

# Expert panel opinion on adult pneumococcal vaccination in the post-COVID era (NAP- EXPO Recommendations-2024)

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## ABSTRACT

**Introduction:** Pneumococcal diseases pose a significant public health concern in India, with substantial morbidity and mortality, with the elderly and those with coexisting medical conditions being most at risk. Pneumococcus was also seen to be one of the main reasons for co-infection, pneumonia and complications in COVID. Current guidelines recommend

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vaccination for specific adult populations, but there is a lack of uniformity and guidance on risk stratification, prioritisation and optimal timing. **Methods:** Nation Against Pneumococcal Infections – Expert Panel Opinion (NAP-EXPO) is a panel convened to review and update recommendations for adult pneumococcal vaccination in India. The panel of 23 experts from various medical specialties engaged in discussions and evidence-based reviews, discussed appropriate age for vaccination, risk stratification for COPD and asthma patients, vaccination strategies for post-COVID patients, smokers and diabetics, as well as methods to improve vaccine awareness and uptake. **Outcome:** The NAP-EXPO recommends the following for adults: All healthy individuals 60 years of age and above should receive the pneumococcal vaccine; all COPD patients, regardless of severity, high-risk asthma patients, post-COVID cases with lung fibrosis or significant lung damage, should be vaccinated with the pneumococcal vaccine; all current smokers and passive smokers should be educated and offered the pneumococcal vaccine, regardless of their age or health condition; all diabetic individuals should receive the pneumococcal vaccine, irrespective of their diabetes control. Strategies to improve vaccine awareness and uptake should involve general practitioners (GPs), primary health physicians (PHPs) and physicians treating patients at high risk of pneumococcal disease. Advocacy campaigns should involve media, including social media platforms. **Conclusion:** These recommendations aim to enhance pneumococcal vaccination coverage among high-risk populations in India in order to ensure a reduction in the burden of pneumococcal diseases, in the post-COVID era. There is a need to create more evidence and data to support the recommendations that the vaccine will be useful to a wider range of populations, as suggested in our consensus.

**KEY WORDS:** Adult, expert panel opinion, high risk population, pneumococcal vaccination, post-COVID era

## INTRODUCTION

As the world grapples with the long-lasting effects of the coronavirus disease (COVID-19) pandemic, there is a heightened awareness of the significance of protecting vulnerable adult populations, especially the elderly and individuals with underlying health conditions. Pneumococcal diseases, caused by the bacterium *Streptococcus pneumoniae*, can lead to serious and significant morbidity and mortality, that not only a healthcare burden for the individual and family, but also a significant strain on the healthcare systems, specifically in densely populated low and lower middle-income countries. Globally, LRTIs caused more than 2.3 million deaths among people of all ages with *Streptococcus pneumoniae* being the leading cause of LRI morbidity and mortality globally, contributing to more deaths than those caused by *Haemophilus influenzae*, RSV and influenza virus combined, and resulting in about 55.4% (1,189,937) of all deaths.<sup>[1]</sup> The number of LRI deaths among the elderly, especially those aged more than 70 years, has registered an increase from 1990 to 2016. *S. pneumoniae* infection can present as either invasive pneumococcal disease (IPD), or non-invasive pneumococcal pneumonia, if it occurs alone.<sup>[2]</sup>

Pneumococcal vaccination has a crucial role to play in reducing the burden on healthcare facilities, preventing severe respiratory illnesses and safeguarding the health of those at risk. This vaccination not only offers effective protection against pneumococcal infections, complications, hospitalisation and risk of invasive pneumococcal disease (IPD), but can also contribute to overall public health resilience by decreasing the incidence of respiratory diseases, allowing healthcare systems to focus on chronic diseases, preparedness for future pandemics, and further

evolving the healthcare landscape. Therefore, the impact of vaccination on health and survival as a whole in the community is important to understand, and this conviction forms the foundation of increasing vaccination coverage and awareness.

Recent data have suggested that vaccination against *S. pneumoniae* could prevent and reduce SARS-CoV-2 pneumonia, in spite of the fact that the vaccinated individuals share the same risk profile as the unvaccinated individuals.<sup>[3]</sup> In another study, significant positive correlations were found between IPD (but not lower respiratory infections) and COVID-19 rates, whereas significant negative correlations were found between pneumococcal vaccination and COVID-19 rates.<sup>[4]</sup> Thus, in the post-COVID era, pneumococcal vaccination emerges as a vital component in ensuring the well-being of vulnerable individuals and promoting community-wide health.<sup>[5]</sup>

### Disease burden of pneumonia in India

Each year, there are approximately 40-45 million cases of community-acquired pneumonia (CAP), which accounts for nearly a quarter of the global pneumonia burden. The burden of CAP is estimated at 2-12 cases per 1000 person-years, highlighting its significant public health impact.<sup>[6]</sup> Pneumococcal pneumonia is responsible for 4-5 million cases annually, making up 0.4% of the total incidence in the Indian population. Pneumococcus is the causative organism in a substantial portion of CAP, contributing to 30-40% of cases, as well as in 70-80% of Community-Acquired Bacterial Pneumonia (CABP) cases.<sup>[7,8]</sup> Notably, Pneumococcus is the primary driver of lower respiratory tract infection (LRTI) morbidity and mortality, and the most frequent secondary complication of viral pneumonia causing morbidity and mortality, underscoring its critical role in respiratory health.<sup>[1,9]</sup>

Pneumococcal pneumonia in India poses a significant public health concern, with hospitalisation rates for this type of pneumonia falling within a range of 10% to 30%, though this rate dramatically increases with age to 60-70% in elderly individuals.<sup>[10,11]</sup> Therefore, awareness of the pneumococcal disease burden and knowing that its occurrence and impact, especially in adults, are very important to improve vaccination rates. Complications arising from pneumococcal pneumonia, mainly invasive pneumococcal disease (IPD), particularly bacteremia and sepsis, are reported at a rate of approximately 10%.<sup>[12]</sup> Additionally, when considering indoor patient data, the incidence of more severe complications like meningitis is 1% or less.<sup>[13]</sup>

The overall mortality rate in cases of pneumococcal pneumonia in India is substantial, ranging from 14% to 30%, and reaching up to 47% in severe CAP.<sup>[14]</sup> The case fatality rate ranges from 2 to 20% reaching up to 50% in patients, especially elderly, admitted to ICUs, with *Pneumococcus* being the cause in 30% of cases.<sup>[14]</sup> Moreover, the mortality rate in IPD like meningitis, is 20-50%, which is on the higher end in developing countries.<sup>[15]</sup> These statistics underscore the pressing need for effective implementation of preventive measures, such as vaccination, to reduce the burden of pneumococcal pneumonia and its severe consequences in India.

#### **Pneumococcal pneumonia in post-COVID-19 era**

The prevalence of secondary or co-infections associated with COVID reached as high as 45.0%, posing an additional challenge during the pandemic.<sup>[16]</sup> Among these co-infections, *Pneumococcus* emerged as the most common pathogen that was co-infected with COVID, further complicating the clinical picture. Notably, in 50% of COVID mortality cases, co-infections played a significant role, highlighting the importance of understanding these dual health threats. The intersection of pneumococcal pneumonia and COVID mortality, particularly with increasing age, can be as high as 25%, emphasising the vulnerability of older populations.<sup>[16]</sup>

The weakened immune function induced by COVID-19 remains a prominent risk factor for pneumococcal disease, warranting enhanced preventive measures. Both pneumococcal disease and COVID-19 share similar risk factors, with underlying medical conditions elevating the risk of severe illness at any age. It is noteworthy that more than 50% of COVID-related deaths in India occurred in the 50-70 years age group, emphasising that pneumococcal vaccination in the era of COVID has gained even greater relevance as a crucial public health measure.<sup>[16]</sup>

#### **Current guidelines and recommendations**

Pneumococcal vaccine has been advocated for adult immunisation in various international and national guidelines. Table 1 presents a summary of guidelines outlining the different adult population cohorts recommended for pneumococcal vaccination.

These guidelines delineate different patient populations for pneumococcal vaccines, yet there is a lack of uniformity and explicit guidance concerning the necessity for vaccination based on the severity of comorbidities or underlying cause, or the optimal timing of vaccination following a disease diagnosis. Considering the changing landscape of disease burden in the post-COVID era, a need was felt to review the current guidelines, as well as update and clarify the recommendations for adult pneumococcal vaccination in India based on the available literature, and practical clinical experience. In India, currently, PCV15 and PCV20 mentioned in the latest CDC-ACIP guidelines are not available; therefore, our recommendations are in line with earlier guidelines of PCV13 and PPSV23.

As a general Indian consensus, it is recommended to administer at least one dose of Pneumococcal Polysaccharide Vaccine (PPSV23) to all adults aged 65 years or older who have no previous vaccination history or whose vaccination history is unknown. For adults aged 18 to 65 years with immunocompromised conditions or co-existing medical conditions, the vaccination protocol involves administering the Pneumococcal Conjugate Vaccine (PCV13) followed by PPSV23. In immune competent adults, regardless of whether PCV13 or PPSV23 is administered first, a minimum one-year time gap is advised between the two vaccinations to maximise their effectiveness. In the case of immunocompromised adults (including asplenia, splenic dysfunction and those with severe immunocompromise), it is crucial to initiate the vaccination series with PCV13 and follow with PPSV23 after a minimum interval of 8 weeks, based on studies demonstrating a better response to serotypes common to both vaccines when PCV was given first, and the combination of PPSV23 with PCV13 should produce a superior immune response than with PPSV23 alone.<sup>[22]</sup> It is important to note that repeating the vaccination with PPSV23 can lead to hyporesponsiveness, due to diminished antibody response. Therefore, the decision to revaccinate an individual with PPSV23 should be solely based on clinical judgement to balance potential benefits and risks, and not before 5 years from the last dose. Vaccination with 1 dose of PPSV23 is recommended in all elderly adults > 65 years because of the overall higher incidence of invasive pneumococcal disease in this age group. As the current Indian Chest Society guidelines 2019-2020 are pre-COVID, there was a need to update certain recommendations in the light of some lessons learnt during the pandemic.<sup>[18]</sup>

#### **METHODOLOGY**

On September 16, 2023, a panel of experts came together to re-review the current guidelines and thereafter update and clarify the recommendations for preventing pneumococcal pneumonia in India through vaccination in adults. The expert group consisted of 20 physicians, comprising pulmonologists, cardiologists, diabetologists

**Table 1: Pneumococcal vaccination guidelines summary**

Guidelines	Year	Recommended adult population for vaccination
Centers for Disease Control and Prevention - Advisory Committee on Immunization Practices CDC-ACIP <sup>[17]</sup>	2022	<ul style="list-style-type: none"> <li>• Vaccinate all adults <math>\geq 65</math> years with no/unknown history of vaccination.</li> <li>• Vaccinate 18-64 years with               <ol style="list-style-type: none"> <li>a) Medical condition: Chronic heart disease (including CHF and cardiomyopathies), chronic lung disease (including COPD and asthma), chronic smoker, diabetes mellitus, alcoholism, chronic liver disease, cerebrospinal fluid leaks and cochlear implants).</li> <li>b) Immunocompromised (immunosuppressive) condition: Congenital or acquired immunodeficiency/HIV, malignancies, nephrotic syndrome or chronic renal disease, immunosuppressive treatment/drugs, organ transplant, asplenia, and sickle cell anemia.</li> </ol> </li> </ul>
Indian Chest Society <sup>[18]</sup>	2019-2020	<ul style="list-style-type: none"> <li>• Pneumococcal vaccination is usually not recommended for healthy adults under 65 years.</li> <li>• Vaccinate immunocompetent patients with chronic conditions such as chronic heart disease, chronic liver disease, poorly controlled diabetes mellitus, chronic lung disease, and in current smokers and those with alcohol abuse.</li> <li>• Vaccinate adults with a history of invasive pneumococcal disease, those with cochlear implants, cerebrospinal fluid (CSF) leak, or impaired splenic function (anatomic/functional asplenia or hyposplenism, sickle cell disease or other hemoglobinopathy)</li> <li>• Vaccinate all immunocompromised individuals, such as those with HIV infection, iatrogenic immunosuppression, chronic kidney disease, hematologic malignancy, other solid tumor malignancies with or without metastasis, hematopoietic stem cell transplantation and solid-organ transplantation.</li> </ul>
RSSDI Consensus group <sup>[19]</sup>	2022	<ul style="list-style-type: none"> <li>• All diabetes subjects should be educated about administering at least pneumococcal and influenza vaccines</li> <li>• People with diabetes aged 2-64 years should receive a 23-valent pneumococcal polysaccharide vaccine (PPSV23).</li> <li>• At age <math>\geq 65</math> years, regardless of vaccination history, additional PPSV23 vaccination is necessary.</li> <li>• The panel recommends the use of PCV13 for adults <math>\geq 50</math> years followed by a dose of PPSV23 at least 1 year later (and at least 5 years after their previous PPSV23 dose) depending on the clinical judgment of the physician.</li> <li>• PPSV23 may be offered to immune-compromised patients with               <ul style="list-style-type: none"> <li>• diabetes for additional coverage after PCV13.</li> </ul> </li> </ul>
Geriatric Society of India <sup>[20]</sup>	2015	<ul style="list-style-type: none"> <li>• Vaccinate individuals aged 50 years and older.</li> <li>• Vaccinate individuals with underlying medical conditions such as coronary artery disease, congestive heart failure, cardiomyopathy, diabetes mellitus, bronchial asthma, chronic obstructive pulmonary disease, cirrhosis of liver and chronic renal failure (CRF).</li> <li>• Vaccinate all immunocompromised individuals with high risk for pneumococcal infections, like those with immunoglobulin deficiency, HIV, leukemia, lymphoma, multiple myeloma, Hodgkin's disease, non-Hodgkin's lymphoma, disseminated malignancy, those with either a reduced response to vaccination or a decline in serum antibody concentrations.</li> <li>• Vaccinate individuals with organ or bone marrow transplantation, receiving long-term therapy with corticosteroids or immunosuppressive agents, who have undergone splenectomy, or have anatomic asplenia, or sickle cell disease as they have reduced clearance of encapsulated bacteria from the blood stream, chronic smokers, suffering from sleep disorders, those who are prone to               <ul style="list-style-type: none"> <li>• nocturnal aspiration.</li> </ul> </li> </ul>
The Indian Society of Nephrology <sup>[21]</sup>	2016	<ul style="list-style-type: none"> <li>• Vaccinate all patients with CKD as early as possible.</li> </ul>

and medical affairs doctors from the pharmaceutical field. This group included three expert panelists, a chairperson and a moderator. The moderator had done a prior review of literature and shared pre-reads and summaries with the panelists.

The meeting had a structured approach to achieving consensus on various topics related to pneumococcal vaccination. The moderator played a crucial role by posing questions that were designed to probe the current understanding of pneumococcal vaccination. The experts engaged in an in-depth discussion on scientific literature related to pneumococcal vaccination. The discussion involved a thorough review of research papers, studies and relevant data, with a focus on understanding the latest developments and findings in this field.

### Outcomes

The extensive discussion led to comprehensive understanding of the subject matter and allowed for a

multifaceted analysis of the available information. As the discussion progressed, recommendations emerged based on the collective expertise of the panel members. The questions and the recommendations/clarifications have been described below:

### What should be the right age for pneumococcal vaccination in healthy adults in the post-COVID-19 era, considering the high mortality rates observed during and after COVID-19 pandemic?

The 50-64 age group represents a vital and diverse section of the population, often comprising the working-age individuals who shoulder numerous responsibilities. This age group frequently contends with high levels of physical and mental stress stemming from the demands of their careers and personal lives. This stress often leads to lifestyle issues and challenges, including unmonitored nutrition, with alcohol and smoking seen as coping mechanisms.<sup>[23]</sup> Those working in office-based desk jobs face the risk associated with sedentary lifestyle and exposure to air

conditioning. Stress induced lifestyle, lowered immunity and increasing age leads to many individuals at this age harbouring undiagnosed or borderline comorbidities, making them more susceptible to infections and various health issues.<sup>[24]</sup> Additionally, a significant proportion of this age group has experienced the effects of the COVID-19 pandemic, either as clinically diagnosed cases (20% of the total 45 million cases) or those who went undiagnosed. India has reported around 45 million COVID cases till date, and around 20% are in this age group.<sup>[25,26]</sup> Given these multifaceted health risks, pneumococcal vaccination is a critical preventative measure for this age group. It helps reduce the risk of pneumococcal infections and their associated complications, contributing to their overall health and well-being.<sup>[27]</sup>

The current guidelines recommend administering the pneumococcal vaccine to high-risk adults with comorbidities and all aged 65 years and older. Although there was a discussion about lowering the age threshold to 50 years, this proposition could not be unanimously accepted due to the absence of published data from the Indian population substantiating the benefits of vaccinating all healthy adults over 50 years. Additionally, since vaccinations in India are not covered by insurance, and adult pneumococcal vaccination rates are generally low, extending the vaccine recommendation to all healthy individuals above 50 years would entail cost implications. Pertinent to note that the Geriatric Society of India guidelines have recommended pneumococcal vaccination for all individuals aged 50 years or above.<sup>[20]</sup> Although the data for these recommendations are scant, it was likely rooted in the low life expectancy of Indians, which would render the age cut-offs of 65 years and above irrelevant in Indian settings at the time of the development of the guidelines.

It is crucial to note that lower respiratory diseases and chronic respiratory conditions rank among the top five causes of hospitalisation burden and premature mortality in India for individuals between the ages of 50 and 69 years.<sup>[1]</sup>

After considering the various advantages and disadvantages of reducing the recommended age for vaccination, a consensus was reached to recommend lowering the age to at least 60 years, as opposed to the current threshold of 65 years. Furthermore, individuals above the age of 50 years, who can afford the vaccine, should be encouraged to receive it to enhance coverage. This approach would contribute to the development of herd immunity, benefiting the broader population, and can also be a cost-effective measure to reduce hospitalisation, morbidity and mortality due to pneumococcal infections in the 50-65 age-group. The vaccination schedule should remain unchanged, with a single dose PCV13 administered first followed by PPSV23 after one year (with a minimum gap of 8 weeks if given earlier in immunocompromised adults)

*Summary of Recommendation: All healthy individuals aged 60 years and above should be given the pneumococcal vaccine, and those aged 50 years and above should be made aware of and encouraged to take the pneumococcal vaccine as a shared clinical decision.*

### Is there a need to risk-stratify COPD patients for pneumococcal vaccination?

Pneumococcus accounts for 43% of CAP cases in COPD, with the risk of pneumococcal pneumonia being 7-8 times higher.<sup>[28,29]</sup> In COPD patients, several factors increase the risk of developing pneumonia, a potentially serious complication that can exacerbate their already compromised respiratory health. Among these are advanced age, the presence of emphysema, and a low forced expiratory volume in one second (FEV1) less than 60%, all signifying diminished lung function, which can hinder the body's ability to clear pathogens, thereby increasing the risk of pneumonia. Interestingly, a high body mass index (BMI) above 22 has also been identified as a risk factor, possibly due to its association with certain metabolic and immune system alterations in COPD patients.<sup>[30]</sup>

Pneumococcal vaccination plays a crucial role in safeguarding the health of individuals with chronic obstructive pulmonary disease (COPD). This vaccination provides substantial protection against Community-Acquired Pneumonia (CAP) and significantly reduces the incidence of lower respiratory tract infections (LRTIs) in COPD patients. By bolstering the immune system's ability to combat pneumococcal infections, it also lessens the likelihood of a COPD exacerbation, a common and potentially severe complication in these individuals. Prevention of acute exacerbations (AECOPD) is a strongly desired goal in the management of COPD, as it leads to an exponential decrease in the lung function of a patient with COPD, is a strong predictor of a future exacerbation, and has considerable morbidity and mortality. Even after surviving an exacerbation, nearly 40% of Indian patients with AECOPD die within 2 years, underscoring the importance of preventing infective AECOPD.<sup>[31]</sup>

When assessing the impact of vaccination on pneumonia risk in COPD patients, a noteworthy difference emerges between those who have received the Pneumococcal Polysaccharide Vaccine (PPSV23) and those who haven't. Among vaccinated COPD patients, the frequency of pneumonia is notably lower, with a rate of 28.4 cases per 1000 patient-years, highlighting the protective effect of vaccination. In contrast, the rate of pneumonia in unvaccinated COPD patients is significantly higher, at 62.4 cases per 1000 patient-years.<sup>[30]</sup> PPSV23 has been shown to reduce CAP incidence in high-risk COPD patients: <65 years, with FEV1 <40% or those with comorbidities (especially cardiac).<sup>[32]</sup> Pneumococcal vaccines had a significant effect on reducing CAP when compared with control (number needed to treat [NNT] =21), but they had no effect on reducing episodes of

pneumococcal pneumonia. A paucity of confirmed cases of pneumococcal pneumonia may contribute to the lack of evidence for pneumococcal vaccines preventing this disease.<sup>[33]</sup>

Pneumococcal vaccination also reduced the hospitalisation risk for pneumococcal pneumonia in COPD patients from 8 times, to 3.8 times (>50% reduction).<sup>[34]</sup> These findings provide evidence of the importance of vaccination in reducing the risk of pneumonia among COPD patients and emphasise the potential benefits of preventive measures to improve COPD management. Pneumococcal vaccines reduced the number of COPD exacerbations (NNT = 8; four RCTs, N = 446; OR = 0.60; 95% CI, 0.39 to 0.93; moderate certainty evidence), but did not significantly reduce the number of hospital admissions (three RCTs, N = 391; OR = 0.74; 95% CI, 0.32 to 1.74; moderate certainty evidence). In a retrospective matched-cohort study from the US, patients with COPD and CAP were 42.3% more likely to experience an exacerbation (16% versus 11%;  $P < 0.001$ ).<sup>[35]</sup>

There are data to suggest that hypogammaglobulinemia is seen in up to a quarter of COPD patients.<sup>[36]</sup> The likelihood of hypogammaglobulinemia increases with the increased severity of AECOPD and may be associated with increased mortality.<sup>[37]</sup> Preliminary data suggest that in AECOPD, low IgM is associated with longer hospital stay and may indicate a patient phenotype that would benefit from efforts to prevent respiratory infections.<sup>[38]</sup> Patients with hypogammaglobulinemia are independently at risk for invasive Pneumococcal disease and would likely benefit from Pneumococcal vaccine. However, data are not available for the efficacy or usefulness of Pneumococcal vaccination in patients with COPD with hypogammaglobulinemia, and as such no separate recommendation can be made.

While there has been a question about the necessity of risk stratification for COPD patients in terms of vaccination, a consensus has been reached of unanimous agreement that all COPD patients, regardless of the severity of their condition or co-existing risk factors or medical conditions, should be vaccinated with the pneumococcal vaccine as soon as possible after diagnosis.

*Summary of Recommendation: All COPD patients, irrespective of the severity and co-existing risk factors or medical conditions, should be vaccinated with the pneumococcal vaccine at the earliest possible time after diagnosis.*

### Can a risk stratification be done for Pneumococcal vaccination in Asthma?

The inclusion of asthma as an indication for pneumococcal vaccination is a topic that involves careful consideration of various guidelines and factors. The Centers for Disease Control and Prevention (CDC) categorise asthma as a part of chronic lung disease (CLD) for adults and recommend

pneumococcal vaccination for individuals with specific medical conditions.<sup>[39]</sup> For children over the age of 2 years, the CDC advises vaccination if asthma is treated with prolonged high-dose oral corticosteroid therapy. These recommendations acknowledge the potential vulnerability of individuals with asthma to pneumococcal infections, particularly those who require intensive treatment. On the other hand, the Global Initiative for Asthma (GINA) guidelines indicate that there is insufficient evidence to recommend routine pneumococcal vaccination for all adults with asthma.<sup>[40]</sup>

However, a compelling argument for risk stratification in asthma patients for pneumococcal vaccination can be made. The publication by Talbot *et al.*<sup>[41]</sup> demonstrated that asthma is an independent risk factor for invasive pneumococcal disease. This study revealed an adjusted odds ratio for invasive Pneumococcal disease ranging from 2.4 for patients with any asthma to 2.6 for those with high-risk asthma and 1.7 for low-risk asthma. High risk asthma was defined as asthma requiring admission to a hospital or a visit to an emergency department, the use of rescue therapy or long-term use of oral corticosteroids, or the dispensing of three or more prescriptions for  $\beta$ -agonists within one year. The revised HEDIS (Healthcare Effectiveness Data and Information Set (HEDIS) measure defines high-risk asthma as meeting any of the following criteria:  $\geq 1$  emergency department visits, or  $\geq 1$  hospitalisations for asthma, or  $\geq 1$  oral steroid prescriptions for asthma in one year.<sup>[42]</sup> Many patients with severe asthma are on biologics and regarding concerns over vaccine administration, nearly all vaccines can be given without interruption of biologic treatment in patients with severe asthma.<sup>[43]</sup>

*Summary of Recommendation: All patients evaluated by the clinician as high-risk asthma should be vaccinated with the pneumococcal vaccine at the earliest possible.*

*It was collectively acknowledged that all patients with chronic lung diseases, whether COPD, asthma, ILD, or other CLDs, face a vulnerability to invasive pneumonia. Therefore, it is advisable that all individuals diagnosed with these conditions should receive the pneumococcal vaccine to enhance their protection against pneumococcal infections and associated complications including IPD. This unified approach ensures comprehensive care and protection for individuals with chronic lung diseases.*

### Should there be a vaccination strategy for post-COVID patients?

A number of COVID-19 survivors have been left with residual pulmonary sequelae and disease symptoms including impaired spirometry in up to 46% cases.<sup>[44-46]</sup> There is documented evidence to support a higher incidence of pneumococcal disease in the post-COVID era.<sup>[47]</sup> Respiratory symptoms and impaired spirometry have been more frequent in those with severe COVID-19. With the emergence of the COVID-19 pandemic, there has been an

ongoing discussion regarding pneumococcal vaccination for clinically diagnosed post-COVID patients, similar to the recommendations of vaccination in post tuberculosis lung disease in order to prevent and/or mitigate complications.<sup>[48]</sup> There are no clear guidelines about when, after COVID, pneumococcal vaccination may be given but a period of 8 weeks should be normally considered as safe.

The decisions would be influenced by factors such as age, the severity of COVID (e.g., hospitalisation), and other risk factors. These considerations aim to address the potential susceptibility of individuals recovering from COVID-19 to pneumococcal infections, emphasising the need for individualised risk assessment. High-risk patients, particularly those who have experienced post-COVID fibrosis or have significant lung damage, should be considered prime candidates for receiving the pneumococcal vaccine.<sup>[49]</sup> From a clinical perspective, hypoxia or respiratory failure (present or in past during COVID) should be considered a high-risk group for persistent respiratory abnormalities and pneumococcal vaccination.

A comprehensive approach to vaccination is essential, especially for individuals who have recovered from COVID-19 and are now dealing with persistent lung issues.

*Summary of Recommendation: High risk post-COVID patients who have been diagnosed with any grade of lung fibrosis, had significant lung damage, or have compromised lung function, should be given the Pneumococcal vaccine.*

#### What should be the vaccination strategy for smokers?

An important aspect of pneumococcal vaccination that emerged is the heightened risk of invasive pneumococcal diseases in individuals who smoke or are exposed to passive smoke. A significant study by Nuorti *et al.*<sup>[50]</sup> revealed compelling findings. The research indicated that the risk of invasive pneumococcal diseases increases substantially, by 4.1 times, in current smokers and by 2.5 times in passive smokers, compared to non-smokers. Additionally, the risk of pneumococcal disease diminishes by just 14 percent each year following an individual's cessation of smoking, eventually reaching the same level as those who have never smoked after roughly 13 years. Given these significant risks associated with current active smokers, passive smokers and former/ex-smokers, it was emphasised that a proactive approach is crucial. All of them should be educated about the importance of pneumococcal vaccination, regardless of their age or current health condition.

In a study current smoking was defined as regular cigarette smoking (duration >6 months) at the time of examination. Former smoking was defined as a history of smoking for longer than 6 months and no current smoking. Passive smoking was evaluated based on responses to questions on whether there were smokers living in the participant's family or present at the workplace and was defined as

exposure to passive smoking more than once per week and for longer than 1 year.<sup>[51]</sup> The vaccination of individuals in these high-risk groups against pneumococcal infections, can substantially reduce their susceptibility and mitigate the potential health complications associated with invasive pneumococcal diseases.

*Summary of Recommendation: All current smokers and even the passive smokers should be educated and offered pneumococcal vaccine irrespective of their age and health condition.*

#### Should there be a risk-stratification for vaccination strategy for those with diabetes?

The role of pneumococcal vaccination in diabetes management is of paramount significance, as individuals with diabetes face a markedly increased risk of contracting pneumococcal infections. Research findings, highlight the substantial risks faced by diabetic individuals.<sup>[52-57]</sup> They are 3 times more likely to contract pneumococcal community-acquired pneumonia (CAP) and experience a 3-fold higher risk of hospitalisation due to the disease. Moreover, the risk of developing invasive pneumococcal disease (IPD) is 3.5 times greater, further underscoring the vulnerability of diabetic patients. In addition to these risks, diabetes also presents a 2-fold increased risk of mortality when pneumococcal infections occur.

In a study, the PPSV-23 vaccinated group had reduced risks of IPD, shorter length of hospitalisation and less respiratory failure by 20-25%, and PPSV23 vaccination was effective in the prevention of pneumococcal diseases and reduction of medical utilisation in diabetic especially in elderly.<sup>[55-57]</sup> Given the substantial evidence and increased susceptibility of diabetic individuals to pneumococcal infections, pneumococcal vaccination is strongly recommended. This vaccination has a pivotal role in reducing the risk of pneumococcal infections, which can lead to severe complications, hospitalisations and even mortality in those with diabetes.<sup>[53]</sup> A call to action has been made to improve immunisation rates among high-risk adults, including those with diabetes. Thus, pneumococcal vaccination is an essential component of diabetes management, enhancing the overall health and well-being of individuals living with this chronic condition.

The question of whether diabetic patients require risk stratification for pneumococcal vaccination based on control of blood sugar achieved and the presence of other medical factors, has been a subject of consideration. However, the consensus that has emerged is clear and unanimous that all individuals with diabetes, regardless of the degree of control of their condition, should be administered the pneumococcal vaccine. While a few guidelines have previously suggested targeting vaccination specifically at those with poorly controlled diabetes, this approach is being revisited and challenged.<sup>[18,58]</sup>

The rationale for vaccinating all diabetic patients lies in the recognition that diabetes itself places individuals at a higher risk of pneumococcal infections, which can lead to severe health complications. Furthermore, the prioritization of certain diabetic subgroups has been emphasised, particularly in the context of India. These “absolute priority groups” within diabetes, as outlined in the provided resource, include those with associated comorbidities, and individuals aged 65 and above. This approach aids in extending the pneumococcal vaccination to a broader spectrum of diabetic individuals, with the aim of reducing their susceptibility to pneumococcal infections and enhancing overall health outcomes. In essence, the prevailing consensus supports a proactive and inclusive strategy that ensures that all individuals with diabetes receives the protection offered by pneumococcal vaccination, irrespective of their diabetes control status.

*Summary of Recommendation: All diabetics should be given the pneumococcal vaccine irrespective of the level of disease control.*

### What should be the strategies to improve vaccine awareness and uptake in India?

Awareness of pneumococcal vaccination in India is of utmost importance, as recent data underscores alarmingly low vaccination rates. The research, encompassing a substantial sample size of over 64,000 respondents, revealed that the coverage of all studied vaccinations, including the pneumococcal vaccine, remained notably deficient, with each of them reaching less than 2% of the population. Pneumococcal vaccination, in particular, emerged with the lowest coverage, at less than 1%.<sup>[59]</sup> This highlights a significant gap in public awareness and underscores the pressing need for educational initiatives and outreach programmes.

Interestingly, the study also illuminated specific trends in vaccine uptake. Respondents with underlying medical conditions, including cardiovascular disease (CVD), diabetes, or lung diseases, demonstrated higher rates of vaccination when compared to those without such health issues. This finding confirms the importance of targeted vaccination efforts for vulnerable populations. Moreover, the research identified several predictors for vaccine uptake, such as male gender, urban residence, higher household income, more years of schooling, the presence of existing medical conditions and sedentary behaviors. These predictors provide valuable insights into the factors that influence vaccination decisions, offering guidance for tailored awareness campaigns. It is evident that a comprehensive strategy is needed to raise awareness about pneumococcal vaccination in India, with a particular focus on reaching those at greater risk due to underlying health conditions and addressing the predictors that impact vaccine uptake.

Improving pneumococcal vaccination rates in adults, especially those with underlying medical conditions, can

be effectively achieved through the involvement of general practitioners (GPs) and primary health physicians (PHPs). A comprehensive understanding of the current scenario reveals that pneumococcal vaccination remains strikingly low across a considerable adult population, as indicated by a recent study involving 255,330 adults. Alarmingly, most adults diagnosed with underlying medical conditions remain unvaccinated, highlighting the need for targeted intervention.<sup>[60]</sup>

Encouragingly, the study also presents compelling evidence of the positive impact of involving GPs and PHPs in the vaccination process. The vaccination rate significantly increased from 6.0% to 21% among adults who received follow-up within one to five years after being diagnosed with a medical condition. It took approximately 2.4 years for adults to receive pneumococcal vaccination after their initial medical condition diagnosis, emphasising the importance of timely intervention.

Moreover, awareness measures implemented in a separate study saw the rates of pneumococcal vaccination surge from 2.5% to an impressive 73.5%.<sup>[61]</sup> Certain factors were found to influence vaccination rates positively, such as age (particularly among adults aged 50-64 and 35-49 years), and receiving the flu vaccine. Additionally, adults with Human Immunodeficiency Virus (HIV) demonstrated higher rates of vaccination, while those with other medical conditions were less likely to be vaccinated compared to those with diabetes.<sup>[60]</sup>

The pivotal role of GPs and PHPs in driving pneumococcal vaccination is underscored by the study’s findings, which indicated that adults diagnosed by these primary care providers were more likely to be vaccinated compared to those diagnosed by other health providers. The involvement of GPs and PHPs not only ensures timely diagnosis and medical recommendations but also facilitates effective vaccine administration and patient education, thereby increasing pneumococcal vaccination rates. By leveraging the influence and accessibility of these primary care providers, healthcare systems can substantially enhance vaccination coverage, particularly among high-risk groups, and work towards reducing the burden of pneumococcal diseases.

The imperative for improving awareness regarding pneumococcal vaccination cannot be overstated. It is evident that many individuals at high risk, for whom the vaccine is strongly indicated, remain unaware of the crucial need for this vaccination. To address this gap in knowledge and ensure that those who would benefit the most receive the vaccine, it is vital to launch special awareness campaigns across various media platforms. These campaigns should be designed to disseminate information about the importance of pneumococcal vaccination, particularly among high-risk populations. By raising awareness through accessible and widespread media channels, healthcare authorities can effectively



reach and educate the public about the significance of this vaccination, ultimately enhancing the overall health and well-being of the population. Healthcare providers also need to be sensitised for offering pneumococcal vaccination to high-risk individuals, as poor sensitisation of healthcare workers has been recognised as one of the most important factors in the poor uptake of vaccines by high-risk individuals.<sup>[62]</sup>

It is significant here to mention about the vaccination of healthcare workers, who are an important vulnerable group, but are not part of any patient vaccination guidelines. While this advisory committee mainly discussed risk assessment and prioritisation of pneumococcal vaccination in chronic lung disease, and cardiometabolic diseases including diabetes, the creation of awareness and execution is also to be emphasised in specific cardiac conditions like coronary artery disease, congestive heart failure and cardiomyopathy, along with immune-compromised conditions including chronic kidney disease (CKD), liver cirrhosis, HIV and cancer, as well as lifestyle risk factors like alcoholism, which come under the ambit of different specialties.

It needs to be emphasized that there is scarcity of knowledge, attitude and practice studies for pneumococcal vaccination in India and efforts should be undertaken to gather real world data for pneumococcal vaccination in India so as to formulate policy. This is especially important for adults, as adult vaccination as a concept has not taken great root in India, and efforts need to be made to have the concept engrained in various stakeholders.

Data also need to be generated on pneumococcal vaccine effectiveness studies so that informed policy decisions can be undertaken based on local data rather than data generated in other geographical locations.

*Summary of Recommendation: Every effort should be made to improve awareness for the need of this vaccination. General practitioners (GPs) and primary health physicians (PHPs) should be actively involved. Special campaigns should be run on various media platforms to improve awareness.*

## CONCLUSION

### The NAP-EXPO panel recommends the following:

1. All healthy individuals above the age of 60 years should receive the pneumococcal vaccine.
2. All COPD patients, regardless of severity, should be vaccinated with the pneumococcal vaccine.
3. High-risk asthma patients (those requiring hospitalisation, emergency department visits, long-term oral corticosteroids, or multiple  $\beta$ -agonist prescriptions within a year) should be vaccinated.
4. High-risk post-COVID patients (those with post-COVID lung fibrosis, hypoxia or respiratory failure currently or

in the past during COVID, or significant lung damage) should receive the pneumococcal vaccine.

5. All current smokers and passive smokers should be educated and offered the pneumococcal vaccine, regardless of their age or health condition.
6. All diabetic individuals should receive the pneumococcal vaccine, irrespective of their diabetes control.
7. Strategies to improve vaccine awareness and uptake should involve GPs and PHPs and should include special and targeted campaigns on various media platforms.

We understand the limitations of an advisory group discussion as compared to a wider, more anonymous Delphi survey or similar anonymous technique for consensus development. However, in our methodology, each medical practitioner brought forth their independent opinions to the floor before the advisory meeting, and the consensus is the result of extensive literature searches, long and rich clinical experience, extensive discussions, and consideration of Indian patients' demographic and cultural characteristics. It is important to note that this is an expert opinion, and for many situations, more clinical studies and real-world evidence are recommended. It is also noteworthy that these recommendations are subject to further amendment once PCV-20 is introduced in our country; however, the cost and access would be something the manufacturers would need to analyse before its wide scale application in the Indian context.

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## Conflicts of interest

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## REFERENCES

1. GBD 2016 Lower Respiratory Infections Collaborators. Estimates of the global, regional, and national morbidity, mortality, and etiologies of lower respiratory infections in 195 countries, 1990-2016: A systematic analysis for the Global Burden of Disease Study 2016. *Lancet Infect Dis* 2018;18:1191-210.
2. Drijkoningen JJ, Rohde GG. Pneumococcal infection in adults: Burden of disease. *Clin Microbiol Infect* 2014;20(Suppl 5):45-51.
3. Morales-Suárez-Varela M, Toledo D, Fernández-Sierra MA, Liébana M, Rubiera G, Navarro G, et al. A profile of adult severe acute respiratory syndrome coronavirus 2 pneumonia patients according to pneumococcal vaccination status. *Vaccines* 2023;11:1630.
4. Root-Bernstein R. Pneumococcal and influenza vaccination rates and pneumococcal invasive disease rates set geographical and ethnic

- population susceptibility to serious covid-19 cases and deaths. *Vaccines (Basel)* 2021;9:474.
5. Lan C, Chen YC, Chang YI, Chuang PC. Impact of COVID-19 outbreak on influenza and pneumococcal vaccination uptake: A multi-center retrospective study. *Vaccines (Basel)* 2023;11:986.
  6. Gupta D, Agarwal R, Aggarwal AN, Singh N, Mishra N, Khilani GC, et al. Pneumonia Guidelines Working Group. Guidelines for diagnosis and management of community and hospital acquired pneumonia in adults: Joint ICS/NCCP (I) recommendations. *Lung India* 2012;29(Suppl 2):S2762.
  7. Capoor MR, Nair D, Aggarwal P, Gupta B. Rapid diagnosis of community-acquired pneumonia using the BacT/Alert 3D system. *Braz J Infect Dis* 2006;10:352–6.
  8. Bansal S, Kashyap S, Pal LS, Goel A. Clinical and bacteriological profile of community acquired pneumonia in Shimla, Himachal Pradesh. *Indian J Chest Dis Allied Sci* 2004;46:17–22.
  9. Sender V, Hentrich K, Henriques-Normark B. Virus-induced changes of the respiratory tract environment promote secondary infections with *Streptococcus pneumoniae*. *Front Cell Infect Microbiol* 2021;11:643326.
  10. Zar HJ, Madhi SA, Aston SJ, Gordon SB. Pneumonia in low and middle income countries: Progress and challenges. *Thorax* 2013;68:1052-6.
  11. Ruiz LA, España PP, Gómez A, Bilbao A, Jaca C, Arámburu A, et al. Age-related differences in management and outcomes in hospitalized healthy and well-functioning bacteremic pneumococcal pneumonia patients: A cohort study. *BMC Geriatr* 2017;17:130.
  12. Koul PA, Chaudhari S, Chokhani R, Christopher D, Dhar R, Doshi K, et al. Pneumococcal disease burden from an Indian perspective: Need for its prevention in pulmonology practice. *Lung India* 2019;36:216-25.
  13. Chang B, Tamura K, Fujikura H, Watanabe H, Tanabe Y, Kuronuma K, et al. Adult IPD Study Group. Pneumococcal meningitis in adults in 2014-2018 after introduction of pediatric 13-valent pneumococcal conjugate vaccine in Japan. *Sci Rep* 2022;12:3066.
  14. Eshwara VK, Mukhopadhyay C, Rello J. Community-acquired bacterial pneumonia in adults: An update. *Indian J Med Res* 2020;151:287-302.
  15. Muley VA, Ghadage DP, Yadav GE, Bhole AV. Study of invasive pneumococcal infection in adults with reference to penicillin resistance. *J Lab Physicians* 2017;9:31-5.
  16. Im H, Ser J, Sim U, Cho H. Promising expectations for pneumococcal vaccination during covid-19. *Vaccines (Basel)* 2021;9:1507.
  17. Pneumococcal Vaccine Recommendations. Centers for Disease Control and Prevention. CDC.gov. Updated Sep 10, 2023. Available from: [https://www.cdc.gov/vaccines/vpd/pneumo/hcp/recommendations.html#:~:text=Routin%20Recommendation-,CDC%20recommends%20routine%20administration%20of%20pneumococcal%20conjugate%20vaccine%20\(PCV15%20or,of%20PPSV23%20one%20year%20later](https://www.cdc.gov/vaccines/vpd/pneumo/hcp/recommendations.html#:~:text=Routin%20Recommendation-,CDC%20recommends%20routine%20administration%20of%20pneumococcal%20conjugate%20vaccine%20(PCV15%20or,of%20PPSV23%20one%20year%20later.). [Last accessed on 2023 Sep 15].
  18. Dhar R, Ghoshal AG, Guleria R, Sharma S, Kulkarni T, Swarnakar R, et al. Clinical practice guidelines 2019: Indian consensus-based recommendations on pneumococcal vaccination for adults. *Lung India* 2020;37(Suppl):S19-29.
  19. Makkar BM, Saboo B, Kumar VC, Agarwal S, et al. On behalf of RSSDI 2022 Consensus Group. RSSDI Clinical Practice Recommendations for the Management of Type 2 Diabetes Mellitus 2022. *Int J Diabetes Dev Ctries* 2022;42 (Suppl 1):1-143.
  20. Ghia CJ, Rambhad G. Pneumococcal vaccine recommendations for old-age home indian residents: A literature review. *Gerontol Geriatr Med* 2022;8:23337214221118237.
  21. Indian Society of Nephrology Vaccination Work Group. Guidelines for vaccination in chronic kidney disease. *Indian J Nephrol* 2016;26:S1–30.
  22. Hayward S, Thompson LA, McEachern A. Is 13-Valent Pneumococcal Conjugate Vaccine (PCV13) combined with 23-Valent Pneumococcal Polysaccharide Vaccine (PPSV23) superior to PPSV23 alone for reducing incidence or severity of pneumonia in older adults? *A Clin-IQ. J Patient Cent Res Rev* 2016;3:111-5.
  23. Khan, J. Nutritional status, alcohol-tobacco consumption behaviour and cognitive decline among older adults in India. *Sci Rep* 2022;12:21102.
  24. Adults 50 and Older Need More Physical Activity. CDC.gov. Updated March 16, 2022. Available from: <https://www.cdc.gov/physicalactivity/inactivity-among-adults-50plus/index.html>. [Last accessed on 2023 Sep 15].
  25. Minhas. A. Number of COVID-19 cases in India by age group. Statista. July 12, 2023. Available from: <https://www.statista.com/statistics/1110522/india-number-of-coronavirus-cases-by-age-group/>. [Last accessed on 2023 Nov 27].
  26. WHO. India COVID Situation. Nov 22, 2023. Available from: <https://covid19.who.int/region/searo/country/in>. [Last accessed on 2023 Nov 27].
  27. Jones MK, Latreille PL, Sloane PJ, Staneva AV. Work-related health risks in Europe: Are older workers more vulnerable? *Soc Sci Med* 2013;88:18-29.
  28. Huerta A, Crisafulli E, Menéndez R, Martínez R, Soler N, Guerrero M, et al. Pneumonic and nonpneumonic exacerbations of COPD: Inflammatory response and clinical characteristics. *Chest* 2013;144:1134–42.
  29. American Lung Association. The connection between pneumonia and lung disease. Nov 11, 2018. Available from: <https://www.lung.org/blog/pneumonia-and-lung-disease>. [Last accessed on 2023 Nov 27].
  30. Kurashima K, Takaku Y, Nakamoto K, Kanauchi T, Takayanagi N, Yanagisawa T, et al. Risk factors for pneumonia and the effect of the pneumococcal vaccine in patients with chronic airflow obstruction. *Chronic Obstr Pulm Dis* 2016;3:610-9.
  31. Koul PA, Dar HA, Jan RA, Shah S, Khan U. Two-year mortality in survivors of acute exacerbation of chronic obstructive pulmonary disease. A North Indian study. *Lung India* 2017;34:511–6.
  32. Alfageme I, Vazquez R, Reyes N, Muñoz J, Fernández A, Hernandez M, et al. Clinical efficacy of anti-pneumococcal vaccination in patients with COPD. *Thorax* 2006;61:189–95.
  33. Walters JA, Tang JN, Poole P, Wood-Baker R. Pneumococcal vaccines for preventing pneumonia in chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2017;1:CD001390.
  34. Lee TA, Weaver FM, Weiss KB. Impact of pneumococcal vaccination on pneumonia rates in patients with COPD and asthma. *J Gen Intern Med* 2007;22:62-7.
  35. Bornheimer R, Shea KM, Sato R, Weycker D, Pelton SI. Risk of exacerbation following pneumonia in adults with heart failure or chronic obstructive pulmonary disease. *PLoS One* 2017;12:e0184877.
  36. Leitao Filho FS, Won Ra S, Mattman A, Schellenberg RS, Fishbane N, Criner GJ, et al. Serum IgG and risk of exacerbations and hospitalizations in chronic obstructive pulmonary disease. *J Allergy Clin Immunol* 2017;140:1164-7.
  37. Holm AM, Andreassen SL, Christensen VL, Kongerud J, Almås Ø, Auråen H, et al. Hypogammaglobulinemia and risk of exacerbation and mortality in patients with COPD. *Int J Chron Obstruct Pulmon Dis* 2020;15:799–807.
  38. Palikhe NS, Niven M, Fuhr D, Sinnatamby T, Rowe BH, Bhutani M, et al. Low immunoglobulin levels affect the course of COPD in hospitalized patients. *Allergy Asthma Clin Immunol* 2023;19:10.
  39. Recommended Vaccines for Adults. CDC.gov. Updated Sep 8, 2023. Available from: <https://www.cdc.gov/vaccines/adults/rec-vac/index.html>. [Last accessed on 2023 Sep 15].
  40. 2023 GINA Report, Global Strategy for Asthma Management and Prevention: Global Initiative for Asthma (GINA). Updated July 10, 2023. Available from: <https://ginasthma.org/2023-gina-main-report/>. [Last accessed on 2023 Sep 15].
  41. Talbot TR, Hartert TV, Mitchel E, Halasa NB, Arbogast PG, Poehling KA, et al. Asthma as a risk factor for invasive pneumococcal disease. *N Engl J Med* 2005;352:2082-90.
  42. Bennett AV, Lozano P, Richardson LP, McCauley E, Katon WJ. Identifying high-risk asthma with utilization data: A revised HEDIS definition. *Am J Manag Care* 2008;14:450-6.
  43. Dorseid DR, Lee JK, Ramesh W, Greenwald M, Carpio JD. Guidance of administering biologic for severe asthma and allergic conditions. *Can Respir J* 2022;2022:9355606.
  44. Hadda V, Suri TM, Iyer H, Jain A, Mittal S, Madan K, et al. A Delphi consensus statement for the management of post-COVID interstitial lung disease. *Expert Rev Respir Med* 2022;16:983-95.
  45. Vishnu NS, Sodhi MK, Aggarwal D, Puri S, Saini V. Persistent respiratory symptoms and lung function abnormalities in recovered patients of COVID-19. *Lung India* 2023;40:507-13.
  46. Rajotiya S, Mishra S, Singh AK, Singh P, Bareth H, Singh M, et al. Post-COVID-19 cardio-pulmonary manifestations after 1-year of SARS-CoV-2 infection among Indian population: A single centre, case-control study (OneCoV2 study). *J Infect Public Health* 2023;17:145-51.
  47. Bertran M, Amin-Chowdhury Z, Sheppard CL, Eletu S, Zamarreño DV, Ramsay ME, et al. Increased incidence of invasive pneumococcal disease among children after covid-19 pandemic, England. *Emerg Infect Dis* 2022;28:1669-72.
  48. Nasiri MJ, Silva DR, Rommasi F, Zahmatkesh MM, Tajabadi Z, Kheghati F,

- et al.* Vaccination in post-tuberculosis lung disease management: A review of the evidence. *Pulmonology* 2023;S2531-0437(23)00129-0. doi: 10.1016/j.pulmoe. 2023.07.002.
49. Bazdyrev E, Rusina P, Panova M, Novikov F, Grishagin I, Nebolsin V. Lung fibrosis after covid-19: Treatment prospects. *Pharmaceuticals (Basel)* 2021;14:807.
  50. Nuorti JP, Butler JC, Farley MM, Harrison LH, McGeer A, Kolczak MS, *et al.* Cigarette smoking and invasive pneumococcal disease. Active Bacterial Core Surveillance Team. *N Engl J Med* 2000;342:681-9.
  51. Liu Y, Dai M, Bi Y, Xu M, Xu Y, Li M, *et al.* Active smoking, passive smoking, and risk of nonalcoholic fatty liver disease (NAFLD): A population-based study in China. *J Epidemiol* 2013;23:115-21.
  52. Torres A, Blasi F, Dartois N, Akova M. Which individuals are at increased risk of pneumococcal disease and why? Impact of COPD, asthma, smoking, diabetes, and/or chronic heart disease on community-acquired pneumonia and invasive pneumococcal disease. *Thorax* 2015;70:984-9.
  53. Al-Dahash R, Kamal A, Amir A, Shabaan A, Ewias D, Jnaid H, *et al.* Insights from the current practice of pneumococcal disease prevention for diabetic patients in Saudi Arabia. *Cureus* 2022;14:e23612.
  54. Petigara T, Zhang D. Pneumococcal vaccine coverage in adults aged 19-64 years, newly diagnosed with chronic conditions in the US. *Am J Prev Med* 2018;54:620-36.
  55. Kuo CS, Lu CW, Chang YK, Yang KC, Hung SH, Yang MC, *et al.* Effectiveness of 23-valent pneumococcal polysaccharide vaccine on diabetic elderly. *Medicine (Baltimore)* 2016;95:e4064.
  56. American Diabetes Association Professional Practice Committee; 4. Comprehensive Medical Evaluation and Assessment of Comorbidities: Standards of Medical Care in Diabetes—2022. *Diabetes Care* 2022;45(Suppl 1):S46–59.
  57. Flynn T, Lesser C. Understanding the Importance of Pneumococcal Disease Prevention in Patients with Diabetes. *Pharmacy Times [Internet]* 2018;84 (7). Available from: <https://www.pharmacytimes.com/view/understanding-the-importance-of-pneumococcal-disease-prevention-in-patients-with-diabetes>.
  58. Shashank RJ, Samika SJ, Siddharth NS. Pneumococcal vaccine in diabetes: Relevance in India. *J Assoc Physicians India* 2015;63(4 Suppl):34-5.
  59. Rizvi AA, Singh A. Vaccination coverage among older adults: A population-based study in India. *Bull World Health Organ* 2022;100:375-84.
  60. Ostropolets A, Shoener Dunham L, Johnson KD, Liu J. Pneumococcal vaccination coverage among adults newly diagnosed with underlying medical conditions and regional variation in the U.S. *Vaccine* 2022;40:4856-63.
  61. Biyik MV, Arslan I, Yengil Taci D. Study to increase the pneumococcal vaccination rates of individuals aged 65 years and older. *Prim Health Care Res Dev* 2020;21:e37.
  62. Koul PA, Mir H. The biggest barrier to influenza vaccination in pregnant females in India: Poor sensitization of the care providers. *Vaccine* 2018;36:3569-70.