PAN AMERICAN JOURNAL OF PUBLIC HEALTH 100 YEARS

Original research

Antibiotic resistance and consumption before and during the COVID-19 pandemic in Valle del Cauca, Colombia

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Suggested citation Hurtado IC, Valencia S, Pinzon EM, Lesmes MC, Sanchez M, Rodriguez J, et al. Antibiotic resistance and consumption before and during the COVID-19 pandemic in Valle del Cauca, Colombia. Rev Panam Salud Publica. 2023;47:e10. https://doi.org/10.26633/RPSP.2023.10

ABSTRACT

Objective. To assess changes in antibiotic resistance of eight of the World Health Organization priority bug-drug combinations and consumption of six antibiotics (ceftriaxone, cefepime, piperacillin/tazobactam, meropenem, ciprofloxacin, vancomycin) before (March 2018 to July 2019) and during (March 2020 to July 2021) the COVID-19 pandemic in 31 hospitals in Valle del Cauca, Colombia.

Methods. This was a before/after study using routinely collected data. For antibiotic consumption, daily defined doses (DDD) per 100 bed-days were compared.

Results. There were 23 405 priority bacterial isolates with data on antibiotic resistance. The total number of isolates increased from 9 774 to 13 631 in the periods before and during the pandemic, respectively. While resistance significantly decreased for four selected bug-drug combinations (*Klebsiella pneumoniae*, extended spectrum beta lactamase [ESBL]-producing, 32% to 24%; *K. pneumoniae*, carbapenem-resistant, 4% to 2%; *Pseudomonas aeruginosa*, carbapenem-resistant, 12% to 8%; *Acinetobacter baumannii*, carbapenem-resistant, 23% to 9%), the level of resistance for *Enterococcus faecium* to vancomycin significantly increased (42% to 57%). There was no change in resistance for the remaining three combinations (*Staphylococcus aureus*, methicillin-resistant; *Escherichia coli*, ESBL-producing; *E. coli*, carbapenem-resistant). Consumption of all antibiotics increased. However, meropenem consumption decreased in intensive care unit settings (8.2 to 7.1 DDD per 100 bed-days).

Conclusions. While the consumption of antibiotics increased, a decrease in antibiotic resistance of four bug-drug combinations was observed during the pandemic. This was possibly due to an increase in community-acquired infections. Increasing resistance of *E. faecium* to vancomycin must be monitored. The findings of this study are essential to inform stewardship programs in hospital settings of Colombia and similar contexts elsewhere.

Keywords Drug resistance, microbial; anti-bacterial agents/therapeutic use; COVID-19; Colombia.

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Antimicrobial resistance (AMR), the ability of microbes to survive in the presence of antimicrobials, is a major public health problem (1). Worldwide in 2019, AMR was the reason for 4.9 million deaths (2), and this is expected to reach 10 million by 2050 (3). In addition to its health implications, AMR increases the financial burden on both patients and health systems (3).

The primary reason for the emergence and spread of AMR is the inappropriate use of antibiotics. This includes irrational prescribing, inadequate disease prevention and control measures, and poor access to accurate diagnostics (4, 5). Appropriate prescriptions, optimized use of antibiotics, quality diagnosis and treatment, and infection prevention and control are the guiding principles of antimicrobial stewardship programs (6).

The World Health Organization (WHO) developed a list of priority bacteria and resistance patterns (so-called bug-drug combinations) that should be closely monitored because of their threat to human health. The most critical ones are bacteria that pose a particular threat in hospital and extended-stay facilities, and among patients whose care requires devices such as ventilators and blood catheters (7, 8). Monitoring the resistance of these priority bacteria to tracer antibiotics is essential to enable corrective actions to be taken.

The unprecedented coronavirus disease 2019 (COVID-19) pandemic has posed a tremendous challenge to health systems, with potential threats that could affect antimicrobial stewardship programs. Prescription of antibiotics for COVID-19 patients when they were not required has been widely documented (9–12). The impact of the COVID-19 pandemic on antibiotic consumption has also been reported for different settings. While consumption increased during the pandemic in hospitals in Belgium (13), it decreased for infections acquired in the community within Europe (14).

In Colombia, like many other settings in the world, AMR is a growing public health problem (15, 16). Therefore, the Ministry of Health in Colombia developed national guidelines for the clinical management of COVID-19 patients. The guidelines recommend the use of antibiotics only for patients with bacterial coinfection. The guidelines do not recommend specific antibiotics but indicate that the choice of antibiotics should be guided by the result of culture and antibiotic susceptibility testing (17).

However, during the early phase of the pandemic, government initiatives in Latin America suggested that early initiation of antibiotics for COVID-19 patients was useful, irrespective of the clinical suspicion of bacterial coinfection (18). This has raised concern that such practices might have led to the irrational use of antibiotics, especially those most frequently used in Colombia (ceftriaxone, cefepime, piperacillin/tazobactam, meropenem, ciprofloxacin, and vancomycin) (19). These antibiotics are in the *Watch* category (these are antibiotics with a higher potential to develop resistance, and their use as first and second choice treatment should be limited) of the WHO AwaRe categories, and their use should be closely monitored (20). During COVID-19, data from the National Institute of Health of Colombia show an increase in the consumption of broad-spectrum antibiotics, especially in intensive care units (ICUs) (21).

To date, there has been no published study from Colombia assessing whether there was a change in bacterial resistance and consumption of antibiotics before and during the COVID-19 pandemic. Therefore, this study was carried out to assess the change in antibiotic resistance of selected priority bug-drug combinations and the consumption of commonly used antibiotics before and during the COVID-19 pandemic in tertiary-level hospitals of Valle del Cauca, Colombia.

MATERIALS AND METHODS

Study design, period, and population

This was a before and after study using routinely collected secondary surveillance data.[1] The study period included "before" (1 March 2018 to 31 July 2019) and "during" (1 March 2020 to 31 July 2021) the COVID-19 pandemic in Valle del Cauca, western Colombia. Bacterial isolates for six priority bacteria (commonly found in Colombia) were included, with data available on resistance to the tracer antibiotic(s) (Table 1) from all 31 tertiary-level hospitals in Valle del Cauca. Included were isolates from blood, respiratory specimens (sputum, bronchial lavage), and cerebrospinal fluid (CSF). For antibiotic consumption, aggregate consumption data were used (ceftriaxone, cefepime, piperacillin/tazobactam, meropenem, ciprofloxacin, vancomycin) separately for the before and during COVID-19 pandemic period.

Setting

The 31 tertiary hospitals in Valle del Cauca included 25 private and 6 public hospitals. Twenty-four of the study hospitals were located in the principal/capital city of Valle del Cauca (Santiago de Cali, home to 51% of Valle del Cauca's population), serving a population of approximately 2.8 million, while 7 were from other surrounding cities. These 31 hospitals had 1 114 ICU beds (74% in the principal city and 26% in the other cities) and 3 254 non-ICU beds (81% in the principal city and 19% in the other cities). In the 17-month study period "during" the COVID-19 pandemic, there were 383 348 reported COVID-19 cases and 11 193 reported COVID-19 deaths in Valle del Cauca (22).

Surveillance of bacterial resistance. In 2012, the National Institute of Health of Colombia established the surveillance of all pathogens responsible for infections in hospitals. All laboratories from secondary and tertiary level institutions (public and private) contribute to the surveillance. Each institution also submits data to the WHONET microorganism database every month, which includes all isolates showing growth from all samples sent for testing, including bacterial species, sample type, and all the useful antibiotics to treat the bacteria, and the tests undertaken according to the Clinical and Laboratory Standards Institute (CLSI) guidance (23, 24).

Surveillance of antimicrobial consumption. Surveillance of the consumption of the main antibiotics used in hospital practice was established in 2012. The antibiotics under surveillance are all those for systemic use (ATC J01) (16, 25). The surveillance reports are received from institutional laboratories of tertiary institutions monthly and are consolidated from the municipal territorial entities.

The daily defined dose (DDD) is the standard medicine unit of measure, the average corresponding to the maintenance dose per day expected for the main indication of a medicine in

[1] Data are available upon request to the corresponding author.

TABLE 1. List of priority bacteria and their resistance to the tracer antibiotics included in the study

Priority bacteria (n = 6)	Bug-drug combination (n = 8)	Definition
Staphylococcus aureus	*S. aureus*, methicillin-resistant	Resistance to oxacillin or cefoxitin
Klebsiella pneumoniae	*K. pneumoniae*, ESBL-producing	Resistance to ceftriaxone, cefepime, and piperacillin/tazobactam
	K. pneumoniae, carbapenem-resistant	Resistance to meropenem, imipenem, or ertapenem
Escherichia coli	*E. coli*, ESBL-producing	Resistance to ceftriaxone, cefepime, and piperacillin/tazobactam
	E. coli, carbapenem-resistant	Resistance to meropenem, imipenem, or ertapenem
Pseudomonas aeruginosa	*P. aeruginosa*, carbapenem-resistant	Resistance to meropenem
Acinetobacter baumannii complex	*A. baumannii* complex, carbapenem-resistant	Resistance to meropenem
Enterococcus faecium	*E. faecium*, vancomycin-resistant	Resistance to vancomycin

Note: ESBL, extended spectrum beta lactamase.
Source: Prepared by the authors based on reference (7).

adults. The formula for calculating DDD per 100 bed-days is as follows (24):

$$\frac{\text{DDD}}{\text{100 bed-day}} = \frac{\text{Consumption*100}}{\text{DDD mg * bed * \% occupancy * days}}$$

Data extraction

For the eight bug-drug combinations (Table 1), individual isolate level microbiological data were extracted from the WHONET database at the Valle del Cauca Secretariat of Health. The first isolate per patient and per sample reported were utilized to determine susceptibility. Repeat isolates were excluded. If a patient had more than one priority bacteria in the specimen (Table 1), all the bacteria were considered for the analysis. Antibiotic consumption data were extracted from the antibiotic consumption database of Valle del Cauca.

Statistical analysis

Data were analyzed using SPSS software (IBM Corp., Armonk, NY). Resistance to a bug-drug combination was defined as the number (%) of priority bacterial isolates with resistance to the tracer antibiotic(s) (Table 1). For each of the eight bug-drug combinations, the "before and during" percentage of resistance were compared overall, as well as stratified by specimen type and the location (within or outside the principal city) and type (public/private) of hospital, using the Z-test for proportions. Significance levels were set at $p < 0.05$.

The consumption data were calculated using the DDD per 100 bed-days for each antibiotic under surveillance for each month of the year. The "before and during" consumption for each antibiotic (DDD per 100 bed-days), overall and stratified by the type and location of hospital, are reported.

Ethics

Clearance was provided by the Valle del Cauca Secretariat of Health to obtain all data, and ethical approval was granted by the Institutional Review Board of the Valle del Cauca Secretariat of Health (No. 18-21, dated 3 November 2021) and The Union Ethics Advisory Group, Paris (No. 22/21, dated 2 September 2021).

RESULTS

Characteristics of priority bacterial isolates

There were 23 405 priority bacterial isolates with data available on resistance to the tracer antibiotic(s). The distribution by bacterial isolate type, period (before and during the COVID-19 pandemic), specimen type, hospital location and type are shown in Table 2. The total number of isolates increased from 9 774 before the pandemic to 13 631 during the pandemic (a 40% increase). The largest proportion of isolates from both before/during the pandemic were from blood specimens. The most common bacteria isolated in both periods was *Klebsiella pneumoniae*. The proportion of isolates reported from private hospitals increased from 75% before the pandemic to 82% during the pandemic.

Bug-drug combination resistance

During the pandemic, out of the eight bug-drug combinations, there was no change in resistance for three combinations (*Staphylococcus aureus*, methicillin-resistant; *Escherichia coli*, ESBL-producing; *E. coli*, carbapenem-resistant) when compared to before the pandemic. The resistance levels significantly changed for five bug-drug combinations. While the level of resistance for four selected bug-drug combinations significantly decreased (*K. pneumoniae*, ESBL-producing, 32% to 24%; *K. pneumoniae*, carbapenem-resistant, 4% to 2%; *Pseudomonas aeruginosa*, carbapenem-resistant, 12% to 8%; *Acinetobacter baumannii*, carbapenem-resistant, 23% to 9%), the level of resistance for *Enterococcus faecium* to vancomycin significantly increased (42% to 57%) (Table 3).

The significant change in the level of resistance of the five bug-drug combinations was also observed when stratifying bacterial isolates by specimen (blood, respiratory, and CSF). The exception was for *K. pneumoniae* isolates obtained from respiratory specimens, where no change was observed in the resistance to carbapenem during the two periods (Table 3).

The significant overall change in the level of resistance of the five bug-drug combinations was also observed in principal city hospitals and private hospitals. The overall decreasing resistance of *P. aeruginosa* to carbapenem and *A. baumannii* to carbapenem was also observed in public hospitals. A significant increase in

TABLE 2. Characteristics of priority bacterial isolates obtained before (March 2018–July 2019) and during the COVID-19 pandemic (March 2020–July 2021) in Valle del Cauca, Colombia

Variables	Bacterial isolates			
	Before pandemic		During pandemic	
	N	(%)	*N*	(%)
Priority bacterial isolates	**9 774**	**(100)**	**13 631**	**(100)**
S. aureus	1 602	(16)	1 228	(9)
K. pneumoniae	3 043	(31)	5 396	(40)
E. coli	2 851	(29)	3 619	(27)
P. aeruginosa	1 972	(20)	3 022	(22)
A. baumannii	230	(2)	284	(2)
E. faecium	76	(1)	82	(1)
Specimen type				
Blood	8 405	(86)	11 141	(82)
Respiratory	1 271	(13)	2 381	(17)
CSF	98	(1)	109	(1)
Hospital location				
Principal city	8 737	(88)	11 995	(89)
Other cities	1 037	(11)	1 636	(12)
Hospital type				
Public	2 444	(23)	2 454	(18)
Private	7 330	(75)	11 177	(82)

Note: CSF, cerebrospinal fluid.
Source: Prepared by the authors based on the study data.

resistance of *P. aeruginosa* to carbapenem was observed in hospitals located in other cities (Table 4).

Antibiotic consumption

The consumption of antibiotics increased in ICUs during the pandemic, except for meropenem. In both the private and public facilities, the use of meropenem decreased from 23.6/DDD bed-days before to 18.5/DDD bed-days during the pandemic. In non-ICU settings, the overall consumption of all selected antibiotics, except meropenem, increased during the pandemic (Table 5).

DISCUSSION

This is the first study from Colombia to document the change in resistance of selected bug-drug combinations and the consumption of frequently used antibiotics during the COVID-19 pandemic.

Overall, there was an increase in the absolute number of bacterial isolates during the pandemic when compared to before; this could be attributed to an increase in community-acquired infections related to COVID-19. There is a growing number of reports of bacterial infections acquired by patients with severe COVID-19 (26, 27). Another possible reason for the increase in isolates could be the high number of invasive procedures performed on COVID-19 patients, which could lead to increased risk of bacterial infection.

We observed a decrease in the prevalence of resistance in four of the eight bug-drug combinations: *K. pneumoniae*, ESBL-producing; *K. pneumoniae*, carbapenem-resistant; *P. aeruginosa*, carbapenem-resistant; and *A. baumannii*, carbapenem-resistant—especially when bacteria were isolated from blood (28–30). Other studies have also reported a decrease in antibiotic resistance during the COVID-19 pandemic, especially for Gram-negative bacteria (27, 31). In all four bug-drug combinations, the increase in isolates from the principal city (likely more community-acquired infection during COVID-19) possibly resulted in a decrease in resistance (32, 33). Additionally, COVID-19-related policies such as social distancing, mobility restrictions, promotion of hand hygiene, and adherence to contact and respiratory precautions may have contributed to a decrease in the transmission of resistant bacteria.

Conversely, we found a significant increase in the prevalence of *E. faecium* vancomycin resistance. *E. faecium* spreads primarily by direct person-to-person contact (including healthcare personnel) and is a common hospital-acquired infection (29). An increased resistance of this bug-drug combination has been linked to hospital outbreaks (34, 35). In Colombia, *E. faecium* vancomycin resistance has been a growing problem (16). This requires vigilant infection control measures and close monitoring.

In bacterial isolates obtained from hospitals located in other cities, the only significant change observed in our study was the increase in the prevalence of carbapenem-resistant *P. aeruginosa*. The resistance of this bug-drug combination needs to be monitored over time and measures implemented to limit worsening resistance.

For antibiotic consumption, we observed an increase in the consumption of all antibiotics in all study hospitals during the pandemic in ICU and non-ICU settings, except for meropenem in ICU settings. The most noticeable increase was for piperacillin/tazobactam. It is a broad-spectrum antibiotic that offers coverage against Gram-positive and Gram-negative bacteria, including anaerobes, which makes it attractive for use in pneumonia. It has been widely recommended for use in COVID-19 with bacterial coinfections (36). Meropenem consumption decreased in both private and public hospitals during the pandemic. The decreased utilization of meropenem may lead to a decrease in resistance for the four drug-bug combinations. An increase in the consumption of antibiotics during the COVID-19 pandemic has been reported by others (31).

Finally, an important operational finding was the lack of data on the use of ciprofloxacin in ICUs, which precluded assessing its consumption in this setting. Ciprofloxacin is a broad-spectrum antibiotic frequently used in ICU and non-ICU settings. Monitoring the use of ciprofloxacin, particularly in ICU settings, should be improved, and measures to ensure completeness of data on its use and consumption need to be undertaken.

The information provided by this study is essential to inform antimicrobial stewardship programs in hospitals in Colombia and similar contexts elsewhere.

Strengths and limitations

The study limitations are as follows. First, as this study involved secondary data, routine data collection errors cannot be ruled out. Second, we did not investigate whether the increase in consumption of antibiotics was rational and followed the results of culture and susceptibility testing, which was beyond the scope of this study. Third, the study did not include clinical data to disaggregate the isolates by community- and

TABLE 3. Prevalence of resistance for the 8 selected bug-drug combinations before (March 2018–July 2019) and during the COVID-19 pandemic (March 2020–July 2021), stratified by type of specimen, in 31 tertiary hospitals in Valle del Cauca, Colombia

Drug-bug combination	Before pandemic			During pandemic			*P*-value*
	Bacterial isolates	Resistant isolates		Bacterial isolates	Resistant isolates		
	N	*n*	(%)	*N*	*n*	(%)	
S. aureus, methicillin-resistant							
All specimens	1 602	660	(42)	1 228	476	(39)	0.082
Blood	1 365	571	(42)	1 035	407	(39)	0.085
Respiratory	217	69	(32)	172	48	(28)	0.080
CSF	20	20	(100)	26	21	(81)	0.060
K. pneumoniae, ESBL-producing							
All specimens	2 967	957	(32)	5 219	1 238	(24)	<0.001
Blood	2 569	852	(33)	4 233	1 052	(25)	<0.001
Respiratory	369	97	(26)	966	183	(19)	0.048
CSF	29	8	(28)	20	3	(15)	0.033
K. pneumoniae, carbapenem-resistant							
All specimens	3 043	116	(4)	5 396	119	(2)	<0.001
Blood	2 631	103	(4)	4 383	103	(2)	<0.001
Respiratory	383	8	(2)	993	15	(2)	0.555
CSF	29	5	(17)	20	1	(5)	<0.001
E. coli, ESBL-producing							
All specimens	2 748	294	(11)	3 478	321	(9)	0.054
Blood	2 635	275	(10)	3 283	291	(9)	0.050
Respiratory	91	19	(21)	179	27	(15)	0.046
CSF	22	0	(0)	16	3	(19)	--
E. coli, carbapenem-resistant							
All specimens	2 851	5	(<1)	3 919	6	(<1)	0.926
Blood	2 735	3	(<1)	3 421	6	(<1)	0.900
Respiratory	94	2	(2)	182	0	(0)	--
CSF	22	0	(0)	16	0	(0)	--
P. aeruginosa, carbapenem-resistant							
All specimens	1 972	234	(12)	3 022	251	(8)	<0.001
Blood	1 442	155	(11)	2 066	186	(9)	<0.001
Respiratory	513	74	(14)	946	65	(7)	<0.001
CSF	17	5	(29)	11	0	(0)	--
A. baumannii, carbapenem-resistant							
All specimens	230	52	(23)	284	28	(9)	<0.001
Blood	196	46	(23)	235	25	(12)	<0.001
Respiratory	27	4	(15)	48	2	(4)	<0.001
CSF	7	2	(29)	1	1	(100)	--
E. faecium, vancomycin-resistant							
All specimens	76	32	(42)	182	103	(57)	0.034
Blood	71	29	(41)	178	101	(57)	0.038
Respiratory	2	2	(100)	3	1	(33)	--
CSF	3	1	(33)	1	1	(100)	--

Notes: * Z-test for two proportions; ESBL, extended spectrum beta lactamase – resistant to ceftriaxone, cefepime, and piperacillin/tazobactam; CSF, cerebrospinal fluid; --, not applicable.
Source: Prepared by the authors based on the study data.

TABLE 4. Prevalence of resistance for the 8 selected bug-drug combinations before (March 2018–July 2019) and during the COVID-19 pandemic (March 2020-July 2021), stratified by location and type of hospital, in 31 tertiary hospitals in Valle del Cauca, Colombia

Drug-bug combination	Before pandemic			During pandemic			*P*-value*
	Bacterial isolates	Resistant isolates		Bacterial isolates	Resistant isolates		
	N	*n*	(%)	*N*	*n*	(%)	
S. aureus, methicillin-resistant							
Principal city	1 354	571	(42)	1 191	448	(38)	0.019
Other cities	30	12	(40)	9	4	(44)	0.812
Public	556	260	(47)	485	223	(46)	0.800
Private	828	323	(39)	715	229	(32)	0.004
K. pneumoniae, ESBL-producing							
Principal city	2 667	883	(33)	4 691	1 147	(25)	<0.001
Other cities	217	31	(14)	476	79	(17)	0.440
Public	667	204	(31)	769	221	(29)	0.445
Private	2 217	710	(32)	4 398	1 005	(23)	<0.001
K. pneumoniae, carbapenem-resistant							
Principal city	2 725	115	(4)	4 788	116	(2)	<0.001
Other cities	235	1	(<1)	556	1	(<1)	0.530
Public	686	75	(11)	837	107	(13)	0.268
Private	2 274	41	(2)	4 507	10	(<1)	<0.001
E. coli, ESBL-producing							
Principal city	2 437	254	(10)	3 066	284	(9)	0.150
Other cities	264	28	(11)	379	30	(8)	0.241
Public	427	28	(7)	417	19	(5)	0.205
Private	2 274	254	(11)	3 028	295	(10)	0.091
E. coli, carbapenem-resistant							
Principal city	2 519	4	(<1)	3 164	5	(<1)	0.994
Other cities	283	1	(<1)	422	1	(<1)	0.776
Public	447	1	(<1)	443	2	(1)	0.558
Private	2 355	4	(<1)	3 143	4	(<1)	0.682
P. aeruginosa, carbapenem-resistant							
Principal city	1 609	228	(14)	2 565	229	(9)	<0.001
Other cities	192	1	(1)	419	16	(4)	0.021
Public	610	160	(26)	723	150	(21)	0.018
Private	1 191	69	(6)	2 261	95	(4)	0.037
A. baumannii, carbapenem-resistant							
Principal city	185	52	(28)	242	28	(12)	<0.001
Other cities	32	0	(0)	41	0	(0)	--
Public	105	50	(48)	110	23	(21)	<0.001
Private	112	1	(2)	173	5	(3)	0.556
E. faecium, vancomycin-resistant							
Principal city	72	31	(43)	159	92	(58)	0.037
Other cities	1	0	(0)	21	10	(48)	--
Public	28	20	(71)	62	44	(71)	0.964
Private	45	11	(24)	118	58	(49)	0.004

Notes: * Z-test for two proportions; ESBL, extended spectrum beta lactamase – resistant to ceftriaxone, cefepime, and piperacillin/tazobactam; CSF, cerebrospinal fluid; --, not applicable.
Source: Prepared by the authors based on the study data.

hospital-acquired infections and by COVID-19 and non-COVID-19 patients, or for detecting outbreaks. However, such data are not routinely reported through WHONET, from which data for this study were sourced. Fourth, we did not investigate other factors that might have an impact on resistance, such as change of type of hospitalized patients, access to diagnostic tests, or adherence to contact isolation strategies (17, 37, 38). Finally, there was a lack of data on the use of ciprofloxacin in ICUs in the antibiotic consumption database.

Our study had several strengths. First, data were collected from hospitals under routine surveillance. We believe the findings reflect the operational reality on the ground. Second, we have included a relatively large sample size of bacterial isolates before and during the pandemic. Third, all the tests for antibiotic resistance in bacterial isolates were performed in well-equipped laboratories under surveillance. Resistance testing was completed according to CLSI guidance (23, 24). Finally, we adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for reporting observational studies (39).

Conclusion

This study can serve as a baseline in Colombia for assessing the change in resistance of priority bacteria to tracer antibiotics. We recommend that similar studies be carried out in other parts of Colombia to confirm our findings.

While our study demonstrated an increasing consumption of antibiotics during the COVID-19 pandemic, we found an overall reduction in the prevalence of resistance for the selected bug-drug combinations. This was possibly due to an increase in community-acquired infections among patients admitted with moderate to severe COVID-19.

Based on the findings of this study and elsewhere, it is important to develop national-level strategies for antimicrobial stewardship and for the implementation and monitoring of all related measures, to reduce both the clinical and social burden of AMR. This is especially important in the current phase of the COVID-19 pandemic, where we are witnessing an epidemiologic transition to ongoing endemic pathology.

Author contributions. ICH, SV, EMP, MCL, MS, JR, BO, HDS, KH, and MK conceptualized the study. ICH, MS, JR, BO, HDS, KH, and MK developed the methodology. ICH, SV, and EMP developed the database. CH, SV, and EMP validated the data. ICH, SV, EMP, and MCL analyzed the data. ICH, SV, EMP, and MCL carried out the investigation. ICH, SV, EMP, and MCL curated the study data. ICH, JKE, HDS, and MK drafted the manuscript. ICH, MS, BO, JKE, HDS, and MK reviewed and edited the draft manuscript. HDS and MK supervised the project. MS, BO, JKE, HDS, and MK were responsible for project administration. All authors reviewed and approved the final version of the manuscript.

Acknowledgment. This research was conducted through the Structured Operational Research and Training Initiative (SORT IT), a global partnership coordinated by TDR, the Special Program for Research and Training in Tropical Diseases at the World Health Organization. The specific SORT IT program that led to these publication included a partnership of TDR with the WHO Country offices in Colombia and Ecuador and the Regional Office for the Americas of the World Health Organization (the Pan American Health Organization) and was implemented along with the nongovernmental organization Tuberculosis Research and Prevention Center, Armenia; The

TABLE 5. Consumption of 6 selected antibiotics for the periods before (March 2018–July 2019) and during the COVID-19 pandemic (March 2020–July 2021) in intensive care units (ICUs) and non-ICU settings in 31 tertiary hospitals, stratified by type and location of hospitals, in Valle del Cauca, Colombia

Antibiotic	DDD daily defined doses per 100 bed-days			
	ICU		Non-ICU	
	Before pandemic	During pandemic	Before pandemic	During pandemic
Ceftriaxone				
Overall	2.7	2.9	16.0	16.4
Principal city	3.2	3.3	8.1	5.8
Other cities	2.1	3.4	21.2	24.3
Public	0.2	0.6	25.4	29.3
Private	2.9	3.1	6.6	5.3
Cefepime				
Overall	5.6	6.3	1.9	2.2
Principal city	5.1	6.9	3.5	3.7
Other cities	3.4	6.1	0.8	1.0
Public	6.3	12.7	0.6	1.0
Private	5.5	5.7	2.8	3.1
Piperacillin/tazobactam				
Overall	11.2	14.6	4.0	5.3
Principal city	13.0	15.0	6.1	7.1
Other cities	8.5	21.9	2.3	3.9
Public	9.2	10.7	2.0	1.9
Private	11.5	14.9	5.4	7.9
Ciprofloxacin				
Overall	--	--	4.1	4.3
Principal city	--	--	5.7	5.8
Other cities	--	--	2.8	3.0
Public	--	--	1.8	1.8
Private	--	--	5.8	6.1
Meropenem				
Overall	23.6	18.5	8.2	7.1
Principal city	13.9	20.5	3.4	3.1
Other cities	21.5	19.2	11.4	10.0
Public	30.5	18.4	11.2	10.0
Private	28.3	18.6	5.6	4.8
Vancomycin				
Overall	10.8	12.6	2.6	3.2
Principal city	12.2	14.3	3.8	4.4
Other cities	8.2	11.2	1.6	2.2
Public	10.9	10.6	1.2	1.5
Private	10.7	12.8	3.6	4.4

Note: -- no data.
Source: Prepared by the authors based on the study data.

International Union Against Tuberculosis and Lung Diseases, Paris and South East Asia offices; Médecins sans Frontières–Luxembourg; Médecins sans Frontières–United States of America; ICMR–National Institute of Epidemiology, Chennai, India; Sustainable Health Systems, Freetown, Sierra Leone; Institute of Tropical Medicine, Antwerp, Belgium; the University of Washington, Seattle, United States of America; Damien Foundation, Jawaharlal Institute of Postgraduate Medical Education & Research (JIPMER); GMERS Medical College, Baroda, India; Sri Manakula Vinayagar Medical College, India; Universidade Federal de Ciencias da Saude de Porto Alegre, Brazil; Ministry of Health of Peru; Universidade de Brasília, Brazil; Central University of Ecuador; Quadram Institute, Norwich, United Kingdom; Universidad de los Andes, Colombia; and California State University, Fullerton, United States of America.

Funding. The United Kingdom Department of Health and Social Care contributed designated funding for this SORT IT-AMR initiative, which is branded as the NIHR-TDR partnership. TDR is able to conduct its work thanks to the commitment and support from a variety of funders.

A full list of TDR donors is available at: https://tdr.who.int/about-us/our-donors.

Conflict of interest. None declared.

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Manuscript submitted on 21 June 2022. Revised version accepted for publication on 26 October 2022.

Resistencia antibiótica y consumo de antibióticos antes y durante la pandemia de COVID-19 en el Valle del Cauca, Colombia

RESUMEN

Objetivo. Evaluar los cambios en la resistencia a los antibióticos de ocho de las combinaciones de fármacos y agentes patógenos incluidos en la lista prioritaria de la Organización Mundial de la Salud y el consumo de seis antibióticos (ceftriaxona, cefepima, piperacilina/tazobactam, meropenem, ciprofloxacina, vancomicina) antes de la pandemia de COVID-19 (de marzo del 2018 a julio del 2019) y durante la pandemia (de marzo del 2020 a julio del 2021) en 31 hospitales del Valle del Cauca (Colombia).

Métodos. En este estudio se analiza el antes y el después empleando datos recopilados de forma rutinaria. Para el consumo de antibióticos, se compararon las dosis diarias definidas (DDD) por 100 días-cama.

Resultados. Hubo 23 405 cepas bacterianas aisladas prioritarias con datos sobre la resistencia a los antibióticos. El número total de cepas aisladas aumentó de 9 774 antes de la pandemia a 13 631 durante la pandemia. Si bien la resistencia disminuyó significativamente en las cuatro combinaciones seleccionadas de agentes patógenos y fármacos (*Klebsiella pneumoniae*, productora de betalactamasa de espectro extendido [BLEE], de 32% a 24%; *K. pneumoniae*, resistente a los carbapenémicos, de 4% a 2%; *Pseudomonas aeruginosa*, resistente a los carbapenémicos, de 12% a 8%; *Acinetobacter baumannii*, resistente a los carbapenémicos, de 23% a 9%), el nivel de resistencia de *Enterococcus faecium* a la vancomicina aumentó significativamente (de 42% a 57%). No hubo cambios en la resistencia en las tres combinaciones restantes (*Staphylococcus aureus*, resistente a la meticilina; *Escherichia coli,* productora de BLEE; ***E. coli***, resistente a los carbapenémicos). El consumo de todos los antibióticos aumentó. Sin embargo, el consumo de meropenem disminuyó en los entornos de las unidades de cuidados intensivos (de 8,2 a 7,1 DDD por 100 días-cama).

Conclusiones. Aunque el consumo de antibióticos aumentó, se observó una disminución en la resistencia a los antibióticos de cuatro combinaciones de agentes patógenos y medicamentos durante la pandemia, que posiblemente se debió a un aumento en las infecciones adquiridas en la comunidad. Es necesario vigilar el aumento de la resistencia de *E. faecium* a la vancomicina. Los resultados de este estudio son esenciales para que sirvan de orientación en los programas de optimización del uso de los antibióticos en los entornos hospitalarios de Colombia y en contextos similares en otros lugares.

Palabras clave Farmacorresistencia microbiana; antibacterianos/uso terapéutico; COVID-19; Colombia.

Resistência a antibióticos e consumo de antibióticos antes e durante a pandemia de COVID-19 no Valle del Cauca, Colômbia

RESUMO

Objetivo. Avaliar as mudanças na resistência a antibióticos em oito das combinações microrganismo/antimicrobiano prioritárias da Organização Mundial da Saúde e o consumo de seis antibióticos (ceftriaxona, cefepima, piperacilina/tazobactam, meropeném, ciprofloxacino, vancomicina) antes (março de 2018 a julho de 2019) e durante (março de 2020 a julho de 2021) a pandemia de COVID-19 em 31 hospitais em Valle del Cauca, Colômbia.

Métodos. Este foi um estudo antes/depois utilizando dados coletados rotineiramente. Para avaliar o consumo de antibióticos, foram comparadas doses diárias definidas (DDD) por 100 leitos-dias.

Resultados. Havia dados sobre resistência a antibióticos para 23.405 isolados bacterianos prioritários. O número total de isolados aumentou de 9.774 para 13.631 antes e durante a pandemia, respectivamente. Embora a resistência tenha diminuído significativamente para quatro das combinações microrganismo/antimicrobiano selecionadas (*Klebsiella pneumoniae,* produtora de betalactamase de espectro estendido [ESBL], 32% a 24%; *K. pneumoniae,* resistente a carbapenêmicos, 4% a 2%; *Pseudomonas aeruginosa,* resistente a carbapenêmicos, 12% a 8%; *Acinetobacter baumannii,* resistente a carbapenêmicos, 23% a 9%), o nível de resistência de *Enterococcus faecium* a vancomicina aumentou significativamente (42% a 57%). Não houve mudança na resistência para as três combinações restantes (*Staphylococcus aureus,* resistente a meticilina; *Escherichia coli*, produtora de ESBL; *E. coli*, resistente a carbapenêmicos). O consumo de todos os antibióticos aumentou. Entretanto, o consumo de meropeném nas unidades de terapia intensiva diminuiu (de 8,2 para 7,1 DDD por 100 leitos-dias).

Conclusões. Embora o consumo de antibióticos tenha aumentado, observou-se uma diminuição na resistência a antibióticos de quatro combinações microrganismo/antimicrobiano durante a pandemia. Isso ocorreu possivelmente devido a um aumento nas infecções adquiridas na comunidade. O aumento da resistência de *E. faecium* à vancomicina deve ser monitorado. Os achados deste estudo são essenciais para guiar os programas de gerenciamento de antimicrobianos em ambientes hospitalares da Colômbia e em outros contextos similares.

Palavras-chave Resistência microbiana a medicamentos; antibacterianos/uso terapêutico; COVID-19; Colômbia.