Journal of Global Antimicrobial Resistance 3 (2015) 155–160

Contents lists available at ScienceDirect

Journal of Global Antimicrobial Resistance

journal homepage: www.elsevier.com/locate/jgar

Review

# Alarming and increasing prevalence of multidrug-resistant *Pseudomonas aeruginosa* among healthcare-associated infections in China: A meta-analysis of cross-sectional studies

Yang Peng [a,b,1], Jing Shi [c,1], Tao Bu [a,d,1], Ying Li [e], Xiaohua Ye [a,b], Xiaofeng Chen [a,b], Zhenjiang Yao [a,b,1,*]

[a] Department of Epidemiology and Health Statistics, Guangdong Pharmaceutical University, Guangzhou, China
[b] Guangdong Key Laboratory of Molecular Epidemiology, Guangdong Pharmaceutical University, Guangzhou, China
[c] Department of Preventative Medicine, Hebei University of Traditional Medicine, Shijiazhuang, China
[d] Department of Prevention and Health Care, The First Teaching Hospital of Xinjiang Medical University, Urumqi, China
[e] Public Health Laboratory Center, Guangdong Pharmaceutical University, Guangzhou, China

A R T I C L E I N F O

*Article history:*
Received 17 January 2015
Received in revised form 7 April 2015
Accepted 9 April 2015

*Keywords:*
Prevalence
*Pseudomonas aeruginosa*
Multidrug-resistant
China
Meta-analysis

A B S T R A C T

A number of studies have reported on the prevalence of multidrug-resistant *Pseudomonas aeruginosa* (MDR-PA) among healthcare-associated infections (HAIs) in China; however, the exact rate of MDR-PA is unclear due to different definitions. Therefore, this meta-analysis was conducted to explore the prevalence of MDR-PA among HAIs in China based on an international recommended standard. Medline, Ovid, Cochrane Library, China National Knowledge Infrastructure (CNKI) and Wanfang databases were systematically searched and papers published before February 2014 providing exact data on MDR-PA in the Chinese population were identified. Overall effects, subgroup analysis and sensitivity analysis were performed using Stata v.13.0 software. Twenty-six studies were finally included. The overall prevalence of MDR-PA was 29.0% (95% confidence interval 24.6–33.4%). The rate of MDR-PA increased over time ($P < 0.001$). The prevalence of MDR-PA was higher among patients in intensive care units (ICUs) (41.4%) than among non-ICU patients (24.1%) ($P < 0.001$). In conclusion, the present meta-analysis comprehensively evaluated the prevalence of MDR PA in China and the findings suggest that MDR-PA should receive more attention.



**Contents**



* Corresponding author at: Department of Epidemiology and Health Statistics, Guangdong Pharmaceutical University, Guangzhou, China. Tel.: +86 20 3405 5806; fax: +86 20 3405 5355.
*E-mail address:* zhjyao200@yahoo.com (Z. Yao).

[1] These authors contributed equally to this work.

http://dx.doi.org/10.1016/j.jgar.2015.04.001
2213-7165/

## 1. Introduction

*Pseudomonas aeruginosa* is an invasive Gram-negative bacterium responsible for a broad range of infections, including otitis externa, osteomyelitis, meningitis, endocarditis, pneumonia, urethritis and septicaemia [1]. *P. aeruginosa* infections are frequent in many countries in recent times. A European survey of healthcare-associated infections (HAIs) in intensive care units (ICUs) suggested that *P. aeruginosa* was the most frequent bacteria, comprising 29% of the total bacteria [2].

According to a 2-year observational investigation conducted in a hospital in Thailand, *P. aeruginosa* accounted for 27.8% of non-fermentative Gram-negative bacteria, which was second to *Acinetobacter baumannii* in proportion [3]. The most worrying issue is the emergence and rise of multidrug-resistant *P. aeruginosa* (MDR-PA), which is becoming troublesome worldwide [4], severely restricting the options for efficacious antimicrobial treatment [5] and increasing both therapeutic costs and mortality [6].

In China, patients are also threatened by infections with *P. aeruginosa* and MDR-PA [7–9]. However, there are no exact data regarding the prevalence of MDR-PA at a national level owing to inconsistent definitions of MDR-PA. For example, some studies defined MDR-PA as *P. aeruginosa* isolates that were resistant to at least two [10] or three classes of antibiotics [11], and some studies did not specify the definition [12]. Fortunately, an international recommended definition of MDR-PA has recently been established, which specified MDR-PA as *P. aeruginosa* isolates that are non-susceptible to at least one agent in at least three antimicrobial categories (including aminoglycosides, antipseudomonal carbapenems, antipseudomonal cephalosporins, antipseudomonal penicillins plus β-lactamase inhibitors, monobactams, phosphonic acids and polymyxins) [13]. Therefore, a meta-analysis of the literature was performed to establish the prevalence of MDR-PA in China based on the international standard in order to provide a reference to clinicians.

## 2. Materials and methods

### 2.1. Search strategy

This meta-analysis followed the MOOSE (Meta-analysis of Observational Studies in Epidemiology) guidelines. Major electronic databases, included Medline, Wanfang, Ovid, the Cochrane Library and the China National Knowledge Infrastructure (CNKI) database, were systematically searched using the combination of the following keywords: 'MDR-PA' or 'multidrug resistant PA' or 'multidrug resistant *P. aeruginosa*' or 'MDR *P. aeruginosa*'. All papers published before February 2014 and providing the prevalence of MDR-PA among the Chinese population were selected. There was no language restriction.

### 2.2. Inclusion and exclusion criteria

Studies meeting the following criteria were included in this meta-analysis: (a) cross-sectional studies; (b) clearly expressed the definition of MDR-PA, in agreement with the international accepted criteria; and (c) provided the accurate total number of patients both with *P. aeruginosa* and MDR-PA infections. Studies were excluded if: (a) they were duplicate reports; (b) they were reviews, letters, editorial articles or meta-analyses; and (c) patients were non-Chinese.

### 2.3. Data extraction

Data from published studies were extracted separately by two authors (J.S. and Y.L.). For each study, the following information was collected: first author; year of publication; language; patient location; and number of MDR-PA and *P. aeruginosa*. In case of conflicting evaluations between the two reviewers, disagreements were resolved by discussions of our team.

### 2.4. Quality assessment

The quality of studies was assessed using a validated quality assessment tool for cross-sectional studies [14]. The following eight items were assessed to calculate a total quality score: (1) clear definition of the target population; (2) representative of probability sampling; (3) sample characteristics matching the overall population; (4) adequate response rate; (5) standardised data collection methods; (6) reliability of survey measures/instruments; (7) validation of survey measures/instruments; and (8) appropriate statistical methods. Answers were scored 0 or 1 for 'No' and 'Yes'. The total quality score varied between 0 and 8 for each study. Total scores of 0–4 and 5–8 were regarded as low and high quality, respectively. Two authors (TB and XC) separately evaluated the quality scores of each study and any disagreement was settled by discussions of the whole group.

### 2.5. Statistical analysis

The meta-analysis was performed using Stata v.13.0 software (Stata Corp., College Station, TX) to calculate the multidrug resistance rate along with 95% confidential intervals (CIs). The $\chi^2$-based Cochran's $Q$ statistic test was applied to examine the between-study heterogeneity, and heterogeneity was considered significant at $P < 0.1$ for the $Q$ statistic. Data from the included studies were analysed using a random-effects model when heterogeneity was present; otherwise, a fixed-effects model was utilised. Moreover, a subgroup analysis, if feasible, was performed to explore sources of heterogeneity. Publication biases were evaluated by Egger's linear regression test and Begg's rank correlation test. All $P$-values were two-tailed with a statistical significant level at 0.05. In addition, a sensitivity analysis was conducted to appraise the influence of a single study on the overall estimate by sequential removal of individual studies.

## 3. Results

### 3.1. Characteristics of eligible studies

The process of selecting studies for the meta-analysis is shown in Fig. 1. Finally, 26 studies were included in the meta-analysis [15–40]; 24 articles were published in Chinese and 2 articles were in English. The characteristics of the included studies are summarised in Table 1. The scores of quality assessment are given in Table 2.