

COVER

LAMAN: <https://jbiomedkes.org/index.php/jbk/issue/view/27>

[Home](#) / [Archives](#) / Vol. 8 No. 2 (2025)



Published: 2025-07-30

EDITORIAL TEAM

LAMAM: <https://jbiomedkes.org/index.php/jbk/about/editorialTeam>



[Home](#) / [Editorial Team](#)

Editorial Team

Editor in Chief

Husnun Amalia

Fakultas Kedokteran Universitas Insaqti, Indonesia

Academic profile: [ORCID](#) [Scopus](#) [Publons](#)

Deputy Editor-in-Chief

ML Edy Parwanto

Fakultas Kedokteran Universitas Insaqti, Indonesia

Academic profile: [ORCID](#) [Scopus](#) [Publons](#)

Associate Editor

Nany Helrunisa

Fakultas Kedokteran Universitas Insaqti, Indonesia

Academic profile: [ORCID](#) [Scopus](#) [Publons](#)

Magdalena Wariono

Fakultas Kedokteran Universitas Insaqti, Indonesia

Academic profile:

Editorial Boards

Laksmi Maharani

Fakultas Kedokteran Universitas Insaqti, Indonesia

Academic profile: [ORCID](#) [Scopus](#) [Publons](#)

Monica Dwi Hartanti

Fakultas Kedokteran Universitas Insaqti, Indonesia

Academic profile: [ORCID](#) [Scopus](#) [Publons](#)

Raditya Wiratbangka

Fakultas Kedokteran Universitas Insaqti, Indonesia

Academic profile: [ORCID](#) [Scopus](#) [Publons](#)

Siti Sugih Hartininguh

SIPKES Uthmaniyah Husada Bandung, Indonesia

Academic profile: [ORCID](#) [Scopus](#) [Publons](#)

Dito Anugroho

Universitas Muhammadiyah (Uinmasu) Makassar, Indonesia

Academic profile: [ORCID](#) [Scopus](#) [Publons](#)

Emad Yousef

Department of Chemistry, College of Science, Al-Nahrain University, Baghdad, Iraq

Academic profile: [ORCID](#) [Scopus](#)

Norsuhana Omar

Department of Physiology & Unit of Integrative Medicine,

School of Medical Sciences, Universiti Sains Malaysia (USM), Kelantan, Malaysia

Academic profile:

Editorial Office



DAFTAR ISI

LAMAN: <https://jbiomedkes.org/index.php/jbk/issue/view/27>

[illegible]

PERINGKAT JURNAL: SINTA 3

LAMAN: <https://jbiomedkes.org/index.php/jbk/indexing>

Journal Information

Author Information Page

Archives

Submissions

Contact

Search


Search


Abstracting & Indexing

[Home](#) / [Abstracting & Indexing](#)

Jurnal Biomedika dan Kesehatan, with registered number: ISSN 2621-5499 (print), ISSN 2621-5497 (online) have been indexed on:

1. Google Scholar
2. Pubmed
3. Scit Scd
4. WorldCat
5. CrossRef
6. Dimensions
7. Getula
8. SINTA (Indonesia Academic Search-Engine)
9. SINTA 3 (Science and Technology Index)





Crossref

Journal Biomedika dan Kesehatan (JBK) is registered under a Creative Commons Attribution-ShareAlike International License.

[View My Stats](#)

Powered by [WordPress](#) by [Open Journal Systems](#)
Designed by [Material Theme](#)

BUKTI KORESPONDENSI

JBK

[JBK] Submission Acknowledgement

DS

Dr. dr. Husnun Amalia, Sp.M
To: me - Tue, Apr 22 at 2:21 PM

Ronald Inwanto Natadidjaja

Thank you for submitting the manuscript, "A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals using Digital Antimicrobial Stewardship" to Jurnal Biomedika dan Kesehatan. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site.

Submission URL: <https://biomedkes.org/index.php/jbk/authorDashboard/submission/589>
Username: ronaldinwanto

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Dr. dr. Husnun Amalia, Sp.M

Jurnal Biomedika dan Kesehatan

Jl. Kyai Tapa No. 260 Kampus B, Grogol, DKJ Jakarta 11440
Telp. (021) 5672731 | E-mail: jbmedkes@tsuakd.ac.id

JBK

[JBK] Editor Decision

HA

Husnun Amalia
To: me, and 21 others - Mon, Jul 14 at 11:06 AM

Ronald Inwanto Natadidjaja, Widyawati Lekok, Azza Ariyani, Hadianti Adiani, Raymond Adianto, Ronaningtyas Mahanani, Hadi Sumarsono, Yenny Yenny, Jihan Samira, Nany Hanurisa, Husnun Amalia, Mervia Atika Faradila, Tubagus Ferli Fadilah, Joice Vladavia Kalumpu, Yuliana Yuliana, Sri Mulyani, Desi Angguat, Tryoko Septo Marja, In Indra Perisi, Dianawati Danawati, Grace Henry Legoh, Alvin Lekinardo Rantung

We have reached a decision regarding your submission to Jurnal Biomedika dan Kesehatan, "A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals using Digital Antimicrobial Stewardship".

Our decision is: Revisions Required.

Jurnal Biomedika dan Kesehatan

Jl. Kyai Tapa No. 260 Kampus B, Grogol, DKJ Jakarta 11440
Telp. (021) 5672731 | E-mail: jbmedkes@tsuakd.ac.id

Manuscript review checklist		
Title: A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals using Digital Antimicrobial Stewardship		
Sent Date: 7 July 2025		
Due Date for Review: 14 July 2025	Adequate	Needs revision

TITLE	√	
Not more than 15 words		
Clearly describes the article		
Abstracts should be of approximately 200-300 words	√	
Reflects the content of the article		
Keywords: provide 3 – 10 keywords		
INTRODUCTION		
1. Rationale for study (need and significance)	√	
2. Summarizes relevant research to provide context, and explains other authors' findings		√
3. Describe the novelty of the study	√	
4. Objective of the study		√
METHODS		
1. The design is suitable for answering the question	√	
2. The sampling is appropriate	√	
3. Data Collection Procedures	√	
4. Measurements have been described	√	
5. Data Analysis (Description of Statistical Evaluation)		√
C. RESULTS		
1. Detail in narrative of the findings	√	
2. Descriptive quality of figures and tables (if relevant)	√	
3. Clearly laid out and in a logical sequence	√	
4. The analysis has been conducted appropriately	√	
DISCUSSION		
1. Findings compared and contrasted with relevant literature		√
2. The results support or contradict previous theories	√	
3. Limitations of the study	√	
4. Clinical implications of the study		√
5. Future directions of the study	√	
CONCLUSIONS		

1. Drawn logically	√	
ACKNOWLEDGEMENT	√	
AUTHOR CONTRIBUTION	√	
FUNDING STATEMENT	√	
CONFLICT OF INTEREST	√	
REFERENCES		
1. Compliance with journal format (Vancouver style)	√	
2. The minimal number of references should be 20 and 85% of them should be recent (published during the last 10 years, with the majority during the last 5 years)	√	
3. Abbreviate journal names according to the Index Medicus system	√	
4. The total number of tables and figures not more than 5	√	

advise for the author(s)

This article is quite relevant and useful regarding the assessment of antibiotic prescription quantity patterns with Digital Antimicrobial Stewardship in Indonesia. However, there are some notes related to this article that need revision.

1. Introduction
 - It should be added with more relevant research to provide context and explain other authors' findings.
 - The aim of the study should be stated clearly, usually at the end of the introduction
2. Method
 - What are the criteria for selecting hospitals? For example, based on the locations, government/private hospitals, or the duration of applying that system?
 - Locations of the hospitals should be stated, at least to the province/ city, since Indonesia is too large.
 - When was the research conducted?
 - What kind of statistical analysis is used? univariate/ bivariate?
3. Result

The results are quite numerous and detailed. The table number should be written in narration following the tables, although all the narratives are sited below the table in question
4. Discussion
 - All subtitles in the discussion section should be deleted, since the table number is already stated, and it is not common.

- It should be elaborated with more references to discuss the gap in findings and clinical implications.
- Limitations must be written, which may affect the results, apart from the fact that this research is a preliminary study.

5. Conclusion

- Since the survey has not been able to describe the causal-effect correlation between e-RASPRO implementation and the quantity of antibiotic prescribing. What is your suggestion/recommendation for the next?

RESPONSE TO REVIEWER'S COMMENT

antibiotics that have greater potency on resistance and antibiotics in Reserve category are types of antibiotics that are used only when there is an infection caused by suspected Multi-Drug Resistant (MDR) bacteria; these antibiotics should not be used carelessly, particularly in large quantity.

In this case, the RASPRO Indonesia Study Group has tried to develop a system, which is called as RASPRO system that can guide clinicians in antibiotic prescribing based on local guideline. The RASPRO system was made by using risk stratification of patients and it directs clinicians in initial prescribing of empirical antibiotics as well as a guideline in changing antibiotics and providing definitive antibiotic treatment including filling out compulsory specialized forms when there is any prolonged use of antibiotics.

Our survey is a continuation of previous survey conducted in a hospital in Central Java, Indonesia. The hospital has implemented a manual RASPRO system to carry out the ASP. The survey, which was carried out before and after the manual system had been implemented for three months, showed that there was a decrease in antibiotic prescribing from 64,799 ampules/vials to 51,661 ampules/vials with reduced mean percentage of antibiotic use within 3 months of implementation reaching 14.44%. The previous RASPRO system using the manual guideline forms was then tested into a digital form of electronic RASPRO (e-RASPRO); therefore, e-RASPRO has become a digital tool in Indonesia designed to carry out ASP in hospitals. Through e-RASPRO, a local antimicrobial guideline is developed digitally by filling out RASPRO forms, which is also made digitally that consists of electronic forms for empirical antibiotics and definitive antibiotics. Previous survey of e-RASPRO implementation showed a 40.0% decrease of Watch category antibiotics Define Daily Dose (DDD) within a month implementation and still showed an increase in Watch category antibiotics DDD by 10.8% within a month implementation.

Clinical pharmacists can also perform direct verification on indication appropriateness, time limitation of antibiotic use and appropriateness of using empirical antibiotics by utilizing the digital guideline on antimicrobial use that is applicable in the hospitals where e-RASPRO has been implemented. By utilizing e-RASPRO, it is expected that there is an altered pattern of antibiotic prescribing, i.e. prioritizing the use of Access category antibiotics in order to suppress the risk of widespread resistance against antibiotics, particularly the wide-spectrum antibiotics. The aim of this study is to show the comparison of antibiotic prescription pattern among a month and a month implementation of e-RASPRO in 3 hospitals.

Ronald Swanto July 16, 2025
Format: Font: Candara, 11 pt

Ronald Swanto July 16, 2025
Format: Font: Candara, 11 pt

Ronald Swanto July 16, 2025
Format: Superscript

Ronald Swanto July 16, 2025
Deleted: 1

Ronald Swanto July 16, 2025
Deleted: 1

Ronald Swanto July 16, 2025
Deleted: 1

METHODS

A survey was conducted at 3 hospitals in Indonesia, i.e. Hospital A, Hospital B and Hospital C. All hospitals are located in West Java, and were chosen by their service level category. One of them is a primary hospital (Hospital A) and other two hospitals are secondary hospitals (Hospital B and C). Previously, various socialization on implementing digital antimicrobial stewardship program using e-RASPRO has been performed that includes socialization on digital prescribing of empirical antibiotics as well as definitive antibiotics, socialization on patient grouping based on the Risk Stratification in order to perform empirical antibiotics prescribing using digital tool and socialization on the digital guideline on using empirical antimicrobial agents, and socialization on prolonged antibiotic use in digital tools.

Jurnal Biomedika dan Kesehatan

3

First Author et al.

Socialization on Digital Prescribing of Empirical Antibiotics in e-RASPRO

Socialization was performed on implementing e-RASPRO in three hospitals to prescribe empirical antibiotics. In prescribing empirical antibiotics, clinicians were guided to determine risk stratification of hospitalized patients based on their immune status, severity of infection and medical history such as history of previous antibiotic use, history of previous hospitalization and history of previous medical instrument usage.

Socialization was also carried out about the guideline and procedure on how to fill out the forms of escalating and stepping down empirical antibiotics, which was consistent with the digital guideline on the use of antimicrobial agents in e-RASPRO. When empirical antibiotic prescription

use through a digital form in e-RASPRO. It would then be verified by clinical pharmacy and it was reported to the ASP team in the hospitals.

When there was a prolonged antibiotic use without any filled out electronic form in e-RASPRO about the concerned issue or without any clear indication, then the clinical pharmacy in accordance with the consent issued by Hospital ASP team could perform Automatic Stop Order (ASO). Socialization was carried out by the investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals and it was continued for clinicians at each hospital. The socialization was performed online and offline.

Survey Setting and Time Period of Data Collection

The retrieved data was secondary data, [univariate analyses](#), which was obtained from reports on the use of injected antibiotics at hospital wards of the three hospitals. [Data was taken from January 2021 – June 2022 in Hospital A, March 2021 – August 2022 in Hospital B and August 2021 – January 2022 in Hospital C.](#) Through implementation of e-RASPRO, initial data collection was performed within the first three-month, which included percentage of patients in each risk stratification group based on the digital e-RASPRO forms as well as appropriateness of initial empirical antibiotic prescribing with the digital guidelines on the use of antimicrobial agents.

The survey was followed by collecting all quantitative data on empirical antibiotic prescribing as well as injected definitive antibiotics prescribing for hospitalized patients within 9 months before and after the implementation of e-RASPRO in two hospitals (Hospital A and B) and within 3 months before and after utilizing e-RASPRO in another hospital (Hospital C). When the data was retrieved, Hospital C had just implemented e-RASPRO for 3 months. Interviews and discussions with the Antimicrobial Resistance Control Program Committee of the three hospitals were carried out during the initial utilization of e-RASPRO as well as when the survey data was retrieved.

RESULTS

The following was data obtained from the survey conducted within the first 3 months of implementing e-RASPRO at 3 hospitals in Indonesia:



Table 1. Demographic Characteristics of 3 Surveyed Hospitals

Demographic Characteristics of Hospitals	A	B	C
Number of Doctors			
General Physicians	14	14	25
Dentists	5	15	8
Specialist Doctors	37	98	102
Total	56	127	135
Number of Pharmacists	9	26	39
Number of Nurses	115	74	368
Number of Beds			
Wards	124	168	259
ICU + HCU + ICCU + NICU + PICU	10	17	26
Total	134	185	285
Ratio on numbers of specialist doctors : beds	1: 3.62	1: 1.89	1: 2.79
Ratio on numbers of pharmacists : beds	1: 14.89	1: 7.12	1: 7.31
Ratio on numbers of nurses : beds	1: 1.17	1: 2.50	1: 0.77
The extent of the Buildings	7,247.35	8,120.00	31,099.94
Data: sirs.kemkes.go.id			

Table 1. Actual demographic data of the three surveyed hospitals, which was collected from sirs.kemkes.go.id, Ministry of Health Republic of Indonesia, was as the following: Hospital A, B and C had 134 beds, 185 beds and 254 beds, respectively; with ratio of specialist doctors per bed of each hospital was 1 per 3.62 beds, 1 per 1.89 beds and 1 per 2.79 beds.

Table 2. Initial Risk Stratification of Patients Receiving Antibiotics that Had Been Filled Out in the Digital Forms within 3 Months Following the Implementation of e-RASPRO in Three Hospitals

	Hospital A		Hospital B		Hospital C	
Risk Stratification	3 Months Oct – Dec 2021		3 Months Dec 2021 – Feb 2022		3 Months Nov 2022 – Jan 2023	
	Number	%	Number	%	Number	%
Type 1	284	90.16%	692	83.98%	1,472	81.15%
Type 2	31	9.84%	15	1.82%	84	4.63%
Type 3	-	0.00%	117	14.20%	258	14.22%
Total	315	100.00%	824	100.00%	1,814	100.00%

Table 2. In the digital e-RASPRO form, which was filled out within 3 months during initial utilization of e-RASPRO, majority of patients were in the Type 1 Risk Stratification category with the percentage in Hospital A, B and C reached 90.16%, 83.98% and 81.15%, respectively.

guideline of antimicrobial use in e-RASPRO						
Empirical antibiotic prescribing has unidentified consistency in e-RASPRO	+	8.32%	-	0.00%	348	19.18%
Total of forms had been filled out	315	100.00%	824	100.00%	1,814	100.00%

Tabel 3. The appropriateness of empirical antibiotic prescribing with the digital guideline on the use of antimicrobial agents contained in e-RASPRO, which was documented in Hospital A, B and C within 3 months before and after implementation of e-RASPRO, reached 84.59%, 76.09% and 24.48%, respectively. Empirical antibiotic prescribing with non-identified appropriateness, which was documented in the digital forms, was defined as antibiotic prescribing using e-RASPRO with vague appropriateness, for example combined antibiotics prescribing in which one of the antibiotic was appropriate; while the other was not consistent with the digital guideline of antimicrobial agents or other variant condition, in which the appropriateness could not be concluded during data collection. Such condition was documented as much as 19.18% in Hospital C.

First Author et al.

Metronidazole	1,180	1,094	-14.92%	1,731	2,414	40.03%	1,610	1,399	-16.83%
Cefuroxime	-	-	-	838	3,074	>100%	-	-	-
Total Access	2,149	2,418	12.41%	4,879	15,411	213.17%	2,119	1,999	-6.8%
Total Access / In Patient	0.5098	0.5232	2.6%	0.6054	2.2256	268.83%	0.7533	0.7361	-2.19%

When the data was collected, e-RASPRO had been implemented for 9 months in Hospital A and B, but it has only been implemented for 3 months in Hospital C; the results were as follows:

Tabel 4. The use of antibiotic included in Reserve category such as **Polymyxin** and **Tigecycline** was not found in this survey. There was reduced quantity of Ceftriaxone prescribing significantly in Hospital A, B and C as much as 62.91%, 40.58% and 11.06%, respectively. Nevertheless, there was a very significant increase of Cefotaxime prescribing in Hospital A and B with increased percentages of 35.32 % and >100% each.

A significant increase also occurred for Ciprofloxacin prescribing in three hospitals. The quantity of 500 mg Levofloxacin prescribing in Hospital A, B and C had some decrease of 45.14%, 64.84% and 76.25%, respectively. The quantity of 750 mg Levofloxacin reduced in Hospital A and B as much as 65.49% and 13.36% each; however, it increased significantly >100% in Hospital C. The quantity of prescribing 1 gram Meropenem in Hospital A and B reduced as much as 41.32% and 13.45%, respectively; however, it still increased in Hospital C as much as 10.04%. The quantity of Azithromycin prescribing also decreased very significantly in Hospital B, i.e. 93.18%. Piperacillin Tazobactam seemed to be very rarely used. The minimum use was found in Hospital B i.e.

as many as 45 ampules/vials within 9 months period before e-RASPRO tool was implemented. In general, there was reduced quantity of antibiotic use included in Watch category at Hospital A, B and C of 54.93% (-58.86% per inpatient), 21.11% (-9.97% per inpatient) and 8.59% (-4.15% per inpatient), respectively. The quantity of Access category antibiotic prescribing in Hospital A, B and C was as follows: there was 100% increase of Amoxicillin and Amoxicillin-Clavulanate prescribing in

the implementation of ASPRO. This survey is a limited survey conducted at three hospitals in Indonesia which have different characteristics as shown in table 1.

In table 1, it can be seen that Hospital C is the hospital with the greatest resources regarding number of physicians, pharmacists and nurses compared to Hospital A and B. It also has the largest building compared to the other two hospitals. Various human resources in the hospital and its large size had brought their own difficulties in terms of socializing antimicrobial stewardship program, either using manual or digital method. In daily practice, unevenly distributed level of socialization may affect the level of appropriateness of antibiotic use with the digital guideline on the use of antimicrobial agents contained in e-RASPRO.

In table 2, we can see that most patients who would receive early empirical antibiotic prescribing at hospital admission are those who had Type 1 Risk Stratification as documented in e-RASPRO. These patients include a group of immunocompetent patients or immunocompromised patients who had ~~unproven~~ bacterial infection or those who are not at risk of having infection caused by MDR microorganisms. Prescribing wide spectrum antibiotics should be avoided as much as possible in patients who were mostly included in the group with Type 1 Risk Stratification. It should be taken into caution considering that using various type of antibiotics may increase the risk of developing resistance.³⁰ As the diseases progress, empirical antibiotic treatment certainly can be escalated in accordance with the patient's condition.

Table 3 describes the appropriateness of initial empirical antibiotic prescribing with the digital antimicrobial guideline as documented in Hospital A, B and C within 3 months of using e-RASPRO, which reach 84.56%, 76.09% and 74.48%. It is categorized as "appropriate prescribing" when the empirical antibiotic is given in accordance with the digital guideline of antimicrobial use included in e-RASPRO that is compliant with patient's risk stratification. There is a high percentage of a group of patients with Type 1 Risk Stratification. This result is expected to bring some changes in the quantitative pattern of antibiotic prescribing from the type of antibiotics included in the Watch category to those in Access category.

The appropriateness of antibiotic prescribing in Hospital C, which is documented in digital e-

Ronald Irawanto July 16, 2023
Deleted: Demographic Characteristics of the 3 Surveyed Hospitals ¶

Ronald Irawanto July 16, 2023
Deleted: Initial Risk Stratification of Patients Receiving Antibiotics Included in the Digital Form within 3 Months Following the Implementation of e-RASPRO in Three Hospitals ¶

Ronald Irawanto July 16, 2023
Deleted: The Appropriateness of Initial Empirical Antibiotic Prescribing with the Digital Guideline on the Use of Antimicrobial Agents within 3 Months after Implementing e-RASPRO in Three Hospitals ¶

Access-category such as Ampicillin Sulbactam or Amoxycillin Clavulanate with or without combination of Aminoglycosides as the anti-ESBLs often serve as empirical antibiotic of choice to be given for patients who are included in the Type 2 Risk Stratification. Nevertheless, in reality, the initial 3-month survey on the implementation of e-RASPRO in three hospitals has shown that the number of patients included in the Type 2 Risk Stratification group were minority. Overall, there is a reduced quantity of Watch category antibiotic prescribing in Hospital A, B and C as much as 54.93% (58.86% per inpatient), 21.4% (9.97% per inpatient) and 8.56% (4.15% per inpatient) following the implementation of e-RASPRO.

In Table 4 a survey conducted for 9 months before and after the utilization of e-RASPRO in Hospital A and B and 3 months before and after implementing e-RASPRO in Hospital C has demonstrated a significant increase in the quantity of antibiotic prescribing of Ampicillin, Amoxycillin Clavulanate and 1.5 g Ampicillin Sulbactam, which are antibiotics included in Access category in the three hospitals. The survey conducted within the first 3 months of e-RASPRO utilization has demonstrated that the majority of patients are included in the Type 1 Risk Stratification group of those three hospitals (Table 2), in which the majority of empirical antibiotic choices indeed are antibiotics included in the Access category. Nevertheless, it certainly requires further surveys to be carried out on the following months in Hospital A and B.

The significant increase of 0.75 g Ampicillin Sulbactam prescribing may also still be associated with the continuity of 1.5 g Ampicillin Sulbactam availability in Hospital B. Some sources in Hospital B, through a discussion with the investigators, suggest that there is often shortage supply of 1.5 Ampicillin Sulbactam in Hospital B. Therefore, considering this reasoning, the Antimicrobial Resistance Control Program Committee in Hospital B has included Cefuroxime in Access category of its guideline on antimicrobial use. This condition explains the presence of increased quantity of Cefuroxime prescribing, which is included in Access category in Hospital B.

Based on the digital guideline on antimicrobial use in e-RASPRO of the three hospitals, Aminoglycosides has actually been used as combined antibiotics. It has not been identified clearly about the cause of reduced Gentamycin prescribing in Hospital A, while in Hospital C, the use of Gentamycin and Amikacin indeed have not been documented either before or after the

Ronald Irawanto July 16, 2023
Deleted: The Quantity of Access Category Antibiotic Prescribing within 9 Months and 3 Months Following the Implementation of e-RASPRO in Three Hospitals ¶

on the quantity of Watch category antibiotic prescribing in three hospitals as well as increased percentage of quantity of Access category antibiotic prescribing in two hospitals (Hospital A and B) following the implementation of e-RASPRO. The increased quantity of Access category antibiotic prescribing, particularly in Hospital B, is extremely significant.

Altered quantity of Watch and Access category antibiotics prescribing, particularly in Hospital A and B, is probably still affected by the appropriateness of empirical antibiotic use, in which it is lead by the digital guideline on antimicrobial use included in e-RASPRO. However, it certainly requires further studies. Hospital characteristics such as the number of hospital bed, the number of physicians and other facilities of each hospital may also affect the pattern of antibiotic prescribing. A systematic review showed a decrease in antimicrobial DDD range from -6.41% to -6.19% related to the digital antimicrobial stewardship tool.

Some studies have demonstrated that the utilization of digital tool to implement ASP can reduce the use of antimicrobial agents and it also can reduce the DDD. In other previous study the duration of digital antimicrobial stewardship implementation may show a different antibiotic DDD result. However, we still cannot conclude what type of digital intervention that will certainly reduce the use of antimicrobial agents. Our study is an initial survey on the utilization of e-RASPRO as one of digital antimicrobial stewardship program that has been used in Indonesia. This study is only a survey and still cannot describe the correlation between e-RASPRO using and the antibiotic prescribing pattern. In order to achieve good results, the utilization of e-RASPRO certainly should be carried out along with compulsory disciplines and full support from hospital management team. Demographic characteristics of the hospitals can also affect the effectiveness of e-RASPRO utilization. In order to provide good explanation on this issue, more extensive studies with full support from managerial team are required to further analyze causal effect correlation between utilization of e-RASPRO and altered quantitative pattern on antibiotic prescribing.

CONCLUSIONS

The survey has not been able to describe the causal-effect correlation between e-RASPRO implementation and the quantity of antibiotic prescribing. However, in general, there is an altered

Ronald Swanto July 26, 2023
Formatted: Superscript

Ronald Swanto July 26, 2023
Deleted: |

Ronald Swanto July 26, 2023
Deleted: |

Ronald Swanto July 26, 2023
Deleted: |

Ronald Swanto July 26, 2023
Deleted: |

Ronald Swanto July 26, 2023
Formatted: Superscript

Unknown
Field Code Changed

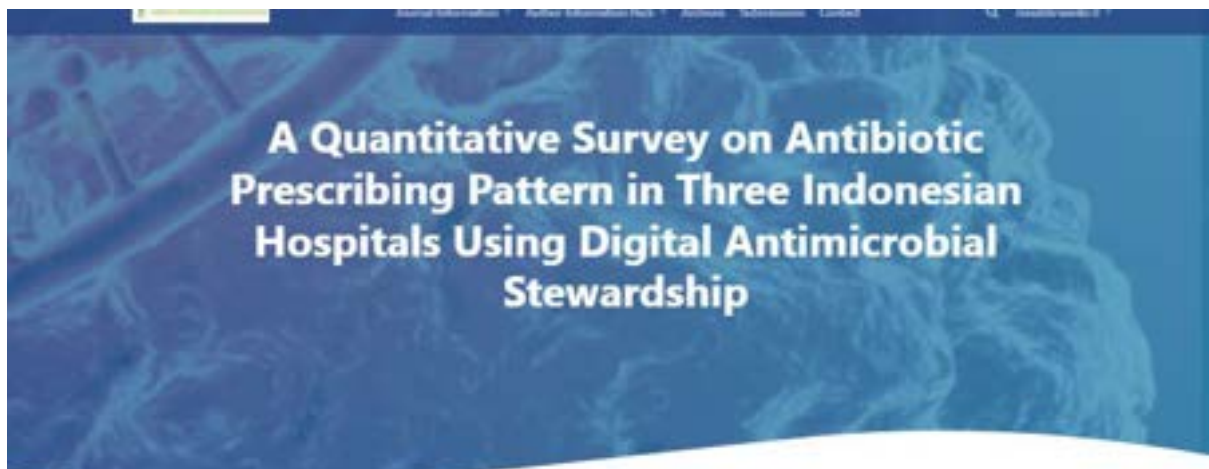
Ronald Swanto July 26, 2023
Deleted: |

Ronald Swanto July 26, 2023
Deleted: |

Ronald Swanto July 26, 2023
Deleted: |

RESEARCH ARTICLE

LAMAN: <https://jbiomedkes.org/index.php/jbk/article/view/689>



Home / Archives / Vol. 8 No. 2 (2025) / Original Article

A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals Using Digital Antimicrobial Stewardship

Ronald Irawanto Hutadidjaja

Faculty of Medicine, Universitas Padjadri
ronaldi@unpad.ac.id

Widyawati Lukuk

Faculty of Medicine, Universitas Padjadri
widyawati@unpad.ac.id

Akies Ariyanti

Faculty of Medicine, Universitas Padjadri
akies@unpad.ac.id

Hadianti Adianti

Faculty of Medicine, Universitas Padjadri
hadianti@unpad.ac.id

Raymond Adianto

Faculty of Medicine, Universitas Padjadri
raymond@unpad.ac.id

Romaningtyas Maharani

Faculty of Medicine, Universitas Padjadri
romaningtyas@unpad.ac.id

Hadi Sumartono

Faculty of Medicine, Universitas Padjadri
hadi@unpad.ac.id

Renny Renny

Faculty of Medicine, Universitas Padjadri
renny@unpad.ac.id

Ibhan Samira

Faculty of Medicine, Universitas Padjadri
ibhan@unpad.ac.id

Mary Hainurrah

Faculty of Medicine, Universitas Padjadri
mary@unpad.ac.id

Husniy Amalia

Faculty of Medicine, Universitas Padjadri
husniy@unpad.ac.id



10.1007

Published
2025-07-30

How to Cite:
Hutadidjaja R, Lukuk W, Ariyanti A, Adianti H, Adianto R, Romaningtyas M, Maharani R, Sumartono H, Renny R, Samira I, Hainurrah M, Amalia H. A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals Using Digital Antimicrobial Stewardship. *Jurnal Biomedika dan Kesehatan*. 2025; 8(2): 101-110.

ORIGINAL ARTICLE

A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals Using Digital Antimicrobial Stewardship

Survei Pola Kuantitas Peresepan Antibiotik di Tiga Rumah Sakit di Indonesia dengan Penatagunaan Antimikroba Digital

Ronald Irwanto Natadidjaja^{1,2,3,4}, Widyawati Lekok^{1,5}, Aziza Ariyani¹, Hadianti Adlani^{1,4,5}, Raymond Adianto¹, Ronaningtyas Maharani¹, Hadi Sumarsono¹, Yenny Yenny^{2,5}, Jihan Samira^{1,5}, Nany Halrunisa^{1,5}, Husnun Amalia^{1,5}, Meutia Atika Faradilla^{1,5}, Tubagus Ferdi Fadilah^{2,5}, Joice Viladelvia Kalumpiu^{2,5}, Yuliana Yuliana², Sri Mulyani⁵, Desi Anggiat⁵, Triyoko Septio Marja⁵, Iin Indra Pertiwi⁵, Dianawati Dianawati⁶, Grace Nerry Legoh⁷, Alvin Lekonardo Rantung⁷

¹RASPRO Indonesia Study Group

²Faculty of Medicine, Universitas Trisakti, Jakarta, Indonesia

³Trisakti – RASPRO Indonesia Antimicrobial Stewardship (TRIASE) Learning Centre, Indonesia

⁴Faculty of Medicine, Syarif Hidayatullah State Islamic University

⁵Hermia Hospital Group Indonesia

⁶Tugu Ibu Hospital, Depok, Indonesia

⁷Advent Bandung Hospital, Indonesia

⁸Trisakti School of Management, Indonesia

✉ronald@trisakti.ac.id

<https://doi.org/10.18051/JBiomedKes.2025.v8.127-141>

ABSTRACT

Background

Antimicrobial Stewardship Program (ASP) is very essential. There are three categories of antimicrobial agents as recommended by WHO: Access, Watch and Reserve. e-RASPRO, a digital ASP model, may alter antibiotic prescribing patterns by prioritizing Access category antibiotic prescribing.

Methods

Our manuscript presented a quantitative survey on antibiotic prescribing patterns within 3 months and 9 months before and after implementing digital electronic-RASPRO (e-RASPRO) in three Indonesian hospitals, utilizing retrospective inpatient data. This analysis included the appropriateness of empirical antibiotic prescribing and the quantity of antibiotic prescribing based on each category.

Results

In the first 3 months, we found that 90.16%, 83.98%, and 81.15% of patients were included in Type 1 Risk Stratification. The appropriateness of initial empirical antibiotic prescribing with the digital guideline on antimicrobial use of e-RASPRO in three hospitals was 81.59%, 76.09% and 24.48%, respectively. Within 9 months after implementing e-RASPRO in Hospital A and B and within 3 months in Hospital C, there was a trend of reduced quantity of Watch category antibiotic prescribing of 54.93% (-58.86% per inpatient), 21.11% (-9.97% per inpatient), and 8.59% (-4.15% per inpatient), respectively. There was a 12.42% (+2.61 % per inpatient) and 223.17% (+268.83% per inpatient) increase in the quantity of Access category antibiotic prescribing in Hospitals A and B,

while in Hospital C, the quantity decreased by 6.81% (-2.29% per inpatient).

Conclusions

There are changes in antibiotic prescribing patterns, particularly in the antibiotics included in the Watch and Access categories following the implementation of e-RASPRO. The relationship between digital antimicrobial stewardship use and the results still needs further research.

Keywords: Access; Digital Antimicrobial Stewardship; Quantity; Survey; Watch.

ABSTRAK

Latar Belakang

Penatagunaan antimikroba (PGA) merupakan hal yang urgen dilakukan. World Health Organization (WHO) telah mengkategorikan antimikroba ke dalam 3 golongan yaitu: Access, Watch, dan Reserve. Perangkat PGA digital e-RASPRO diharapkan dapat merubah pola persepsian antibiotik dengan mengedepankan persepsian antibiotik kategori Access.

Metode

Artikel ini merupakan survei pola kuantitas persepsian antibiotik 3 bulan dan 9 bulan sebelum dan sesudah terapan perangkat digital elektronik-RASPRO (e-RASPRO) dengan data retrospektif pada rawat inap di 3 rumah sakit di Indonesia, mencakup kesesuaian persepsian antibiotik empirik, dan kuantitas persepsian antibiotik berdasarkan masing-masing kategori.

Hasil

Dalam 3 bulan pertama, didapatkan 90.16%, 83.98% dan 81.15% dari pasien yang diberikan antibiotik termasuk dalam Stratifikasi Risiko Tipe 1. Kesesuaian persepsian antibiotik empirik inisiasi dengan panduan penggunaan antimikroba digital perangkat e-RASPRO pada ketiga rumah sakit masing-masing mencapai 81.59%, 76.09%, dan 24.48%. 9 bulan sesudah terapan perangkat e-RASPRO di Rumah Sakit A dan B dan 3 bulan sesudah terapan perangkat e-RASPRO di Rumah Sakit C terdapat tren penurunan kuantitas persepsian antibiotik kategori Watch masing-masing sebesar 54.93% (-58.86% per pasien rawat inap), 21.11% (-9.97% per pasien rawat inap) dan 8.59% (-4.15% per pasien rawat inap). Kuantitas persepsian antibiotik kategori Access di Rumah Sakit A dan B meningkat 12.42% (+2.61% per pasien rawat inap) and 223.17% (+268.83% per pasien rawat inap), sementara itu di Rumah Sakit C menurun 6.81% (-2.29% per pasien rawat inap).

Kesimpulan

Terdapat perubahan pola persepsian antibiotik kategori Watch dan Access paska terapan perangkat e-RASPRO. Analisis hubungan antara penggunaan perangkat PGA digital dengan hasil yang ada masih membutuhkan penelitian lebih lanjut.

Kata Kunci: Access; Penatagunaan Antimikroba Digital; Kuantitas; Survei; Watch.

INTRODUCTION

The implementation of the Antimicrobial Stewardship Program (ASP) has been planned globally with the aim of promoting the prudent use of antimicrobial agents and reducing the risk of antimicrobial resistance development.¹ The World Health Organization (WHO) has categorized antibiotics into three categories: Access, Watch, and Reserve (AWARE).² Antibiotics included in Access category are antibiotics that have potency of lower incidence on resistance; while those in Watch category are types of antibiotics that have greater potency on resistance and antibiotics in Reserve category are types of antibiotics that are used only when there is an infection caused by suspected Multi-Drug Resistant (MDR) bacteria; these antibiotics should not be used carelessly, particularly in large quantity.

In this case, the RASPRO Indonesia Study Group has attempted to develop a system, known as the RASPRO system, that can guide clinicians in antibiotic prescribing based on local guidelines.¹ The RASPRO system was made by using risk stratification of patients, and it directs clinicians in initial prescribing of empirical antibiotics, as well as a guideline in changing antibiotics and providing definitive antibiotic treatment, including filling out compulsory specialized forms when there is any prolonged use of antibiotics.¹

Our survey is a continuation of a previous survey conducted in a hospital in Central Java, Indonesia. The hospital has implemented a manual RASPRO system to carry out the ASP. The survey, conducted before and after the manual system had been implemented for three months, revealed a decrease in antibiotic prescribing from 64,799 ampules/vials to 51,661 ampules/vials, with a reduced mean percentage of antibiotic use within three months of implementation reaching 14.44%.¹ The previous RASPRO system, which used manual guideline forms, was then converted into an electronic form of RASPRO (e-RASPRO); therefore, e-RASPRO has become a digital tool in Indonesia designed to facilitate ASP in hospitals. Through e-RASPRO, a local antimicrobial guideline is developed digitally by completing RASPRO forms, which are also created digitally and comprise electronic forms for empirical antibiotics and definitive antibiotics. A previous survey of e-RASPRO implementation showed a 49.01% decrease in Watch category antibiotics Define Daily Dose (DDD) within 9 months of implementation, but still showed an increase in Watch category antibiotics DDD by 20.18% within 3 months of implementation.²

Clinical pharmacies can also perform direct verification on the appropriateness of indications, time limitations of antibiotic use, and the appropriateness of using empirical antibiotics by utilizing the digital guidelines on antimicrobial use that are applicable in hospitals where e-RASPRO has been implemented. By utilizing e-RASPRO, it is expected that there will be an altered pattern of antibiotic prescribing, i.e., prioritizing the use of Access category antibiotics to suppress the risk of widespread antibiotic resistance, particularly against wide-spectrum antibiotics. The aim of this study is to show the comparison of antibiotic prescription patterns among 9 months and 3 months of implementation of e-RASPRO in 3 hospitals.

METHODS

A survey was conducted at three hospitals in Indonesia: Hospital A, Hospital B, and Hospital C. All hospitals are located in West Java and were selected based on their service level category. One of them is a primary hospital (Hospital A), and the other two hospitals are secondary hospitals (Hospital B and C). Previously, various socialization on implementing digital antimicrobial stewardship program using e-RASPRO has been performed that includes socialization on digital prescribing of empirical antibiotics as well as definitive antibiotics, socialization on patient grouping based on the Risk Stratification in order to perform empirical antibiotics prescribing using digital tool and socialization on the digital guideline on using empirical antimicrobial agents, and socialization on prolonged antibiotic use in digital tools.

Socialization on Digital Prescribing of Empirical Antibiotics in e-RASPRO

Socialization was conducted on the implementation of e-RASPRO in three hospitals to guide the prescription of empirical antibiotics. When prescribing empirical antibiotics, clinicians were advised to determine the risk stratification of hospitalized patients based on their immune status, severity of infection, and medical history, such as previous antibiotic use, prior hospitalizations, and history of medical instrument usage.

Socialization also covered the guidelines and procedures for filling out forms for escalating and stepping down empirical antibiotics, aligning with the digital guideline on antimicrobial agent use in e-RASPRO. When empirical antibiotic prescribing did not follow the digital guideline, clinical

pharmacy would confirm with clinicians and the ASP team in the hospital to decide if the antibiotic could be used. The socialization was conducted by the investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals and continued for clinicians at each hospital. It was held both online and offline.

Socialization on Patient Grouping based on Risk Stratification for Empirical Antibiotics Prescribing in e-RASPRO

Socialization was conducted on patient grouping based on their risk stratification in e-RASPRO. The socialization was carried out by the investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals and was continued with the clinicians at each hospital. The socialization was performed both online and offline.

The administration of initial empirical antibiotics in hospitalized patients should be based on patients' risk stratification, as recommended by the digital guideline on the use of antimicrobial agents, which has been incorporated into e-RASPRO. The e-RASPRO categorized patients into three groups for risk stratification in initial empirical antibiotic treatment.¹³

The Group of Patients with Type 1 Risk Stratification was a group of patients who could receive empirical antibiotics covering multidrug-resistant microorganisms. This group included immunocompetent patients and immunocompromised patients with a non-threatening severity of bacterial infection or without a risk of MDR, as classified by Non-Type 2 and/or Type 3 Risk Stratification.

The Group of Patients with Type 2 Risk Stratification was a group of (immunocompromised patients and/or uncontrolled diabetes mellitus with unthreatening severity of bacterial infection) PLUS (a history of receiving antibiotic treatment within 90 days ago (31-90 days in the system) and/or a history of having treatment at a healthcare facility of ≥48 days within 90 days ago (31-90 days in the system), and/or a history of using medical instrumentation within 90 days ago (31-90 days in the system)). This group was at risk of having a multidrug-resistant (MDR) Extended-Spectrum Beta-Lactamase (ESBL) infection.¹³⁻⁸

The Group of Patients with Type 3 Risk Stratification was a group of (patients with threatening infection, and/or immunocompromised individuals and/or individuals with uncontrolled diabetes mellitus) PLUS (a history of receiving antibiotic treatment within 30 days ago and/or having treatment at a healthcare facility ≥48 hours within 30 days ago, and/or a history of using medical instrument within 30 days ago). This group was a group with high severity of infection or a group that was at risk of having ESBL infection and infection caused by other Multi-Drug Resistant (MDR) mikroorganisms, including MDR *Pseudomonas* sp.¹³⁻⁹⁻¹⁴ A group of patients with Healthcare-Associated Infections (HAIs) was also included in the group with Type 3 Risk Stratification. The group with the HAI category was a group with a period of infection of ≥48 hours of treatment at a healthcare facility, even within 90 days following a surgery.¹³⁻⁸

Socialization on the Digital Guideline of Using Empirical Antimicrobial Agents in e-RASPRO

Socialization was conducted on the implementation of e-RASPRO, which included the digital guideline on the use of antimicrobial agents in three Indonesian hospitals. The socialization was carried out by the investigators for the Antimicrobial Resistance Control Program Committee of each hospital and was continued for clinicians at each facility.

A digital guideline on the use of antimicrobial agents was developed, incorporating antibiotic categories based on the AWARE category proposed by the World Health Organization (WHO) in 2021. The guideline was then mutually agreed upon by the hospital management and the Antimicrobial Resistance Control Program Committee, which was subsequently incorporated into

e-RASPRO. The three hospitals used similar digital guidelines on using antimicrobial agents, which were developed by the RASPRO Indonesia Study Group by considering the WHO AWARE category as follows:

Empirical Antibiotic Choice for Patients with Type 1 Risk Stratification In e-RASPRO Digital Guidelines on the Use of Antimicrobial Agents

Most of empirical antibiotic choice included in the digital guideline on antimicrobial use for patients with type-1 risk stratification were the Access category antibiotics such as: Ampicillin, Ampicillin Sulbactam, Amoxycillin Clavulanate, Amikacin and Gentamicin; with the exception of Hospital B, in accordance with and on consideration of the continuity of drug availability as well as based on the agreement made by the Antimicrobial Resistance Control Program Committee, Cefuroxime (second generation of Cephalosporin) was included as the Access category antibiotic. Whenever necessary, most empirical antibiotic choices for the Type 1 Risk Stratification patient group could include antibiotics in the Watch category, i.e., third-generation cephalosporins such as Cefotaxime and Ceftizoxime.

Empirical Antibiotic Choice for Patients with Type 2 Risk Stratification in e-RASPRO Digital Guidelines on the Use of Antimicrobial Agents

For the group of patients with Type 2 Risk Stratification in e-RASPRO, the empirical antibiotic options included anti-ESBL antibiotics. Most of the antibiotic choices fell into either the Access category, such as Ampicillin-Sulbactam / Amoxicillin-Clavulanate combined with Amikacin / Gentamicin, or the Watch category, as outlined in the digital guidelines for antimicrobial use, which include Piperacillin-Tazobactam or the single use of Ertapenem.

Empirical Antibiotic Choice for Patients with Type 3 Risk Stratification in e-RASPRO Digital Guidelines on the Use of Antimicrobial Agents

Patients included in the Type 3 Risk Stratification group of the e-RASPRO system were a group of patients at risk of having sepsis. Therefore, for this group, the empirical antibiotic choice was an antibiotic capable of eradicating ESBL-producing bacteria and other MDR bacteria, with the majority of antibiotic selection following the digital guidelines on antimicrobial agents. These guidelines include categories such as Watch to Reserve, which encompasses antibiotics like Meropenem and Imipenem, with or without combination with Access category antibiotics, including Amikacin or Gentamicin, or with the use of Polymyxin or Tigecycline.

The e-RASPRO system with digital guidelines also guide clinicians if they need to step down or escalate the antibiotic empirically while the culture result still in progress.¹³

Socialization on Prescribing Definitive Antibiotics in e-RASPRO

Socialization was performed by implementing e-RASPRO in three hospitals to prescribe definitive antibiotics. In e-RASPRO, a digital form was used to administer definitive antibiotics, which clinicians were required to fill out when prescribing antibiotics in accordance with culture findings.¹³ The socialization was conducted by the investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals, and it was subsequently continued for clinicians at each hospital. The socialization was performed online and offline.

Socialization on Prolonged Antibiotic Use in e-RASPRO

Socialization was performed by implementing e-RASPRO in three hospitals. When there is a prolonged antibiotic prescribing, a clinician must describe the indication for prolonged antibiotic use through a digital form in e-RASPRO.¹³ It would then be verified by the clinical pharmacy, and the results would be reported to the ASP team in the hospital.

When prolonged antibiotic use occurred without a completed electronic form in e-RASPRO regarding the concerned issue or without clear indication, the clinical pharmacy, in accordance with the consent issued by the Hospital ASP team, could perform an Automatic Stop Order (ASO). Socialization was conducted by the investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals, and it was also continued for clinicians at each hospital. The socialization was performed online and offline.

Survey Setting and Time Period of Data Collection

The retrieved data were secondary, univariate analyses obtained from reports on the use of injected antibiotics in the hospital wards of the three hospitals. Data was taken from January 2021 – June 2022 in Hospital A, March 2021 – August 2022 in Hospital B and August 2021 – January 2022 in Hospital C. Through implementation of e-RASPRO, initial data collection was performed within the first three-month, which included percentage of patients in each risk stratification group based on the digital e-RASPRO forms as well as appropriateness of initial empirical antibiotic prescribing with the digital guidelines on the use of antimicrobial agents.

The survey was followed by collecting all quantitative data on empirical antibiotic prescribing, as well as definitive antibiotic prescribing, for hospitalized patients within 9 months before and after the implementation of e-RASPRO in two hospitals (Hospital A and B), and within 3 months before and after utilizing e-RASPRO in another hospital (Hospital C). When the data was retrieved, Hospital C had just implemented e-RASPRO for 3 months. Interviews and discussions with the Antimicrobial Resistance Control Program Committee of the three hospitals were conducted during the initial implementation of e-RASPRO, as well as when the survey data were retrieved.

RESULTS

The following was data obtained from the survey conducted within the first 3 months of implementing e-RASPRO at 3 hospitals in Indonesia:

Table 1. Demographic Characteristics of 3 Surveyed Hospitals

Demographic Characteristics of Hospitals	Hospital		
	A	B	C
Number of Doctors			
General Physicians	14	14	25
Dentists	5	15	8
Specialist Doctors	37	98	102
Total	56	127	135
Number of Pharmacists	9	26	39
Number of Nurses	115	74	368
Number of Beds			
Wards	124	168	259
ICU + HCU + ICCU + NICU + PICU	10	17	26
Total	134	185	285
Ratio on numbers of specialist doctors : beds	1 : 3.62	1 : 1.89	1 : 2.79
Ratio on numbers of pharmacists : beds	1 : 14.89	1 : 7.12	1 : 7.31
Ratio on numbers of nurses : beds	1 : 1.17	1 : 2.50	1 : 0.77
The extent of the Buildings	7,247.35	8,120.00	31,099.94

Data: sirs.kemkes.go.id

Table 1. Actual demographic data of the three surveyed hospitals, which was collected from sirs.kemkes.go.id, Ministry of Health, Republic of Indonesia, was as follows: Hospital A, B, and C had 134 beds, 185 beds, and 254 beds, respectively; with a ratio of specialist doctors per bed of each hospital was 1 per 3.62 beds, 1 per 1.89 beds, and 1 per 2.79 beds.

Table 2. Initial Risk Stratification of Patients Receiving Antibiotics that Had Been Filled Out in the Digital Forms within 3 Months Following the Implementation of e-RASPRO in Three Hospitals

Risk Stratification	Hospital A 3 Months Oct – Dec 2021		Hospital B 3 Months Dec 2021 – Feb 2022		Hospital C 3 Months Nov 2022 – Jan 2023	
	Number	%	Number	%	Number	%
Type 1	284	90.16%	692	83.98%	1,472	81.15%
Type 2	31	9.84%	15	1.82%	84	4.63%
Type 3	-	0.00%	117	14.20%	258	14.22%
Total	315	100.00%	824	100.00%	1,814	100.00%

Table 2. In the digital e-RASPRO form, which was completed within 3 months during the initial utilization of e-RASPRO, the majority of patients were in the Type 1 Risk Stratification category, with percentages of 90.16%, 83.98%, and 81.15% in Hospitals A, B, and C, respectively.

Table 3. Appropriateness of Initial Empirical Antibiotic Prescribing with the Digital Guideline on the Use of Antimicrobial Agents within 3 Months Following the Implementation of e-RASPRO in Three Hospitals

	Hospital A 3 Months Oct – Dec 2021		Hospital B 3 Months Dec 2021 – Feb 2022		Hospital C 3 Months Nov 2022 – Jan 2023	
	Number	%	Number	%	Number	%
Empirical antibiotic prescribing is consistent with the digital guideline of antimicrobial use in e-RASPRO	257	81.59%	627	76.09%	444	24.48%
Empirical antibiotic prescribing is not consistent with the digital guideline of antimicrobial use in e-RASPRO	57	18.09%	197	23.91%	1,022	56.34%
Empirical antibiotic prescribing has unidentified consistency in e-RASPRO	1	0.32%	-	0.00%	348	19.18%
Total of forms had been filled out	315	100.00%	824	100.00%	1,814	100.00%

Table 3. The appropriateness of empirical antibiotic prescribing, as documented in Hospitals A, B, and C, using the digital guideline on the use of antimicrobial agents contained in e-RASPRO, reached 81.59%, 76.09%, and 24.48%, respectively, within 3 months before and after the implementation of e-RASPRO. Empirical antibiotic prescribing with non-identified appropriateness, which was documented in the digital forms, was defined as antibiotic prescribing using e-RASPRO with vague appropriateness, for example combined antibiotics prescribing in which one of the antibiotic was appropriate; while the other was not consistent with the digital guideline of antimicrobial agents or other variant condition, in which the appropriateness could not be concluded during data collection. Such a condition was documented in as many as 19.18% of cases at Hospital C.

Table 4. The Quantity of Intravenous Watch and Access Category Antibiotic Prescribing for Inpatient within 9 Months and 3 Months Before and After Implementing e-RASPRO

Antibiotics	Hospital A			Hospital B			Hospital C		
	Pre-implementation of e-RASPRO (Jan - Sept 2021)	9 months post-implementation of e-RASPRO (Oct 2021 - June 2022)	Increase / Decrease	Pre-implementation of e-RASPRO (Mar-Nov 2021)	9 months post-implementation of e-RASPRO (Dec 2021 - August 2022)	Increase / Decrease	Pre-implementation of e-RASPRO (August - Oct 2021)	3 months post-implementation of e-RASPRO (Nov 2021 - Jan 2022)	Increase / Decrease
	Number of patients: 4,215	Number of patients: 4,518		Number of patients: 3,754	Number of patients: 5,264		Number of patients: 1,505	Number of patients: 1,675	
	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials
Ceftriaxone	15,514	5,753	-40,935	15,602	8,894	-40,555	4,573	4,014	-4,065
1g Cefotaxime	756	1,003	25,115	958	4,059	3005	1,388	1,137	-9,045
0.5 g Cefotaxime	-	-	-	76	145	68,795	-	-	-
Ceftazidime	-	-	-	868	309	-35,355	724	724	8,935
Cefepime	-	-	-	131	473	34,005	-	-	-
Cefepime	-	-	-	-	-	-	-	198	100,005
Cefazolin	-	181	100,005	327	396	15,095	139	-	-100,005
Cefepime	-	-	-	14	6	-12,145	1,485	1,089	-15,605
750 mg Levofloxacin	1,147	791	-45,495	1,279	1,490	-12,385	360	854	100,005
500 mg Levofloxacin	835	457	-45,145	3,987	1,134	-44,845	1,000	138	-76,155
Ciprofloxacin	-	188	100,005	136	1,158	100,005	-	134	100,005
Moxifloxacin	-	-	-	487	120	-34,605	-	-	-
1g Meropenem	968	968	-41,305	8,490	7,517	-15,455	1,619	1,781	10,005
0.5 g Meropenem	-	-	-	79	-	-100,005	558	475	-15,845
Imipenem + Cilastatin	-	-	-	133	43	-42,605	-	-	-

Antibiotics	Hospital A			Hospital B			Hospital C		
	Pre-implementation of e-RASPRO Jan - Sept 2021	9 months post implementation of e-RASPRO Oct 2021 - June 2022	Increase / Decrease	Pre-implementation of e-RASPRO Mar - Nov 2021	9 months post implementation of e-RASPRO Dec 2021 - August 2022	Increase / Decrease	Pre-implementation of e-RASPRO August - Oct 2021	9 months post implementation of e-RASPRO Nov 2021 - Jan 2022	Increase / Decrease
	Number of patients: 4,115	Number of patients: 4,618		Number of patients: 3,794	Number of patients: 5,294		Number of patients: 3,845	Number of patients: 3,671	
	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials	Amputes/vials
Piperacillin Tazobactam	-	-	-	41	-	-40%	-	-	-
Acidocymycin 0.5	-	-	-	1,842	179	91.0%	-	-	-
Vancomycin	-	-	-	107	378	83.0%	334	198	-44.3%
Total Watch	20,118	9,113	-54.9%	31,819	25,737	-18.8%	10,078	8,440	-16.3%
Total Watch / In Patient	4,798.7	1,827.1	-62.3%	8,106	5,286.7	-34.7%	4,379.9	3,171.1	-27.6%
Ampicillin	-	947	100.0%	-	81	-100%	-	-	-
1.5 g Ampicillin Sulbactam	-	-	-	218	484	121.1%	307	466	51.8%
0.75 g Ampicillin Sulbactam	-	-	-	748	6,191	734.1%	398	164	-58.8%
Amoxicillin - Clavulanic	-	283	100.0%	-	-	-	-	-	-
Gentamicin	969	203	-79.1%	333	1,310	294.3%	-	-	-
Amikacin	-	-	-	428	1,191	180.1%	-	-	-
Metronidazole	1,180	1,004	-14.9%	1,731	1,814	4.5%	1,810	1,139	-37.6%
Cefuroxime	-	-	-	838	3,074	266.8%	-	-	-
Total Access	3,149	3,416	8.4%	4,529	11,211	148.2%	3,113	3,969	27.5%
Total Access / In Patient	6,599.8	6,519.1	-1.2%	8,804	8,196.7	-6.8%	6,753.1	6,734.1	-0.3%

When the data was collected, e-RASPRO had been implemented for 9 months in Hospitals A and B, but it had only been implemented for 3 months in Hospital C; the results were as follows:

Table 4. The use of antibiotics included in the Reserve category, such as Polymixin and Tetracycline, e was not found in this survey. There was a significant reduction in the quantity of Ceftriaxone prescribed in Hospitals A, B, and C, by 62.92%, 40.58%, and 11.06%, respectively. Nevertheless, there was a significant increase in Cefotaxime prescribing in Hospitals A and B, with increases of 35.32% and more than 100%, respectively. A significant increase also occurred for Ciprofloxacin prescribing in three hospitals. The quantity of 500 mg Levofloxacin prescribed in Hospitals A, B, and C decreased by 45.14%, 64.84%, and 76.25%, respectively. The quantity of 750 mg Levofloxacin was reduced in Hospitals A and B by 65.49% and 13.36%, respectively; however, it increased significantly by more than 100% in Hospital C. The quantity of prescribing 1 gram of Meropenem in Hospitals A and B decreased by 41.32% and 13.45%, respectively; however, it increased in Hospital C by 10.01%. The quantity of azithromycin prescribed also decreased significantly in Hospital B, by 93.28%. Piperacillin-Tazobactam seemed to be used very rarely. The minimum use was found in Hospital B i.e.

as many as 45 ampules/vials within 9 9-month period before the e-RASPRO tool was implemented. In general, the quantity of antibiotic use included in the Watch category at Hospitals A, B, and C was reduced by 54.93% (-58.86% per inpatient), 21.11% (-9.97% per inpatient), and 8.59% (-4.15% per inpatient), respectively. The quantity of Access category antibiotic prescribing in Hospitals A, B, and C was as follows: there was a 100% increase in Ampicillin and Amoxicillin-Clavulanate prescribing in Hospital A. While the prescribing of 1.5 g Ampicillin Sulbactam had also increased by >100% in Hospitals B and C.

Antibiotic prescribing of 0.75 g ampicillin-sulbactam increased by more than 100% in Hospital B; however, there was a decrease of 44.59% in Hospital C. The quantity of Gentamycin prescribing had a reduction of 79.15% in Hospital A; nevertheless, there was a significant increase up to >100% in Hospital B. Meanwhile, in Hospital C, Gentamycin had not been used before and after the implementation of e-RASPRO. Increased Cefuroxime prescribing was also found very significant in Hospital B, based on the agreement made by the Antimicrobial Resistance Control Program Committee, as well as continuity of drug availability in Hospital B, Cefuroxime was included in the Access category. In general, the quantity of Access category antibiotic prescribing in Hospitals A and B increased by 12.42% (+2.61 % per inpatient) and 223.17% (+268.83% per inpatient), respectively. Meanwhile, in Hospital C, it decreased by 6.81% (-2.29% per inpatient)

DISCUSSION

An integrated survey on Antimicrobial Resistance (AMR) and Antimicrobial Use (AMU) is very essential, and it should be carried out in order to evaluate the effectiveness of policy, evidence and the implementation of ASP.^{24,25} This survey is a limited survey conducted at three hospitals in Indonesia, which have different characteristics as shown in Table 1.

In Table 1, it is evident that Hospital C has the greatest resources in terms of the number of physicians, pharmacists, and nurses compared to Hospitals A and B. It also has the largest building compared to the other two hospitals. The various human resources in the hospital, along with its large size, presented their own challenges in implementing the antimicrobial stewardship program, whether using manual or digital methods. In daily practice, unevenly distributed levels of socialization may affect the level of appropriateness of antibiotic use with the digital guideline on the use of antimicrobial agents contained in e-RASPRO.

In Table 2, we can see that most patients who would receive early empirical antibiotic prescribing at hospital admission are those who have a Type 1 Risk Stratification, as documented in e-RASPRO. These patients include a group of immunocompetent patients or

immunocompromised patients who had unthreatening bacterial infection or those who are not at risk of having infection caused by MDR mikroorganisms.¹ Prescribing wide-spectrum antibiotics should be avoided as much as possible in patients who were mostly included in the group with Type 1 Risk Stratification. It should be taken into consideration that using various types of antibiotics may increase the risk of developing resistance.^{36,37} As the disease progresses, empirical antibiotic treatment certainly can be escalated in accordance with the patient's condition.

Table 3 describes the appropriateness of initial empirical antibiotic prescribing using the digital antimicrobial guideline as documented in Hospitals A, B, and C within 3 months of implementing e-RASPRO, which achieved rates of 81.59%, 76.09%, and 24.48%. It is categorized as "appropriate prescribing" when the empirical antibiotic is given in accordance with the digital guideline of antimicrobial use included in e-RASPRO that is compliant with the patient's risk stratification. There is a high percentage of patients in a group with Type 1 Risk Stratification. This result is expected to bring some changes in the quantitative pattern of antibiotic prescribing from the type of antibiotics included in the Watch category to those in the Access category.

The appropriateness of antibiotic prescribing in Hospital C, which is documented in digital e-RASPRO forms, is still relatively low. Through discussions and interviews with the investigators, it may be caused by the socialization associated with e-RASPRO implementation that has not been thoroughly conducted for the clinicians, or there might be other unidentified obstacles.

Table 4 is a table describing the quantity of antibiotic prescribing, both empirical and definitive antibiotics prescribed using e-RASPRO. The absence of Reserve category antibiotic prescribing in our survey may be due to difficulties in supplying those antibiotics in the three hospitals, or it may also be attributed to the extremely small number of cases associated with this issue in the three hospitals.

Table 4 describes the quantity of Watch category antibiotic prescribing within 9 months before and after implementing e-RASPRO in Hospital A and B as well as within 3 months before and after implementing the tool in Hospital C. There was a significant decrease of Ceftriaxone prescribing in Hospital A, B and C since those three hospitals had carried out some efforts to lower Ceftriaxone prescribing either as empirical or definitive antibiotics; therefore, in the digital guidelines on the antimicrobial use in e-RASPRO of the three hospitals, the use of Ceftriaxone could be minimized.

In some group of patients with Type 1 Risk Stratification when the Third Generation of Cephalosporins should be administered, Cefotaxime becomes the appropriate choice as recommended by the digital antimicrobial guidelines in the three hospitals; therefore, although in most cases the empirical antibiotics used in patients with Type 1 Risk Stratification are those in the Access category, but there are some focal infection that can be treated with Cefotaxime as the empirical antimicrobial agent of choice. The Antimicrobial Resistance Control Program Committee of Hospitals A and B has obviously included Ceftizoxime as the Cephalosporin that has been commonly used, and it can be administered when necessary. This might explain the relatively significant increase in Cefotaxime and Ceftizoxime prescribing in Hospital A and B. Meanwhile, in Hospital C, Ceftizoxime had not been included in the digital antimicrobial guideline; therefore, Ceftizoxime had not been used within 3 months following the implementation of e-RASPRO.

The significant increase in Ciprofloxacin prescribing in three hospitals may occur because the prescribing was less consistent with the recommendation included in the digital antimicrobial guideline of e-RASPRO. Nevertheless, the guideline recommends that Ciprofloxacin may serve as a β -lactam antibiotic, which is optional for all types of risk stratifications when patients have a Penicillin allergy. Based on the digital guidelines for antimicrobial use in e-RASPRO, Ciprofloxacin has also been used as the antibiotic of choice for tropical infectious diseases in the three hospitals, such as typhoid fever, and many cases have been reported in Indonesia. For such

infections, according to the digital guideline of antimicrobial use in e-RASPRO, Ciprofloxacin is recommended as one of the antibiotics of choice. Moreover, increased prescribing of Cefotaxime and Ciprofloxacin may also be caused by clinicians who have prescribed definitive antimicrobial treatments using e-RASPRO. However, we still require additional data to confirm this event.

In general, there is a significant decrease in the quantity of Meropenem and Levofloxacin prescribing in hospitals A and B. This is consistent with the digital guideline on antimicrobial use included in e-RASPRO of the three hospitals, which minimizes the use of Levofloxacin for patients with Type 1 Risk Stratification, who are the majority in the three hospitals. Meanwhile, Meropenem can only be administered to patients with Type 3 Risk Stratification. The use of Meropenem cannot be separated from the possibility of escalating antibiotic treatment, which is in accordance with the digital guideline on antimicrobial use included in e-RASPRO.

The increased prescribing quantity of 750 mg Levofloxacin and 1 g Meropenem in Hospital C still persists. It is probably caused by a compliance issue or inconsistency with the digital guideline on antimicrobial use. In the first 3 months of survey conducted in Hospital C, the appropriateness level of antimicrobial prescribing with the digital guideline on the use of antimicrobial agents is still considered to be low; while the majority of patients actually are included in the Type 1 Risk Stratification group, in which most of their empirical antibiotic choices are those included in the Access category. Nevertheless, further review should be conducted to assess the situation that has occurred at Hospital C.

This survey has not found antimicrobial prescribing of Piperacillin-Tazobactam and Ertapenem for patients included in the Type 2 Risk Stratification group following the implementation of e-RASPRO. Through various discussions with those hospitals, we identified that it is difficult to provide antimicrobial agents of Piperacillin Tazobactam and Ertapenem; therefore antibiotics of Access category such as Ampicillin Sulbactam or Amoxycillin Clavulanate with or without combination of Aminoglycosides as the anti-ESBLs often serve as empirical antibiotic of choice to be given for patients who are included in the Type 2 Risk Stratification. Nevertheless, in reality, the initial 3-month survey on the implementation of e-RASPRO in three hospitals has shown that the number of patients included in the Type 2 Risk Stratification group was a minority. Overall, there is a reduction in the quantity of antibiotic prescribing in the Watch category at Hospitals A, B, and C, by 54.93% (-58.86% per inpatient), 21.1% (-9.97% per inpatient), and 8.59% (-4.15% per inpatient), respectively, following the implementation of e-RASPRO.

In Table 4 a survey conducted for 9 months before and after the utilization of e-RASPRO in Hospital A and B and 3 months before and after implementing e-RASPRO in Hospital C has demonstrated a significant increase in the quantity of antibiotic prescribing of Ampicillin, Amoxycillin Clavulanate and 1.5 g Ampicillin Sulbactam, which are antibiotics included in Access category in the three hospitals. The survey conducted within the first 3 months of e-RASPRO utilization has demonstrated that the majority of patients are included in the Type 1 Risk Stratification group at those three hospitals (Table 2), in which the majority of empirical antibiotic choices are indeed antibiotics included in the Access category. Nevertheless, further surveys are certainly required to be carried out in Hospitals A and B in the following months.

The significant increase of 0.75 g Ampicillin Sulbactam prescribing may also still be associated with the continuity of 1.5 g Ampicillin Sulbactam availability in Hospital B. Some sources at Hospital B, through discussions with investigators, suggest that there is often a shortage of 1.5 Ampicillin-Sulbactam in the hospital. Therefore, considering this reasoning, the Antimicrobial Resistance Control Program Committee in Hospital B has included Cefuroxime in the Access category of its guideline on antimicrobial use. This condition explains the presence of an increased quantity of Cefuroxime prescribing, which is included in the Access category in Hospital B.

Based on the digital guideline on antimicrobial use in e-RASPRO of the three hospitals, Aminoglycosides have actually been used as combined antibiotics. It has not been identified clearly about the cause of reduced Gentamycin prescribing in Hospital A, while in Hospital C, the use of Gentamycin and Amikacin has not been documented either before or after the implementation of e-RASPRO. Increased Gentamycin and Amikacin prescribing in Hospital B could occur because the digital guideline on antimicrobial use for those three hospitals recommends using aminoglycosides as combined empirical antibiotics for some focal infections in patients with Type 1 risk stratification and almost all focal infections in patients with Type 3 Risk Stratification. Overall, there is increased quantity of Access category antibiotic prescribing in Hospital A and B of 12.42% (+2.61% per inpatient) and 223.17% (+268.83% per inpatient), respectively. A survey conducted within 3 months before and after the implementation of e-RASPRO in Hospital C demonstrated a reduction in Access category antibiotic prescribing of 6.81% (-2.29% per inpatient).

In Table 4, regarding the number of patients before and after the implementation of e-RASPRO in those three hospitals, it can also be seen that the numbers were not significantly different. This survey has not correlated the quantity of prescribing with the duration of antibiotic use; furthermore, it has not calculated the percentage of escalating and stepping down empirical antibiotic treatment. However, in this survey, we observed a reduced percentage of Watch category antibiotic prescribing in three hospitals, as well as an increased percentage of Access category antibiotic prescribing in two hospitals (Hospital A and B) following the implementation of e-RASPRO. The increased quantity of Access category antibiotic prescribing, particularly in Hospital B, is extremely significant.

The altered quantity of Watch and Access category antibiotics prescribed, particularly in Hospitals A and B, is likely still influenced by the appropriateness of empirical antibiotic use, which is guided by the digital guideline on antimicrobial use included in e-RASPRO. However, it certainly requires further studies. Hospital characteristics, such as the number of hospital beds, the number of physicians, and other facilities, may also affect the pattern of antibiotic prescribing. A systematic review showed a decrease in the antimicrobial DDD range from -8.42% to -61.29% related to the use of a digital antimicrobial stewardship tool.²⁴

Some studies have demonstrated that the utilization of digital tools to implement ASP can reduce the use of antimicrobial agents and also decrease the DDD.^{24,25} In other previous study the duration of digital antimicrobial stewardship implementation may show a different antibiotic DDD result.² However, we still cannot conclude what type of digital intervention will certainly reduce the use of antimicrobial agents.²⁵ Our study is an initial survey on the utilization of e-RASPRO, one of the digital antimicrobial stewardship programs used in Indonesia. This study is a survey only and cannot yet describe the correlation between e-RASPRO use and antibiotic prescribing patterns. To achieve good results, the utilization of e-RASPRO should be carried out in conjunction with compulsory disciplines and with full support from the hospital management team. Demographic characteristics of the hospitals can also affect the effectiveness of e-RASPRO utilization. To provide a comprehensive explanation of this issue, more extensive studies with full support from the managerial team are required to further analyze the causal correlation between the utilization of e-RASPRO and the altered quantitative pattern in antibiotic prescribing.

CONCLUSION

The survey has not been able to describe the causal-effect correlation between e-RASPRO implementation and the quantity of antibiotic prescribing. However, in general, there is an altered quantitative pattern in the quantity of empirical antibiotic prescribing, particularly for those included in the Watch and Access categories, following the implementation of e-RASPRO. We

suggest a broader scope of research on digital antimicrobial stewardship tools to evaluate their effectiveness in implementing antimicrobial stewardship programs.

ACKNOWLEDGEMENT

Our highest appreciation goes to the Faculty of Medicine Universitas Trisakti, Pelita RASPRO Indonesia Foundation, and all authors who have contributed to this manuscript.

AUTHORS CONTRIBUTION

The authors confirm their contribution to the paper as follows: study conception and design: RIN; data collection: WL, RA, RM, HS, SM, DA, TSM, IIP, DD, CNL, ALR; analysis and interpretation of results: RIN, WL, AA, HA; draft manuscript preparation: RIN, WL, YY, JS, NH, HA, MAF, TFF, JVK, YY. All authors reviewed the results and approved the final version of the manuscript.

FUNDING

None.

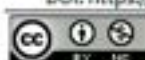
CONFLICT OF INTEREST

Competing interests: No relevant disclosures.

REFERENCES

1. Natadidjaja RI, Henry T, Adlani H, et al. Antibiotic usage at a private hospital in Central Java: results of implementing the Indonesian Regulation on the Prospective Antimicrobial System (Regulasi Antimikroba Sistem Prospektif Indonesia [RASPRO]). *Int J Infect Control*. 2021;17(1):1–10. DOI: <https://doi.org/10.3396/ijic.v17.20411>
2. World Health Organization. The WHO A Wa Re (Access, Watch, Reserve) antibiotic book [Internet]. Geneva, Switzerland: World Health Organization; 2022. 1–160 p. Available from: <http://apps.who.int/bookorders>.
3. Natadidjaja RI, Ariyani A, Adlani H, et al. A survey on define daily dose of watch- and access-category antibiotics in two Indonesian hospitals following the implementation of digital antimicrobial stewardship tool. *Clin eHealth*. 2024;7:176–89. DOI: <https://doi.org/10.1016/j.cel.2024.12.004>
4. Artero A, Esparcia A, Alberola J, et al. Prospective cohort study of risk factors for extended-spectrum β -lactamase-producing *Escherichia coli* urinary tract infections in elderly patients admitted to hospital. *Int J Clin Pract*. 2017;71(9):1–7. DOI: [10.1111/ijcp.13001](https://doi.org/10.1111/ijcp.13001)
5. Larramendy S, Deglaire V, Dusollier P, et al. Risk factors of extended-spectrum beta-lactamases-producing *Escherichia coli* community acquired urinary tract infections: A systematic review. *Infect Drug Resist*. 2020;13:3945–55. DOI: [10.2147/IDR.S269033](https://doi.org/10.2147/IDR.S269033)
6. Baek YJ, Kim YA, Kim D, et al. Risk factors for extended-spectrum- β -lactamase-producing *Escherichia coli* in community-onset bloodstream infection: Impact on long-term care hospitals in Korea. *Ann Lab Med*. 2021;41(5):455–62. DOI: [10.3343/ALM.2021.41.5.455](https://doi.org/10.3343/ALM.2021.41.5.455)
7. Vance MK, Cretella DA, Ward LM, et al. Risk Factors for Bloodstream Infections Due to ESBL-Producing *Escherichia coli*, *Klebsiella* spp., and *Proteus mirabilis*. *Pharmacy*. 2023;11(2):74. DOI: [10.3390/pharmacy11020074](https://doi.org/10.3390/pharmacy11020074)
8. Çeken S, İskender G, Gedik H, et al. Risk factors for bloodstream infections due to extended-spectrum β -lactamase producing enterobacteriaceae in cancer patients. *J Infect Dev Ctries*. 2018;12(4):265–72. DOI: [10.3855/jidc.9720](https://doi.org/10.3855/jidc.9720)
9. Capsoni N, Bellone P, Aliberti S, et al. Prevalence, risk factors and outcomes of patients coming from the community with sepsis due to multidrug resistant bacteria. *Multidiscip Respir Med*. 2019;14(23):1–11. DOI: <https://doi.org/10.1186/s40248-019-0185-4>

10. Gomila A, Shaw E, Carratalà J, et al. Predictive factors for multidrug-resistant gram-negative bacteria among hospitalised patients with complicated urinary tract infections. *Antimicrob Resist Infect Control*. 2018;7(1):1-11. DOI: <https://doi.org/10.1186/s13756-018-0401-6>
11. Falcone M, Russo A, Giannella M, et al. Individualizing risk of multidrug-resistant pathogens in community-onset pneumonia. *PLoS One*. 2015;10(4):1-16. DOI: [10.1371/journal.pone.0119528](https://doi.org/10.1371/journal.pone.0119528)
12. Madrazo M, López-Cruz I, Piles L, et al. Risk Factors and the Impact of Multidrug-Resistant Bacteria on Community-Acquired Urinary Sepsis. *Microorganisms*. 2023;11(5):1-13. DOI: [10.3390/microorganisms11051278](https://doi.org/10.3390/microorganisms11051278)
13. Patolia S, Abate G, Patel N, et al. Risk factors and outcomes for multidrug-resistant Gram-negative bacilli bacteremia. *Ther Adv Infect Dis*. 2018;5(1):1-8. DOI: <https://doi.org/10.1177/2049936117727497>
14. Kang JS, Moon C, Mun SJ, et al. Antimicrobial Susceptibility Trends and Risk Factors for Antimicrobial Resistance in *Pseudomonas aeruginosa* Bacteremia: 12-Year Experience in a Tertiary Hospital in Korea. *J Korean Med Sci*. 2021;36(43):1-15. DOI: [10.3346/jkms.2021.36.e273](https://doi.org/10.3346/jkms.2021.36.e273)
15. Prina E, Ranzani OT, Polverino E, et al. Risk factors associated with potentially antibiotic-resistant pathogens in community-acquired pneumonia. *Ann Am Thorac Soc*. 2015;12(2):153-60. DOI: [10.1513/AnnalsATS.201407-305OC](https://doi.org/10.1513/AnnalsATS.201407-305OC)
16. Haque M, Sartelli M, McKimm J, et al. Health care-associated infections-an overview. *Infect Drug Resist*. 2018;11(1):321-33. DOI: <https://doi.org/10.2147/IDR.S177247>
17. Revelas A. Healthcare-associated infections: A public health problem. *Niger Med J*. 2012;53-64(2):59. DOI: [10.4103/0300-1652.103543](https://doi.org/10.4103/0300-1652.103543)
18. Cardoso T, Almeida M, Friedman ND, et al. Classification of healthcare-associated infection: a systematic review 10 years after the first proposal. *AJIC Am J Infect Control*. 2014;12(40):1-13. DOI: [10.1186/1741-7015-12-40](https://doi.org/10.1186/1741-7015-12-40)
19. World Health Organization. Report on the Burden of Endemic Health Care-Associated Infection Worldwide Clean Care is Safer Care. World Health Organization. Geneva, Switzerland; 2011. Available from: www.who.int
20. Natadidjaja RI, Kusuma AS, Sudradjat GB, et al. The Association between Medical History-based Risks and Sepsis Events in Immunocompromised Patients according to Type III Stratification of the Indonesian Regulation on the Prospective Antimicrobial System (Regulasi Antimikroba Sistem Prospektif / RASPRO). *Bali Med J*. 2021;10(3):1031-6. DOI: [10.15562/bmj.v10i3.2561](https://doi.org/10.15562/bmj.v10i3.2561)
21. Otto SJG, Haworth-Brockman M, Miazga-Rodriguez M, et al. Integrated surveillance of antimicrobial resistance and antimicrobial use: Evaluation of the status in Canada (2014-2019). *Can Vet J*. 2022;63(2):161-70. DOI: [10.17269/141997-021-00600-w](https://doi.org/10.17269/141997-021-00600-w)
22. Bennisani H, Cornelsen L, Stärk KDC, et al. Evaluating Integrated Surveillance for Antimicrobial Use and Resistance in England: A Qualitative Study. *Front Vet Sci*. 2021;8(November):1-16. DOI: [10.3389/fvets.2021.743857](https://doi.org/10.3389/fvets.2021.743857)
23. Bassetti D, Bassetti M, Mantero E. Strategies for antibiotic selection in empirical therapy. *Clin Microbiol Infect*. 2000;6(5):98-100. DOI: [10.1111/j.1469-0691.2000.tb02058.x](https://doi.org/10.1111/j.1469-0691.2000.tb02058.x)
24. Trotter NE, Slight SP, Karimi R, et al. The effect of digital antimicrobial stewardship programmes on antimicrobial usage, length of stay, mortality and cost. *Informatics Med Unlocked*. 2023;37(January 2023):101183. DOI: <https://doi.org/10.1016/j.imu.2023.101183>
25. Van Dort BA, Penm J, Ritchie A, et al. The impact of digital interventions on antimicrobial stewardship in hospitals: A qualitative synthesis of systematic reviews. *J Antimicrob Chemother*. 2022;77(7):1828-37. DOI: <https://doi.org/10.1093/jac/dkac112>



This work is licensed under a Creative Commons Attribution Non-Commercial 4.0 International License

A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals Using Digital Antimicrobial Stewardship

By Ronald Irwanto Natadidjaja

WORD COUNT	7924	TIME SUBMITTED	18-SEP-2025 03:13PM
		PAPER ID	118235471

ORIGINAL ARTICLE

A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals Using Digital Antimicrobial Stewardship

Survei Pola Kuantitas Peresepan Antibiotik di Tiga Rumah Sakit di Indonesia dengan Penatagunaan Antimikroba Digital

Ronald Irwanto Natadidjaja^{1,2,3,✉}, Widyawati Lekok^{2,8}, Aziza Ariyani¹, Hadianti Adlani^{1,4,5}, Raymond Adianto¹, Ronaningtyas Maharani¹, Hadi Sumarsono¹, Yenny Yenny^{2,3}, Jihan Samira^{2,3}, Nany Hairunisa^{2,3}, Husnun Amalia^{2,3}, Meutia Atika Faradilla^{2,3}, Tubagus Ferdi Fadilah^{2,3}, Joice Viladelvia Kalumpiu^{2,3}, Yuliana Yuliana², Sri Mulyani⁵, Desi Angglat⁵, Triyoko Septio Marja⁵, Iin Indra Pertiwi⁶, Dianawati Dianawati⁶, Grace Nerry Legoh⁷, Alvin Lekonardo Rantung⁷

¹RASPRO Indonesia Study Group

²Faculty of Medicine, Universitas Trisakti, Jakarta, Indonesia

³Trisakti – RASPRO Indonesia Antimicrobial Stewardship (TRIASE) Learning Centre, Indonesia

⁴Faculty of Medicine, Syarif Hidayatullah State Islamic University

⁵Hermima Hospital Group Indonesia

⁶Tugu Ibu Hospital, Depok, Indonesia

⁷Advent Bandung Hospital, Indonesia

⁸Trisakti School of Management, Indonesia

✉ronald@trisakti.ac.id

<https://doi.org/10.18051/JBlomedKes.2025.v8.127-141>

ABSTRACT

Background

Antimicrobial Stewardship Program (ASP) is **very** essential. There are three categories of antimicrobial agents as recommended by WHO: Access, Watch and Reserve. e-RASPRO, a digital ASP model, **may alter antibiotic prescribing patterns by prioritizing Access category antibiotic prescribing.**

Methods

Our manuscript presented a **quantitative** survey on antibiotic prescribing patterns within 3 months and 9 months before and after implementing digital electronic-RASPRO (e-RASPRO) in three Indonesian hospitals, utilizing retrospective inpatient data. This analysis included the appropriateness of empirical antibiotic prescribing and the quantity of antibiotic prescribing based on each category.

Results

In the first 3 months, we found that 90.16%, 83.98%, and 81.15% of patients were included in Type 1 Risk Stratification. The appropriateness of initial empirical antibiotic prescribing with the digital guideline on antimicrobial use of e-RASPRO in three hospitals was 81.59%, 76.09% and 24.48%, respectively. Within 9 months after implementing e-RASPRO in Hospital A and B and within 3 months in Hospital C, there was a trend of reduced quantity of Watch category antibiotic prescribing of 54.93% (-58.86% per inpatient), 21.11% (-9.97% per inpatient), and 8.59% (-4.15% per inpatient), respectively. There was a 12.42% (+2.61% per inpatient) and 223.17% (+268.83% per inpatient) increase in the quantity of Access category antibiotic prescribing in Hospitals A and B,

while in Hospital C, the quantity decreased by 6.81% (-2.29% per inpatient).

Conclusions

There are changes in antibiotic prescribing patterns, particularly in the antibiotics included in the Watch and Access categories following the implementation of e-RASPRO. The relationship between digital antimicrobial stewardship use and the results still needs further research.

Keywords: Access; Digital Antimicrobial Stewardship; Quantity; Survey; Watch.

ABSTRAK

Latar Belakang

Penatagunaan antimikroba (PGA) merupakan hal yang urgen dilakukan. World Health Organization (WHO) telah mengkategorikan antimikroba ke dalam 3 golongan yaitu: Access, Watch, dan Reserve. Perangkat PGA digital e-RASPRO diharapkan dapat merubah pola persepsian antibiotik dengan mengedepankan persepsian antibiotik kategori Access.

Metode

Artikel ini merupakan survei pola kuantitas persepsian antibiotik 3 bulan dan 9 bulan sebelum dan sesudah terapan perangkat digital elektronik-RASPRO (e-RASPRO) dengan data retrospektif pada rawat inap di 3 rumah sakit di Indonesia, mencakup kesesuaian persepsian antibiotik empirik, dan kuantitas persepsian antibiotik berdasarkan masing-masing kategori.

Hasil

Dalam 3 bulan pertama, didapatkan 90.16%, 83.98% dan 81.15% dari pasien yang diberikan antibiotik termasuk dalam Stratifikasi Risiko Tipe 1. Kesesuaian persepsian antibiotik empirik inisiasi dengan panduan penggunaan antimikroba digital perangkat e-RASPRO pada ketiga rumah sakit masing-masing mencapai 81.59%, 76.09%, dan 24.48%. 9 bulan sesudah terapan perangkat e-RASPRO di Rumah Sakit A dan B dan 3 bulan sesudah terapan perangkat e-RASPRO di Rumah Sakit C terdapat tren penurunan kuantitas persepsian antibiotik kategori Watch masing-masing sebesar 54.93% (-58.86% per pasien rawat inap), 21.11% (-9.97% per pasien rawat inap) dan 8.59% (-4.15% per pasien rawat inap). Kuantitas persepsian antibiotik kategori Access di Rumah Sakit A dan B meningkat 12.42% (+ 2.61% per pasien rawat inap) and 223.17% (+268.83% per pasien rawat inap), sementara itu di Rumah Sakit C menurun 6.81% (-2.29% per pasien rawat inap).

Kesimpulan

Terdapat perubahan pola persepsian antibiotik kategori Watch dan Access pasca terapan perangkat e-RASPRO. Analisis hubungan antara penggunaan perangkat PGA digital dengan hasil yang ada masih membutuhkan penelitian lebih lanjut.

Kata Kunci: Access; Penatagunaan Antimikroba Digital; Kuantitas; Survei; Watch.

INTRODUCTION

The implementation of the Antimicrobial Stewardship Program (ASP) has been planned globally with the aim of promoting the prudent use of antimicrobial agents and reducing the risk of antimicrobial resistance development.¹ The World Health Organization (WHO) has categorized antibiotics into three categories: Access, Watch, and Reserve (AWARE).² Antibiotics included in Access category are antibiotics that have potency of lower incidence on resistance; while those in Watch category are types of antibiotics that have greater potency on resistance and antibiotics in Reserve category are types of antibiotics that are used only when there is an infection caused by suspected Multi-Drug Resistant (MDR) bacteria; these antibiotics should not be used carelessly, particularly in large quantity.

In this case, the RASPRO Indonesia Study Group has attempted to develop a system, known as the RASPRO system, that can guide clinicians in antibiotic prescribing based on local guidelines.¹ The RASPRO system was made by using risk stratification of patients, and it directs clinicians in initial prescribing of empirical antibiotics, as well as a guideline in changing antibiotics and providing definitive antibiotic treatment, including filling out compulsory specialized forms when there is any prolonged use of antibiotics.¹

Our survey is a continuation of a previous survey conducted in a hospital in Central Java, Indonesia. The hospital has implemented a manual RASPRO system to carry out the ASP. The survey, conducted before and after the manual system had been implemented for three months, revealed a decrease in antibiotic prescribing from 64,799 ampules/vials to 51,661 ampules/vials, with a reduced mean percentage of antibiotic use within three months of implementation reaching 14.44%.¹ The previous RASPRO system, which used manual guideline forms, was then converted into an electronic form of RASPRO (e-RASPRO); therefore, e-RASPRO has become a digital tool in Indonesia designed to facilitate ASP in hospitals. Through e-RASPRO, a local antimicrobial guideline is developed digitally by completing RASPRO forms, which are also created digitally and comprise electronic forms for empirical antibiotics and definitive antibiotics. A previous survey of e-RASPRO implementation showed a 49.01% decrease in Watch category antibiotics Define Daily Dose (DDD) within 9 months of implementation, but still showed an increase in Watch category antibiotics DDD by 20.18% within 3 months of implementation.³

Clinical pharmacies can also perform direct verification on the appropriateness of indications, time limitations of antibiotic use, and the appropriateness of using empirical antibiotics by utilizing the digital guidelines on antimicrobial use that are applicable in hospitals where e-RASPRO has been implemented. By utilizing e-RASPRO, it is expected that there will be an altered pattern of antibiotic prescribing, i.e., prioritizing the use of Access category antibiotics to suppress the risk of widespread antibiotic resistance, particularly against wide-spectrum antibiotics.⁶ The aim of this study is to show the comparison of antibiotic prescription patterns among 9 months and 3 months of implementation of e-RASPRO in 3 hospitals.

METHODS

A survey was conducted at three hospitals in Indonesia: Hospital A, Hospital B, and Hospital C. All hospitals are located in West Java and were selected based on their service level category. One of them is a primary hospital (Hospital A), and the other two hospitals are secondary hospitals (Hospital B and C). Previously, various socialization on implementing digital antimicrobial stewardship program using e-RASPRO has been performed that includes socialization on digital prescribing of empirical antibiotics as well as definitive antibiotics, socialization on patient grouping based on the Risk Stratification in order to perform empirical antibiotics prescribing using digital tool and socialization on the digital guideline on using empirical antimicrobial agents, and socialization on prolonged antibiotic use in digital tools.

Socialization on Digital Prescribing of Empirical Antibiotics in e-RASPRO

Socialization was conducted on the implementation of e-RASPRO in three hospitals to guide the prescription of empirical antibiotics. When prescribing empirical antibiotics, clinicians were advised to determine the risk stratification of hospitalized patients based on their immune status, severity of infection, and medical history, such as previous antibiotic use, prior hospitalizations, and history of medical instrument usage.

Socialization also covered the guidelines and procedures for filling out forms for escalating and stepping down empirical antibiotics, aligning with the digital guideline on antimicrobial agent use in e-RASPRO. When empirical antibiotic prescribing did not follow the digital guideline, clinical

pharmacy would confirm with clinicians and the ASP team in the hospital to decide if the antibiotic could be used. The socialization was conducted by the investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals and continued for clinicians at each hospital. It was held both online and offline.

Socialization on Patient Grouping based on Risk Stratification for Empirical Antibiotics Prescribing in e-RASPRO

Socialization was conducted on patient grouping based on their risk stratification in e-RASPRO. The socialization was carried out by the investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals and was continued with the clinicians at each hospital. The socialization was performed both online and offline.

The administration of initial empirical antibiotics in hospitalized patients should be based on patients' risk stratification, as recommended by the digital guideline on the use of antimicrobial agents, which has been incorporated into e-RASPRO. The e-RASPRO categorized patients into three groups for risk stratification in initial empirical antibiotic treatment.¹³

The Group of Patients with Type 1 Risk Stratification was a group of patients who could receive empirical antibiotics covering multidrug-resistant microorganisms. This group included immunocompetent patients and immunocompromised patients with a non-threatening severity of bacterial infection or without a risk of MDR, as classified by Non-Type 2 and/or Type 3 Risk Stratification.

The Group of Patients with Type 2 Risk Stratification was a group of (immunocompromised patients and/or uncontrolled diabetes mellitus with unthreatening severity of bacterial infection) PLUS (a history of receiving antibiotic treatment within 90 days ago (31-90 days in the system) and/or a history of having treatment at a healthcare facility of ≥48 days within 90 days ago (31-90 days in the system)), and/or a history of using medical instrumentation within 90 days ago (31-90 days in the system)). This group was at risk of having a multidrug-resistant (MDR) Extended-Spectrum Beta-Lactamase (ESBL) infection.¹³⁻¹⁸

The Group of Patients with Type 3 Risk Stratification was a group of (patients with threatening infection, and/or immunocompromised individuals and/or individuals with uncontrolled diabetes mellitus) PLUS (a history of receiving antibiotic treatment within 30 days ago and/or having treatment at a healthcare facility ≥48 hours within 30 days ago, and/or a history of using medical instrument within 30 days ago). This group was a group with high severity of infection or a group that was at risk of having ESBL infection and infection caused by other Multi-Drug Resistant (MDR) microorganisms, including MDR *Pseudomonas* sp.^{16,9-14} A group of patients with Healthcare-Associated Infections (HAIs) was also included in the group with Type 3 Risk Stratification. The group with the HAI category was a group with a period of infection of ≥48 hours of treatment at a healthcare facility, even within 90 days following a surgery.¹⁵⁻¹⁸

Socialization on the Digital Guideline of Using Empirical Antimicrobial Agents in e-RASPRO

Socialization was conducted on the implementation of e-RASPRO, which included the digital guideline on the use of antimicrobial agents in three Indonesian hospitals. The socialization was carried out by the investigators for the Antimicrobial Resistance Control Program Committee of each hospital and was continued for clinicians at each facility.

A digital guideline on the use of antimicrobial agents was developed, incorporating antibiotic categories based on the AWARE category proposed by the World Health Organization (WHO) in 2021. The guideline was then mutually agreed upon by the hospital management and the Antimicrobial Resistance Control Program Committee, which was subsequently incorporated into

e-RASPRO. The three hospitals used similar digital guidelines on using antimicrobial agents, which were developed by the RASPRO Indonesia Study Group by considering the WHO AWARE category as follows:

1 Empirical Antibiotic Choice for Patients with Type 1 Risk Stratification in e-RASPRO Digital Guidelines on the Use of Antimicrobial Agents

1 Most of empirical antibiotic choice included in the digital guideline on antimicrobial use for patients with type-1 risk stratification were the Access category antibiotics such as: Ampicillin, Ampicillin Sulbactam, Amoxycillin Clavulanate, Amikacin and Gentamicin; with the exception of Hospital B, in accordance with and on consideration of the continuity of drug availability as well as based on the agreement made by the Antimicrobial Resistance Control Program Committee, Cefuroxime (second generation of Cephalosporin) was included as the Access category antibiotic. Whenever necessary, most empirical antibiotic choices for the Type 1 Risk Stratification patient group could include antibiotics in the Watch category, i.e., third-generation cephalosporins such as Cefotaxime and Ceftizoxime.

1 Empirical Antibiotic Choice for Patients with Type 2 Risk Stratification in e-RASPRO Digital Guidelines on the Use of Antimicrobial Agents

1 For the group of patients with Type 2 Risk Stratification in e-RASPRO, the empirical antibiotic options included anti-ESBL antibiotics. Most of the antibiotic choices fell into either the Access category, such as Ampicillin-Sulbactam / Amoxici-Clavulanate combined with Amikacin / Gentamicin, or the Watch category, as outlined in the digital guidelines for antimicrobial use, which include Piperacillin-Tazobactam or the single use of Ertapenem.

1 Empirical Antibiotic Choice for Patients with Type 3 Risk Stratification in e-RASPRO Digital Guidelines on the Use of Antimicrobial Agents

1 Patients included in the Type 3 Risk Stratification group of the e-RASPRO system were a group of patients at risk of having sepsis. Therefore, for this group, the empirical antibiotic choice was an antibiotic capable of eradicating ESBL-producing bacteria and other MDR bacteria, with the majority of antibiotic selection following the digital guidelines on antimicrobial agents. These guidelines include categories such as Watch to Reserve, which encompasses antibiotics like Meropenem and Imipenem, with or without combination with Access category antibiotics, including Amikacin or Gentamicin, or with the use of Polymyxin or Tigecycline.

The e-RASPRO system with digital guidelines also guide clinicians if they need to step down or escalate the antibiotic empirically while the culture result still in progress.^{1,3}

Socialization on Prescribing Definitive Antibiotics in e-RASPRO

Socialization was performed by implementing e-RASPRO in three hospitals to prescribe definitive antibiotics. In e-RASPRO, a digital form was used to administer definitive antibiotics, which clinicians were required to fill out when prescribing antibiotics in accordance with culture findings.^{1,3} The socialization was conducted by the Investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals, and it was subsequently continued for clinicians at each hospital. The socialization was performed online and offline.

Socialization on Prolonged Antibiotic Use in e-RASPRO

Socialization was performed by implementing e-RASPRO in three hospitals. When there is a prolonged antibiotic prescribing, a clinician must describe the indication for prolonged antibiotic use through a digital form in e-RASPRO.^{1,3} It would then be verified by the clinical pharmacy, and the results would be reported to the ASP team in the hospital.

When prolonged antibiotic use occurred without a completed electronic form in e-RASPRO regarding the concerned issue or without clear indication, the clinical pharmacy, in accordance with the consent issued by the Hospital ASP team, could perform an Automatic Stop Order (ASO). Socialization was conducted by the investigators for the Antimicrobial Resistance Control Program Committee of the three hospitals, and it was also continued for clinicians at each hospital. The socialization was performed online and offline.

Survey Setting and Time Period of Data Collection

The retrieved data were secondary, univariate analyses obtained from reports on the use of injected antibiotics in the hospital wards of the three hospitals. Data was taken from January 2021 – June 2022 in Hospital A, March 2021 – August 2022 in Hospital B and August 2021 – January 2022 in Hospital C. Through implementation of e-RASPRO, initial data collection was performed within the first three-month, which included percentage of patients in each risk stratification group based on the digital e-RASPRO forms as well as appropriateness of initial empirical antibiotic prescribing with the digital guidelines on the use of antimicrobial agents.

The survey was followed by collecting all quantitative data on empirical antibiotic prescribing, as well as definitive antibiotic prescribing, for hospitalized patients within 9 months before and after the implementation of e-RASPRO in two hospitals (Hospital A and B), and within 3 months before and after utilizing e-RASPRO in another hospital (Hospital C). When the data was retrieved, Hospital C had just implemented e-RASPRO for 3 months. Interviews and discussions with the Antimicrobial Resistance Control Program Committee of the three hospitals were conducted during the initial implementation of e-RASPRO, as well as when the survey data were retrieved.

RESULTS

The following was data obtained from the survey conducted within the first 3 months of implementing e-RASPRO at 3 hospitals in Indonesia:

Table 1. Demographic Characteristics of 3 Surveyed Hospitals

Demographic Characteristics of Hospitals	Hospital		
	A	B	C
Number of Doctors			
General Physicians	14	14	25
Dentists	5	15	8
Specialist Doctors	37	98	102
Total	56	127	135
Number of Pharmacists	9	26	39
Number of Nurses	115	74	368
Number of Beds			
Wards	124	168	259
ICU + HCU + ICCU + NICU + PICU	10	17	26
Total	134	185	285
Ratio on numbers of specialist doctors : beds	1 : 3.62	1 : 1.89	1 : 2.79
Ratio on numbers of pharmacists : beds	1 : 14.89	1 : 7.12	1 : 7.31
Ratio on numbers of nurses : beds	1 : 1.17	1 : 2.50	1 : 0.77
The extent of the Buildings	7,247.35	8,120.00	31,099.94

Data: sirs.kemkes.go.id

Table 1. Actual demographic data of the three surveyed hospitals, which was collected from sirs.kemkes.go.id, Ministry of Health, Republic of Indonesia, was as follows: Hospital A, B, and C had 134 beds, 185 beds, and 285 beds, respectively; with a ratio of specialist doctors per bed of each hospital was 1 per 3.62 beds, 1 per 1.89 beds, and 1 per 2.79 beds.

Table 2. Initial Risk Stratification of Patients Receiving Antibiotics that Had Been Filled Out in the Digital Forms within 3 Months Following the Implementation of e-RASPRO in Three Hospitals

Risk Stratification	Hospital A 3 Months Oct – Dec 2021		Hospital B 3 Months Dec 2021 – Feb 2022		Hospital C 3 Months Nov 2021 – Jan 2022	
	Number	%	Number	%	Number	%
Type 1	284	90.16%	692	83.98%	1,472	81.15%
Type 2	31	9.84%	15	1.82%	84	4.63%
Type 3	-	0.00%	117	14.20%	258	14.22%
Total	315	100.00%	824	100.00%	1,814	100.00%

Table 2. In the digital e-RASPRO form, which was completed within 3 months during the initial utilization of e-RASPRO, the majority of patients were in the Type 1 Risk Stratification category, with percentages of 90.16%, 83.98%, and 81.15% in Hospitals A, B, and C, respectively.

Table 3. Appropriateness of Initial Empirical Antibiotic Prescribing with the Digital Guideline on the Use of Antimicrobial Agents within 3 Months Following the Implementation of e-RASPRO in Three Hospitals

	Hospital A 3 Months Oct – Dec 2021		Hospital B 3 Months Dec 2021 – Feb 2022		Hospital C 3 Months Nov 2021 – Jan 2022	
	Number	%	Number	%	Number	%
Empirical antibiotic prescribing is consistent with the digital guideline of antimicrobial use in e-RASPRO	257	81.59%	627	76.09%	444	24.48%
Empirical antibiotic prescribing is not consistent with the digital guideline of antimicrobial use in e-RASPRO	57	18.09%	197	23.91%	1,022	56.34%
Empirical antibiotic prescribing has unidentified consistency in e-RASPRO	1	0.32%	-	0.00%	348	19.18%
Total of forms had been filled out	315	100.00%	824	100.00%	1,814	100.00%

Table 3. The appropriateness of empirical antibiotic prescribing, as documented in Hospitals A, B, and C, using the digital guideline on the use of antimicrobial agents contained in e-RASPRO, reached 81.59%, 76.09%, and 24.48%, respectively, within 3 months before and after the implementation of e-RASPRO. Empirical antibiotic prescribing with non-identified appropriateness, which was documented in the digital forms, was defined as antibiotic prescribing using e-RASPRO with vague appropriateness, for example combined antibiotics prescribing in which one of the antibiotic was appropriate; while the other was not consistent with the digital guideline of antimicrobial agents or other variant condition, in which the appropriateness could not be concluded during data collection. Such a condition was documented in as many as 19.18% of cases at Hospital C.

Table 4. The Quantity of Intravenous Watch and Access Category Antibiotic Prescribing for Inpatient within 9 Months and 3 Months Before and After Implementing e-RASPRO

Antibiotics	Hospital A			Hospital B			Hospital C		
	Pre-implementation of e-RASPRO Jan – Sept 2021	9 months post implementation of e-RASPRO Oct 2021 – June 2022	Increase / Decrease	Pre-implementation of e-RASPRO Mar – Nov 2021	9 months post implementation of e-RASPRO Dec 2021 – August 2022	Increase / Decrease	Pre-implementation of e-RASPRO August – Oct 2022	3 months post implementation of e-RASPRO Nov 2022 – Jan 2023	Increase / Decrease
	Number of patients: 4,215	Number of patients: 4,618		Number of patients: 7,754	Number of patients: 6,794		Number of patients: 1,805	Number of patients: 2,675	
	Ampules/vials	Ampules/vials	Ampules/vials	Ampules/vials	Ampules/vials	Ampules/vials	Ampules/vials	Ampules/vials	Ampules/vials
Ceftriaxone	15,514	5,753	-61.92%	11,602	6,894	-40.58%	4,513	4,014	-11.06%
1g Cefotaxime	756	1,023	35.32%	950	4,189	>100%	1,360	1,237	-9.04%
0.5 g Cefotaxime	-	-	-	76	145	90.79%	-	-	-
Ceftazidime	-	-	-	866	359	-58.55%	724	774	6.91%
Cefoperazone	-	-	-	232	413	78.02%	-	-	-
Cefoperazone Sulbactam	-	-	-	-	-	-	-	146	100.00%
Ceftiozime	-	282	100.00%	527	596	13.09%	129	-	-100.00%
Cefepime	-	-	-	14	6	-57.14%	1,465	1,089	-25.67%
750 mg Levofloxacin	2,147	741	-65.49%	2,770	2,400	-13.36%	360	854	>100%
500 mg Levofloxacin	833	457	-45.14%	3,197	1,124	-64.84%	1,002	238	-76.25%
Ciprofloxacin	-	288	100.00%	136	1,258	>100%	-	234	100.00%
Moxifloxacin	-	-	-	487	221	-54.62%	-	-	-
1g Meropenem	968	568	-41.32%	8,690	7,511	-13.45%	1,619	1,781	10.01%
0.5 g Meropenem	-	-	-	19	-	-100%	550	475	-13.64%
Imipenem + Cilastatin	-	-	-	133	43	-67.67%	-	-	-

Antibiotics	Hospital A			Hospital B			Hospital C		
	Pre-Implementation of e-RASPHO Jan - Sept 2021	9 months post Implementation of e-RASPHO Oct 2021 - June 2022	Increase / Decrease	Pre-Implementation of e-RASPHO Mar - Nov 2021	9 months post Implementation of e-RASPHO Dec 2021 - August 2022	Increase / Decrease	Pre-Implementation of e-RASPHO August - Oct 2022	9 months post Implementation of e-RASPHO Nov 2022 - Jan 2023	Increase / Decrease
	Number of patients: 4,215	Number of patients: 4,618		Number of patients: 2,794	Number of patients: 6,294		Number of patients: 1,803	Number of patients: 2,675	
	Angiodes / total	Angiodes / total	Angiodes / total	Angiodes / total	Angiodes / total	Angiodes / total	Angiodes / total	Angiodes / total	Angiodes / total
Piperacillin	-	-	-	45	-	-	-	-	-
Tazobactam	-	-	-	2,662	179	-92,381	-	-	-
Azithromycin	-	-	-	307	379	83,091	316	918	-44,381
Cl-S	-	-	-	-	-	-	-	-	-
Vancomycin	-	-	-	-	-	-	-	-	-
Total Watch	16,118	8,112	-54,951	32,613	25,727	-8,115	12,078	11,049	-8,991
Total Watch / In Patient	4,7967	1,0778	-58,861	4,2060	3,7847	-9,871	4,3959	4,1278	-4,911
0.75 E									
Amoxicillin	-	947	100,001	-	93	1001	-	-	-
15 g Amoxicillin / Subcutan	-	-	-	214	484	11001	217	466	10001
0.75 E Amoxicillin / Subcutan	-	-	-	746	6,291	11001	296	854	-44,556
Amoxicillin - Clavulanic	263	-	100,001	-	-	-	-	-	-
Gentamicin	969	302	-79,911	722	1,650	11001	-	-	-
Amikacin	-	-	-	418	1,195	11001	-	-	-
Netronidazole	1,180	1,004	-14,991	1,731	2,424	40,031	1,616	1,339	-16,831
Ceftriaxone	-	-	-	838	3,074	11001	-	-	-
Total Access	3,149	3,446	69,421	4,679	9,101	323,171	3,013	5,964	-4,841
Total Access / In Patient	0,5108	0,5312	2,611	0,6694	2,2256	268,891	0,7933	0,7964	-2,291

When the data was collected, e-RASPRO had been implemented for 9 months in Hospitals A and B, but it had only been implemented for 3 months in Hospital C; the results were as follows:

Table 4. The use of antibiotics included in the Reserve category, such as Polymixin and Tetracycline, e was not found in this survey. There was a significant reduction in the quantity of Ceftriaxone prescribed in Hospitals A, B, and C, by 62.92%, 40.58%, and 11.06%, respectively. Nevertheless, there was a significant increase in Cefotaxime prescribing in Hospitals A and B, with increases of 35.32% and more than 100%, respectively. A significant increase also occurred for Ciprofloxacin prescribing in three hospitals. The quantity of 500 mg Levofloxacin prescribed in Hospitals A, B, and C decreased by 45.14%, 64.84%, and 76.25%, respectively. The quantity of 750 mg Levofloxacin was reduced in Hospitals A and B by 65.49% and 13.36%, respectively; however, it increased significantly by more than 100% in Hospital C. The quantity of prescribing 1 gram of Meropenem in Hospitals A and B decreased by 41.32% and 13.45%, respectively; however, it increased in Hospital C by 10.01%. The quantity of azithromycin prescribed also decreased significantly in Hospital B, by 93.28%. Piperacillin-Tazobactam seemed to be used very rarely. The minimum use was found in Hospital B i.e.

as many as 45 ampules/vials within 9 9-month period before the e-RASPRO tool was implemented. In general, the quantity of antibiotic use included in the Watch category at Hospitals A, B, and C was reduced by 54.93% (-58.86% per inpatient), 21.11% (-9.97% per inpatient), and 8.59% (-4.15% per inpatient), respectively. The quantity of Access category antibiotic prescribing in Hospitals A, B, and C was as follows: there was a 100% increase in Ampicillin and Amoxicillin-Clavulanate prescribing in Hospital A. While the prescribing of 1.5 g Ampicillin Sulbactam had also increased by >100% in Hospitals B and C.

Antibiotic prescribing of 0.75 g ampicillin-sulbactam increased by more than 100% in Hospital B; however, there was a decrease of 44.59% in Hospital C. The quantity of Gentamycin prescribing had a reduction of 79.15% in Hospital A; nevertheless, there was a significant increase up to >100% in Hospital B. Meanwhile, in Hospital C, Gentamycin had not been used before and after the implementation of e-RASPRO. Increased Cefuroxime prescribing was also found very significant in Hospital B, based on the agreement made by the Antimicrobial Resistance Control Program Committee, as well as continuity of drug availability in Hospital B, Cefuroxime was included in the Access category. In general, the quantity of Access category antibiotic prescribing in Hospitals A and B increased by 12.42% (+2.61 % per inpatient) and 223.17% (+268.83% per inpatient), respectively. Meanwhile, in Hospital C, it decreased by 6.81% (-2.29% per inpatient)

DISCUSSION

An integrated survey on Antimicrobial Resistance (AMR) and Antimicrobial Use (AMU) is very essential, and it should be carried out in order to evaluate the effectiveness of policy, evidence and the implementation of ASP.^{21,22} This survey is a limited survey conducted at three hospitals in Indonesia, which have different characteristics as shown in Table 1.

In Table 1, it is evident that Hospital C has the greatest resources in terms of the number of physicians, pharmacists, and nurses compared to Hospitals A and B. It also has the largest building compared to the other two hospitals. The various human resources in the hospital, along with its large size, presented their own challenges in implementing the antimicrobial stewardship program, whether using manual or digital methods. In daily practice, unevenly distributed levels of socialization may affect the level of appropriateness of antibiotic use with the digital guideline on the use of antimicrobial agents contained in e-RASPRO.

In Table 2, we can see that most patients who would receive early empirical antibiotic prescribing at hospital admission are those who have a Type 1 Risk Stratification, as documented in e-RASPRO. These patients include a group of immunocompetent patients or

immunocompromised patients who had unthreatening bacterial infection or those who are not at risk of having infection caused by MDR microorganisms.¹ Prescribing wide-spectrum antibiotics should be avoided as much as possible in patients who were mostly included in the group with Type 1 Risk Stratification. It should be taken into consideration that using various types of antibiotics may increase the risk of developing resistance.^{16,23} As the disease progresses, empirical antibiotic treatment certainly can be escalated in accordance with the patient's condition.

Table 3 describes the appropriateness of initial empirical antibiotic prescribing using the digital antimicrobial guideline as documented in Hospitals A, B, and C within 3 months of implementing e-RASPRO, which achieved rates of 81.59%, 76.09%, and 24.48%. It is categorized as "appropriate prescribing" when the empirical antibiotic is given in accordance with the digital guideline of antimicrobial use included in e-RASPRO that is compliant with the patient's risk stratification. There is a high percentage of patients in a group with Type 1 Risk Stratification. This result is expected to bring some changes in the quantitative pattern of antibiotic prescribing from the type of antibiotics included in the Watch category to those in the Access category.

The appropriateness of antibiotic prescribing in Hospital C, which is documented in digital e-RASPRO forms, is still relatively low. Through discussions and interviews with the investigators, it may be caused by the socialization associated with e-RASPRO implementation that has not been thoroughly conducted for the clinicians, or there might be other unidentified obstacles.

Table 4 is a table describing the quantity of antibiotic prescribing, both empirical and definitive antibiotics prescribed using e-RASPRO. The absence of Reserve category antibiotic prescribing in our survey may be due to difficulties in supplying those antibiotics in the three hospitals, or it may also be attributed to the extremely small number of cases associated with this issue in the three hospitals.

Table 4 describes the quantity of Watch category antibiotic prescribing within 9 months before and after implementing e-RASPRO in Hospital A and B as well as within 3 months before and after implementing the tool in Hospital C. There was a significant decrease of Ceftriaxone prescribing in Hospital A, B and C since those three hospitals had carried out some efforts to lower Ceftriaxone prescribing either as empirical or definitive antibiotics; therefore, in the digital guidelines on the antimicrobial use in e-RASPRO of the three hospitals, the use of Ceftriaxone could be minimized.

In some group of patients with Type 1 Risk Stratification when the Third Generation of Cephalosporins should be administered, Cefotaxime becomes the appropriate choice as recommended by the digital antimicrobial guidelines in the three hospitals; therefore, although in most cases the empirical antibiotics used in patients with Type 1 Risk Stratification are those in the Access category, but there are some focal infection that can be treated with Cefotaxime as the empirical antimicrobial agent of choice. The Antimicrobial Resistance Control Program Committee of Hospitals A and B has obviously included Ceftizoxime as the Cephalosporin that has been commonly used, and it can be administered when necessary. This might explain the relatively significant increase in Cefotaxime and Ceftizoxime prescribing in Hospital A and B. Meanwhile, in Hospital C, Ceftizoxime had not been included in the digital antimicrobial guideline; therefore, Ceftizoxime had not been used within 3 months following the implementation of e-RASPRO.

The significant increase in Ciprofloxacin prescribing in three hospitals may occur because the prescribing was less consistent with the recommendation included in the digital antimicrobial guideline of e-RASPRO. Nevertheless, the guideline recommends that Ciprofloxacin may serve as a β -lactam antibiotic, which is optional for all types of risk stratifications when patients have a Penicillin allergy. Based on the digital guidelines for antimicrobial use in e-RASPRO, Ciprofloxacin has also been used as the antibiotic of choice for tropical infectious diseases in the three hospitals, such as typhoid fever, and many cases have been reported in Indonesia. For such

infections, according to the digital guideline of antimicrobial use in e-RASPRO, Ciprofloxacin is recommended as one of the antibiotics of choice. Moreover, increased prescribing of Cefotaxime and Ciprofloxacin may also be caused by clinicians who have prescribed definitive antimicrobial treatments using e-RASPRO. However, we still require additional data to confirm this event.

In general, there is a significant decrease in the quantity of Meropenem and Levofloxacin prescribing in hospitals A and B. This is consistent with the digital guideline on antimicrobial use included in e-RASPRO of the three hospitals, which minimizes the use of Levofloxacin for patients with Type 1 Risk Stratification, who are the majority in the three hospitals. Meanwhile, Meropenem can only be administered to patients with Type 3 Risk Stratification. The use of Meropenem cannot be separated from the possibility of escalating antibiotic treatment, which is in accordance with the digital guideline on antimicrobial use included in e-RASPRO.

The increased prescribing quantity of 750 mg Levofloxacin and 1 g Meropenem in Hospital C still persists. It is probably caused by a compliance issue or inconsistency with the digital guideline on antimicrobial use. In the first 3 months of survey conducted in Hospital C, the appropriateness level of antimicrobial prescribing with the digital guideline on the use of antimicrobial agents is still considered to be low; while the majority of patients actually are included in the Type 1 Risk Stratification group, in which most of their empirical antibiotic choices are those included in the Access category. Nevertheless, further review should be conducted to assess the situation that has occurred at Hospital C.

This survey has not found antimicrobial prescribing of Piperacillin-Tazobactam and Ertapenem for patients included in the Type 2 Risk Stratification group following the implementation of e-RASPRO. Through various discussions with those hospitals, we identified that it is difficult to provide antimicrobial agents of Piperacillin Tazobactam and Ertapenem; therefore antibiotics of Access category such as Ampicillin Sulbactam or Amoxycillin Clavulanate with or without combination of Aminoglycosides as the anti-ESBLs often serve as empirical antibiotic of choice to be given for patients who are included in the Type 2 Risk Stratification. Nevertheless, in reality, the initial 3-month survey on the implementation of e-RASPRO in three hospitals has shown that the number of patients included in the Type 2 Risk Stratification group was a minority. Overall, there is a reduction in the quantity of antibiotic prescribing in the Watch category at Hospitals A, B, and C, by 54.93% (-8.86% per inpatient), 21.11% (-9.97% per inpatient), and 8.59% (-4.15% per inpatient), respectively, following the implementation of e-RASPRO.

In Table 4 a survey conducted for 9 months before and after the utilization of e-RASPRO in Hospital A and B and 3 months before and after implementing e-RASPRO in Hospital C has demonstrated a significant increase in the quantity of antibiotic prescribing of Ampicillin, Amoxycillin Clavulanate and 1.5 g Ampicillin Sulbactam, which are antibiotics included in Access category in the three hospitals. The survey conducted within the first 3 months of e-RASPRO utilization has demonstrated that the majority of patients are included in the Type 1 Risk Stratification group in those three hospitals (Table 2), in which the majority of empirical antibiotic choices are indeed antibiotics included in the Access category. Nevertheless, further surveys are certainly required to be carried out in Hospitals A and B in the following months.

The significant increase of 0.75 g Ampicillin Sulbactam prescribing may also still be associated with the continuity of 1.5 g Ampicillin Sulbactam availability in Hospital B. Some sources at Hospital B, through discussions with investigators, suggest that there is often a shortage of 1.5 Ampicillin-Sulbactam in the hospital. Therefore, considering this reasoning, the Antimicrobial Resistance Control Program Committee in Hospital B has included Cefuroxime in the Access category of its guideline on antimicrobial use. This condition explains the presence of an increased quantity of Cefuroxime prescribing, which is included in the Access category in Hospital B.

Based on the digital guideline on antimicrobial use in e-RASPRO of the three hospitals, Aminoglycosides have actually been used as combined antibiotics. It has not been identified clearly about the cause of reduced Gentamycin prescribing in Hospital A, while in Hospital C, the use of Gentamycin and Amikacin has not been documented either before or after the implementation of e-RASPRO. Increased Gentamycin and Amikacin prescribing in Hospital B could occur because the digital guideline on antimicrobial use for those three hospitals recommends using aminoglycosides as combined empirical antibiotics for some focal infections in patients with Type 1 risk stratification and almost all focal infections in patients with Type 3 Risk Stratification. Overall, there is increased quantity of Access category antibiotic prescribing in Hospital A and B of 12.42% (+2.4% per inpatient) and 223.17% (+268.83% per inpatient), respectively. A survey conducted within 3 months before and after the implementation of e-RASPRO in Hospital C demonstrated a reduction in Access category antibiotic prescribing of 6.81% (-2.29% per inpatient).

In Table 4, regarding the number of patients before and after the implementation of e-RASPRO in those three hospitals, it can also be seen that the numbers were not significantly different. This survey has not correlated the quantity of prescribing with the duration of antibiotic use; furthermore, it has not calculated the percentage of escalating and stepping down empirical antibiotic treatment. However, in this survey, we observed a reduced percentage of Watch category antibiotic prescribing in three hospitals, as well as an increased percentage of Access category antibiotic prescribing in two hospitals (Hospital A and B) following the implementation of e-RASPRO. The increased quantity of Access category antibiotic prescribing, particularly in Hospital B, is extremely significant.

The altered quantity of Watch and Access category antibiotics prescribed, particularly in Hospitals A and B, is likely still influenced by the appropriateness of empirical antibiotic use, which is guided by the digital guideline on antimicrobial use included in e-RASPRO. However, it certainly requires further studies. Hospital characteristics, such as the number of hospital beds, the number of physicians, and other facilities, may also affect the pattern of antibiotic prescribing. A systematic review showed a decrease in the antimicrobial DDD range from -8.42% to -61.29% related to the use of a digital antimicrobial stewardship tool.²⁴

Some studies have demonstrated that the utilization of digital tools to implement ASP can reduce the use of antimicrobial agents and also decrease the DDD.^{24,25} In other previous study the duration of digital antimicrobial stewardship implementation may show a different antibiotic DDD result.³ However, we still cannot conclude what type of digital intervention will certainly reduce the use of antimicrobial agents.²⁵ Our study is an initial survey on the utilization of e-RASPRO, one of the digital antimicrobial stewardship programs used in Indonesia. This study is a survey only and cannot yet describe the correlation between e-RASPRO use and antibiotic prescribing patterns. To achieve good results, the utilization of e-RASPRO should be carried out in conjunction with compulsory disciplines and with full support from the hospital management team. Demographic characteristics of the hospitals can also affect the effectiveness of e-RASPRO utilization. To provide a comprehensive explanation of this issue, more extensive studies with full support from the managerial team are required to further analyze the causal correlation between the utilization of e-RASPRO and the altered quantitative pattern in antibiotic prescribing.

CONCLUSION

The survey has not been able to describe the causal-effect correlation between e-RASPRO implementation and the quantity of antibiotic prescribing. However, in general, there is an altered quantitative pattern in the quantity of empirical antibiotic prescribing, particularly for those included in the Watch and Access categories, following the implementation of e-RASPRO. We

suggest a broader scope of research on digital antimicrobial stewardship tools to evaluate their effectiveness in implementing antimicrobial stewardship programs.

ACKNOWLEDGEMENT

Our highest appreciation goes to the Faculty of Medicine Universitas Trisakti, Pelita RASPRO Indonesia Foundation, and all authors who have contributed to this manuscript.

AUTHORS CONTRIBUTION

The authors confirm their contribution to the paper as follows: study conception and design: RIN; data collection: WL, RA, RM, HS, SM, DA, TSM, IIP, DD, GNL, ALR; analysis and interpretation of results: RIN, WL, AA, HA; draft manuscript preparation: RIN, WL, YY, JS, NH, HA, MAF, TFF, JVK, YY. All authors reviewed the results and approved the final version of the manuscript.

FUNDING

None.

CONFLICT OF INTEREST

Competing interests: No relevant disclosures.

REFERENCES

1. Natadidjaja RI, Henry T, Adlani H, et al. Antibiotic usage at a private hospital in Central Java: results of implementing the Indonesian Regulation on the Prospective Antimicrobial System (Regulasi Antimikroba Sistem Prospektif Indonesia [RASPRO]). *Int J Infect Control*. 2021;17(1):1–10. DOI: <https://doi.org/10.3396/ijc.v17.20411>
2. World Health Organization. The WHO A Wa Re (Access, Watch, Reserve) antibiotic book [Internet]. Geneva, Switzerland: World Health Organization; 2022. 1–160 p. Available from: <http://apps.who.int/ibookorders>
3. Natadidjaja RI, Ariyani A, Adlani H, et al. A survey on define daily dose of watch- and access-category antibiotics in two Indonesian hospitals following the implementation of digital antimicrobial stewardship tool. *Clin eHealth*. 2024;7(1):6–8p. DOI: <https://doi.org/10.1016/j.ceh.2024.12.004>
4. Artero A, Esparola A, Alberola J, et al. Prospective cohort study of risk factors for extended-spectrum β -lactamase-producing *Escherichia coli* urinary tract infections in elderly patients admitted to hospital. *Int J Clin Pract*. 2017;71(9):1–7. DOI: [10.1111/ijcp.13001](https://doi.org/10.1111/ijcp.13001)
5. Larremendy S, Deglaire V, Dusollier P, et al. Risk factors of extended-spectrum beta-lactamases-producing *Escherichia coli* community acquired urinary tract infections: A systematic review. *Infect Drug Resist*. 2020;13:3945–55. DOI: [10.2147/IDR.S269033](https://doi.org/10.2147/IDR.S269033)
6. Baek YJ, Kim YA, Kim D, et al. Risk factors for extended-spectrum- β -lactamase-producing *Escherichia coli* in community-onset bloodstream infection: Impact on long-term care hospitals in Korea. *Ann Lab Med*. 2021;41(5):455–62. DOI: [10.3343/ALM.2021.41.5.455](https://doi.org/10.3343/ALM.2021.41.5.455)
7. Vance MK, Cretella DA, Ward LM, et al. Risk Factors for Bloodstream Infections Due to ESBL-Producing *Escherichia coli*, *Klebsiella* spp., and *Proteus mirabilis*. *Pharmacy*. 2023;11(2):74. DOI: [10.3390/pharmacy11020074](https://doi.org/10.3390/pharmacy11020074)
8. Çeken S, Iskender G, Gedik H, et al. Risk factors for bloodstream infections due to extended-spectrum β -lactamase producing enterobacteriaceae in cancer patients. *J Infect Dev Ctries*. 2018;12(4):265–72. DOI: [10.3855/jidc.9720](https://doi.org/10.3855/jidc.9720)
9. Caporini N, Bellone P, Aliberti S, et al. Prevalence, risk factors and outcomes of patients coming from the community with sepsis due to multidrug resistant bacteria. *Multidiscip Respir Med*. 2019;14(23):1–11. DOI: <https://doi.org/10.1186/s140248-019-0185-4>

10. Comilla A, Shaw E, Carratala J, et al. Predictive factors for multidrug-resistant gram-negative bacteria among hospitalised patients with complicated urinary tract infections. *Antimicrob Resist Infect Control*. 2018;7(1):1–11. DOI: <https://doi.org/10.1186/s13756-018-0405-6>
11. Falcone M, Russo A, Giannella M, et al. Individualizing risk of multidrug-resistant pathogens in community-onset pneumonia. *PLoS One*. 2015;10(4):1–16. DOI: [10.1371/journal.pone.0119538](https://doi.org/10.1371/journal.pone.0119538)
12. Madrazo M, López-Cruz I, Piles L, et al. Risk Factors and the Impact of Multidrug-Resistant Bacteria on Community-Acquired Urinary Sepsis. *Microorganisms*. 2023;11(5):1–13. DOI: [10.3390/microorganisms11051278](https://doi.org/10.3390/microorganisms11051278)
13. Patola S, Abate C, Patel N, et al. Risk factors and outcomes for multidrug-resistant Gram-negative bacilli bacteremia. *Ther Adv Infect Dis*. 2018;2(1):1–8. DOI: <https://doi.org/10.1177/2049995617727497>
14. Kang JS, Moon C, Mun SJ, et al. Antimicrobial Susceptibility Trends and Risk Factors for Antimicrobial Resistance in *Pseudomonas aeruginosa* Bacteremia: 12-Year Experience in a Tertiary Hospital in Korea. *J Korean Med Sci*. 2021;36(43):1–15. DOI: [10.3346/jkms.2021.36.e273](https://doi.org/10.3346/jkms.2021.36.e273)
15. Prina E, Ranzani OT, Polverino E, et al. Risk factors associated with potentially antibiotic-resistant pathogens in community-acquired pneumonia. *Ann Am Thorac Soc*. 2015;12(2):153–60. DOI: [10.1513/AnnalsATS.201407-305OC](https://doi.org/10.1513/AnnalsATS.201407-305OC)
16. Haque M, Sartelli M, McKinn J, et al. Health care-associated infections-an overview. *Infect Drug Resist*. 2018;11(1):2321–33. DOI: <https://doi.org/10.2147/IDR.S177247>
17. Revelas A. Healthcare-associated infections: A public health problem. *Niger Med J*. 2012;53–64(2):59. DOI: [10.4103/0300-1652.103543](https://doi.org/10.4103/0300-1652.103543)
18. Cardoso T, Almeida M, Friedman ND, et al. Classification of healthcare-associated infection: a systematic review 10 years after the first proposal. *Am J Infect Control*. 2014;42(4):1–13. DOI: [10.1186/1741-7015-12-40](https://doi.org/10.1186/1741-7015-12-40)
19. World Health Organization. Report on the Burden of Endemic Health Care-Associated Infection Worldwide: Clean Care is Safer Care. World Health Organization, Geneva, Switzerland; 2011. Available from: www.who.int
20. Notodidjaja RI, Kusuma AS, Sudradjat GB, et al. The Association between Medical History-based Risks and Sepsis Events in Immunocompromised Patients according to Type III Stratification of the Indonesian Regulation on the Prospective Antimicrobial System (Regulasi Antimikroba Sistem Prospektif / RASPRO). *Bali Med J*. 2021;10(3):1031–6. DOI: [10.15562/bmj.v10i3.2561](https://doi.org/10.15562/bmj.v10i3.2561)
21. Otto SJC, Haworth-Brockman M, Miazga-Rodriguez M, et al. Integrated surveillance of antimicrobial resistance and antimicrobial use: Evaluation of the status in Canada (2014-2019). *Can Vet J*. 2022;63(1):161–70. DOI: [10.1177/095457992110100600-W](https://doi.org/10.1177/095457992110100600-W)
22. Bernani H, Cornelien L, Stärk KDC, et al. Evaluating Integrated Surveillance for Antimicrobial Use and Resistance in England: A Qualitative Study. *Front Vet Sci*. 2021;8(November):1–16. DOI: [10.3389/fvets.2021.743857](https://doi.org/10.3389/fvets.2021.743857)
23. Bassetti D, Bassetti M, Mantero E. Strategies for antibiotic selection in empirical therapy. *Clin Microbiol Infect*. 2000;6(5):98–100. DOI: [10.1111/j.1469-0691.2000.tb02058.x](https://doi.org/10.1111/j.1469-0691.2000.tb02058.x)
24. Trotter NE, Slight SP, Karimi R, et al. The effect of digital antimicrobial stewardship programmes on antimicrobial usage, length of stay, mortality and cost. *Informatics Med Unlocked*. 2023;137(January 2023):101183. DOI: <https://doi.org/10.1016/j.imu.2023.101183>
25. Van Dort BA, Fenin J, Ritchie A, et al. The impact of digital interventions on antimicrobial stewardship in hospitals: A qualitative synthesis of systematic reviews. *J Antimicrob Chemother*. 2022;77(7):1818–37. DOI: <https://doi.org/10.1093/jac/dkac112>



This work is licensed under a Creative Commons Attribution Non-Commercial 4.0 International License

A Quantitative Survey on Antibiotic Prescribing Pattern in Three Indonesian Hospitals Using Digital Antimicrobial Stewardship

ORIGINALITY REPORT

14%

SIMILARITY INDEX

PRIMARY SOURCES

1	Ronald Irwanto Natadidjaja, Aziza Ariyani, Hadiani Adlani, Raymond Adlanto et al. "A survey on define daily dose of watch- and access-category antibiotics in two Indonesian hospitals following the implementation of digital antimicrobial stewardship tool", Clinical eHealth, 2024 <small>Crossref</small>	689 words — 10%
2	repository.karyailmiah.trisakti.ac.id <small>Internet</small>	67 words — 1%
3	www.ijic.info <small>Internet</small>	46 words — 1%
4	Veena Kumari, Ann Devapriya, Mariamma Philip, Muralidharan K, Shashank Devapur Vasant. "The impact of different pre-operative interventional hair- removal behaviours on biophysical characteristics and surgical site infection -a comparative analysis", Antimicrobial Stewardship & Healthcare Epidemiology, 2025 <small>Crossref</small>	37 words — 1%
5	www.researchgate.net <small>Internet</small>	20 words — < 1%
6	www.researchsquare.com <small>Internet</small>	19 words — < 1%
7	openpublichealthjournal.com <small>Internet</small>	18 words — < 1%
8	www.frontiersin.org <small>Internet</small>	16 words — < 1%

- 9 Nicole E. Trotter, Sarah P. Slight, Radin Karimi, David W. Bates, Aziz Sheikh, Christopher Weir, Clare L. Tolley. "The effect of digital antimicrobial stewardship programmes on antimicrobial usage, length of stay, mortality and cost", Informatics in Medicine Unlocked, 2023
[Crossref](#) 12 words — < 1%
- 10 [pdffox.com](#)
[Internet](#) 12 words — < 1%
- 11 Munther S. Alnajjar, Mamoon A. Aldeyab, Michael G. Scott, Mary P. Kearney et al. "Influence of primary care antibiotic prescribing on incidence rates of multidrug-resistant Gram-negative bacteria in hospitalised patients", Infection, 2019
[Crossref](#) 10 words — < 1%
- 12 [turkjpediatr.org](#)
[Internet](#) 9 words — < 1%
- 13 [www.mastek.com](#)
[Internet](#) 9 words — < 1%
- 14 Alex Riolexus Ario, Benjamin Djoudalbaye, Saheedat Olatinwo, Abbas Omaar, Romina Stelter, Ludy Suryantoro. "National Interagency collaboration for public health", Elsevier BV, 2024
[Crossref](#) 8 words — < 1%
- 15 Candice Torres de Melo Bezerra Cavalcante, Andrea Consuelo de Oliveira Teles, Isabel Cristina Leite Maia, Valdeste Cavalcante Pinto et al. "Extracorporeal membrane oxygenation support in children with severe coronavirus disease-2019: A case series", The Lancet Regional Health - Americas, 2022
[Crossref](#) 8 words — < 1%
- 16 Luyan Dong, Yingbin Huang, Shengcen Zhang, Binbin Xu, Bin Li, Yingping Cao. "Risk Factors for Development and Mortality of Carbapenem-Resistant Pseudomonas aeruginosa Bloodstream Infection in a Chinese Teaching Hospital: A Seven-Year Retrospective Study", Infection and Drug Resistance, 2025
[Crossref](#) 8 words — < 1%

EXCLUDE QUOTES	ON
EXCLUDE BIBLIOGRAPHY	ON

EXCLUDE SOURCES	OFF
EXCLUDE MATCHES	OFF