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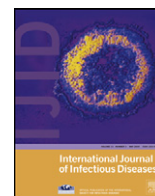
Age and other risk factors of pneumonia among residents of Polish long-term care facilities

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SUMMARY

Background: Pneumonia is one of the leading causes of morbidity and mortality in the elderly population. Nursing home-acquired pneumonia (NHAP) is probably the largest health problem in long-term care facilities (LTCFs). It is the second most common infection in LTCFs and frequently requires hospitalization. The aim of this study was to investigate the incidence rate of NHAP among LTCF residents, its microbial etiology, and the frequency of multidrug-resistant microorganisms. Risk factors for NHAP were analyzed.
Methods: This was a prospective study conducted on a group of 217 elderly subjects aged ≥ 65 years, recruited from the inhabitants of LTCFs, with disabled elderly individuals living in the community serving as controls. Continuous surveillance was carried out from December 1, 2009 to November 30, 2010.
Results: The incidence rate of NHAP in the observed population of Polish residents was 0.6/1000 resident-days. Vulnerability to NHAP was due to the poor general condition of residents, expressed by low Barthel index values (relative risk (RR) 1.6), the activities of daily living (ADL) score (RR 1.7), the Katz scale (RR 1.2), and limited physical activity (RR 1.6). Also significant were malnutrition (RR 2.3), the use of a bladder catheter (RR 1.3), dysphagia (RR 1.7), tracheotomy tube (RR 3.1), and gastric feeding tube (RR 3.5). *Enterobacteriaceae* were the predominant etiological agents of NHAP (56.3%).
Conclusions: The significance of risk factors for NHAP among residents in LTCFs was confirmed. Unfortunately, we also found that a lack of proper supervision with regard to the microbiology of infections is characteristic of Polish health care and LTCFs. There is an opportunity to improve the medical care of patients with severe disabilities, limit the rise in antimicrobial resistance and the need for hospitalization, and improve the prognosis.

1. Introduction

Pneumonia is one of the leading causes of morbidity and mortality in the elderly population worldwide.[1,2] The classification of pneumonia is becoming increasingly complex as the patient population becomes more diverse.[3] Patients exposed to a non-hospital risk have been categorized as having community-acquired pneumonia (CAP). However, even the outpatient population is nowadays subjected to many procedures and therapies, such as hemodialysis, wound care, infusion therapy, and therapy causing immunosuppression. Pneumonia in such a population is now referred to as health care-associated pneumonia (HCAP) and is frequently caused by multidrug-resistant bacteria.[3] Patients residing in non-hospital health care facilities, such as nursing homes, form a specific subpopulation themselves. Pneumonia in this group of patients has been classified as nursing home-acquired pneumonia (NHAP). Although NHAP is currently treated with the same protocols as CAP, it differs from CAP with respect to pathogens and the prognosis, and more closely resembles hospital-acquired pneumonia (HAP).[2,3]

NHAP is probably the largest health problem in long-term care facilities (LTCFs). It is the second most common infection in LTCFs and the leading cause of mortality and hospitalization.[4,5] NHAP frequently requires hospitalization and worsens the prognosis.[4,5] A number of factors may increase the risk of pneumonia among LTCF residents. Individual factors include malnutrition, long-term

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diseases, functional impairment, invasive devices, and prolonged antimicrobial exposure.[6] Institutional factors include larger facilities, low immunization rates, excessive antimicrobial use, and the widespread colonization of residents with antimicrobial-resistant organisms.[7] Other important aspects include many age-related changes with non-adaptive immunity, a decline in the cough reflex, diminished immunoglobin A secretion, loss of elastic tissue, decreased mucociliary transport, increased Gram-negative colonization of oropharynx, etc.[8,9]

There are also problems connected with the proper diagnosis and treatment of NHAP. Pneumonia among older residents of LTCFs does not manifest itself with typical symptoms. A third may not present fever and many do not have a cough or dyspnea either.[5] Patients frequently receive empirical antibiotic treatment before specimens are obtained for diagnostic testing.[4,5] Moreover, the etiology of most cases of NHAP is underdetermined.[10] *Streptococcus pneumoniae* is the most common causative agent. However, *Staphylococcus aureus* and Gram-negative organisms may be more common in severe cases of NHAP.[10] Accurate data on the etiologic agents and the epidemiology of severe NHAP have been limited by low bacteriology yields, the poor quality of respiratory specimens, and potential contamination of the upper respiratory tract.[10] Knowledge of the determinant factors responsible for NHAP is crucial for optimal management of this frail population and for improvement of the prognosis.

The aim of this study was to investigate the incidence rate of NHAP among residents of two different types of LTCF, with a comparison to a control group consisting of patients treated by the same family doctor in their homes, and to determine the microbial etiology and frequency of multidrug-resistant microorganisms. Secondly, we aimed to determine possible risk factors for NHAP and the possibility of improving microbiological surveillance. The former included demographic and clinical characteristics analyzed with respect to the severity scores.

2. Methods

Prospective continuous surveillance was carried out from December 2009 to November 2010 among elderly subjects aged ≥65 years, recruited from the inhabitants of LTCFs; disabled elderly individuals living in the community served as controls. The selected LTCFs – one nursing home and two residential homes – represent the essential forms of institutional care in Poland. A nursing home is an institution that provides skilled nursing care and rehabilitation services to people with illnesses, injuries, or functional disabilities and where care is provided by professionals, including medical doctors, nurses, and physical therapists. A residential home is a type of care home suitable for elderly people who are unable to live alone, do not require 24-h medical care, and where non-skilled nursing care is provided. The sample of 193 subjects who agreed to participate in the study, recruited from the residents of these three LTCFs, corresponded to 2.6% of the total LTCF population in Malopolska in 2010.[11]

Elderly individuals living in the community constituted the control group. These patients were treated by the same family doctor and their home care was provided by family members. Recruitment into the control group was carried out in collaboration with the family doctor. Twenty-four persons agreed to participate in the study.

The study protocol was approved by the local ethics committee at the Jagiellonian University and conforms to the guidelines set forth by the Declaration of Helsinki. The study protocol was carefully explained to the participants, who then gave their written informed consent prior to inclusion.

The medical documentation of all the residents was analyzed for the presence of chronic diseases and medical problems. In addition, the activities of daily living score (ADL; scores range from 0 to 6), the Katz scale (scores range from 0 to 6), and the Barthel index (scores range from 0 to 100) were obtained for all participants studied. The abbreviated mental test score (AMTS; scores range from 0 to 10) was obtained for the LTCF residents studied. Physical dependence was also classified according to a five-point scale: 1, independent; 2, independent with falls; 3, limitations in movement; 4, bedridden, mobile; 5, bedridden, dependent.

Continuous prospective infection surveillance was carried out between December 1, 2009 and November 30, 2010. In this study we used the incidence rate, which expresses the risk of disease and case-fatality rate: a ratio of the number of deaths from a specific disease divided by the number of cases of disease. Cases of NHAP were detected and recorded using the standard McGeer definition, i.e., both of the following criteria had to be met: (1) interpretation of a chest radiograph as demonstrating pneumonia, probable pneumonia, or the presence of an infiltrate; (2) the resident had to have at least two of the following signs and symptoms: chills, new headache or eye pain, myalgia, malaise or loss of appetite, sore throat, and new or increased dry cough,[12] observed by trained nurses in collaboration with a physician. Expectorated sputum or tracheal aspirate specimens were taken for the microbiological confirmation of NHAP, depending on the clinical status of the resident. The specimens were cultured on MacConkey agar, horse blood agar (at 37 °C, each for 24 h), and Sabourand agar (at 37 °C for 48 h). Identification with API tests (bioMérieux) was then performed. Antimicrobial susceptibility testing was performed using the disk diffusion antimicrobial susceptibility method on Mueller–Hinton agar plates, in accordance with the current European Committee on Antimicrobial Susceptibility Testing (EUCAST) guidelines.[13] The microbiological diagnosis was carried out at outside facilities, at the Department of Microbiology, Jagiellonian University Medical College (at a distance of not more than 5 km).

Data consisted of descriptive statistics based on the frequencies of nominal/categorical variables, and the parameters of distribution (mean and standard deviation (SD)) for continuous/quantitative data. Comparisons were made between LTCF residents (nursing home + residential home) and home care patients. In addition, the influence of selected risk factors for NHAP was also studied. The analysis of relationships between qualitative/categorical data was based on contingency table tests (Chi-square). If the classical analysis of variance (ANOVA) test could not be used due to non-homogeneous variances, the Welsh ANOVA test was used. The common influence of several factors on the probability of NHAP was analyzed using multivariate nominal logistic regression. All analyses were done with SAS JMP 7.01 package (JMP Software).[14]

For the continuous data usually presented as categories (age, Barthel index) and for variables with Poisson distribution and a limited number of given values (physical dependence scale), the analyses were supplemented by tests of frequencies in particular categories. For the analysis of the common influences of risk factors, multivariable analysis was done using general linear model (GLM) techniques. The model based on binominal distribution of the explanatory variable and logit link function was used.[15]

3. Results

Of the original number of 217 enrolled patients, one patient was discharged, one was transferred to another facility, and 31 patients died before the study was completed. Eighty-six (39.6%) of the subjects lived in residential homes, 107 in nursing homes (49.3%), and 24 were in home care (11.1%). The mortality rate in home care was 12.5% (three persons).

Table 1
Demographic and clinical characteristics of studied groups at baseline

Clinical characteristics	Home care, n (%) (n = 24)	Residential home, n (%) (n = 86)	Nursing home, n (%) (n = 107)	p-Value
Male	6 (25)	36 (41.9)	35 (32.7)	-
Female	18 (75)	50 (58.1)	72 (67.3)	-
Age, years				
Mean ± SD, 95% CI	82.9 ± 9.9 (78.7–87.0)	76.2 ± 10.5 (73.9–78.4)	76.8 ± 11.1 (74.6–78.9)	0.080
>70	3 (12.5)	22 (25.6)	25 (23.4)	<0.001
71–75	4 (16.7)	9 (10.5)	17 (15.9)	
76–80	0 (0)	22 (25.6)	15 (14.0)	
81–85	7 (29.2)	21 (24.4)	23 (21.5)	
86–90	5 (20.8)	8 (9.3)	20 (18.7)	
>91	5 (20.8)	4 (4.7)	7 (6.5)	
Malnutrition	0 (0)	2 (2.3)	6 (5.6)	
Coronary heart disease	16 (66.7)	55 (64.0)	61 (57.0)	-
Heart failure	16 (66.7)	23 (26.7)	54 (50.5)	<0.001
Diabetes	2 (8.3)	23 (26.7)	31 (29.0)	0.060
Asthma/COPD	5 (20.8)	17 (19.8)	19 (17.8)	-
Varicose veins	8 (33.3)	21 (24.4)	15 (14.0)	0.059
Pressure ulcers	0 (0)	6 (7.0)	10 (9.3)	-
Adenoma prostate	3 (12.5)	3 (3.5)	6 (5.6)	-
Dementia	5 (20.8)	10 (11.6)	19 (17.8)	0.010
Depression	4 (16.7)	34 (39.5)	34 (31.8)	-
Stroke	2 (8.3)	24 (27.9)	21 (19.6)	0.070
Cancer	2 (8.3)	6 (7.0)	5 (4.7)	-
Coronary heart disease	2 (8.3)	5 (5.8)	25 (23.4)	<0.001
Incontinence				
Diapers	6 (25)	23 (26.7)	39 (36.4)	<0.001
Catheter	1 (4.2)	0 (0)	39 (36.4)	
Fecal incontinence	4 (16.7)	6 (7.0)	67 (62.6)	<0.001
Dysphagia	0 (0)	4 (4.7)	26 (24.3)	<0.001
Tube feeding	0 (0)	0 (0)	24 (22.4)	<0.001
Tracheostomy tube	0 (0)	0 (0)	3 (2.8)	-

SD, standard deviation; CI, confidence interval; COPD, chronic obstructive pulmonary disease.

The average age of the residents in the residential homes, of whom 58.1% were female, was 76.2 years (SD ± 10.5). The average age of the residents in the nursing home was similar: 76.8 years (SD ± 11.1). The average length of LTCF stay was 6.5 years. The studied sample was heterogeneous and significantly diverse with regard to the incidence of hospitalization before the study, body weight, problems with maintaining personal hygiene (indicated as urinary/stool incontinence and a low score on the Katz scale), and expressed necessity of care (Barthel index; Tables 1 and 2). Of significance, a higher percentage of older subjects (aged ≥80 years) were in home care, while younger subjects (age <80 years) were mostly residents of residential homes. Differences were also observed in the physical activity of LTCF residents. Nursing home residents had a limited ability to walk independently (Table 2).

Table 2
Physical and mental status among the studied groups at baseline

Scales	Home care, n (%) (n = 24)	Residential home, n (%) (n = 86)	Nursing home, n (%) (n = 107)	p-Value
Barthel index				
Mean ± SD, 95% CI	75.4 ± 27.7 (63.7–87.1)	75.6 ± 34.5 (68.2–83.0)	19.5 ± 17.4 (16.1–22.9)	0.001
0	1 (4.2)	4 (4.7)	28 (26.2)	<0.001
1–15	1 (4.2)	11 (12.8)	24 (22.4)	
16–50	2 (8.3)	4 (4.7)	51 (47.7)	
51–75	4 (16.7)	7 (8.1)	1 (0.9)	
76–100	16 (66.7)	60 (69.8)	0 (0)	
Abbreviated mental test score				
Mean ± SD, 95% CI	N/D	6.6 ± 2.8 (6.0–7.2)	6.3 ± 3.5 (5.6–7.0)	-
0–2		9 (10.5)	21 (19.6)	-
3–6		22 (25.6)	22 (20.6)	
7–10		54 (62.8)	61 (57.0)	
Activities of daily living score				
Mean ± SD, 95% CI	4.4 ± 2.2 (3.5–5.3)	4.7 ± 2.1 (4.2–5.1)	1.3 ± 1.6 (0.9–1.6)	<0.001
0–1	4 (16.7)	14 (16.3)	73 (68.2)	<0.001
2–4	5 (20.8)	8 (9.3)	20 (18.7)	
5–6	15 (62.5)	64 (74.4)	9 (8.4)	
Physical dependence scale				
Mean ± SD 95% CI	2.4 ± 1.6 (1.7–3.1)	1.9 ± 1.2 (1.7–2.2)	3.7 ± 1.1 (3.5–3.9)	<0.001
1	12 (50)	48 (55.8)	5 (4.7)	<0.001
2	1 (4.2)	8 (9.3)	1 (0.9)	
3	6 (25)	24 (27.9)	47 (43.9)	
4	0 (0)	2 (2.3)	19 (17.8)	
5	5 (20.8)	4 (4.7)	33 (30.8)	

SD, standard deviation; CI, confidence interval; N/D, unknown or missing data.

With regard to vaccination, 36.8% of the residents were vaccinated against pneumococcal disease (Pneumo 23, Sanofi Pasteur) and 72.0% against influenza. Among patients in home care, none were vaccinated. The survey was conducted over a full calendar year (365 days); the total number of resident-days of stay in LTCFs reached 62 035 and in home care reached 7987 days.

In a study group of 114 subjects (52.5% of the total), 188 cases of infection (175 in LTCFs) were detected. These included 42 cases of pneumonia that were reported for 29 patients. Two or more cases of infection were confirmed for eight patients. The incidence rate of NHAP reached 19.3/100 residents and the incidence density was 0.6/1000 resident-days. No cases of pneumonia were recognized among control patients. A significantly higher risk of NHAP was found in nursing home residents (nursing home vs. residential homes, relative risk (RR) 1.5).

The significance of the frequency test (Chi-square of likelihood ratio) is presented for the categorized continuous parameters. A significant risk factor for NHAP among the LTCF residents was their general condition, expressed by the following scales: Barthel index (the highest incidence among residents with a value 0: RR 1.6, 95% confidence interval (CI) 1.0925–2.1331), the ADL (residents with a value of 0–2: RR 1.7, 95% CI 0.8919–2.511), and the Katz scale (residents with a value of 0–1: RR 1.2, 95% CI 0.6452–1.9242). The following were also statistically significant: limited physical activity (bedridden residents: RR 1.6, 95% CI 1.0712–2.3127), malnutrition/cachexia (RR 2.3, 95% CI 1.2966–5.9511), the use of a bladder catheter (RR 1.3, 95% CI 0.8211–2.0715), dysphagia (RR 1.7, 95% CI 0.8096–2.5102), the presence of a tracheotomy tube (RR 3.1, 95% CI 1.9706–4.5122), gastric feeding tube (RR 3.5, 95% CI 2.7112–4.1846), and others (Table 3). Patients with NHAP required hospitalization more frequently than patients with other types of infection. Eleven residents with NHAP died (case-fatality rate 37.9%). All of them were patients in palliative care and none was the subject of a do-not-resuscitate order. This case-fatality rate was considerably higher than the mortality rate in the group of residents without NHAP (10.4%).

The age of residents was not linearly correlated with NHAP, i.e., NHAP was observed significantly more frequently in those aged 71–80 years and in the oldest patients (>90 years).

The multivariate model, which included age, Barthel index, AMTS, Katz scale, and the physical activity scale as predictors, presented a general significant fit (log likelihood R^2 = 0.2491; Chi-square = 31.69401; $p < 0.0001$). However the analysis of parameters showed that significant influence on the model was

Table 3

Characteristics of residents with at least one nursing home-acquired pneumonia episode and those with no symptoms of nursing home-acquired pneumonia in the prospective study

Risk factors	Residents with NHAP episode, n (%) (n = 29)	No NHAP symptoms, n (%) (n = 188)	p-Value
Hospitalization	14 (48.3)	29 (15.4)[a]	<0.001
Residential home	10 (34.5)	86 (45.7)	0.013
Nursing home	19 (65.5)	107 (56.9)	
Malnutrition	4 (13.8)	9 (4.8)	0.008
Pressure ulcers	4 (13.8)	12 (6.8)	0.038
Dementia	14 (48.3)	74 (39.4)	0.019
Incontinence – catheter	10 (34.5)	40 (21.3)	0.018
Fecal incontinence	16 (55.2)	77 (41.0)	0.019
Dysphagia	10 (34.5)	30 (16.0)	<0.001
Tracheostomy tube	3 (10.3)	5 (2.7)	0.002
Tube feeding	7 (24.1)	27 (14.4)	0.016
Age, years[b]			
Mean ± SD, 95% CI	77.3 ± 12.5 (72.5–82.0)	77.2 ± 10.6 (75.7–78.7)	–
<71	5 (17.2)	45 (23.9)	0.049
71–75	7 (24.1)	23 (12.2)	
76–80	8 (27.6)	29 (15.4)	
81–85	4 (13.8)	47 (25.0)	
86–90	1 (3.4)	30 (16.0)	
>90	4 (13.8)	12 (6.4)	
Barthel index[b]			
Mean ± SD, 95% CI	20.0 ± 28.4 (8.9–31.0)	52.6 ± 38.2 (47.1–58.1)	<0.001
0	10 (34.5)	23 (12.2)	0.030
1–15	9 (31.0)	27 (14.4)	
16–50	6 (20.7)	51 (27.1)	
51–75	0 (0)	12 (6.4)	
76–100	3 (10.3)	73 (38.8)	
Abbreviated mental test score[b]			
Mean ± SD, 95% CI	4.6 ± 3.7 (3.1–5.9)	6.8 ± 3.0 (6.3–7.2)	0.004
0–2	10 (34.5)	20 (10.6)	0.005
3–6	8 (27.6)	36 (19.1)	
7–10	11 (37.9)	104 (55.3)	
Activities of daily living score[b]			
Mean ± SD, 95% CI	1.4 ± 2.0 (0.6–2.1)	3.3 ± 2.5 (2.9–3.6)	<0.001
0–1	21 (72.4)	70 (37.2)	<0.001
2–4	3 (10.3)	30 (16.0)	
5–6	4 (13.8)	86 (45.7)	
Physical dependence scale[b]			
Mean ± SD, 95% CI	3.9 ± 1.3 (3.4–4.4)	2.7 ± 1.4 (2.5–2.9)	<0.001
1	3 (10.3)	62 (33.0)	<0.001
2	0 (0)	10 (5.3)	
3	8 (27.6)	69 (36.7)	
4	5 (17.2)	16 (8.5)	
5	13 (44.8)	29 (15.4)	

NHAP, nursing home-acquired pneumonia; SD, standard deviation; CI, confidence interval.
[a] Hospitalization of residents with different types of infection, other than NHAP.
[b] Some missing data.

Table 4
Cases of infections and etiology of nursing home-acquired pneumonia in the continued study ($n = 7$)

Etiological factor of NHAP	Number of microorganisms (%)
Staphylococcus aureus	2 (12.5)
Enterobacteriaceae	9 (56.3)
Pseudomonas aeruginosa	4 (25)
Candida albicans	1 (6.3)
Total	16 (100)
Polymicrobial infection	5 (71.4)

NHAP, nursing home-acquired pneumonia.

presented only by the Barthel index ($p = 0.0046$), AMTS ($p = 0.03652$), and physical activity scale ($p = 0.02081$); the influence of age ($p = 0.6212$) and the Katz scale ($p = 0.07138$) were non-significant.

Seven specimens were taken from patients (16.7% of all NHAP cases) for microbiological examination. The specimens were usually taken on day 12 of disease (median: day 7). None of these examined patients died. There were two or more etiological agents of infection in five specimens tested (polymicrobial). The predominant etiological agents were microorganisms belonging to the *Enterobacteriaceae* family – nine strains, which accounted for 56.3% of all isolates (Table 4). Among the *Enterobacteriaceae*, *Klebsiella pneumoniae* dominated, and three (33.3%) isolates exhibited extended-spectrum beta-lactamase (ESBL) phenotype (ESBL producers). Bacteria of the genus *Pseudomonas* (25%) with the ability to produce carbapenemases (metallo-beta-lactamase) were found. Both isolated strains of *S. aureus* exhibited the methicillin-resistant *S. aureus* (MRSA) phenotype, and what is more, were multidrug-resistant to fluoroquinolones and aminoglycosides or macrolides and lincosamides. *Candida albicans* was associated with one NHAP case. *C. albicans* was observed in a patient in connection with the diagnosis of NHAP previously treated empirically for 45 days with antibiotics from three different groups: fluoroquinolones, beta-lactams, and aminoglycosides.

The following antimicrobials were used for the treatment of NHAP in the studied group: beta-lactams (66.0% of all used antibiotics), quinolones (14.9%), aminoglycosides (6.4%), vancomycin (2.1%), and others. The most frequently used beta-lactams were the fourth-generation cephalosporins (45.2%) and penicillins (29%).

4. Discussion

The presented results were obtained from the first Polish surveillance system for infection control among residents of LTCFs. The study included different populations of patients, including those with severe risk factors for infection. The incidence of NHAP in the observed population of Polish LTCF residents was 0.6/1000 resident-days and was lower than that found in other studies, although the range of results from other research is quite large – from 0.27 to 2.5/1000 resident-days (median 1/1000 resident-days).[16–19] This may be due to the characteristics of the Polish population staying in LTCFs presented in this research. A limitation of the current study was that the population studied did not consist of all the residents of selected LTCFs, but was limited to those residents who gave written consent. Thus the research was focused on the younger and generally healthier residents of LTCFs, which could have influenced the observed data.

Among the risk factors for NHAP, advanced age is usually an important factor increasing the risk of infection.[5–7] However age did not increase morbidity in the current study. Only a trend towards a greater development of NHAP appeared in the subgroup of the oldest residents (>90 years). Although the average ages of

patients with symptomatic NHAP and those without did not differ significantly (77.3 vs. 77.2 years), this was lower than the age of residents in such units in other countries. The mean age of such residents in Italy is 81 years,[16] in Canada is 89 years,[18] and in Germany is 83 years.[19] In Norwegian LTCFs more that 78% of residents are aged ≥81 years.[17] For this reason the morbidity associated with NHAP among the residents studied may be lower than indicated in the literature.

Other authors have included the following as predictors of NHAP: decreased functional ability and cognitive impairment and significant co-morbid conditions, e.g., chronic obstructive pulmonary disease, dementia, and atherosclerotic heart disease.[5,6,20] Risk factors identified have included swallowing problems, frailty, incontinence, and medical procedures.[5,6,20] Strong risk factors for pneumonia that were found to increase the likelihood of infection were the presence of a tracheotomy tube or gastric feeding tube. Malnutrition doubled the risk of pneumonia, and poor functional status (both physical and mental, and swallowing disorders) increased the risk by 60–70%. A smaller but also significant risk factor was the presence of urinary incontinence.

The observations confirm the importance of almost all of these risk factors. Functional status was more important than the occurrence of chronic diseases. An increased risk is evident among residents fed by gastric feeding tubes and residents with tracheotomy tubes. Among the risk factors of NHAP, researchers also mention the excessive use of antibiotics and sedatives. Unfortunately, the importance of chronic treatment was not analyzed in this study. However, we did check whether the occurrence of hospitalizations before the observation period influenced the risk of NHAP development and found this to be insignificant. As for the place of residence, the results indicate that NHAP occurred more frequently in the nursing home than in the residential homes, probably due to the poor functional status of nursing home residents (Tables 1 and 2). The use of more invasive medical procedures among nursing home residents may also be of importance.

The etiology of infections in the presented data was determined only for a small percentage of the patients as a result of difficulties obtaining the appropriate test material – this is the weakest part of the study. The microbiological diagnosis of pneumonia can be done using two methods: culture and Gram stain. According to the Infectious Diseases Society of America guidelines, both can be useful when the patient is ill enough to be admitted to the hospital.[21] The American Thoracic Society suggests limiting cultures to those in whom drug resistance is suspected,[22] hence cultures were selected in our study, and allowed the identification of the microbial agent and also an indication of its drug resistance. Unfortunately the presented data show the potential therapeutic problem of using empirical treatment: a large number of isolates were characterized by multidrug resistance. On the other hand the data presented on the microbiological etiology and antimicrobial resistance – because of the small number of microbiological tests, which were performed too late – are largely speculative.

Unfortunately, a lack of proper supervision of the microbiology of infections is typical of Polish health care, not only for infections acquired and treated outside of hospital (called common infections), but also for hospital patients.[23] The implementation of effective surveillance of microbial infections and drug resistance must always be associated with the full availability and use of infection control groups and microbiological diagnostics.[24]

To improve the prognosis of NHAP in the increasing number of elderly residents of LTCFs, in addition to microbiological supervision, the introduction of standards for the diagnosis and treatment of NHAP and other infections may also be important. Recent American guidelines for the diagnosis and management of nursing home-acquired pneumonia were published in 2008.[25] Studies by

Hutt et al. have shown that guidelines can also be efficiently implemented in the residential home, and their use helps to increase the frequency of vaccination and leads to faster medical intervention, the use of appropriate diagnostic procedures, improves the selection of appropriate antibiotic therapy, and influences decisions on the necessity for hospitalization.[26–28] However, although the use of guidelines may reduce the incidence of hospitalization, it does not decrease the fatal cases rate.[29]

On the basis of our results, new recommendations on the diagnosis and empirical treatment of NHAP in Polish LTCFs will be released.

In the literature, the most common pathogen associated with NHAP is *S. pneumoniae*. However, the incidence of this etiology varies from 0 to 39%.[4,5,30] Other pathogens are *Haemophilus influenzae*, Gram-negative bacteria, and *S. aureus*.[10] It has recently been emphasized that Gram-negative bacteria and *S. aureus* are becoming more important as the etiologic agents of NHAP.[31] About a fifth of NHAP cases presented a mixed flora. The pathogens in the material studied here were dominated by Gram-negative bacteria, including those with multidrug resistance. There were no pneumococcal infections, and this was probably related to vaccination of the residents. Influenza and pneumococcal vaccine are recommended, but are not mandatory for persons over 55 years of age in Poland. In 2010, 4.3% of those aged >65 years in Malopolska were inoculated against influenza and 0.2% against pneumococci.[32]

The data of El-Solh et al. showed that exposure to antibiotics within the preceding 6 months and a worse functional status according to the ADL score greatly increased the likelihood of infection with drug-resistant bacteria.[33] Exposure to antibiotics continues to increase as a result of the use of ineffective empiric therapy, as was seen in a third of treated NHAP cases in this study.

The NHAP case-fatality rate described in the literature ranges from 9.2% to 44%,[34,35] and is generally lower than the value obtained in this study. This may be related to the lack of supervision of microbial infections in Poland. Only a small proportion of NHAP cases were confirmed by microbiological examination, which implies that more than 80% of cases were treated empirically; this was ineffective in 31.4% of cases. This could also contribute to the high proportion of multidrug-resistant strains isolated from NHAP, which impedes antimicrobial therapy. Such a situation probably occurred in the study group; an unusual etiology and its multidrug resistance made the empirical treatment in a third of cases ineffective.

The presence of NHAP increased the risk of death three-fold and the risk of hospitalization 3.5-fold.

The presented observation also has some limitations. The group studied, although diverse in terms of prevalence of risk factors for infection, was limited to persons who were able to agree to participate in the survey. The results would probably be worse if the survey covered the entire population of LTCF residents. This observation, however, also indicates that the NHAP risk among the 'healthier' part of the residents is significant, and all possible methods for reducing the incidence and improving the prognosis in this group of older people should be recommended. In the present study no analysis of the influence of treatment on the incidence of NHAP was conducted. It was also not possible to provide the full etiology of infections observed, because a microbiological examination was conducted in only a few residents.

In conclusion, invasive medical procedures and poor functional status significantly increase the incidence of NHAP among the Polish residents of LTCFs. These contribute to the need for hospitalization and the rise in the case-fatality rate. The occurrence of multidrug-resistant microorganisms isolated from NHAP and the low efficiency of antimicrobial treatment are associated with the poor use of microbiological diagnostics and empirical

long-term treatment. The Polish health care system has not yet developed a reliable and effective means of infection control in LTCFs. In the coming years, due to expected changes in the demographic structure of Poland and the growing share of the oldest people in the general population, it will be necessary to implement surveillance programs for infections (especially pneumonia), which have been proven to be effective in other developed countries. There is an urgent need to develop a viable system of prevention, diagnosis, treatment, and surveillance of microbial infections in the growing population of older people resident in LTCFs. There is the opportunity to improve medical care for patients with severe disabilities, limiting the rise in antimicrobial resistance and the need for hospitalization, and most importantly, improving the prognosis.

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