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Original Article

Adherence to antibiotic treatment guidelines and outcomes in the hospitalized elderly with different types of pneumonia

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ABSTRACT

Background: Few studies evaluated the clinical outcomes of Community Acquired Pneumonia (CAP), Hospital-Acquired Pneumonia (HAP) and Health Care-Associated Pneumonia (HCAP) in relation to the adherence of antibiotic treatment to the guidelines of the Infectious Diseases Society of America (IDSA) and the American Thoracic Society (ATS) in hospitalized elderly people (65 years or older).
Methods: Data were obtained from REPOSI, a prospective registry held in 87 Italian internal medicine and geriatric wards. Patients with a diagnosis of pneumonia (ICD-9 480-487) or prescribed with an antibiotic for pneumonia as indication were selected. The empirical antibiotic regimen was defined to be adherent to guidelines if concordant with the treatment regimens recommended by IDSA/ATS for CAP, HAP, and HCAP. Outcomes were assessed by logistic regression models.
Results: A diagnosis of pneumonia was made in 317 patients. Only 38.8% of them received an empirical antibiotic regimen that was adherent to guidelines. However, no significant association was found between adherence to guidelines and outcomes. Having HAP, older age, and higher CIRS severity index were the main factors associated with in-hospital mortality.
Conclusions: The adherence to antibiotic treatment guidelines was poor, particularly for HAP and HCAP, suggesting the need for more adherence to the optimal management of antibiotics in the elderly with pneumonia.

1. Introduction

Pneumonia is a common infectious disease and is among the leading causes of hospitalization and death [1]. In the frail elderly suffering from multiple chronic diseases pneumonia is more severe and leads to increased mortality [1]. Many scientific societies and working groups have prepared guidelines on the most suitable antibiotics for the empirical treatment of patients with different types of pneumonia. Among such guidelines the most used worldwide are those of the Infectious Disease Society of America (IDSA) [2] and of the American Thoracic Society (ATS) [3], that include recommendations for the treatment of Community Acquired Pneumonia (CAP), Hospital Acquired Pneumonia (HAP), and for the new category Health Care-Associated Pneumonia (HCAP) [4,5].

Even though several studies have evaluated the degree of adherence to guidelines for empirical antibiotic therapy, especially in CAP [6], very few of them did evaluate adherence for the different categories of pneumonia and its impact on clinical outcomes [7]. Furthermore, a paucity of studies has specifically considered the hospitalized elderly population [8]. With this background, the aims of this study were to evaluate adherence to IDSA/ATS guidelines and its relationship with the main clinical outcomes (length of hospital stay, re-hospitalization rate, in-hospital and 3-month mortality) in elderly people consecutively admitted to Italian internal medicine and geriatric wards participating in the prospective REPOSI registry.

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2. Methods

2.1. Data collection

This study was conducted in internal medicine and geriatric wards participating to REPOSI (Registro Politerapie SIMI), a collaborative and independent registry of the Italian Society of Internal Medicine (SIMI), IRCCS Fondazione Cà Granda Policlinico Hospital, and the IRCCS Istituto di Ricerche Farmacologiche Mario Negri. The registry design was described in details elsewhere [9]. In brief, patients aged 65 years or more consecutively admitted to hospital during four index periods which lasted one week each separated from each other by 3 months were enrolled in the biannual study runs in 2008, 2010, and 2012.

The principal data collected included socio-demographic factors, clinical parameters, patterns of comorbidities according to the Cumulative Illness Rating Scale (CIRS), and medications prescribed. In particular, CIRS was developed in 1968 and successively reviewed for elderly patients in 1991. It allows to calculate the number and functional severity (score) of chronic illnesses in the frame of the comorbid state of a given patient, according to 13 items, one for each biological system, plus one for psychiatric conditions. Thus, a comorbidity index was computed by counting the number of items for which moderate to severe illness was reported (scores ≥ 3), while overall illness severity was represented by the mean of the (score for) first 13 CIRS items [10].

Participation was voluntary and all patients provided signed informed consent. In this study on pneumonia, patients from REPOSI 2008 were excluded because no information about their living environments and previous hospitalizations and hospital visits were available, preventing the accurate classification of the type of pneumonia and making particularly difficult the distinction between CAP and HCAP.

2.2. Criteria for pneumonia classification

All patients with a diagnosis of pneumonia [International Classification of Diseases – Ninth Revision (ICD9) codes 480-487] or prescribed antibiotic therapy with pneumonia as an indication were included. We classified patients as having CAP when the onset of symptoms did occur outside the hospital setting or alternatively within 48 h since hospital admission. Patients were classified as having HAP if diagnosed with pneumonia after being hospitalized for more than 48 h. They were classified as HCAP if hospitalized in an acute care ward for two or more days within 90 days before the infection; or resided in a nursing home or long-term care facility; or had received intravenous antibiotic therapy, chemotherapy or wound care within the past 30 days before the current infection; or had attended a hospital or hemodialysis clinic [2,3,5].

2.3. Antibiotic treatment adherence

In the REPOSI database microbiological investigations were not recorded. We are cognizant that in the presence of microbiological methods identifying etiology of CAP, antimicrobial therapy should be specifically directed to that pathogen [2]. However, in the present analysis, because this specific information was missing, adequacy of antibiotic therapy according to microbiological tests could not be evaluated. Hence we defined empirical antibiotic regimens those administered on the first day of therapy for pneumonia and considered the antibiotic regimen adherent to IDSA/ATS guidelines if concordant with the current recommendations for CAP, HAP, and HCAP [2,3]. For treatment of CAP, the use of beta-lactam antibiotics (ceftriaxone, cefotaxime, amoxicillin, amoxicillin/clavulanate, and ampicillin/sulbactam) in combination with a macrolide (azithromycin or clarithromycin) and that of a respiratory fluoroquinolone alone (moxifloxacin or levofloxacin) was considered treatments consistent with guidelines. In the presence of risk factors for *Pseudomonas* species, the use of an antipseudomonas antibiotic (piperacillin/tazobactam, ceftazidime, cefepime, imipenem or meropenem) in combination with ciprofloxacin or with an aminoglycoside was considered consistent.

For treatment of HAP, provided that the infection began within the first 4 days of hospitalization, ceftriaxone, levofloxacin, moxifloxacin, ciprofloxacin, ampicillin/sulbactam or ertapenem were considered consistent with the guidelines. For late onset HAP or in the presence of risk factors for multi-drug resistant (MDR) pathogens, antipseudomonas cephalosporins or carbapenems or beta-lactam/beta-lactamase inhibitors plus antipseudomonas fluoroquinolone or an aminoglycoside plus linezolid or vancomycin were prescribed. Most patients with HCAP are at risk of infection with MDR pathogens: accordingly, the recommended therapy is that of late-onset HAP.

2.4. Statistical analysis

Data were summarized as frequencies (%), means and standard deviations or medians and interquartile ranges, as appropriate. The association between pneumonia types and socio-demographic factors and other co-morbidities was assessed by univariable multinomial logistic regression model (CAP was the reference category). Multivariable selection was performed according to the results of univariable analysis and then assessed by a lasso regularized multinomial regression [11]. Adherence to clinical guidelines was assessed by means of a mixed effect logistic regression model, in order to account for possible within-ward correlation [12]. Three regression models were fitted to account for pneumonia classification (model 1), age and gender (model 2), and clinical features affecting classification (model 3). The year of REPOSI enrolment was also considered in adjusted models.

The main clinical patient outcomes (re-hospitalization, in-hospital and 3-month mortality) were analyzed by means of a logistic regression model, accounting for pneumonia classification, adherence to clinical guidelines, demographic characteristics and possible clinical features. Length of hospital stay was evaluated as a continuous variable.

The analysis was performed using the SAS/STAT software Version 9.1 (SAS Institute Inc., Cary, NC, USA). The Proc GLIMMIX was used to fit mixed effect models.

3. Results

3.1. Demographic characteristics

Among 4035 patients included in the REPOSI registry, a sample of 529 had a diagnosis of pneumonia at the time of admission or during hospitalization. From the REPOSI 2010 and 2012 runs 142 patients were excluded because of missing data, 58 because enrolled in 2008 and 12 because they have viral or fungal pneumonia, so that a total of 317 patients enrolled in 72 wards were available for analysis (Fig. 1): 167 (53.6%) were males and mean age was 80.7 years. Overall, 191 patients had CAP, 55 HAP, and 71 HCAP.

Table 1 reports the socio-demographic and main clinical characteristics at the time of hospital admission according to the type of pneumonia. Compared to those with CAP, HAP patients were significantly older and presented with a slight lower degree of physical ability (Barthel index). Patients with HCAP were also less likely to live alone or with relatives, used a higher number of medications, had more co-morbidities at admission and also a higher illness severity score (CIRS severity index). The multivariate multinomial regression model confirmed the results of univariable analysis: almost the same factors were independently associated to the pneumonia type with almost the same effect, but no association was seen for the number of co-morbidities and a lower BMI seemed to be associated to HCAP. Pertaining to the co-morbidity profiles, no relevance between-group differences were found, but HCAP patients were more often affected by malignancies and vascular diseases (p-value < 0.1), HAP patients by genitourinary diseases (p-value < 0.1).

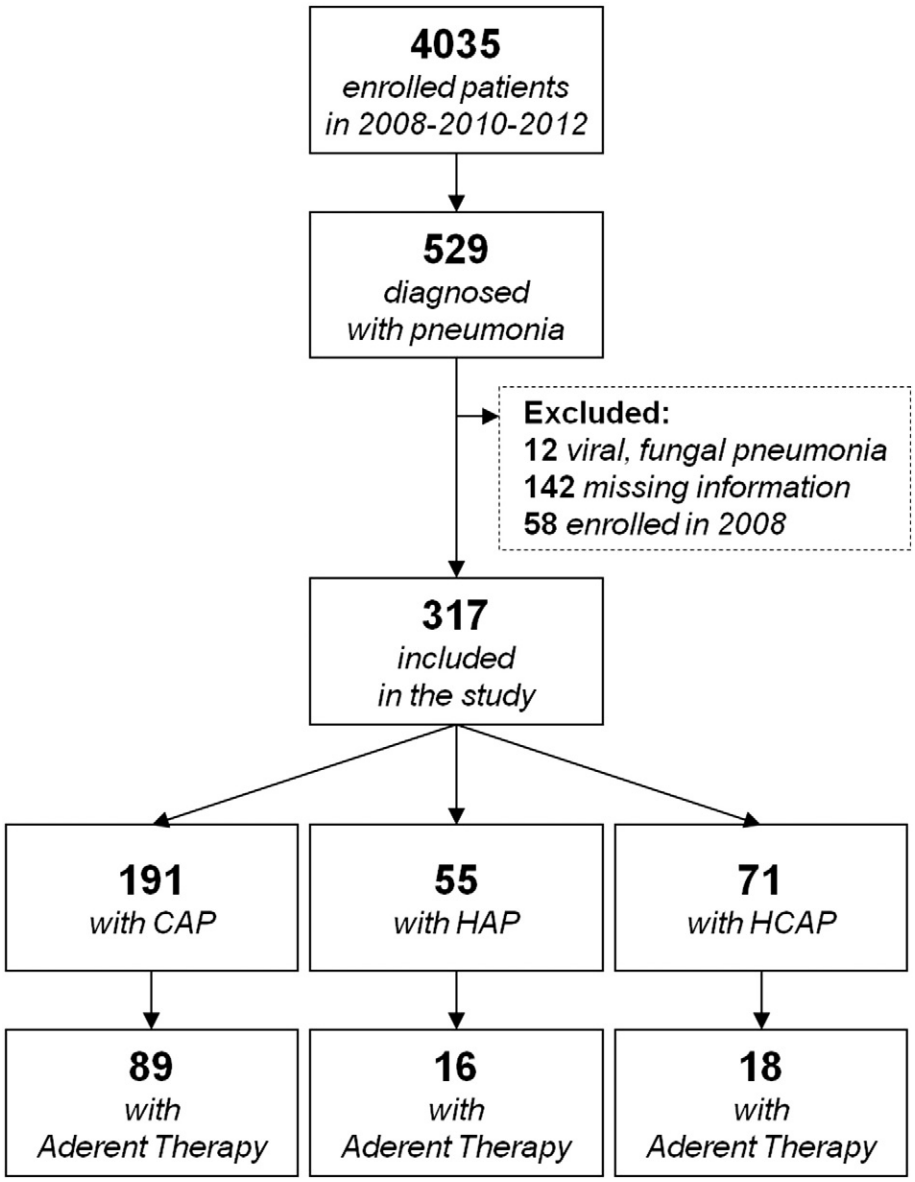

Fig. 1. Flow-chart of the study. CAP: community-acquired pneumonia; HAP: hospital-acquired pneumonia; HCAP: health-care acquired pneumonia.

3.2. Adherence to the IDSA/ATS guidelines

The initial empirical antimicrobial regimen was adherent in 123 of 317 patients (38.8%). Table 2 reports these regimens according to pneumonia type.

Among patients with CAP the initial regimen was prescribed in agreement with the IDSA/ATS guidelines in 89 patients (46.6%). The guideline-concordant group included patients treated with a beta-lactam plus a macrolide (n = 42) or fluoroquinolone in monotherapy (n = 34). In 13 patients therapy was still considered adherent to guidelines because they were at risk of *Pseudomonas* infection. The most common poor adherence was lack of coverage for atypical pathogens (n = 54) and the second most common was being a beta-lactam plus a fluoroquinolone, (n = 25), a regimen considered non-adherent because it is reserved for patients admitted to intensive care units.

Among patients with HAP, 16 patients (29.1%) received guideline-concordant antibiotic therapy. If the infection began within the first 4 days of hospitalization ceftriaxone, levofloxacin, moxifloxacin, ciprofloxacin, ampicillin/sulbactam or ertapenem were considered concordant with guidelines: 9 patients had a concordant treatment. For late onset HAP or the presence of risk factors for MDR pathogens, antipseudomonas cephalosporin or carbapenem or a beta-lactam/beta-lactamase inhibitor plus fluoroquinolone or aminoglycoside plus linezolid or vancomycin were considered appropriate: 7 patients were treated in accordance with guidelines, two of them being treated for methicillin-resistant *Staphylococcus aureus*. Among 39 patients not treated in accordance with guidelines, the most common inadequate therapy was beta-lactam monotherapy.

Among patients with HCAP, there was a low compliance with guidelines, because only 18 (25.3%) received a concordant therapy, i.e., that of late onset HAP owing to the high risk of MDR pathogens.

Results of mixed logistic regression models are in Table 3. This analysis confirmed that patients with HAP and HCAP were not treated in agreement with the empirical antibiotic regimen recommended by guidelines (p-value 0.001). There was no evidence of association between demographic and clinical characteristics with adherence or not to guidelines.

Table 1
Socio-demographics and clinical characteristics of the patients included in the study according to the classification of pneumonia at hospital admission.

	CAP	HAP	OR — HAP vs CAP (95% CI)	HCAP	OR — HCAP vs CAP (95% CI)
	191 (60.25)	55 (17.35)		71 (22.40)	
Sex (males)	99 (51.83)	29 (52.73)	1.04 (.56–1.89)	39 (54.93)	1.13 (.65–1.95)
Age	80.07 (7.6)	83.35 (6.8)	1.06 (1.02–1.1)†	80.45 (7.78)	1.07 (.97–1.04)
Body mass index (BMI)	25.50 (5.15)	24.58 (4.0)	0.96 (.90–1.03)	24.33 (4.78)	0.95 (.91–1.03)
Living arrangement:					
Alone	35 (18.72)	14 (27.45)		14 (20.59)	
With spouse	87 (46.52)	22 (43.14)	0.63 (.29–1.37)	22 (32.35)	0.63 (.29–1.37)
With sons	37 (19.79)	5 (9.80)	0.33 (.11–1.03)	8 (11.76)	0.54 (.20–1.44)
With spouse and sons	14 (7.49)	4 (7.84)	0.71 (.2–2.55)	4 (5.88)	0.71 (.2–2.55)
Other	14 (7.49)	6 (11.76)	1.07 (.34–3.35)	20 (29.41)	3.57 (1.42–8.98)‡
Caregiver	123 (65.78)	40 (74.07)	1.48 (.75–2.93)	53 (77.94)	1.83 (.96–3.5)
Smoking:					
No	86 (45.26)	32 (58.18)		30 (43.48)	
Ex	89 (46.84)	20 (36.36)	0.60 (.32–1.14)	35 (50.72)	1.12 (.63–1.99)
Yes	15 (7.89)	3 (5.45)	0.53 (.14–1.98)	4 (5.80)	0.76 (.23–2.48)
Number of drugs[a]	5 (4–7)	6 (4–8)	1.03 (.92–1.15)	8 (5–10)	1.23 (1.12–1.35)‡
Number of diagnosis[a]	6 (4–8)	6 (5–7)	1.00 (.89–1.11)	7 (5–9)	1.1 (1–1.2)‡
Barthel index[a]	68.30 (32.1)	56.8 (36.5)		61.2 (35.3)	0.99 (.98–1.01)
Barthel index < 25	27 (14.1)	18 (32.7)	0.34 (.17–.68)†	16 (22.5)	0.57 (.28–1.13)
CIRS — severity index	1.68 (0.3)	1.71 (0.29)	1.44 (.54–3.86)	1.81 (0.35)	3.67 (1.58–9.03)‡
CIRS — comorbidity index[a]	3 (2–4)	3 (2–4)	3.37 (1.5)	3 (3–5)	1.18 (1.01–1.38)‡
Cancer	35 (18.32)	8 (14.81)	0.77 (.33–1.78)	25 (35.21)	2.42 (1.31–4.46)‡
Vascular diseases	174 (91.10)	51 (94.44)	1.66 (.46–5.89)	70 (98.58)	6.83 (0.89–52.36)
Genitourinary	63 (32.98)	25 (46.30)	1.75 (.95–3.24)	22 (30.99)	0.97 (.50–1.64)

CAP: community-acquired pneumonia; HAP: hospital-acquired pneumonia; HCAP: health-care acquired pneumonia.
[a] Median and interquartile ranges.
† Statistically significant at $p < 0.05$ for HAP vs CAP.
‡ Statistically significant at $p < 0.05$ for HAP vs CAP.

Table 2
Adherence to the recommended antibiotic treatment according to pneumonia classification.

CAP		HAP		HCAP	
Antibiotic treatment recommended	Patient (N)	Antibiotic treatment recommended	Patient (N)	Antibiotic treatment recommended	Patient (N)
Adherent	89	Adherent	16	Adherent	18
Beta-lactam plus macrolide	42	Within the 4 days of hospitalization	9	Antipseudomonal cephalosporin or antipseudomonas carbapenemi or beta-lactam/beta-lactamase inhibitor plus antipseudomonal fluoroquinolone or aminoglycoside	17
Respiratory fluoroquinolone	34	Fluoroquinolones	5	Antipseudomonal cephalosporin or antipseudomonas carbapenemi or beta-lactam/beta-lactamase inhibitor plus antipseudomonal fluoroquinolone or aminoglycoside plus vancomycin	1
Treatment with coverage of *Pseudomonas*	13	Ceftriaxone	4		
		After day 4 of hospitalization	7		
		Antipseudomonal cephalosporin or antipseudomonas carbapenem or beta-lactam/beta-lactamase inhibitor plus antipseudomonal fluoroquinolone or aminoglycoside	5		
		Antipseudomonal cephalosporin or antipseudomonas carbapenemi or beta-lactam/beta-lactamase inhibitor plus antipseudomonal fluoroquinolone or aminoglycoside plus vancomycin	2		
Non-adherent	102	Non-adherent	40	Non-adherent	53
Beta-lactam alone	54	Beta-lactam alone	17	Beta-lactam alone	27
Macrolide alone	5	Macrolide alone	2	Macrolide alone	2
Quinolone alone	2	Quinolone alone	4	Quinolone alone	7
Beta-lactam plus quinolone	25	Other monotherapies	4	Other therapy combination	17
Beta-lactam anti-pseudomonal plus macrolide	4	Other therapy combination	13		
Other monotherapies	5				
Other therapy combination	7				

CAP: community-acquired pneumonia; HAP: hospital-acquired pneumonia; HCAP: health-care acquired pneumonia.

Table 3
Risk factors for adherence to clinical guidelines: results from adjusted mixed logistic regression models.

	OR (95% CI)		
	Model 1	Model 2	Model 3
HAP vs CAP	0.42 (0.22–0.82)	0.42 (0.22–0.83)	0.39 (0.19–0.78)
HCAP vs CAP	0.38 (0.20–0.7)	0.38 (0.20–0.7)	0.32 (0.17–0.62)
2010 vs 2012	1.98 (1.22–3.2)	1.98 (1.22–3.22)	2.12 (1.28–3.53)
Males		1.17 (0.73–1.88)	1.20 (0.73–1.96)
Age		0.99 (0.97–1.03)	1.00 (0.96–1.03)
CIRS — severity index			0.91 (0.36–2.3)
Number of drugs			1.08 (0.98–1.2)

CAP: community-acquired pneumonia; HAP: hospital-acquired pneumonia; HCAP: health-care acquired pneumonia.

Curiously, patients enrolled in 2010 were more likely to be treated according to guidelines with than those admitted in 2012 (p-value 0.005).

3.3. Outcomes

3.3.1. Length of hospital stay

Overall 265 patients (83.1%) were discharged (4 critically ill), 27 patients (8.6%) were transferred to another ward or rehabilitation unit, 23 (7.3%) died, and for two patients the discharge status was not available. The mean length of hospital stay was nearly 14 days for patients with both CAP and HCAP, but length did significantly increase for patients with HAP up to nearly 24 days ($p < 0.0001$).

3.3.2. In-hospital mortality

The overall mortality rate was 7.3%, being significantly higher for HAP (18.2%) than for CAP (3.6%) and HCAP (8.4%). Among the adherent patients the observed mortality was 4.9% (6 patients) versus 8.66% (17 patients) among the non-adherent ones.

Results of multivariable regression model suggests that adherence to clinical guidelines may improve the outcome (OR = 0.66, 95% CI 0.25–1.79) although the fairly wide confidence interval did not provide statistical evidence. The main risk factors associated to higher in-hospital mortality (Table 4) were having HAP (OR 4.36, 95% CI 1.4–13.46), older age (OR (1 year) 1.12, 95% CI 1.04–1.21) and higher CIRS severity index (OR (1 point) 9.77, 95% CI 1.9–50.36).

3.3.3. Three-month follow-up

Among 220 patients with available 3-month follow-up, 46 were readmitted to hospital at least once within 3 months post-discharge: 28/138 (20.3%) had CAP, 11/76 (11.8%) HAP, and 12/48 HCAP (25%). Thirty three of them died within 3 months post-discharge (15%). The 3-month mortality rate was lower among patients with CAP (13/184 patients, 9.4%) than among those with HAP (10/45, 29.4%) and HCAP (10/65 patients, 20.8%). Fourteen patients that have received treatment according to guidelines died (15.7%) versus 19 patients (14.5%) that did received non-adherent treatment.

Table 4
Risk factors associated with in-hospital mortality: results from adjusted mixed logistic regression models.

	OR (95% CI)		
	Model 1	Model 2	Model 3
HAP vs CAP	5.48 (1.96–15.36)	4.33 (1.5–12.46)	4.36 (1.4–13.46)
HCAP vs CAP	2.24 (0.71–7.01)	2.19 (0.68–7.09)	2.37 (0.68–8.53)
Adherence	0.66 (0.25–1.79)	0.61 (0.22–1.71)	0.71 (0.25–2.05)
Males		1.60 (0.63–4.06)	0.72 (0.27–1.92)
Age		1.13 (1.05–1.21)	1.12 (1.04–1.21)
CIRS — severity index			9.77 (1.9–50.36)
Number of drugs			0.86 (0.7–1.05)

CAP: community-acquired pneumonia; HAP: hospital-acquired pneumonia; HCAP: health-care acquired pneumonia.

After adjustment for gender, age, adherence, and severity index, multivariable analysis confirmed higher 3 months mortality among patients with HAP or HCAP. Older age and higher CIRS severity index (at discharge) were also significantly associated with a higher likelihood of death post-discharge (data not shown). There was no statistically significant evidence that adherence to clinical guidelines did affect the outcomes considered.

4. Discussion

Because the elderly population has dramatically increased in the last decades and it is expected to further increase, improving the treatment of acute and chronic illness in this segment of the population becomes more and more important. Changes in the living environment and more frequent need of health care support are associated with the findings that healthcare-associated pneumonias are becoming much more frequent in elderly [4,5].

While several studies on adherence to guidelines of empirical antibiotic therapy for CAP have been conducted in medical wards and intensive care units [6,13–15], a relatively small number of studies have investigated adherence in patients with healthcare-associated pneumonias such as HAP or HCAP [7,16–19].

In this study carried out in the elderly overall adherence to clinical guidelines was poor, because also for CAP it was less than 50%, slightly lower than in other studies [7,8,14], but it was even lower for HAP (29%) and HCAP (25%). The lack of specific microbiological test could, at least, explain the poor adherence among CAP.

Perhaps the fact that HCAP has been only recently recognized in the frame of clinical guidelines as a specific pneumonia type may partially explain such discrepancies, because patients with HCAP were traditionally categorized as CAP [4,14] and therefore not appropriately managed [7]. A possible explanation for the under-recognition of HCAP is the inaccurate documentation collected by physicians at patient hospital admission pertaining to the living environments and/or previous hospitalizations, that are crucial criteria for an accurate identification of HCAP. By the way, we were impressed to notice that patients enrolled in REPOSI in the year 2010 were more frequently treated according to guidelines that those admitted in 2012 (p-value 0.005), suggesting worsening rather than an improvement of adherence.

Several factors could explain this finding, including guidelines applicability to individual patients, level of local participation, physician's knowledge, and attitudes [20]. Moreover available clinical guidelines did not consider elderly patients, in whom treatment is more complex because they are usually affected by multimorbidity and thus handed with polypharmacy, with possible risk of drug–drug interactions. Accordingly, clinicians who are aware of this complexity, may choose to treat them differently from guidelines. Continuing education of hospital personnel seems to be necessary to improve clinical practice.

Many studies have shown that an appropriate selection of the empirical antibiotic regimen for patients with CAP is associated with improved survival and decreased length of hospital stay [13,14]. We surprisingly found that in our elderly patients adherence to guidelines did not significantly improve outcomes. Increasing age and the severity index associated to multiple chronic illnesses were the main predictors for both in-hospital and short-term mortality in all types of pneumonia. Also in another study that included a larger number of patients, adherence to the ATS guidelines was not predictive for in-hospital mortality [6]. Perhaps an adequate antibiotic therapy may affect less clinical outcomes and mortality in complex elderly patients with multimorbidity and polypharmacy than in younger population. [9,21,22]. Data on the impact of comorbidities and combination therapies in the outcome of pneumonias in the elderly are still controversial and need to be further investigated.

The major strength of the study is the multicenter design of the REPOSI registry and the inclusion of patients in four different year periods, which enabled us to balance the seasonal effect. Moreover, the

large number of participating centers makes the study representative of the overall Italian setting of internal medicine and geriatric wards. The small sample size reached for the present analysis, may affect the precision of the estimates resulting in wide confidence intervals. Among limitations, it must be also mentioned that the standardized data on the specific risk factors needed to accurately diagnose patients with health care-associated pneumonias, may be missing in the frame of a registry, perhaps introducing bias in the subsequent classification of pneumonia type. Furthermore because REPOSI did not collect data on the occurrence in patients of confusion, serum urea levels and respiratory rate, we could not stratify them into risk classes, using for example the CURB-65 criteria and the pneumonia severity index [23], that are used to help predict pneumonia severity, prognosis, and short-term mortality. Finally data on microbiological investigation were not available.

In conclusion, physicians should strive to better recognize and differentiate patients with CAP from those with HAP and HCAP in order to provide optimal clinical management of the elderly with pneumonia. Moreover, considering that the segment of the elderly population is increasing worldwide and that among them the very old individuals aged more than 85 years are even more rapidly increasing, clinical guidelines should take into account the peculiarities of the oldest old.

Learning points

- Pneumonia is a common infectious disease and is among the leading causes of hospitalization and death, especially in elderly.
- The guidelines most used worldwide are those of the Infectious Disease Society of America (IDSA) and of the American Thoracic Society (ATS).
- In this study, the adherence to these antibiotic treatment guidelines was poor, particularly for HAP and HCAP.
- However adherence to guidelines did not significantly improve outcomes.

Disclosure statement

All authors have no conflicts of interests to disclose.

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Appendix A

Investigators and co-authors of the REPOSI (Registro Politerapie SIMI, Società Italiana di Medicina Interna) study group are as follows:

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