



Colonization with drug-resistant pathogens among patients in long-term care facilities and under home hospice care – a cross-sectional study

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Abstract

Introduction. The spread of drug-resistant bacteria is deemed a worldwide threat. Patients in long-term care, including those under palliative care, are exposed to a high risk of colonization and infection with drug-resistant pathogens. This refers primarily to long-term care facilities as opposed to home care. A cross-sectional study was carried out between 1 January 2018 – 30 June 2019. The study was approved by the Bioethics Committee at the Medical University of Warsaw (KB/222/2017).

Objective. The aim of the study was to assess the frequency and type of colonization with drug-resistant pathogens among patients in long-term care facilities and those under home hospice care. An additional aim was evaluation the risk of pathogen transmission according to the type of provided long-term care.

Materials and method. The study included 129 participants: 68 patients under the care of 3 long-term care facilities in Warsaw, Poland, 42 patients under home hospice care, and 19 household members of hospice patients. All included participants provided written informed consent. Oropharyngeal and rectal swabs were obtained from all participants for microbiological assessment.

Results. Colonization with pathogens was more common in long-term care facilities residents (82.4%) than in at-home hospice patients (42.9%). Risk of colonization was significantly lower in patients staying at home than in long-term care facilities patients (OR 0.16; 95% CI 0.06–0.38).

Conclusions. Risk of colonization with drug-resistant pathogens depends on the type of care and is significantly higher in patients staying at long-term care facilities. Systemic measures, such as microbiological screening, are necessary to provide optimal patient care and to ensure epidemiological safety, both to patients and their caregivers.

Key words

drug-resistance, multiple, bacterial, long-term care, hospice

KEY QUESTIONS AND STATEMENTS

What is already known about the topic?

- Long-term care facilities and hospices are recognized as a potential source of pathogen transmission.
- Patients staying at long-term care facilities have a high risk of colonization with drug-resistant microorganisms.
- Epidemiological data from Poland are scarce.

What does this article add?

- This study demonstrates that the risk of colonization with drug-resistant pathogens is significantly higher in patients staying at long-term care facilities than in home hospice.

Implications for practice theory or policy

- To ensure the safety of patients and their caregivers, systemic measures are necessary to monitor the epidemiology of infections and colonization by drug-resistant pathogens.
- The risk of pathogen transmission should be considered during infection risk assessment of caregivers in the case of hospital admission.

INTRODUCTION

Rapid population aging is observed in many developed countries, including Poland. According to the Polish Central Statistical Office, by 2050 people at the age of 60 years or older will constitute nearly 40% of the Polish population. Importantly, it is estimated that 67% of people over the age of 60 are diagnosed with at least one chronic disease [1, 2]. This may necessitate long-term care for these patients either at home or in an institution.

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In Poland, the following long-term care services are covered by the public health insurance system: 1) nursing care, nursing, and care services for chronically ill patients who do not require hospitalization, but require continued treatment with professional care and nursing; and 2) palliative and hospice care services. These services can be provided either on a stationary basis (e.g., in long-term care facilities [LTCFs] or hospices) or at home (e.g., by home care professionals for mechanically ventilated patients) [3].

LTCFs and hospices are recognized as potential places for pathogen transmission. Patients staying at LTCFs have a high risk of infection with drug-resistant microorganisms. The World Health Organization has identified the spread of antibiotic-resistant bacteria, known as alarm pathogens (in Polish *patogeny alarmowe*), as a global threat that requires comprehensive action by governments and societies [4]. Methicillin-resistant *Staphylococcus aureus* (MRSA) is one of the most common pathogens responsible for nosocomial infections, also in long-term care patients [5, 6]. Other threats include the Enterobacterales strains producing extended-spectrum β -lactamases (ESBLs) and carbapenemases. According to the European Centre for Disease Prevention and Control, the largest number of bacterial isolates with antibiotic resistance mechanisms belong to *Escherichia coli* and *S. aureus* species [7].

Epidemiological studies and microbiological screening of residents in LTCFs are necessary to provide adequate patient care. However, while the incidence of infections and the prevalence of multidrug-resistant microorganisms in LTCFs have been extensively described in the European literature [8–14], data from Poland are scarce. To fill this gap, the aim of the study was to assess the frequency and type of colonization with drug-resistant pathogens among patients staying in LTCFs, and those under home hospice care in Poland. An additional aim was to evaluate the risk of pathogen transmission according to the type of long-term care (at-home vs. facility).

MATERIALS AND METHOD

Study design. The cross-sectional study included patients staying at LTCFs, patients under home hospice care, and household members of at-home hospice patients, conducted between 1 January 2018 – 30 June 2019. All participants (or their legal guardians) were informed about the nature and objectives of the study and provided their written informed consent. Participants who did not provide signed informed consent were excluded. A nasopharyngeal swab was collected to test for MRSA, and a rectal swab or a stool sample was collected to test for other pathogens. All swabs were taken using Amies transport medium (Copan, Brescia, Italy) and sent to the Department of Medical Microbiology of the Medical University of Warsaw within 24 hours for microbiological assessment. The samples were tested for the following pathogens listed in the Regulation of the Minister of Health on drug-resistant pathogens [15]: 1) MRSA, vancomycin-intermediate *S. aureus*, vancomycin-resistant *S. aureus*; 2) vancomycin-resistant *Enterococci* (VRE), oxazolidinone-resistant *Enterococci*; 3) carbapenem-resistant Enterobacterales or β -lactamase-producing Enterobacterales (ESBL, AmpC, *Klebsiella pneumoniae* carbapenemases); and 4) other bacteria resistant to carbapenems or to a minimum of two antibiotic classes.

Microbiological assessment. All swabs were cultured on chromogenic agar media including chromID™ MRSA, chromID™ VRE, chromID™ ESBL, and chromID™ CARBA or MacConkey agar medium (all bioMérieux, Marcy-l'Étoile, France). All cultures were incubated for 18 – 24 hours at 37°C in aerobic conditions. In the absence of microbial growth, incubations were extended to 48 hours. If there was growth on the chromogenic or MacConkey media, a single colony was seeded onto Columbia agar with 5% sheep blood and incubated for 18 – 24 hours at 37°C.

Bacteria species were identified using the matrix-assisted laser desorption ionization time-of-flight mass spectrometry system VITEK® v. 3.0 (bioMérieux, Marcy-l'Étoile, France), following the manufacturer's instructions.

The drug susceptibility of isolated strains was tested using the disc diffusion method (Thermo Fisher Scientific, Waltham, USA) on Mueller Hinton 2 agar medium (bioMérieux, Marcy-l'Étoile, France). For *S. aureus*, susceptibility to cefoxitin and mupirocin, as well as inducible resistance to macrolides, lincosamides, and streptogramin B, were tested. The following antimicrobial susceptibility discs were used: cefoxitin (30 μ g), mupirocin (200 μ g), erythromycin (15 μ g), and clindamycin (2 μ g). For *Enterococcus* spp., sensitivity to vancomycin, teicoplanin, and a high level of aminoglycosides was determined. The following antimicrobial susceptibility discs were used: vancomycin (5 μ g), teicoplanin (30 μ g), gentamicin (30 μ g), and streptomycin (300 μ g).

ESBL-producing gram-negative rods were tested using antimicrobial susceptibility discs: cefotaxime (30 μ g), ceftazidime (30 μ g), amoxicillin/clavulanic acid (20/10 μ g), and cefepime (30 μ g). Susceptibility to carbapenems was tested using meropenem (10 μ g), imipenem (10 μ g), and ertapenem (10 μ g). For strains with ambiguous ESBL test results and suspected of producing AmpC cephalosporinase, the ESBL test was repeated on Mueller-Hinton medium with the addition of cloxacillin. For strains resistant to carbapenems, phenotypic screening tests were performed: EDTA test for metallo- β -lactamase, boronic acid test for *Klebsiella pneumoniae* carbapenemases, and 30- μ g temocillin disc diffusion test for OXA-48 carbapenemases.

Statistical analysis. For nominal variables, the nonparametric chi-square test was used to test the compliance of nominal features. If this test was not possible owing to an insufficient number of samples, the Fisher test was performed. The normal distribution of the parameters was assessed using the Shapiro-Wilk test. The given p-values were calculated with an alternative hypothesis that the tested proportions were different. The null hypothesis, assuming the equality of the examined features, was rejected in favour of the alternative hypothesis if the obtained p-value was lower than 0.05 (adopted significance level – $p=0.05$). The values of the odds ratio (OR) estimator and 95% confidence intervals (95% CIs) for OR were calculated using the Fisher or Wald method.

The statistical analysis was performed using analytical and statistical software STATISTICA 10.0 PL Dell Inc. (2016), version 13 and SPSS Statistics version 26 (IBM).

Ethics. The study was approved by the Bioethics Committee at the Medical University of Warsaw (Approval No. KB/222/2017).

RESULTS

Characteristics of participants. The study included 129 participants: 68 patients (52.7%) under the care of 3 LTCF in Warsaw, 42 patients (32.6%) under home hospice care, and 19 household members of at-home hospice patients (14.7%).

Among patients staying at LTCFs, there were 59 women (86.8%) and 9 men (13.2%), mean age – 84.7 ± 7.2 years. The most common reason for staying at LTCF was dementia ($n=31$; 45.6%), followed by Alzheimer disease ($n=26$; 38.2%) and femur or pelvic fracture ($n=12$; 17.6%). Patients under home hospice care included 22 women (52.4%) and 20 men (47.6%), mean age – 75.0 ± 10.9 years. Almost all patients received home hospice care because of malignancy, the most common being lung cancer ($n=13$, 31.0%), colon cancer ($n=3$; 7.1%), and skin cancer ($n=3$; 7.1%). Household members included 12 women (63.2%) and 7 men (36.8%), mean age – 66.0 ± 7.1 years.

Colonization with drug-resistant pathogens in LTCF and home hospice patients. Colonization with drug-resistant pathogens was found more often in LTCF residents than in at-home hospice patients (Fig. 1). The risk of colonization with drug-resistant pathogens was significantly lower in patients receiving home hospice care than in LTCF residents (OR 0.16; 95% CI 0.06–0.38).

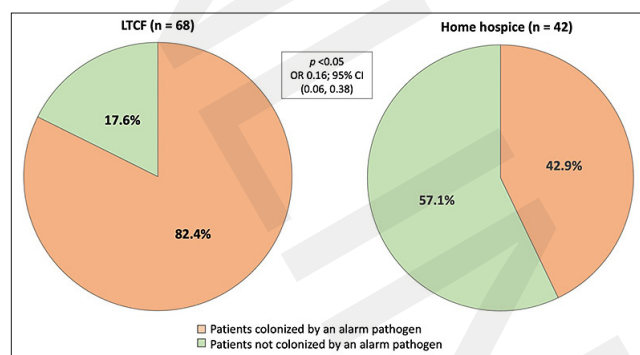


Figure 1. Proportion of patients staying at long-term care facilities and those receiving home hospice care colonized by an drug-resistant pathogen. LTCF – long-term care facility; OR – odds ratio

Detailed data on the prevalence of isolated pathogens are presented in Table 1. The most common pathogens in LTCF residents were MRSA and ESBL-producing *E. coli*. At-home

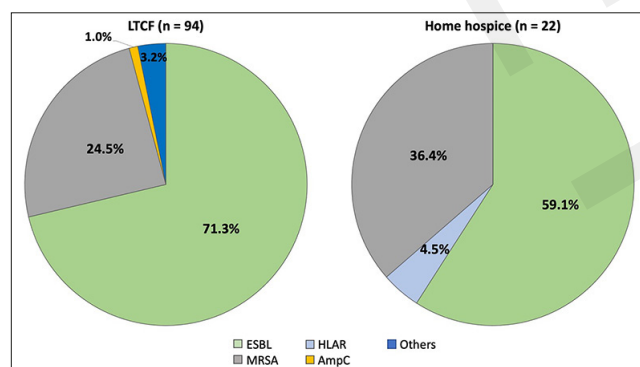


Figure 2. Distribution of the resistance mechanisms of pathogens isolated from patients staying at long-term care facilities and those receiving home hospice care. ESBL – extended spectrum β -lactamase; HLAR – high-level aminoglycoside resistance; LTCF – long-term care facility; MRSA – methicillin-resistant *Staphylococcus aureus*

Table 1. Characteristics of drug-resistant pathogens colonizing patients staying at long-term care facilities and those receiving home hospice care.

Pathogen	Number of colonized patients	Percentage of all patients	Percentage of colonized patients
LTCF (n=68)			
MRSA	23	33.8% (23/68)	41% (23/56)
<i>Escherichia coli</i> ESBL+	22	32.4% (22/68)	39.3% (22/56)
<i>Pseudomonas aeruginosa</i> ESBL+	21	30.9% (21/68)	37.5% (21/56)
<i>Proteus mirabilis</i> ESBL+	20	29.4% (20/68)	35.7% (20/56)
<i>Klebsiella pneumoniae</i> ESBL+	2	2.9% (2/68)	3.6% (2/56)
<i>Enterococcus cloacae</i> ESBL+	2	2.9% (2/68)	3.6% (2/56)
<i>Stenophomonas maltophilia</i> *	1	1.5% (1/68)	1.8% (1/56)
<i>Achromobacter denitrificans</i> *	1	1.5% (1/68)	1.8% (1/56)
<i>Citrobacter freundii</i> *	1	1.5% (1/68)	1.8% (1/56)
<i>Enterococcus cloacae</i> AmpC+	1	1.5% (1/68)	1.8% (1/56)
Home hospice (n=42)			
MRSA	8	19% (8/42)	44.4% (8/18)
<i>Pseudomonas aeruginosa</i> ESBL+	6	13.2% (6/42)	33.3% (6/18)
<i>Escherichia coli</i> ESBL+	5	11.9% (1/42)	27.7% (1/18)
<i>Klebsiella pneumoniae</i> ESBL+	2	4.7% (2/42)	11.1% (2/18)
<i>Enterococcus</i> HLAR	1	5.2% (1/42)	16.7% (1/18)

* Resistant to ≥ 2 antibiotic classes.

ESBL – extended-spectrum β -lactamase; HLAR – high-level aminoglycoside resistance; LTCF – long-term care facility; MRSA – methicillin-resistant *Staphylococcus aureus*

Table 2. Pathogen transmission in at-home hospice patients and their household members

Trans- mission	Pathogens isolated from the patient	Pathogens isolated from the household member	Comments
1	MRSA	MRSA, <i>E. coli</i> ESBL+	Household member colonized by > 1 drug-resistant pathogen
2	MRSA, <i>E. faecium</i> HLAR	MRSA	Patient colonized by > 1 drug-resistant pathogen
3	<i>P. deovorans</i> ESBL+	<i>P. deovorans</i> ESBL+	Householder and patient colonized by the same pathogen
4	-	<i>Enterobacter cloacae</i> ESBL+ <i>P. aeruginosa</i> ESBL+	Colonization with <i>P. aeruginosa</i> ESBL+ in the patient's medical history in the last 12 months
5	-	<i>Citrobacter braakii</i> AmpC+	Colonization with <i>Citrobacter spp.</i> ESBL+ in the patient's medical history in the last 12 months
6	<i>P. aeruginosa</i> ESBL+	<i>S. aureus</i> MRSA	Colonization with <i>P. aeruginosa</i> ESBL+ in the patient's medical history in the last 12 months

ESBL – extended spectrum β -lactamase; HLAR – high level aminoglycoside resistance; MRSA – methicillin-resistant *Staphylococcus aureus*

hospice patients were most often colonized with MRSA and ESBL-producing *P. aeruginosa*. A total of 38 patients (34.5%) were colonized by more than one pathogen.

The most common resistance mechanisms of isolated pathogens both in LTCF and at-home hospice patients were ESBL and MRSA (Fig. 2).

Transmission of drug-resistant pathogens in the home hospice setting. Colonization with drug-resistant pathogens was found in 18 patients (42.9%) under home hospice care and 6 household members (31.5%). Three household members (50%) were colonized by MRSA. In 3 household members (50%), the same microorganism was found as in hospice patients. The remaining patients had a negative microbiological test result, but their medical history revealed previous colonization with the same pathogen that was later detected in a household member (Tab. 2).

DISCUSSION

LTCFs and hospices are considered a potential source of pathogen transmission. However, data on the prevalence and type of pathogens colonizing LTCF residents and at-home hospice patients in Poland are limited. The presented study shows that pathogen colonization was significantly more common in patients staying at LTCFs than in those under home hospice care. Therefore, home hospice care was shown to reduce the risk of pathogen colonization. A home hospice has an advantage over an LTCF in that it has a limited number of caregivers, thus lowering the probability of pathogen transmission. In the home setting, patients have contact only with their own bacterial flora, which maintains the immune function as part of physiological microbiota and may inhibit the growth of potentially pathogenic bacteria as commensal flora [16]. The obtained results are in line with other studies. A prospective study from France found that the proportion of patients with multidrug-resistant organisms was 3-fold higher among institutionalized individuals than in those under home care [17]. In a study conducted in Singapore, the prevalence of MRSA colonization on hospital admission was 41% for LTCF residents, compared with 6% for patients staying at an acute care hospital (RR, 6.89; 95% CI, 5.74–8.26) [18].

Residency at an LTCF is a known risk factor for pathogen colonization. Guifrè et al [9] reported that 63.2% of 489 Italian LTCF residents were colonized by at least one pathogen. The prevalence of ESBL-producing Enterobacterales was 57.3%, and the most common isolates were *E. coli* (49.0%) and *K. pneumoniae* (7.1%). In a study by Pulcini et al. [19], elderly people in nursing homes had a 40% higher risk of having a urine culture positive for antibiotic-resistant Enterobacterales, including ESBL-producing *E. coli*, compared with community-dwelling adults. Their findings support the results of the current study, suggesting that LTCFs might be a reservoir of ESBL-producing *E. coli*.

The second most prevalent pathogen in this study, both in LTCF residents and at-home hospice patients, was MRSA. In other studies, the prevalence of MRSA colonization ranged from 4.1% – 17.2% [19–22]. Gleeson et al. [20] indicated that this type of pathogen colonization did not negatively affect patient survival. However, colonization was associated with an increased risk of developing a systemic infection during a stay in the palliative unit. Thus, since MRSA colonization is common among patients in LTCFs, it is necessary for these patients to undergo microbiological assessment at each hospitalization to prevent in-hospital pathogen transmission.

There are limited data on VRE colonization. The most important known risk factors for this type of colonization and symptomatic infection include catheterization, malignancies

(mainly haematological), solid organ transplants, prolonged hospital stay, old age, dialysis, pressure ulcers, and prolonged antibiotic therapy [23, 24]. In the current study, no cases of VRE colonization was found, which may be due to the limited number of patients and the fact that none of the patients had a history of haematological malignancies or organ transplant.

The obtained results suggest possible pathogen transmission in the home hospice setting; however, definitive conclusions cannot be drawn because the study included a relatively small group of patients and their household members. Nevertheless, this study is one of the few to report such findings in recent literature.

Determining the risk of colonization with drug-resistant pathogens in healthy people providing home care for chronically ill patients has important practical implications. For example, questions about this type of care should be included in standard questionnaires for infection risk assessment, and such persons should undergo microbiological screening on admission to hospital. The basic principle of preventing pathogen transmission at home is hand hygiene, as described previously by other researchers [25, 26]. The risk of pathogen transmission among household members is also important from the ethical and psychological perspective. The fact that a patient is colonized with a multidrug-resistant microorganism may cause health anxiety among caregivers. Currently, the household members of a patient colonized with a drug-resistant pathogen are not subject to any restrictions, but it is necessary to inform them about the principles of hand hygiene. There is also no need to isolate patients, which is important because isolation might have negative psychological effects, both for the patient and his or her caregivers (often family).

Strengths and limitations of the study. This study provides one of the first data about the colonization with drug-resistant pathogens in long-term care patients. A limitation of the study is the relatively small group of participants, especially those under home hospice care and their household members. However, because of the coronavirus disease 2019 (COVID-19) pandemic, it was not possible to continue the study on a larger scale as originally planned. The negative impact of the COVID-19 pandemic on the quality of care for patients requiring palliative care was reported previously [27].

CONCLUSION

The risk of colonization with drug-resistant pathogens in long-term care patients depends on the type of care, and is significantly higher in patients who stay at LTCFs than in those who remain at home. To ensure the safety of patients and their caregivers, systemic measures are necessary to monitor the epidemiology of infections and colonization by drug-resistant pathogens. Household members of patients under home hospice care are at risk of pathogen transmission. This has to be considered during infection risk assessment of caregivers in the case of hospital admission.

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Data sharing. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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