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World of Vaccinology 2024

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CHAPTER 1

Introduction

Vaccination is a powerful method of disease prevention for people of all ages worldwide as evidenced by its impact during the coronavirus disease 2019 (COVID-19) pandemic. It is a common misconception that the importance of immunizations wanes after childhood. Vaccines continue to play a critical role throughout adolescence and adulthood, bolstering the defenses established in early years and safeguarding against diseases that can emerge when immunity fades. The importance of vaccination in adult populations, particularly those aged over 60 years, is frequently overlooked, despite their continued critical role in maintaining health.

Immunization currently prevents 3.5–5 million deaths every year from diseases such as diphtheria, tetanus, pertussis, influenza, and measles. India's strides in child health over the last two decades are commendable, with the country achieving polio-free status in 2014 and eliminating maternal and neonatal tetanus a year later. Yet challenges persist as evidenced by the 1.6 million children who were unvaccinated or undervaccinated in 2022, despite high national coverage rates of 93%.

India's Universal Immunization Program (UIP) provides free vaccinations to combat 12 vaccine-preventable diseases (VPDs). These include diphtheria, pertussis (whooping cough), tetanus, polio, measles, rubella, a severe form of childhood tuberculosis, rotavirus diarrhea, hepatitis B, as well as meningitis and pneumonia caused by Haemophilus influenzae type b (Hib), among others. On the flip side, many medical students and young physicians today have limited firsthand experience with these diseases due to the success of the vaccines. This detachment from the real impact of VPDs underscores the hidden burden of these illnesses, especially among adults, where vaccination rates are dismally low. Without national guidelines, the adult immunization strategy in India remains fragmented and unclear.

The true burden of VPDs among Indian adults is unknown, with coverage for adult vaccination remaining critically low. Adults are particularly vulnerable during outbreaks due to a lack of immunization, waning immunity, age-related factors (e.g., chronic conditions and immunosenescence), and epidemiological shifts; the adult population beyond 18 years of age is particularly vulnerable during outbreaks.

There are no national adult immunization guidelines in India and although several medical societies have published adult immunization guidelines, these vary, making it unclear who should receive which vaccines (based on age, underlying conditions, etc.). *Other barriers to adult immunization* include vaccine hesitancy, missed opportunities, and cost. Steps to improve adult vaccination could include the adoption of national guidelines, education of the public, and promotion of courses on vaccinology and immunization. Improving adult vaccine coverage could help reduce the burden of VPDs, particularly among older adults.

Vaccines stand as one of the most monumental achievements in medical history. They not only confer individual protection against bacterial and viral diseases but also safeguard the broader community by fostering herd immunity. This communal protection is vital for those with health complications and for all age groups within a society.

Increased vaccination rates promote herd immunity which not only protects individuals with serious conditions but also protects all children and adults in a community. Unlike the Pediatric Immunization Guidelines, given by the Indian Academy of Pediatrics (IAP) and the National Immunization Programs (NIP), the strategies for vaccination in healthy adults are not mandatory and may vary from region to region. Usually, parents are particular and regular when it comes to vaccinating their children, but they fail to realize that adult vaccination is just as important as getting their children vaccinated. Also, any adults above the age of 65 years or any age with chronic conditions such as diabetes, heart conditions, chronic lung disease, chronic liver disease, and cancer are also at high risk and must take age-appropriate vaccination protections.

This "World of Vaccinology Tablet" is a brochure that attempts to synthesize the evolving evidence for current immunization and immunotherapies beyond pediatrics.

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Recent global outbreaks of VPDs have predominantly affected unvaccinated individuals. This lack of vaccination often stems from eligibility issues, such as age constraints or preexisting medical conditions. However, there is also a notable portion of the unvaccinated population who opt out due to personal belief or religious exemptions.

Unvaccinated children drive surge in deadly outbreaks: The world is witnessing significant outbreaks of diseases that are particularly lethal to children. This concerning trend is a direct consequence of health system disruptions during the COVID-19 pandemic. As a result, over 60 million children globally have missed out on standard childhood vaccinations.

Many of the children who missed their shots have now aged out of routine immunization programs. So-called "zero-dose children" account for nearly half of all child deaths from VPDs, according to the Global Alliance for Vaccines and Immunization (GAVI), the organization that helps fund vaccination in low- and middle-income countries.

Furthermore, many of the large outbreaks of VPDs occur among religious groups and the major concerns are over the vaccine safety which drives them to avoid vaccines not based on any real religious doctrine. The main problem is that these groups of unvaccinated people become clustered together in religious activities, helping to fuel large outbreaks of VPDs.

FUTURE OF IMMUNIZATION/ IMMUNOTHERAPIES

The future of immunization hinges on the ongoing progress in medical research aimed at developing innovative vaccines. Future vaccines are anticipated to offer broader protection against variants, longer-lasting effects, and superior capabilities in preventing infection and transmission, including mucosal vaccines, compared to the vaccines currently available. Although predicting the specific characteristics of future vaccines is challenging, numerous promising research and development areas are shaping the future of immunization.

Ideally, vaccines of the future will not only be quick to develop but can offer:

- *Long-term stability at warm temperatures:* This addresses a crucial challenge in vaccine distribution, particularly in regions where maintaining cold chains is difficult, thereby facilitating global accessibility.
- *High efficacy in immune-compromised and elderly populations:* This is an important goal, as these groups are often more vulnerable to diseases yet may respond less effectively to current vaccines.
- *Durable immunity with minimal dosing and self-administration capability:* This would enhance vaccine uptake and compliance, making immunization more convenient and accessible to a broader population.

For the first time, the COVID-19 pandemic brought messenger ribonucleic acid (mRNA) vaccines to the forefront, demonstrating their potential of providing a more rapid response to emerging infectious diseases (IDs) compared to traditional vaccines.

The *mRNA technology* has emerged as a revolutionary breakthrough in vaccine development, highlighting its potential and leading to the rapid deployment of mRNA-based vaccines. This technology provides a platform for quicker and adaptable vaccine production, offering hope in the fight against emerging IDs.

Current vaccines are typically designed to target specific strains or variants of a pathogen. However, the development of universal vaccines aims to create vaccines that provide broad protection against multiple strains or even entire families of pathogens. Universal influenza vaccines, for example, would eliminate the need for annual vaccine updates and provide long-lasting immunity against multiple influenza strains.

Also, there are many "personalized vaccines" that involve tailoring vaccines to an individual's specific immune profile or genetic makeup. This approach has the potential to improve vaccine responses in individuals with weakened immune systems or to target specific cancer cells in cancer immunotherapy.

It is important to note that these futuristic vaccine/immunotherapy technologies are still in various stages of research and development. While they hold great promise, it may take time before they become widely available for clinical use. Omalizumab (Xolair), recently approved by the United States (US) Food and Drug Administration (FDA) as monotherapy for the treatment of food allergies, may now bring peace of mind to these patients and their families by reducing their risk of dangerous allergic reactions to accidental exposure.

In recent years, the pace of innovation in the field of immunizations has accelerated like never before. Pioneering technologies, from mRNA and deoxyribonucleic acid (DNA) platforms to artificial intelligence (AI), are reshaping the landscape of vaccine development,

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distribution, and administration. These innovations hold the promise of not only enhancing the efficacy and safety of vaccines but also addressing critical challenges such as accessibility and affordability, bequeathing a future where preventable diseases are minimized or eradicated.

mRNA-based Vaccines and mRNA Therapeutics—What is Beyond COVID-19?

The COVID-19 mRNA vaccines were developed and approved at unprecedented speed and have demonstrated significant effectiveness against infections and acute COVID-19 in the real world. The knowledge of using mRNA as a simple and promising way to deliver vaccines or therapeutic drugs had been around for decades before the onset of the recent global pandemic. The success of mRNA vaccines against COVID-19 has created huge enthusiasm around this concept and significantly boosted the applications of this class of medicines in other areas. As the pandemic gradually fades, we cannot stop thinking about what the world has gained in this chaos—the realization and authentication of the power of mRNA in modern medicine.

As the recent global pandemic gradually fades, a significant amount of research has now been concentrated on developing mRNA vaccines, mRNA therapeutic drugs, and delivery systems against infectious and immune diseases, cancer, and other debilitating noncommunicable diseases (NCDs) and has demonstrated encouraging results. *RNA therapeutics are the medicines of the future.*

At this crucial juncture of the pandemic, what we need is an "infection-blocking vaccine" and not vaccines that only protect you against severe disease. While these vaccines have saved countless lives, it is unlikely that they will, on their own, stop viral transmission and prevent the emergence of new viral variants.

Intramuscular injections generate systemic immunity but little or no immune response in the nose, where respiratory viruses such as SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) typically enter the body. In contrast, *intranasal vaccines*, which can elicit both mucosal and systemic immune responses, are targeting SARS-CoV-2 and are in development. Could they pave the way for widespread nasal vaccination in the future?

Noncommunicable Diseases' Vaccines and Immunotherapies

As life expectancy has increased, the burden of NCDs such as cancer, hypertension, atherosclerosis, and diabetes has increased. Therefore, scientists hope a new type of vaccine could treat and prevent NCDs; this could include autoimmune diseases, such as multiple sclerosis (MS), type 1 diabetes, allergic asthma, Alzheimer's, myasthenia gravis, and Crohn's disease, among others. The NCD vaccines present an interesting challenge for the US FDA which is tasked with approving new treatments on the basis of efficacy and safety.

Like traditional vaccines, NCD vaccines work by modulating the human immune system, but target cells, proteins, or other molecules that are associated with the NCD in question rather than pathogens or pathogen-infected cells. These vaccines are still in development and have not been systematically tested on humans.

- Effective vaccination will have a significant impact on the disease burden of both VPDs and NCDs and beyond.
- Immunotherapies, for example, monoclonal antibodies (mAbs) and T-cell therapies in cancer treatment approach based on the concept of harnessing the patient's immune system to fight tumor cells. Newly evolving tumor cell-specific mAbs have redefined cancer treatment and identify how human gut microbiomes alter the body's response to a common form of cancer immunotherapy.
- Over the past two decades, the immune system has attracted increasing attention for its role in fighting cancer. As researchers have learned more and more about the cancer-immune system interplay, several antitumor immunotherapies have become FDA-approved and are now regularly used to treat multiple cancer types.

Yet despite these advances, much remains unknown about how the immune system fights cancer and about immunity in general. CRISPR-based gene editing, in which scientists modify the genome using a tool developed just over a decade ago, has become a mainstay of biological discovery, providing relatively quick insight into the function of individual genes and targets for new therapies.

Gene and cell therapies have seen a massive transformation over the past decade from promising experimental treatments to approved medicines for a wide range of patients with genetic or acquired diseases.

Vaccine hesitancy and vaccine refusal (anti-vaxxers)—growing public health concerns:

Multiple factors are associated with vaccine hesitancy, and this has been increasingly identified as a global

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health worry. This may upset the success of vaccination programs against IDs.

There are many likely contributing factors for vaccine refusal, such as unfamiliarity with VPDs, cultural–social differences, religious beliefs, and media information. Most major religions like Christianity, Judaism, Islam, and Hinduism do not oppose the idea of vaccinations, however, for certain sociocultural reasons oppose the immunization benefits. Notably, religious affiliations have been linked with lower vaccination coverage, especially in more conservative religious communities globally. Therefore, engaging religious leaders in immunization programs is crucial for enhancing the vaccine's uptakes significantly.

The government of India is set to launch a "U-Win" portal, designed on the lines of "Co-Win" that was launched during the COVID-19 pandemic. The U-Win program has been designed to digitize the UIP and it is presently being run in a pilot mode in certain districts of each state and Union Territory Official sources claim. It is expected that this U-Win platform will be used to register and vaccinate every pregnant woman, record her delivery outcome, register every newborn delivery, administer birth doses, and all vaccination events thereafter.

CONCLUSION

This introductory paragraphs of this World of Vaccinology book offers a comprehensive overview of the current and future state of vaccines. It serves as an essential resource for students, public health professionals, researchers, and anyone keen to deepen their knowledge of vaccines, vaccinations, and vaccinology. It addresses prevalent queries about vaccine usage in an era increasingly influenced by antivaccine sentiments and it deliberates on the societal versus individual benefits of vaccines.

Furthermore, it is important to acknowledge and appreciate the remarkable contributions of ID scientists and healthcare professionals. Their unwavering commitment to research and innovation plays a pivotal role in guiding us toward a healthier, disease-free future. Immunization transcends personal choice; it represents a shared duty to uphold global health and well-being.

Compilation of immunotherapies against diseases prevention including human vaccinology has been complex with substantial challenges, but we have attempted to bring together recent knowledge about the immune system including the immune-mediated illnesses and types of immunotherapies. The development of new specialized equipment and immunological techniques, genetic approaches, animal models, and a long list of mAbs, among many other factors, are improving our knowledge of this sophisticated human systems.

This knowledge is filling many of the gaps through immunotherapies, i.e., on the different types of cell subsets, cytokines soluble factors, membrane molecules, and cell functionalities are some aspects that we are starting to understand, together with their roles in health, aging, illness, and immunization. With significant advances in protein nanoparticle science, mRNA technology, adjuvant development, and B-cell and antibody analyses, a new wave of clinical trials are on the way.

As we delve into these above chapters, we embark on an exploratory journey of these transformative innovations in immunization. This journey is not only about scientific discovery but also about instilling hope and securing the health of humanity for generations to come.

SUGGESTED READING

1. Human Vaccines & Immunotherapeutics, Volume 20, Issue 1 (2024). https://www.tandfonline.com/toc/khvi20/current
2. Thomas A. Waldmann, Immunotherapy: past, present and future. Nature Medicine. 2003;9:269-77
3. Vaccines and Immunizations (Basics and Common Questions). Centers for Disease Control and Prevention (CDC and P) 24/7. https://www.cdc.gov/vaccines/vac-gen/imz-basics.htm
4. Zeng Z, Fu J, Cibulskis C, Jhaveri A, Gumbs C, Das B, et al. Cross-site concordance evaluation of tumor DNA and RNA sequencing platforms for the CIMAC-CIDC network. Clin Cancer Res. 2021;27(18):5049-61.

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World of Vaccinology 2024

Salient Features

- Our book, *World of Vaccinology* 2024, is a multidisciplinary scientific initiative dedicated to understanding the evolving cellular and molecular biology of vaccines within bio- and regenerative medicine
- The book's primary focus is to explain its relevance to vaccinology and immunotherapy. Summarize the vaccine development and immunotherapy advancements discussed in the book, including new therapeutic strategies and technological innovations
- Recent breakthroughs in vaccination have illuminated the therapeutic applications of vaccines for a broader array of cancers and immunologically mediated, noncommunicable diseases (NCDs), revealing new possibilities in disease prevention and treatment
- The book reviews the evolution of immunotherapies from early bacterial approaches like Bacillus Calmette–Guérin (BCG) therapy for bladder cancer to modern prophylactic and therapeutic vaccines
- Building on the success of mRNA vaccines for infectious diseases, this book explores their potential in cancer nanomedicine and highlights recent immunotherapy advances and their future prospects
- Section 2 on "Immunotherapies: Preventive and Therapeutic Advancements", (Chapters 9 through 13), explores cancer vaccines and other NCDs and disorders. Some types of immunotherapies only target certain cells of the immune system. Others can disturb the immune system in a general way by therapeutic monoclonal antibodies (mAbs), and immune checkpoint inhibitors, oncolytic virus therapy including cancer vaccines, and T-cell transfer therapies
- These points provide a comprehensive overview of the dynamic field of immunotherapy, setting the stage for detailed discussions throughout the book. Highlight the book's unique aspects, such as multidisciplinary approaches, the latest research findings, or case studies
- The book is intended for immunologists, researchers, clinicians, and students. It aims to serve its readers by providing new insights, techniques, and frameworks for understanding complex immunological interactions
- The authors anticipate that this book will contribute to the education and advancement of its readers, detailing included resources like case studies, diagrams, and interactive content. We aim to elevate role models in this field and underscore the benefits of these advancements to human health and scientific innovation
- *World of Vaccinology 2024* is not just a product of one individual's work but a testament to the principles of collaboration and teamwork. It encourages contributions from experts across various disciplines, both nationally and internationally.

MI Sahadulla MD FRCP (Ire) FRCP (Lon) MBA is an Internist by profession with more than 45 years' experience in the healthcare industry, spanning several countries such as India, UK, USA, and the Middle East. He presently leads KIMSHEALTH, a public limited company that has healthcare as its focused activity with a workforce of about 7000 in India and GCC countries. He is Chairman and Managing Director, KIMS Healthcare Management Ltd, Thiruvananthapuram, Kerala, India. Dr Sahadulla has earlier worked with Aramco, Saudi Arabia, one of the most advanced medical organizations in the world. His association with Saudi Aramco, for over 25 years in various capacities as Physician, Internist, and Administrator, gave him immense opportunities for understanding American standards in healthcare delivery, quality & patient safety, medical disasters and industrial emergencies. In 2002, he returned to Thiruvananthapuram on India's south-west coast, to establish his dream of offering high quality, cost-effective and ethical healthcare and founded KIMSHEALTH, Thiruvananthapuram, which is an 850-bed flagship hospital of KIMS Healthcare Management Ltd. Dr Sahadulla's pivotal role as an Industry Leader is reflected in his positions in some of the reputed organizations in the country. He also works as the Chairman of the APHI Management Association, Kerala Chapter, FICCI Kerala Chapter, and as the Chairman of Confederation of Indian Industries (CII) Healthcare Committee.

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