JAC Antimicrob Resist
doi:10.1093/jacamr/dlaa093

JAC-Antimicrobial Resistance

Oral and parenteral antibiotic use in Norwegian nursing homes: are primary care institutions becoming our new local hospitals?

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Received 6 July 2020; accepted 23 September 2020

Background: Norwegian nursing homes (NHs) have over the last 10 years increasingly applied the use of parenteral treatment, which in turn allows more broad-spectrum use of antibiotics. Previous studies from Norwegian NHs have for the most part not described parenteral formulations.

Objectives: To describe systemic antibiotic use in Norwegian NHs.

Methods: Thirty-seven NHs in the county of Østfold, Norway, were invited to participate in this retrospective cross-sectional study. Associated pharmacies provided sales data for systemic antibiotic use for the participating NHs for 1 year (October 2015 to October 2016). General institutional characteristics were collected through a questionnaire.

Results: Thirty-four NHs participated in the study. Mean use of antibiotics was 9.5 DDD/100 bed days (range 0.6–30.9 DDD/100 bed days). Oral antibiotics accounted for 83% and parenteral antibiotics for 17% of the total antibiotic use. Of parenteral antibiotics, ampicillin was most used (31.1%) followed by cefotaxime (17.7%) and penicillin G (16.6%). The proportion of antibiotics compliant with guideline recommendations was 60%. Being a short-term NH was associated with increased antibiotic use, with an unstandardized coefficient of 13.1 (95% CI 4.2–21.9; $P = 0.005$).

Conclusions: We found a high level of total and parenteral antibiotic use compared with previous studies from Norwegian NHs. Data showed wide variations in total antibiotic use and that only a moderate proportion of the antibiotic use was considered guideline compliant. This highlights the necessity of further implementation strategies regarding the national guidelines for antibiotic use in NHs.

Introduction

The challenges posed by antimicrobial resistance (AMR) are increasing worldwide. Antibiotic use according to guidelines is essential since an overuse of broad-spectrum agents (BSAs) is the main driver for AMR.[1,2] Globally, an increase in infections and colonization pressure from antibiotic-resistant bacteria is also reported in nursing home (NH) residents.[3–5] Antibiotics may also cause untoward drug interactions and adverse reactions. Frail and elderly patients, often subjects of polypharmacy, are particularly prone to these complications.[6]

Norway has more than 900 NHs with a total of approximately 40 000 residents. The average nursing home resident is 85 years of age, often has several diagnoses and is cognitively and physically debilitated, which complicate the diagnosis e.g. of infections.[7,8] The prevalence of bacterial infections is higher within the NH population than in the elderly living at home, and they more often require antibiotic treatment for their conditions.[9] A retrospective analysis of patients in a large Norwegian NH showed that about half of the NH residents would receive one or more courses of antibiotics during a calendar year.[10] In Norway, NHs and hospitals each account for approximately 8% of the total human antibiotic use.[1]

Urinary tract infection (UTI) is the main indication for antibiotic prescribing in NHs.[11–15] However, a common pitfall in interpretation of surveillance data is asymptomatic bacteriuria (ABU) commonly being reported as UTI.[16–20] Several drugs, both antibiotics and other substances, are used prophylactically against recurrent UTIs.[11,14,15,21] The UTI prophylactic agent methenamine, a urinary tract antiseptic, is frequently used in Norway and accounted for 24% of the total human antibacterial consumption in 2018.[1]

In the last decade, Norwegian NHs have increasingly provided parenteral treatment to residents.[22,23] In part, this has coincided with the introduction of the Norwegian Care Coordination Reform effective as of January 2012,[24] whereby more resources are allocated to public healthcare to alleviate rising pressure on the hospital system. Few oral BSAs are available in Norway, and more widespread parenteral antibiotic therapy in NHs may have contributed to higher BSA use driving antibiotic resistance. To our knowledge, only two other studies have described the use of parenteral antibiotics in Norwegian NHs[11,22] and both were conducted before the introduction of the National Care Coordination Reform.

Previous studies have shown significant variations in the total use of antibiotics between NHs both in Norway[11,22,25] and abroad.[26–28] Such differences may in part stem from differences in the case mix of residents, but need to be investigated further for quality improvement purposes. In a recent point-prevalence study conducted in 540 Norwegian NHs, 7.2% of NH residents received antibiotic treatment, a high prevalence compared with other point-prevalence studies from European NHs.[15,29] Further investigations of antibiotic use in Norwegian NHs seem therefore warranted to identify potential improvement areas.

Since 2013, specific guidelines for antibiotic use in NHs were added to the national guidelines for the use of antibiotics in primary care.[30] The guidelines are well known and have a high standing among primary care physicians.

The aims of this study were to: (i) examine the patterns and variability of oral and parenteral antibiotics in 34 Norwegian NHs; (ii) search for predictors of high and low antibiotic use; and (iii) assess compliance with the national guideline recommendations to identify potential improvement areas.

Materials and methods

Ethics

The Regional Committees for Medical and Health Research Ethics of South-East Norway granted ethics approval for the study (ref.: 30475). Municipality officials of the participating institutions gave written consent before the start of the project for pharmacy sales data to be retrieved for research purposes.

Study design

In this retrospective cross-sectional study, we analysed 1 year of antibiotic sales data to NHs between October 2015 and October 2016. We invited all 37 NHs in the Østfold county by e-mail and phone calls to participate. Østfold is Norway's fifth most populated county, with approximately 300 000 inhabitants. NHs purchase drugs directly from the pharmacies. Drugs are ordered by the NHs in batches and not individually for each resident, i.e. reports of drug consumption are based on aggregated sales data.

Most NH physicians in Norway are GPs who combine their work at the NH with their practices. In some municipalities and cities, large NHs have employed physicians on a full-time basis. During weekends and outside of ordinary working hours, the NH nurses usually consult GPs working at out-of-hours services when acute medical care is required.[23] If a resident acquires a bacterial infection requiring treatment, the physician prescribes an antibiotic, which is administered by a nurse from the NH's stock or ordered from the pharmacy.

Data collection and antibiotic classification

We retrieved sales data electronically from the pharmacy's database containing the dates of purchase, customer characteristics, generic drug name, Anatomical Therapeutic Chemical (ATC) code, administration form and total DDDs from all participating NHs. One DDD of an antibiotic is defined as the assumed average daily dose used for its main indication in adults.[31] We used the Anatomical Therapeutic Chemical Index (ATC/DDD) version 2016.[32] All analyses were performed at the ATC fourth (ATC4) or fifth level (ATC5)[33] and included antibiotics for systemic use (ATC group J01), oral metronidazole (P01AB01), oral rifampicin (J04AB02) and oral vancomycin (A07AA09). The number of bed days was calculated per NH as the number of beds × occupancy rate as of September 2016. Antibiotic consumption was registered as aggregated pharmacy sales data and measured in DDDs per 100 occupied bed days (BD).

Sales data contain no information about indications for use; hence we classified the oral antibiotics into four separate groups based on the main indication for each antibiotic according to the national guidelines for antibiotic use (Table S1, available as Supplementary data at *JAC-AMR* Online). At an aggregated level of NH categories, analyses of these four antibiotic indication groups give insights into the magnitude of antibiotic use and the patterns of substance distribution.[11,25] To further validate our indication group classification, we examined three point-prevalence surveys on infections and antibiotic use in Østfold NHs, conducted between May 2015 and May 2016.[34] These surveys showed that oral antibiotics for UTI (UTI-ABs) accounted for 73/81 (90%) of all oral treatments for UTIs and oral antibiotics for respiratory tract infection (RTI-ABs) accounted for 51/58 (88%) of all oral treatments for RTIs, while oral skin and soft tissue antibiotics (SSTI-ABs) constituted 12/22 (55%) of all oral treatments for these indications. The low share of oral SSTI-ABs is partly due to penicillin V, which the guidelines recommended for erysipelas. However, penicillin V was registered only in 4/22 (18%) of oral treatments for SSTIs in the prevalence surveys. On the contrary, 17/23 (74%) of all penicillin V prescriptions in the surveys were for RTIs and thus it was defined as an RTI-AB antibiotic by us. The remaining oral antibiotics were denoted as the fourth indication group, and all intravenously administered antibiotics (IV-ABs) as the fifth indication group. The urinary tract antiseptic methenamine (J01XX05) was classified and analysed separately since the agent is not an antibiotic *sensu stricto*. To approximate a quality judgement of antibiotic use, we labelled each antibiotic agent within the indication groups as guideline compliant or guideline deviant according to the national recommendations (Table S1).[30]

Nursing home characteristics

The participating NHs received a questionnaire before the study, asking for general information such as the numbers of beds, wards and personnel; ward type; occupancy rate; physician-hours per week; and total nurse full-time equivalents (FTEs). After receiving the completed questionnaires, the study team contacted the responsible municipal authorities by phone to verify that the information given was indeed correct. We classified the NHs into different categories based on the type of residency: long-term, short-term and mixed NHs. Long-term NHs covered residents with a permanent stay with physical frailties and dementia; short-term NHs covered residents with a time-limited rest and somatic diseases mainly in need of medical treatment, physical rehabilitation and/or palliative care. Mixed NHs had both long-term and short-term residents. Finally, NH sizes were categorized based on their number of beds: small NHs (0–40 beds), medium NHs (41–69 beds) and large NHs (≥70 beds).

Data analyses

Antibiotic use was measured in DDD/100 BD for each NH, and a weighted mean was calculated for all NHs and per NH category. We determined the relative distribution of single antibiotics and indication groups as a percentage of aggregated total DDDs. Differences between the categories of NH regarding proportions of oral UTI-ABs, oral RTI-ABs and IV-ABs as well as between appropriate and inappropriate antibiotics were examined by the two-sample test of proportions. The use of oral antibiotics in total DDDs was also calculated and ranked from high to low within their respective indication groups. We used linear regression to identify any association on an institutional level with overall and UTI-AB use. In subsequent multivariate analyses, we included all independent factors with a P value <0.2 in the univariate analyses.

We used IBM SPSS® 25.0[35] and STATA 16[36] statistics programs for all statistical analysis.

Results

We included 34 (92%) of 37 NHs in the county of Østfold, representing approximately 4.6% of all NH beds in Norway. Of the three NHs not included, one was undergoing renovation at the time of data collection and two did not respond to the invitation. There were 14 long-term, 3 short-term and 17 mixed NHs. Ten were small, 15 were medium-sized and 9 were large. Single rooms accounted for 99.2% of the total number of beds. Mean doctor hours per bed per week were 0.48 (range 0.16–1.56) and mean nurse FTEs per bed 0.37 (range 0.20–0.83).

Total antibiotic use (excluding methenamine)

Mean overall use of antibiotics was 9.5 DDD/100 BD (range 0.6–30.9) (Figure 1). There was an approximately 4-fold difference in mean antibiotic use between long-term NHs (7.1 DDD/100 BD; range 0.6–10.0) and short-term NHs (27.8 DDD/100 BD; range 19.2–30.9). Mean antibiotic use for mixed NHs was 9.1 DDD/100 BD (range 3.9–15.2). Both UTI-AB and RTI-AB use showed a trend towards increased use during the cold months and decreased use during the warm months. The most used antibiotic groups, measured in DDDs and ranked from high to low, were penicillins (69.6%), sulfonamides and trimethoprim derivatives (6.9%), fluoroquinolones (5.2%), cephalosporins (4.9%), tetracyclines (4.0%) and nitrofuran derivatives (2.6%). Penicillins with extended spectrum represented the majority of overall antibiotic use (47.7%), followed by β-lactamase-susceptible- (13.0%) and β-lactamase-resistant (8.4%) penicillins. The total number of different antibiotics used by the participating NHs was 39 (range 2–31).

Oral antibiotic use (excluding methenamine)

The proportion of oral UTI-ABs was 43% and that of oral RTI-ABs was 29%, while SSTI-ABs and other oral antibiotics were 7% and 4% of total DDDs, respectively. Pivmecillinam was the most-used oral antibiotic, representing 35.3% of all oral antibiotics (Table S2) and 67.7% of oral UTI-ABs (Table 1). Amoxicillin was the second most-used oral antibiotic overall (15.3%) (Table S2) and the most-used oral RTI-AB (44.7%) (Table 2). Penicillin V, being the recommended first-choice oral antibiotic for RTI-ABs, was the third most-used oral antibiotic (12.2%) (Table S2) and second most-used oral RTI-AB (35.5%) (Table 2). Overall, penicillins accounted for 70.3% of all oral antibiotics (Table S2).

Parenteral antibiotic use

In terms of IV-AB use, there was a 7-fold difference between the NHs with the highest and lowest use (range 0.0–7.4 DDD/100 BD). Two long-term NHs did not use any IV-ABs. Mean total IV-AB use in short-term NHs was 6.2 DDD/100 BD, while for mixed and long-term NHs it was 1.4 and 1.0 DDD/100 BD, respectively. IV-ABs represented 17% of all antibiotics measured in DDDs. Proportion-wise,

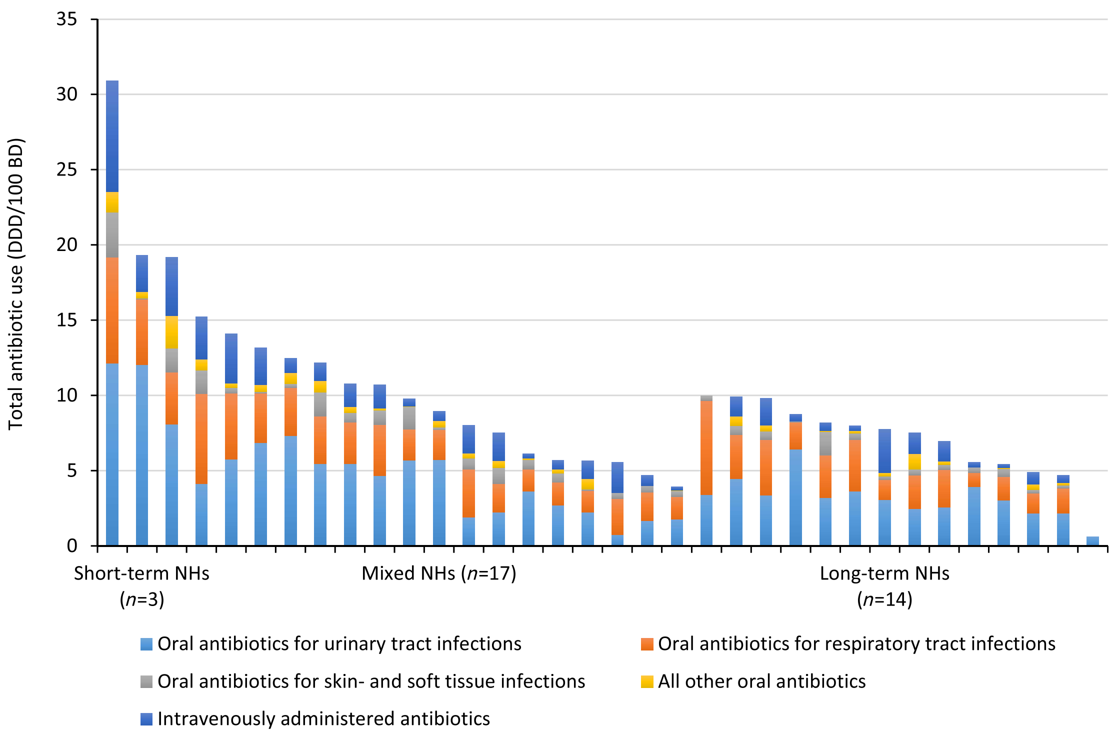

Figure 1. Total antibiotic use in DDD/100 BD (excluding methenamine) in 34 NHs in Østfold County, arranged by NH category.

Table 1. Use and distribution of oral UTI-ABs by category of NH in Østfold County

ATC 5	Oral UTI-AB	Short-term NHs (*n* = 3), DDD (%)	Long-term NHs (*n* = 14), DDD (%)	Mixed NHs (*n* = 17), DDD (%)	Total oral UTI-ABs, DDD (%)
J01CA08	pivmecillinam	3630 (71.3%)†***	5540 (64.4%)§***	9257 (68.4%)¶***	18 427 (67.7%)
J01MA01/02	ofloxacin/ciprofloxacin	533 (10.5%)	972 (11.3%)§**	1369 (10.1%)	2874 (10.5%)
J01EE01	co-trimoxazole	561 (11.0%)†***	707 (8.2%)§***	1353 (10.0%)¶*	2621 (9.6%)
J01EA01	trimethoprim	158 (3.1%)†***	777 (9.0%)§**	750 (5.5%)¶***	1685 (6.2%)
J01XE01	nitrofurantoin	207 (4.1%)†***	608 (7.1%)§**	809 (6.0%)¶***	1624 (6.0%)
Total oral UTI-ABs		5089 (100%)	8604 (100%)	13 538 (100%)	27 231 (100%)

Two-sample test of proportions to identify differences between categories of NHs: †short-term versus long-term NHs, §long-term versus mixed NHs, ¶mixed versus short-term NHs; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 2. Use and distribution of oral RTI-ABs by category of NHs in Østfold County

ATC 5	Oral RTI-AB	Short-term NHs (*n* = 3), DDD (%)	Long-term NHs (*n* = 14), DDD (%)	Mixed NHs (*n* = 17), DDD (%)	Total oral RTI-ABs, DDD (%)
J01CA04	amoxicillin	1483 (54.7%)†***	2752 (44.2%)§**	3755 (42.0%)¶***	7990 (44.7%)
J01CE02	penicillin V	878 (32.4%)†***	2355 (37.8%)§***	3135 (35.0%)¶*	6368 (35.5%)
J01AA02	doxycycline	210 (7.7%)†***	758 (12.2%)§*	3135 (35.0%)¶*	2179 (12.2%)
J01FA01	erythromycin	135 (5.0%)	315 (5.1%)§***	780 (8.7%)¶***	1230 (6.9%)
J01FA09/10	clarithromycin/azithromycin	7 (0.3%)†**	50 (0.8%)§*	67 (0.5%)	124 (0.7%)
Total oral RTI-ABs		5089 (100%)	8604 (100%)	13 538 (100%)	17 891 (100%)

Two-sample test of proportions to identify differences between categories of NHs: †short-term versus long-term NHs; §long-term versus mixed NHs; ¶mixed versus short-term NHs; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

penicillins accounted for 65% of total IV-ABs (Table 3). Ampicillin was the most used IV-AB overall, representing 31.1% of total IV-ABs and 47.9% of penicillin IV-ABs. Penicillin G accounted for 25.5% of all penicillin IV-ABs and 16.6% of total IV-ABs. The second-largest IV-AB group was the cephalosporins, almost exclusively second- and third-generation agents, representing 24.8% of total IV-ABs (Table 3). Cefotaxime, being the second most-used IV-AB overall, represented 17.7% of IV-ABs. Combined, penicillins and cephalosporins accounted for 89.8% of total IV-ABs.

Antibiotic use according to guidelines

The proportion of guideline compliant antibiotic use was 60% of total DDDs, with no significant difference between the NH categories.

Institutional factors associated with antibiotic use

Being a short-term NH was associated with increased antibiotic use, with an unstandardized coefficient of 13.1 (4.2–21.9; $P = 0.005$) (Table 4). All other independent factors were non-significant. Short-term NHs were also associated with the increased use of oral UTI-ABs, with an unstandardized coefficient of 7.26 (95% CI 3.9–10.6; $P < 0.001$) (Table S3).

Methenamine

Methenamine accounted for the majority of all antibiotic DDDs reported (36%). Mean total methenamine use was 5.3 DDD/100 BD. As for most other study drugs, the use of methenamine also varied considerably between the different NHs, ranging from 0.0 to 19.0 DDD/100 BD. Two NHs did not use methenamine. Methenamine use correlated positively with UTI-AB use, with an unstandardized coefficient of 0.31 (95% CI 0.19–0.44; $P < 0.001$) (Table S3).

Discussion

This study examined 1 year of antibiotic use in 34 nursing homes in the county of Østfold, Norway. We found a high use of antibiotics: higher by approximately 20% than in two previous Norwegian studies (when excluding methenamine),[11,25] and higher by 110% than in a 2016 French study[37] and 30% than in a 2017 Dutch study.[27]

The majority of antibiotics were administered orally, in proportions similar to those found in previous studies conducted in Norwegian NHs.[14,15,25,38] Oral UTI-ABs were used most, which we believe represents both adequate treatment of UTIs and treating ABU. Strengthening the assumption that ABU is responsible for a large proportion of UTI treatments in NH residents, D'Agata *et al.*[39] found in an NH population that antibiotic treatment was initiated in three-quarters of bacteriuric episodes that lacked minimum criteria to justify UTI therapy, while Sundvall *et al.*[40] found that a positive urine culture was not more common among Swedish NH residents with non-specific symptoms of urinary tract infection compared with asymptomatic residents. A recent antimicrobial

Table 3. Use and distribution of parenteral antibiotics (IV-ABs) by category of NHs in Østfold County

ATC 4	IV-AB	Short-term NHs (*n* = 3), DDD (%)	Long-term NHs (*n* = 14), DDD (%)	Mixed NHs (*n* = 17), DDD (%)	Total IV-ABs, DDD (%)
J01CA	penicillins with extended spectrum	351 (13.0%)†***	877 (31.3%)§***	2114 (43.1%)¶***	3342 (32.1%)
J01DC/DD	second- and third-generation cephalosporins[a]	668 (24.8%)†***	857 (30.6%)§***	1040 (21.2%)¶***	2565 (24.6%)
J01CE	β-lactamase-susceptible penicillins	385 (14.2%)†***	543 (19.4%)§***	798 (16.3%)¶*	1726 (16.6%)
J01CF	β-lactamase-resistant penicillins	503 (18.6%)†***	285 (10.2%)	503 (10.3%)¶***	1291 (12.4%)
J01CR	combination of penicillins, including β-lactamase inhibitors[a]	223 (8.2%)†***	46 (1.6%)§**	134 (2.7%)¶***	403 (3.9%)
J01MA	fluoroquinolones[a]	216 (8.0%)†***	60 (2.1%)	116 (2.4%)¶***	392 (3.8%)
J01FF	lincosamides	58 (2.2%)†***	20 (0.7%)§***	122 (2.5%)	200 (1.9%)
J01DH/J01DF	carbapenems[a] and monobactams	112 (4.1%)†***	24 (0.9%)§**	20 (0.4%)¶***	156 (1.5%)
J01GB	aminoglycosides	83 (3.1%)†***	0 (0.0%)§**	15 (0.3%)¶***	98 (0.9%)
J01DB/J01FA/J01X	other IV-ABs[b]	104 (3.8%)	87 (3.1%)§***	45 (0.9%)¶***	236 (2.3%)
Total IV-ABs		2703 (100%)	2799 (100%)	4907 (100%)	10 409 (100%)

Two-sample test of proportions to identify differences between categories of NHs: †short-term versus long-term NHs; §long-term versus mixed NHs; ¶mixed versus short-term NHs; $*P < 0.05$; $**P < 0.01$; $***P < 0.001$.
[a]Broad-spectrum antibiotics in hospitals according to the Norwegian 'Action plan against antibiotic resistance in the health services'.
[b]J01DB03 cephalothin, J01FA01 erythromycin, J01XD01 metronidazole, J01XA01 vancomycin.

Table 4. Linear regression to identify factors associated with total antibiotic use in DDD/100 bed days for each nursing home (excluding methenamine)

	Univariate			Multivariate[a]		
Factor	β	95% CI	*P*	β	95% CI	*P*
Nursing home category						
long-term	ref.			ref.		
mixed	2.01	(−0.48 to 4.67)	0.107	1.64	(−1.28 to 4.56)	0.259
short-term	16.14	(11.61–20.68)	<0.001	13.06	(4.24–21.88)	0.005
Size of nursing home						
small	ref.			ref.		
medium	−3.81	(−8.32 to 14.70)	0.095	−0.78	(−4.16 to 2.60)	0.640
large	−016	(−5.24 to 4.92)	0.948	0.92	(−2.70 to 4.55)	0.605
Doctor hours/bed/week[b]	13.52	(8.87–18.18)	<0.001	2.57	(−6.17 to 11.31)	0.551
Nurse FTEs/bed[b]	3.33	(0.52–6.15)	0.022	0.98	(−14.85 to 16.81)	0.899
Constant				6.02	(−0.61 to 12.65)	0.074

ref., reference.
[a]$R^2 = 0.656$.
[b]Continuous variable.

stewardship study reported that, after an intervention, the incidence of antimicrobial use for unlikely cystitis was reduced by 27% with no subsequent increase in complications.[41]

The proportion of IV-ABs in our study is markedly higher than in a Norwegian study from 10 years earlier, when only 1% of DDDs were administered parenterally.[11] Following the Care Coordination Reform in 2012, the municipalities got more responsibility and also economic incentives to treat NH residents locally. Also, the reform has reduced the length of hospital stay, as was the intention, leading to patients more often being discharged to the NHs with ongoing parenteral treatment. A certain 'contamination effect' of hospital physicians' choice and administration of antibiotics might also have contributed to an increase in the use of both IV-ABs and BSAs in NHs. Together, these factors have effectively increased the use of IV-ABs in the NHs. The large share of cephalosporin use in our study may in part be explained by the Norwegian guideline recommendations of second- and third-generation cephalosporins as first-choice agents for IV-AB treatment of pyelonephritis.[30] Of the few comparable studies we found, a Dutch study reported an IV-AB share of 9.0%–16.4%, a result in the same range as ours.[42]

We find similar trends in antibiotic choice in this study compared with other Scandinavian countries, but a markedly lower proportion of quinolones (J01M), other β-lactams (J01D) and combinations of penicillins (J01CR) than what is reported from several southern and central/eastern European countries.[13,29] Higher resistance rates in these countries are part of the reason for this finding. Still, this is a paradox since higher resistance rates increase the need for more broad-spectrum empirical options, thus worsening the already existing problem.

The significant variation in total antibiotic use between the NHs found in our study has already been described previously both in Norway and internationally.[11,22,25–28] Short-term NHs had a significantly higher antibiotic use, which is no surprise as the residents in these institutions are, for the most part, recently discharged from hospital and/or on active rehabilitation or palliation. This finding is in line with Fagan *et al.*,[38] who found that short-term wards had a higher total antibiotic use than long-term wards, and Eriksen *et al.*,[12] who found that prevalence of nosocomial infections was highest in rehabilitation and short-term wards. We did not find any significant association between total antibiotic use and size of the NH, contradicting two previous studies where larger NHs used fewer antibiotic doses,[11,13] nor did we observe any effect of doctor hours per bed per week or nurse FTEs per bed. Also, we observed considerable variations within the different NH categories that may not be explained by the factors in the regression analysis, illustrating that the antibiotic use in NHs is complex and multifactorial.

We found that approximately 40% of all antibiotic doses were guideline deviant according to our definition, reflecting a moderate adherence to the national guideline recommendations. Interestingly, the proportion of guideline-compliant antibiotic use did not differ significantly between the different NH subgroups, contradicting Fagan *et al.*,[38] who observed a higher proportion of non-compliant prescribing in short-term than long-term wards. One reason for the high percentage of guideline-deviant antibiotic use is that we lacked the necessary data to differentiate between simple and complicated cases of infections. As a prevalent example, ampicillin and amoxicillin are regarded as guideline-compliant antibiotics when prescribed for pneumonia caused by exacerbation of COPD but are guideline deviant for our only category of 'simple' pneumonia.

The four recommended antibiotics for oral UTI-ABs accounted for approximately 90% of DDDs overall in this indication group. Although we believe that a substantial number of treatments for UTI in NH residents are unnecessary, this result indicates an acceptable adherence to the national recommendations for the choice of antibiotic regimens. The Norwegian action plan against antimicrobial resistance,[43] published in December 2015, targets five selected BSA groups (combinations of penicillins, including β-lactamase inhibitors, second- and third-generation cephalosporins, carbapenems and fluoroquinolones) to be reduced overall by 30% in Norwegian hospitals by the end of 2020, compared with 2012.[44] Applying the same classification of BSAs in our study, we find an overall low proportion of 4.1% compared with an overall BSA proportion of 23.5% at our county hospital (Østfold Health Trust) during the same period.

The use of methenamine exclusively as a urinary antiseptic drug is a trait peculiar to Norway and Finland,[29,45] and this drug accounted for one-third of total DDDs in this study. Several authors have commented on the extensive consumption of methenamine by Norwegian NH residents.[11,15,21] The use of methenamine is increasing in Norway,[1] which is interesting in the light of a recent Cochrane review stating no effect of methenamine as a long-term UTI prophylaxis.[46] On a single NH level, our data show a positive correlation between the use of methenamine and the use of oral UTI-ABs (Table 4). This association might strengthen the conclusion that methenamine lacks any effect in long-term UTI prevention as described in the Cochrane review.

The main limitation of this study is that sales data from pharmacies may not accurately reflect antibiotics consumed by residents, and no clinical indication for actual prescriptions is available. We have no information on the proportion of antibiotics not used on patients due to surplus ordering, disposal or exceeding their expiry date. On the other hand, when we examined the sales data, the participating NHs tended to order antibiotics in frequent and small batches, indicating that they usually order antibiotics when needed. The expiration dates for antibiotics are generally between 2 and 5 years for both oral and IV agents, giving the NHs sufficient time to use the antibiotics ordered, but not necessarily during the time of the study. Due to the shortcomings of the analysed data in assessing indication and guideline compliance, these classifications only represent assumptions, and should therefore be interpreted with great caution. To better understand prescribing patterns, information regarding indications, duration of antibiotic treatments and investigation of microbiological laboratory data is needed. The high rate of NH participation should be considered a strength of the study.

Conclusions

To our knowledge, this is the first study describing both oral and parenteral antibiotic use and giving an overview of current prescribing patterns in Norwegian NHs after the introduction of the Norwegian Care Coordination Reform. A marked increase in both total and parenteral antibiotic use compared with previous studies, all conducted before the initiation of the reform, suggest that especially short-term NHs may increasingly be regarded as new 'local hospitals' in Norway. We found a wide variation in both total antibiotic use and methenamine use between the different NHs, where short-term NHs had a 4-fold higher mean antibiotic use than long-term NHs. Adding to the finding that only a moderate proportion of the antibiotic use was considered guideline compliant, this highlights the need for more active implementation strategies of the national guidelines for antibiotic use in the NH sector.

Acknowledgements

The authors thank the participating NHs and their respective municipalities who gave consent and participated in this study. The authors also thank Gunnar Fyllingen at Apotek 1 for the contribution of pharmacy data, Svein Gjelstad and Ibrahimu Mdala for help with statistical analyses and Hege Salvesen Blix for valuable comments and evaluation of the manuscript.

Funding

This work was supported by the Norwegian Research Fund for General Practice.

Transparency declarations

None to declare.

Supplementary data

Tables S1 to S3 are available as Supplementary data at *JAC-AMR* Online.

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