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Original article

Adherence to evidence-based guidelines for the management of pneumonia in a tertiary teaching hospital in Riyadh

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ABSTRACT

Background: Adherence to therapeutic guidelines is crucial when treating pneumonia, as it reduces mortality rate, length of hospital stay and duration of antibiotic therapy. However, the high non-adherence rate to treatment guidelines, in general, and to the Infectious Disease Society of America (IDSA) guidelines, are still reported globally. According to our knowledge, no existing data is available regarding the rate of physicians' adherence to the IDSA guidelines for managing pneumonia in Saudi Arabia. Therefore, we aim to assess the adherence rate and the clinical outcomes among patients treated according to the IDSA guidelines, in a tertiary care center in Riyadh.

Methods: A single-centered, retrospective, cross-sectional, observational study was conducted at King Khalid University Hospital, Riyadh, Saudi Arabia. All data were extracted from the hospital's electronic information system, known as Esihi. Adult patients (≥18 years old) diagnosed and treated in the hospital for community-acquired pneumonia, hospital-acquired pneumonia, or ventilator-associated pneumonia from Nov 2019 to Nov 2021 were included.

Results: A total of 148 patients were included in this study, and the management of 50% of them (74 patients) adhered to the guidelines' recommendations. Even though the patients who received guidelines-adhered management were older (70 ± 16 vs 59 ± 22; p = 0.001), and had a higher CURB-65 score for pneumonia severity (1.86 ± 1.03 vs 1.39 ± 1.26; p = 0.026) and an average calculated Charlson comorbidity index (4.62 ± 2.19 vs 3.28 ± 2.80; p = 0.001) than patients who were treated irrespectively of the guidelines, yet they had a better cure rate (95% vs 84%; adjusted OR, 3.9; 95% CI, 0.82–18.58), lower mortality (5% vs 14%; adjusted OR, 0.38; 95% CI, 0.04–4.05) and shorter length of hospital stay (LOS) (6.5 vs 8 days; p = 0.082); compared to patients who were treated irrespectively of the guidelines.

Conclusions: Comparable to previous literature, non-adherence to evidence-based guidelines has been observed in 50% of patients treated for pneumonia. Despite being nonsignificant, higher clinical cure rates, shorter LOS, and lower mortality rates have been observed in patients who were treated based on evidence-based guidelines. Further measures to improve guidelines compliance in pneumonia treatment are needed.

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1. Introduction

Pneumonia is the most frequent lower respiratory tract illness and a major source of morbidity and mortality worldwide (Feldman & Shaddock, 2019). Several attempts have categorized pneumonia according to its origin, the clinical setting in which the patient contracted the infection, the pattern of lung parenchyma involvement, and other factors. It can be either community-acquired pneumonia (CAP), hospital-acquired pneumonia (HAP), or ventilator-associated pneumonia (VAP) (Cillóniz, Dominedò, & Torres, 2019; Modi & Kovacs, 2020).

The global incidence of CAP is 1.5 to 14 cases per 1,000 persons per year. The incidence rate in the United States (US) is 24.8 cases per 10,000 persons per year, while in the Kingdom of Saudi Arabia (KSA), CAP represents 30.3% among other types of community-acquired infections (Balkhy et al., 2006; Regunath & Oba, 2021). For HAP, it represents 5 to 10 per 1000 hospitalized cases in Europe and the US, while in the KSA, it represents 4.4% among other types of infection acquired from the hospital (Balkhy et al., 2006; Shebl et al., 2022).

Various scientific societies have developed clinical practice guidelines for the management of pneumonia, some of the best known are the Infectious Diseases Society of America (IDSA), the British Thoracic Society (BTS), the American Thoracic Society (ATS), the Spanish Society of Pulmonology and Thoracic Surgery, and the European Respiratory Society (ERS) (Mandell et al., 2007). The ATS and the IDSA updated their 2007 guidelines on CAP in 2019 (Metlay et al., 2019). They also updated the 2005 guidelines for HAP and VAP in 2016 (Kalil et al., 2016). Although these guidelines are difficult to generalize due to significant regional disparities in antibiotic resistance, the Saudi Ministry of Health (MOH) has implemented pneumonia management protocols primarily based on ATS/IDSA guidelines' recommendations (Kalil et al., 2016; Metlay et al., 2019; MOH). For the management of HAP/VAP infections, both guidelines recommend the use of a local antibiogram when choosing between the agents to avoid bacterial resistance (Kalil et al., 2016; Metlay et al., 2019; Saudi MOH, 2019).

Therefore, adherence to the guideline is crucial as it will reduce the mortality rate, length of hospital stay (LOS) and duration of antibiotic therapy. However, adherence may differ among physicians and is conditioned by factors such as the site of care, the correct treatment timing, and the choice of empiric therapy (Costantini et al., 2016). On the other hand, non-adherence to the guideline is a common issue among healthcare providers. Many studies were conducted to assess the adherence rate among physicians worldwide (Alshehri, Almangour, Alhifany, & Alhossan, 2022; Bodi et al., 2005; Costantini et al., 2016; Pflanzner, Phillips, Mailman, & Vanstone, 2019). However, no studies are regionally conducted regarding the overall compliance with the updated 2019 CAP along with updated 2016 HAP/VAP IDSA clinical practice guidelines with general health outcomes for pneumonia patients. In addition, it is the first study to assess the adherence rate to pneumonia guidelines in Intensive Care Units (ICUs) and non-ICU hospitalized patients. Therefore, our study aimed to assess physicians' adherence rate to the IDSA guidelines for managing CAP, HAP, and VAP in a tertiary care center in Riyadh, KSA. In addition, we aim to compare the rate of clinical cure, LOS, and mortality rate among the patients treated according to the IDSA guidelines versus those treated regardless of the guidelines' recommendations.

2. Methods

2.1. Objective

Primary objective: To assess the adherence rate to the IDSA guidelines for the management of CAP and HAP/VAP.

Secondary objective: To compare the rate of clinical cure, LOS, and mortality rate among the patients treated according to the IDSA guidelines versus those treated regardless of the guidelines' recommendations.

2.2. Study setting and design

This was a retrospective, cross-sectional, chart review study of patients who were diagnosed with CAP, HAP, or VAP in the period between November 2019 to November 2021 at King Saud University Medical City (KSUMC), a 1500-bed tertiary care academic medical center, in Riyadh, Saudi Arabia.

2.3. Inclusion and exclusion criteria

All adult patients $\geq$ 18 years old, admitted and treated as cases of CAP, HAP, and VAP; were included. Moreover; pregnant women, immune-compromised patients including (patients with HIV, malignancy, or on chemotherapy or systemic corticosteroids), and COVID-19-positive patients were accordingly excluded.

2.4. Data collection tool and study variables

The data collection sheet was composed of two main domains. First: patients' characteristics and investigations (gender, age, type of infection, lab tests result including CBCs, serum creatinine, creatinine clearance, liver enzymes, microbiology cultures result, and radiographic tests). Second: management and outcome (full description of the used antibiotics, and clinical outcomes including LOS, mortality rates, and full-resolution rates). In addition, the Charlson comorbidity index score has been calculated for all included patients.

2.5. Data recruitment strategies

During the period between November 2019 to November 2021, all relevant patients' medical records were collected from the hospital's electronic information system, and a retrospective chart review was conducted. The information was gathered in a data collection sheet and appropriately coded. Further, antibiotic suitability was assessed using our local guidance in accordance with the IDSA guidelines recommendations. This guidance is based on local susceptibility (antibiogram). In addition, doses were given per the institution's antibiotic dosing guidance.

2.6. Data analysis

Data obtained from the data collection sheet was entered and analyzed using Excel. Descriptive statistics were used to summarize the data. Categorical variables were presented as numbers and percentages, while continuous variables were presented as mean ± standard deviation (SD) or median and interquartile range (IQR), depending on the normality of the data. The $\chi 2$ test or Fisher exact test were used to compare categorical variables, whereas the independent *t*-test or Wilcoxon rank-sum test were used to

compare continuous variables. A *p*-value < 0.05 was considered statistically significant. Multivariate analysis using logistic regression was used to determine the independent impact of compliance with the guidelines on mortality and clinical cure. All statistical analyses were performed using STATA 15.1 (StataCorp LP, College Station, Texas, USA).

2.7. Ethical considerations

Ethical approval (Ref. no. 21/0957/IRB) was obtained from the IRB of the King Saud University – College of Medicine, Institutional Review Board, Riyadh, KSA. All information was kept private and safe. After the study was over, the researchers did not utilize or save any patient identification. Furthermore, the data was only accessible by the PI and co-investigators.

2.8. Microbiology testing

Throughout the data collection period, we obtained some microbiology tests using the Esihi system to ensure the use of local antibiogram in the treatment, including blood cultures, respiratory cultures with their types, urine antigen test and baseline leukocytosis.

2.9. Definitions

Any pneumonia obtained outside of a hospital in a community environment or within but not more than 48 h from admission is considered CAP (Cillóniz et al., 2019). While any pneumonia acquired 48 h or more after being admitted to an inpatient facility, such as a hospital, is considered HAP. VAP refers to pneumonia that develops greater than 48 h following endotracheal intubation (Modi & Kovacs, 2020). The clinical cure is the resolution of signs and symptoms of respiratory infection along with the normalization of vital signs.

3. Results

A total of 148 patients were included in this study, who were diagnosed with CAP, HAP, or VAP (Fig. 1), with an average age of 65 ± 20 years. The data showed that only 74 (50%) were treated according to the guidelines' recommendations, while the other 74 (50%) were not. Patients who were treated according to the guidelines are older (70 ± 16 vs 59 ± 22; p = 0.001), had a higher CURB-65 score for pneumonia severity and average calculated Charlson comorbidity index than patients who were treated irrespectively of the guidelines (1.86 ± 1.03 vs 1.39 ± 1.26; p = 0.026) and (4.62 ± 2.19 vs 3.28 ± 2.80; p = 0.001), respectively (Tables 1 and 2). In addition, admission to the ICU and the use of mechanical ventilation were lower in patients treated according to the guidelines' recommendations than in patients treated irrespective of the guidelines (11% vs 22%; p = 0.074) and (7% vs 12%; p = 0.099), respectively. More details about the demographics and baseline characteristics of the included patients are shown in Table 1.

Patients who were treated according to the guidelines had lower rate of mortality (5% vs 14%; p = 0.087; adjusted OR, 0.38; 95% CI, 0.04–4.05) and shorter LOS (6.5 vs 8 days; p = 0.082); compared to patients who were treated irrespectively of the guidelines; however, these differences were not statistically significant. Clinical cure was significantly higher in patients who were treated according to the guidelines (95% vs 84%; p = 0.034; OR, 3.38; 95% CI, 1.04–11.05); however, when adjusting the difference between the 2 groups (for age, CURB-65, admission to the ICU, use of mechanical ventilation, and Charlson comorbidity index), the difference in clinical cure was not statistically significant (adjusted OR, 3.9; 95% CI, 0.82–18.58) (Table 3 and Fig. 2). Furthermore, all antibiotics were dosed and administered per institution's antibiotic dosing protocol. For information about the isolated pathogens and antibiotics used, refer to Appendices 1 and 2.

4. Discussion

The study's results showed that non-adherence to evidence-based guidelines has been observed in 50% of patients treated for pneumonia, which is comparable to previous literature. Furthermore, the study's results emphasize that inappropriate adherence to treatment guidelines for managing patients hospitalized with pneumonia is highly associated with a harmful impact on patients' prognosis in a single tertiary hospital in Riyadh, Saudi Arabia. On the other hand, despite being nonsignificant, higher clinical cure rates, shorter LOS and lower mortality rates, have been observed in patients who were treated based on evidence-based guidelines.

The findings are also consistent with what has been reported by Costantini E. et al. (Costantini et al., 2016). They showed that the rate of adherence to the guideline's empirical antibiotic therapy in a teaching hospital in Italy was 56.7% in 2012, which was associated with lower odds of in-hospital mortality and lower mean length of hospital stay (Costantini et al., 2016). Another study conducted by Shelby Pflanzner et al. showed that the noncompliance rate to CAP and HAP guidelines by healthcare providers (HCPs) were 45% and 59%, respectively, in multiple Emergency Departments in Canada (Pflanzner et al., 2019).

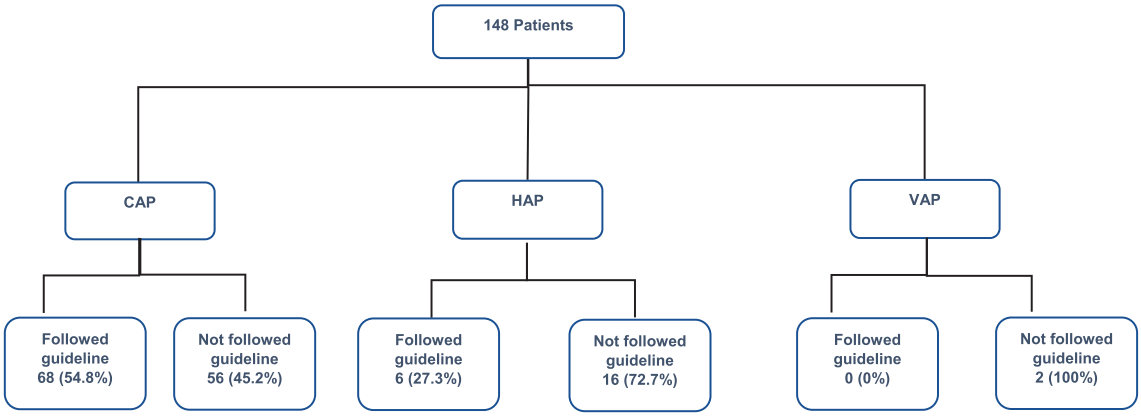

Fig. 1. Types of pneumonia and Guidelines' recommendations adherence.

Table 1
Demographics and clinical outcomes of included patients n = 148.

Variables	Treated per guideline's recommendations n = 74	Not treated per guideline's recommendations n = 74	*P* value
Age in years (mean ± SD)	**70 ± 16**	**59 ± 22**	**0.001**
Gender, n			
Male	**40 (54)**	**46 (62)**	**0.317**
Average CURB-65* (mean ± SD)	**1.86 ± 1.03**	**1.39 ± 1.26**	**0.026**
Admitted to ICU, n	**8 (11)**	**16 (22)**	**0.074**
Use of Mechanical ventilator, n	**7 (9)**	**14 (19)**	**0.099**
Mechanical ventilator use due to ICU admission, n		**9 (12)**	
Active smoker, n	**9 (12)**	**8 (11)**	**0.797**
Diagnostic test**			
Blood cultures, n	**8 (11)**	**9 (12)**	**0.797**
Respiratory cultures, n (Sputum and Endotracheal aspiration)	**7 (9)**	**7 (9)**	**1.00**
Urine antigen, n	**8 (11)**	**5 (7)**	**0.384**
Baseline-Leukocytosis (WBCs > 11,000/mm3)	**39 (53)**	**34 (46)**	**0.411**
Average Calculated Charlson comorbidity index (mean ± SD)	**4.62 ± 2.19**	**3.28 ± 2.80**	**0.001**
Severe CAP	**5**	**9**	**0.127**
Concomitant infections			
Bacteremia	**8**	**9**	**0.897**
Sepsis	**2**	**4**	**0.405**
Urinary tract infection	**0**	**2**	**0.154**
Meningitis	**0**	**1**	**0.316**

Abbreviations: LOS: length of hospital stay, CURB-65: confusion, uremia, respiratory rate ≥ 30 breaths/min, blood pressure < 90 mmHg (systolic) or < 60 mmHg (diastolic), and age ≥ 65 years, ICU: Intensive Care Unit, WBCs: White Blood Cells.
Categorical variables were presented in number (%).
* For CAP patients only.
** Positive cultures.

Table 2
Charlson Comorbidity Index*.

	Treated per guideline's recommendations	Not treated per guideline's recommendations
Prior myocardial infarction	13	7
Congestive Heart Failure	24	17
Peripheral Vascular Disease	5	1
Cerebrovascular disease	12	10
Dementia	4	7
Chronic pulmonary diseases	8	3
Rheumatologic disease	8	0
Peptic Ulcer Disease	3	2
Mild liver disease	1	2
Moderate to severe liver disease		
Diabetes mellitus (DM)		
DM with chronic complications		
Cerebrovascular (hemiplegia) event		
moderate to severe renal disease		
Average Calculated Charlson comorbidity index		

* All immunocompromised patients were excluded from the study and thus all included patients received zero score for AIDS, solid tumor, lymphoma, and leukemia in Charlson comorbidity index.

Another 15-month study of 529 patients with severe CAP admitted in 33 Spanish ICUs, using a multivariate analysis, reported that the main four variables associated with mortality were age, APACHE-II score, immunodeficiency and non-adherence to the IDSA good clinical practice guidelines. Non-adherence to good clinical practice guidelines is the only modifiable factor associated with an increase in mortality from 24.2% to 33.2% (Bodi et al., 2005).

Most of the CAP-diagnosed patients in our study received treatment according to the guidelines, unlike HAP and VAP-diagnosed patients (Fig. 1). This is consistent with Rossio, R et al. (Rossio et al., 2015), who investigated 317 patients diagnosed with pneumonia in Italy and found that the number of patients with CAP who were treated according to the guidelines' recommendations were higher (46.6%) compared to patients with VAP and healthcare-associated pneumonia (HCAP) (29.1% and 25.3%), respectively.

Furthermore, a cost-effectiveness study investigated 1635 pneumonia patients reported that adherence to antibiotic guidelines was correlated with lower costs and enhanced quality of life, yet, they found conflicting results in pneumonia patients admitted to the ICUs, mainly due to prolonged and over-treatment of complicated conditions (Egger et al., 2016).

Table 3
Outcomes of pneumonia treatment.

Outcome	Treated per guideline's recommendations n = 74	Not treated per guideline's recommendations n = 74	*P* value	Odds Ratio (95% CI)	Adjusted Odds* Ratio (95% CI)
Clinically cure, n (%)	70 (95)	62 (84)	P = 0.034	3.38 (1.04–11.05)	3.9 (0.82–18.58)
Mortality, n (%)	4 (5)	10 (14)	P = 0.087	0.36 (0.11–1.22)	0.38 (0.04–4.05)
LOS (days) median (IQR)	6.5 (4–9)	8 (4–17)	P = 0.082	–	–

* Adjusted for age, CURB-65, admission to the ICU, use of mechanical ventilation, and Charlson comorbidity index.

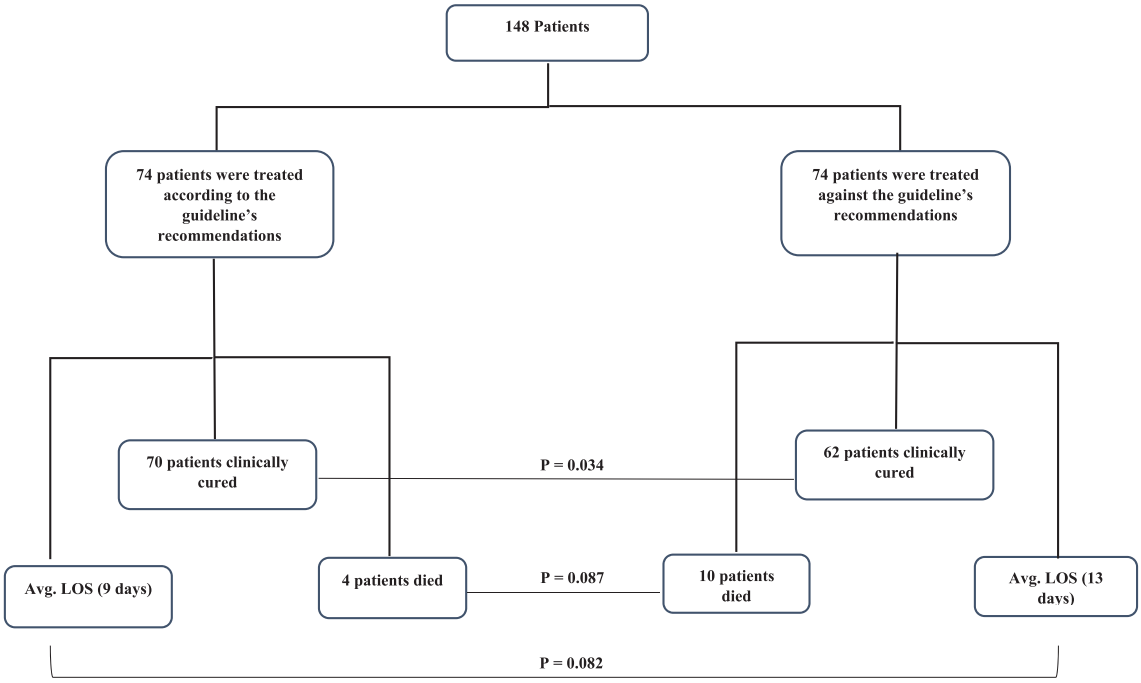

Fig. 2. Clinical outcomes of pneumonia treatment.

Table 4
Reasons for guidelines non-compliance.

Reasons	Not treated per guideline's recommendations n = 74
Inappropriate medication	**59**
• No MRSA* coverage	12
• Unnecessary MRSA* coverage	4
• No beta lactam added	1
• No macrolides/ fluoroquinolones added	9
• No antipseudomonal coverage added	1
• Two antipseudomonal agents needed	5
• Unnecessary combination	8
• Others	19
Inappropriate duration	**12**
Inappropriate setting of treatment for CAP	**3**

* MRSA: Methicillin-resistant staphylococcus aureus.

The limitations to our study, including but not limited to, the retrospective nature of the study design, single site, the small sample size, and the lack of an investigation about the triggers for guidelines non-compliance by the prescribing physician, which could be the existence of mixed isolates/infections, insufficient training, outdated knowledge of advancements in pharmacotherapy, busy emergency departments, lack of auditing and follow-up by the clinical pharmacist, or inappropriate prescribing behaviors due to financial incentives (Sefah et al., 2021), yet, we were able to report the four main reasons for guidelines non-compliance in our study (Table 4). Another strength of our study, it is the first study, to our knowledge, to assess the adherence and the outcomes of managing patients diagnosed with pneumonia according to the IDSA guidelines in Saudi Arabia.

5. Conclusion

Comparable to previous literature, non-adherence to evidence-based guidelines has been observed in 50% of patients treated for pneumonia. Despite being nonsignificant, higher clinical cure rates, shorter lengths of stay, and lower mortality rates have been observed in patients who were treated based on evidence-based guidelines. Further measures to improve guidelines compliance in pneumonia treatment are needed.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1. Isolated pathogens

Pathogen	Treated per guideline's recommendations	Not treated per guideline's recommendations	Total No.
None			115
Escherichia coli	8	3	11
Staphylococcus species	4	5	9
Klebsiella pneumoniae	2	3	5
MRSA	1	2	3
Yeast	1	2	3
Pseudomonas aeruginosa	2	0	2
Acinetobacter baumannii	0	1	1
Enterococcus faecalis	0	1	1

Appendix 2. Antibiotics used

Medication class	Treated per guideline's recommendations	Not treated per guideline's recommendations	Total No.
Cephalosporins	62	39	101
Macrolides	58	32	90
Penicillin B-Lactamase inhibitors	11	38	49
Glycopeptides	9	14	23
Carbapenems	7	11	18
Fluoroquinolones	3	12	15
Lincosamides	0	4	4
Nitroimidazoles	0	2	2
Oxazolidinones	0	2	2
Glycylcyclines	0	1	1
Aminoglycosides	0	1	1
Polymyxins	0	1	1
Sulfonamides	0	1	1

References

Alshehri, A.F., Almangour, T.A., Alhifany, A.A., Alhossan, A., 2022. Assessment of Caspofungin use at a Tertiary Teaching Hospital and compliance with IDSA guidelines and FDA labelings. Saudi Pharm. J. 30 (3), 212–216.

Balkhy, H.H., Cunningham, G., Chew, F.K., Francis, C., Al Nakhli, D.J., Almuneef, M.A., Memish, Z.A., 2006. Hospital-and community-acquired infections: a point prevalence and risk factors survey in a tertiary care center in Saudi Arabia. Int. J. Infect. Dis. 10 (4), 326–333.

Bodi, M., Rodriguez, A., Solé-Violán, J., Gilavert, M., Garnacho, J., Blanquer, J., Almirall, J., 2005. Antibiotic prescription for community-acquired pneumonia in the intensive care unit: impact of adherence to Infectious Diseases Society of America guidelines on survival. Clin. Infect. Dis. 41 (12), 1709–1716.

Cillóniz, C., Dominedò, C., Torres, A., 2019. An overview of guidelines for the management of hospital-acquired and ventilator-associated pneumonia caused by multidrug-resistant Gram-negative bacteria. Curr. Opin. Infect. Dis. 32 (6), 656–662.

Costantini, E., Allara, E., Patrucco, F., Faggiano, F., Hamid, F., Balbo, P.E., 2016. Adherence to guidelines for hospitalized community-acquired pneumonia over time and its impact on health outcomes and mortality. Intern. Emerg. Med. 11 (7), 929–940.

Egger, M.E., Myers, J.A., Arnold, F.W., Pass, L.A., Ramirez, J.A., Brock, G.N., 2016. Cost effectiveness of adherence to IDSA/ATS guidelines in elderly patients hospitalized for Community-Aquired Pneumonia. BMC Med. Inf. Decis. Making 16, 34. https://doi.org/10.1186/s12911-016-0270-y.

Feldman, C., Shaddock, E., 2019. Epidemiology of lower respiratory tract infections in adults. Expert Rev. Respir. Med. 13 (1), 63–77.

Kalil, A.C., Metersky, M.L., Klompas, M., Muscedere, J., Sweeney, D.A., Palmer, L.B., Carratalà, J., 2016. Management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 clinical practice guidelines by the Infectious Diseases Society of America and the American Thoracic Society. Clin. Infect. Dis. 63 (5), e61–e111.

Mandell, L.A., Wunderink, R.G., Anzueto, A., Bartlett, J.G., Campbell, G.D., Dean, N.C., Niederman, M.S., 2007. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. Clin. Infect. Dis. 44 (Supplement_2), S27–S72.

Metlay, J.P., Waterer, G.W., Long, A.C., Anzueto, A., Brozek, J., Crothers, K., Flanders, S.A., 2019. Diagnosis and treatment of adults with community-acquired pneumonia. An official clinical practice guideline of the American Thoracic Society and Infectious Diseases Society of America. Am. J. Respir. Crit. Care Med. 200 (7), e45–e67.

Modi, A.R., Kovacs, C.S., 2020. Hospital-acquired and ventilator-associated pneumonia: Diagnosis, management, and prevention. Cleve. Clin. J. Med. 87 (10), 633–639.

Moh, S., 2019. National Antimicrobial Therapy Guidelines for Community and Hospital Acquired Infections in Adults.

Pflanzner, S., Phillips, C., Mailman, J., Vanstone, J.R., 2019. AMS in the ICU: empiric therapy and adherence to guidelines for pneumonia. BMJ Open Quality 8 (2), e000554.

Regunath, H., Oba, Y., 2021. Community-acquired pneumonia. In: StatPearls [Internet]: StatPearls Publishing.

Rossio, R., Franchi, C., Ardoino, I., Djade, C.D., Tettamanti, M., Pasina, L., Mannucci, P. M., 2015. Adherence to antibiotic treatment guidelines and outcomes in the hospitalized elderly with different types of pneumonia. Eur. J. Intern. Med. 26 (5), 330–337. https://doi.org/10.1016/j.ejim.2015.04.002.

Saudi MOH, N.A.R.C., 2019. National Antimicrobial Therapy Guidelines for Community and Hospital Acquired Infections in Adults Retrieved from https://www.moh.gov.sa/en/CCC/healthp/regulations/Documents/National%20Antimicrobial%20%20Guidelines.pdf.

Sefah, I.A., Essah, D.O., Kurdi, A., Sneddon, J., Alalbila, T.M., Kordorwu, H., Godman, B., 2021. Assessment of adherence to pneumonia guidelines and its determinants in an ambulatory care clinic in Ghana: findings and implications for the future. JAC-Antimicrob. Resistance 3 (2). https://doi.org/10.1093/jacamr/dlab080.

Shebl, E., Mirabile, V.S., Sankari, A., Burns, B., 2022. Respiratory failure. In: StatPearls [Internet]: StatPearls publishing.