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Antibiotic consumption at 46 VINCat hospitals from 2007 to 2009, stratified by hospital size and clinical services

Santiago Grau[a,*], Esther Fondevilla[b], Sergi Mojal[c], Mercedes Palomar[d], Jordi Vallès[e] and Francesc Gudiol[f], on behalf of VINCat Antimicrobial Group[☆]

[a]*Pharmacy Service, Hospital del Mar, Parc de Salut Mar, Universitat Autònoma de Barcelona, Barcelona, Spain*
[b]*Coordinating Center of the VINCat Program, Barcelona, Spain*
[c]*Biostatistics Assistance Service, IMIM, Barcelona, Spain*
[d]*Department of Intensive Medicine, Hospital Universitari Vall d'Hebron, Barcelona, Spain*
[e]*Department of Intensive Medicine, Hospital de Sabadell, Sabadell, Barcelona, Spain*
[f]*Department of Infectious Diseases, Hospital Universitari de Bellvitge, L'Hospitalet de Llobregat, Barcelona, Spain*

Keywords:
Antibiotic consumption
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A B S T R A C T

The aim of the study was to assess the evolution of antibiotic consumption in acute care hospitals in Catalonia (population 7.5 million), according to hospital size and department, during the period 2007-2009.

The methodology used for monitoring antibiotic consumption was the ATC/DDD system, and the unit of measurement was DDD/100 occupied bed-days (DDD/100 OBD). Hospitals were stratified according to size: I) large university hospitals (with more than 500 beds); II) medium-sized hospitals (between 200 and 500 beds); and III) small hospitals (fewer than 200 beds). The consumption was also analyzed and stratified according to department: medical, surgical and intensive care unit (ICU). Specific training in data management on antibiotic consumption was given to all participant hospitals before the implementation of the program.

The mean antibiotic (J01) consumption, calculated in DDD/100 OBD, increased although without statistical significance (p=0.640): 74.68 (2007), 75.13 (2008) and 78.04 (2009). The values of the medians expressed in DDD/100 OBD in group I were 83.27 (in 2007), 82.16 (2008) and 86.93 (2009), in group II 72.60 (2007), 70.78 (2008) and 75.17 (2009) and in group III 65.66 (2007), 69.32 (2008) and 72.39 (2009). Antibiotic consumption was higher in large hospitals than in medium-sized or small hospitals.

Catalan hospitals recorded an increase of 4.49% from 2007 to 2009, especially due to the rising use of carbapenems, cephalosporins, monobactams and the other antibiotic groups.

Palabras clave:
Consumo de antibióticos
Estudio nacional
DDD

Consumo de antibacterianos en 46 hospitales VINCat de 2007 a 2009, estratificado por tamaño de hospital y servicios clínicos

R E S U M E N

El objetivo del estudio fue evaluar la evolución del consumo de antibióticos durante el periodo 2007-2009 en hospitales de agudos en Cataluña, estratificados por número de camas y servicios.

La monitorización del consumo de antibióticos se efectuó siguiendo el sistema ATC/DDD y utilizando como unidad de medida las DDD/100 estancias.

Los hospitales fueron estratificados según el número de camas: *a)* hospitales universitarios de gran tamaño (más de 500 camas); *b)* medianos (entre 200 y 500 camas), y *c)* pequeños (menos de 200 camas). El consumo también fue analizado y estratificado por servicios: médicos, quirúrgicos y unidades de cuidados intensivos. Previamente al inicio del estudio se impartió una formación específica para la recogida estandarizada de la información sobre consumo de antibióticos.

Durante el período de estudio se observó un aumento en la media de consumo de antibióticos (J01) calculada en DDD/100 estancias sin alcanzar significación estadística (p = 0,640): 74,68 (2007), 75,13 (2008) y 78,04 (2009).

*Corresponding author.
E-mail: sgrau@parcdesalutmar.cat (S. Grau).

☆A detailed list of the members is available at additional data of the electronic version of the supplement.

Los valores de las medianas expresadas en DDD/100 estancias fueron de 83,27 (2007), 82,16 (2008) y 86,93 (2009) en el grupo I, de 72,60 (2007), 70,78 (2008) y 75,17 (2009) en el grupo II, y de 65,66 (2007), 69,32 (2008) y 72,39 (2009) en el grupo III. El consumo de antibióticos fue superior en los hospitales de mayor tamaño.

En el período 2007-2009 se observó un aumento del 4,49% en el consumo de antibióticos, destacando los carbapenemes, cefalosporinas, monobactámicos y el grupo de otras moléculas.

Introduction

The appropriate prescription of antibiotics is essential to reducing the development of bacterial resistance and to controlling hospital infections. Therefore, information on antibiotic consumption may help to improve prescription practices. Some European countries have recently implemented projects based on a standardized methodology for monitoring antibiotic use, both in local programs (STRAMA in Sweden, SWAB in the Netherlands, DANMAP in Denmark, RAISIN-CCLIN in France, NORM NORM-VET in Norway, HSE-HPSC in Ireland)[1-7] and in Europe-wide programs such as the European Surveillance of Antimicrobial Consumption (ESAC).[8,9] These studies provide specific indicators that can help to establish measures for promoting a more rational use of antibiotics.

In 2006, the VINCat surveillance program for nosocomial infections in acute care hospitals in Catalonia (Spain) was established. The program's main objective is to help reduce the rates of these infections by means of active, continued and epidemiological surveillance. Among the program's six broad surveillance objectives, one is standardized monitoring of hospital antimicrobial consumption.

The aim of the present study was to assess the evolution of antibiotic consumption in acute care hospitals in Catalonia (population 7.5 million), according to hospital size and department, during the period 2007-2009.

Methods

Study design

All Catalan hospitals that met the VINCat Program's minimum conditions[10] were invited to participate in a voluntary registration of their antibiotic consumption. In a retrospective observational study during the first trimester of each year from 2008 to 2010, 46 (74%) of 62 Catalan hospitals (excluding paediatric and cancer hospitals) agreed to record their annual consumption, hospital characteristics and activity indicators from 2007 to 2009.

Hospitals were stratified according to size: I) large university hospitals (with more than 500 beds); II) medium-sized hospitals (between 200 and 500 beds); and III) small hospitals (fewer than 200 beds). Overall consumption was also analyzed and stratified according to department: medical, surgical and intensive care unit (ICU). However, in 2007, consumption was divided only into ICU and non-ICU departments. The general characteristics of the participating hospitals were also recorded.

Data collection

The VINCat Coordination Center (VINCat CC) was responsible for establishing the same criteria in the compilation data, including hospital wards and classification of the medical, surgery and ICU departments for all hospitals. Consumption of antibiotics (J01) from the ATC (Anatomical Therapeutic Chemical) classification[11] for systemic use was recorded. All consumption from acute care hospitals was counted, including surgical prophylaxis, except: paediatrics (defined daily dose [DDD] always refers to adults), hospital wards that generated very low antibiotic consumption (e.g. psychiatry), and those that did not generate occupied bed-days (OBD), such as emergency services, outpatient clinics, outpatient dispensary units and day hospitals. The lists of wards included or excluded and the services provided by each department are shown on the VINCat Program Website[10].

In order to ensure standardized data collection, a pharmacist from the VINCat CC team provided specific training in antibiotic consumption data management to the pharmacy services of all participating hospitals before the program was implemented. The data collected was then assessed and validated, and finally antibiotic consumption was calculated and measured in DDD/100 OBD. Antibiotic consumption data were also audited. Hospitals that provided data obtained using non-standardized methods were excluded.

The hospital pharmacists collected and entered annual data through an online program at the most basic level: units of medication consumed, OBD, discharges and hospital characteristics. Then all data were downloaded and processed by the VINCat CC using a local program designed and built by a member of this center. The program was permanently updated to incorporate new antimicrobials and new commercial presentations coming onto the market.

This central program was inspired by ABC Calc software,[12] developed by the Statens Serum Institute of Denmark. It also incorporated some improvements, as this new system was able to recognize every medicine, not only the drug. It also automatically converted the data to DDD/100 OBD, for six types of association: antibiotics; therapeutic subgroup; chemical subgroup; chemical substance; chemical substance with route of administration; and medicine, without the need to include the grams per unit dose. The chemical substances included in the J01X group (other antibiotics group) according to ATC classification were metronidazole, vancomycin, teicoplanin, colistin, linezolid, daptomycin, fosfomycin and nitrofurantoin.

Measurement of drug consumption

The methodology used for monitoring antibiotic consumption was the ATC/DDD system,[11,13] developed by the Drug Utilization Research Group and the Nordic Council of Medicines, revised and periodically updated by the WHO's International Working Group for Drug Statistics Methodology.

The ATC/DDD system is a research tool that allows the comparison of drug consumption in different hospitals, regions and countries. It is also an international classification system for drugs used in studies of consumption. Drugs are classified into groups according to the organ or system on which they act and according to their chemical, pharmacological and therapeutic properties. The DDD is the habitual mean daily maintenance dose of a drug used for its main indication in adults. This is a technical measurement unit that may be different from the prescribed daily dose (PDD).

Antibiotic consumption was expressed in DDD/100 OBD and calculated for each hospital according to the following formula: DDD/100 OBD=(consumption/DDD) x (100/OBD). The consumption, expressed in grams and divided by DDD, was transformed into number of DDD. The OBD was obtained by multiplying the number

of beds in each ward with the occupancy rate and with the number of days of the period studied. The occupancy rate was calculated considering the admission and discharge days as a single day.

The consumption (in DDD/100 OBD) of groups I, II, III and all groups was calculated as a weighted mean from the sum of each hospital's consumption expressed in DDD, and divided by the sum of each hospital OBD.

The 2010 update of Defined Daily Doses was applied for calculating the consumption of each year included in the study period.

Statistical analysis

Antibiotic consumption data were presented as DDD/100 OBD. For every year and/or hospital group, overall pooled mean consumption was calculated, aggregating data on antibiotic use from hospitals in each group (year and type of hospital). Evolution over time (trends) and differences between hospital groups were evaluated with a linear mixed model, using consumption data for each hospital and their units, with the hospital as cofactor in all the analyses. P values less than 0.05 were considered statistically significant. All statistical analyses were performed with SPSS 16.0 (SPSS Inc, Chicago, IL).

Results

Participant hospitals and resource indicators

Forty-six acute care hospitals provided data on antibiotic consumption. Seven were from group I (100% of the hospitals in this group) and 13 from group II (81%). In group III, the participation increased from 19 (50%) in 2007, to 25 (66%) in 2008 and 26 (68%) in 2009, as the program expanded. All 39 hospitals that provided data in 2007 participated in 2008 and 2009. In 2009, 34 hospitals provided data from the medical and surgical departments (six in group I, 12 in group II and 16 in group III), and 24 hospitals (100% of VINCat hospitals with ICU) also provided data from the ICU (seven in group I, 12 in group II and five in group III). One hospital from group I was excluded during the validation process (over all three years), and two from group II were excluded (only 2009 data).

In 2009, the total number of beds in these hospitals was 11,028, with a median of 245 per hospital. Group I had 4,849 beds (median 638), group II 3,469 (median 298) and group III 2,710 (median 111). The number of OBD and other characteristics of participating hospitals are described in detail in Table 1.

Trends in hospital use of systemic antibiotics (J01)

Antibiotic consumption in VINCat hospitals increased over the three years of the study, though not significantly, from 74.68 to 78.04 DDD/100 OBD (+4.5%). Antibiotic consumption in the non-ICU departments rose from 71.84 to 75.18 DDD/100 OBD (+4.7%). An increase was also observed from 2008 to 2009 in the medical departments (+5.8%) and the surgical departments (+ 3.0%). ICU antibiotic consumption decreased from 155.28 to 147.11 DDD/100 OBD (-5.3%) between 2007 and 2009. The increases and decreases were not statistically significant in any of the departments. All antibiotic consumption is shown in Table 2, distributed according to hospital size. Consumption by medical departments was higher in small hospitals (group III) than in medium-sized or large hospitals (group II and I). However, antibiotic consumption was higher in the surgical departments and ICUs of the largest hospitals. The differences between large hospitals (group I) and the other two groups of hospitals were significant in all departments, with the exception of medical departments.

The box plot in Figure 1 shows the global consumption for each group of hospitals according to year (2007-2009). The length of the box plots shows the variability in hospital consumption, and the middle line represents the median. The values of the medians expressed in DDD/100 OBD in group I were 83.27 (in 2007), 82.16 (2008) and 86.93 (2009); in group II 72.60 (2007), 70.78 (2008) and 75.17 (2009); and in group III 65.66 (2007), 69.32 (2008) and 72.39 (2009). The range of the consumption of the hospitals in group I was 24.27 (2007), 14.47 (2008) and 13.75 (2009); in group II 57.80 (2007), 28.99 (2008) and 24.38 (2009); and in group III 27.30 (2007), 49.06 (2008) and 55.52 (2009).

The five most frequently used groups of antibiotics were (Table 3): penicillins (J01C), quinolones (J01M), cephalosporins (J01DB, J01DC, J01DD and J01DE), other antibiotics (J01X) and carbapenems (J01DH). In 2009, these antibiotic groups represented 88.9% of total antibiotic consumption. Penicillins (J01C) had the highest consumption in all three hospital groups: 45.5% of the total in group I, 43.3% in group II and 31.7% in group III.

The variability, expressed in % of the difference between 2009 and 2007 of antibiotic consumption by hospital size (Fig. 2), was positive in all hospital groups for carbapenems (J01DH, 44.57%), cephalosporins (J01DB, J01DC, J01DD and J01DE, 7.78%), monobactams (J01DF, 53.33%) and other antibiotics (J01X, 32.05%). In small and large hospitals quinolone consumption (J01M) increased, but penicillin consumption (J01C) decreased.

Amoxicillin/clavulanic acid was the most commonly used antibiotic, both in the ICU (2009: 22.78 DDD/100 OBD, 15.5% of the total antibiotic use, a 1.2% increase between 2007 and 2009) and non-ICU departments (2009: 23.31 DDD/100 OBD, 31.0% of the total antibiotic use, a decrease of 4.7%) (Figs. 3 and 4).

In 2009, piperacillin/tazobactam was the second most commonly used antibiotic in ICU departments (11.67 DDD/100 OBD, a 3.7% decrease between 2007 and 2009), followed by meropenem (9.41 DDD/100 OBD, an increase of 68.4%) and ciprofloxacin (7.79 DDD/100 OBD, a decrease of 32.8%). The greatest increases in antibiotic consumption between 2007 and 2009 were observed in daptomycin (1538%), fosfomycin (977%) and tigecycline (224%).

In non-ICU departments, in 2009, ciprofloxacin was the second most used antibiotic (6.30 DDD/100 OBD, a decrease of 5.6% since 2007), followed by levofloxacin (6.04 DDD/100 OBD, an increase of 18.2%) and ceftriaxone (3.84 DDD/100 OBD, an increase of 20.4% over the three years).

Overall, antibiotic prescription by parenteral route represented 56.82%, 59.79% and 61.17% of consumption in 2007, 2008 and 2009, respectively. In ICU departments, this route represented 88.05% (2007), 88.59% (2008) and 88.77% (2009), in medical departments 52.91% (2008) and 55.06% (2009), and in surgical departments 67.04% (2008) and 64.72% (2009).

Discussion

This is the first study of antibiotic consumption based on a representative sample of acute care hospitals in Catalonia, an autonomous community in Spain. Participation in the study was 100% among large university hospitals, very high in medium-sized hospitals and small hospitals participated in the third year.

Additionally, an upward trend in antibiotic consumption was observed in all departments except the ICU. However, the differences in trends were not statistically significant. Overall, antibiotic consumption was higher in large hospitals than in medium-sized or small hospitals. Major differences in ICU beds, complex surgery, transplant programs, hematology and oncology service activity were observed between the three hospital types, which accounted for the differences in antibiotic consumption. In this regard, in the smaller hospitals the higher consumption is in the medical wards, probably due to the differing profile of patients treated in these hospitals. The decrease in the range of consumption in large and medium-sized hospitals over the three years may have been due to improvements in antibiotic policies or to

Table 1
Main characteristics of Catalan hospitals divided according to hospital size

	Group I	Group II	Group III	Total
No. of hospitals	7	13	26	46
Tertiary care hospitals with transplants	6	0	1	7
Tertiary care hospitals without transplants	1	6	1	8
Secondary care hospitals	0	7	7	14
Primary care hospitals	0	0	16	16
Other	0	0	1	1
Mean ICU beds	28	12	5.60	16.29
Minimum - Maximum	12-53	5-22	5-7	5-53
n (%)	7 (100%)	12 (92%)	5 (19%)	25 (54%)
Mean coronary ICU beds	10.71	4	-	9.22
Minimum - Maximum	4 - 20	2 - 6	-	2-20
n (%)	6 (85%)	2 (15%)	-	8 (17%)
Complex surgery	100%	100%	73%	84%
Neurosurgery	100%	38%	7%	30%
Heart surgery	71%	23%	0%	17%
Plastic surgery	71%	69%	30%	47%
Maxillofacial surgery	85%	69%	30%	50%
Orthopedic surgery	85%	100%	77%	85%
General surgery	100%	92%	77%	85%
Transplant program	100%	7%	4%	20%
Bone marrow transplant	57%	7%	0%	11%
Solid organ transplant	100%	7%	7%	21%
Heart transplant	42%	0%	0%	6%
Kidney transplant	71%	0%	0%	15%
Liver transplant	42%	0%	0%	6%
Lung transplant	28%	0%	0%	2%
Mean no. of infectious disease specialists	6.40	1.58	0.26	1.28
Written antibiotics policy	100%	100%	92%	95%
Guidelines for empirical treatments	100%	100%	77%	87%
Specific antibiotics policy for ICU: n (n ICU)	5 (7)	1 (12)	0 (5)	6 (24)
Global mean OBD 2009	169,641	73,248	26,095	63,141
Minimum	115,525	36,880	5,506	5,506
Maximum	254,406	99,933	53,154	254,406
Global mean discharges 2009	29,295	13,490	5,224	10,646
Minimum	19,711	6,086	865	865
Maximum	42,891	19,387	10,175	42,891
Case mix index	1.9354	1.4853	1.3639	1.4801
Global median mean stay 2009	6.67	5.78	4.8	5.33

Group I: >500 beds; Group II: 200-500 beds; Group III: <200 beds.

the implementation of new policies in response to the annual reports sent to each hospital showing their rates of consumption and nosocomial infections and the benchmark within the group. The increase in the range in small hospitals may be attributable to the entry of new hospitals with very different characteristics. Perhaps in future studies it would be useful to split the small hospitals into two groups with more homogenous characteristics.

Catalan hospitals recorded overall antibiotic consumption of 78.04 DDD/100 OBD in 2009, an increase of 4.49% compared with 2007 (74.68 DDD/100 OBD). This was especially due to the rising use of carbapenems, cephalosporins, monobactams and the other antibiotic groups. Penicillins were the most commonly used antibiotic group in all types of hospital. However, the smaller the hospital, the smaller the DDD/100 OBD of penicillins with regard to total antibiotic consumption. Amoxicillin/clavulanic acid was the most commonly used antibiotic in both ICU and non-ICU departments, followed by piperacillin/tazobactam (in the ICU) and ciprofloxacin (in other departments).

The parenteral route was the most commonly used in all departments. With the exception of the surgical units, all departments increased use of this route of administration during the three years of the survey.

Several nationwide studies in other countries have assessed antibiotic consumption. Rates similar to ours were observed in

Table 2
Consumption of antibiotics for systemic use (J01) in Catalan hospitals between 2007 and 2009, divided by hospital size and expressed in DDD per 100 occupied bed days (OBD)

	Year	Group I	Group II	Group III	P [2]	P [3]	P [4]	Total
Global	2007	82.38	70.40	68.49	0.004	<0.001	0.376	74.68
	2008	84.45	70.64	69.84				75.13
	2009	86.46	73.32	73.33				78.04
	P [1]	0.253	0.499	0.393				0.640
ICU	2007	179.38	130.91	-	0.003	0.027	0.953	155.28
	2008	163.24	121.26	140.35				143.54
	2009	164.93	125.65	133.86				147.11
	P [1]	0.462	0.806	0.446				0.763
Non-ICU	2007	77.74	67.85	68.49	0.034	0.011	0.749	71.84
	2008	77.32	68.30	69.28				71.66
	2009	81.56	71.07	72.64				75.18
	P [1]	0.290	0.425	0.197				0.461
Medical departments	2007	NA	NA	NA	0.200	0.180	0.986	-
	2008	66.97	75.29	79.68				73.03
	2009	74.50	78.78	80.15				77.25
	P [1]	0.096	0.992	0.861				0.669
Surgical departments	2007	NA	NA	NA	<0.001	<0.001	0.963	-
	2008	91.84	62.06	61.49				70.02
	2009	90.02	62.76	58.38				72.13
	P [1]	0.591	0.579	0.852				0.876

The values represent an overall pooled mean (weighted mean) by aggregating data on quantity of antibiotic use with respect to OBD for each hospital. P-values calculated for antibiotic consumption of each hospital independent of OBD (non-weighted means).
Group I: >500 beds; Group II: 200-500 beds; Group III: <200 beds.
P values: [1]Trend 2007-2009; [2]Group I vs. Group II; [3]Group I vs. Group III; [4]Group II vs. Group III.
NA: not available.

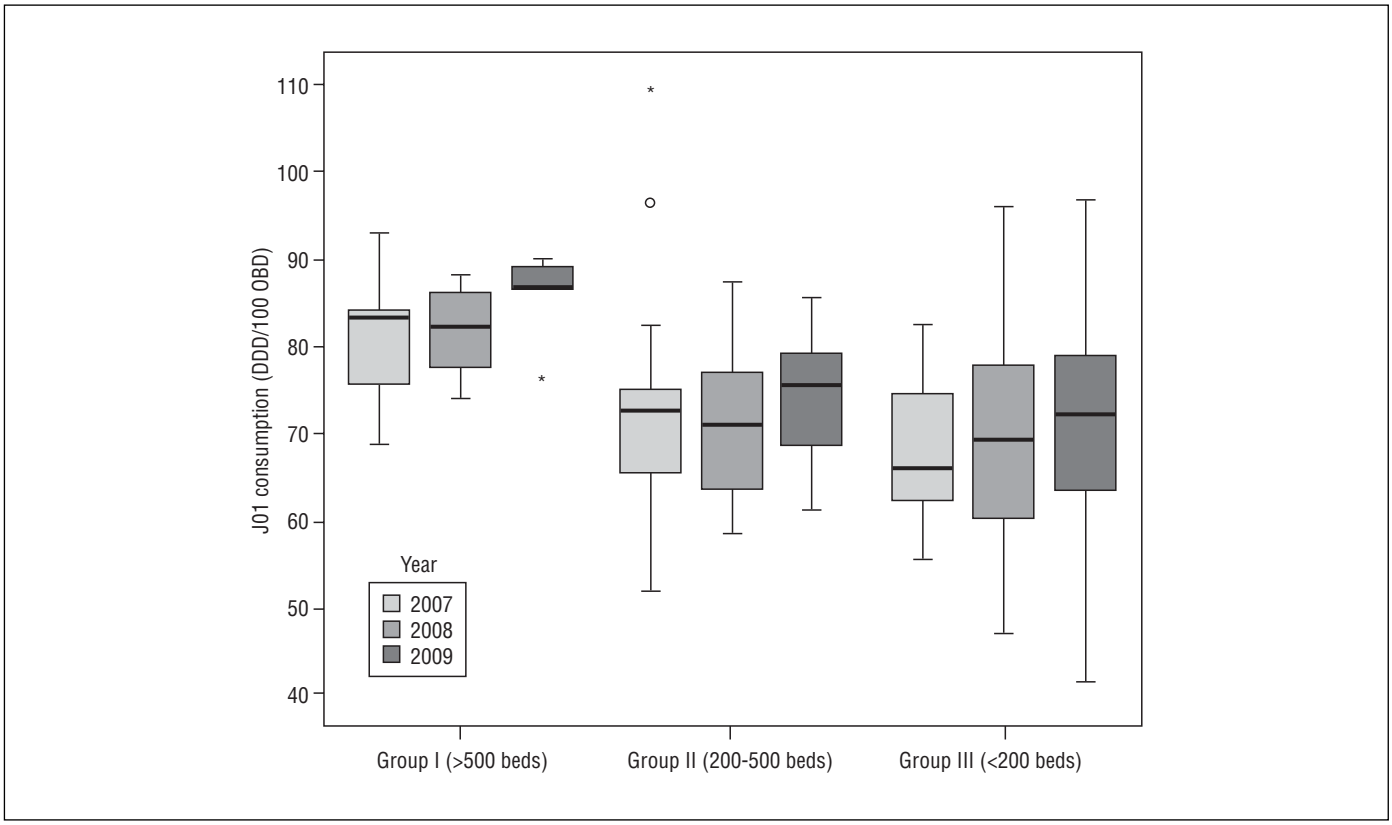

Figure 1. Distribution (box plot) of antibiotics for systemic use (J01) among Catalan hospitals (between 2007 and 2009) divided by hospital size and expressed in DDD per 100 occupied bed days.

Table 3
Consumption of groups of antibiotics for systemic use (J01) in Catalan hospitals (between 2007 and 2009) divided according to hospital size and expressed in DDD per 100 occupied bed days

	Year	Group I	Group II	Group III	P [2]	P [3]	P [4]	Total
Penicillins (J01C)	2007	41.41	30.93	29.80	0.050	<0.001	0.071	34.63
	2008	39.46	31.04	28.70				33.35
	2009	39.32	31.77	29.28				33.82
	P [1]	0.794	0.644	0.476				0.379
Quinolones (J01M)	2007	11.56	12.77	13.50	0.124	0.014	0.302	12.49
	2008	12.15	11.94	14.46				12.61
	2009	11.69	12.50	15.19				12.92
	P [1]	0.688	0.467	0.261				0.787
Cephalosporins (J01DB,J01DC,J01DD,J01DE)	2007	10.28	12.20	13.02	0.859	0.189	0.058	11.69
	2008	11.24	12.15	12.80				11.97
	2009	12.02	12.46	13.58				12.60
	P [1]	0.559	0.677	0.654				0.655
Other antibiotics * (J01X)	2007	6.18	4.06	2.93	<0.001	<0.001	0.146	4.68
	2008	7.92	4.47	3.37				5.41
	2009	9.15	4.89	3.99				6.18
	P [1]	0.367	0.587	0.019				0.041
Carbapenems (J01DH)	2007	3.77	2.21	1.63	<0.001	<0.001	0.011	2.67
	2008	4.58	2.79	2.22				3.28
	2009	5.41	3.27	2.60				3.86
	P [1]	0.011	0.184	0.021				0.001
Macrolides, lincosamides and streptogramins (J01F)	2007	3.32	3.53	3.49	0.861	0.920	0.713	3.45
	2008	3.18	3.74	3.50				3.46
	2009	3.18	4.18	3.57				3.66
	P [1]	0.720	0.973	0.722				0.732
Aminoglycosides (J01G)	2007	2.42	3.00	2.81	0.308	0.047	0.257	2.80
	2008	2.30	3.03	3.34				2.83
	2009	2.20	2.62	3.56				2.72
	P [1]	0.728	0.207	0.177				0.602
Sulfonamides and trimethoprim (J01E)	2007	2.63	1.33	1.00	<0.001	<0.001	0.046	1.75
	2008	2.81	1.07	0.91				1.63
	2009	2.45	1.18	1.15				1.63
	P [1]	0.781	0.152	0.903				0.318
Tetracyclines (J01A)	2007	0.53	0.30	0.25	0.007	<0.001	0.374	0.38
	2008	0.40	0.34	0.36				0.37
	2009	0.64	0.36	0.21				0.42
	P [1]	0.427	0.625	0.708				0.818
Monobactams (J01DF)	2007	0.28	0.07	0.06	<0.001	<0.001	0.371	0.15
	2008	0.42	0.07	0.17				0.22
	2009	0.41	0.09	0.19				0.23
	P [1]	0.329	0.842	0.131				0.073
Amphenicols (J01B)	2007	0.00	0.00	0.00	-	-	-	0.00
	2008	0.00	0.00	0.00				0.00
	2009	0.00	0.00	0.00				0.00
	P [1]	-	-	-				-

*Other antibiotics: metronidazole, vancomycin, teicoplanin, colistin, linezolid, daptomycin, fosfomycin, nitrofurantoin.
The values represent an overall pooled mean (weighted mean) by aggregating data of quantity of antibiotic use with respect to OBD for each hospital. P-values calculated for antibiotic consumption of each hospital independent of OBD (non-weighted means).
Group I: >500 beds; Group II: 200-500 beds; Group III: <200 beds. P values: [1]Trend 2007-2009; [2]Group I vs. Group II; [3]Group I vs. Group III; [4]Group II vs. Group III.

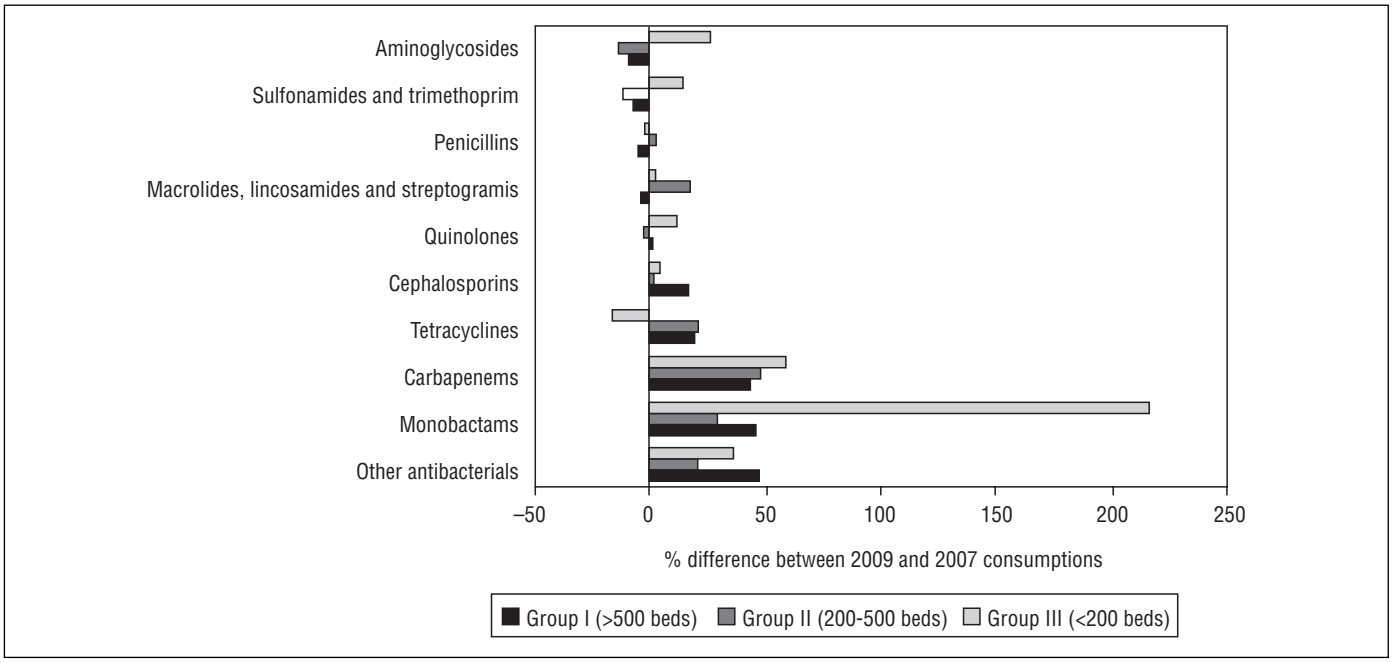

Figure 2. Overall variability of antibiotics for systemic use (J01), consumption expressed in % of the difference between 2009 and 2007 and divided according to hospital size.

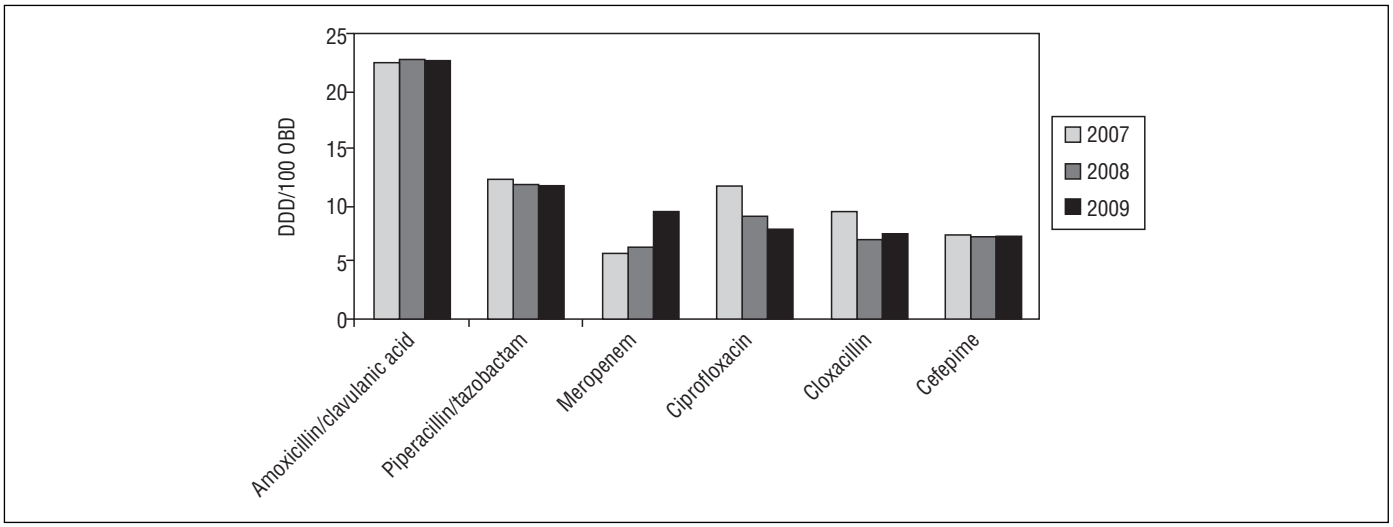

Figure 3. Consumption of the most commonly used antibiotics for systemic use (J01) in ICU (between 2007 and 2009) expressed in DDD per 100 occupied bed days.

studies performed in countries like Denmark, where the annual report (DANMAP)[14] showed an increase from 69.94 DDD/100 OBD in 2007 to 78.13 DDD/100 OBD in 2009 (11.71%). As in the VINCat study, changes in Danish antimicrobial consumption were attributable to the increase in carbapenems (38.03%), cephalosporins (20.04%) and the monobactam group (50.00%). In the Netherlands, the NETHMAP report[15] showed an increase of 16.42% in antibiotic consumption, from 60.9 DDD/100 OBD in 2007 to 70.9 DDD/100 OBD in 2009. Cephalosporins (20.24%), carbapenems (37.50%) and penicillins (14.95%) were involved in this increase in consumption. In Ireland,[7] consumption decreased 2.56% between 2007 and 2009, with DDD/100 OBD values of 78.0 and 76.0, respectively. This downward trend was mainly due to the quinolone group (ciprofloxacin).

Studies from other countries showed lower rates of antibiotic consumption than Catalonia. In 2007, the surveillance network implemented by the CCLIN (Coordinating Centres for Nosocomial Infection Control) in French hospitals[4] found antibiotic use of 55.77 DDD/100 OBD in 27 teaching hospitals, 41.69 DDD/100 OBD in 158 private, non-teaching hospitals and 37.15 DDD/100 OBD in 165 public, non-teaching hospitals. In a recent study of 57 hospitals in Switzerland,[16] antibiotic consumption was also lower than in the VINCat study: 53.4 DDD/100 OBD in 2008. Comparison with the figures from Norway[6] and Sweden[17] is hampered by the fact that these countries used different measurement units (DDD/1000 inhabitants/day) in their annual reports in order to compare the rates with their outpatient consumption. Therefore, no benchmarking with Catalan hospital consumption was possible.

In the VINCat Program, antibiotic consumption in the ICU varied from 155.28 in 2007 to 147.11 DDD/100 OBD in 2009, a rate more than twice that in non-ICU units (71.84 in 2007 to 75.18 DDD/100 OBD in 2009) and far above the surgical and medical ward values of 70.02 and 73.03 DDD/100 OBD in 2008, respectively. In France,[4] ICU consumption in 2007 (146.6 DDD/100 OBD) was also higher than in other wards, with 55.3 DDD/100 OBD in surgery wards and 58.3 OBD/100 DDD in medical wards. Antibiotic use in the ICU is higher than in other medical or surgical wards because recommendations

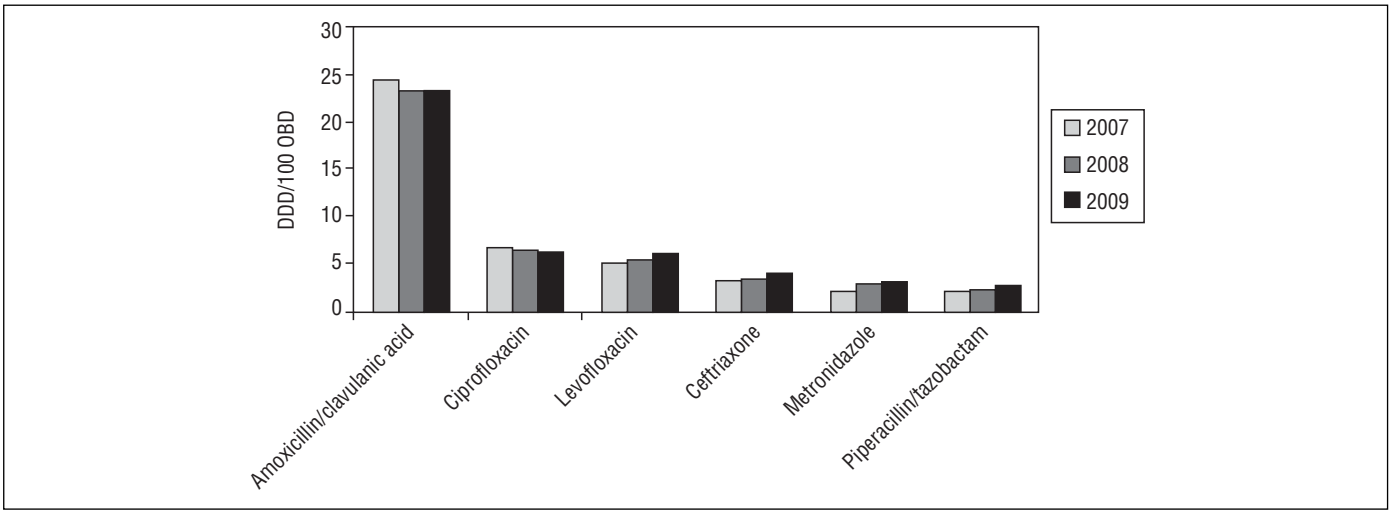

Figure 4. Consumption of the most commonly used antibiotics for systemic use (J01) in non-ICU departments (between 2007 and 2009) expressed in DDD per 100 occupied bed days.

for antibiotic dosage in critically ill patients usually include higher doses than in non-ICU patients.[18] In Germany,[19] the mean antibiotic consumption of 53 ICUs was only 116.7 DDD/100 OBD in 2008, but the population may not be comparable. In 2005 there were 8.2 ICU beds available in Spain per 100,000 inhabitants, while there were 24.6 beds in Germany per 100,000 inhabitants, which may modify the type of patients and admissions, with Spanish ICU beds having a more gravely ill patient population.[20] Another study carried out in 44 hospitals in Hungary[21] showed different ICU consumption: 98.69 DDD/100 OBD (ranging from 27.91 and 167.79) in 2006.

In conclusion, little information is available in the literature on studies that stratify a large number of hospitals according to size. Our experience with this new program has been highly positive. We achieved a high level of participation among hospitals due to their interest in taking part in a global nosocomial infection program, and also thanks to our use of a homogeneous methodology and continuous support from the coordination center. The data have enabled us to compare Catalan antibiotic consumption with that recorded in other national studies. The information we provided was highly valued by the infection commission at each hospital because of its direct bearing on the design of antibiotic policies, and was an important factor in their adherence to the VINCat Program.

However, the results of the study indicate three new areas that the program should focus on in the coming years. First, during the years of the study, large hospitals in Catalonia had higher case mix indexes than medium-sized and small hospitals, which may explain the differences in antimicrobial consumption. In a Swiss retrospective observational study[22] of antibiotic use performed in 12 acute care hospitals, a correlation between this measure of clinical complexity and antibiotic use was found. In our study we did not perform mathematical correlations. Second, to calculate antimicrobial consumption in Catalonia, an additional unit of measure like DDD/100 admissions[23] may be a good way to supplement our information and knowledge of antibiotic use trends. Finally, statistical differences in antibiotic consumption were observed in the increase of the other antibiotic groups (including new molecules) and in the group of carbapenems. Higher expenditure on antibiotics in Catalan hospitals is to be expected because new antibiotics are more expensive than older ones. The increase in carbapenem consumption is of concern because of its wide spectrum of activity and the potential impact of its overuse on bacterial resistance. Moreover, the high consumption of quinolones should be assessed carefully, because of the limited alternatives available in patients with beta-lactam allergy and the rate of bacterial resistance against this family of antibiotics.

The results of this study have enabled the VINCat researchers to form a team of experts comprising pharmacists, intensive care physicians and microbiologists, with the aim of improving antibiotic prescription in ICU patients. We also advocate measures to switch therapy from the parenteral to the oral route.

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Conflicts of Interest

All authors declare that they have no conflicts of interest in this article.

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