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Editorial

Vaccine Technology VII: Beyond the "decade of vaccines"

The Vaccine Technology Conference series has been the main forum where industry, academia, public health authorities, and philanthropic organizations meet to facilitate linkages and enable collaborations between all regions of the world. The goal is to gather key leaders in the vaccine field to discuss progress and technological challenges facing vaccine development and manufacturing for global needs. Each meeting is organized by scientists from academia and industry in an intimate setting. The Vaccine Technology Conference series differentiates itself from commercial conferences by providing very high quality and cutting-edge scientific content on technological trends in developing vaccines to meet the global needs of public health priorities. The format provides an outstanding opportunity for exchange of ideas among scientists from diverse backgrounds and a good representation from different regions of the world. National and international organizations including The Bill and Melinda Gates Foundation, CEPI (Coalition for Epidemic Preparedness Innovations), the Global Health Initiative, and the vaccine industry have supported the meetings in this conference series. Vaccine Technology VII was exceptionally well supported, thus enabling the participation of researchers from low- and medium-income countries.

Vaccine Technology VII (http://www.engconf.org/past-conferences/2018-conferences/vaccine-technology-vii/) was held in Mont-Tremblant within the Natural Park in the Laurentide's region of Quebec, Canada, on June 17–22, 2018. With over 200 participants from 27 countries on 5 continents, the meeting celebrated diverse participations involving many graduate students, academics, government, international bodies and industry representatives to invest and sustain the future and growth of the vaccine field as a global priority.

The conference program included over 45 oral presentations, two keynote addresses and six lead lectures. In addition, four thematic workshops were organized. The first workshop titled "Meet the funders for Global Health" recognizes the importance of funding for the sustainability of vaccine development for global interventions. The other workshops provided technical insights into cell and process engineering, -omics tools and vaccine analytics. One of the key points of difference for the Vaccine Technology Conference series is the active participation and discussion during the poster sessions. At the Vaccine Technology VII meeting, more than 90 posters were presented and selected posters were also highlighted in short talks to underline the important topics covered.

A snapshot of the Vaccine Technology VII content is provided in this *Vaccine* Special Issue to highlight the topics that have been addressed at the conference.

Innovation in antigen design and deployment of advanced vaccine technologies are essential to strengthen the public health vaccination policies and support the preparedness plans against emerging and re-emerging infectious diseases. Infectious diseases caused by pandemic influenza virus strains, Zaire Ebola virus (EBOV), and Zika virus are addressed from the perspective of antigen design and process development. This included the development of purification processes and creation of novel analytical tools. Chen et al. [1] propose an adjuvanted vaccine based on the production of H7 antigens from the H7N9 avian influenza virus using the well-established CHO platform. Whereas Lehrer et al. [2] describe insect cell-produced vaccines containing the EBOV glycoprotein formulated with different adjuvants. These formulations were evaluated in guinea pigs for immunogenicity and efficacy against lethal EBOV challenge. Different antigen expression and presentation systems are presented in the article. Simian adenovirus vectors involving multiple serotypes are discussed by Fedosyuk et al. [3] as a method amenable to rapid testing of candidate vaccines in early-phase clinical trials. Virus-like particle (VLP) platforms remain a solid trend for antigen presentations in response to emerging infectious diseases, however solutions to production challenges are required. Pastor et al. [4] assessed critical process parameters for the production of Zaire Ebola VLPs in the insect-cell baculovirus expression system. Selecting a mammalian cell expression system, Alvim et al. [5] produced Zika VLPs using HEK293 stable cell lines and continuous perfusion processes as a new potential vaccine manufacturing platform. Gerritzen et al. [6] explore the use of outer membrane vesicles (OMVs) displaying heterologous antigens to be used as vaccines.

VERO cell line remains a dominant platform for vaccine manufacturing. To enable scalable and streamlined manufacturing processes using this cell line, two research groups describe their efforts in adapting the VERO cell line to serum-free suspension cultures. Rourou et al. [7] describes the selection of serum-free media for adaptation of VERO cells to suspension growth for the production of rabies virus. Another research group (Shen et al. [8]) provided data supporting growth of VERO cells in suspension and serum free-media in a 3L bioreactor and improved the production of Vesicular Stomatitis Virus (VSV) as a vector for vaccination. As an alternative to egg-based production of influenza vaccine, significant efforts are dedicated to improving cell-culture produced influenza vaccines using different cell lines coupled with process intensification to achieve cost-effectiveness. Bissingern et al. [9] describe semi-perfusion mode cultures using suspension MDCK cells, whereas Coronel et al. [10] describe single-use orbital shaken bioreactor with ATF or TFF perfusion systems using the AGE1.CR.pIX avian suspension cells. Alternatively, Gränicher et al. [11] describe the use of porcine suspension cell line PBG.PK2.1 in high

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cell density. All three studies focus on the production of influenza A virus.

Recently, the potential of therapeutic vaccines are being realized with more trials reaching patients. As such, health authorities are challenging the field to speed up the development of these new medical interventions that harness the human immune system. Recombinant adenovirus vectored antigens combined to adjuvanted proteins for prime-boost are presented as a strong antigen-specific mechanism for cell-mediated and humoral responses critical to the development of successful therapeutic vaccine [12].

Process intensification is also actively pursued for veterinary vaccines within the global view of 'One World, One Health'. Sousa et al. [13] presents strategies to improve process performance using VERO cells on microcarriers for the production of a "Peste des Petits Ruminants" virus vaccine. Important efforts remain dedicated to developing efficient and cost-effective downstream processing schemes for rabies vaccines [14] and flavivirus VLPs [15] as well as novel chromatographic media [16] for VLP-based vaccines.

Effective process development relies on advanced process analytical technologies for which a case study is presented on the analysis of all available process data by Suares-Zuluaga et al. [17]. A generic method based on flow cytometric granularity is proposed as an assay for the quantification of infectious virus [18]. Examples of studies on critical quality attributes of vaccine products are documented by Venereo-Sanchez et al. [19] using proteomic analyses to characterise influenza H1N1 Gag VLPs and extracellular vesicles. The aspects of adjuvants for influenza vaccine including the use of a novel archaeal glycolipid adjuvants are covered by Stark et al. [20] in their study of immune responses in young and aged mice. Tzeng et al. [21] cover an important aspect of vaccine formulation and delivery by studying the stability and immunogenicity of inactivated influenza whole viruses.

The technological progress and new knowledge contributed by these studies in the vaccine field enable us to be in a better position to respond to emerging and re-emerging pathogens of epidemic potential. Additionally, these advances have broader impact on routine immunization, as it allows for the rapid development and future supply of cost-effective vaccines for all.

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