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Evaluation of inpatient pneumococcal vaccination rate among adult patients with diabetes in a tertiary care teaching hospital in Saudi Arabia

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Background: Diabetes mellitus was found to be one of the most common comorbidities for pneumococcal diseases. Pneumococcal vaccinations can reduce morbidity and mortality in this patient population. The purpose of this study was to estimate pneumococcal vaccination rate of these populations in inpatient hospital setting.
Materials and methods: We performed a retrospective chart review involving adult patients with diabetes who were admitted to King Abdulaziz Medical City (KAMC) in Riyadh, Saudi Arabia between the period of March 2016 and March 2017.
Results: A total of 1087 eligible patients were included. The overall vaccination rate for pneumococcus was 1.6% among the vaccine-eligible subjects. The most common risk factors were older age (65 years old or over – 53.9%), chronic renal failure (28.2%) and chronic heart failure (27%), respectively. The majority of the patients in this study were eligible for pneumococcal vaccine (77.6%) due to one or more risk factor other than diabetes mellitus. The mean number of other risk factors other than diabetes mellitus was 1.5 (SD 1.1, 95% CI 1.39–1.53). None of the included patients had documentation on pneumococcal vaccination status.
Conclusion: The pneumococcal vaccine coverage rates among hospitalised patients with diabetes were low in a tertiary care teaching hospital in Saudi Arabia. Further studies are needed to assess the impact of electronic interventions in promoting vaccination assessment and administration among patients with diabetes.

Keywords: Evaluation, inpatient, pneumococcal, vaccination, diabetes

Introduction

Pneumococcal disease is associated with significant morbidity and mortality in both developing and developed countries, causing 1.6 million deaths annually.[1] The incidence rate of pneumococcal disease increases with advancing age with the majority of the fatality cases in elderly. Because the number of people age 60 years or older worldwide is expected to double between 2015 and 2050 (from 900 million to 2.1 billion), pneumococcal disease in older adult will continue to be an important public health concern.[2,3] Multiple studies showed a significant reduction in the incidence rate of all pneumococcal infections after the introduction of 7-valent pneumococcal conjugate (PCV7) vaccine.[4–7] With the availability of PCV 13-valent pneumococcal conjugate (PCV13) and 23-valent pneumococcal polysaccharide (PPV23) vaccines, the rate of invasive pneumococcal infections caused by the organism *Streptococcus pneumoniae* has further reduced.[8,9] Besides its efficacy, the pneumococcal vaccine has been shown to be cost-effective with saving up to $340 millions of medical costs in the United States.[10,11]

Diabetes mellitus was found to be one of the most common comorbidities for pneumococcal diseases. In addition, one of the most frequent respiratory infections associated with diabetes was caused by *S. pneumoniae*.[12,13] Furthermore, a surveillance study reported a relative risk for invasive pneumococcal disease of 3–6-fold higher in patients with diabetes, chronic lung or heart diseases in comparison to healthy individuals.[14] Therefore, the Centers for Disease Control and Prevention (CDC) recommends pneumococcal vaccination for all adults of the age of 65 years or older and for people 2 through 64 years old age with certain medical conditions including diabetes mellitus.[15] Additionally, multiple international diabetes guidelines recommend vaccination against pneumonia with pneumococcal polysaccharide vaccine (PPSV23) for any patient with diabetes at the age of 2 through 64 years.[16,17] For those with the age of 65 years or older, the recommendation also includes administering the pneumococcal conjugate vaccine (PCV13) at least 1 year after vaccination with PPSV23, followed by another dose of vaccine PPSV23 at least 1 year after

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PCV13 and at least 5 years after the last dose of PPSV23.[17]

In 2016, the Saudi Thoracic Society published a recommendation for administering the pneumococcal vaccination to all high-risk groups for invasive pneumococcal disease as described in Table 1.[18] In Saudi Arabia alone, diabetes accounts for 20% of the country's total health expenditures.[19] A national survey in Saudi Arabia showed that the percentage of diabetes mellitus in adults was 23.7%; and up to 44% of these patients had severe long-term diabetes complications which known to be leading causes of hospitalisation among patients with diabetes.[20,21] A recent study demonstrated that patients with diabetes who admitted to the hospital remain at higher risk of pneumococcal infections which can be explained by patients' low vaccination rate.[13] The high rates of hospitalisation with the risk of re-admission in this patient population make the inpatient setting a suitable place for proper assessment and administration of needed vaccines among patients with diabetes.[22]

King Abdulaziz Medical City (KAMC) in the Central Region of Saudi Arabia is a tertiary care hospital under the umbrella of the Health Affairs of National Guard Ministry. The medical city provides primary health care services including immunisation to all National Guard military and civilians in addition to their dependent individuals with full and free access to all primary health care services. In KAMC, the vaccination against pneumococcus for high-risk individuals is carried out in KAMC primary care clinics. In the hospital setting the treating medical team is responsible for carrying out the vaccination in high-risk patients.

The data on pneumococcal vaccination rate in adult patients in Saudi Arabia is lacking based on the data from other countries, pneumococcal vaccination rates for high-risk population have been suboptimal despite the opportunities to get vaccinated when visiting clinics for underlying medical conditions as diabetes mellitus, kidney and cardiovascular diseases.[14,23–24] Additionally, the CDC 2014 and 2015 national surveillances, only 20 and 23% of patients with age of 65 or younger who met high-risk criteria were vaccinated, respectively.[25]

Table 1. Risk factors that indicate receiving pneumococcal vaccine other than diabetes in the study population.

Risk factors	% of Patients
Age 65 or greater	53.9
Chronic heart disease	27.0
Chronic lung disease	12.7
Chronic renal failure	28.2
Nephrotic syndrome	0.1
Chronic liver disease	6.2
Alcoholism	0.2
Cigarette smoking	5.2
CSF fluid leaks	0.0
Cochlear implant	0.0
Congenital immunodeficiency	0.0
HIV infection	0.2
Steroids or immunosuppressive	4.7
Solid organ transplant	4.0
Sickle cell anaemia	0.0
Leukemia or lymphoma	0.4
Hodgkin disease	0.1
Generalised malignancy	3.9
Multiple Myeloma	0.0

Given the profound clinical impact of vaccination against pneumococcus especially in patients with comorbidities like diabetes and because of the high annual rate of admission of this patient population, the inpatient setting could represent a prime setting to provide the proper assessment and administration of needed vaccines. In this study, we aimed to estimate the pneumococcal vaccination rate among patients with diabetes admitted to a tertiary teaching hospital and to analyse the other risk factors that indicate pneumococcal vaccinations in this patient population.

Methodology

We performed a retrospective descriptive study involving patients who were admitted to King Abdulaziz Medical City (KAMC) between the period of March 2016 and March 2017. Inclusion criteria were adult patients aged 18 years or older with diabetes mellitus who were admitted to any hospital general wards. Patients were excluded if they were transferred from other hospital or had documented pneumococcal vaccination allergy. Patients information and immunisation status were collected using electronic medical records (EMR). Collected data included demographic data, admission diagnosis, number and type of other risk factors for pneumococcal vaccination. Subjects eligible for pneumococcal vaccine were defined by the recent recommendation of the Saudi Thoracic Society which included all adults 65 years of age or older or adults with certain medical conditions: chronic pulmonary disease, chronic cardiovascular disease, diabetes, chronic hepatic disease, chronic renal failure, nephrotic syndrome, functional or anatomic asplenia, immune-compromised patients, prolonged use of high-dose corticosteroids or immunosuppressive therapy.[18] We also used the patient electronic chart to check if the assessment for the candidacy of pneumococcal vaccination was documented at any point prior, during or after hospitalisation. Patients who are eligible to be enrolled in this study were identified from the electronic patient charts using age (18 years of age or older) and diabetes mellitus per International Classification of Diseases, Clinical Modification codes. Surgical patients were those who primarily admitted for a surgical intervention. Cardiac patients were those who admitted under cardiac services, while medical patients were all other patients not under cardiac or surgical services. The study was approved by the Institutional Review Board of King Abdullah International Medical

Research Center (KAIMRC). No external or internal fundings were received in for the completion of this study.

Statistics

This was a descriptive study and descriptive statistics such as mean and median were used. The 95% confidence intervals were calculated when applicable using Microsoft Excel (Microsoft Office Excel 2016, Microsoft, Inc., Redmond, Washington).

Results

During the study period, a total of 1143 adult patients (of the age of 18 years or older) with diabetes were identified from the electronic medical system. Fifty-six patients were excluded because of the transfer from other hospitals. One thousand and eighty-seven diabetic patients were eligible for the pneumococcal vaccine and included in our study due to diabetes alone or diabetes with other risk factors for pneumococcal infections. Of these 678 (52.3%) were medical patients, 216 (19.9%) cardiac patients and 193 (17.8%) surgical patients. The mean age was 65.1 years and 52.2% of patients were male. The most common admission diagnosis was pneumonia (13.6%), heart failure (12.8%) and ischaemic heart disease (10.7%), respectively. The assessment of the presence of risk factors for receiving pneumococcal vaccines other than diabetes is presented in Table 1. The most common risk factors were age more than 65 (53.9%), chronic renal failure (28.2%) and chronic heart failure (27%), respectively. Other than diabetes, the majority of our patients (77.6%) were having one or more risk factor that indicates immunisation against pneumococcus. The mean number of other risk factors that indicate pneumococcal vaccination other than diabetes is 1.5 (SD 1.1, 95% CI 1.39–1.53). Table 2 presents the numbers of risk factors other than diabetes that indicate pneumococcal vaccinations in the study population.

Out of 1087 patients with diabetes, only 17 (1.6%) received the pneumococcal vaccine during their hospital admission. Of those who got vaccinated, 13 were under medical services, 3 were cardiac patients and one patient was under surgical services. Upon reviewing the medical charts of the included patients, there was no documentation concerning the immunisation status of the admitted patients or if the immunisation was assessed at any time before or during hospital admission, at transition of care or at the time of patient discharge out of the hospital. Additionally, no documentation if any of the included patients had received the pneumococcal vaccination in the last 10 years.

In addition, we reviewed medical chart documentation for outpatient clinic visits of pre- or post-hospital admission for all the included patients and found no mention of the assessment of the pneumococcal vaccination status.

Table 2. Numbers of other risk factors that indicate pneumococcal vaccinations other than diabetes mellitus in the study population.

Number of other risk factors	Number of patients	% of Patients
0	244	22.4
1	356	32.8
2	284	26.1
3	154	14.2
4	38	3.5
5	10	0.9
6	1	0.1
Total	1087	100.0

Discussion

Among the patients who were admitted to KAMC academic tertiary care hospital during the study period, the pneumococcal vaccination rate was 1.6% in diabetic patients with or without other risk factors that indicate pneumococcal vaccinations. The pneumococcal vaccination rate at our study is lower than that reported in studies for other countries.[23–25]

Our study demonstrates that the inpatient setting at our hospital represents a prime setting to provide diabetic patients the proper assessment and administration of needed vaccines due to the high number of admissions every year. The results showed that the majority of the diabetic patients admitted to our hospital had one or more risk factor- in addition to diabetes mellitus- to receive pneumococcal vaccination according to the recently updated CDC recommendations. Despite the large number of patients who were eligible for the vaccine in our study, none of our patients were assessed for prior or current vaccinations status during their hospital admission.[15]

Inpatient setting represents a missed opportunity for administration of the pneumococcal vaccine to eligible patients. This may increase the risk for pneumococcal diseases in this high-risk population that would benefit from vaccination against a common and serious pathogen.[13,14]

Looking at previous studies that assessed the pneumococcal inpatient administration rate, a US study was conducted in the intensive care unit and found that only 5.3% of patients with indication for pneumococcal vaccine have received the vaccine during their admission and the need for vaccination was not routinely assessed.[26] In this study, diabetic patients who were at the age of 65 years or older, with chronic renal failure or chronic cardiovascular diseases showed the highest vaccination rate. In 2015, another cross-sectional Korean study had evaluated the rate of pneumococcal and influenza vaccination rate for patients admitted to a teaching hospital in South Korea.[27] The overall vaccination rate for pneumococcus was 17.6% among the vaccine-eligible subjects. In that study, pneumococcal vaccination rates of diabetic patients were 17.2%. The author concluded that pneumococcal vaccine coverage rates among hospitalised patients

were low in South Korea especially the case for young adult patients with chronic medical illnesses.

Based on the low rate of assessment and vaccination rate of pneumococcal vaccination in the inpatient population in our hospital, we strongly suggest reviewing patient immunisation at the time of admission to the hospital to increase pneumococcal vaccination rate in diabetic patients. In addition, implementing a standardised assessment form of patient immunisation status by health care providers may reduce the missing information in reviewing the immunisation history of the admitted patient.[28] Assessment of pneumococcal vaccination status should be a part of patient discharge documentation to remind the patient and health care providers about the next appointment for pneumococcal vaccine. Physicians, nurses, pharmacists and other health care professionals are encouraged to participate in implementing a programme for assessment and administering pneumococcal vaccines.

To the best of our knowledge, this is the first study to estimate pneumococcal vaccination rates of hospitalised diabetic patients in Saudi Arabia. In addition, we evaluated the assessment of pneumococcal vaccine rates in groups of people with different comorbidities. Our study may assist the public health jurisdiction and health care providers raising awareness of vaccine recommendations among high-risk populations and hospitalised patients.

Few potential barriers to inpatient vaccinations have been identified including lack of documentation of risk factors and prior vaccination status and patient refusal of vaccinations. A suggestion to overcome these barriers is to implement an EMR to improve documentation and rates of vaccination administration. Brownfield et al. demonstrated that EMR systems that depend on the physician solely on documentation of information regarding the pneumococcal vaccination often continue to have missing information.[28] In addition, Res et al presented an experience of pharmacists at the University of Wisconsin Hospital and Clinics in screening all adult inpatients for pneumococcal and influenza vaccination.[29] The study showed that rates of screening patients improved to nearly 100%, but the rate of actual administration of the vaccines hovered around 45%. However, other study showed that systems rely on nurses for evaluating patients are more successful.[30]

We strongly encourage all health care providers to review the vaccination status through the medical electronic system upon admission to the hospital. Nurse systemic assessment of the immunisation status for diabetic patients during their admission and at different points of transition of care pneumococcal vaccination rate should be considered. A strategy that may improve the vaccination rate for hospitalised patient is standing order systems. Also, the creation of immunisation reminders in the electronic system may improve vaccination assessment and administrations among hospitalised patients especially now that the electronic hospital systems are available in most Saudi large medical centres.[31] In Saudi Arabia, the parents of children aged 12 years or younger are reminded by a phone text messages about the children's time of vaccination.[32] Expanding such system to adult patient vaccination can be a helpful tool to improve the vaccination in adults.[33]

The result of this study is under ongoing discussion from different aspects of health care system to implement various strategies to improve the vaccination rate in our institution. Another study in the future will evaluate the success of implementation of these interventions in improving the rate of vaccination and will be published after comparison of pre and post intervention implementation.

One of the limitations of our study is that it evaluated the vaccination rate among patients in only one institution. It is possible that we underestimated the actual number of vaccine-eligible patients. However, the systemic assessment of the immunisation status for patients with diabetes during their admission and at different points of transition of care pneumococcal vaccination rate is lacking.

Conclusion

In conclusion, the pneumococcal vaccine coverage rates among hospitalised adult patients with diabetes in a tertiary care institution in Saudi Arabia are low. Increasing the vaccine coverage rates would reduce the occurrence of invasive pneumococcal disease and the risk of serious complications. The high number of hospital admission of adult patients with diabetes provides a unique opportunity for proper immunisation assessment and administration of vaccines for eligible patients with diabetes. Further studies are needed to assess the impact of electronic interventions in promoting vaccination assessment and administration among patients with diabetes.

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References

1. Pneumococcal disease. World Health Organization. [online] Available from: http://www.who.int/ith/diseases/pneumococcal/en/ [Accessed 21 Jan. 2018]
2. Kupronis BA, Richards CL Jr, Whitney CG. Invasive pneumococcal disease in older adults residing in long-term care facilities and in the community. *J Am Geriatr Soc*. 2003;51:1520–5.
3. World Population Prospects The 2015 Revision Key Findings and Advance Tables. 2015. [ebook] p.241. Available from: https://esa.un.org/unpd/wpp/publications/files/key_findings_wpp_2015.pdf [Accessed 20 Jan. 2018]
4. Drijkoningen JJ, Rohde GG. Pneumococcal infection in adults: burden of disease. *Clin Microbiol Infect*. 2014;20(5):45–51.
5. Griffin MR, Zhu Y, Moore MR, Whitney CG, Grijalva CG. U.S. hospitalizations for pneumonia after a decade of pneumococcal vaccination. *N Engl J Med*. 2013;369(2):155–63.
6. Robke JT, Woods M. A decade of experience with an inpatient pneumococcal vaccination program. *Am J Health Syst Pharm*. 2010;67(2):148–52.
7. Myint T, Madhava H, Balmer P, Christopoulou D, Attal S, Menegas D, et al. The impact of 7-valent pneumococcal conjugate vaccine on invasive pneumococcal disease: a literature review. *Adv Ther*. 2013;30(2):127–51.
8. Moore M, Link-Gelles R, Schaffner W, Lynfield R, Lexau C, Bennett NM, et al. Effect of use of 13-valent pneumococcal conjugate vaccine in children on invasive pneumococcal disease in children and adults in the USA: analysis of multisite, population-based surveillance. *Lancet Infect Dis*. 2015;15(3):301–9.
9. Daniels C, Rogers P, Shelton C. A review of pneumococcal vaccines: current polysaccharide vaccine recommendations and future protein antigens. *J Pediatr Pharmacol Ther*. 2016;21(1): 27–35.
10. Black S, Lieu TA, Ray GT, Capra A, Shinefield HR. Assessing costs and cost effectiveness of pneumococcal disease and vaccination within Kaiser Permanente. *Vaccine*. 2000;19(Suppl. 1):S83–6.
11. Cho BH, Stoecker C, Link-Gelles R, Moore MR. Cost-effectiveness of administering 13-valent pneumococcal conjugate vaccine in addition to 23-valent pneumococcal polysaccharide vaccine to adults with immunocompromising conditions. *Vaccine*. 2013;31(50):6011–21.
12. Nirmal J, Caputo GM, Weitekamp MR, Karchmer AW. Infections in patients with diabetes mellitus. *N Engl J Med*. 1999;341:1906–12.
13. Seminog O, Goldacre MJ. Risk of pneumonia and pneumococcal disease in people hospitalized with diabetes mellitus: English record-linkage studies. *Diabet Med*. 2013;30(12):1412–9.
14. Kyaw MH, Rose Jr CE, Fry AM, Singleton JA., Moore Z, Zell ER, et al. The influence of chronic illnesses on the incidence of invasive pneumococcal disease in adults. *J Infect Dis*. 2005;192:377–86.
15. Pneumococcal Vaccine Recommendations. Centers for disease control and prevention. [online]. Available from: https://www.cdc.gov/vaccines. [Accessed 12 Jan. 2018].
16. Canadian Diabetes Association Clinical Practice Guidelines Expert Committee, Cheng AY. Canadian Diabetes Association 2013 clinical practice guidelines for the prevention and management of diabetes in Canada. *Can J Diab*. 2013;37(sup 1):S1–S3.
17. American diabetes association standards of medical care in diabetes. *Diabetes Care*. 2017;40(sup 1):S1–S138.
18. Al-Hajjaj MS, Alharbi NS, Zeitouni MO, Idrees MM, Al-Barrak AM, Al-Moamary MS, et al. The Saudi Thoracic Society pneumococcal vaccination guidelines-2016. *Ann Thorac Med*. 2016;11(2):93–102.
19. Al-Nozha M, Al-Maatouq M, Al-Mazrou Y, Al-Harthi SS, Arafah MR, Khalil MZ, et al. Diabetes mellitus in Saudi Arabia. *Saudi Med J*. 2004;25:1603–10.
20. Alqurashi KA, Aljabri KS, Bokhari SA. Prevalence of diabetes mellitus in a Saudi community. *Ann Saudi Med*. 2011;31(1):19–23.
21. Alsenany S, Al Saif A. Incidence of diabetes mellitus type 2 complications among Saudi adult patients at primary health care center. *J Phys Ther Sci*. 2015;27(6):1727–30.
22. Rubin DJ. Hospital readmission of patients with diabetes. *Curr Diab Rep*. 2015;15(4):504.
23. Nowalk MP, Middleton DB, Zimmerman RK, Hess MM, Skledar SJ, Jacobs MA. Increasing pneumococcal vaccination rates among hospitalized patients. *Infect Control Hosp Epidemiol*. 2003;24(7):526–31.
24. Smith JG, Metzger NL. Evaluation of pneumococcal vaccination rates after vaccine protocol changes and nurse education in a tertiary care teaching hospital. *J Manag Care Pharm*. 2011;17(9):701–8.
25. Williams WW, Lu PJ, O'Halloran A, Kim DK, Grohskopf LA, Pilishvili T, et al. Surveillance of vaccination coverage among adult populations—United States, 2015. *MMWR Surveill Summ*. 2017;66(11):1–28.
26. Wall GC, Van Der Veer JJ, Romine MJ, Yeager SM. Assessment of candidacy for pneumococcal vaccination in intensive care patients. *Intensive Crit Care Nurs*. 2013;29(4):212–5.
27. Yang TU, Song JY, Noh JY, Cheong HJ, Kim WJ. Influenza and pneumococcal vaccine coverage rates among patients admitted to a teaching hospital in South Korea. *Infect Chemother*. 2015;47(1):41.
28. Brownfield E, Marsden JE, Iverson PJ, Zhao Y, Mauldin PD, Moran WP. Point of care experience with pneumococcal and influenza vaccine documentation among persons aged ≥65 years: high refusal rates and missing information. *Am J Infect Control*. 2012;40:672–4.
29. Rees S, Stevens L, Drayton J, Engledow N, Sanders J. Improving inpatient pneumococcal and influenza vaccination rates. *J Nurs Care Qual*. 2011;26:358–63.
30. Kishel JJ, Maguire M, Pankratz L, Julian K. Implementing an electronically based, nurse-driven pneumococcal vaccination protocol for inpatients. *Am J Health Syst Pharm*. 2009;66:1304–8.
31. Fiks AG, Hunter KF, Localio AR, Grundmeier RW, Bryant-Stephens T, Luberti AA, et al. Impact of electronic health record-based alerts on influenza vaccination for children with asthma. *Pediatr*. 2009;124(1):159–69.
32. Immunization, MOH. Kingdom of Saudi Arabia — Ministry of Health Portal. [online]. Available from: https://www.moh.gov.sa/en/eServices/Pages/VaccinationsDescription.aspx. [Accessed 20 Jan. 2018]
33. Stockwell MS, Kharbanda EO, Martinez RA, Vargas CY, Vawdrey DK, Camargo S. Effect of a text messaging intervention on influenza vaccination in an urban, low-income pediatric and adolescent population: a randomized controlled trial. *JAMA*. 2012;307(16):1702–8.