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Unit No. 1

VACCINATION AND CONTROL OF INFECTIOUS DISEASES AND PNEUMOCOCCAL DISEASES

Dr Tan Seow Yen

ABSTRACT

Vaccination in Infectious Disease Control

Vaccination stimulates the immune system to develop immunity against specific infectious agents, preventing and controlling diseases. Healthcare professionals are primarily motivated by professional responsibility, education, evidence-based practice, and first-hand experience of vaccine-preventable diseases. The public is driven by the desire to protect themselves and loved ones, trust in vaccine safety, recommendations from healthcare professionals, and awareness of the importance of vaccination.

Vaccines and Antimicrobial Resistance (AMR)

Vaccines combat AMR by reducing infections caused by resistant or susceptible pathogens and decreasing antibiotic use. Vaccines against viral infections, like influenza, reduce inappropriate antibiotic consumption, which is a significant driver of AMR. Resistance to bacterial vaccines is rare and does not render them ineffective. Vaccines also decrease the risk of acquiring and transmitting resistant microbes, promoting healthier populations, and retaining antibiotic effectiveness.

Pneumococcal Disease

Pneumococcal disease is caused by Streptococcus pneumoniae and can lead to respiratory tract infections and invasive diseases.

Common manifestations include pneumonia, invasive diseases (bacteraemia, meningitis, etc.), sinusitis, and otitis media. Understanding pathophysiology helps guide diagnosis and treatment. Vaccination, surveillance, and appropriate management are crucial to prevent and mitigate the impact of pneumococcal disease.

Keywords: vaccines, pneumococcus, antimicrobial resistance

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DR TAN SEOW YEN
Consultant, Department of Infectious Diseases
Changi General Hospital

INTRODUCTION

Vaccination plays a critical role in the control and prevention of infectious diseases. It is a vital public health intervention that has been proven to be highly effective in preventing and controlling infectious diseases.[1] National immunisation guidelines are in place to guide the discussion for personalised vaccine recommendations based on individual health status and risk factors.[2,3,4]

Concepts of Vaccination in Infectious Disease Control

The following revises some key concepts related to vaccination in infectious disease control:

Immunisation

Vaccination, also known as immunisation, is the process of administering a vaccine to stimulate the immune system and develop immunity against a specific infectious agent, such as a virus or bacteria. They can contain either weakened or inactivated forms of the pathogen, parts of the pathogen, or substances that mimic the pathogen, which prompt an immune response without causing the disease.

Herd Immunity

Also called community immunity, herd immunity occurs when a significant proportion of the population is immune to a specific infectious disease. When a large portion of individuals are immune, the spread of the pathogen is effectively limited, protecting those who are unable to receive the vaccine or have a weakened immune system. Achieving herd immunity through vaccination is crucial in controlling outbreaks and protecting vulnerable populations.

Vaccine Efficacy

Vaccine efficacy refers to the ability of a vaccine to prevent the development of a specific disease in vaccinated individuals under controlled conditions (e.g., clinical trials). Efficacy is typically expressed as a percentage and provides an estimate of the vaccine's effectiveness in preventing the disease.

Vaccine Effectiveness

Vaccine effectiveness measures the real-world protection provided by a vaccine when used in the general population. Effectiveness may be influenced by various factors, including the individual's immune response, the circulating strains of the pathogen, and the vaccine's ability to induce immunity against those strains.

What are the Drivers of Vaccination Among Healthcare Professionals and the Population?

Several drivers influence healthcare professionals' motivation to engage in vaccination.[5] Healthcare professionals have

a strong sense of professional responsibility to protect their patients and communities from infectious diseases. Vaccination is seen as a fundamental aspect of patient care, preventing illness and promoting public health. They recognise their role as advocates for immunisation and prioritise the well-being of their patients, as well as the professional responsibility to do so.

Throughout their career journey, healthcare professionals receive extensive education and training on immunisation, infectious diseases, and vaccine safety and efficacy. They have a deep understanding of the benefits of vaccination and the potential risks of vaccine-preventable diseases. This knowledge empowers them to confidently recommend and administer vaccines.

The rigorous training also means that healthcare professionals rely on evidence-based practice to guide their clinical decision-making. Vaccination is supported by robust scientific evidence and research, demonstrating its effectiveness in preventing diseases. Therefore, they prioritise evidence and base their recommendations on the latest guidelines and studies. There is also a high level of trust in the regulatory bodies that thoroughly evaluate and monitor vaccines. This trust extends to the rigorous scientific research and peer-reviewed studies that support vaccine recommendations.

The connection to professional networks facilitates information sharing, collaborative efforts, and the dissemination of best practices related to immunisation. Professional guidelines and consensus statements further guide healthcare professionals in making informed decisions regarding vaccination.

Many a time, healthcare professionals often witness the consequences of vaccine-preventable diseases first-hand. They may have treated patients suffering from severe complications of diseases that could have been prevented by vaccination. These experiences serve as powerful motivators to advocate for vaccination and prevent future cases.

On a personal level, when healthcare professionals understand the importance of protecting themselves and their colleagues from vaccine-preventable diseases, they would also see that vaccination reduces the risk of occupational exposure and transmission of infectious agents in healthcare settings, safeguarding the healthcare workforce and maintaining continuity of care.

Finally, on the legal and ethical front, healthcare professionals adhere to legal and ethical standards that promote the health and well-being of their patients. Vaccination aligns with these obligations, ensuring patient autonomy, preventing harm, and promoting the common good. Compliance with vaccination requirements and policies is part of professional practice.

On the other side of the house, the primary driver for vaccination among the public is often the desire to protect oneself and loved ones from vaccine-preventable diseases. People understand that vaccines can provide immunity and reduce the risk of getting sick or experiencing severe complications from infectious diseases.[6,7]

Trust in the safety and effectiveness of vaccines is a crucial driver. Public trust is built on the rigorous testing and regulatory processes that vaccines undergo before approval, as well as the monitoring of vaccine safety and ongoing research. Communication from healthcare professionals, public health authorities, and credible sources play a significant role in fostering trust.

It is therefore not an exaggeration that recommendations from healthcare professionals, including doctors, nurses, and pharmacists, are influential drivers of vaccination. When healthcare providers communicate the benefits and importance of vaccines, it strengthens public confidence and motivates individuals to get vaccinated.

There is a high level of concern for the well-being of vulnerable populations, such as infants, the elderly, pregnant women, and individuals with weakened immune systems. People understand that by getting vaccinated, they can help protect those who are more susceptible to severe illness or complications.

The COVID-19 pandemic has brought about public awareness of the importance of vaccination in preventing outbreaks and maintaining community health. Vaccination contributes to achieving herd immunity, which helps to control the spread of infectious diseases and protect individuals who cannot receive vaccines due to medical reasons.

In general, accessibility and availability of vaccines are crucial drivers. When vaccines are easily accessible, affordable, and offered through various healthcare settings, people are more likely to get vaccinated. Convenient access to vaccination clinics, healthcare providers, schools, and community centres can positively impact vaccination rates.

Other factors that can also contribute to the motivation to get vaccinated include education and awareness; vaccine mandates and policies; social norms and peer influence; and personal experience.

There is little doubt as to the importance of the motivation of healthcare professionals to advocate for vaccination, and of the population to get vaccinated. When putting the two together, it is expected that recommendations from healthcare professionals would be a very important driver for individuals to get vaccinated, and for them to encourage their loved ones to get vaccinated as well.

This is also strongly echoed in local surveys done with the intention to understand the sentiments around vaccines and its impact and influence on general well-being; as well as respondents' perception of trusted sources and decision-making when deciding on vaccines.

It has been observed that recommendations from healthcare professionals is the top reason to encourage individuals to take vaccines, as well as to encourage one's family members to take their vaccines.

Availability of higher subsidies is also among the top reasons to encourage individuals to take vaccines, as well as to encourage one's family members to take their vaccines. Besides that, healthcare professionals and local government or health authorities are the most trusted and influential sources, with almost 4 in 5 individuals citing healthcare professionals and the Singapore government and health authorities as their trusted sources for vaccine-related information and are sources of influence that convince individuals to take recommended vaccines.

At the end of the day, while the benefits of vaccinations are well described and well known, it is important to note that individual attitudes, beliefs, and circumstances may vary.[8] Continuous education, supportive policies, and a culture of vaccine promotion within healthcare settings can further strengthen healthcare professionals' commitment to vaccination. Tailored communication, addressing vaccine hesitancy, and ensuring equitable access to vaccines are essential strategies to enhance public motivation for vaccination.

Vaccines and Their Relationship with Antimicrobial Resistance

Antimicrobial resistance (AMR) is a growing threat to global health, and was associated with 4.95 million deaths in 2019 globally, more than HIV and malaria combined. Vaccines can be highly effective tools in combating AMR and have been highlighted by the World Health Organisation (WHO) as such.

Vaccines work through multiple mechanisms to reduce AMR.[9] Vaccines targeting bacterial pathogens reduce infections caused by antibiotic-resistant or susceptible pathogens, and contribute to the protection of unvaccinated populations if sufficient levels of immunity are maintained.

This is achieved by both reducing the overall burden of infectious disease, caused by resistant or susceptible bacteria, as well as by reducing antibiotic use associated with bacterial or viral infections. In addition, vaccines against viral infections (especially respiratory infections) reduce inappropriate antibiotic consumption, which is one of the key drivers of AMR.

Although resistance has emerged for every antibiotic that has been introduced into clinical practice, resistance to bacterial vaccines is generally rare and tends not to render them ineffective. However, some vaccines have been shown to select for non-vaccine serotypes, causing replacement with those serotypes not covered by the vaccine over time.

Overall, vaccines decrease the risk of both acquiring and transmitting resistant microbes and reduce antibiotic use. This promotes healthier populations and helps to retain the effectiveness of antibiotics. In addition, vaccines prevent infections, and their associated unpleasantness and discomfort, before they happen. This is cost-effective for health systems and can mean populations that have limited access to care are better protected.

Overview of Pneumococcal Disease and Its Pathophysiology

Pneumococcal disease is an infection caused by the bacteria Streptococcus pneumoniae, or pneumococcus. This gram-positive, encapsulated bacterium is a leading cause of respiratory tract infections and can result in a range of illnesses, from mild to severe, including invasive diseases. Pneumococcus colonises the upper respiratory tract asymptomatically in many individuals. However, when host defences are compromised or the bacteria gain access to sterile sites, they can cause localised and systemic infections.

The most common clinical manifestation of pneumococcal disease is community-acquired pneumonia, which presents with symptoms such as productive cough, fever, pleuritic chest pain, and shortness of breath. Pneumonia caused by S. pneumoniae can range from uncomplicated cases treated in the outpatient setting to severe cases requiring hospitalisation and intensive care. Invasive pneumococcal disease occurs when the bacterium invades sterile sites such as the bloodstream, meninges, joints, or pleural space. This can lead to life-threatening conditions including bacteraemia, meningitis, septic arthritis, and empyema.

Certain populations are at higher risk for pneumococcal disease, including young children, older adults, individuals with immunocompromising conditions, and those with underlying medical comorbidities such as chronic lung or heart diseases.

The pathogenesis of pneumococcal disease begins with the attachment of pneumococcal surface proteins to host epithelial cells in the respiratory tract. This allows the bacteria to establish colonisation and evade the host's immune defences. Pneumococcus possesses a polysaccharide capsule that plays a critical role in its virulence. The capsule helps the bacteria evade phagocytosis by the host's immune cells and facilitates its survival and multiplication in the respiratory tract.

In susceptible individuals, factors such as impaired host defence mechanisms, underlying medical conditions, or a weakened immune system can allow pneumococcus to overcome the local defence barriers and invade sterile sites. The bacteria can disseminate from the respiratory tract to other parts of the body through the bloodstream, leading to invasive pneumococcal disease. Invasive disease can manifest as bacteraemia, meningitis, septic arthritis, empyema, or other severe infections.

The host immune response to pneumococcal infection involves both innate and adaptive immunity. Innate immune cells such as neutrophils and macrophages are activated to recognise and phagocytose the bacteria. The adaptive

immune system produces antibodies against pneumococcal antigens, which can enhance bacterial clearance.

Pneumococcal disease severity is influenced by factors such as the virulence of the bacterial strain, host immune response, and underlying health conditions. Certain serotypes of S. pneumoniae have been associated with increased invasiveness and more severe disease outcomes.

Understanding the pathophysiology of pneumococcal disease helps guide diagnostic and treatment strategies. Prompt recognition of invasive pneumococcal infections and appropriate antibiotic therapy are important for improving patient outcomes. Regular surveillance of pneumococcal isolates for antibiotic resistance patterns is crucial for selecting appropriate empiric antibiotic therapy and monitoring for emerging resistance.

Understanding the local epidemiology and serotype distribution of pneumococcal isolates is essential for selecting the appropriate vaccine formulations. Vaccination helps reduce the incidence of pneumococcal disease and its associated complications. Pneumococcal vaccines, including the pneumococcal conjugate vaccine (PCV) and the pneumococcal polysaccharide vaccine (PPSV), have been developed to target the most common disease-causing serotypes. Vaccination plays a crucial role in preventing pneumococcal disease and reducing its burden.

Management of pneumococcal infections involves prompt diagnosis, initiation of appropriate antibiotic therapy, and supportive care when indicated. In cases of invasive disease, blood and/or cerebrospinal fluid cultures should be obtained to guide targeted antimicrobial treatment.

Overall, pneumococcal disease remains a significant public health concern, and a comprehensive approach involving vaccination, surveillance, and appropriate management is essential in preventing and mitigating its impact.

Pneumococcal Disease Presentation in Adults and Children

Pneumococcal disease can present differently in adults and children, and understanding these variations is important for accurate diagnosis and management.

In adults, the most common presentation of pneumococcal disease is pneumonia. It manifests as symptoms such as cough, fever, chest pain, shortness of breath, and fatigue. Pneumonia caused by Streptococcus pneumoniae can range from mild cases treated in the outpatient setting to severe cases requiring hospitalisation and intensive care.

Other manifestations in adults include pneumococcal sinusitis and otitis media, which can cause symptoms such as facial pain, nasal congestion, headache, and ear pain. Invasive pneumococcal disease, though less common in adults, can lead to serious conditions such as bacteraemia, meningitis, septic arthritis, and empyema.

In children, pneumococcal disease commonly presents as pneumonia. Symptoms include cough, rapid or difficult breathing, chest pain, fever, fatigue, and bluish skin colour in severe cases. Infants may exhibit irritability, poor feeding, and lethargy.

Pneumococcal bacteraemia in children may present with symptoms such as fever, rapid breathing, poor feeding, irritability, and pale or mottled skin. Pneumococcal meningitis, though rare, can occur in children and presents with symptoms such as high fever, severe headache, neck stiffness, sensitivity to light, irritability, drowsiness, poor feeding, and vomiting. Infants with meningitis may show a bulging fontanelle.

Children also commonly experience pneumococcal otitis media, which presents with symptoms such as ear pain, tugging or pulling at the ear, irritability, difficulty sleeping, hearing loss, and fever.

CONCLUSION

In summary, pneumococcal disease can manifest differently in adults and children, with varying presentations ranging from mild respiratory infections to severe invasive diseases. Familiarity with these presentations aids in prompt diagnosis and appropriate management, leading to improved patient outcomes.

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LEARNING POINTS

- **Healthcare professional recommendation is an important driver towards vaccine acceptance.**
- **Vaccines are an important tool in the fight against antimicrobial resistance.**
- **Pneumococcal disease remains a significant public health concern, and a comprehensive approach involving vaccination, surveillance, and appropriate management is essential to prevent and mitigate its impact.**