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Trends in antibiotic use in long-term care hospitals during the COVID-19 pandemic: a nationwide cohort study during 2020 and 2023

Yong Chan Kim[1†], Jungmi Chae[2†], Jihye Shin[2], Yeseul Kim[2], Eugene Lee[3] and Dong-Sook Kim[4*]

Abstract

Objective Information regarding the use of antibiotics in long-term care hospitals (LCHs) during COVID-19 remains limited. The aim of the study was to examine the antibiotics use in Korean LCHs during the COVID-19 pandemic period.

Methods We conducted a nationwide cohort study between 2020 and 2023. During this period, a total of 1,835,398 patients were admitted to 1,829 LCHs.

Results 1,043,346 (56.9%) received antibiotics. The overall antibiotic use in LCHs was 133.33 days of therapy (DOT) per patient-days (PDs), which was lower than that observed in tertiary (933.89), secondary (798.26), and primary care hospitals (566.77). In contrast, the intensity of antibiotic use among treated patients was highest in LCHs (40.01 DOT), exceeding that in tertiary (15.22), secondary (14.60), and primary care hospitals (11.74). Antibiotic use in LCHs steadily rose from 116.18 in January 2020 to 160.65 DOT per 1000 PDs in December 2023, with a notable increase during surge of COVID-19 cases. Segmented regression analysis showed a sustained increase in antibiotic use before the Omicron wave that persisted afterward. Most statistically significant increases were observed in the use of broad-spectrum antibiotics: fourth-generation cephalosporins increased by 348.0%, carbapenems by 114.6%, and glycopeptides by 92.5%.

Conclusions During the COVID-19 pandemic, we found a significant increasing trend in antibiotic use, particularly in broad-spectrum antibiotics. These findings highlight the deed for strengthened antibiotic stewardship in LCHs during public health crises.

Clinical trial registration Clinical trial number: Not applicable.

Keywords Antibacterial agents, Antimicrobial stewardship, COVID-19, Korea, Long-term care

†Yong Chan Kim and Jungmi Chae contributed equally and share first authorship.

*Correspondence:
Dong-Sook Kim
sttone@kongju.ac.kr
[1]Department of Internal Medicine, Yonsei University College of Medicine, Yongin, Republic of Korea
[2]Review and Assessment Research Department, Health Insurance Review and Assessment Service, Wonju, Republic of Korea
[3]Department of Biology, Duke University, Durham, USA
[4]Department of Health Administration, College of Health, Kongju National University, 56, Gongjudaehak-ro, Gongju-si, Chungcheongnam-do, Republic of Korea

Introduction

The COVID-19 pandemic has drastically altered healthcare practices worldwide, including the use of antibiotics. In the early stages of the pandemic, the lack of consensus on the optimal therapy led many physicians to prescribe antibiotics to hospitalized patients with COVID-19 [1]. Since COVID-19 is a viral infection and the likelihood of a bacterial infection is low [2, 3], a substantial portion of these antibiotic prescriptions were inappropriate [4, 5]. Nevertheless, the misuse of specific antibiotics has continued throughout the pandemic [1, 6], raising concerns regarding the subsequent risk of increased antibiotic resistance [7].

Patients in long-term care hospitals (LCHs) are at a high risk of infections [8]. Their vulnerability is primarily due to multiple underlying comorbidities and advanced age [9]. The spatial constraints of LCHs, coupled with frequent close contact among patients, facilitate the transmission of infections [10]. Furthermore, diagnosing infections in these patients is challenging because many have difficulty expressing their symptoms accurately due to cognitive impairments or other health issues, and the diagnostic tools available in these settings are often limited [11, 12].

Considering these characteristics, it was hypothesized that antibiotic use in LCHs was significantly influenced by COVID-19. However, to date, there has been limited information available regarding changes in antibiotic use in LCHs during the COVID-19 pandemic. Understanding how antibiotic use has shifted during the pandemic can help improve current antibiotic prescribing practices in LCHs. Additionally, this knowledge can offer valuable insights to prepare future pandemics in LCHs.

This study aimed to investigate the trends in antibiotic use in Korean LCHs during the COVID-19 pandemic between 2020 and 2023 using nationwide claims data.

Methods

Study setting

We conducted a nationwide cohort study to evaluate the use of antibiotics among patients hospitalized in Korean LCHs during the pandemic. In Korea, an LCH is defined as a medical institution that is capable of accommodating 30 or more patients requiring long-term hospitalization, with doctors and nurses available to provide necessary medical services. These institutions rarely have outpatient clinics, focusing primarily on inpatient care. The primary reasons for hospitalization in LCHs include the management of geriatric diseases, chronic conditions, and subacute illnesses, with a significant focus on chronic neurological conditions such as dementia and stroke. The health and functional statuses of patients in LCHs are diverse, leading to varying medical needs among patients. Since November 2019, patients in Korean LCHs have been categorized into five groups based on their medical needs: ultra-high medical care, high medical care, medium medical care, mild medical care, and reduced physical function. The characteristics and classification of the patients in Korean LCHs are detailed in Supplementary Table 1.

The study period, from January 2020 to December 2023, encompassed the entire duration of the COVID-19 pandemic, including its emergence, global spread, and subsequent transition to a post-emergency phase. This timeframe was selected to capture changes in antibiotic use throughout the pandemic period in long-term care hospitals [13].

Data collection

We analyzed antibiotic use in LCHs using claims data from the National Health Insurance (NHI). Korea operates a unified health insurance system that covers the medical expenses of approximately 98% of its population [14]. Since 2007, patients have been assigned unique anonymized identification numbers to facilitate electronic billing processes [15, 16]. By employing these distinct identification numbers, we collected data on prescription details—including drug name, ingredients, and prescription period—along with patient demographics, underlying diseases, and length of hospitalization from the NHI claims data. It is important to note that all oral and injectable antibiotics require a doctor's prescription for use, ensuring that most antibiotic use in LCHs is recorded in the NHI claims database [17, 18].

The subjects of this study were patients hospitalized in LCHs from January 1, 2020, to December 31, 2023. We gathered data on various patient characteristics, including demographics, medical care group, length of hospital stay, the two primary diagnoses at the time of hospitalization, and type of insurance. The criteria for determining underlying comorbidities at hospitalization were based on the International Classification of Diseases, 10th revision [19]. Additionally, we collected information on the antibiotics prescribed to these patients. These antibiotics were categorized according to the Anatomical Therapeutic Chemical (ATC) classification system of the World Health Organization Collaborating Center [20]. Only antibiotics classified under J01 (systemic antibacterial substances) of the ATC classification system were included in the analysis.

For contextual comparison, basic antibiotic utilization data—such as the number of institutions, days of therapy (DOT), number of patients treated, and patient-days (PDs)—were also collected from tertiary, secondary, and primary care hospitals using the NHIS database for the period of 2020 to 2023. These data were used solely for descriptive comparison and were not included in detailed analyses of prescribing patterns or patient characteristics.

Table 1 Characteristics of patients in Long-term care hospitals between 2020 and 2023

	Total (*N* = 1,392,171)		No. of patients who received antibiotic therapy (*n* = 778,434)		No. of patients who did not received antibiotic therapy (*n* = 613,737)		*P* value
Age (years) Mean ± SD	76	± 14	79	± 13	73	± 16	< 0.001
Female sex, n (%)	1,124,153	(61.2)	631,521	(60.5)	492,632	(62.2)	< 0.001
Medical care group, n (%)							
Ultra-high medical care	36,704	(2.0)	23,896	(2.3)	12,808	(1.6)	< 0.001
High medical care	593,211	(32.3)	387,945	(37.2)	205,266	(25.9)	
Medium medical care	712,272	(38.8)	327,926	(31.4)	384,346	(48.5)	
Mild medical care	416,121	(22.7)	174,687	(16.7)	241,434	(30.5)	
Reduced physical function	278,624	(15.2)	76,041	(7.3)	202,583	(25.6)	
Others	251,364	(13.7)	80,979	(7.8)	170,385	(21.5)	
Length of days (days) Mean ± SD	170.2	± 146.5	206.8	± 146.5	122.0	± 138.4	< 0.001
Diagnoses at admission, n (%)							
Hypertension	362,521	(19.8)	213,424	(20.5)	149,097	(18.9)	< 0.001
Diabetes mellitus	218,100	(11.9)	131,540	(12.6)	86,560	(10.9)	< 0.001
Stroke	352,264	(19.2)	240,314	(23.0)	111,950	(14.1)	< 0.001
Dementia	760,731	(41.4)	500,290	(48.0)	260,441	(32.9)	< 0.001
Parkinson's disease	114,170	(6.2)	77,772	(7.5)	36,398	(4.6)	< 0.001
Heart failure	39,955	(2.2)	26,774	(2.6)	13,181	(1.7)	< 0.001
Arrythmia	25,651	(1.4)	16,812	(1.6)	8,839	(1.1)	< 0.001
Cerebrovascular disease	34,432	(1.9)	21,937	(2.1)	12,495	(1.6)	< 0.001
Asthma	19,132	(1)	13,705	(1.3)	5,427	(0.7)	< 0.001
Renal disease	78,579	(4.3)	54,993	(5.3)	23,586	(3)	< 0.001
Liver disease	5,728	(0.3)	3,061	(0.3)	2,667	(0.3)	< 0.001
Cancer	310,218	(16.9)	144,159	(13.8)	166,059	(21)	< 0.001
Insurance type, n (%)							
National health insurance	1,440,976	(78.5)	817,706	(78.4)	623,270	(78.7)	< 0.001
Medical aid	394,308	(21.5)	225,558	(21.6)	168,750	(21.3)	

Antibiotic prescription was assessed using three metrics. First, antibiotic use was defined as DOT per 1,000 PDs, reflecting facility-level antibiotic exposure. Second, the proportion of treated patients was defined as the percentage of patients who received at least one dose of a systemic antibiotic during their stay. Third, intensity of use was calculated as the total DOT divided by the number of treated patients, representing the average antibiotic exposure per treated patient.

Statistical analysis

Analysis was conducted according to the characteristics of the variables involved. Categorical variables were presented as frequencies and percentages, with the chi-square test employed to evaluate differences between groups. Continuous variables were reported as mean (SD), and comparisons between groups were made using either the independent t-test for normally distributed data or the Mann-Whitney U test for data that was not normally distributed.

We analyzed the trends in antibiotic use in LCHs using a general linear model. The number of newly confirmed COVID-19 cases fluctuated throughout the study period, with a dramatic surge during the Omicron wave (November 2021 to May 2022) (Supplementary Fig. 1). Since this period marked a significant shift in COVID-19 pandemic, we designated it as the transition period and conducted an interrupted time series analysis to evaluate changes in antibiotic use before and after this phase.

All statistical analyses were performed using SAS (version 9.4; SAS Institute, Cary, NC, USA). Statistical significance was set at $P < .05$.

Results

Study population

Between 2020 and 2023, a total of 1 835 398 patients were hospitalized in 1829 LCHs. Over a follow-up period totaling 312 438 411 PDs, 1 043 346 patients (56.8%) received treatment with at least one antibiotic agent, while 792 052 patients (43.2%) did not receive any antibiotic treatment (Supplementary Table 2).

The mean (SD) age was 76 (14) years, with 1 124 153 (61.2%) patients being female. The mean (SD) length of hospitalization was 170.20 (146.54) days. The most common diagnosis at the time of hospitalization was dementia (*n* = 760 731, 41.4%). Throughout the study period, the largest patient group was in the medium medical care category (*n* = 712 272, 38.8%), followed by

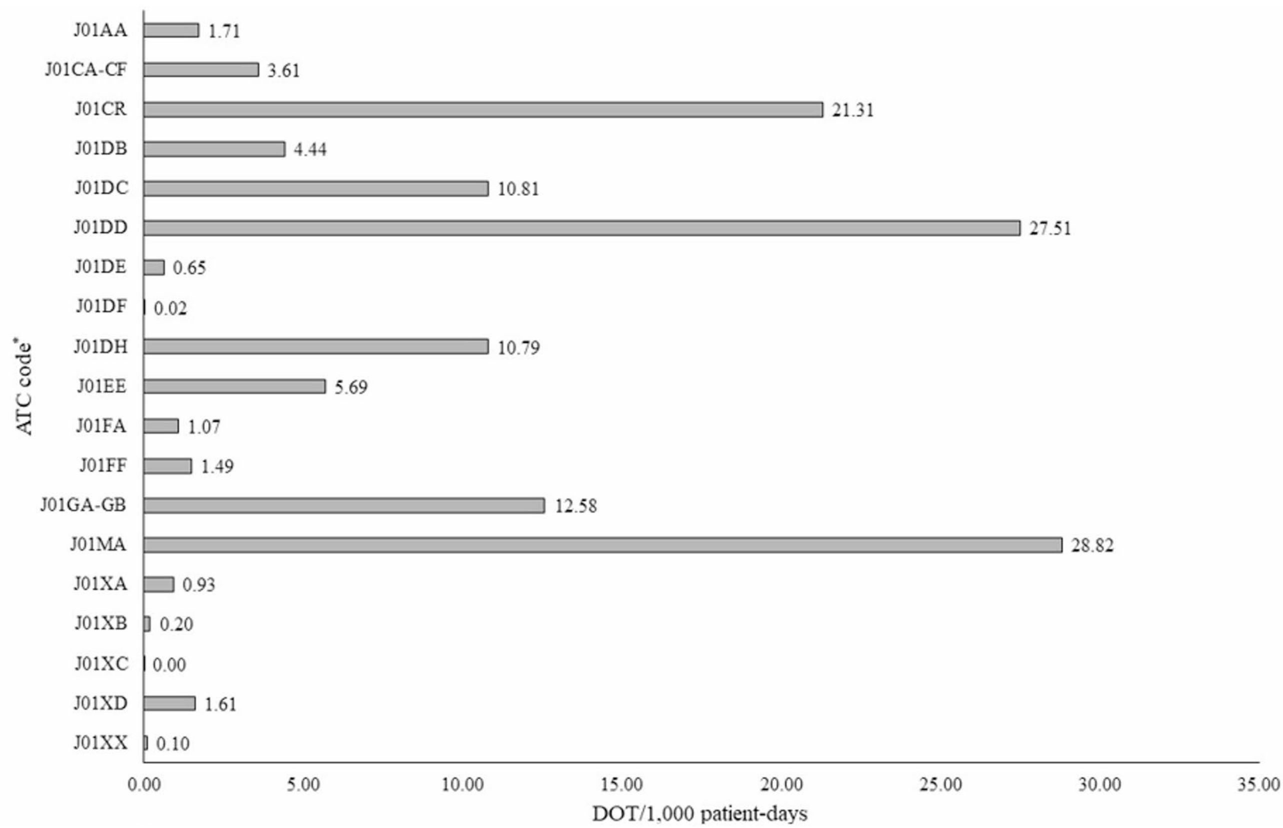

Fig. 1 Total antibiotic use by Anatomical Therapeutic Chemical (ATC) Classification in long-term care hospitals over a 4-year period (2020–2023) (see footnote for ATC code description). *J01AA - Tetracyclines, J01CA- Penicillins with extended spectrum, J01CE - Beta-lactamase sensitive penicilins, J01CF - Beta-lactamase resistant penicillins, J01CR - Combinations of penicillins, including beta-lactamase inhibitors, J01DB - First-generation cephalosporins, J01DC - Second-generation cephalosporins, J01DD - Third-generation cephalosporins, J01DE - Fourth-generation cephalosporins, J01DF - Monobactams, J01DH - Carbapenems, J01DI - Other cephalosporins and penems, J01EE - Combinations of sulfonamides and trimethoprim, including derivatives, J01FA – Macrolides, J01FF - Lincosamides; J01GA - Streptomycins, J01GB - Other aminoglycosides, J01MA - Fluoroquinolones, J01RA - Combinations of antibacterials, J01XA - Glycopeptide antibacterials, J01XB – Polymyxins, J01XC - Steroid antibacterials, J01XD - Imidazole derivatives, J01XE - Nitrofuran derivatives, J01XX - Other antibacterials. Abbreviations: ATC, anatomical therapeutic chemical; DOT, Days of Therapy

the high medical care group (n = 593 211, 32.3%). Most of the patients (78.5%) were covered by National Health Insurance. Patients who received antibiotic treatment were generally older (mean [SD] age, 79 [13] vs. 73 [16] years, P < .001), had longer stays in the hospital (mean [SD] duration, 206.80 [141.90] vs. 121.97 [138.38] days, P < .001), and were more likely to have dementia as their primary diagnosis for hospitalization (48% vs. 32.9%, P < .001) compared to those who did not receive antibiotics (Table 1).

Antibiotic use

Table 2 presents the proportion of patients who received antibiotic therapy and the total antibiotic use, categorized by sex, age, medical care group, hospital size, and number of doctors. The percentage of patients treated with antibiotics rose from 55.1% in 2020 to 59.7% in 2023. Additionally, antibiotic use was higher among males than females. In the group of patients older than 65 years, around 60% were prescribed antibiotics, with this age group showing the highest use rates. Antibiotic use among the medical care groups declined as the demand for medical services decreased. Annually, the ultra-high medical care group recorded the highest levels of antibiotic use, which were 5–6 times greater than those in the group with reduced physical function, which had the lowest levels. In terms of hospital size, the highest antibiotic use was observed in hospitals with 300–449 beds. Furthermore, hospitals with 3 or more doctors per 100 beds reported the highest antibiotic use.

During the study period, the total antibiotic use in LCHs was 133.33 DOT per 1000 PDs. Fluoroquinolones were the most frequently prescribed class of antibiotics, with 28.82 DOT per 1000 PDs, followed by third-generation cephalosporins at 27.51 DOT per 1000 PDs, and combinations of penicillin, including beta-lactamase inhibitors, at 21.32 DOT per 1000 PDs (Fig. 1). Supplementary Table 3 provides details on the different classes of antibiotics used in LCHs from 2020 to 2023.

Table 2 Proportion of patients who received antibiotic therapy and the total antibiotic use categorized by Sex, Age, medical care Group, number of Doctors, and hospital size

Category	2020		2021		2022		2023	
	Proportion of patients who received antibiotic therapy (%)	**DOT/1,000 PDs**	**Proportion of patients who received antibiotic therapy (%)**	**DOT/1,000 PDs**	**Proportion of patients who received antibiotic therapy (%)**	**DOT/1,000 PDs**	**Proportion of patients who received antibiotic therapy (%)**	**DOT/1,000 PDs**
Total	257,918/468,391 (55.1)	114.65	244,837/452,438 (54.1)	126.34	275,855/471,345 (58.5)	146.12	264,736/443,224 (59.7)	151.7
Sex								
Men	257,918/468,391 (55.1)	132.27	244,837/452,438 (54.1)	154.67	275,855/471,345 (58.5)	177.96	106,290/171,337 (62)	182.06
Women	157,085/283,698 (55.4)	104.32	148,229/274,503 (54)	110.85	167,761/294,065 (57)	128.87	158,446/271,887 (58.3)	134.53
Age								
0–39 years	3,459/13,428 (25.8)	56.39	2,270/11,026 (20.6)	85.58	2,100/7,453 (28.2)	127.4	1,752/4,545 (38.5)	133.18
40–64 years	38,418/100,396 (38.3)	74.73	33,068/90,946 (36.4)	97.23	33,980/75,976 (44.7)	117.56	32,862/72,989 (45)	118.72
≥ 65 years	216,041/354,567 (60.9)	126.32	209,499/350,466 (59.8)	132.63	239,775/387,916 (61.8)	151.44	230,122/365,690 (62.9)	157.88
Medical care group								
Ultra-high medical care	6,756/9,904 (68.2)	363.34	6,233/9,392 (66.4)	358.18	5,714/8,937 (63.9)	324.91	5,193/8,471 (61.3)	329.17
High medical care	96,149/144,419 (66.6)	253.01	93,525/142,718 (65.5)	244.43	101,201/153,947 (65.7)	232.46	97,070/152,127 (63.8)	231.40
Medium medical care	87,925/189,178 (46.5)	121.52	78,188/173,874 (45)	115.64	81,933/172,473 (47.5)	114.93	79,880/176,747 (45.2)	116.52
Mild medical care	45,538/109,113 (41.7)	94.38	41,388/102,865 (40.2)	92.78	44,970/102,711 (43.8)	93.34	42,791/101,432 (42.2)	96.96
Reduced physical function	18,667/67,495 (27.7)	59.87	17,971/67,254 (26.7)	57.47	19,800/70,973 (27.9)	57.93	19,603/72,902 (26.9)	58.62
Hospital size in bed								
< 150 beds	48,574/97,497 (49.8)	117.64	44,562/96,435 (46.2)	120.58	49,926/100,284 (49.8)	133.50	44,715/92,615 (48.3)	136.22
150–299 beds	167,583/301,077 (55.7)	128.58	160,386/289,286 (55.4)	141.12	182,524/306,870 (59.5)	162.06	176,966/287,518 (61.5)	171.42
300–449 beds	31,330/59,211 (52.9)	130.51	31,484/58,916 (53.4)	151.35	36,462/63,952 (57)	174.94	34,602/58,564 (59.1)	184.91
≥ 450 beds	16,566/33,700 (49.2)	104.33	14,813/31,839 (46.5)	127.25	15,350/29,716 (51.7)	152.26	15,797/29,053 (54.4)	170.79
No. of doctor per 100 beds								
< 2	4,495/12,218 (36.8)	86.83	5,119/15,539 (32.9)	95.51	4,850/14,889 (32.6)	87.35	4,869/16,343 (29.8)	84.81
2–3	69,552/135,510 (51.3)	113.20	66,590/138,000 (48.3)	118.75	80,188/150,739 (53.2)	140.54	78,670/143,650 (54.8)	147.17
> 3	188,380/339,848 (55.4)	130.49	177,991/319,864 (55.6)	146.64	197,212/330,369 (59.7)	167.38	187,190/305,050 (61.4)	178.51

Abbreviations: DOT, days of therapy; PDs, patient-days

During the same period, antibiotic use in acute care hospitals was higher, with 933.89, 798.26, and 566.77 DOT per 1000 PDs in tertiary, secondary, and primary care hospitals, respectively. However, the intensity of antibiotic use among treated patients was highest in LCHs, at 40.01 DOT, compared to 15.22, 14.60, and 11.74 DOT in tertiary, secondary, and primary care hospitals, respectively (Supplementary Table 2).

Trends of antibiotic use

The use of antibiotics steadily increased from 116.18 DOT/1000 PDs in January 2020 to 160.65 DOT/1000 PDs in December 2023. Confirmed COVID-19 cases surge during the Omicron wave was accompanied by a notable rise in antibiotic use, particularly in March and April 2022. According to the segmented regression analysis, antibiotic use steadily increased before the Omicron wave (estimate 0.9005657, $P < .001$), and this increasing trend in antibiotic use remained after the Omicron wave (Fig. 2, Supplementary Tables 4 and 5).

The antibiotic classes that exhibited the most significant increases in use were fourth-generation cephalosporins (348.0% increase, estimate 0.062, $P < .001$), carbapenems (114.6% increase, estimate 0.564, $P < .001$), and glycopeptide antibacterials (92.5% increase, estimate 0.039, $P < .001$) (Table 3). Table 4 lists the top 10 individual antibiotics prescribed in LCHs between 2020 and 2023. Levofloxacin was the most frequently prescribed antibiotic, followed by ciprofloxacin and piperacillin with a β-lactamase inhibitor. Meropenem showed the largest increase in use, rising from 4.53 DOT/1000 PDs in the first quarter of 2020 to 11.79 DOT/1000 PDs in the fourth quarter of 2023, a 160.3% increase (estimate 0.501, $P < .001$). This increase was followed by piperacillin with a β-lactamase inhibitor, which saw a 87.2% increase (estimate 0.560, $P < .001$), and ceftriaxone, with a 40.0% increase (estimate 0.313, $P < .001$).

Discussion

In this nationwide cohort study, more than half of patients hospitalized in Korean LCHs were prescribed antibiotics during the COVID-19 pandemic. These patients were typically older, experienced longer hospital stays, and had a higher likelihood of having dementia as a primary diagnosis. While the total antibiotic use was greater in acute-care hospitals, the intensity of antibiotic use among treated patients was higher in LCHs. There was an increasing trend in antibiotic use, particularly in broad-spectrum antibiotics during the pandemic. Levofloxacin was the most frequently prescribed antibiotic, with meropenem experiencing the most significant rise in use. Our study offers detailed insights into the shifts in antibiotic use in Korean LCHs throughout the COVID-19 pandemic.

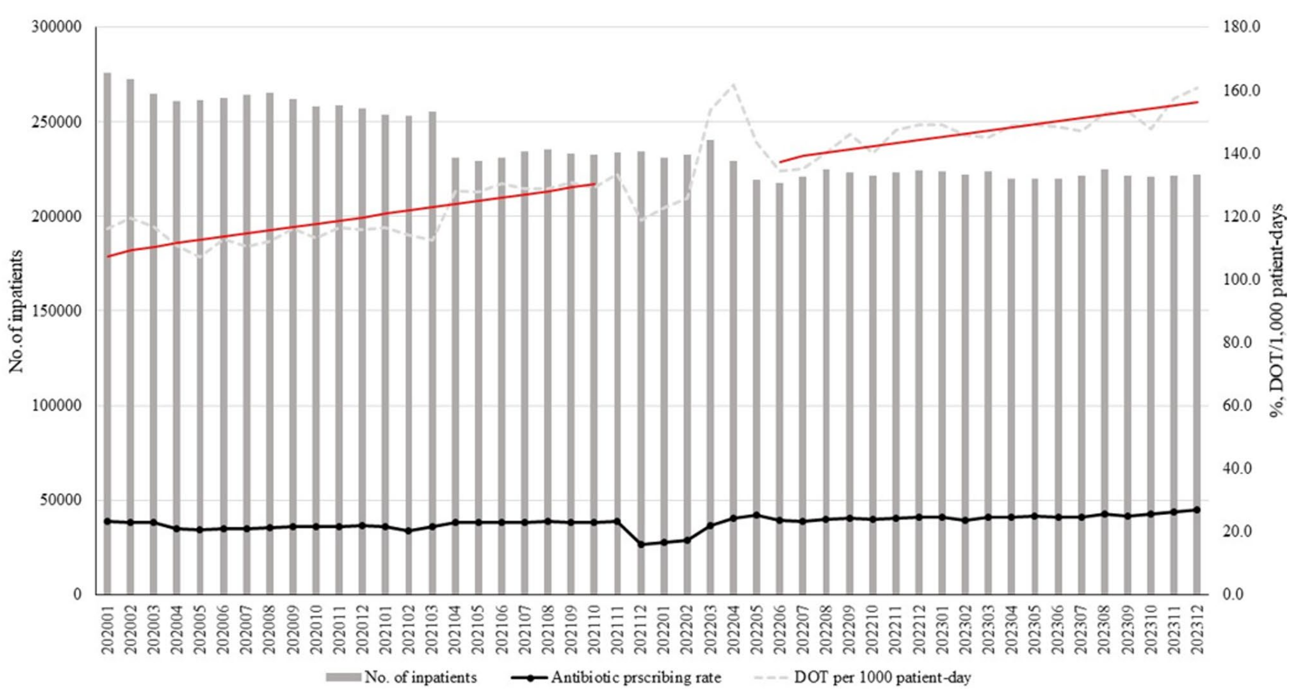

Fig. 2 Trends in antibiotic use and the number of hospitalized patients in long-term care hospitals in Korea between 2020 and 2023. From January 2020 to December 2023, the monthly number of inpatients in Korean long-term care hospitals initially declined but stabilized after mid-2021. While the antibiotic prescribing rate remained steady at around 25%, the DOT per 1,000 patient-days gradually increased, indicating a growing intensity of antibiotic use among treated patients. Abbreviations: DOT, Days of Therapy

Table 3 Trends of antibiotic use in Long-term care hospitals by therapeutic class from 2020 to 2023 (Unit: DOT/1000 patient-days)

ATC code	Antibiotic class*	2020				2021				2022				2023				Change (%)†	Estimate	P value
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th			
J01AA	Tetracyclines	1.55	1.63	1.65	1.42	1.36	1.41	1.42	1.51	1.53	1.75	1.82	1.77	2.02	2.22	2.29	2.24	44.5	0.054	< 0.001
J01CA-CF	Penicillins	4.55	3.82	3.75	3.65	3.53	3.36	3.28	3.24	4.32	3.63	3.36	3.46	3.37	3.47	3.40	3.55	-22.0	0.002	0.986
J01CR	Combinations of penicillins, including beta-lactamase inhibitors	18.45	16.53	17.00	17.59	17.51	19.72	20.13	21.01	24.05	24.37	22.86	24.40	24.73	24.83	25.53	26.32	42.7	0.684	< 0.001
J01DB	First-generation cephalosporins	4.59	4.36	4.48	4.53	4.35	4.47	4.52	4.41	4.71	4.64	4.51	4.52	4.55	4.12	4.09	4.05	-11.8	-0.020	0.058
J01DC	Second-generation cephalosporins	11.18	10.13	10.37	10.30	9.77	10.47	10.39	10.20	11.72	11.35	10.66	11.18	11.13	11.31	11.37	11.90	6.4	0.088	0.005
J01DD	Third-generation cephalosporins	23.30	21.42	22.06	23.10	23.29	26.72	27.11	27.67	31.72	32.38	30.12	31.81	31.16	30.75	30.87	31.62	35.7	0.753	< 0.001
J01DE	Fourth-generation cephalosporins	0.25	0.26	0.31	0.33	0.38	0.51	0.59	0.67	0.73	0.89	0.83	0.89	0.90	1.00	1.05	1.12	348.0	0.062	< 0.001
J01DF	Monobactams	0.02	0.03	0.04	0.04	0.06	0.05	0.01	0.00	0.00	0.00	0.00	.	.	0.00	.	.		-0.004	0.014
J01DH	Carbapenems	6.91	7.04	7.53	7.87	8.45	9.97	10.33	11.00	11.90	13.43	12.55	12.83	13.33	13.70	14.29	14.83	114.6	0.564	< 0.001
J01EE	Combinations of sulfonamides and trimethoprim, including derivatives	5.21	5.41	5.62	5.57	5.40	5.89	5.73	5.76	5.14	5.64	5.86	5.95	6.06	5.87	5.89	6.25	20.0	0.047	0.001
J01FA	Macrolides	1.30	1.02	0.91	1.02	0.94	1.05	1.11	1.11	1.33	1.11	0.97	1.16	1.01	0.94	0.98	1.16	-10.8	-0.001	0.837
J01FF	Lincosamides	1.47	1.27	1.29	1.28	1.28	1.43	1.42	1.64	1.71	1.82	1.68	1.59	1.56	1.53	1.52	1.51	2.7	0.020	0.02
J01GA-GB	Aminoglycosides	11.43	11.24	11.49	11.55	11.82	13.67	13.12	10.62	11.37	13.36	13.24	13.71	14.31	14.82	14.88	14.88	30.2	0.056	0.78
J01MA	Fluoroquinolones	25.80	24.59	24.85	25.30	24.70	28.18	28.53	29.48	31.29	32.13	30.51	31.64	31.06	31.61	32.30	32.84	27.3	0.595	< 0.001
J01XA	Glycopeptide antibacterials	0.67	0.70	0.74	0.72	0.84	0.96	0.91	0.86	0.84	1.03	1.02	1.07	1.13	1.14	1.22	1.29	92.5	0.039	< 0.001
J01XB	Polymyxins	0.16	0.17	0.20	0.18	0.17	0.23	0.25	0.22	0.21	0.28	0.24	0.22	0.21	0.18	0.15	0.16	0.0	0.000	0.871
J01XC	Steroid antibacterials	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00		0.000	0.695
J01XD	Imidazole derivatives	1.22	1.19	1.16	1.22	1.21	1.40	1.43	1.57	1.71	1.93	1.85	1.87	1.98	2.17	2.22	2.12	73.8	0.079	< 0.001
J01XX	Other antibacterials	0.09	0.09	0.07	0.06	0.07	0.09	0.10	0.10	0.08	0.09	0.09	0.12	0.15	0.15	0.10	0.12	33.3	0.004	0.002

*Antibiotics classified as nitrofuran derivatives were not prescribed in Korean long-term care hospitals between 2020 and 2023

†Change (%): This value was calculated by subtracting the antibiotic use in the first quarter of 2020 from the antibiotic use in the fourth quarter of 2022, dividing the result by the antibiotic use in the first quarter of 2020, and then multiplying by 100

Abbreviations: ATC, anatomical therapeutic chemical; DOT, days of therapy; N/A, not applicable

Table 4 Trends of top 10 antibiotics prescribed in Long-term care hospitals from 2020 to 2023

ATC code	Antibiotic	2020				2021				2022				2023				Change (%)†	Estimate	*P* value
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th			
J01MA12	Levofloxacin	11.36	10.72	10.76	11.19	10.91	12.74	13.01	13.84	15.73	16.13	14.55	15.25	15.05	15.21	15.66	16.34	43.8	0.402	< 0.001
J01MA02	Ciprofloxacin	12.10	11.86	12.14	12.08	11.84	13.33	13.36	13.54	13.47	13.88	13.95	14.33	13.90	14.23	14.41	14.09	16.4	0.183	< 0.001
J01CR05	Piperacillin and beta-lactamase inhibitor	8.33	7.86	8.27	8.64	8.97	10.46	10.67	11.40	13.13	14.33	13.14	14.01	14.24	14.50	14.88	15.59	87.2	0.560	< 0.001
J01DD04	Ceftriaxone	8.72	7.92	8.10	8.43	8.40	9.66	9.83	10.09	11.43	12.29	11.12	11.76	11.77	11.69	11.88	12.21	40.0	0.313	< 0.001
J01DC04	Cefaclor	10.11	9.18	9.40	9.33	8.92	9.54	9.39	9.18	10.65	10.43	9.82	10.32	10.30	10.32	10.40	10.97	8.5	0.093	0.002
J01GB06	Amikacin	9.29	9.07	9.32	9.52	9.75	11.52	10.44	5.51	5.96	8.56	9.27	10.21	11.02	11.61	11.93	11.91	28.2	0.150	0.147
J01CR02	Amoxicillin and beta-lactamase inhibitor	8.70	7.32	7.44	7.71	7.24	7.72	7.88	7.95	9.15	8.31	8.08	8.81	8.86	8.75	9.03	9.18	5.5	0.102	0.002
J01DD08	Cefixime	6.48	5.99	6.18	6.55	6.67	7.62	7.63	7.67	8.87	8.82	8.11	8.57	8.01	8.00	8.65	9.56	47.5	0.198	< 0.001
J01DH02	Meropenem	4.53	4.68	5.12	5.44	5.95	7.12	7.50	7.94	8.67	9.93	9.35	9.73	10.17	10.48	11.17	11.79	160.3	0.501	< 0.001
J01EE01	Sulfamethoxazole and trimethoprim	5.21	5.41	5.62	5.57	5.40	5.89	5.73	5.76	5.14	5.64	5.86	5.95	6.06	5.87	5.89	6.25	20.0	0.047	0.001

†Change (%): This value was calculated by subtracting the antibiotic use in the first quarter of 2020 from the antibiotic use in the fourth quarter of 2022, dividing the result by the antibiotic use in the first quarter of 2020, and then multiplying by 100

Abbreviations: ATC, anatomical therapeutic chemical

Antibiotics are among the most frequently prescribed medications for patients in LCHs [21]. The Centers for Disease Control and Prevention report that up to 70% of these patients are treated with antibiotics more than once annually. However, between 40% and 75% of these antibiotic prescriptions are regarded as inappropriate use, which can accelerate the rise of antibiotic resistance in LCHs [22–24]. As antibiotic-resistant bacteria from LCHs can spread to acute care hospitals, this issue extends to a broader healthcare concern. Therefore, accurately assessing antibiotic use in LCHs and implementing appropriate countermeasures is crucial from a public health perspective.

Antibiotic use in LCHs during the COVID-19 pandemic may be profoundly affected due to their structural vulnerabilities and the unique characteristics of their patients [9, 10, 12]. However, data on antibiotic use in LCHs during the pandemic has remained limited to date. A thorough analysis of antibiotic use in this specific circumstance will provide valuable insights for developing effective antibiotic stewardship strategies in LCHs. To our knowledge, this study is the first to comprehensively investigate antibiotic use among patients in LCHs during the pandemic.

We demonstrated that the overall use of antibiotics in LCHs was lower than that in acute care hospitals; however, the intensity of use among patients who were prescribed antibiotics was higher in LCHs. Patients in LCHs, often of advanced age and with multiple comorbidities, tend to have longer stays compared to those in acute care hospitals, increasing their risk of hospital-acquired infections [25]. Additionally, some patients are susceptible to recurrent infections, such as aspiration pneumonia or infections from decubitus ulcers, due to chronic conditions that are not correctable [26]. As a result, these patients frequently receive multiple antibiotic prescriptions or undergo longer antibiotic treatments during their hospitalization, contributing to the increased intensity of antibiotic use among those treated. Furthermore, the limited availability of diagnostic resources and specialists in LCHs may also influence antibiotic use in these settings [27].

Interestingly, hospitals with three or more physicians per 100 beds exhibited higher rates of antibiotic administration. This trend may be partially explained by a higher proportion of clinically complex patients requiring more frequent medical intervention, including antibiotic therapy. Alternatively, increased physician availability may lead to more active diagnostic and treatment practices, contributing to higher antibiotic use. Further investigation is needed to better understand the relationship between physician staffing levels and prescribing behavior in LCHs.

This study revealed that fluoroquinolones, which are primarily used to treat urinary and respiratory tract infections, were the most commonly prescribed antibiotics in Korean LCHs during the COVID-19 pandemic, consistent with findings from studies conducted in US nursing homes prior to pandemic [28]. However, use of broad-spectrum antibiotics such as penicillins with β-lactamase inhibitors and carbapenems was also concerningly high, and exhibited a significant upward trend during the pandemic. Several factors may have contributed to this rise in the use of broad-spectrum antibiotics in LCHs. In Korea, the number of inpatients decreased temporarily over the three years of the pandemic (2020–2022), due to the cancellation of admissions for patients requiring only simple medical care [29]. This reduction could have led to an increase in the severity of illnesses in LCHs, heightened the risk of hospital-acquired infections, and fostered the development of antibiotic-resistant bacteria, potentially explaining the increased reliance on broad-spectrum antibiotics [30]. Moreover, changes in the healthcare system during the pandemic likely influenced the escalation in broad-spectrum antibiotic use. Throughout the COVID-19 pandemic, patient transfers between medical institutions were restricted. The total number of patient transfers was significantly lower for most of the pandemic compared to pre-pandemic levels [31]. Consequently, some patients with infections who would normally have been transferred to an acute care hospital remained in LCHs, where they received treatment with broad-spectrum antibiotics, even though their conditions were severe enough to warrant transfer to a higher level of care.

This study is significant as it provides a comprehensive analysis of antibiotic use in all LCHs nationwide throughout the most extended period of the COVID-19 pandemic. Despite its strengths, the study has several limitations. Firstly, due to the reliance on claims data, we could not verify the appropriateness of the antibiotic use during the pandemic. Further research is needed to assess the suitability of antibiotic use in LCHs during the COVID-19 pandemic. Secondly, this study did not compare antibiotic use in LCHs during the pandemic with the period before the COVID-19 pandemic. Since Korean LCHs operate under a fixed payment system for medical services, gathering data on antibiotic use through claims data from the NHIS proved challenging. Consequently, our investigation was limited to antibiotic prescriptions recorded in the NHIS database starting from 2020. Lastly, factors such as the availability of COVID-19 testing, vaccination rates, and the introduction of antiviral agents in LCHs might have influenced antibiotic use. Moreover, the vulnerability of patients to COVID-19 could have affected the patterns of antibiotic prescriptions. It is important to acknowledge that varying trends might be observed based on the specific conditions of the LCHs and the demographic characteristics of populations in different countries.

In conclusion, a sustained increase in antibiotic use was observed in Korean LCHs during the COVID-19 pandemic, with a particularly notable rise in broad-spectrum antibiotic prescriptions. Our study underscores the importance of continuous surveillance to monitor antibiotic use and the critical need for enhanced antibiotic stewardship in LCHs during public health crises. These measures are essential for optimizing antibiotic practices and mitigating the spread of resistant bacteria.

Abbreviations

LCHs long	Term care hospitals
COVID	19 Coronavirus Disease 2019
NHI	National Health Insurance
ATC	Anatomical Therapeutic Chemical
DOT	Days of Therapy
PDs	Patient-days
SD	Standard Deviation

Supplementary Information

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Supplementary Material 1

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None.

Author contributions

DK conceptualized the study. JC curated the data. YCK, JC, JS, YK and DK were involved the formal analysis, performed the investigations, and devised the methodology, while also providing the resources and software for analysis. YCK, JC and DK took care of the project administration. YCK and DK supervised the study. YCK and JC wrote the original draft of the manuscript, while EL and DK were involved in the review & editing of the manuscript.

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Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request. De-identified participant-level data that support the findings of this study can be made available upon reasonable request and subject to approval by the institutional ethics committee and data-sharing agreements, where required.

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of the Yonsei University Health System, Clinical Trial Center (approval number: 9-2023-0145). The study was conducted in accordance with the ethical standards of the Declaration of Helsinki. Given the retrospective design and the use of anonymized patient data, the Institutional Review Board of the Yonsei University Health System waived the requirement for written informed consent to participate.

Consent for publication

Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. O'Leary EN, Neuhauser MM, Srinivasan A, Dubendris H, Webb AK, Soe MM, et al. Impact of the COVID-19 pandemic on inpatient antibiotic use in the united States, January 2019 through July 2022. Clinical infectious diseases. Official Publication Infect Dis Soc Am. 2024;78(1):24–6. https://doi.org/10.1093/cid/ciad453. PubMed PMID: 37536269; PubMed Central PMCID: PMCPMC11629484.
2. Baskaran V, Lawrence H, Lansbury LE, Webb K, Safavi S, Zainuddin NI, et al. Co-infection in critically ill patients with COVID-19: an observational cohort study from England. J Med Microbiol. 2021;70(4). https://doi.org/10.1099/jmm.0.001350. PubMed PMID: 33861190; PubMed Central PMCID: PMCPMC8289210.
3. Langford BJ, So M, Raybardhan S, Leung V, Westwood D, MacFadden DR, et al. Bacterial co-infection and secondary infection in patients with COVID-19: a living rapid review and meta-analysis. clinical microbiology and infection: the official publication of the European society of clinical microbiology and infectious diseases. 2020;26(12):1622–9. Epub 20200722. https://doi.org/10.1016/j.cmi.2020.07.016. PubMed PMID: 32711058; PubMed Central PMCID: PMCPMC7832079.
4. Langford BJ, So M, Raybardhan S, Leung V, Soucy JR, Westwood D, et al. Antibiotic prescribing in patients with COVID-19: rapid review and meta-analysis. clinical microbiology and infection: the official publication of the European society of clinical microbiology and infectious diseases. 2021;27(4):520–31. Epub 20210105. https://doi.org/10.1016/j.cmi.2020.12.018. PubMed PMID: 33418017; PubMed Central PMCID: PMCPMC7785281.
5. Tan SH, Ng TM, Tay HL, Yap MY, Heng ST, Loo AYX, et al. A point prevalence survey to assess antibiotic prescribing in patients hospitalized with confirmed and suspected coronavirus disease 2019 (COVID-19). J Global Antimicrob Resist. 2021;24:45–7. PubMed PMID: 33307276; PubMed Central PMCID: PMCPMC7722492.
6. Rose AN, Baggs J, Wolford H, Neuhauser MM, Srinivasan A, Gundlapalli AV, et al. Trends in antibiotic use in united States hospitals during the coronavirus disease 2019 pandemic. Open Forum Infect Dis. 2021;8(6):ofab236. https://doi.org/10.1093/ofid/ofab236. Epub 20210603.
7. Langford BJ, Soucy JR, Leung V, So M, Kwan ATH, Portnoff JS, et al. Antibiotic resistance associated with the COVID-19 pandemic: a systematic review and meta-analysis. clinical microbiology and infection: the official publication of the European society of clinical microbiology and infectious diseases. 2023;29(3):302–9. Epub 20221209. https://doi.org/10.1016/j.cmi.2022.12.006. PubMed PMID: 36509377; PubMed Central PMCID: PMCPMC9733301.
8. Montoya A, Mody L. Common infections in nursing homes: a review of current issues and challenges. Aging Health. 2011;7(6):889–99. https://doi.org/10.2217/AHE.11.80. PubMed PMID: 23264804; PubMed Central PMCID: PMCPMC3526889.
9. Juthani-Mehta M, Quagliarello VJ. Infectious diseases in the nursing home setting: challenges and opportunities for clinical investigation. Clin Infect Dis. 2010;51(8):931–6. https://doi.org/10.1086/656411. PubMed PMID: 20822459; PubMed Central PMCID: PMCPMC3083824.
10. Lee MH, Lee GA, Lee SH, Park YH. A systematic review on the causes of the transmission and control measures of outbreaks in long-term care facilities: back to basics of infection control. PLoS ONE. 2020;15(3):e0229911. https://doi.org/10.1371/journal.pone.0229911. Epub 20200310.
11. Kim YC, Park JY, Kim B, Kim ES, Ga H, Myung R, et al. Prescriptions patterns and appropriateness of usage of antibiotics in non-teaching community hospitals in South korea: a multicentre retrospective study. Antimicrob Resist Infect Control. 2022;11(1):40. https://doi.org/10.1186/s13756-022-01082-2. Epub 20220222.
12. Nicolle LE, Bentley DW, Garibaldi R, Neuhaus EG, Smith PW. Antimicrobial use in long-term-care facilities. SHEA Long-Term-Care committee. Infect Control Hosp Epidemiol. 2000;21(8):537–45. https://doi.org/10.1086/501798. PubMed PMID: 10968724.
13. Sarker R, Roknuzzaman ASM, Nazmunnahar, Shahriar M, Hossain MJ, Islam MR. The WHO has declared the end of pandemic phase of COVID-19: way to come back in the normal life. Health Sci Rep. 2023;6(9):e1544. PubMed PMID: 37674622; PubMed Central PMCID: PMCPMC10478644.
14. Kim DS, Ahn HS, Kim HJ. Statin use and incidence and mortality of breast and gynecology cancer: a cohort study using the national health insurance claims database. Int J Cancer. 2022;150(7):1156–65. https://doi.org/10.1002/ijc.33869. Epub 20211206.
15. Chae J, Kim B, Kim DS. Changes in antibiotic consumption patterns after the implementation of the National Action Plan according to the Access, Watch, Reserve (AWaRe) classification system. Int J Infect Dis. 2022;122:345 – 51. Epub 2022/06/16. https://doi.org/10.1016/j.ijid.2022.06.013. PubMed PMID: 35705118.
16. Park D, Lee H, Kim DS. J Gen Intern Med. 2022;37(10):2390–7. https://doi.org/10.1007/s11606-021-07165-x. Epub 2021/10/28. High-cost users of prescription drugs: national health insurance data from South Korea.
17. Cho HJ, Chae J, Yoon SH, Kim DS. Aging and the prevalence of polypharmacy and hyper-polypharmacy among older adults in South Korea: a national retrospective study during 2010–2019. Front Pharmacol. 2022;13:866318. https://doi.org/10.3389/fphar.2022.866318. Epub 2022/05/27.
18. Park J, Han E, Lee SO, Kim DS. Antibiotic use in South Korea from 2007 to 2014: a health insurance database-generated time series analysis. PLoS ONE. 2017;12(5):e0177435. https://doi.org/10.1371/journal.pone.0177435. Epub 20170517.
19. WHO. International statistical classification of diseases and related health problems. 10th revision (ICD 10). Geneva: World Health Organization; 2016.
20. Anatomical Therapeutic Chemical (ATC)/Defined Daily Dose (DDD) Index [Internet]. WHOCC. 2024. Available from: https://www.whocc.no/atc_ddd_index/
21. Yun IJ, Park HJ, Chae J, Heo SJ, Kim YC, Kim B, et al. Infect Chemother. 2024;56(2):256–65. Nationwide Analysis of Antimicrobial Prescription in Korean Hospitals between 2018 and 2021: The 2023 KONAS Report. PubMed PMID: 38960739; PubMed Central PMCID: PMCPMC11224044.
22. CDC. The core elements of antibiotic stewardship for nursing homes. Georgia: Centers for Disease Control and Prevention; 2015.
23. Lim CJ, Kong DC, Stuart RL. Reducing inappropriate antibiotic prescribing in the residential care setting: current perspectives. Clin Interv Aging. 2014;9:165–77. Epub 20140113. https://doi.org/10.2147/CIA.S46058. PubMed PMID: 24477218; PubMed Central PMCID: PMCPMC3894957.
24. Ricchizzi E, Latour K, Karki T, Buttazzi R, Jans B, Moro ML, et al. Antimicrobial use in European long-term care facilities: results from the third point prevalence survey of healthcare-associated infections and antimicrobial use, 2016 to 2017. Euro Surveill. 2018;23(46). https://doi.org/10.2807/1560-7917.ES.2018.23.46.1800394. PubMed PMID: 30458913; PubMed Central PMCID: PMCPMC6247460.
25. Pulia M, Kern M, Schwei RJ, Shah MN, Sampene E, Crnich CJ. Comparing appropriateness of antibiotics for nursing home residents by setting of prescription initiation: a cross-sectional analysis. Antimicrob Resist Infect Control. 2018;7:74. https://doi.org/10.1186/s13756-018-0364-7. Epub 20180614.
26. Llor C, Bjerrum L. Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem. Ther Adv Drug Saf. 2014;5(6):229–41. https://doi.org/10.1177/2042098614554919. PubMed PMID: 25436105; PubMed Central PMCID: PMCPMC4232501.
27. Jeon CY, Neidell M, Jia H, Sinisi M, Larson E. On the role of length of stay in healthcare-associated bloodstream infection. Infect Control Hosp Epidemiol. 2012;33(12):1213–8. Epub 20121019. https://doi.org/10.1086/668422. PubMed PMID: 23143358; PubMed Central PMCID: PMCPMC3510977.
28. Seshadri S, Felsen CB, Sellers CR, Dumyati GK. There is no one to pick up the pieces: sustainability of antibiotic stewardship programs in nursing homes. Infect Control Hosp Epidemiol. 2021;42(4):440–7. Epub 20201026. https://doi.org/10.1017/ice.2020.1217. PubMed PMID: 33100251.
29. Riester MR, Deng Y, Zullo AR. Antibiotic prescribing in united States nursing Homes, 2013–2017. J Infect Dis. 2023;228(4):464–8. https://doi.org/10.1093/infdis/jiad087. PubMed PMID: 37017192; PubMed Central PMCID: PMCPMC10428191.
30. Thompson ND, Stone ND, Brown CJ, Penna AR, Eure TR, Bamberg WM, et al. Antimicrobial use in a cohort of US nursing Homes, 2017. JAMA. 2021;325(13):1286–95. https://doi.org/10.1001/jama.2021.2900. PubMed PMID: 33821897; PubMed Central PMCID: PMCPMC8025112.

31. Chae J, Kim DS, Shin J, Kim YC, Ji SY, Kim Y, et al. Ten-year trends of antibiotics used for patients with pneumonia at long-term care hospitals in the Republic of korea: an analysis based on National health insurance claims data. Heliyon. 2024;10(12):e33047. PubMed PMID: 39021963; PubMed Central PMCID: PMCPMC11252976.

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