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Original article

# Adults with symptoms of pneumonia: a prospective comparison of patients with and without infiltrates on chest radiography

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ABSTRACT

*Objective:* Most studies on patients hospitalized with community-acquired pneumonia (CAP) require confirmation of an infiltrate by chest radiography, but in practice admissions are common among patients with symptoms of pneumonia without an infiltrate (SPWI). The aim of this research was to compare clinical characteristics, microbial etiology, and outcomes among patients with CAP and SPWI.
*Methods:* Adults suspected of CAP were prospectively recruited at Landspitali University Hospital over a 1-year period, 2018 to 2019. The study was population based. Those admitted with two or more of the following symptoms were invited to participate: temperature $\geq$38°C or $\leq$36°C, sweating, shaking/chills, chest pain, a new cough, or new onset of dyspnea. Primary outcome was mortality at 30 days and one year.
*Results:* Six hundred twenty-five cases were included, 409 with CAP and 216 with SPWI; median age was 75 (interquartile range [IQR] 64–84) and 315 (50.4%) were females. Patients with CAP were more likely to have fever ($\geq$38.0°C) (66.9% [273/408]) vs. 49.3% (106/215), $p < 0.001$), a higher CRP (median 103 [IQR 34–205] vs. 55 (IQR 17–103), $p < 0.001$), identification of Streptococcus pneumoniae (18.0% [64/355]) vs. 6.3% (10/159) of tested, $p = 0.002$) and to receive antibacterial treatment (99.5% [407/409]) vs. 87.5% (189/216), $p < 0.001$) but less likely to have a respiratory virus detected (25.4% [33/130]) vs. 51.2% (43/84) of tested, $p < 0.001$). The adjusted odds ratios for 30-day and 1 year mortality of SPWI compared to CAP were 0.86 (95% CI 0.40–1.86) and 1.46 (95% CI 0.92–2.32), respectively.
*Discussion:* SPWI is a common cause of hospitalization and despite having fever less frequently, lower inflammatory markers, and lower detection rate of pneumococci than patients with CAP, mortality is not significantly different. **Kristján Godsk Rögnvaldsson, Clin Microbiol Infect 2023;29:108.e1–108.e6**


## Introduction

Lower respiratory tract infections, most commonly pneumonia, accounted for over two million deaths each year globally in the pre-COVID-19 era [1].

The microbial etiology of community-acquired pneumonia (CAP) requiring hospitalization has changed in recent years; however, a large proportion of patients continue to have no pathogen identified [2,3]. With advances in molecular techniques, viruses are increasingly being detected, but *Streptococcus pneumoniae* (pneumococci) is declining in rate, most notably in the United States [4]. The identification of a viral pathogen in a sample from the lower respiratory tract does not rule out concurrent bacterial infection [2,4].

Traditionally, guidelines have recommended diagnosing pneumonia in hospital settings with a chest x-ray (CXR) or other comparable radiological assessments [5–7]. However, the diagnostic sensitivity of a CXR is only 44 to 77% [8,9] and is frequently negative in the first couple of days in older patients with pneumonia [10]. Additionally, older patients more often have fewer and less specific symptoms [11,12]. Therefore, the diagnosis of pneumonia in older people can be challenging and result in treatment delay or overuse of antibiotics [13]. Most studies on patients hospitalized with CAP exclude patients without radiological confirmation [2,14–16]. As a result, there are few studies comparing radiologically confirmed pneumonia to symptomatic pneumonia without infiltrate on CXR or chest CT scan (SPWI). Basi et al. defined this group in the same way as CAP, the only difference being no infiltrate on chest imaging [17]. Basi et al. found that one patient with SPWI was admitted for

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every two patients with CXR-confirmed CAP. The SPWI patients were older with a higher severity classification but a slightly lower in-hospital mortality (8% vs. 10%, p = 0.09) [17]. Furthermore, patients with SPWI less commonly had *S. pneumoniae* [17]. Since that study was performed, pneumococcal vaccination among children has become widespread, PCR testing for respiratory viruses and atypical bacteria have become more common, and the population of older adults and immunosuppressed individuals has grown [5,18–20]. The incidence and mortality of pneumonia increases with advancing age [12]. Given the previously mentioned diagnostic limitations of pneumonia and the fast-growing proportion of older adults in the general population [19], the number of patients with lower respiratory tract infections lacking guideline-based treatment recommendations is predicted to increase.

The goal of this work was to expand the current knowledge regarding patients with SPWI requiring hospitalization, with a special focus on prognosis and survival. This observational study was performed in a population-based setting, comparing clinical characteristics, laboratory diagnostics, and outcomes among patients with CAP and SPWI.

## Methods

### *Setting, patient recruitment, and data collection*

Patient recruitment and most of the data were gathered prospectively for a study on pneumonia etiology; however, the research question was formulated following data collection. Participants were recruited at Landspitali University Hospital (LUH), Reykjavik, Iceland, over a 12-month period, May 1, 2018 to April 30, 2019. It is population based as LUH is the only hospital serving the population of the capital area. Individuals aged ≥18 who were admitted (hospitalized for at least one night) with suspected CAP were invited to participate.

Screening was done by monitoring electronic patient lists at the emergency departments and electronically reported admissions to internal medical wards, which contain the preliminary diagnosis and/or the chief complaints of patients. If a patient had a chief complaint or preliminary diagnosis that was compatible with a lower respiratory tract infection, the patient was approached and inclusion and exclusion criteria verified, even though at this stage there were certain doubts of patients meeting the criteria they were nevertheless offered to participate. This was done to not inadvertently exclude patients with pneumonia. Later the inclusion and exclusion criteria were thoroughly assessed for all participants after obtaining questionnaire and medical record data. This is referred to as the final inclusion criteria.

The inclusion criteria included two or more of the following: body temperature ≥38°C or ≤36°C, sweating, shaking/chills, chest pain, a new cough, or new onset of dyspnea [3,21]. Additionally, a new radiograph (CXR or CT scan) within 48 hours of admission was required. All radiographs were reviewed by a specialist in medical imaging at the hospital. Exclusion criteria for both groups were prior hospitalization within the past 14 days, a clear other main infectious focus, severe neutropenia (<500 cells/microL), active cancer therapy, organ recipients, or AIDS (CD4+ T cells less than 200 cells/mm$^3$).

Categorization of cases into the CAP and SPWI groups was made following data gathering but was based on the real-time assessments by radiologists of imaging studies obtained within 48 hours of admission. The cases were assigned to the CAP group if the assessment of the radiographs/CT included pneumonia infiltrate, infiltrate of infectious origin, or a different wording with the same meaning. These cases were categorized to the CAP group even though the radiologist preceded the pneumonia infiltrate assessment with something like: suggests, beginning, possibly, suspecting, or if the first differential diagnosis made by the radiologist was pneumonia. All other cases were assigned to the SPWI group; this included cases where pneumonia could not be ruled out, often because of image quality and or extensive heart failure. If a subsequent image taken within 48 hours was of better quality (e.g. CXR done on patient standing if prior image was made with the patient lying, or if later image was a CT scan), then the later image ruled. A detailed overview of the chest imaging of patients has been included in Table S1.

Basic demographic information was gathered using a research questionnaire that the first author went through with all the cases. Detailed information regarding how data were gathered and variable definitions is provided in the online supplement. This study was an observational study, thus the researchers had no influence over the management and treatment of patients.

### *Ethics statement*

All necessary permits were obtained in accordance with Icelandic law and the Declaration of Helsinki. Permission was granted from the Chief Medical Executive and from the Health Research Ethics Committee at LUH (application number 19/2018). All participants or their next of kin signed an informed consent.

### *Statistical analysis*

The research electronic data capture tool REDCap (hosted at the University of Iceland) was used for collecting data [22]. Rstudio and R were used for statistical analysis (R Foundation for Statistical Computing, Vienna, Austria) [23,24].

For the primary outcome, whether the lack of an infiltrate was associated with mortality, logistic regression was performed with results described using odds ratios (OR) with 95% CIs. The variables were chosen a priori; as there were only 32 endpoints for the 30-day mortality, only four variables were chosen—age, sex, Charlson-comorbidity, and the variable of interest: absence of infiltrate. For the 1-year mortality, three additional a priori selected variables were used: daily smoking, do not resuscitate directive, and nursing home residence. Information on smoking was missing in 8.5% of cases; therefore, multiple imputation by chained equations of missing variables was performed using the mice package in R, 20 imputations were done [25]. If the same individual was included in the study more than once within the follow-up, only the first admission was used for the mortality calculations. Therefore 4 episodes were removed from the calculations on 30-day mortality and 49 episodes on the 1-year mortality.

Descriptive analyses in table 1 through 3 were performed using Fisher's exact test and Mann-Whitney U test for comparing categorical and numerical variables, respectively. In light of around 70 planned secondary statistical analyses, an increased risk of presenting false positive associations was evident. Therefore, we decided to perform adjustment of the p-values accounting for multiple testing, using a well-known method limiting false discovery rate (the Benjamini-Hochberg method) [26].

## Results

### *Baseline characteristics*

Overall, 625 cases met the clinical inclusion criteria and consented to participate; 409 in the CAP group and 216 in the SPWI group (Fig. 1). Overall median age was 75 (IQR 64–84) and females comprised 50.4% (315/625) of the study participants. Chronic obstructive pulmonary disease (46.3% [100/216] vs. 34.7% [142/409], p = 0.026) and chronic

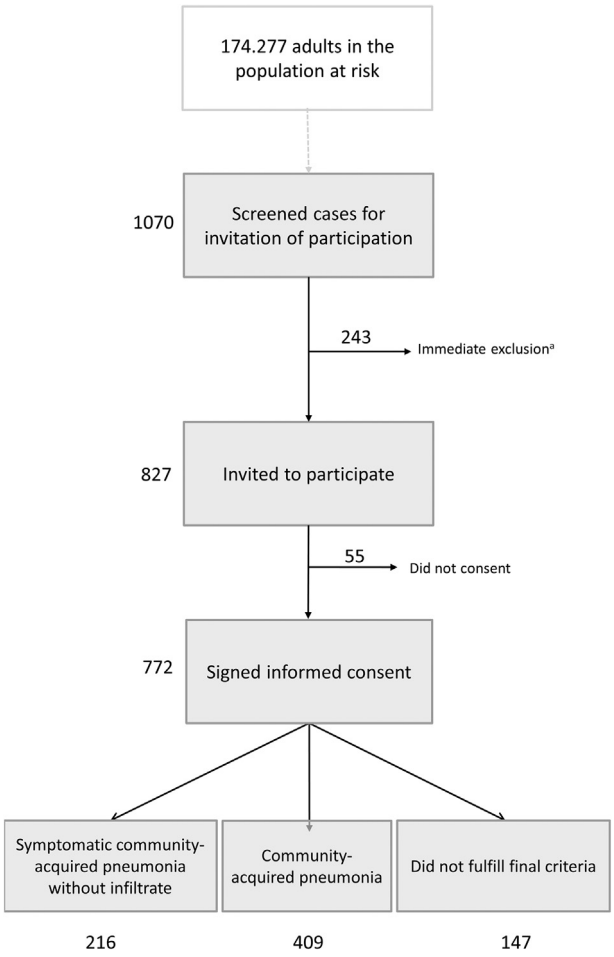


**Fig. 1.** Flowchart of patient inclusion. [a]Immediate exclusion: 75 had a recent (<14 days ago) hospitalization, 62 had a clear lack of pneumonia symptoms, 38 recently (<30 days) received chemotherapy, 20 were unable to give informed consent (not because of language), 12 had a clear other main infectious focus, 9 were not hospitalized for 1 night at least, 9 language barriers, 6 were discharged before they were approached by researcher, 4 neutropenia, 3 organ recipients, 3 died before they were approached by researcher, and 2 had AIDS (CD4 T cells <200/microL).

**Table 1**
Patient characteristics

| Variable | CAP ($n = 409$) $n$ (%) | SPWI ($n = 216$) $n$ (%) | P value[a] |
|---|---|---|---|
| Demographics | | | |
| Age, median (IQR) | 75 (62–84) | 76 (67–85) | 0.119 |
| Female | 200 (48.9) | 115 (53.2) | 0.602 |
| Nursing home dwelling | 27 (6.6) | 11 (5.1) | 0.701 |
| FRAIL questionnaire score, median (IQR)[b] | 1 (0–3) | 2 (1–3) | 0.132 |
| ECOG performance scale, median (IQR)[c] | 1 (0–2) | 1 (0–2) | 0.381 |
| Past medical history | | | |
| Chronic obstructive pulmonary disease | 142 (34.7) | 100 (46.3) | 0.026 |
| Daily smoking[d] | 74/369 (20.1%) | 45/203 (22.2%) | 0.805 |
| Alcoholism[e] | 53/333 (15.9) | 26/186 (14.0%) | 0.805 |
| Diabetes mellitus | 61 (14.9) | 45 (20.8) | 0.198 |
| Ischemic heart disease | 99 (24.2) | 69 (31.9) | 0.146 |
| Heart failure | 78 (19.1) | 53 (24.5) | 0.282 |
| Liver disease | 10 (2.4) | 7 (3.2) | 0.805 |
| Solid cancer | 68 (16.6) | 29 (13.4) | 0.629 |
| Metastatic solid cancer | 20 (4.9) | 11 (5.1) | 0.699 |
| Blood and bone marrow cancers | 13 (3.2) | 9 (4.2) | 0.711 |
| Chronic kidney failure | 70 (17.1) | 56 (25.9) | 0.049 |
| Dementia | 27 (6.6) | 10 (4.6) | 0.632 |
| Autoimmune disease | 96 (23.5) | 61 (28.2) | 0.421 |
| HIV | 1 (0.2) | 0 (0) | 1.000 |
| Glucocorticoid use | 66 (16.1) | 36 (16.7) | 0.972 |
| Other immunosuppressants | 35 (8.7) | 17 (7.9) | 0.972 |
| Asthma | 32 (7.8) | 13 (6) | 0.714 |
| Cerebrovascular diseases | 44 (10.8) | 26 (12) | 0.851 |
| No chronic disease | 16 (3.9) | 0 (0) | 0.011 |
| Charlson score, median, mean, (IQR) | 2, 2.4, (1–3) | 2, 2.9 (1–4) | 0.007 |

CAP, community-acquired pneumonia; ECOG, Eastern Cooperative Oncology Group; SPWI, symptoms of pneumonia without an infiltrate.
[a] False discovery rate adjusted p value; original p value using Fisher's exact and Mann-Whitney U test.
[b] Missing 21.1%
[c] Missing 17.6%
[d] Missing 8.5%
[e] Missing 17.0%

kidney failure (25.9% [56/216] vs 17.1% [70/409], p = 0.049) were more commonly observed in the SPWI group. The Charlson comorbidity score was slightly higher in the SPWI group (median 2 [1–4] vs. 2 [1–3], mean 2.9 vs. 2.4, p = 0.007) (Table 1).

### *Clinical characteristics*

In general, the symptom profile was similar in both groups except for a higher prevalence of fever among CAP patients (Table 2). White blood cell count (median $13\times10^9$/L [IQR 10–17] vs. median $11\times10^9$/L [IQR 8–14]), p = 0.002), neutrophil count (median $10\times10^9$/L [IQR 7–14]) vs. median $8\times10^9$/L (IQR 6–12), p < 0.001) and C-reactive protein levels (median 103 mg/L [IQR 34–205]) vs. median 55 mg/L (IQR 17–103), p < 0.001) were higher in CAP cases than in SPWI cases (p < 0.001). The disease severity scores (Pneumonia Severity Index (PSI), quick Sequential Organ Failure Asessment (qSOFA), CRB65) were similar among CAP patients compared to SPWI patients.

### *Etiologic testing*

Etiologic tests were in general more frequently obtained from CAP patients, apart from sputum and viral swabs for PCR analysis (Table 3). The PCR analysis searching for respiratory viruses was less often positive among CAP patients than among SPWI patients (25.4% [33/130]) vs. 51.2% (43/84), p < 0.001, of those tested). *Streptococcus pneumoniae* was more commonly identified in CAP than in SPWI (18.0% [64/355]) vs. 6.3% (10/159) of those tested, p = 0.002).

### *Treatment*

Antibacterial therapy was more commonly administered in the CAP group (99.5% [407/409]) vs. 87.5% ([189/216] p < 0.001), 5.6% (23/409) of CAP patients were admitted to ICU versus 1.9% (4/216) of SPWI patients (p = 0.125) (Table 3). However, the use of BiPAP/cPAP was similar in both groups. The median length of stay was 5 days (IQR 2–10) for CAP and 5 days (IQR 2–9) for SPWI (p = 0.680).

### *Mortality*

Unadjusted 30-day mortality was 5.2% (21/407) in the CAP group and 5.1% (11/214) in the SPWI group, but at one-year it was 17.4% (66/380) for the CAP group but 25.0% (49/196) for the SPWI group (Table 3). The adjusted odds ratio for death within 30 days in SPWI compared to CAP was 0.86 (95% CI, 0.40–1.86) (Fig. 2). When

**Table 2**
Patient reported symptoms, vital signs, test results, and severity scores at admission

| Variable | CAP ($n = 409$) $n$ (%) | SPWI ($n = 216$) $n$ (%) | P value[a] |
|---|---|---|---|
| Presenting symptoms | | | |
| Cough | 351 (85.8) | 196 (90.7) | 0.241 |
| Dyspnea | 318 (77.8) | 178 (82.4) | 0.381 |
| Fever[b] | 309 (75.6) | 141 (65.3) | 0.038 |
| Sputum production | 260 (63.6) | 135 (62.5) | 0.923 |
| Chills/shaking | 237 (57.9) | 133 (61.6) | 0.636 |
| Loss of appetite | 220 (53.8) | 112 (51.9) | 0.851 |
| Sweating | 186 (45.5) | 95 (44) | 0.881 |
| Pleuritic chest pain | 158 (38.6) | 87 (40.3) | 0.881 |
| Headache | 150 (36.7) | 83 (38.4) | 0.851 |
| Delirium | 125 (30.6) | 58 (26.9) | 0.629 |
| Flu-like symptoms | 66 (16.1) | 52 (24.1) | 0.072 |
| Diarrhea | 76 (18.6) | 33 (15.3) | 0.602 |
| Abdominal pain | 67 (16.4) | 36 (16.7) | 0.972 |
| Vomiting | 60 (14.7) | 26 (12) | 0.636 |
| Blood in sputum[c] | 19 (4.6) | 15 (6.9) | 0.526 |
| Vital signs | | | |
| Temperature ≥38.0°C[d,e] | 273 (66.9) | 106 (49.3) | <0.001 |
| Temperature <36°C[d,e] | 31 (7.6) | 21 (9.8) | 0.629 |
| Respiratory rate, per minute[f] | 22 (18–28) | 22 (20–28) | 0.851 |
| Oxygen saturation[f], % | 93 (90–95) | 94 (91–96) | 0.119 |
| Heart rate[f], beats per minute | 97 (84–110) | 96 (82–111) | 0.680 |
| Mean arterial pressure <65 mmHg[f] | 2.7% (11/409) | 0.5% (1/215) | 0.188 |
| White blood cells[f], $\times 10^9$/L | 13 (10–17) | 11 (8–14) | 0.002 |
| Neutrophils[e], $\times 10^9$/L | 10 (7–14) | 8 (6–12) | <0.001 |
| C-reactive protein[e], mg/L | 103 (34–205) | 55 (17–103) | <0.001 |
| Glucose[g], mmol/L | 7 (6–8) | 7 (6–8) | 0.978 |
| Severity scores | | | |
| Pneumonia severity index (PSI), median (IQR) | 102 (74–125) | 99 (79–123) | 0.972 |
| CRB-65, median (IQR) | 1 (1–2) | 1 (1–2) | 0.951 |
| Quick Sequential Organ Failure Asessment (qSOFA) | 2 (1–2]) | 1.5 (1–2) | 0.637 |

CAP, community-acquired pneumonia; SPWI, symptoms of pneumonia without an infiltrate.
[a] False discovery rate adjusted p value; original p value using Fisher's exact and Mann Whitney U test.
[b] Patients asked if they had either a temperature below <36°C or ≥38°C.
[c] By self-report.
[d] The first 24 hours.
[e] Information was available for all cases except for two cases.
[f] Information was available for all cases except for one case.
[g] Missing 4.8%

**Table 3**
Etiological testing, antibiotic therapy, and prognosis

| | CAP ($n = 409$) $n$ (%) | SPWI ($n = 216$) $n$ (%) | P value[a] |
|---|---|---|---|
| Tests performed | | | |
| Blood culture done | 275 (67.2) | 109 (49.5) | <0.001 |
| Sputum culture performed[b] | 184 (45.1) | 97 (45.1) | 1.000 |
| Acceptable quality sputum | 99/184 (53.8) | 35/97 (36.1) | 0.026 |
| Urinary pneumococcal antigen test done[c] | 214 (52.6) | 65 (30.2) | <0.001 |
| Viral PCR done | 130 (31.8) | 84 (38.9) | 0.203 |
| Atypical bacterial PCR done[b] | 34 (8.4) | 9 (4.2) | 0.188 |
| Pathogens identified | | | |
| Positive pneumococcal antigen test | 46/214 (21.5) | 2/65 (3.1) | 0.002 |
| Pneumococcal bacteremia | 11/275 (4) | 1/109 (0.9) | 0.188 |
| Positive atypical bacterial PCR | 1/34 (2.9) | 0/9 (0) | 1.000 |
| Respiratory virus detected | 33/130 (25.4) | 43/84 (51.2) | <0.001 |
| Influenza A | 17/130 (13.1) | 26/84 (31) | 0.004 |
| Streptococcus pneumoniae by any test | 64/355 (18) | 10/159 (6.3) | 0.002 |
| Antibiotics | | | |
| Did not receive antibiotics | 2 (0.5) | 27 (12.5) | <0.001 |
| Intravenous antibiotics | 367/407 (90.2) | 138/189 (73) | <0.001 |
| First antibiotic; Amoxicillin/clavulanate | 170/407 (41.8) | 76/189 (40.2) | 0.923 |
| Ceftriaxone | 170/407 (41.8) | 65/189 (34.4) | 0.224 |
| Azithromycin, clarithromycin, doxycycline or erythromycin | 91/407 (22.4) | 50/189 (26.5) | 0.951 |
| Ampicillin | 24/407 (5.9) | 8/189 (4.2) | 0.680 |
| Clinical course | | | |
| Length of stay, median (IQR) | 5, (2–10) | 5 (2–9) | 0.680 |
| Intensive care unit admission | 23 (5.6) | 4 (1.9) | 0.125 |
| Bilevel positive airway pressure/continous positive airway pressure ventilation | 45 (11) | 29 (13.4) | 0.629 |
| Mechanical ventilation[d] | 7 (1.7) | 0 | 0.245 |
| Re-admission within 30 d | 63 (15.4) | 43 (19.9) | 0.381 |
| Coverage for "atypical pneumonia" in admission | 215 (52.6) | 86 (39.8) | 0.013 |
| 30-d mortality | 21/407 (5.2) | 11/214 (5.1) | 1.000 |
| 1-y mortality | 66/380 (17.4) | 49/196 (25.0) | 0.120 |

CAP, community-acquired pneumonia; SPWI, symptoms of pneumonia without an infiltrate.
[a] False discovery rate adjusted p value; original p value using Fisher's exact and Mann Whitney U test.
[b] Missing information in two cases.
[c] Missing information in three cases.
[d] Missing information in four cases.

assessing the 1-year mortality the adjusted OR was 1.50 (95% CI 0.93–2.42) for SPWI patients compared to CAP in a complete case analysis (8.5% of cases had missing information on smoking) and 1.46 (95% CI 0.92–2.32) using multiple imputation (Fig. 2).

## Discussion

This prospective study compared hospitalized patients with pneumonia symptoms but without infiltrate (SPWI) to those with a confirmed infiltrate on CXR (CAP). For every two CAP patients hospitalized one SPWI patient was hospitalized, and no major difference in short- and long-term mortality rates was found. The clinical picture largely overlapped but fever was less common among SPWI patients, along with lower levels of inflammatory markers. Additionally, SPWI patients had a higher detection rate of respiratory viruses, but lower detection rates of *S. pneumoniae* compared to CAP patients.

Basi et al. performed a population-based study in Canada, 2000 to 2001, comparing patients hospitalized with pneumonia symptoms without infiltrates to patients with pneumonia confirmed by CXR [17]. In that study, there was roughly one patient with unconfirmed pneumonia for every two patients with CAP [17]. A study performed in Malawi used symptoms and clinical signs as diagnostic criteria for pneumonia [27], where 3:1 (76%) of the patients with a CXR had radiographic confirmation of pneumonia. However, the median age of participants was much younger than in our study.

The adjusted mortality for SPWI and CAP was not significantly different at 30 days or 1 year; however, given the small sample size and relatively low mortality at 30 days, only a large difference could

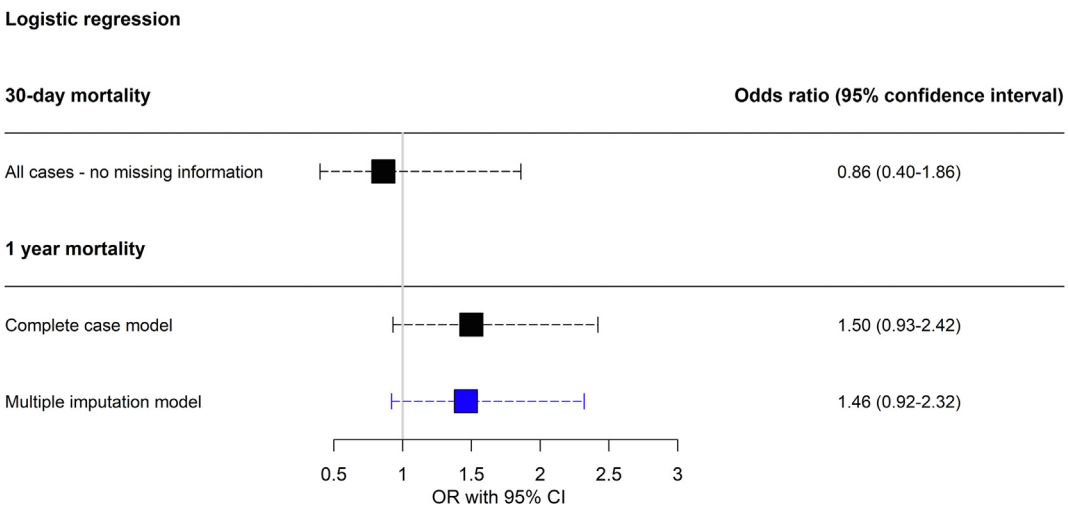


**Fig. 2.** The odds ratio for mortality among patients in the symptoms of pneumonia without an infiltrate group compared to the community-acquired pneumonia group. The variable of interest was the absence of infiltrate (symptoms of pneumonia without an infiltrate). For the 30-day mortality adjustment was made for age, sex, and Charlson-comorbidity, for the one-year mortality adjustment was made using the same variables and also: daily smoking, do not resuscitate directive, and nursing home residence. Information on smoking was missing in 8.5% of cases; therefore, complete case analysis and multiple imputation analysis were performed.

be reliably detected. Basi et al. reported 8% versus 10% ($p = 0.09$) in-hospital mortality of the CAP versus the SPWI group, but long-term follow-up was not provided [17].

It could be argued that the differences in symptoms, laboratory tests, intensive care admission rates, and identification of pneumococci may be reflective of higher numbers of acute bronchitis and other non-pneumonic illnesses in the SPWI group; however, these differences would be expected to translate into lower mortality, which is not borne out by the results. The high rate of viral detection from upper respiratory samples by PCR among patients in the SPWI group is interesting, not least considering the low rates (4%) of respiratory viral carriage observed among asymptomatic adults in previous studies [28]. Pneumococci were detected in nasopharynx in 4% of SPWI patients in a recent study focusing on PCR methods [29]. Furthermore, it is also important to keep in mind that fewer effective treatment options are available for viruses than bacteria.

Claessens et al. found that a CT scan improved diagnostic accuracy in patients in an emergency ward with suspected CAP in 59% of cases [13], which led to antibiotic prescription in 16% and discontinuation in 9% of participants. Thus, increased use of CT imaging would be expected to improve differentiation of these patient groups. Sensitivity analysis excluding patients who underwent chest CT imaging did however not show a major change to the ORs (Supplementary Table 3).

It is known that a portion of patients with a negative CXR on admission will develop an infiltrate within 48 hours [10]. The majority in both groups had only one CXR. Of note 33 patients underwent initial radiography that was negative, with a subsequent better quality study (CXR or CT scan within 48 hours) revealing an infiltrate. In contrast, 10 patients initially had a chest radiography where an infiltrate was described but a follow-up better quality radiography yielded no infiltrate.

### *Limitations*

Several limitations should be noted. Due to the observational nature, etiologic testing and use of imaging was physician directed and not uniform across the two groups. Due to the sample size and relatively low mortality rate this study is only powered to identify large mortality differences. Furthermore, the inherent problem of prospective studies in acute illness requiring informed consent can lead to the inclusion of disproportionally fewer patients with the highest disease severity, potentially underestimating mortality.

## Conclusions

Among patients hospitalized with symptoms of pneumonia, a large portion lacks infiltrate as detected by chest radiography (SPWI). Nevertheless, this group of patients lacks representation in studies and clinical guidelines. Adjusted mortality rates at 30 days and 1 year after the infection were not significantly different from patients with CAP, despite SPWI patients having fever less often, lower CRP levels, lower detection rate of pneumococci, and a higher detection rate of respiratory viruses.

## Transparency declaration

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## Author contributions

KGR, AB, and MG conceived the original study. KGR screened participants, recruited patients, went through questionnaire with patients, and gathered data from medical records. Reviewing inclusion criteria for participants was done by KGR, AB, and ISÓ. Planning data and statistical analysis was done by KGR, AB, and MG. KGR performed the statistical analysis and prepared final pictures. Writing of the original draft was done by KGR and MG, editing and rewing of the manuscript was done by all authors.

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## Appendix A. Supplementary data

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