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China Against Drug Resistance (CARE) Point Prevalence Study: A Tool for Evaluating Hospital Acquired Infections and Antimicrobial Prescription at Patient Bedside

Yonghong Xiao[1], Qiang Wang[2], Jing Yang[3], Jingping Zhang[4], Hongyi Lin[5], Wenjie Yang[6], Changwen Feng[7], Yukun Chen[8], Wenxiang Huang[9], Pascal Vincelot[10], Qizhi Liao[11], Stanley Gong[12], Yijun Xia[12] and Vincent Jarlier[13,*]

[1]*State Key Laboratory for Diagnosis & Treatment of Infectious Diseases, the First Affiliated Hospital, School of Medicine Zhejiang University, Hangzhou, China*
[2]*Department of Infection Control, First Affiliated Hospital of Xi'an Jiaotong University, Xi'an, China*
[3]*Department of Infectious Diseases/Department of Infectious Management, The Third Central Hospital of Tianjin, Tianjin, China*
[4]*Department of Infectious Diseases, The First Hospital of China Medical University, Shenyang, China*
[5]*Infection Control Department, Nanjing Drum Tower Hospital, Nanjing, China*
[6]*Infection Diseases Department, Tianjin First Central Hospital, Tianjin, China*
[7]*Pharmacy Department, Zhaoqing First People's Hospital, Zhaoqing, China*
[8]*Jilin Medical University Infection Control, China and the First Hospital of Jilin University, Changchun, China*
[9]*Department of Infectious Diseases, The First Affiliated Hospital Chongqing Medical University, Chongqing, China*
[10]*Fondation Mérieux, Lyon, France*
[11]*Fondation Mérieux and Biomérieux, China*
[12]*Biomérieux China*
[13]*Groupe hospitalo-universitaire APHP Sorbonne Université, Site Pitié-Salpêtrière, Laboratoire de Bactériologie-Hygiène and CIMI-Paris, Inserm U1135, Sorbonne Université, Paris, France*

Abstract:

Background: China Against Drug Resistance (CARE) project was launched for improving antimicrobial use and infection control in Chinese hospitals. The first step was developing a Point Prevalence Survey (PPS) tool for assessing at patient bedside risk factors and rates of hospital acquired infections (HAIs) and quality indicators of antimicrobial usage and testing its workability.

Methods: After a pilot phase (2016), the CARE PPS tool was deployed in 2018-9 in eight large Chinese hospitals. Each hospital selected 3-5 adult departments (intensive care, surgery, medicine). The questionnaire in English and Chinese, on paper and tablet computer, was filled out directly at the patient's bedside by local infection control teams, microbiologists, pharmacists and clinicians.

Results: The number of patients visited per day and per investigator team increased from 20-30 during the pilot phase in the first hospital to 40-50 in the eight other hospitals. The main characteristics of the 1,170 patients included (ICU 138, medicine 430, surgery 602) were: median age 60 years; Mac Cabe score 1 74.7%; catheters: central vascular 14.3%, peripheral vascular 50.9%, urinary 19.8%; surgery during stay 31.8%. HAIs prevalence was 6.3% (mainly respiratory tract, surgical-site; main bacteria: *Acinetobacter*, *Pseudomonas*, *Klebsiella*). 54.4% of the patients were receiving antimicrobials for therapeutical use (≈3/4 single drug): from 36% in surgery to 78.3% in ICU, mostly large spectrum beta-lactams. Examination of patient records at the bedside found the reason for the treatment (53%), treatments based on microbiological results (9.3%), and prescription reassessment (30.7%).

Conclusion: The study showed that antimicrobial policy and HAI prevention could be improved by using Care-PPS in Chinese hospitals. Although obtained on a limited number of patients, the results demonstrated that there is room for improvement in antimicrobial policy and HAI prevention in the participating hospitals.

Keywords: Chinese hospitals, Point prevalence survey, Patient bedside visit, Hospital-acquired infections, Risk factors, Antibiotic usage, Quality indicators.

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*Address correspondence to this author at the Groupe hospitalo-universitaire APHP Sorbonne Université, Site Pitié-Salpêtrière, Laboratoire de Bactériologie-Hygiène and CIMI-Paris, Inserm U1135, Sorbonne Université, Paris, France; E-mail: jarliervincent@gmail.com

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1. INTRODUCTION

The threat of antibiotic resistance and hospital acquired infections (HAIs) led WHO to call on all countries to pay more attention to these issues with the aim of ensuring patient care safety and avoiding the development of a "post-antibiotic era" [1, 2]. In a hospital setting, antibiotic stewardship, infection control and hygiene constitute the backbone of the programs for controlling antibiotic resistance and HAIs. To evaluate the efforts done in these fields, several methods are available: cross sectional studies yielding point prevalence data, longitudinal studies yielding incidence data and audits yielding process evaluation. Each of these methods has its own characteristics and demands, advantages, limitations and drawbacks. Point prevalence survey (PPS) has been used for decades in hospital settings to evaluate antimicrobial usage and HAIs and has been promoted for its efficiency and its feasibility at large scales (multisite, regional, national) [3].

In China, antibiotic resistance and HAIs remain serious clinical issues [4-7]. Thus, the global aim is to improve the rational use of antimicrobials and infection control in Chinese hospitals. This aim justified that the Mérieux Foundation and the Chinese Medical Association jointly launched the China Against Drug Resistance (CARE) project. The first step of this project was to develop an easy to implement PPS tool for assessing, directly at the patient's bedside, the risk factors and rates of HAIs as well as the rates and quality indicators of antimicrobial usage. The PPS tool developed was a ready to use questionnaire derived from two sources: (a) the documents developed by European Surveillance of Antimicrobial Consumption (ESAC) to assess antibiotic prescriptions [8] and successfully used for the large international Global point prevalence survey recently published [9] and (b) those used by the European Centre for Disease Prevention and Control (ECDC) for the large PPS on healthcare-associated infections and antimicrobial use in European acute care hospitals [10, 11].

The questionnaire, available in English and Chinese, both on paper and tablet computer, has been designed to be filled out directly at the patient's bedside, as recommended by ECDC in 2016 [11]. The questionnaire was organized into four sections: patient characteristics, individual risk factors for HAI, HAI occurrence, and antibiotic treatment.

The PPS tool was designed to obtain major indicators concerning HAI risk factors such as Mac Cabe score, invasive procedures (vascular or urinary catheter, surgery), occurrence of HAI and antimicrobial treatment. The targeted indicators also included information to be obtained by examination of patient records at the bedside: written reason for the treatment, if treatment is based on microbiological results and prescription reassessment.

The specific objective of the present report was to test the workability of the CARE PPS tool and the feasibility to deploy surveys in Chinese hospitals using this tool. This report presents the methodology and the results of the CARE-PPS progressively deployed from 2016 to 2019 in nine large Chinese hospitals scattered over different parts of the country.

2. MATERIAL AND METHODS

2.1. Study Participation and Organization

Nine large Chinese hospitals located in eight distinct provinces or municipalities participated in the study. They were scattered over (a) Northeast China: in Liaoning province (the First Hospital of China Medical University in Shenyang), in Jilin province (the First Bethune Hospital of Jilin University in Changchun); (b) Northern China: in Tianjin municipality (Tianjin First Central Hospital and Tianjin Third Central Hospital); (c) Northwest China: in Shaanxi province (the First Affiliated Hospital of Xi'an Medical University); (d) Eastern China: in Zhejiang province (First Affiliated Hospital, Zhejiang University School of Medicine in Hangzhou; that was the first hospital included in the study for testing the tool during a pilot phase) and in Jiangsu province (Nanjing Drum Tower Hospital); (e) Western China: in Chongqing municipality (the First Affiliated Hospital of Chongqing Medical University); (e) Southern China: in Guangdong province (the First People's Hospital of Zhaoqing). A pilot phase was first conducted in 2016 at the First Affiliated Hospital in Hangzhou for testing the organization and the work was then extended to the other eight hospitals in 2018-19.

Since the main objective of the present study was to test a methodology that could be implemented in Chinese hospitals rather than obtain a complete picture of HAI and antimicrobial usage in China, each participating hospital selected 3 to 5 departments concerned by HAIs and antibiotic use and resistance such as intensive care unit (ICU), orthopedic surgery or pulmonology.

Each hospital set up a "CARE PPS project group" to conduct the study in which the departments of infection diseases (ID) and infection control (IC) played a coordinating role. Each team of investigators included one member of each of the following departments: ID, IC, microbiology laboratory and pharmacy, as well as one clinician from the units covered by the survey. It was strongly recommended that the latter did not investigate in his own unit but cross with another clinician, *e.g*. orthopedist investigating in neurosurgery, or vice-versa. The number of investigator teams was deduced from the number of beds that each hospital intended to cover and the number of patients that a single team was expected to investigate at the bedside in a single working day, based on previous experiences, *i.e*., 20-30 patients.

2.2. Investigator Training

The investigators were trained for 1-2 days by professionals with experience in PPS. The training included (a) investigator team composition and task, (b) organization of bedside visits, (c) account permission of the web-based in-line questionnaire, (d) definitions used for each questionnaire item, and (e) overview of the type of statistical data that was expected to be obtained through the PPS as well as of the potential benefit for the hospital policy.

2.3. Detailed Protocol, Definitions and Data Collection

Each hospital was free to choose the period of the PPS depending on the local situation. An "Investigator guide" was provided to explain in detail how to implement the PPS and the definitions to be used for filling out the questionnaire.

Patients included were all the inpatients present at 8 am in the selected units. Patients undergoing surgery and patients admitted or transferred in/out from/to another ward or discharged after 8 am the day of PPS were not included. Other exclusion criteria were patients hospitalized only during a part of the day (*e.g*. for endoscopy or dialysis).

Following individual patient data were recorded (a) general patient characteristics: age, gender, current ward/room/bed, date of admission, previous hospitalization; (b) risk factors for HAI: McCabe score, immunosuppression (anti-cancerous chemotherapy, radiotherapy, corticotherapy for more than 30 days, corticotherapy at high doses, haemopathy, metastatic cancer, HIV+ with CD4 <500/mm^3), invasive devices or procedures (intravascular device, indwelling urinary catheter, mechanical ventilation, surgery during the present stay); (c) availability of alcohol based solution; (d) HAI, using definitions recommended by US Centers for Disease Control (CDCs) [12]; (e) antibiotic or antifungal prescription: type, therapy or prophylaxis, microbiology lab results in patient chart, reason written in patient chart, guideline compliance, stop/review date documented in patient chart.

The PPS was implemented with the help of the hospital management, which has been beforehand, through meetings with hospital key opinion leader and administration, convinced of the potential benefit that such an approach would bring to their institution. In particular, the management involvement allowed freeing up time for investigator team members during training and PPS periods. PPS was usually organized in the middle of the week for avoiding both ends of the week when admissions or discharges make the work more difficult. Depending on the hospital, a single day or at most two consecutive days were required to complete the survey. Patient visits always took place in the presence of the physicians in charge of the patient. No patient sample was collected, no patient identification (patient name, number or date of birth…) was recorded, and there was no medical intervention (modification of care, prescription…), justifying that ethics approval and consent were waived.

2.4. Data Analysis

SAS Enterprise Guide statistical software (version 7.1) was used to perform all data analysis. Frequencies (%) were calculated. Although the study was only descriptive, comparisons were performed when appropriate using Pearson's chi-squared test. Patients who presented with multiple HAIs or received multiple antibiotics or antifungals on the PPS day were counted only once.

3. RESULTS

3.1. Workload and Feasibility

The PPS went smoothly in all the nine hospitals. The pilot PPS carried out in 2016 allowed to test the training, which has been subsequently slightly tuned to focus more on practical aspects of bedside visits, thus leading to improve the pace of visits, from 20-30 patients per day and per investigator team during the pilot PPS to an average of 40-50 patients in the eighth following hospitals. Very few data (0 to 3%, depending on the item) were missing.

3.2. Characteristics of the Patients Included

Overall, 1,170 patients were included in the nine hospitals: 138 from ICUs, 430 from medical units (mainly respiratory, infectious diseases and hematology units) and 602 from surgical units (mainly orthopedics, general surgery and neurosurgical units). The number of patients included in each hospital ranged between 100 and 178 (median 124, mean 130). The median age of the patients was 60 years. The global male/female sex ratio was 1.4.

A third of the patients had been previously hospitalized within the 6 preceding months. Mac Cabe score was 1 for 74.7% of the patients (43% in ICU *vs*. 88.6% in surgery, $p<0.01$). The part of the immuno-compromised patients was 10.7%

Overall, 14.3% of the patients had a central vascular catheter, 50.9% a peripheral vascular catheter and 19.8% an indwelling urinary catheter. The most common invasive procedures were urinary catheter (85.4%) and central vascular catheter (57.2%) in ICU, peripheral vascular catheter in medical (65%) and surgical (41.2%) wards. A large proportion (39.4%) of ICU patients was mechanically ventilated and 31.8%, of the patients underwent surgery during their hospital stay. Finally, the overall proportion of patients with no invasive device or surgery during the stay was 26% (2.4% in ICU *vs*. 29.3% in medicine, p<0.01).

For 55% of the patients, the date of bottle opening was written on the nearest available bottle of alcohol-based hand rub solution (the bottle was usually fixed to the room wall or corridor wall in front of the room). In such case, the number of days between the date of opening and the day of survey was 0-9 in 33.6%, 10-19 in 15.6%, 20-29 in 29.4% and >29 in 21.4% (Table 1).

Table 1. Characteristics of the patients, risk factors for HAI.

-	ICU (n=138)	Medicine (n=430)	Surgery (n=602)	Total (n=1,170)
Median age (years)	67	63	55	60
25-75% quartiles (years)	49 - 79	52 - 74	41-64	48 -71
Sex ratio	1.9	1.7	1.2	1.4
Mac Cabe score 1	56/130 (43%)	278/428 (65%)	528/596 (88.6%)	862/1,154 (74.7%)
Mac Cabe score 2	44/130 (33.9%)	122/428 (28.5%)	64/596 (10.7%)	230/1,154 (19.9%)
Mac Cabe score 3	30/130 (23.1%)	28/428 (6.5%)	4/596 (0.7%)	62/1,154 (5.4%)
Immuno-compromised	13/137 (9.5%)	81/430 (18.8%)	31/598 (5.2%)	125/1,165 (10.7%)
Surgery during the stay	43/138 (31.2%)	14/430 (3.3%)	315/602 (52.3%)	372/1,170 (31.8%)
Central vascular catheter	79/138 (57.2%)	24/428 (5.6%)	61/578 (10.6%)	164/1,144 (14.3%)
Peripheral vascular catheter	78/137 (56.9%)	278/428 (65.0%)	240/583 (41.2%)	596/1,148 (50.9%)
Indwelling urinary catheter	117/137 (85.4%)	30/428 (7.0%)	80/580 (13.8%)	227/1,145 (19.8%)
Mechanical ventilation	54/137 (39.4%)	0/427 (0.0%)	5/576 (0.9%)	59/1,140 (5.2%)
Not any invasive device or surgery	3/135 (2.4%)	125/426 (29.3%)	167/575 (29.0%)	295/1,136 (26.0%)

Table 2. HAI rates and types, related microorganisms.

-	Total (n = 1,170)
Active HAI	**74 (6.3%)**
ICU (n = 138)	32 (23.2%)
Medicine (n = 430)	16 (3.7%)
Surgery (n = 602)	26 (4.3%)
% HAI present at admission	**30/74 (40.5%)**
ICU	6/32 (18.8%)
Medicine	13/16 (81.3%)
Surgery	11/26 (42.3%)
Types of HAIs	-
Lower respiratory tract infection	33 (45%)
Surgical-site related infection	12 (16%)
Intra-abdominal, gastrointestinal and genital infections	9 (12%)
Central nervous system	3 (4%)
intravascular catheter related infection	3 (4%)
Others	14(19%)
Microorganisms identified in HAIs	N=50
Acinetobacter baumannii	11 (22%)
Pseudomonas aeruginosa	9 (18%)
Klebsiella pneumoniae	9 (18%)
Escherichia coli	8 (16%)
Other *Enterobacteriaceae* and Gram negative species	6 (12%)
Staphylococcus aureus	2 (4%)
coagulase negative *Staphylococci*	2 (4%)
Candida and other fungi	3 (6%)

3.3. Active HAI, Detected Microorganisms and Antibiotic Treatments

Among the 1.170 patients, 74 (6.3%) had an active HAI the day of PPS (23.2% in ICUs *vs*. 3.7% in medicine, 4.3% in surgery, p<0.01), 30 of them being already infected at admission. The most common types of HAIs were lower respiratory tract infection and surgical-site related infection. The microorganisms causing HAIs were mainly *Acinetobacterbaumannii* (22%), *Pseudomonas aeruginosa* (18%) and *Klebsiella pneumoniae* (18%) (Table 2).

3.4. Antimicrobials received for therapy (Tables 3 and 4)

Overall, 54.5% of patients received antibiotics or antifungals for therapeutic use on the day of the survey (36% in surgery *vs*. 78.3% in ICU, p<0.01). The majority (71.2%) of treated patients received a single drug whereas 4.6% received ≥3 drugs.

The most common antibiotics used as single drugs were beta-lactams (83%), mainly with large spectrum, *i.e*. 3rd generation cephalosporins or carbapenems with or without beta-lactamase inhibitor. In contrast, few patients received aminopenicillins, ureidopenicillins without beta-lactamase inhibitors or antistaphylococcal antibiotics (Tables 3 and 4).

3.5. Antibiotic Received for Prophylaxis

Overall, 199 (17%) of the patients received antibiotic prophylaxis on the day of the survey (29.7% in surgery, 14.5% ICU, 0% in medicine), mainly for surgical procedures. The most common antibiotics used for prophylaxis in surgery were 1st and 2nd generation cephalosporins and antianaerobes.

3.6. Antibiotic and Antifungal Treatments: Quality Indicators

For half of the 453 patients receiving a single antimicrobial drug for therapeutic use, the reason for the treatment was documented in the patient medical records (62.5% in ICU *vs*. 35.7% in surgery, p<0.01). In contrast, only <10% of antibiotic treatments were targeted, *i.e*. based on microbiological results from relevant clinical samples and available at the time of the survey. A stop/review process (*i.e*. a prescription reassessment) was documented in medical records for 30.7% of the treated patients (43.1% in ICU *vs*. 14.9% in surgery, p<0.01) (Table 5).

Table 3. Antibiotics or antifungals treatment (therapeutic use).

-	ICU (n = 138)	Medicine (n = 430)	Surgery (n = 602)	Total (n = 1,170)
Treated patients	108/138 (78.3%)	312/430 (72.6%)	216/600 (36.0%)	636/1,168 (54.5%)
Number of drugs received per treated patient	-	-	-	-
1	72/108 (66.7%)	213/312 (68.3%)	168/216 (77.8%)	453/636 (71.2%)
2	23/108 (21.3%)	84/312 (26.9%)	48/216 (22.2%)	155/636 (24.3%)
3	11/108 (10.2%)	13/312 (4.2%)	2/216 (0.9%)	26/636 (4.1%)
>3	1 (0.9%)	2/312(0.6%)	0 (0.0%)	3/636 (0.5%)

Table 4. Antibiotics or antifungals received for therapeutic use (453 patients receiving a single drug).

1st generation cephalosporins	33 (7.3%)
2nd generation cephalosporins	13 (2.9%)
Cefoxitin	22 (4.8%)
3rd generation cephalosporins	90 (19.9%)
3rd generation cephalosporins + inhibitor*	58 (12.8%)
4th generation cephalosporins	23 (5.1%)
Carbapenems	48 (10.6%)
Carbapenems + inhibitor*	22 (4.8%)
Ureidopenicillins	14 (3.1%)
Ureidopenicillins + inhibitor*	50 (11.0%)
Aminopenicillins	3 (0.7%)
Fluoroquinolones	39 (8.6%)
antistaphylococcal antibiotics**	14 (3.1%)
antifungals	6 (1.3%)
others	18 (4.0%)

Note: * beta-lactamase inhibitors ** vancomycin, teicoplanin, linezolid.

Table 5. Patients receiving a single antibiotic or antifungal for therapeutic use: quality indicators of prescription.

-	ICU (n=72)	Medicine (n=213)	Surgical (n=168)	Total (n=453)
Reason of treatment documented in medical records	45/72 (62.5%)	135/213 (63.7%)	60/168 (35.7%)	240/453 (53.0%)
Guideline compliance[a]	45/72 (62.5%)	162/213 (76.1%)	46/168 (27.4%)	253/453 (55.8%)
Stop/review date documented[b]	31/72 (43.1%)	83/213 (39.0%)	25/168 (14.9%)	139/453 (30.7%)
Targeted treatment[c]	12/72 (16.7%)	20/213 (9.4%)	10/168 (5.9%)	42/453 (9.3%)
Treatment based on biomarker[d]	54/72 (75.0%)	136/213 (63.8%)	54/168 (32.1%)	244/453 (53.9%)

Note: [a] Guideline compliance: antibiotic choice is in compliance with local guidelines, local policy or infection specialist advice.
[b] Stop/review documented in medical records: prescription reassessment planned or already done.
[c] Targeted treatment: based on microbiological results *i.e.* culture ± susceptibility test result, from a relevant clinical sample (screening samples excluded) available at the time of survey.
[d] Treatments based on biomarker: C-reactive protein (CRP), procalcitonin (PCT).

4. DISCUSSION

The results of the CARE point prevalence survey (PPS) showed that the methodology and the standardized tool designed for evaluating, at the patient level and through direct bedside visits, the risk factors for HAIs, the occurrence of HAIs, as well as the occurrence of antimicrobial treatments and prescription process, was successfully deployed in a sample of large Chinese hospitals scattered over different parts of the country. This demonstrates the feasibility to organize studies based on such an approach at a large scale in China. The involvement of hospital management and the infection control, pharmacy and microbiology laboratory teams played a decisive role in the CARE PPS success.

The principle adopted for the CARE project has been used for decades in the field to evaluate HAI burden [3], and risk factor for HAI [13, 14] as well as to measure antimicrobial usage [15]. First used at the local level, PPS has been extended to multisite surveys at national [3, 16] and international levels [9-11, 17].

The backbone of the CARE PPS was the methodologies successfully used for the "Global-PPS" worldwide study on hospitalized patients receiving antimicrobials performed in 2015 [9] and for the European healthcare-associated infections and antimicrobial use studies conducted in Europe by ECDC in 2011-12 and 2016 [10, 11]. As the ECDC studies, CARE PPS included all patients of the selected wards, whether receiving antimicrobials or not. An important point is that data collection in CARE project was organized at the patient bedside for obtaining by direct observation and with the help of the clinicians in charge of the patients, accurate information, particularly concerning patients' status (Mac Cabe score, reason for antimicrobial treatment, HAI symptoms…) that are often difficult to ascertain by only reading patients notes [18]. Indeed, many hospital PPS rely mainly or exclusively on patient records examination, *e.g.*, through pharmacy or laboratory information system, which is less time consuming [9, 17] but less accurate [18]. However, after gaining experience, an average of 40-50 patients were visited at the bedside each day by each investigator team, a workload making it possible to cover in 5 working days with 10 investigators teams a 2,000 beds hospital, a common size for tertiary care hospitals in China.

Even if the present study, which enrolled only 1,170 patients in 9 hospitals, aimed at assessing the workability of the CARE PPS methodology based on bedside visits, and not at obtaining a global picture of antimicrobial use and HAIs in Chinese hospitals, some valuable insights were obtained. When compared with the results obtained during the ECDC 2011-12 study [10], the proportions of patients with HAI risk factors found in the present study were rather comparable for several variables: Mac Cabe score 1, *i.e.* no ultimately fatal underlying disease (74.7% in the present study *vs.* 66.3%), peripheral venous catheter (50.9% *vs.* 46.7%) and urinary catheter (19.8% *vs.* 17.2%). Moreover, the HAI prevalence was 6.3% in the present study, *i.e.* close to that measured by the ECDC study (mean of the countries 6.0%, median 5.7%). In contrast, there was a large difference in the proportion of patients receiving antibiotic or antifungal for therapeutic use: 54.5% in the present study but 23.6% in the ECDC study. The proportion of patients receiving antibiotics or antifungals for therapeutic use was also far lower (23%) in the Global-PPS performed in 2015 in 53 countries [9]. The difference observed could be partly due to a larger proportion of ICU patients in the present study (11.8%) than in ECDC 2011-12 and Global-PPS 2015 studies (4.7 and 6%, respectively). But it should be noted that higher rates of treatments in the present study hold true when considering separately ICU patients: 78.3% of treated patients *vs.* 56% in ECDC study and 53% in the global-PPS study. Proportion of treated patients was also higher for surgical and medical patients in the present study than in the two above studies used as comparators (data not shown).

Importantly, there were also large differences with ECDC study concerning the type of antibiotic received for treatment: far less (0.7 in the present study *vs*. 18%) aminopenicillins combined or not with beta-lactamase inhibitor, but in contrast far more 3rd generation cephalosporins without (19.9 *vs*. 9.4%) or with (12.8 *vs*. 0.2%) combined beta-lactamase inhibitor, and 4th generation cephalosporins (5.1 *vs*. 0.3%). The common use of antibiotics with a large spectrum covering multiresistant organisms, particularly Gram negative bacteria, is likely due to the high prevalence of such bacteria in Chinese hospitals [6, 7].

Indicators of the antimicrobial prescription process are often used as quality indicators [9, 10].

The reason for prescription entered into patient records is especially noteworthy since it makes it possible for a doctor who isn't physically caring for the patient like a resident on call to comprehend the circumstances at any point.

In the present study, 53% of treatments met this indicator, as compared to 79.4% in the ECDC study [10] and 76.9% in the Global-PPS study (range between world regions: 64.3% in Eastern Europe to 84.9% in North America) [9].

A stop/review process was noted in the patient's chart for 30.7% of the treated patients in this study. This rate is similar to the Global-PPS rate of 38.3%, meaning that both are quite low given the critical role that systematic reassessments play in limiting the length of antibiotic treatments.

The proportion of targeted treatments (based on microbiological results) was low in the present study (9.3%) as in the Global-PPS (19.8%, range 7.8% in Eastern Europe to 24-27% in Western Europe, Northern and Latin America), suggesting a limited use of microbiological investigations. The rate of guideline compliance was also lower (55.8%) than that yielded by the Global-PPS (77.4%) [9]. Thus, the indicator rates reported in the nine Chinese hospitals included in the present study suggest that there is room for improvement in antimicrobial policy and that the indicators for prescription could be usefully included in future Key Performance Indicators (*KPIs*).

An important point is that CARE PPS also paid attention to the use of alcohol based hand rub solutions (ABHRs), a major tool for preventing HAIs and cross-transmission of resistant bacteria in hospitals. The use ABHRs can be indeed evaluated globally as liters per 1000 patient days [10], but during the present study, visits from bed to bed allowed looking at the ABHR bottle nearest to each patient. Interestingly, the date of opening was not written on the bottle in 45% of the cases, hampering to follow the use of the product by hospital personnel. When written, the number of days between the date of opening and the day of the survey was >20 in half of the cases, suggesting limited usage. Indeed, considering that ABHR bottles (mostly 500 ml) are shared by 3-4 patients in the room, 20 days of use allow only 3 to 4 uses (3 ml each) per patient and per day. This point should trigger audit studies and justify intensifying ABHR campaigns.

In the past, multisite PPS surveys have been often used during the last decade in China, focusing either on antimicrobial use [19, 20] or on HAIs [21-23], but very few addressed both aspects [24]. Moreover, these studies did not investigate the risk factors for HAI, the types of antimicrobial used and the quality indicators for prescription. The PPS aiming at measuring HAI prevalence found low rates: 2.1% of infected patients in 2014 in 124 hospitals in Beijing [21], 2.9% in 2015 in 51 hospitals in Dong Guan [22] and 3.9% in 2007-08 13 hospitals in Hubei province [23]. An important PPS was organized in 2012 in 1.313 hospitals by the National Health and Family planning commission which aimed at measuring the prevalence of antimicrobial use and found that 38.4% of treated patients (2/3 for therapeutic uses, 1/3 for prophylaxis; 75% of treatment with a single drug) [19]. An interesting study by Chunhui Li reported the results of repeated PPS in a very large set of tertiary hospitals over 31 Chinese provinces (~1000 hospitals for each PPS), showing a decrease in the proportion of patients receiving antimicrobials, from 54.8% in 2001 to 45.2% in 2010, following the introduction at the national level of documents on rational use and local programs [20]. Moreover, in the latter study, the proportion of treated patients who received a single drug increased from 61% to 70%. A PPS combining HAI and antibiotic use study performed in 2017-18 in 189 hospitals in Guangdong province found a very low HAI rate (1.2%) and that 46% of the patients received antibiotics [24]. Interestingly, this study also reported the result of a hand hygiene audit, compliance being globally 74% and that the rate of microbiology testing before therapeutic antibiotic use was 45%.

It should be stressed that beyond the direct interest of producing a snapshot picture of HAI and antimicrobial use, PPS can play a pivotal role in hospital setting. A large body of published data showed that PPS methodology is a fruitful tool for addressing a broad range of aspects connected with the quality of care strategy.

First, PPS brings an invaluable indirect benefit to the hospital community, particularly if the study is based on direct bedside visits. It is why the ECDC protocol for the 2016 European PPS says “Walk around the ward. For each patient, observe for invasive devices…” [11]. Organizing and training the teams of investigators who will walk during the PPS through the hospital wards and will include not only professionals from infection control, infection diseases, microbiology and pharmacy departments but also clinicians of the institution studied, represent a unique collective experience leading to increase the consciousness and motivation on infection control and antibiotic stewardship in real life and increase cohesion around improvement targets. For this reason, PPS is often taken as a starting experience in institutions willing to engage in quality care programs [25].

Second, PPS allows to focus on particular sectors of care, such as neonates and children, to identify specific risk factors for HAI [26] or nursing homes and long term care facilities where HAIs are linked with the general conditions of long lasting stay [27]. Repeating PPS at given intervals of time maintains focus on HAIs and antimicrobial use in the institution and measures changes in practices [28]. Trends in HAI rates and prescriptions can also be identified through repeated studies [29-31].

Third, PPS can be organized simultaneously in different settings, allowing pointing out differences in HAI rates or converging issues in antimicrobial use between study sites, thus potentially leading to a benchmark process. For example, this approach has been applied to countries within continents of Europe [32] or Latin America [33].

Finally, PPS results may be used as a valuable source for designing quality indicators for an institution or a set of institutions [*e.g.* at regional or national levels] [34]. PPS data also constitute a robust basis for developing models to predict HAI risk [35].

In a nutshell, as emphasized in a systematic review, PPS approach is a useful tool to quantify HAIs and antimicrobial use and provides a rational basis for policymakers [36], providing that the methodology is standardized [37].

Importantly, PPS on HAI risk factors and antimicrobial use in hospitals remains a tool of high value in the wake of the COVID-19 pandemic. Indeed, the severity of hospitalized Covid patients led to an increase in HAI risk, overuse of antimicrobial drugs and a subsequent growing frequency of antimicrobial resistance. Despite a strong call to follow antimicrobial stewardship principles [38], the use of large spectrum antibiotics was recommended in the early period of the pandemic by the Surviving Sepsis Campaign guidelines on the management of critically ill adults with COVID-19 [39]. The negative impact of the pandemic on HAIs and antibiotic resistance has been assessed in many countries [40-43], including in China [44.45]. When the zero policy came to an end in late 2022, severe COVID outbreaks occurred all over China, which resulted in a huge increase in antibiotic use and prevalence of multidrug resistant bacteria (MDRB) [46]. The burden of MDRBs in Chinese hospitals has been largely documented in recent studies [47-49], particularly carbapenem resistant *Klebsiella*, *Enterobacter* and *Acinetobacter* which cause difficult to treat infections [50-52].

So, either before or after COVID, antimicrobial resistance and HAIs are always major challenges in hospital settings. It is why the Chinese government announced a new national action plan in 2022, the “National Action Plan for Combating Antimicrobial Resistance (2022-2025)” [53]. This plan, led by the National Health Commission (NHC), updates the medical quality control indicators for HAI management and antibiotic policy, justifying the diffusion of PPS tools such as that proposed in the present report.

CONCLUSION

The present report demonstrated the workability of the CARE project methodology in Chinese hospitals. The implementation of the CARE project at a large scale would help improving the prevention of nosocomial infections and provide an effective basis for the rational usage of antimicrobials. Engagement in the project would provide an authoritative decision basis for the proper management of antimicrobial prescribing and infection control strategies that will be suitable for China.

AUTHORS’ CONTRIBUTIONS

YX and VJ conceived the study. YX organized the pilot phase of the study in Hangzhou. YX ensured relations with the management of the hospitals and organized the training of the investigator teams. QW, JY, JZ, HL, WY, CF, YC, WH organized the study in their respective hospitals. YX, SG, PV and QL ensured relations with Chinese Health authorities and the Chinese Medical Association. VJ conceived and drafted the manuscript and produced the different versions. YX and YX reviewed the manuscript.

LIST OF ABBREVIATIONS

PPS	=	Point Prevalence Survey
HAIs	=	Hospital Acquired Infections
ICU	=	Intensive Care Unit

ETHICAL STATEMENT

No patient sample was collected, no patient identification (patient name, number or date of birth…) was recorded, and there was no medical intervention (modification of care, prescription…), justifying that ethics approval and consent were waived.

CONSENT FOR PUBLICATION

Not applicable.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIAL

Datasets generated during this study are not publicly available as they are the property of the participating hospitals, but are available from each hospital on reasonable request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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REFERENCES

[1] Pittet D, Donaldson L. Clean care is safer care: The first global challenge of the who world alliance for patient safety. Infect Control Hosp Epidemiol 2005; 26(11): 891-4. http://dx.doi.org/10.1086/502513 PMID: 16320985

[2] Global action plan on antimicrobial resistance. 2015. Available from: https://ahpsr.who.int/publications/i/item/global-action-plan-on-antimicrobial-resistance Accessed May 2015.

[3] Llata E, Gaynes RP, Fridkin S. Measuring the scope and magnitude of hospital-associated infection in the United States: The value of prevalence surveys. Clin Infect Dis 2009; 48(10): 1434-40. http://dx.doi.org/10.1086/598328 PMID: 19351269

[4] Li C, Wen X, Ren N, *et al.* Point-prevalence of healthcare-associated infection in china in 2010: A large multicenter epidemiological survey. Infect Control Hosp Epidemiol 2014; 35(11): 1436-7. http://dx.doi.org/10.1086/678433 PMID: 25333447

[5] Cui D, Liu X, Hawkey P, *et al.* Use of and microbial resistance to antibiotics in China: A path to reducing antimicrobial resistance. J Int Med Res 2017; 45(6): 1768-78. http://dx.doi.org/10.1177/0300060516686230 PMID: 29239248

[6] Ma X, Wu Y, Li L, *et al.* First multicenter study on multidrug resistant bacteria carriage in Chinese ICUs. BMC Infect Dis 2015; 15(1): 358. http://dx.doi.org/10.1186/s12879-015-1105-7 PMID: 26290050

[7] Hu FP, Guo Y, Zhu DM, *et al.* Resistance trends among clinical isolates in China reported from CHINET surveillance of bacterial resistance, 2005–2014. Clin Microbiol Infect 2016; 22 (Suppl. 1): S9-S14. http://dx.doi.org/10.1016/j.cmi.2016.01.001 PMID: 27000156

[8] Zarb P, Amadeo B, Muller A, *et al.* Identification of targets for quality improvement in antimicrobial prescribing: The web-based ESAC Point Prevalence Survey 2009. J Antimicrob Chemother 2011; 66(2): 443-9. http://dx.doi.org/10.1093/jac/dkq430 PMID: 21084362

[9] Versporten A, Zarb P, Caniaux I, *et al.* Antimicrobial consumption and resistance in adult hospital inpatients in 53 countries: Results of an internet-based global point prevalence survey. Lancet Glob Health 2018; 6(6): e619-29. http://dx.doi.org/10.1016/S2214-109X(18)30186-4 PMID: 29681513

[10] ECDC. Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals 2011-2012. Surveillance report. 2013. Available from: http://www.ecdc.europa.eu Accessed July 2013.

[11] ECDC. Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals-protocol version 5.3. 2016. Available from: http://www.ecdc.europa.eu Accessed October 2016.

[12] Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care–associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008; 36(5): 309-32. http://dx.doi.org/10.1016/j.ajic.2008.03.002 PMID: 18538699

[13] Pittet D, Harbarth S, Ruef C, *et al.* Prevalence and risk factors for nosocomial infections in four university hospitals in Switzerland. Infect Control Hosp Epidemiol 1999; 20(1): 37-42. http://dx.doi.org/10.1086/501554 PMID: 9927264

[14] Weinstein JW, Mazon D, Pantelick E, Reagan-Cirincione P, Dembry LM, Hierholzer WJ Jr. A decade of prevalence surveys in a tertiary-care center: Trends in nosocomial infection rates, device utilization, and patient acuity. Infect Control Hosp Epidemiol 1999; 20(8): 543-8. http://dx.doi.org/10.1086/501675 PMID: 10466554

[15] Cooke DM, Salter AJ, Phillips I. The impact of antibiotic policy on prescribing in a London Teaching Hospital A one–day prevalence survey as an indicator of antibiotic use. J Antimicrob Chemother 1983; 11(5): 447-53. http://dx.doi.org/10.1093/jac/11.5.447 PMID: 6874630

[16] Prevalence of nosocomial infections in France: results of the nationwide survey in 1996. J Hosp Infect 2000; 46(3): 186-93. http://dx.doi.org/10.1053/jhin.2000.0833 PMID: 11073727

[17] Ansari F, Erntell M, Goossens H, Davey P. The European surveillance of antimicrobial consumption (ESAC) point-prevalence survey of antibacterial use in 20 European hospitals in 2006. Clin Infect Dis 2009; 49(10): 1496-504. http://dx.doi.org/10.1086/644617 PMID: 19842976

[18] Zarb P, Coignard B, Griskeviciene J, *et al.* The European centre for disease prevention and control (ECDC) pilot point prevalence survey of healthcare-associated infections and antimicrobial use. Euro Surveill 2012; 17(46): pil-20316. http://dx.doi.org/10.2807/ese.17.46.20316-en PMID: 23171822

[19] Ren N, Zhou P, Wen X, *et al.* Point prevalence survey of antimicrobial use in Chinese hospitals in 2012. Am J Infect Control 2016; 44(3): 332-9. http://dx.doi.org/10.1016/j.ajic.2015.10.008 PMID: 26717869

[20] Li C, Ren N, Wen X, *et al.* Changes in antimicrobial use prevalence in China: results from five point prevalence studies. PLoS One 2013; 8(12): e82785. http://dx.doi.org/10.1371/journal.pone.0082785 PMID: 24376580

[21] Liu JY, Wu YH, Cai M, Zhou CL. Point-prevalence survey of healthcare-associated infections in Beijing, China: A survey and analysis in 2014. J Hosp Infect 2016; 93(3): 271-9. http://dx.doi.org/10.1016/j.jhin.2016.03.019 PMID: 27140419

[22] Wang J, Hu J, Harbarth S, Pittet D, Zhou M, Zingg W. Burden of healthcare-associated infections in China: results of the 2015 point prevalence survey in Dong Guan City. J Hosp Infect 2017; 96(2): 132-8. http://dx.doi.org/10.1016/j.jhin.2017.02.014 PMID: 28325579

[23] Xie D, Xiong W, Xiang L, *et al.* Point prevalence surveys of healthcare-associated infection in 13 hospitals in Hubei Province, China, 2007–2008. J Hosp Infect 2010; 76(2): 150-5. http://dx.doi.org/10.1016/j.jhin.2010.04.003 PMID: 20692727

[24] Zhang Y, Zhong ZF, Chen SX, *et al.* Prevalence of healthcare-associated infections and antimicrobial use in China: Results from the 2018 point prevalence survey in 189 hospitals in Guangdong Province. Int J Infect Dis 2019; 89: 179-84. http://dx.doi.org/10.1016/j.ijid.2019.09.021 PMID: 31580939

[25] Abdulrazzaq N, Chkhis A. Prevalence of antimicrobial use and healthcare-associated infections in the UAE: Results from the first nationwide point-prevalence survey. Infectious Diseases Now 2024; 54(4): 104891. http://dx.doi.org/10.1016/j.idnow.2024.104891 PMID: 38537707

[26] Zingg W, Hopkins S, Gayet-Ageron A, *et al.* Health-care-associated infections in neonates, children, and adolescents: An analysis of paediatric data from the European Centre for Disease Prevention and Control point-prevalence survey. Lancet Infect Dis 2017; 17(4): 381-9. http://dx.doi.org/10.1016/S1473-3099(16)30517-5 PMID: 28089444

[27] Latour K, Catry B, Devleesschauwer B, Buntinx F, De Lepeleire J, Jans B. Healthcare-associated infections and antimicrobial use in Belgian nursing homes: Results of three point prevalence surveys between 2010 and 2016. Arch Public Health 2022; 80(1): 58. http://dx.doi.org/10.1186/s13690-022-00818-1 PMID: 35180883

[28] Antonioli P, Manzalini MC, Stefanati A, *et al.* Temporal trends of healthcare associated infections and antimicrobial use in 2011-2013, observed with annual point prevalence surveys in Ferrara University Hospital, Italy. J Prev Med Hyg 2016; 57(3): E135-41. PMID: 27980377

[29] Aghdassi SJS, Hansen S, Peña Diaz LA, *et al.* Healthcare-associated infections and the use of antibiotics in german hospitals results of the point prevalence survey of 2022 and comparison with earlier findings. Dtsch Arztebl Int 2024; (Forthcoming): arztebl.m2024.0033. PMID: 38471129

[30] Mitchell R, Taylor G, Rudnick W, *et al.* Trends in health care–associated infections in acute care hospitals in Canada: An analysis of repeated point-prevalence surveys. CMAJ 2019; 191(36): E981-8.
http://dx.doi.org/10.1503/cmaj.190361 PMID: 31501180

[31] Liang JJ, Rudnick W, Mitchell R, *et al.* Canadian nosocomial infection surveillance program. Infect Control Hosp Epidemiol 2022; 43(11): 1558-64.
http://dx.doi.org/10.1017/ice.2021.519 PMID: 35249564

[32] Kärki T, Plachouras D, Cassini A, Suetens C. Burden of healthcare-associated infections in European acute care hospitals. Wien Med Wochenschr 2019; 169(S1) (Suppl. 1): 3-5.
http://dx.doi.org/10.1007/s10354-018-0679-2 PMID: 30680486

[33] Huerta-Gutiérrez R, Braga L, Camacho-Ortiz A, *et al.* One-day point prevalence of healthcare-associated infections and antimicrobial use in four countries in Latin America. Int J Infect Dis 2019; 86: 157-66.
http://dx.doi.org/10.1016/j.ijid.2019.06.016 PMID: 31229613

[34] Aghdassi SJS, Schwab F, Hansen S, *et al.* The quality of antimicrobial prescribing in acute care hospitals: Results derived from a national point prevalence survey, Germany, 2016. Euro Surveill 2019; 24(46): 1900281.
http://dx.doi.org/10.2807/1560-7917.ES.2019.24.46.1900281 PMID: 31771705

[35] Golfera M, Toscano F, Cevenini G, *et al.* Predicting Healthcare-associated Infections: Are point of prevalence surveys data useful? J Prev Med Hyg 2022; 63(2): E304-9.
PMID: 35968075

[36] Saleem Z, Godman B, Hassali MA, Hashmi FK, Azhar F, Rehman IU. Point prevalence surveys of health-care-associated infections: A systematic review. Pathog Glob Health 2019; 113(4): 191-205.
http://dx.doi.org/10.1080/20477724.2019.1632070 PMID: 31215326

[37] Reilly JS, Price L, Godwin J, *et al.* A pilot validation in 10 European union member states of a point prevalence survey of healthcare-associated infections and antimicrobial use in acute hospitals in Europe, 2011. Euro Surveill 2015; 20(8): 21045.
http://dx.doi.org/10.2807/1560-7917.ES2015.20.8.21045 PMID: 25742434

[38] Huttner BD, Catho G, Pano-Pardo JR, Pulcini C, Schouten J. COVID-19: Don't neglect antimicrobial stewardship principles! Clin Microbiol Infect 2020; 26(7): 808-10.
http://dx.doi.org/10.1016/j.cmi.2020.04.024 PMID: 32360446

[39] Alhazzani W, Møller MH, Arabi YM, *et al.* Surviving sepsis campaign: Guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). Intensive Care Med 2020; 46(5): 854-87.
http://dx.doi.org/10.1007/s00134-020-06022-5 PMID: 32222812

[40] Fried MW, Crawford JM, Mospan AR, Watkins SE, Munoz Hernandez B, Zink RC. Patient characteristics and outcomes of 11 721 patients with coronavirus disease 2019 (COVID-19) hospitalized across the United States. Clin Infect Dis 2021; 72(10): e558-65.
http://dx.doi.org/10.1093/cid/ciaa1268

[41] Sepulveda J, Westblade LF, Whittier S, *et al.* Bacteremia and blood culture utilization during COVID-19 surge in New York City. J Clin Microbiol 2020; 58(8): e00875-20.
http://dx.doi.org/10.1128/JCM.00875-20 PMID: 32404482

[42] Cataldo MA, Tetaj N, Selleri M, *et al.* Incidence of bacterial and fungal bloodstream infections in COVID-19 patients in intensive care: An alarming "collateral effect". J Glob Antimicrob Resist 2020; 23: 290-1.
http://dx.doi.org/10.1016/j.jgar.2020.10.004 PMID: 33130024

[43] Amarsy R, Trystram D, Cambau E, *et al.* Surging bloodstream infections and antimicrobial resistance during the first wave of COVID–19: A study in a large multihospital institution in the Paris region. Int J Infect Dis 2022; 114: 90-6.
http://dx.doi.org/10.1016/j.ijid.2021.10.034 PMID: 34688945

[44] Guan W, Ni Z, Hu Y, *et al.* Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020; 382(18): 1708-20.
http://dx.doi.org/10.1056/NEJMoa2002032 PMID: 32109013

[45] Zhang H, Zhang Y, Wu J, *et al.* Risks and features of secondary infections in severe and critical ill COVID-19 patients. Emerg Microbes Infect 2020; 9(1): 1958-64.
http://dx.doi.org/10.1080/22221751.2020.1812437 PMID: 32815458

[46] Shen H, Xiao D, Zhang Q, *et al.* The features of multidrug-resistant organisms between 2016 and March 2023 and its change after the end of zero-COVID-19 policy in a teaching hospital in Shenzhen, China. J Glob Antimicrob Resist 2024; 37: 91-2.
http://dx.doi.org/10.1016/j.jgar.2024.02.021 PMID: 38458536

[47] Luo Q, Lu P, Chen Y, *et al.* ESKAPE in China: Epidemiology and characteristics of antibiotic resistance. Emerg Microbes Infect 2024; 13(1): 2317915.
http://dx.doi.org/10.1080/22221751.2024.2317915 PMID: 38356197

[48] Bai HJ, Geng QF, Jin F, Yang YL. Epidemiologic analysis of antimicrobial resistance in hospital departments in China from 2022 to 2023. J Health Popul Nutr 2024; 43(1): 39.
http://dx.doi.org/10.1186/s41043-024-00526-2 PMID: 38449053

[49] Balasubramanian R, Van Boeckel TP, Carmeli Y, Cosgrove S, Laxminarayan R. Global incidence in hospital-associated infections resistant to antibiotics: An analysis of point prevalence surveys from 99 countries. PLoS Med 2023; 20(6): e1004178.
http://dx.doi.org/10.1371/journal.pmed.1004178 PMID: 37310933

[50] Yan Z, Ju X, Zhang Y, *et al.* Analysis of the transmission chain of carbapenem-resistant Enterobacter cloacae complex infections in clinical, intestinal and healthcare settings in Zhejiang province, China (2022-2023). Sci Total Environ, 2023.

[51] Jia Y, Liu Y, Huang Y, *et al.* Clinical characteristics, drug resistance, and risk factors for death of *Klebsiella pneumoniae* infection in patients with acute pancreatitis: A single-center retrospective study from China. Infect Drug Resist 2023; 16: 5039-53.
http://dx.doi.org/10.2147/IDR.S410397 PMID: 37576517

[52] Hu F, Pan Y, Li H, *et al.* Carbapenem-resistant Klebsiella pneumoniae capsular types, antibiotic resistance and virulence factors in China: A longitudinal, multi-centre study. Nat Microbiol 2024; 9(3): 814-29.
http://dx.doi.org/10.1038/s41564-024-01612-1 PMID: 38424289

[53] Ding L, Hu F. China's new national action plan to combat antimicrobial resistance (2022–25). J Antimicrob Chemother 2023; 78(2): 558-60.
http://dx.doi.org/10.1093/jac/dkac435 PMID: 36575634