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Review Article

Drug-resistant pathogens in community-acquired pneumonia

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ABSTRACT

An increasing prevalence of pneumonia caused by drug-resistant pathogens (DRPs) has been identified. The 2005 American Thoracic Society (ATS)/Infectious Diseases Society of America (IDSA) guidelines proposed the health care-associated pneumonia (HCAP) model in order to identify an increased risk of DRPs in patients coming from the community. These patients are known to have a worse prognosis, mostly due to poor functional status and treatment restrictions. New useful scores have been developed to help physicians in predicting DRPs. This manuscript is a review of currently published literature concerning the impact of CAP caused by DRPs and the different predictive models available.

Key words: Community-acquired pneumonia (CAP), drug-resistant pathogens (DRPs), health care-associated pneumonia (HCAP), prediction models

INTRODUCTION

Pneumonia has been traditionally categorized as either community- or hospital-acquired, being caused by different organisms and characterized by different clinical outcomes. Community-acquired pneumonia (CAP) is predominantly caused by *Streptococcus pneumoniae* followed by *Haemophilus influenzae*, *Staphylococcus aureus*, viruses, and atypical bacterial pathogens.[1] However, over the last 20 years new pathogens that were usually confined within the hospital setting have emerged in the community including methicillin-resistant *S. aureus* (MRSA), multidrug resistant *Pseudomonas aeruginosa*, or extended spectrum B-lactamase-producing *Enterobacteriaceae*.[2] The present paper aims at reviewing the clinical and epidemiological impact of CAP caused by drug-resistant pathogens (DRPs) and available tools supporting physicians in predicting it.

MAIN DRIVERS FOR THE OCCURRENCE ON PNEUMONIA CAUSED BY DRUG-RESISTANT PATHOGENS IN THE COMMUNITY

Different explanations for an increased prevalence of pneumonia caused by DRPs in the community could be identified. 1) During the past decades, health care systems

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in high-income countries underwent major changes. Along with the improvement of health care technologies, home health care, outpatient hemodialysis centers, nursing homes (NHs), and other long-term facilities became more widespread in the community. These changes led to a dynamic process with patients and physicians going in and out of health care facilities around the community and thus, DRPs. 2) The excessive and inappropriate use of antibiotics has been recognized as one of the major problems in Western countries.[3] Antibiotic selection pressure is thought to be an important mechanism of selection for antibiotic resistance by reducing susceptible bacterial strains and shifting the competitive balance in favor of existing resistant strains. 3) The impact of an aging population has become a major issue of concern. Due to the growing elderly population, the use of antibiotics has notably increased with a higher number of patients being admitted to hospitals.[4] Furthermore, these patients are regularly in contact with health care systems dealing with an increasing number of infections due to traditionally hospital-related pathogens.[2] In the early 2000, the above demographic and sociocultural changes led to the introduction of the new concept of "health care-associated infection." Friedman and coworkers first developed the new classification of "health care-associated bloodstream infections," drawing the conclusion that these were similar to hospital-acquired infections in terms of frequency of various comorbid conditions, source of infection, pathogens and their susceptibility patterns, and mortality.[5] In 2005, guidelines published by the American Thoracic Society (ATS)/Infectious Disease Society of America (IDSA) developed the definition of health care-associated pneumonia (HCAP) as a novel clinical entity including patients with frequent health care contacts and with an increased risk of pneumonia caused by DRPs.[2] The definition of HCAP included any patient who was hospitalized in an acute care hospital for 2 or more days within 90 days of the infection, resided in a NH or long-term care facility (LTCF), received recent intravenous antibiotic therapy, chemotherapy, or wound care within the past 30 days of the current infection, attended a hospital or hemodialysis clinic, or had a family member with DRPs. The idea of HCAP was strengthened by a retrospective, multicenter study conducted in the USA by Kollef *et al*. enrolling 4,543 patients with pneumonia and positive cultures.[6] The authors suggested that patients with HCAP were different from those with other types of pneumonia including CAP but similar in etiology to those patients with hospital-acquired pneumonia (HAP) and ventilator-associated pneumonia (VAP). However, this study was heavily criticized for showing that *S. aureus* was the most common cause of CAP, and that resistant pathogens were very common in CAP. These results were controversial and are discussed in more detail in the sections below.

RISK FACTORS FOR DRUG-RESISTANT PATHOGENS IN PATIENTS WITH PNEUMONIA COMING FROM THE COMMUNITY

Several risk factors are currently considered to be associated with the risk for DRPs in patients with pneumonia coming from the community. First of all, the importance of the evaluation of local patterns of antibiotic resistance as well as the rate of DRPs that could vary not only from country to country but also among different areas within the same country should be highlighted.[6,7] Among all the risk factors for DRPs that constitute the HCAP definition, "recent hospitalization" seems to be the most frequent.[8,9] Although the guidelines suggest "90 days" as the time limit for this risk factor, recent literature advocates that patients may be at risk for DRPs for even a 1-year period prior admission.[8] These patients are known to be at an increased risk of colonization of the upper respiratory tract due to an alteration of normal flora probably secondary to a more recent antibiotic exposition with broad-spectrum antimicrobials that lead to a selection pressure for resistance.[10] Moreover, previous antibiotic use by itself has been postulated as a risk factor for colonization and infection.[11]

NH and LTCF residences have been evaluated as risk factors for DRPs. Patients residing in NH/LTCF have an increased risk of death *per se* due to advanced age, a high number of comorbidities, and a poor functional status.[12] Solh *et al*. evaluated 88 NH patients with severe pneumonia confirmed by culture and showed that both the previous use of antibiotics and poor functional status were risk factors for DRPs.[13] In this study, *S. aureus* was the predominant isolated pathogen (31%) followed by enteric gram-negative bacilli (28%) and *S. pneumoniae* (25%). Nevertheless, other authors described similarities in pathogen distribution between NH pneumonia and CAP.[12] Part of the explanation for this heterogeneity may be the differences in what is considered a NH or skilled nursing facility in different countries. Therefore, the characteristics and functional status of patients classified as "nursing home residents" from one country may be very different to patients from another country.

Patients undergoing chronic hemodialysis usually have increased risk for both DRPs colonization and infection due contact with chronic indwelling vascular catheters, frequent skin punctures, severe comorbidities, and treatment with broad-spectrum antimicrobial agents.[14] One study conducted among patients attending an ambulatory hemodialysis unit reported that 28% of the patients were colonized with one or more DRPs. In 2006, several outpatient hemodialysis facilities from the USA reported that the most frequent pathogen was *S. pneumoniae* with a very low rate of *Staphylococcus* species (2.2%) even though an etiological confirmation was reached only in 18% of the cases.[15] Little is known about the risk of patients receiving home infusion

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therapy or wound care with a lack of epidemiological studies evaluating these patients. Different authors estimate a prevalence with a variance of 2-18%.[7,16] Finally, having a family member infected/colonized with DRPs has also been described as a risk factor for DRPs pneumonia. However, this recommendation made by international guidelines is not supported by strong evidence and it is based on an expert's opinions.[2] Immunosuppression and/or immunosuppressive therapy have gained special interest as risk factors for DRPs during the past decades. Cecere *et al*. identified increasing age, use of immunosuppressant drugs, neutropenia, and cerebrovascular disease as predictors of increased mortality in patients with HCAP.[17] However, several authors evaluated patients with immunosuppression and failed to demonstrate an association with infection due to DRPs.[18,19] A possible explanation for this could be the presence of underlying conditions leading to a clearly different prognosis. The population of patients with immunosuppression is extremely heterogeneous including subjects infected with HIV, those receiving treatment for cancer or using immunosuppressive medications as well as patients with bone marrow or solid organ transplantations.

Among other risk factors not included in the original definition of HCAP that nevertheless could be associated with infections due to DRPs, we should finally acknowledge a poor functional status and multicomorbid condition. More specifically, chronic lung disease, diabetes, cerebrovascular disease, dementia, risk of aspiration, and use of gastric acid suppressive agents have been described among different studies.[7,18,19] Health care-associated pneumonia versus community-acquired pneumonia: Who is the Ryder Cup winner?

Since the introduction in 2005 of the HCAP concept by the ATS/IDSA guidelines, many investigators have questioned its validity to identify pneumonia due to DRPs in patients coming from the community.[20-24] The heterogeneous category of HCAP was firstly developed in the USA according to a retrospective multicenter study conducted among 4,543 patients with culture-positive pneumonia.[6] As mentioned above, the prevalence of *S. aureus* in the HCAP, HAP, and VAP groups in this study was significantly higher than in patients with CAP. In addition, mortality risk was higher in HCAP when compared to CAP (19.8% vs. 10%; <0.0001) while *S. aureus* was the only pathogen associated with increased mortality in that population. However, the high incidence of resistant organisms even among patients coming from the community makes these results controversial. Micek *et al*., in a retrospective study in the USA enrolling 639 patients with culture-positive CAP and HCAP showed that not only was MRSA significantly higher among the HCAP population (26%) but also that *S. pneumoniae*, *Haemophilus* species, and methicillin-sensitive *S. aureus* (MSSA) were the predominant pathogens in CAP.[8] The authors observed that patients with HCAP were more likely to receive inappropriate initial antimicrobial treatment and they drew the conclusion that consequently they were more likely to die during their hospitalizations.

Similarly, in both retrospective and prospective multicenter studies from Korea and Japan, a different spectrum of pathogens was described between HCAP and CAP patients. In this sense, a higher incidence of DRPs was reported among HCAP patients with *Klebsiella pneumoniae* followed by *S. pneumoniae* being the most frequent pathogen among HCAP patients in both the studies.[7,25] More recently, another retrospective study from Korea described a higher incidence of DRPs in HCAP patients when compared to those with CAP.[26] However, there were no differences between both the groups when compared to each pathogen alone while *S. pneumoniae* was the most frequent microorganism followed by *S. aureus* in both the groups. With regard to mortality, Jung *et al*. described a higher rate among HCAP patients, describing a relationship between excess of mortality and the presence of DRPs in patients with low or intermediate risk.[25] Nevertheless, these data should be interpreted with caution due to the retrospective design and high prevalence of immunosuppressed patients. Shindo *et al*. stated that HCAP patients had more severe diseases, higher initial inappropriate antimicrobial treatment, and higher mortality when compared to CAP patients.[7] Despite having more severe diseases, the rate of mechanical ventilation was similar in both groups, which leads to the idea that treatment restrictions could explain mortality differences between both the groups as suggested by Ewig *et al*.[27] Contrary to previous data, several European studies addressed similarities in the etiological pattern between HCAP and CAP, with *S. pneumoniae* being the main causative microorganism and with a very low incidence of DRPs in both entities.[28-31] In addition, García-Vidal *et al*. showed that aspiration pneumonia was more frequent in HCAP patients, suggesting the same treatment for both CAP and HCAP patients after ruling out the presence of aspiration pneumonia.[28] The conducted among the Community-Acquired Pneumonia Organization (CAPO) database highlights the idea of different microorganism patterns around the world while describing a predominance of *Staphylococcus* spp. in the USA (52%), with *S pneumoniae* being the most frequent pathogen in Europe (46%) and Latin America (25%).[32]

Likewise, a study from UK showed that HCAP patients had high mortality rates as well as a high age and comorbid conditions. In addition, they appeared to have more risk factors for aspiration and interestingly, the authors collected a higher rate of treatment restrictions.[30] After adjustment for all these factors, HCAP was not independently associated with a 30-day mortality. The rates of DRPs in this study were very low (<2% of cases). Moreover, in a prospective observational study conducted in Spain, HCAP patients showed a decreased autonomy in the Barthel score and a clear poorer prognosis with an increased short- and long-term

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mortality.[33] The authors revealed a stronger association between HCAP and 1-year mortality rather than with the 30-day mortality, which emphasized the idea that a worse functional status could impact long-term outcomes.

Even though it seems there is an agreement about an increased mortality in HCAP patients, no significant difference in mortality was found between HCAP and CAP in a study conducted among critically ill patients in 34 intensive care units (ICUs) in Spain.[34] These results may be partly due to the exclusion of immunosuppressed patients from the HCAP definition and the lower impact treatment restrictions have in these types of patients. Rello *et al*. also endorsed an excess of mortality among HCAP patients in a prospective cohort study with patients with bacteraemic pneumococcal pneumonia.[16] However, the authors suggested that differences in mortality were probably due to differences in a patient's characteristics and indirect limitations of treatment support in this population.

Many studies failed to validate the HCAP concept outside the USA partly due to differences in methodologies with inclusion of immunocompromised patients and more severe patients as well as differences in antibiotic policies and health care systems. In this sense, Chalmers *et al*. conducted a meta-analysis of 24 studies that clearly weakened the concept of HCAP because of its poor ability to identify potentially resistant pathogens.[35] The HCAP concept was only 70% accurate in identifying DRPs, with better accuracy for MRSA but poor accuracy for *P. aeruginosa*. In addition, the meta-analysis identified publication bias, suggesting that studies with a high frequency of DRPs were being preferentially published.[35] The recommendation supported by the studies from the USA in targeting DRPs with broad-spectrum antibiotics could lead to overtreatment, resulting in increased cost, *Clostridium difficile* infection, drug toxicity, and antibiotic resistance.[36] Still, there is a wide heterogeneity among different health care systems around the world with different managements concerning pneumonia in each country and a general approach becomes a crucial issue. Prevalence of DRPs across different countries is shown in Figure 1, according to both retrospective and prospective studies published so far.[6-9,13,18,19,28-31,33,37-42]Drug-resistant pathogen forecast: How can we predict drug-resistant pathogen storm?

Different data from very heterogeneous studies have weakened the HCAP concept, making it difficult to get a consensus. Due to the limitations of the HCAP concept, identifying DRPs remains a difficult challenge. In an attempt to deal with these difficulties, some investigators have developed risk scores to identify DRPs; see Table 1.

In 2004, Solh *et al*. conducted an observational study among 88 NH severe patients admitted to the ICU.[13] The authors developed a classification tree using functional status and antibiotic use within 180 days with a sensitivity of 100% [95% confidence interval (CI), 80.3-100%] and a specificity of 53.5% (95% CI, 41.3-65.5%). Specificity increased up to 69.4% (95% CI, 51.9-83.6%) when validated in a separate cohort with 47 patients over a 24-month period. Similarly, Brito *et al*. proposed an algorithm that divided patients into four groups based on the severity of illness (need of mechanical ventilation or ICU admission) and several risk factors previously published (immunosuppression, hospitalization within the past 3 months, antibiotic therapy within the past 6 months, and poor functional status).[37] This decision tree has been recently validated in a multicenter Japanese study with 445 patients with CAP and HCAP.[38] The authors observed that by using this algorithm only 7.1%

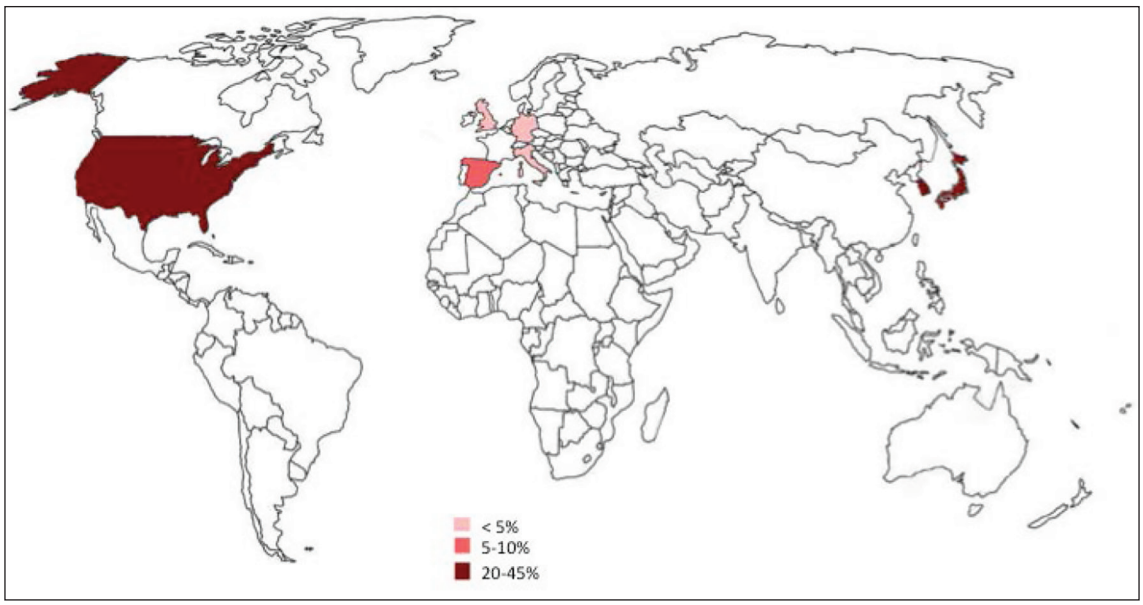

Figure 1: Worldwide revalence of drug-resistant pathogens in patients with pneumonia coming from the community

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Table 1: Clinical prediction models for drug-resistant pathogens (DRPs) in community-acquired pneumonia (CAP)

Author and year	Country	Population, design, and validation	Risk factors	AUROC
Solh 2004[13]	USA	*n:* 88 patients *Design:* Prospective, single center. Severe nursing home patients. Decision tree *External validation:* No	Antibiotic use 180 days Functional status	0.89
Brito 2009[37]	USA	*n:* Data from 8 studies *Design:* Retrospective review. Decision tree *External validation:* Yes	Need of mechanical ventilation or ICU admission Immunosuppression Hospitalization 90 days Antibiotic use 180 days Poor functional status	N/A
Shorr 2008[18]	USA	*n:* 639 patients *Design:* Retrospective, single center. Probabilistic *External validation:* Yes	Hospitalization 90 days Resident of long-term care facilities Hemodialysis ICU admission	0.74
Aliberti 2012[19]	Italy	*n:* 935 patients *Design:* Prospective, single center. Probabilistic *External validation:* Yes	Resident of long-term care facilities Hospitalization 90 days Chronic renal failure Chronic obstructive pulmonary disease Cerebrovascular disease Diabetes mellitus Antibiotic use 90 days Wound care Immunosuppression Home infusion therapy	0.79
Park 2012[40]	Korea	*n:* 339 patients *Design:* Retrospective, single center. Probabilistic *External validation:* No	Tube Feeding Hospitalization 90 days Intravenous antibiotic previous 30 days Resident of long-term care facilities Chemotherapy 30 days Wound care 30 days Hemodialysis	0.71
Shindo 2013[7]	Japan	*n:* 1413 patients *Design:* Prospective, multicenter. Cumulative *External validation:* No	Hospitalization 90 days Antibiotic use 90 days Immunosuppression Gastric acid suppression Tube feeding Poor functional status	0.79
Schreiber *et al.* 2010[41]	USA	*n:* 190 patients *Design:* Retrospective, single center. ICU patients Probabilistic. *External validation:* No	Immunosuppression Resident of long-term care facilities Antibiotic use	0.71
Madaras–Kelly *et al.* 2012[42]	USA	*n:* 375 patients *Design:* Retrospective, multicenter. Only HCAP patients Probabilistic. *External validation:* No	MRSA colonization Resident of LTCF Home infusion therapy Cephalosporin use Diabetes mellitus ICU admission	0.71

USA: United States of America; *n*: Number; AUROC: Area under the receiver operating characteristic curve; N/A: Not applicable; ICU: Intensive care unit; LTCF: Long-term care facility; HCAP: Health care-associated pneumonia; MRSA: Methicillin-resistant *S. aureus*

of HCAP patients received inappropriate therapy, mostly those with ≥2 risk factors. However, inappropriate therapy was not associated with increased risk of 30-day mortality.

In 2008, Shorr *et al*. highlighted that HCAP criteria led to misclassification of one-third of the patients with current presence of DRPs.[18] Moreover, the authors published the first prediction score derived in a retrospective cohort with 639 patients with pneumonia, out of whom 45.2% presented with DRPs. The score included recent hospitalization, NH residence, hemodialysis, and intensive care unit admission assigning 4, 3, 2, and 1 points, respectively, with an area under the receiver operating characteristic (ROC) curve of 0.74 (95% CI, 0.65-0.80). When the same group validated the score in a similar retrospective cohort with a high prevalence of DRPs, the area under receiver operating characteristic (AUROC) for HCAP was 0.62 (95% CI, 0.58-0.65) versus 0.71 (95% CI, 0.66-0.73%) for the risk score.[43] According to the score, only 24.3% of the patients would receive unnecessary extended-spectrum antibiotics. Nevertheless, the generalizability of this model is limited due to the high prevalence of DRPs and high rate of severe patients with more than half of the patients being admitted to ICU; see Table 1.

In an attempt to predict DRP causing pneumonia in a more heterogeneous cohort, Aliberti *et al*. derived a weighted, prospective score including NH or extended care facility,

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recent hospitalization, chronic renal failure as well as minor risk factors such as chronic obstructive pulmonary disease, cerebrovascular disease, diabetes mellitus, antimicrobial therapy in the preceding 90 days, immunosuppression, home wound care, and home infusion therapy including antibiotics.[19] The variables were pointed from 0.5 points if minor risk factors were met to 5 points if chronic renal failure was met with an AUROC of 0.79 (95% CI, 0.71-0.87). Later on, the model was prospectively validated for the presence of DRPs pneumonia in Spanish and Scottish cohorts with an AUROC of 0.89 (95% CI, 0.70-0.83) and 0.77 (95% CI, 0.71-0.84), respectively.[39] Both Aliberti and Shorr scores performed better than HCAP classification in predicting DRP pneumonia while Aliberti score showed a slightly better performance than Shorr's one without reaching statistical significance. In contrast to Shorr's study, the prevalence of DRPs was very low in this population.

Park *et al*., developed a predicting score among a population with 36% prevalence of DRP by assigning 5 points for nasogastric tube feeding, 3 points for hospitalization within previous 90 days, 2 points for intravenous antibiotics within previous 30 days, and 1 point each for residence in a NH or extended-care facility, chemotherapy or wound care within 30 days of diagnosed pneumonia, or undergoing chronic dialysis.[40] The predictive accuracy of the new scoring system was significantly higher than that of the current HCAP criteria with an AUC of 0.71 (95% CI, 0.66-0.76) and 0.63 (95% CI, 0.58-0.69). Recently, Wang *et al*. showed that the addition of a few risk factors to the pneumonia severity index (PSI) score could slightly improve the accuracy to predict DRP pathogens.[44] The authors suggested broad-spectrum antibiotics covering *P. aeruginosa* for PSI risk classes III and IV patients with bronchiectasis and tube feeding as well as additional antibiotics covering MRSA for PSI risk class V patients who received wound care within 1 month.

Another multicenter study from Japan described a prospective model assigning 1 point to each risk factor (hospitalization within the previous 90 days, antibiotics within the previous 90 days, immunosuppression, use of gastric acid-suppressive agents, tube feeding, and poor functional status).[7] The sum of six risk factors showed an AUROC of 0.79 (95% CI, 0.74-0.84) in contrast to 0.71 (95% CI, 0.66-0.77) and 0.66 (95% CI, 0.61-0.71) of Shorr and Aliberti scores, respectively.

Schreiber *et al*. described another predicting score derived in a retrospective cohort of severe patients admitted to the ICU with respiratory failure requiring mechanical ventilation.[41] The authors assigned 3 points to immunosuppression, 2 points to long-term care, and 1 point to prior antibiotic use with a moderately well performance. Madaras-Kelly *et al*. derived a retrospective model among HCAP patients by the inclusion of risk factors for MRSA colonization, long-term care, infusion therapy, cephalosporin use, diabetes, and severity with an AUROC of 0.71 (95% CI, 0.65-0.77).[42] Still, the last three models proposed have not been validated.

Finally, Prina *et al*. proposed the acronym "PES" in order to identify the three most common pathogens that need a different treatment in CAP; *P. aeruginosa*, *Enterobacteriaceae* extended-spectrum β-lactamase-positive, and methicillin-resistant *Staphylococcus aureus*.[45] In an observational prospective study evaluating only immunocompetent patients with CAP, they identified 6% of the patients with pneumonia caused by PES. Furthermore, the presence of PES pathogens seems to be independently associated with an increased risk of 30-day mortality. As noted above, it is difficult to establish even in prospective studies if this increase in mortality is directly due to the pathogens or the marked differences in the demographics of patients' susceptibility to DRPs.

How to identify a pneumonia caused by *P. aeruginosa* in the community?

Few studies have been designed to help physicians in predicting pneumonia due to a single DRP in patients coming from the community including *P. aeruginosa* and MRSA. Despite being infrequent, CAP due to *P. aeruginosa* has been associated with more severe illness and worse outcomes.[46,47] In this sense, Oriol *et al*., developed a retrospective study among 150 hospitals from the USA focused on identifying risk factors for *P. aeruginosa*.[48] The authors described that only one-third of the current risk factors could identify *P. aeruginosa*. Additionally, they found that not receiving empirical antibiotics against it was associated with an increased 30-day mortality, especially among patients with cerebrovascular disease or dementia but without other specific risk factors.

How to identify a pneumonia caused by methicillin-resistant *S. aureus* in the community?

Patients with MRSA pneumonia present with more severe illness and higher morbidity and mortality rates compared to pneumonia caused by other pathogens.[49] A study conducted in the USA from 2008 through 2012 described an increasing incidence of health care-related MRSA pneumonia.[50] However, identifying pneumonia caused by MRSA by the current definition of HCAP seems to be difficult in clinical practice.

Shorr *et al*., developed a retrospective multicenter study enrolling 5,975 patients with pneumonia among 62 hospitals from the USA.[51] The authors tried to identify the presence of MRSA by developing a weighted score based on age, prior health care exposure, severity of illness, and various comorbid conditions. Each variable was assigned 1 point except for recent hospitalization and severity of illness that were assigned two points. The score was able to identify patients at low risk for MRSA in whom unnecessary antibiotic treatments could be avoided. In this study, HCAP definition

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was an independent predictor of MRSA but not as robust as some of its components; thus, it was finally excluded from the final model. Furthermore, most of the variables in the score for MRSA were similar to those in the score for DRPs in general, highlighting the need for a more comprehensive evaluation of risk factors for MRSA. Minejima *et al*. compared retrospectively 134 MRSA pneumonia patients versus non-MRSA pneumonia and showed that most MRSA pneumonias (66%) were treated empirically with MRSA therapy.[49] However, better outcomes were not observed among those patients.

More recently, Teshome *et al*. conducted a retrospective study enrolling 80,330 patients hospitalized in the Veterans Health Administration (VA) in order to assess the effect of initial MRSA therapy on the 30-day mortality in the three risk groups of the above score.[52] The authors observed a lower mortality rate among high-risk patients with an initial MRSA therapy. Moreover, five patients should be treated with initial MRSA therapy in order to save one life in the high-risk group. In contrast, initial MRSA therapy was not beneficial in low- or medium-risk groups. However, the score proposed by Shorr *et al*. could not be completely assessed in this study due to the lack of patients <65 years as well as the higher prevalence of males in the VA system.

All the above scores have demonstrated a better accuracy than HCAP. However, most scores were focused on predicting DRPs in general but none could distinguish between different etiological microorganisms probably due to an overlap in this path of lights and shadows. At the moment, a Global Initiative for MRSA Pneumonia (GLIMP) study is being developed. This is the first international study to assess risk factors for MRSA in adult patients admitted to the hospital with either CAP or HCAP worldwide and promising results are expected in the near future. Therefore, further studies should be developed focused on identifying specific risk factors for specific drug-resistant microorganisms in order to help clinicians with decision-making while avoiding unnecessary broad-spectrum antibiotic treatments.

CONCLUSIONS

During the last few decades, an increased prevalence of pneumonia caused by DRPs has been described due to dynamic changes of different health care systems, antibiotic selection pressure, and an aging population. The HCAP definition has shown several limitations for identifying DRPs in patients with CAP, especially outside the USA. However, different useful prediction scores have been recently developed. Further research is needed in order to support physicians in distinguishing between different DRPs causing pneumonia.

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Conflicts of interest

There are no conflicts of interest.

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