The impact of information quality of antimicrobial susceptibility test report on the rational antimicrobial use

Ming Wei
Tianjin Cancer Hospital Airport Hospital

Yanting Wang
Huazhong University of Science and Technology

Xinping Zhang (xpzhang602@hust.edu.cn)
Huazhong University of Science and Technology

Xiaojun Xu
The First Affiliated Hospital of Gannan Medical College

Yan Li
The First Affiliated Hospital of Gannan Medical College

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Abstract

Background

Antimicrobial susceptibility test (AST) report was important for rational antimicrobial use. However, the reference value of AST report was sometimes limited due to poor information quality (IQ). This study aimed to measure the IQ of AST and evaluate the impact of IQ of AST report on rational antimicrobial use as a reference for antimicrobial therapy.

Methods

The retrospective study included data of AST report, antimicrobials prescribed after reporting AST results and related inpatient information. The inclusion criteria of the AST report included three conditions: 1. The AST reports were from inpatients with diagnosis of infection. 2. The bacteria were extracted from a sterile-site specimen. 3. The interpretive categories (i.e., sensitive, intermediary or resistance) were firstly reported during one hospitalization. The IQ of AST report was measured by the total IQ and IQ of completeness, usefulness, accuracy and consistency. The rational antimicrobial use was measured by the antimicrobial adherence to the interpretive categories of AST report. Fractional logit regression model (FLRM) was chosen to evaluate the impact of IQ on the rational antimicrobial use.

Results

The median of the total IQ, completeness, usefulness, accuracy and consistency were 0.7345, 0.6082, 0.9167, 0.8966 and 1.0000, respectively. The results of FLRM showed that usefulness, accuracy and consistency had significant positive impacts on the rational antimicrobial use ($\beta=4.220, P<0.01$; $\beta=3.987, P<0.01$; $\beta=0.511, P<0.05$, respectively), while the total IQ and completeness had no statistically significant impacts on the rational antimicrobial use ($\beta=-0.820, P>0.1$; $\beta=-0.793, P>0.1$, respectively).

Conclusion

This study confirmed that usefulness, accuracy and consistency performed well and had positive impacts on the rational antimicrobial use, which indicated that improving IQ especially usefulness, accuracy and consistency would make AST report play a greater role in promoting the rational antimicrobial use.

Introduction

Antimicrobial resistance (AMR) occurs when bacteria, viruses, fungi and parasites no longer respond to medicine, making infections harder to treat and increasing the risk of disease, severe illness and death[1]. Considering that one of the major causes of AMR is the abuse of antimicrobials, comprehensive response measures to ensure the rational antimicrobial use have been utilized for decades.

Antimicrobial use was driven by multiple factors, including clinical diagnosis, severity of infection, pathogens, antimicrobial susceptibility test (AST), knowledge and attitude of healthcare providers and so on[2,3]. Antimicrobial use guided by AST results, as a part of antimicrobials stewardship, contributed to predicting the clinical response of pathogenic bacteria and modifying to adequate antimicrobials[4,5] thus improving treatment outcomes, reducing collateral harm and avoiding using newer drugs when older drugs worked[6,7]. The Chinese guideline "Guiding Principles of Clinical Application of Antibacterial Drugs (2015 version)”, which aimed to standardize the clinical application of antimicrobials[8], regulated that the pathogenic examination rates of non-restricted, restricted, and special antimicrobials should be more than 80%, 50% and 30%, respectively, which indicated that AST should be an important reference for antimicrobials use.

However, the guiding significance of AST was sometimes limited[9]. One reason was that physicians suffered from information overload, which meant that physicians did not have enough energy to absorb all information provided by the AST report because of an excessive amount of terminal clinical data[9,10]. Another was that AST report did not have the same absolute validity as most biochemical or haematological reports[9,11]. For example, the significance and treatment options of 10 mmol/L were clear, whereas the guiding significance of AST reports was absolute only when the isolate was the cause of infection[12].

According to the previous studies, it was hypothesized that improving information quality (IQ) of AST report was able to reduce information overload and increase its guiding significance, which in turn promoted the rational antimicrobial use[13–15]. Firstly, IQ impacted the ability to process information. High-quality information improved processing efficiency while low-quality information, which meant structure-chaotic, incorrect and unrelated information, would increase burden on users and lead to information overload[13,14,15]. Thus, it could be speculated that improving IQ of AST report provided more useful information for physicians and reduced the burden on information and information overload. Secondly, previous researches revealed that high-quality information provided good references for action[16]. Improving IQ of AST report was able to provide more valuable and understandable information for physicians, thus making AST a better guide for prescribing antimicrobial[12,17].

Accordingly, the impact of IQ of AST report on the rational antimicrobial use was very worthy of being studied. Based on the idea indicated by Peter Drucker “no measurement, no management”, the measurement of IQ of AST report was the first step to improving it. Although researches have pointed out that AST reports existed IQ issues, including over-reporting, mistakenly reporting and insufficient interpretation, the evidence of comprehensive measurement of IQ of AST report was scarce[12,18]. Therefore, this study firstly comprehensively measured the IQ of AST report to identify the key points for improvement.
Furthermore, there was no evidence of the impact of IQ of AST report on the rational antimicrobial use. Thus, this study secondly explored whether higher IQ of AST reports promoted rational antimicrobial use, aiming to provide evidence for the necessity to improve IQ of AST reports, improve its clinical applicability and promote the rational antimicrobial use to fight AMR.

The Researches Of Definition And Measurement Of IQ

The definition of IQ focused on accuracy originally, and was expanded to a multi-dimensional concept in related research\[19\]. Strong D.M. proposed the concepts of IQ from two aspects. One was the degree of conforming to specification, and another was the degree of meeting or exceeding consumer expectation\[20\]. Correspondingly, there were two ways of the identification and measurement of IQ. One was based on the specification such as policy document, industry standard and guidelines\[21–23\]. Another was based on consumer expectation, namely the indicators were formed by the need, satisfaction and experience of information users and stakeholders\[23, 24\]. Numerous researches have developed frameworks to measure IQ with a thorough classification of dimensions\[20, 21, 25\]. However, no general agreement existed either on which set of dimensions defined IQ, or on the exact meaning of each dimension\[21\]. Batini C. et al combed the most important researches and defined a basic set of IQ dimensions, including accuracy, completeness, consistency and timeliness\[21\]. Other dimensions were mentioned frequently in literatures including conciseness, readability, accessibility, usefulness, reliability, security and interactivity\[26\].

In the medical field, the high-quality information was said to be critical for quality health care and for effective and efficient management of the health care system\[17\], and a common way of identifying and measuring IQ was based on the specification.\[17\] A working group in the International Federation of Clinical Chemistry and Laboratory Medicine designed a routine, formal and proactive system to evaluate IQ of laboratory medicine based on evidence of adherence to specifications\[27\]. Many countries established nationwide health data center to drive improvements in the quality of health information, such as NHS Digital in England, Canadian Institute for Health Information in Canada, and the Health Information and Quality Authority in Ireland\[23\]. One of the functions of these institutions was setting standards and assessing adherence to standards for quality improvement\[23\]. The dimensions that were frequently mentioned in the medical and medical informatics literature included accuracy, currency, completeness, readability, usefulness, confidentiality, representational, interpretability and timeliness\[20\].

Methods

Study design and data Collection.

This retrospective study was carried out in a tertiary hospital in Jiangxi Province, southeast of China. Participants of the study were inpatients with diagnosis of infection. The AST report, antimicrobials prescribed after reporting AST results and related inpatient information of participants were collected. Firstly, The AST reports of the inpatients were collected according to the following conditions: 1. The report time was between 1 January 2019 and 30 June 2021. 2. The bacteria for detection were extracted from a sterile-site specimen, which was more likely to be the causative agent of infection, and mentioned in Clinical and Laboratory Standards Institute (CLSI) M100 Table 2. 3. The AST report firstly gave interpretive categories (ie. sensitive, intermediary or resistance) during this hospitalization. Secondly, antimicrobials prescribed after reporting AST results were collected according to the following conditions: 1. If there was only one AST report during the hospitalization, the antimicrobials prescribed after reporting AST results were collected. 2. If there were equal to or greater than two AST reports and the time interval between the first and second AST reports was equal to or greater than 7 days, the antimicrobials prescribing between the first and second AST reports were collected. 3. If the time interval between the first and second AST reports was less than 7 days, the antimicrobials prescribed within 7 days after the first AST report were collected. All the information was exported from hospital electronic information system. A total of 709 cases were enrolled according to the above conditions.

Identification to the species level and AST of all isolates were performed using the Vitek 2 system (bioMérieux, Marcy l'Etoile, France) at the department of clinical laboratory in the Hospital. The protocols for identification and susceptibility testing of isolates in China were the same as those followed by the Central Laboratory of International Health Management Association\[28\]. AST was performed by disk diffusion method and broth microdilution method in accordance with the CLSI recommendations.

Variables and Measurement.

Firstly, IQ indicators were established through reference to relevant literature, which contained an overall indicator of IQ namely the total IQ and four sub IQ namely completeness, usefulness, accuracy and consistency\[17, 20, 21, 24, 29\]. (All indicators were presented in Appendix I). The evaluation of the total IQ and four sub IQ was based on the specifications, including CLSI M100 and the related standardization of AST report in China which combined requirements in CLSI M100 and China's situation\[30–32\]. Basis for inclusion, definition and calculation formula were as follows:

The total IQ. To evaluate the overall situation of the IQ of AST report, the total IQ was defined as the degree to which the information of AST report meeting the requirements of all criteria in the four sub IQ. Simple ratio was used as the function forms to assess the level of the total IQ and four sub IQ according to Batini C's research\[22\]. The calculation formula of the total IQ was as follow: The total IQ = The sum of information fulfilled the criteria in four sub IQ / The sum of information involved in the judgement of four sub IQ.

Completeness. Completeness was chosen because it was one of the basic dimensions according to the research of Batini C. et al\[21\], and incompleteness was a prominent problem in AST report such as incomplete annotation information\[15, 17, 21\]. Completeness was defined as the degree to which the information that guidelines recommended AST reporting was given in AST report, with reference to Cario B’s definition, that was the degree to which a given data collection
included data describing the corresponding set of real-world objects\textsuperscript{21}. In this study, “information that guidelines recommended AST reporting” corresponded to “data describing the corresponding set of real-world objects”. For example, according to the guideline requirements, AST report should contain interpretation comments such as the annotation of symbols and abbreviation, interpretation of microbiology results and recommendations of antimicrobial prescriptions\textsuperscript{30,33}. The information which guideline recommended AST reporting would be seen as complete information if given in the AST report. The calculation formula of completeness was as follows: Completeness = The amount of information given in AST report which guidelines recommended AST reporting / The amount of information which guidelines recommended AST reporting.

Usefulness. Usefulness was chosen because improving IQ was able to reduce information overload, and in turn, help users better understand and make more informed choices according to previous researches\textsuperscript{13,14,34}, and researches have pointed out that AST report existed useless information such as reporting nitrofurantoin for bloodstream infection\textsuperscript{18}. Usefulness was defined as the degree to which the information given in the AST report was in the range of the information recommended by guidelines, because guidelines have regulated the useful information in AST report\textsuperscript{30,39}. For example, the antimicrobials in AST report were useful information if listed in group A of CLSI M100, while daptomycin given in the AST report of respiratory specimen was useless information based on the guidelines\textsuperscript{33}. The calculation formula of usefulness was as follows: Usefulness = The amount of information given in AST report which guidelines recommended AST reporting / The amount of information given in AST report.

Accuracy. Accuracy was chosen because it was one of the basic dimensions according to the research of Batini C. et al., and inaccuracy was a prominent problem in AST report such as the errors of interpretive categories and bacterial identification\textsuperscript{18,21}. Accuracy was defined as the degree to which the information given in AST report was correct according to the guidelines, with reference to Wang's definition, that was the extent to which data were correct, reliable and certified\textsuperscript{24}. In this study, the criteria to judge the accuracy of the information given in AST report was the standard information in the guidelines. For example, guidelines gave the standards of antimicrobial’s generic name, susceptibility testing methods and breakpoints. The information in AST report was accurate information if the same as the standard information in guidelines. The calculation formula of accuracy was as follows: Accuracy = The amount of accurate information / The amount of information given in AST report.

Consistency. Consistency was chosen because it was one of the basic dimensions according to the research of Batini C. et al.\textsuperscript{21}, and it was the guideline recommendation to assess the consistency of information in AST reports\textsuperscript{24,33}. Consistency was defined as the internal consistency between the information of AST report with reference to the definition of Batini C. et al.\textsuperscript{21}, such as the consistency of the results from individual agents within a specific drug class and the established hierarchy of activity rules. The calculation formula of consistency was as follows: Consistency = The amount of consistent information / The amount of information given in AST report.

Secondly, antimicrobial adherence was used to measure the rational antimicrobial use based on the interpretive categories of AST report. Medication adherence was generally defined as the extent to which the patient’s actual history of drug administration corresponds to the prescribed regimen\textsuperscript{36}. In this study, it was the evaluation of antimicrobial prescription behavior, thus antimicrobial adherence was defined as the antimicrobial prescribed was effective against isolated bacteria with reference to the interpretive categories of AST report, which included direct and indirect situations. Direct adherence was defined as using antimicrobials to which the bacterium was susceptible, or using antimicrobials to which the bacterium was intermediate without reporting susceptible results. Indirect adherence was defined as using antimicrobials that did not be reported but the susceptible result was able to be inferred according to equivalent agents in CLSI M100, or using antimicrobials that did not be reported but the intermediate result was able to be inferred according to equivalent agents in CLSI M100 without reporting susceptible and referred susceptible results (The summary of equivalent agents in CLSI M100 was presented in Appendix II).\textsuperscript{33}. The adherence rate was used to measure the degree of antimicrobial adherence. The calculation formula was as follows: The adherence rate = The number of direct and indirect adherence antimicrobial prescriptions after reporting AST results / The number of antimicrobial prescriptions after reporting AST results.

Data analysis.

In the analysis of the impact of IQ of AST report on the rational antimicrobial use, the total IQ and four sub IQ were independent variables, and the adherence rate was dependent variable. Considering the dependent variable defined and observed only on the standard unit interval, 0 ≤ y ≤ 1, fractional logit regression model (FLRM) was chosen because it was more common and easily applied alternative that would yield more precise and trustworthy research results\textsuperscript{37}. The functional form for the conditional mean of the fractional outcome was: E (y' | X) = G(X, β), where the nonlinear function G ( ), ensured that predictions lied inside the unit interval. RESET test, which was proposed by Papke and Wooldridge (1996), was used to detect whether the model had specification problems, and P-values > 0.10 indicated that the model was appropriate specified at 10\textsuperscript{5}\textsuperscript{38}. In nonlinear models, the magnitude of the change in the dependent variable caused by a unit change in the predictor varied with the starting level of the latter. The procedure for the estimation of average partial effects (APE) within the FLRM was particularly appealing due to the fact that its identication required no assumptions in terms of serial dependence in the dependent variable of the economic magnitude of the relations of interest\textsuperscript{39}. The interpretation of APE's was similar to that of linear regression coefficients\textsuperscript{40}.

We added some control variables to excluded other possible impact factors of antimicrobials use. Age and sex were used to control the impact of patient characteristics. The Age-adjusted Charlson Comorbidity Indicator (ACCI) was used to control the impact of disease severity\textsuperscript{41}. Average Administration Time (AAT) and Total Numbers of Antimicrobials (TNA) were used to control the impact of length and number of prescriptions\textsuperscript{42}.

Two FLRM equations were built to evaluate the impact of the total IQ and four sub IQ separately, which were as follows:

\[
y(\text{theadherence rate}) = G(\beta_1 + \beta_2(\text{the total IQ}) + \beta_3(\text{Age}) + \beta_4(\text{Sex}) + \beta_5(\text{ACCI}) + \beta_6(\text{AAT}) + \beta_7(\text{TNA}))
\]

\[
y(\text{theadherence rate}) = G(\beta_1 + \beta_{21}(\text{completeness}) + \beta_{22}(\text{usefulness}) + \beta_{23}(\text{accuracy}) + \beta_{24}(\text{consistency}) + \beta_3(\text{Age}) + \beta_4(\text{Sex}) + \beta_5(\text{AAT}) + \beta_6(\text{TNA}))
\]
The computation of the IQ of AST report and antimicrobial adherence were implemented in Python programming language using PyCharm 2022 community edition. Eq. (1) and Eq. (2) was modeled using the "fractional logit regression" package in R (The Python code was presented in Appendix III).

This study included four datasets, which was AST reports, the IQ of AST, antimicrobial adherence and FLRM. The datasets were attached in the Appendix IV to Appendix VII.

Ethics Statement

The Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology approved the study. Any information that could identify participants was guaranteed confidentiality.

Results

The characteristics of variables was described in Table 1. The mean age was 53.32 years, 57.55% were male (N = 709). The mean ACCI score was 4.28 ± 2.85. 88.31% had at least one comorbidity. Averagely, 4 prescriptions were used after reporting AST results, and the mean duration of every prescription was 3.50 days.

The median of the total IQ was 0.7345. Among the dimensions, completeness had the worst performance with the lowest median (0.6082), followed by accuracy (median = 0.8966), usefulness (median = 0.9167), and consistency (median = 1.0000). The median adherence rate was 0.5714, which indicated that overall 57.14% prescriptions were adherence to AST reports.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Results; N = 709</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, No. (%)</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>301(42.45)</td>
</tr>
<tr>
<td>Male</td>
<td>408(57.55)</td>
</tr>
<tr>
<td>Age (years), mean (SD)</td>
<td>53.32(19.63)</td>
</tr>
<tr>
<td>ACCI, No. (%)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>83(11.69)</td>
</tr>
<tr>
<td>1–3</td>
<td>229(32.30)</td>
</tr>
<tr>
<td>4–5</td>
<td>169(23.84)</td>
</tr>
<tr>
<td>6–7</td>
<td>135(19.04)</td>
</tr>
<tr>
<td>≥8</td>
<td>93(13.12)</td>
</tr>
<tr>
<td>AAT (days), mean (SD)</td>
<td>3.50(3.20)</td>
</tr>
<tr>
<td>TNA, median (IQR)</td>
<td>3.00(2.00–5.00)</td>
</tr>
<tr>
<td>IQ, median (IQR)</td>
<td>0.7345(0.6973-0.8000)</td>
</tr>
<tr>
<td>Completeness, median (IQR)</td>
<td>0.6082(0.5831–0.7459)</td>
</tr>
<tr>
<td>Usefulness, median (IQR)</td>
<td>0.9167(0.8571–0.9474)</td>
</tr>
<tr>
<td>Accuracy, median (IQR)</td>
<td>0.8966(0.8679–0.9127)</td>
</tr>
<tr>
<td>Consistency, median (IQR)</td>
<td>1.0000(0.8000-1.0000)</td>
</tr>
<tr>
<td>Adherence rate, median (IQR)</td>
<td>0.5714(0.0000–1.0000)</td>
</tr>
</tbody>
</table>

The results of FLRM about the impact of the total IQ and four sub IQ on the adherence rate was illustrated in Table 2, respectively. With a P-value above 0.05, the RESET test indicated that the functional form used by the FLRM of Eq. (1) and Eq. (2) were appropriately specified[40]. The coefficients showed that the total IQ had no statistically significant impact on the adherence rate. For the dimensions, the positive relationship between usefulness, accuracy and the adherence rate were all statistically significant at 1% level. 0.1 increase in usefulness, accuracy and consistency led to 0.100, 0.094 and 0.012 increase in the adherence rate, respectively. Completeness had no statistically significant impact on the adherence rate.
Table 2
FLRM of the IQ of AST report on the adherence rate.

<table>
<thead>
<tr>
<th></th>
<th>The relationship between the total IQ and the adherence rate</th>
<th>The relationship between four sub IQ and the adherence rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficients</td>
<td>APE</td>
<td>Coefficients</td>
</tr>
<tr>
<td>The total IQ</td>
<td>-0.820</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(0.872)</td>
<td>(0.214)</td>
</tr>
<tr>
<td>Completeness</td>
<td>-</td>
<td>-0.793</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>(0.621)</td>
</tr>
<tr>
<td>Usefulness</td>
<td>-</td>
<td>4.220***</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>(0.846)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>-</td>
<td>3.987***</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>(1.121)</td>
</tr>
<tr>
<td>Consistency</td>
<td>-</td>
<td>0.511***</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>(0.150)</td>
</tr>
<tr>
<td>Age</td>
<td>-0.009</td>
<td>-0.008**</td>
</tr>
<tr>
<td></td>
<td>(0.004)</td>
<td>(0.004)</td>
</tr>
<tr>
<td>Sex</td>
<td>0.141</td>
<td>0.089</td>
</tr>
<tr>
<td></td>
<td>(0.121)</td>
<td>(0.122)</td>
</tr>
<tr>
<td>ACCI</td>
<td>0.075</td>
<td>0.019***</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.006)</td>
</tr>
<tr>
<td>AAT</td>
<td>-0.020</td>
<td>-0.024</td>
</tr>
<tr>
<td></td>
<td>(0.020)</td>
<td>(0.020)</td>
</tr>
<tr>
<td>TNA</td>
<td>0.007</td>
<td>0.021</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.704</td>
<td>-7.016***</td>
</tr>
<tr>
<td></td>
<td>(0.730)</td>
<td>(1.319)</td>
</tr>
<tr>
<td>R²</td>
<td>0.019</td>
<td>0.085</td>
</tr>
<tr>
<td>RESET test</td>
<td>1.871</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Below the coefficients we report standard errors in parentheses; for the test statistics we report P-values; ***, ** and * denote coefficients statistics which are significant at 1%, 5% or 10%, respectively. The RESET test was implemented as described in Papke and Wooldridge (1996).

Discussion

This study was the first to comprehensively evaluate IQ of AST reports and explore the impact of the IQ of AST on rational antimicrobial use. The results showed that the total IQ of AST report had no statistically significant impact on antimicrobial adherence, which indicated that the current level of the total IQ played a limited role in the reduction of information overload and improvements in guiding significance for rational antimicrobial use. Therefore, it was necessary to identify the specific problems with the analysis of the results of four dimensions.

Usefulness had a significant positive impact on antimicrobial adherence. Considering that the increase of useful information was able to decrease information overload, which in turn prompted physicians to place more emphasis on AST report, thus improving antimicrobial adherence[14]. Hence, it was necessary to increase useful information in line with current guidelines such as equivalent agents in CLSI M100 and the pharmacotherapy recommendation of multidrug resistant bacteria[33, 43]. Accuracy had a significant positive impact on antimicrobial adherence. Linda W. Byrd found that the accuracy attribute of IQ was positively and significantly related to the safety, collaboration and professionalism attribute of healthcare quality[15]. In this study, accurately reporting break points and interpretive categories was able to increase physician trust to AST report, thus improving antimicrobial adherence and enhancing the guiding significance for prescribing antimicrobials[17]. Consistency had a significant positive impact on antimicrobial adherence. Gail Keenan et al. found that meaningfully and substantively improving the consistency of core information in electronic health records had the potential to increase the validity and reliability of health information[44]. In this study, the increase of consistency, which meant that the antimicrobials given in AST report was related to the detected bacteria and the interpretive categories was consistent with the established hierarchy of activity rules, also increased the validity of the information, thus improving antimicrobial adherence and enhancing the guiding significance.
Completeness had no statistically significant impact on antimicrobial adherence, which indicated that reporting more information recommended by guidelines had no impact on antimicrobial adherence at the current level. One reason for this was the homogenization of information and lack of instructive information in the AST report. Completeness did not differ much among the AST report with 0.1628 interquartile range, which indicated the existence of the homogenization of information. A survey on laboratory users’ perceptions of regarding the quality of the medical microbiology services showed that 70% general practitioners and 72% hospital doctors requested more interpretation of AST results\textsuperscript{[45]}. Nevertheless, less than 50% AST reports gave the interpretation comments in this study, and most of them were homogeneous annotations of the full name of S, I, R, intrinsically resistant and the specific name of multidrug resistant bacteria. In the 50 of 709 samples physicians prescribed antimicrobials to which the bacterium was intrinsically resistant after reporting AST results, 28 (56.00\%) of which have given the annotation of intrinsic resistance in the AST reports, whereas physicians still prescribed these ineffective antimicrobials. This phenomenon revealed that physicians did not put more value on the annotations due to the homogenization of information and lack of instructive information, which was also the direction of improvement of AST report.

This study found that the median of the total IQ was 0.7345, which had scope to improve. Among the dimensions, completeness and accuracy had poor performance, and similar findings have been mentioned in previous studies that incompleteness and inaccuracy were common in healthcare information\textsuperscript{[18, 46, 47]}. A case study found that 4.8% case record forms of patient data was inaccuracy and 3.3% was incomplete\textsuperscript{[47]}. From the above analysis, it was important to improve usefulness, accuracy and consistency of information of AST reports according to the relative guidelines. For completeness, the improvements in the homogenization of information and the increase in the specific interpretation such as treatment recommendations were necessary\textsuperscript{[9, 11, 48]}. The measurements of quality improvements were assessing IQ of AST on a regular basis and identifying and acting on problems\textsuperscript{[49]}. In addition, selectively reporting antimicrobials with reference to the relative guidelines was necessary to improve the guiding significance of AST report\textsuperscript{[50]}. The above measurements were in hopes of AST report playing a greater role in promoting the rational antimicrobial use and mitigating AMR.

The limitations of this study were as follows. Firstly, some information such as bacteriostatic zone diameter and MIC value in AST results did not have a reference standard, which was not included in the accuracy analysis. Secondly, the dose and dosage form were not included in the measurement of rational antimicrobial use, considering that AST report did not give the corresponding information as a reference. Thirdly, physicians’ prescribing habits and antimicrobial stewardship policy were not included as control variables in the evaluation of the impact of IQ of AST report on the rational antimicrobial use because the data were not available.

**Conclusion**

The study confirmed that usefulness, accuracy and consistency had significant positive impacts on the rational antimicrobial use, although the total IQ and completeness had no statistically significant impact on the rational antimicrobial use. Thus, it was necessary to improve the usefulness, accuracy and consistency of information of AST report. For completeness, reducing homogenization and increasing instructive information were necessary. The above improvements were able to enhance the clinical applicability of AST reports, thus promoting the rational antimicrobial use to reduce AMR.

**Declarations**

**Ethical Approval**

*Ethical committees:* The Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology

*Internal Review Boards:* The Ethics Committee of Tongji Medical College, Huazhong University of Science and Technology

*Guidelines followed:* Good Clinical Practice and Declaration of Helsinki

**Competing interests**

I declare that the authors have no competing interests as defined by BMC, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

**Authors’ contributions**

Ming Wei collected the data, carried out the empirical analysis and drafted the manuscript. Xinping Zhang designed the project, contributed to grasp the subject and revise the manuscript. Yanting Wang made substantial contributions to the revision of manuscript, was involved in supplementing further interpretation of data, revising logistics in the introduction and discussion part, and improving format and language in the whole writing. Xiaojun Xu and Yan Li made substantial contributions to the collection of the data and funding support. All authors reviewed the manuscript.

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Grant ID: 72074085

**Availability of data and materials**

This study included four datasets, which was AST reports, the IQ of AST, antimicrobial adherence and FLRM. We have attached all the datasets in the Appendix IV to Appendix VII.
References


**Supplementary Files**

This is a list of supplementary files associated with this preprint. Click to download.

- AppendixITheindicatorsonformationqualityofantimicrobialsusceptibilitytestreport.docx
- AppendixIThesummaryofequivalentagentsinCLSIM100.docx
- AppendixIIIPythonprogram.docx
- AppendixIVASTReportEnglishversion.xlsx
- AppendixVinformationqualityscoreofASTEnglishversion.xlsx
- AppendixVIIantimicrobialadherenceEnglishversion.xlsx
- AppendixVIIIFLRM.xlsx
- ASTreportEnglishversion.xlsx