Muhamad (MGVI, Malaysia) and Dr. Lee Khai Wooi (Taylor's University, Malaysia). b) A group photograph of the workshop trainees and facilitators. c) Dr. Azira Muhamad demonstrating techniques to the trainees. d) Participants engaged in a practical session of the workshop.



Fig. 5. Social Program. a), b) Scientists mingling and dancing with Malaysian folk art performers at the Gala Dinner. c) A performance of Malaysian folk dance. d) Participants on the Hop-on Hop-off Kuala Lumpur city tour. e, f) Scientists enjoying the sights during the city tour.

collaboration.

2. Special highlights

2.1. Capacity building-pre-conference Workshop

The Virus Like Particle (VLP) purification for vaccine application workshop was held on 5 May 2025 at the Malaysia Genome and Vaccine Institute, National Institutes of Biotechnology Malaysia. The workshop brought together 20 participants for an intensive hands-on session focusing on advanced vaccine platform technologies. Led by Azira Muhamad (Malaysia Genome and Vaccine Institute) and Lee Khai Wooi (School of Biosciences, Taylor's University), the workshop provided participants with practical insights into VLP purification techniques and their translational potential in vaccine development. The event was formally inaugurated by Ahmed S. Abdel-Moneim, founder of the WSV, a day prior to the conference, highlighting the WSV's ongoing commitment to capacity building and fostering innovation in global virology research (Fig. 4).

2.2. Sponsors

The conference was a triumph of collaborative effort, meticulously organized by NIBM as the dedicated local partner and WSV as the primary organizer. NIBM provided crucial seed funds that initially secured the prestigious Impiana KLCC as the venue, laying a strong foundation for the event. As participant numbers grew beyond original projections, WSV's funds adeptly covered the additional associated expenses, ensuring a seamless experience for all. Further bolstering the financial framework, meeting grants were successfully secured before the event from both ICGEB, Italy, and the Malaysia Convention & Exhibition Bureau (MyCEB). These grants proved immensely helpful in providing the necessary monetary support for an international event of this magnitude.

Beyond these foundational contributions, the invaluable support from numerous sponsors was pivotal. We gratefully acknowledge our Diamond Sponsors, Monash University Malaysia, Pharmaniaga, and University of Malaya; our Platinum Sponsors, Takeda and INFORS HT; our Gold Sponsors, ICGEB and Biotechne; our Silver Sponsor, Erinha; and our Bronze Sponsors, NG, Arlene Tan, and Leong. Their generous funding directly supported critical conference elements, including delegate bags, lanyards, printed materials, and unique souvenirs, and extended to key social functions such as the elegant gala dinner and the engaging KL city tour. This multifaceted backing not only ensured the event's smooth execution but also powerfully underscored a vibrant collaborative spirit among Malaysian biotechnology entities, highlighting their shared commitment to advancing virological research and strengthening global public health preparedness.

2.3. Gala dinner and cultural event

The concluding gala dinner, held at Saloma Bistro, served as a pivotal component of the WSV 2025 program, strategically designed to foster informal networks that are fundamental to scientific progress. More than a mere social gathering, the event was a curated immersion into Malaysia's rich cultural heritage, effectively showcasing the nation's diversity in alignment with the forthcoming "Visit Malaysia 2026" campaign (Fig. 5).

The evening commenced with formal acknowledgments of the conference's co-organizers and sponsors, recognizing their essential contributions. The "Cultural Diversity" theme was then brought to life through a series of vibrant performances by a local dance troupe. These presentations offered a narrative of Malaysia's multicultural tapestry, encompassing traditions from the Malay, Chinese, and Indian communities, as well as the indigenous peoples of Sabah and Sarawak.

A highlight of the evening was the active participant engagement. International attendees were invited to the stage for an impromptu lesson in the Zapin dance, followed by a blowpipe challenge that demonstrated traditional hunting techniques. These interactive sessions successfully broke down formal barriers, facilitating cross-cultural dialogue and camaraderie.

The combination of delicious authentic local cuisine and this dynamic cultural program created a uniquely engaging atmosphere. The event concluded at 22:30, leaving participants not only with a deeper appreciation for the host country but also with strengthened professional bonds as a proven catalyst for future collaboration.

2.4. Kuala Lumpur Hop on Hop off bus tour

An exclusive logistical arrangement was provided for international participants of the WSV event: a complimentary, two-hour, open-top double-decker bus tour of Kuala Lumpur. Departing immediately post-ceremony from the Impiana KLCC, this chartered service operated on a first-come, first-served basis. The route was a curated, panoramic circuit designed for maximum exposure to the city's key landmarks. The journey presented a systematic overview of Kuala Lumpur's urban

development, passing significant modern structures like the KLCC Twin Towers, Menara 118, and Menara TRX, alongside historical and cultural sites such as Istana Negara and Dataran Merdeka. The activity concluded as scheduled at 10:30 p.m. at the point of origin. Initial feedback indicates the tour was highly successful, serving as an effective introduction to the city for first-time visitors and generating a positive impression that increased the likelihood of their future return to Malaysia (Fig. 5).

3. Conclusion and future perspectives

The 3rd International Conference of the WSV was a resounding success. It not only provided an outstanding scientific forum but also reinforced the vitality and cohesion of the global virology community. The theme, "The Virosphere of Our Cellular World," proved to be a profound and effective framework for understanding our interconnected biological reality.

The robust participation from 26 countries, 291 attendees and the high quality of discourse demonstrated the enduring need for a society that embraces all of virology. As WSV looks to the future, the momentum generated in Kuala Lumpur will undoubtedly propel society forward, strengthening its role in promoting scientific exchange, education, and collaboration to mitigate the impact of viral diseases worldwide. The outcomes of WSV2025 promise to significantly contribute to the field, echoing the collaborative spirit and "One World" vision that has defined the society from its first committee meeting to its present-day international conferences (Abdel-Moneim et al., 2017, 2020) (Söderlund-Venermo et al., 2022) (Abdel-Moneim et al., 2024).

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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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.virol.2026.110792.

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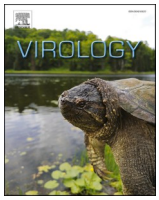

Corrigendum



Corrigendum to "Meeting Report: The 3rd international conference of the World Society for Virology (WSV 2025) - The Virosphere of Our Cellular World"☆

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The authors regret the error that appeared in their paper in the name of one author, which has been corrected from Nor Azfa Binti Johari to Nor Azfa Johari. In addition, the affiliation listed for three authors from the same institution (Nor Azfa Johari, Azira Muhamad, and Khatijah Yusoff) was incorrect. The corrected author name and the accurate affiliations for all authors are provided below.

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