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A nationwide mixed-methods study of gaps and barriers to implementation of antimicrobial stewardship programmes in hospitals in Indonesia

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SUMMARY

Background: There is an urgent need to understand the implementation barriers of antimicrobial stewardship programmes (ASPs) in low- and middle-income countries.
Methods: We conducted a mixed-methods study in public and private hospitals across all provinces in Indonesia (March—December 2023). We used a self-assessment questionnaire with a scoring system, and multi-level ordinal regression to assess associations with hospital and district-level characteristics. Focus group discussions (FGDs) with hospital stakeholders examined barriers and enablers. We applied a patient safety framework to integrate results.
Results: A total of 575 (19%) of 3026 hospitals completed the self-assessment, of whom 516 (89.7%) had a formal ASP (median 4 (interquartile range (IQR) 1—5] years), and 14 participated in FGD. The median overall ASP development score was 48.4% (35.9—62.5%), classifying 41 (8.0%) hospitals as inadequate (0—25%), 237 (45.9%) as basic (26—50%), 179 (34.7%) as intermediate (51—75%) and 59 (11.4%) as advanced (76—100%). Scores were highest for hospital leadership support (83.4% (IQR 66.7—100%)), followed by ASP team and infectious disease training (66.7% (IQR 55.6—77.8%)); education (50% (IQR 0.0—75.0%)); ASP interventions (43.8% (IQR 18.7—68.7%)); hospital infrastructure (42.9% (IQR 14.3—71.4%)); and monitoring, reporting and feedback (40.9% (IQR 27.3—54.5%)). A higher ASP development score was associated with higher hospital tiered level, longer ASP duration, and higher district-level Public Health Development Index and per capita domestic

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expenditure, but not with hospital ownership or geographic region. FGDs highlighted barriers related to hospital leadership support, staff technical and behavioural skills, cross-disciplinary collaboration, fear of loss of prescriber autonomy, microbiology and IT support, and hospital accreditation.

Conclusions: Identified implementation barriers can inform actions for context-specific, sustainable improvement of ASPs.

Introduction

Southeast Asia is a region of great importance in the development and spread of antimicrobial-resistant bacteria [1,2] due to the widespread and unregulated use of antimicrobial agents, poor infection prevention and control (IPC), amongst other factors [1,2]. Implementation of antimicrobial stewardship programmes (ASPs) in hospitals is an essential component of antimicrobial resistance (AMR) prevention and control efforts, although most available evidence comes from high-income countries [3—5]. To achieve effective ASP implementation, especially in low- and middle-income countries (LMICs), there is an urgent need to better understand the key organizational, sociocultural and behavioural challenges [6]. A comprehensive outlook that considers both the people working within the system, the wider socio-technical influences on their environment, and the tools and tasks required to deliver high-quality care [7] is required to unravel the multiple and interconnected layers and domains that contribute to the barriers to successful implementation of ASP [8].

Indonesia is a populous (275 million) middle-income country, with widely varying socio-economic and health indicators, and a decentralized public healthcare system, alongside a substantial private health sector [9]. Antimicrobial consumption is high and poorly regulated, and an estimated 34,530—133,753 people died as a result of bacterial AMR in 2019 [10,11]. As part of its National Action Plan for AMR, the Ministry of Health (MOH) launched a standard that included having an ASP as a requirement for hospital accreditation (e.g., antimicrobial prescribing guidelines, hospital antibiogram, and conducting periodic antibiotic audits) in 2018 [12], guidelines for hospital ASP implementation (e.g., for structure, tasks and evaluation procedures) in 2021 [13], and a national practice guideline on antibiotic prescribing for common infections in 2021 [14].

The aim of this nationwide mixed-methods study was to evaluate the current structures, activities and challenges of ASPs in Indonesian public and private hospitals, in order to identify gaps, barriers and potential solution strategies to ASP implementation.

Methods

Study design

This nationwide mixed-methods study comprised an ASP self-assessment in each participant hospital to score their current ASP development level (March—July 2023), followed by focus group discussions (FGDs) with ASP stakeholders in selected hospitals (August—December 2023) to identify barriers and enablers of ASP implementation. Our analysis also incorporated impacts of the COVID-19 pandemic on ASP implementation. To integrate the quantitative and qualitative findings, and formulate future recommended actions, we applied the Systems Engineering Initiative for Patient Safety (SEIPS) [7], a human-centred, systems approach to address complex problems, which considers the people working within the system, the wider socio-technical influences on their environment, and the tools and tasks required to deliver high-quality care.

The study was approved by the Faculty of Medicine Universitas Indonesia Ethics Committee and Oxford Tropical Research Ethics Committee. FGD participants provided written consent. The study was endorsed by the MOH, and all hospital directors gave their written permission. This study is reported as per the Strengthening the Reporting of Observational Studies in Epidemiology guideline (Supplementary Table S1).

Self-assessment survey procedures

Eligible hospitals were all 3026 (1092 public and 1934 private) MOH-registered hospitals in all 34 provinces (as per September 2022). The MOH designates hospital tiered levels as type A ($\geq$251 beds, $\geq$6 specialists), B (201—250 beds, $\geq$3 specialists), C (101—200 beds, $\geq$2 specialists), or D (51—100 beds, $\geq$1 specialist) [15]. We excluded hospitals that were not in operation, not able or willing to participate, and/or uncontactable. We used a systematic sampling approach, adopted from the ECDC point prevalence survey protocol [16], with substitution of non-respondent hospitals, to achieve a representative sample of ASPs for each province (total target sample size $N = 562$) (Supplementary Table S2).

The self-assessment questionnaire was developed by multidisciplinary experts (infectious disease specialists, clinical microbiologist, epidemiologist, health system researcher) based on existing questionnaires, and covered six ASP domains (i.e., hospital leadership support; ASP team and infectious disease training; hospital infrastructure; ASP interventions; ASP monitoring and reporting, and education) [13,17—19] (64 yes/no items) plus COVID-19 impacts [20,21] (45 yes/no or Likert-scale items) (Supplementary Table S3). The final 109-item questionnaire was piloted in 10 hospitals to improve clarity and flow, and took about 60 min to complete.

The self-assessment questionnaire was electronically delivered to each hospital with an invitation letter from the MOH, and completed by the ASP team. The research team held three online training sessions with detailed explanations about each item, prior to completing the self-assessment. For data

quality control, the research team checked data reliability by repeating the data collection for the core items of the self-assessment through telephone interviews with the ASP team lead or delegate for a 10% random sample of the participant hospitals (agreement between responses expressed as Cohen's kappa) (Supplementary Table S4). We collected district-level human development and health-system capacity indicators from relevant government sources (Supplementary Table S5).

Focus group discussions

For the FGDs, we developed an interview guide based on the ASP domains [13,17—19] and our previous study findings [6]. To obtain different perspectives, we purposively selected a varied sample of 14 hospitals based on ownership (public or private), tiered level (A—D), and geographical region. The FGDs were conducted by videoconference, and each included six to seven people (i.e., ASP leader, clinician, pharmacist, microbiology staff, IPC staff, and hospital manager). The FGDs were conducted iteratively, with follow-up questions in line with participant responses. The FGDs were conducted in Indonesian, audio-recorded, verbatim-transcribed, and then translated to English. The FGDs lasted between 50 and 110 min (average 80 min).

Data analysis

Hospital anonymity was maintained during analysis and reporting. Self-assessment results were analysed using descriptive and regression statistics. The percentage of participant hospitals selecting each answer choice was calculated using the total number of responding hospitals as the denominator. We calculated the ASP self-assessment scores as a proportion of the number of items for each domain and overall. ASP development was based on the total scores classified as inadequate (0—25%); basic (26—50%); intermediate (51—75%); or advanced (76—100%). We used multi-level ordinal regression, with province as a random-effect variable to adjust for clustering of observations within provinces, to estimate associations between total ASP scores (overall and per domain) and independent variables at the hospital and district level. District-level data were categorized into quartiles (i.e., lowest, low-middle, middle-high, and highest). Each independent variable with a $P<0.20$ in the univariable model was forwarded to the multi-variable model. Final model selection was informed by likelihood ratio test. Data were analysed with Stata v15.1 (StataCorp, TX, USA) and visualized with GraphPad Prism v8.3.0 (La Jolla, CA, USA). Three researchers (R.S., R.L. and S.P.R.) performed thematic analysis of the FGD data [22] using inductive and deductive approaches [21].

Results

Participant characteristics

A total of 575 (19.0%) of the 3026 hospitals completed the self-assessment (Supplementary Figure S1), with the highest response rate in type A hospitals, accredited hospitals, the public sector, and the geographic regions of Bali, Kalimantan and Java (Figure 1, Supplementary Tables S6—8); 323 (56.2%) participant hospitals were situated in Java island, where 50% of all hospitals are located. Self-assessment data were found to be reliable (Cohen's kappa 0.91 overall and ≥0.83 for each item, indicating near-perfect agreement) (Supplementary Table S4). Table I summarizes hospital characteristics. Five-hundred and sixteen (89.7%) of 575 hospitals had a formal ASP, with a median duration of four (interquartile range (IQR) 1—5) years, which were included in further analysis (Supplementary Figure S1). The following main themes emerged from the FGDs (Table I, Supplementary Table S9): health system and external environment; hospital leadership; ASP team and roles; hospital infrastructure; organization and culture; and COVID-19 pandemic (Supplementary Table S10).

ASP self-assessment scores

Across all 516 participant hospitals with an ASP, the total percentage score for overall ASP development was median 48.4% (IQR 35.9—62.5%) (31 (IQR 23—40) of 64 points) (Supplementary Table S11, Supplementary Figure S2), classifying 41 (8.0%) as inadequate, 237 (45.9%) as basic, 179 (34.7%) as intermediate and 59 (11.4%) as advanced. In multi-variable analysis, higher overall ASP development scores were associated with hospital level (A or B, versus D), ASP duration (>5 versus ≤2 years), district-level Public Health Development Index (highest, upper-middle or lower-middle, versus lowest quartile), and district-level per-capita domestic expenditure (highest or upper-middle, versus lowest quartile), but not with hospital ownership or geographic region (Figure 2, Supplementary Tables S12—14, Supplementary Figure S3). ASP domain-specific percentage scores were highest for hospital leadership support (83.4% (66.7—100%)), followed by ASP team and infectious disease training (66.7% (55.6—77.8%)); education (50% (0.0—75.0%)); ASP interventions (43.8% (18.7—68.7%)); hospital infrastructure (42.9% (14.3—71.4%)); and monitoring, reporting and feedback (40.9% (27.3—54.5%)) (Figure 3, Supplementary Table S11).

Hospital leadership support

Formal hospital leadership support through a written document and dedicated funding for antimicrobial stewardship (AS) activities (e.g., ASP-related training) were in place in 97.7% (504/516) and 83.1% (429/516) of hospitals, respectively. In multi-variable analysis, higher leadership support scores were associated with private hospitals (versus public), ASP duration, and district-level per-capita domestic expenditure, but not with hospital level or geographic region. Hospital leadership promoted ASP development by allocating budget, establishing key performance indicators, and addressing friction between prescribers and the ASP team.

ASP team and infectious disease training

AS activities were led by a physician in 94.4% (487/516) of hospitals, and involved a pharmacist, IPC staff and clinical microbiologist/pathologist in 97.9% (505/516), 89.5% (462/516) and 36.1% (186/516) of hospitals, respectively. In multi-variable analysis, higher ASP team and infectious disease training scores were associated with hospital level and ASP duration, but not with hospital ownership.

Collaboration between the ASP team and pre-existing IPC programme and/or the pharmacy and therapeutics committee was perceived as promoting ASP implementation. High staff

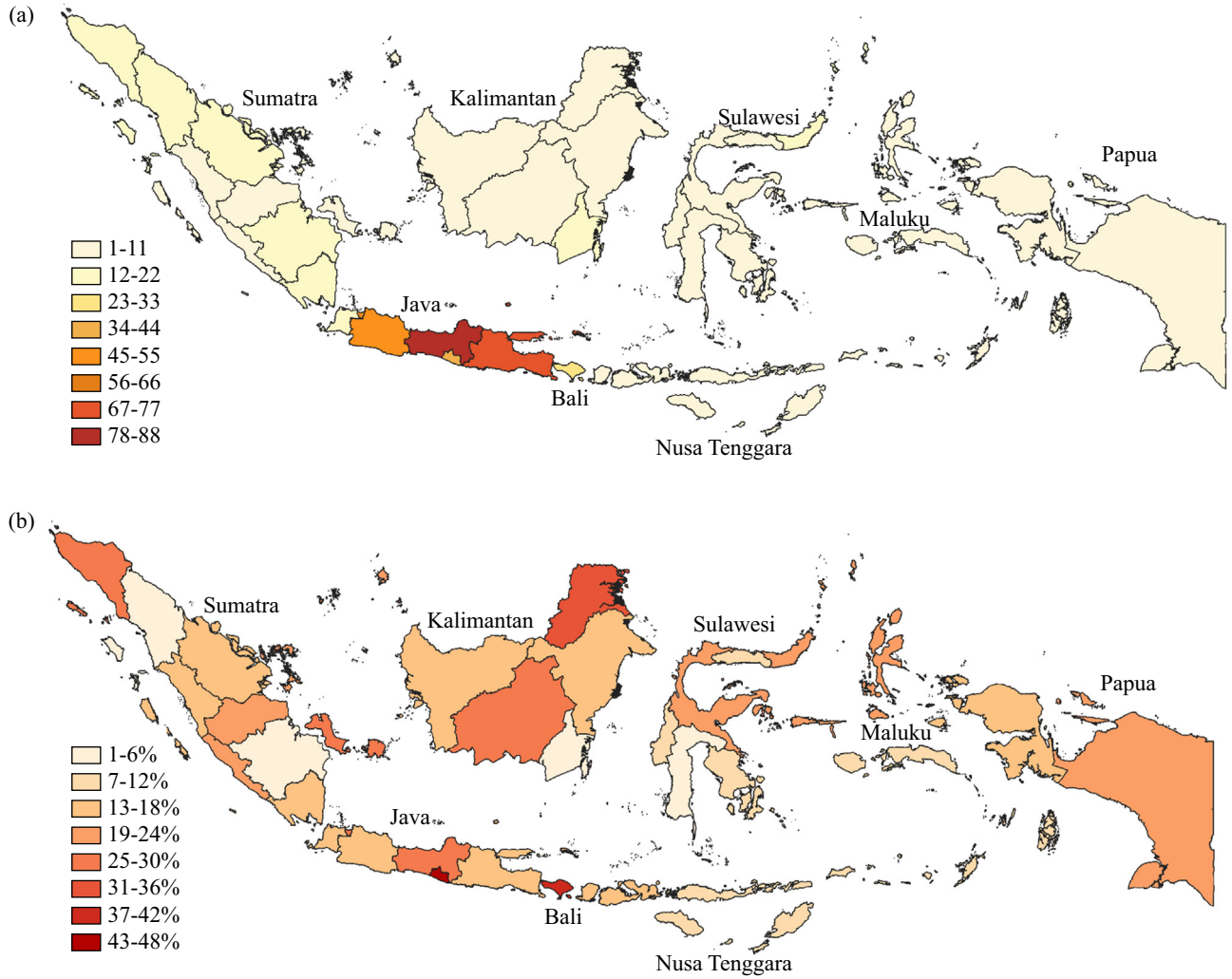

Figure 1. Geographical map of Indonesia showing the geographical distribution of all hospitals that participated in the antimicrobial stewardship programme self-assessment across all 34 provinces. (a) Number of participant hospitals per province. (b) Participant hospitals as a percentage of the total number of hospitals per province.

turnover across ASP roles was perceived as a barrier to ASP sustainability. AS activities incurred substantial additional workload, without financial incentives, which limited the dedicated time available.

> *'All of us have a main job, but here [ASP], we do a double job, even a triple job. We don't even have one staff assigned to work for the ASP. It is the same story for our ward nurses who collect ASP data.'* (FGD5, ASP leader/clinician)

Hospitals in remote locations encountered additional challenges related to the part-time or intermittent availability of crucial ASP team members, such as a clinical microbiologist/pathologist.

Hospital infrastructure

Overall, 45.5% (240/516) of hospitals had access to a microbiology service, ranging from 80.6% (29/36) of type A to 21.1% (20/95) of type D hospitals. In multi-variable analysis, higher hospital infrastructure scores were associated with hospital level, accreditation and district-level life expectancy, but not with hospital ownership.

Some hospitals with on-site microbiology reported long turn-around times of culture results.

> *'We have access to culture testing. However, it still takes six to seven days before the results are released.'* (FGD1, clinician/IPC staff)

Hospitals in remote settings in eastern Indonesia, specifically Maluku, East Nusa Tenggara and Papua, reported limited access to microbiology, including slow and costly specimen referral to a main island, such as Java or Sulawesi.

> *'From this hospital, you must take a speedboat for approximately 40 minutes, then travel overland for approximately 4 hours to reach the city.'* (FGD2, IPC staff/clinical pathologist)

Many hospitals reported a lack of IT support (59.5%, 209/516) to collect and analyse AS-relevant data. Hospital information systems could offer opportunities for ASP including electronic prescribing, automatic stop orders and tracking of antibiotic use for surveillance.

Table I
Characteristics of participant hospitals

Characteristic	All hospitals nationwide ($N = 3026$)	Participant hospitals in self-assessment ($N = 575$)	Participant hospitals in self-assessment with ASP ($N = 516$)	Participant hospitals in FGD [e] ($N = 14$)
Hospital level [a]				
A	65 (2.2%)	36 (6.3%)	36 (7%)	1 (7.1%)
B	442 (14.6%)	123 (21.4%)	123 (23.8%)	4 (28.6%)
C	1608 (53.1%)	299 (52%)	262 (50.8%)	5 (35.7%)
D	911 (30.1%)	117 (20.4%)	95 (18.4%)	4 (28.6%)
Hospital size [b]				
<101	1555 (51.4%)	230 (40%)	192 (37.2%)	4 (28.6%)
101–250	1171 (38.7%)	260 (45.2%)	239 (46.3%)	6 (42.8%)
>250	300 (9.9%)	85 (14.8%)	85 (16.5%)	4 (28.6%)
Hospital ownership				
Private	1934 (63.9%)	332 (57.7%)	299 (57.9%)	7 (50.0%)
Public	1092 (36.1%)	243 (42.3%)	217 (42.1%)	7 (50.0%)
Hospital accreditation [c]				
Accredited	1147 (37.9%)	301 (52.3%)	285 (55.2%)	11 (78.6%)
Not accredited	1879 (62.1%)	274 (47.7%)	231 (44.8%)	3 (21.4%)
National health insurance service provider [d]				
Yes	2613 (86.3%)	523 (91.0%)	473 (91.7%)	11 (78.6%)
No	413 (13.7%)	52 (9.0%)	43 (8.3%)	3 (21.4%)
Geographic region				
Java	1523 (50.3%)	323 (56.2%)	305 (59.1%)	2 (14.3%)
Sumatra	725 (24%)	110 (19.1%)	91 (17.6%)	2 (14.3%)
Sulawesi	277 (9.2%)	33 (5.7%)	27 (5.2%)	1 (7.1%)
Kalimantan	208 (6.9%)	46 (8%)	38 (7.4%)	1 (7.1%)
Nusa Tenggara	98 (3.24%)	13 (2.3%)	13 (2.5%)	3 (21.4%)
Bali	74 (2.5%)	30 (5.2%)	28 (5.4%)	2 (14.3%)
Papua	69 (9.2%)	13 (2.3%)	9 (1.7%)	1 (7.1%)
Maluku	52 (1.7%)	7 (1.2%)	5 (1.0%)	2 (14.3%)

ASP, antimicrobial stewardship programme; FGD, focus group discussion.
[a] Ministry of Health defines hospital tiered levels based on number of inpatients beds and specialists as type A (≥251 beds and ≥6 specialists), B (201–250 beds and ≥3 specialists), C (101–200 beds and ≥2 specialists), or D (51–100 beds and ≥1 specialist).
[b] Hospital size was based on number of inpatient beds at the time of the self-assessment.
[c] By the Indonesian Hospital Accreditation Commission (Komisi Akreditasi Rumah Sakit) at time of the self-assessment.
[d] Hospital providing patient services under the national health insurance (*Jaminan Kesehatan Nasional*).
[e] Further details of the hospital and individual participants selected for FDGs are provided in Supplementary Table S6.

ASP interventions

Pre-authorization of Watch and Reserve antimicrobials, prospective review and feedback before antimicrobial administration, and regular AS ward rounds were carried out in 42.8% (221/516), 36.6% (189/516) and 40.1% (207/516) of hospitals, respectively. Hospital-specific treatment guidelines for common infections were available in 62.6% (323/516) of hospitals. In multi-variable analysis, higher ASP intervention scores were associated with hospital level, but not with hospital ownership or geographic region.

FGD participants reported that antibiotic pre-authorization was effective in reducing irrational antibiotic prescribing and improving guideline adherence, provided that the ASP team actively engaged all stakeholders in addressing friction with prescribers. FGD participants from both public and private hospitals agreed that effective AS strategies could reduce expenses. The FGDs revealed that hierarchical relationships and the fear of loss of prescribers' autonomy, especially in private hospitals, continue to hinder multidisciplinary work.

> *'In private hospitals, specialists have the highest authority, especially those who 'supply' the hospitals with patients. They are like kings.'* (FGD2, ASP leader/clinician)

Monitoring, reporting and feedback

Antibiotic consumption was monitored in 47.7% (246/516; Defined Daily Dose) and 35.9% (185/516; Duration of Treatment) of hospitals. Surveys or audits of antibiotic prescribing had been performed in 36.8% (190/516) of hospitals; 81.6% (155/190) of those communicated survey results directly to prescribers with specific action points. Availability of an institutional antibiogram was reported by 40.9% (211/516) of hospitals. In multi-variable analysis, higher monitoring, reporting, and feedback scores were associated with hospital level, ASP duration, district-level Public Health Development Index,

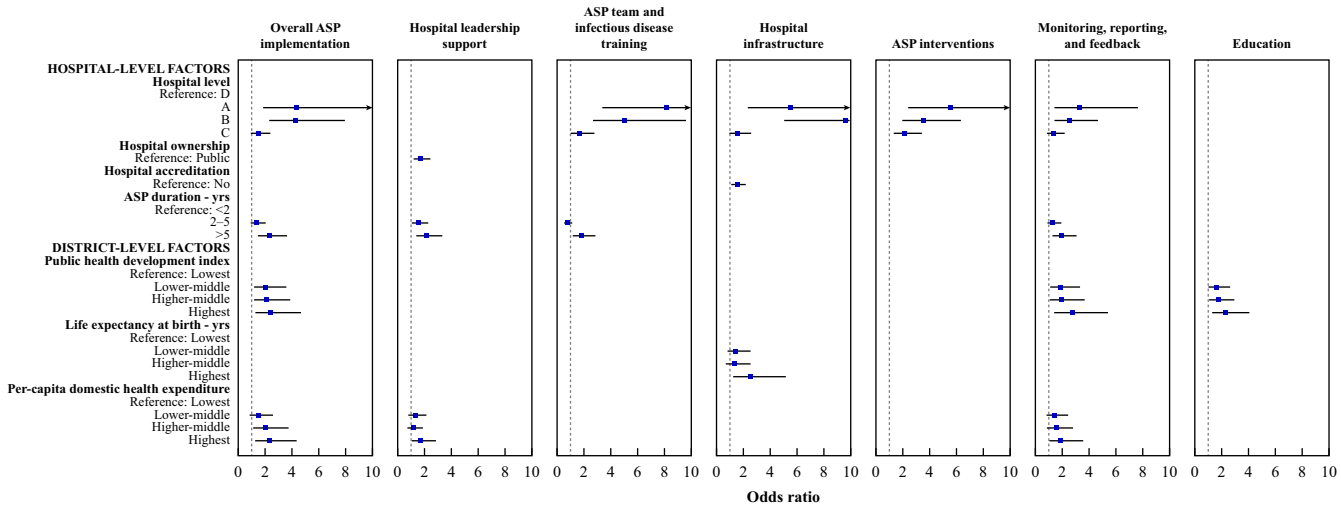

Figure 2. Summary of hospital and district-level factors associated with antimicrobial stewardship programme (ASP) self-assessment scores. Figure shows the independent variables at the hospital and district level that were found to be significantly associated with total ASP scores (overall and per domain) in the multi-variable ordinal regression models. Province was included as a random-effect variable to adjust for clustering of observations within provinces. District-level data were categorized into quartiles (i.e., lowest, low-middle, middle-high, and highest). See Supplementary Table S10 for further details on the regression models. * Per 100,000 population.

district-level per-capita domestic expenditure, but not with hospital ownership. In some hospitals, mandatory monthly reporting of antibiotic use quality indicators to the MOH was only partially done or not at all, due to the additional workload.

Education

AS-related education/training for clinical staff had been provided in 61.6% (318/516) of hospitals. In multi-variable analysis, higher education scores were associated with district-level public health development index, but not with hospital level, ownership or geographic region. Hospital management generally supported AS-related trainings. Participants highlighted specific knowledge needs, including how to use AS metrics to achieve behaviour change.

External environment

Implementation of national ASP guidelines and antibiotic prescribing guidelines from professional societies were mentioned as important enablers. Participants agreed that including ASP in the national hospital accreditation standard, could be the most important factor to advance ASP implementation.

'The reason behind the ASP initiation in 2018 was because our hospital was undergoing hospital accreditation. One of the

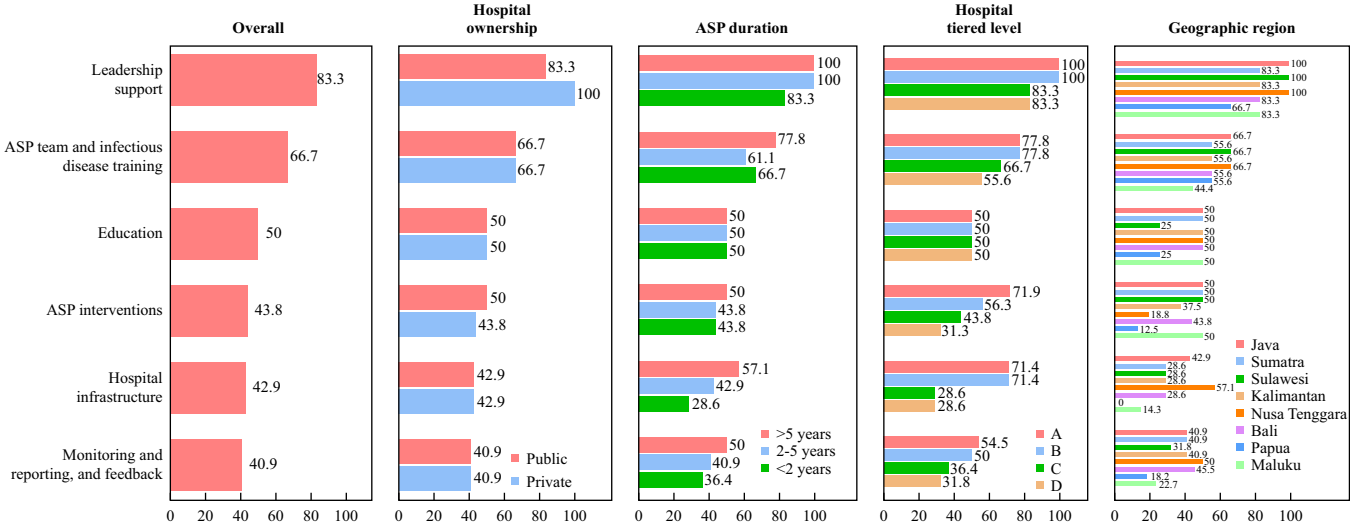

Figure 3. Antimicrobial stewardship programme (ASP) implementation scores across all participant hospitals. The aggregated scores of the Antimicrobial stewardship programme (ASP) implementation self-assessment survey are shown for all 516 participant hospitals with a formal ASP, expressed as median percentage overall score and domain-specific scores.

requirements was that we must establish an ASP.' (FGD8, ASP leader/clinician)

However, due to a simplification of the national hospital accreditation standard by the MOH in 2022, ASP is no longer compulsory to achieve accreditation, which resulted in reduced prioritization and motivation to implement ASP.

COVID-19 impacts

During COVID-19, many AS activities were limited or on hold due to re-allocation of human and financial resources. There was reduced availability of pharmacists, infectious disease physicians and IPC staff for AS activities. Antibiotic consumption increased overall, backed up by COVID-19 treatment guidelines. In contrast, improvements during COVID-19 included increased bacterial culture use; updated treatment guidelines for common infections; enhanced analysis and reporting of antibiotic consumption data; and improved IPC practices, especially the use of alcohol-based hand rub, personal protective equipment and hand hygiene (Supplementary Figure S4, Supplementary Table S15).

Table II integrates all the identified barriers and enablers of ASP implementation in a framework.

Table II
Summary of barriers to and enablers of antimicrobial stewardship programmes (ASPs) in Indonesian hospitals

	Barriers	Enablers
Organization	Lack of formal hospital leadership support, limited understanding by hospital leaders of relevance of ASPs	Written formal leadership support
	Lack of designated ASP leader	Designated ASP leader
	Lack of dedicated budget for AS activities and staff	Dedicated budget for AS activities and staff
	Lack of dedicated time for ASPs	Key performance indicators for ASPs
	Type of hospital, especially in level C and D hospitals and remote settings	Hospital leaders engage in ASP (e.g., support discussion around antibiotic practice changes, and addresses friction with prescribers)
	Hierarchical relationships	Potential for cost savings from effective AS strategies
	Frequent staff turnover	ASP development included in national standard for hospital accreditation
	Excessive workload	
	Lack of staff compensation/incentive model	
	Restriction in national formulary and reimbursement as part of national health insurance	
Individuals	Hierarchical relationships	Physician as designated ASP leader
	Irrational antibiotic prescribing practices, including non-adherence to antibiotic guidelines	Multi-disciplinary work routines
	Fear of loss of prescribers' autonomy, especially in private hospitals	ASP team engage all relevant stakeholders in addressing friction with prescribers
	Limited awareness of local AMR data	ASP team engage in communicating antibiotic use survey/audit results to prescribers with specific action points
	Limited adoption of AS principles	
	Limited knowledge of AS metrics and how to use these to change behaviour	
Tasks	Excessive workload	Build ASP with IPC programme and/or pharmacy and therapeutics committee
	Inability to monitor antibiotic use data on a regular basis	Daily ward rounds by infectious disease consultant, microbiologist and/or pharmacist
	Part-time or intermittent availability of key ASP team members	
	Microbiology laboratory has long turn-around-times of bacterial culture results	
	Complex sample logistics for bacterial cultures in remote settings	

(*continued on next page*)

Table II (*continued*)

	Barriers	Enablers
	Limited training in quality improvement implementation	
	Inefficient processes for approval of bacterial cultures and restricted antimicrobials	
Tools and information technology	Lack of reliable and timely microbiological laboratory services, especially in level C and D hospitals and in remote settings	Electronic prescriptions and automatic stop orders
	Lack of IT support to collect and analyse ASP-relevant data	Electronic medical record to allow efficient tracking of antimicrobial resistance/antibiotic use data
	Limited opportunities for AS training	Microbiology results integrated in electronic medical record
	Lack of hospital treatment guidelines for common infections	Training in quality improvement, patient safety and how to change behaviour
External environment	Limited guidance from public authorities on initiatives to improve antibiotic use, ASP implementation, etc.	COVID-19 pandemic (e.g., improved IPC)
	Lack of feedback from MOH on annual hospital reports on antibiotic use and resistance	Reporting antibiotic use and consumption data to public authorities
	COVID-19 pandemic (e.g., re-allocation of staff and resources)	Implementation of national ASP guidelines
	Low district-level public health development index	Implementation of antibiotic prescribing guidelines from professional societies
	Low district-level per-capita domestic health expenditure	Include ASP in national standard for hospital accreditation
	Restriction in national formulary and reimbursement as part of national health insurance	

Integration of barriers and enablers of antimicrobial stewardship programme identified from the quantitative and qualitative study data using the Systems Engineering Initiative for Patient Safety Framework (13). AMR, antimicrobial resistance; AS, antimicrobial stewardship; ASP, antimicrobial stewardship programme; IPC, infection prevention and control; IT, information technology; MOH, Ministry of Health.

Based on our integrated study findings, Box 1 summarizes recommended future actions to implement effective and sustainable ASPs in Indonesia.

Discussion

This is the first comprehensive nationwide evaluation of the current ASP structures, activities, and key barriers and enablers of ASP implementation in Indonesian hospitals. Notably, 9 out of 10 Indonesian hospitals had already initiated an ASP; however, to date about half of those had only reached an inadequate or basic level of implementation. Overall, the ASP self-assessment identified substantial gaps regarding education, ASP interventions, hospital infrastructure, and monitoring, reporting and feedback, whereas the levels of hospital leadership support and ASP team and infectious disease training scored reasonably highly.

ASP development was most advanced in hospitals that had operated their ASP for a longer time and, overall, was similar between government and private hospitals. Specifically, the identified gaps in hospital infrastructure and ASP interventions were most pronounced in the lower tier hospitals (types C and D), whereas monitoring, reporting and feedback was least developed in the lower-tier hospitals and in recently established ASPs. Districts that were in the lowest quartile regarding their Public Health Development Index and/or per capita health expenditure featured the least-developed ASP programs overall, specifically regarding monitoring, reporting and feedback, and education.

The findings expand on ASP implementation challenges identified in our previous qualitative study among hospital and national stakeholders in Jakarta, which highlighted a lack of support from hospital management, limited national health insurance cover for bacterial cultures, limited functionality of enabling infrastructures, such as microbiology laboratories and surgical facilities, profit generation and interprofessional dynamics as key barriers [6].

Hospital accreditation by the Indonesian Commission on Hospital Accreditation, was cited as one of the most fundamental enablers for ASP development [12]. Due to changing government priorities, however, since 2022, ASP implementation is no longer compulsory for hospitals to acquire national accreditation [23], which has led to deprioritization and demotivation among hospital managers and ASP teams. There is a need for more robust national and sub-national regulations to help prioritize ASPs, set minimum requirements, and develop rigorous structures to evaluate progress on reaching improvement targets (e.g., quality of prescribing, incident AMR infections) [13]. This also requires better reimbursement models to incentivize ASP development in Indonesia, and other LMICs [24].

Box 1
Summary of recommended future actions for implementing effective and sustainable antimicrobial stewardship programmes (ASPs) in Indonesian hospitals

Organization and hospital support
- Improve engagement of hospital leadership and clinical leaders in antimicrobial stewardship (AS) activities
- Set ASP as a hospital priority, with relevant key performance indicators and financial support
- Ensure minimum staffing requirements, ensure ASP members have dedicated time and incentives to operate an ASP

Individuals, tasks and culture
- Identify key areas for improving antimicrobial use locally
- Develop and disseminate hospital-specific treatment guidelines for common infections
- Improve processes for tracking and monitoring antimicrobial use and resistance data
- Improve access to AS-related training, including quality improvement and behaviour change, for pharmacists, physicians and nurses
- Engage frontline healthcare workers in AS activities (e.g., provide feedback on inappropriate use, share AS-related data) and create a learning healthcare system
- Promote multi-disciplinary teamwork between ASP team, prescribers, infection prevention and control programme and Pharmacy and Therapeutics committee

Tools and technology
- Build functional laboratory infrastructure and local sample referral systems to enable reliable and timely microbiology services, also covering lower tier (type C and D) hospitals as well as remote settings
- Improve information technology to support AS activities (e.g., for antibiotic use tracking, identifying patients that need improved antibiotic use)
- Leverage the government-initiated national electronic medical record to facilitate electronic prescribing, automatic stop order, antimicrobial pre-authorization, and integration of microbiology lab results.

External environment
- Include ASP development in the national standard for hospital accreditation.
- Provide implementation resources for ASPs (e.g., guidance on ASP implementation strategies, educational resources about inappropriate antibiotic use)
- Develop mechanisms for local and national level reporting of antimicrobial use/resistance data and measurable outcomes.

Strong hospital leadership support was identified as critical, not only for allocating resources for ASP structures and activities, but also for establishing key performance indicators, enforcing compliance with hospital-specific clinical practice guidelines, as well as addressing friction between ASP team members and prescribers. This aligns with findings in various settings, that identified the presence of an accountable and supportive governance structure as an important enabler [25—27].

The findings further highlighted that cultural determinants remain an important obstacle to the multi-disciplinary approaches needed to improve rational antibiotic use, and the need to address counter-productive hierarchical relationships among healthcare workers (e.g., prescribers versus ASP clinician, pharmacist, nurse) and developing cohesive work routines across disciplines with shared responsibilities. There is an urgent need for culture-resonant strategies to strengthen both technical (e.g., consequences of antibiotic over-use, best treatment practices) and AS-related behavioural skills (e.g., effective communication, teamwork and quality improvement), which are a prerequisite for any ASP [28,29]. Educational initiatives, mostly in high-income settings, that incorporated both technical and behavioural aspects using patient safety as a framework, have been successful in improving antibiotic prescribing [28—30]. Furthermore, excessive workload and lack of appropriate financial compensation posed additional barriers, which echoes earlier reports related to IPC programme implementation [31].

Robust microbiology services, a basic pillar for diagnostic stewardship [32], are underdeveloped in Indonesia; a survey in 2022 found that only 11% of hospitals had an in-house microbiology laboratory [33]. Consequently, blood culture utilization has been very low in Indonesia [34,35]. The gaps in microbiology were most evident in the lower-tier (types C and D) hospitals (comprising 83% of all hospitals), particularly in remote and underdeveloped islands. The MOH, with support from international donors, are making investments to further strengthen the microbiological laboratory capacity [33]. Furthermore, in 2024, the MOH will launch a national electronic medical record to be rolled out to all registered health facilities [36] which will create important opportunities for enhanced AS activities such as electronic prescribing and ASP-related data aggregation and reporting. Whereas the COVID-19 pandemic has exposed structural vulnerabilities in national health systems in Indonesia and other LMICs [37], its positive impacts, such as improved bacterial culture [38] and IPC practices, have also contributed to strengthening ASP structures [39,40].

Several of the barriers highlighted above can be feasibly addressed in the short term (e.g., education, hospital leadership engagement, and making a business case for ASP), whereas additional barriers will require longer-term efforts and investments (e.g., improving microbiology and IT resources, staff compensation, cross-disciplinary collaborations, and ASP re-inclusion in hospital accreditation).

Our study has some limitations. First, we have made deliberate efforts to achieve a hospital study sample that was

representative of the distribution of hospital types across the major islands and all provinces in terms of ownership, tiered level and size. The geographical representation of hospitals across the major islands was fairly balanced (based on total number of hospitals and study participation rates). None the less, substantial non-participation could have introduced selection bias, and hospital participation was higher for some regions and the upper-level hospitals, with potential of over-representation of hospitals with more resources (e.g., microbiology laboratory) and more advanced ASP development. Second, the ASP self-assessment relied on self-reporting, which has potential for social desirability and recall bias, although the high data reliability observed during the quality control process suggested that this effect may have been limited. Third, the qualitative data collected through the FGDs have potential for subjectivity as they relied on the perceptions and experience from both the researchers and participants. Lastly, the study design was unable to robustly assess AS outcome indicators, such as prevalence of rational antibiotic use and antibiotic resistance.

In conclusion, this comprehensive nationwide evaluation found that most public and private hospitals in Indonesia have to date only reached an inadequate or basic level of ASP implementation. We identified several globally relevant as well as context-specific gaps and barriers that hinder robust and sustainable ASP implementation, and we formulated specific recommendations for immediate and longer-term action.

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Author contributions

R.S. was the principal investigator. R.S., R.L., A.K. and R.L.H. conceptualized the study. R.S. and R.L.H. obtained the funding. R.S., R.L., B.A.M. and R.L.H. developed the questionnaire. R.S., S.P.R., M.N.H. and B.A.M. collected the survey data. R.S., R.L., S.P.R., M.N.H. and B.A.M. verified the data. R.S. and S.P.R. performed the statistical analysis and data visualizations, with critical input from H.S. and R.L.H. The focus group discussions and the qualitative data analysis were conducted by R.S., R.L., S.P.R. R.S. drafted the manuscript, with critical input from R.L., S.P.R., A.K. and R.L.H. R.S., R.L. and R.L.H. had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. All authors critically revised the manuscript for important intellectual content and all authors gave final approval for this version to be published.

Conflict of interest statement

The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2024.10.001.

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