Vol. 11, No. 2, 2026, pp. 980-997
DOI: https://doi.org/10.29210/027157jpgi0005

Contents lists available at Journal IICET

JPGI (Jurnal Penelitian Guru Indonesia)
ISSN: 2541-3163(Print) ISSN: 2541-3317 (Electronic)

Journal homepage: https://jurnal.iicet.org/index.php/jpgi

Model for preventing antibiotic resistance in MDRO nosocomial infections: integrating clinical pharmacy education and islamic medical ethics

Luthfiah Mawar[*)1], M. Agung Rahmadi[2], Agustina Bangun[1], Helsa Nasution[2], Suranta Bill Fatric Ginting[1]
[1]Sekolah Tinggi Ilmu Kesehatan Sehati, Medan, Indonesia
[2]Universitas Al Washliyah, Medan, Indonesia

Article Info

Article history:

Received Jun 15th, 2026
Revised Jul 20th, 2026
Accepted Jul 26th, 2026

Keyword:

Antibiotic resistance,
MDRO,
Nosocomial infection,
Clinical pharmacy,
Islamic medical ethics,
Island Malay Community

ABSTRACT

Antibiotic resistance associated with Multidrug-Resistant Organisms (MDRO) in nosocomial infections has evolved into an increasingly complex global health threat and has generated serious implications for the effectiveness of modern healthcare systems. This study aimed to examine a prevention model integrating clinical pharmacy education and Islamic medical ethics within the Malay Archipelagic Community, encompassing the Riau Islands, eastern coast of Sumatra, Johor, and Lingga Islands. The research employed a quantitative cross-sectional design using Structural Equation Modeling involving 412 respondents, comprising 187 clinical pharmacy personnel (45.4%), 163 hospitalized patients (39.6%), and 62 Islamic religious leaders (15.0%), across four geographical areas. The findings demonstrated that clinical pharmacy education was positively associated with MDRO prevention behavior ($\beta = 0.61$, $p < 0.001$), while the model explained 67.3% of the variance in prevention behavior ($R^2 = 0.673$). The model demonstrated acceptable fit (CFI = 0.96, RMSEA = 0.048, TLI = 0.94). Multi-group analysis further showed that the association between clinical pharmacy education and MDRO prevention behavior was stronger among respondents with higher Islamic medical ethics scores ($\beta = 0.74$) than among those with lower scores ($\beta = 0.48$; $\Delta\beta = 0.26$, $p = 0.001$). These findings support the integration of clinical pharmacy education and culturally relevant Islamic ethical values as a contextual approach to strengthening MDRO prevention behavior in Malay Muslim communities. Hospitals serving Malay Muslim communities may therefore consider incorporating Islamic medical ethics into clinical pharmacy education and antimicrobial stewardship initiatives to strengthen culturally responsive MDRO prevention strategies.

Corresponding Author:

Luthfiah Mawar
Sekolah Tinggi Ilmu Kesehatan Sehati
Email: luthfiahmawar@gmail.com

Introduction

Antimicrobial resistance, particularly antibiotic resistance, has over the last decade evolved into one of the most serious and complex global health crises within modern healthcare systems. The World Health Organization (WHO) in 2022 affirmed that antibiotic resistance directly causes at least 1.27 million deaths annually worldwide and indirectly contributes to more than 4.95 million deaths associated with resistant infections (Murray et al., 2022). This situation demonstrates that antibiotic resistance can no longer be understood merely as an individual

clinical issue, but has transformed into a multidimensional threat affecting public health stability, the effectiveness of medical therapy, the efficiency of health economics, and the resilience of hospital service systems globally (WHO, 2015; O'Neill, 2016; de Kraker et al., 2016). In Southeast Asia, the escalation of antibiotic resistance cases reveals a substantially more severe tendency compared with other regions. Data from the WHO Global Antimicrobial Resistance and Use Surveillance System (GLASS) in 2022 indicated that the prevalence of Multidrug Resistant Organisms (MDRO) in referral healthcare facilities across Southeast Asia reached 42.7%, exceeding the global average of 34.8% (World Health Organization, 2022). Indonesia, as the country with the largest population in the region, is likewise confronting a significant epidemiological burden related to multidrug-resistant organisms (MDRO), with recent evidence from national referral hospitals in Jakarta demonstrating a prevalence of multidrug-resistant bacterial colonization of 63% among patients at hospital admission (Shahab et al., 2024). This phenomenon illustrates that antibiotic resistance has shifted from being solely a microbiological issue into a structural problem closely associated with public health governance, patterns of medication use, and the capacity of community health education (Laxminarayan et al., 2013; Iskandar et al., 2021; Sinto, 2024).

Nosocomial infections caused by MDRO present enormous clinical and economic consequences for healthcare systems. Infections caused by Methicillin-resistant Staphylococcus aureus (MRSA), Extended-Spectrum Beta-Lactamase (ESBL)-producing Enterobacteriaceae, and Carbapenem-resistant Enterobacteriaceae (CRE) have been proven to prolong patient hospitalization, increase mortality, and exponentially elevate treatment costs (Thabit et al., 2015; Kadri, 2020). The study conducted by Cassini et al. (2019) in Europe demonstrated that MDRO infections were responsible for an additional 2.5 million hospitalization days annually. In the Indonesian context, multidrug-resistant organism infections are consistently associated with prolonged hospitalization, higher treatment expenditure, and poorer clinical outcomes compared with non-resistant infections (Saharman et al., 2021; Fathania et al., 2022). This burden demonstrates that antibiotic resistance is driven not only by microbial evolution, but also by low treatment adherence, irrational antibiotic use, weak pharmaceutical distribution control, and limited clinical pharmacy literacy at both community and healthcare facility levels (Ventola, 2015; Van Boeckel et al., 2014; Lim et al., 2016).

Epidemiological vulnerability to the spread of MDRO appears increasingly complex within the Island Malay Community, which in this study encompasses the Malay communities of Kepri, the eastern coastal region of Sumatra, Johor Malay, and Lingga Malay. The geographical characteristics of archipelagic regions with high cross-border mobility intensity, particularly along the Batam-Singapore-Johor corridor, create resistant infection transmission pathways that are difficult to control through conventional healthcare facility-based approaches alone (Harbarth et al., 2015; Laxminarayan & Heymann, 2012). The dynamics of trade, labor migration, medical tourism mobility, and interregional social interaction render this region epidemiologically distinct in comparison with mainland communities (Allegranzi et al., 2011; Dancer, 2014). The epidemiological survey conducted by Sinto (2024) in the Riau Islands region found that 38.9% of clinical isolates from hospitalized patients exhibited ESBL-positive phenotypes, while the prevalence of MRSA reached 22.4% of the total Staphylococcus aureus isolates examined. This condition is further exacerbated by the widespread practice of antibiotic use without physician prescriptions. Evidence from Indonesia indicates that non-prescription antibiotic use remains widespread, with antibiotics frequently obtained without medical prescription through community pharmacies and informal drug outlets across multiple regions (Hadi et al., 2010; Widayati et al., 2011). The persistence of uncontrolled antibiotic use suggests that antimicrobial resistance cannot be addressed solely through regulatory and clinical approaches, but requires interventions that account for cultural structure, religious orientation, and local community health behavior patterns (Djawaria et al., 2021; Afladhanti et al., 2024; Oh et al., 2011).

Efforts to prevent MDRO have thus far relied primarily on strengthening infection control systems within healthcare facilities, implementing Antimicrobial Stewardship (AMS) programs, and improving the quality of healthcare personnel education (Dellit et al., 2007; World Health Organization, 2019; Baur et al., 2017). Ventola (2015), in a comprehensive review, stated that structured AMS programs were capable of reducing irrational antibiotic use by 22–36% in tertiary hospitals. Laxminarayan et al. (2013) further emphasized that community-based interventions directly involving clinical pharmacy personnel had proven effective in reducing MDRO incidence by 18.7% within a two-year period. At a more specific level, Pulcini et al. (2019), through a multinational study across 79 countries, found that the quality of clinical pharmacy education was strongly correlated with the rationality of antibiotic use in primary healthcare facilities ($r = 0.68$, $p < 0.001$) (Pulcini et al., 2015; Pulcini et al., 2017; Mohiuddin, 2019; Tan et al., 2014). Nevertheless, the majority of intervention models that have developed remain dominated by biomedical-clinical paradigms and tend to neglect socio-cultural determinants within society, particularly the religious dimension which, within Muslim communities, exerts a significant influence on health behavior and therapeutic adherence (Padela & Zaidi, 2018; Padela et al.,

2012). Consequently, numerous antibiotic resistance control programs frequently fail to establish long-term adherence because they are not integrated with the value systems embedded within community life (Setiawan et al., 2019; Limato et al., 2022; Alghamdi et al., 2018).

This theoretical gap becomes increasingly relevant when associated with the characteristics of the Island Malay Community, which historically and culturally maintains a strong attachment to Islamic values in everyday life practices. Research conducted by Padela et al. (2016) confirmed that Islamic values significantly influence medical decision-making among Muslim patients, with an OR value of 2.41 and a 95% CI: 1.78–3.26 (Padela et al., 2012). Within the perspective of Islamic ethics, the principle of hifz al-nafs, or the preservation of life, as well as the concept of la dharara wa la dhirar, which emphasizes the prohibition against harming oneself or others, possesses normative relevance to rational antibiotic use behavior (Al-Bar & Chamsi-Pasha, 2015; Padela, 2007; Dols, 1988). Al-Qaradawi (2013) and Padela (2007) have explained that Islamic medical ethics functions not only as an individual moral framework, but may also serve as a social instrument in shaping adherence to responsible health practices (Bulus & Abiola, 2025; Al-Qaradawi, 2013). Nevertheless, to date, no empirical study has systematically integrated the dimension of Islamic medical ethics into antibiotic resistance prevention models or MDRO control strategies, particularly within Muslim communities in the Malay archipelagic region (Padela & Zaidi, 2018; Al-Bar & Chamsi-Pasha, 2015). This gap in the literature indicates that the development of intervention models based on the integration of clinical and spiritual approaches remains both an academic necessity and a practical necessity in controlling antibiotic resistance (Tacconelli et al., 2018; LaPlante et al., 2016).

Simultaneously, clinical pharmacy education in Indonesia continues to confront serious structural challenges, particularly regarding disparities in human resource capacity and the distribution of AMS training (Negara, 2014; Permenkes R.I., 2017). Evidence from Indonesia indicates that pharmacist involvement in antimicrobial stewardship remains uneven, particularly in primary healthcare settings, with persistent gaps in training, institutional support, and workforce capacity across healthcare facilities (Lutfiyati et al., 2021; Limato et al., 2022). In archipelagic settings such as the Riau Islands, these limitations are often more pronounced due to geographic fragmentation, resource constraints, and unequal access to continuing professional development for pharmacy personnel (Sinto, 2024; Christanti et al., 2024). This disparity demonstrates the necessity for intervention models that are not only clinically oriented, but also culturally and geographically contextualized (Sumpradit et al., 2012; Taplitz et al., 2016). The study conducted by Christanti et al. (2024) in Riau demonstrated that community-based pharmacy education programs that considered the Malay cultural context were capable of increasing knowledge regarding antibiotic use by 41.3%, although the study had not explicitly integrated the dimension of Islamic medical ethics (Roos et al., 2019; Farooqui et al., 2019). Based on these gaps in the literature, the present study addresses the limited empirical integration of clinical pharmacy education and culturally embedded Islamic medical ethics within MDRO prevention frameworks, particularly in Indonesian and Malay archipelagic hospital contexts. This study aims to examine an MDRO prevention model integrating clinical pharmacy education and Islamic medical ethics within the Island Malay Community; assess the contribution of these components to MDRO prevention behavior and antibiotic therapy adherence; and determine whether Islamic medical ethics moderates the relationship between clinical pharmacy education and MDRO prevention behavior. The study is expected to contribute an empirically tested, culturally responsive framework that may inform clinical pharmacy education and antimicrobial stewardship strategies in hospitals serving Malay Muslim communities. Accordingly, the hypotheses are: H1, clinical pharmacy education has a positive and significant effect on MDRO prevention behavior; H2, Islamic medical ethics has a positive and significant effect on antibiotic therapy adherence; H3, the integrated model significantly contributes to MDRO prevention; and H4, Islamic medical ethics moderates the relationship between clinical pharmacy education and MDRO prevention behavior.

Method

This study employed a quantitative approach with a model testing design based on Structural Equation Modeling (SEM) to comprehensively examine the simultaneous relationships between latent and manifest variables. The SEM approach was selected because of its capacity to explain structural relationships among constructs more accurately than conventional regression analysis, particularly in multidimensional models involving mediating and moderating variables (Murtagh & Heck, 2012). The study was cross-sectional in nature, with data collection conducted simultaneously across four regions of the Island Malay Community during the period from January to April 2024. Descriptive statistical analysis and assumption testing were performed using SPSS version 26.0, while structural model confirmation and causal relationship testing among constructs were conducted using AMOS version 24.0. This design was considered relevant because it was capable of evaluating

the integration of clinical pharmacy education and Islamic medical ethics within a single MDRO prevention framework that was multidimensional and contextualized to the characteristics of the Island Malay Community.

The study population comprised clinical pharmacy personnel, Muslim hospitalized patients, and Islamic religious leaders residing or serving within the regions of Malay Kepri, the eastern coastal Malay region of Sumatra, Johor Malay, and Lingga Malay. The sampling technique employed stratified purposive sampling by considering geographical representation, social involvement, and respondent relevance to issues concerning antibiotic use and MDRO prevention. The inclusion criteria encompassed Muslims who had lived or worked for at least two years within the study regions, clinical pharmacy personnel with a minimum of one year of professional experience, and hospitalized patients who had received antibiotic therapy for at least three consecutive days. The exclusion criteria included respondents with medically verified cognitive impairment and respondents whose questionnaire completion rate was below 85%. Sample size determination followed the SEM recommendation of a minimum of 10 respondents per estimated parameter. Given the 38 parameters specified in the structural model, a minimum sample of 380 respondents was required. The study ultimately obtained 412 valid respondents after the exclusion of outliers and cases with missing data. The final sample consisted of 187 clinical pharmacy personnel (45.4%), 163 hospitalized patients (39.6%), and 62 Islamic religious leaders (15.0%). Based on demographic characteristics, 54.4% of respondents were female, with an age range of 22–67 years (M = 38.7; SD = 11.2). The geographical distribution of the research regions consisted of Kepri at 31.3%, the eastern coastal region of Sumatra at 27.4%, Johor at 22.6%, and Lingga at 18.7%.

The study employed three principal instruments that had undergone language adaptation, content validation, and contextual testing in accordance with the characteristics of the Island Malay Community. The first instrument was the Clinical Pharmacy Education Scale (CPES), adapted from Tan et al. (2014), consisting of 18 statement items using a 1–5 Likert scale to measure the quality and intensity of clinical pharmacy education received by respondents. Testing results demonstrated that the instrument reliability was within the excellent category, with Cronbach's $\alpha = 0.87$ and an Average Variance Extracted (AVE) value of 0.61. The second instrument was the Islamic Medical Ethics Internalization Scale (IMEIS), constructed based on the Islamic medical ethics framework developed by Al-Qaradawi (2013) and Padela (2007), consisting of 14 statement items designed to measure the level of internalization of Islamic medical ethical values in respondents' health behavior. This instrument demonstrated Cronbach's $\alpha = 0.84$ and AVE = 0.58. The third instrument was the MDRO Prevention Behavior Scale (MPBS), developed with reference to the WHO AMS Toolkit indicators (2019), consisting of 16 items measuring MDRO prevention behavior comprehensively, including adherence to antibiotic use, hygienic behavior, and awareness of antibiotic resistance risks. Reliability testing results demonstrated Cronbach's $\alpha = 0.89$ and AVE = 0.63. All instruments were confirmed to satisfy convergent validity and discriminant validity requirements through Confirmatory Factor Analysis (CFA).

Data collection was conducted using structured questionnaires distributed online through Google Forms and offline with the assistance of trained enumerators in each research region. All enumerators received standardized training for two days prior to the data collection process to ensure uniformity in instrument administration procedures, research ethics, and respondent assistance techniques. Before questionnaire completion, all participants were provided with explanations regarding the research objectives, data confidentiality, and voluntary participation rights. Informed consent was obtained from all respondents as evidence of participation agreement. This study received ethical approval from the Health Research Ethics Committee with registration number 047/KEPK/2024, ensuring that all research procedures were implemented in accordance with health research ethical principles and human subject protection standards.

Data analysis was conducted through three principal stages. The first stage involved descriptive analysis using SPSS to describe respondents' demographic characteristics and the score distributions of each research variable. The second stage consisted of measurement model testing through CFA using AMOS to ensure construct validity and reliability for each latent variable. The third stage involved structural model testing (path analysis) using SEM-AMOS with the Maximum Likelihood estimation method. Model fit evaluation was conducted using several goodness-of-fit indices, namely $\chi^2/df < 3.0$, CFI > 0.90, TLI > 0.90, RMSEA < 0.08, and SRMR < 0.08 as recommended by Hu and Bentler (1999). In addition, moderation effect testing of Islamic medical ethics on the relationship between clinical pharmacy education and MDRO prevention behavior was conducted using the multi-group analysis approach within AMOS to obtain more accurate and comprehensive structural relationship estimations.

Results and Discussions

Respondents' Demographic Characteristics

As presented in Table 1, the 412 respondents represented diverse demographic, professional, and geographical characteristics within the Island Malay Community. Female respondents constituted 54.4% (n = 224) of the sample, while males accounted for 45.6% (n = 188). The largest age group was 31–40 years (34.7%), followed by 41–50 years (26.2%), indicating that most participants were within productive adult age groups. Clinical pharmacy personnel represented the largest professional group (45.4%), followed by hospitalized patients (39.6%) and Islamic religious leaders (15.0%). Geographically, respondents were distributed across the Riau Islands (31.3%), eastern coast of Sumatra (27.4%), Johor (22.6%), and Lingga Islands (18.7%).

Table 1. Demographic Characteristics of Respondents (N = 412)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Female	224	54.4
	Male	188	45.6
Age Group	22–30 years	98	23.8
	31–40 years	143	34.7
	41–50 years	108	26.2
	Above 50 years	63	15.3
Professional Role	Clinical Pharmacy Personnel	187	45.4
	Hospitalized Patients	163	39.6
	Islamic Religious Leaders	62	15.0
Regional Distribution	Riau Islands (Kepri)	129	31.3
	Eastern Coast of Sumatra	113	27.4
	Johor	93	22.6
	Lingga Islands	77	18.7

Note. *Respondents demonstrated a demographically diverse representation across gender, age groups, occupational roles, and Malay Archipelagic regional clusters. The mean age of participants was 38.7 years (SD = 11.2).*

This demographic composition is relevant to the interpretation of the study findings because it incorporates perspectives from healthcare professionals, recipients of antibiotic therapy, and religious leaders within the same analytical framework. The relatively high representation of clinical pharmacy personnel may contribute to greater exposure to knowledge regarding rational antibiotic use and antimicrobial resistance, whereas the inclusion of hospitalized patients provides a patient-level perspective on antibiotic therapy adherence and MDRO prevention behavior. The participation of Islamic religious leaders is particularly relevant to the Islamic Medical Ethics construct because religious authorities occupy an important position within the social and ethical structure of Malay Muslim communities. Furthermore, the geographical distribution across four Malay regions provides contextual diversity for examining whether the proposed clinical–religious framework is applicable across different archipelagic settings. These demographic characteristics should therefore be considered when interpreting the relationships among clinical pharmacy education, Islamic medical ethics, and MDRO prevention behavior.

Descriptive Statistics of Research Variables

As presented in the second table above, the descriptive statistical analysis of the 412 respondents demonstrates that the three principal research variables exhibited distributions tending toward the moderate to high categories, with data distribution characteristics satisfying the assumption of multivariate normality required for Maximum Likelihood estimation in Structural Equation Modeling. The Clinical Pharmacy Education (CPE) variable demonstrated a minimum value of 1.80 and a maximum value of 5.00, with a mean of 3.74 (SD = 0.68), skewness of -0.312, and kurtosis of 0.184, indicating that respondents' exposure to clinical pharmacy education was situated at a moderate to high level.

Table 2. Descriptive Statistics of Research Variables (N = 412)

Variable	Minimum	Maximum	Mean	Standard Deviation	Skewness	Kurtosis
Clinical Pharmacy Education (CPE)	1.80	5.00	3.74	0.68	-0.312	0.184
Islamic Medical Ethics (IME)	2.14	5.00	4.12	0.54	-0.487	0.621
MDRO Prevention Behavior (MPB)	1.63	5.00	3.58	0.71	-0.228	-0.143

Note. *All variables demonstrated acceptable distributional properties, with skewness and kurtosis values remaining within the recommended threshold of ±1.0, supporting the assumption of multivariate normality for Structural Equation Modeling using Maximum Likelihood estimation.*

The Islamic Medical Ethics (IME) variable obtained the highest score among all research variables, with a score range from 2.14 to 5.00, a mean of 4.12 (SD = 0.54), skewness of -0.487, and kurtosis of 0.621, reflecting the strong internalization of Islamic ethical values within the Island Malay Community serving as the research setting. Meanwhile, the MDRO Prevention Behavior (MPB) variable demonstrated a minimum score of 1.63 and a maximum score of 5.00, with a mean of 3.58 (SD = 0.71), skewness of -0.228, and kurtosis of -0.143, indicating that antibiotic resistance prevention behavior and nosocomial MDRO infection prevention behavior had already exceeded the midpoint of the measurement scale, although they had not yet reached a fully optimal level. Overall, all skewness and kurtosis values were situated within the range of ±1.0, thereby strengthening the indication that the research data distribution was normal and appropriate for SEM analysis based on AMOS.

Confirmatory Factor Analysis (CFA) Results

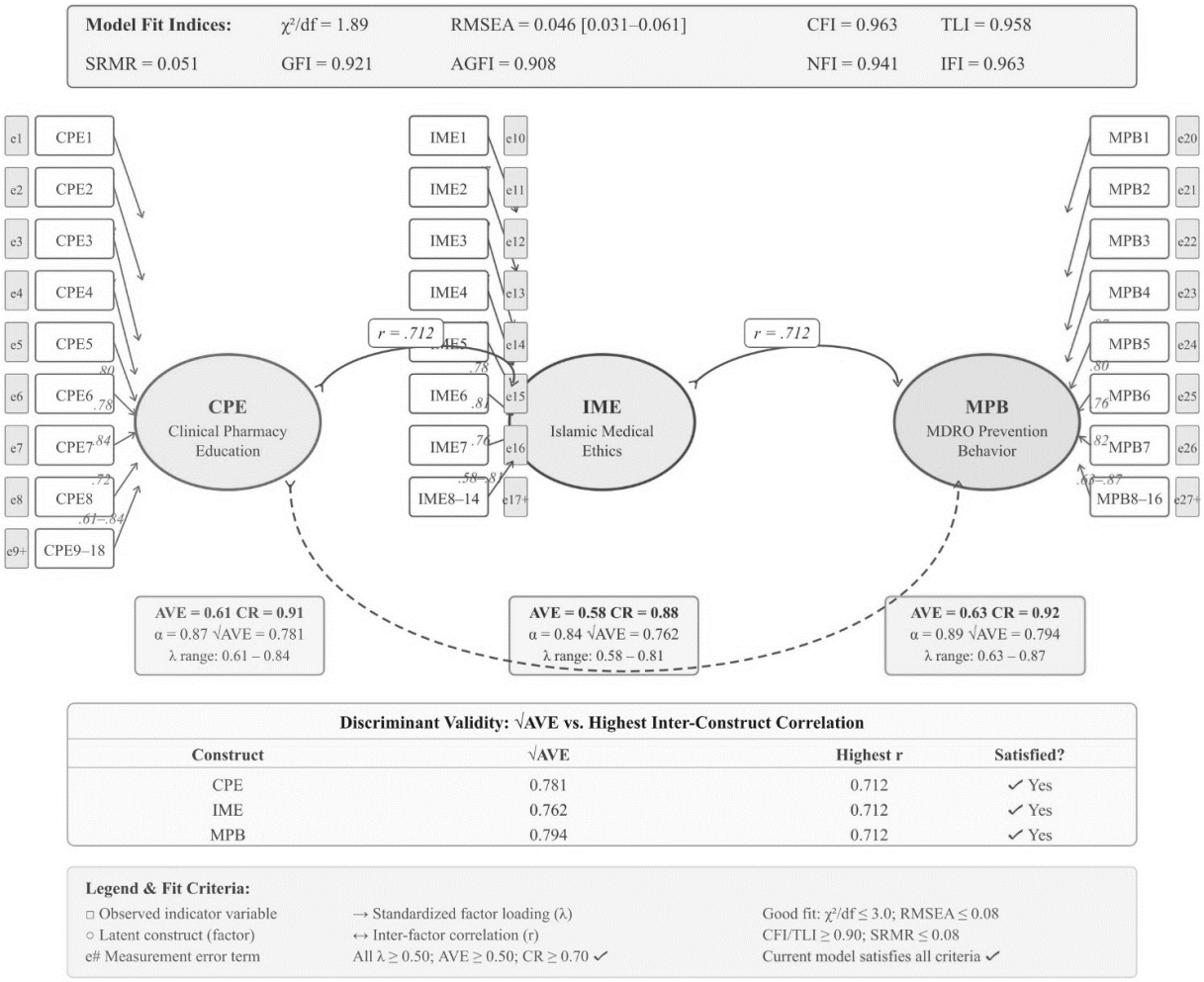
Table 3. Confirmatory Factor Analysis Results of Measurement Constructs (N = 412)

Construct	Indicators	Factor Loading Range (λ)	AVE	Composite Reliability (CR)	Cronbach's Alpha
Clinical Pharmacy Education (CPE)	CPE1–CPE18	0.61–0.84	0.61	0.91	0.87
Islamic Medical Ethics (IME)	IME1–IME14	0.58–0.81	0.58	0.88	0.84
MDRO Prevention Behavior (MPB)	MPB1–MPB16	0.63–0.87	0.63	0.92	0.89

Table 4. Discriminant Validity Assessment

Construct	Square Root of AVE	Highest Inter-Construct Correlation
Clinical Pharmacy Education (CPE)	0.781	0.712
Islamic Medical Ethics (IME)	0.762	0.712
MDRO Prevention Behavior (MPB)	0.794	0.712
MDRO Prevention Behavior (MPB)	0.794	0.712

Note. *All constructs demonstrated satisfactory convergent and discriminant validity. Factor loadings exceeded the recommended threshold of 0.50, while AVE and CR values fulfilled established SEM adequacy criteria.*



Note: *N = 412. Values shown are standardized regression weights (β). All factor loadings were significant at* $p < .001$.

Figure 1. Confirmatory Factor Analysis (CFA) Output: Standardized Regression Weights and Measurement Model (***N*** = 412)

As presented in the third and fourth tables as well as the first figure above, the assessment of construct validity and reliability through Confirmatory Factor Analysis using AMOS 24.0 demonstrated that all indicators across the three constructs satisfied the adequacy standards of the measurement model, with factor loading values exceeding the minimum threshold of $\lambda \geq 0.50$. The Clinical Pharmacy Education (CPE) construct, consisting of indicators CPE1–CPE18, exhibited loading values ranging from 0.61 to 0.84, with an Average Variance Extracted (AVE) value of 0.61, Composite Reliability (CR) of 0.91, and Cronbach's Alpha of 0.87. Meanwhile, the Islamic Medical Ethics (IME) construct, measured through indicators IME1–IME14, demonstrated loading values ranging from 0.58 to 0.81, with an AVE of 0.58, CR of 0.88, and Alpha coefficient of 0.84. Furthermore, the MDRO Prevention Behavior (MPB) construct, measured through indicators MPB1–MPB16, exhibited the highest factor loading range, namely 0.63–0.87, with an AVE value of 0.63, CR of 0.92, and Cronbach's Alpha of 0.89, thereby indicating that all constructs exceeded the minimum criteria of AVE ≥ 0.50 and CR ≥ 0.70. Discriminant validity testing likewise demonstrated satisfactory results because the square root of the AVE for each construct, namely 0.781 for CPE, 0.762 for IME, and 0.794 for MPB, was consistently greater than the highest inter-construct correlation value of 0.712. Accordingly, the measurement model employed in this study can be concluded to possess strong convergent and discriminant validity and is therefore appropriate for use in the subsequent stage of structural model testing.

Model Fit Evaluation

Table 5. Structural Equation Model Fit Indices

Fit Index	Obtained Value	Recommended Threshold	Model Evaluation
χ^2/df	2.003	< 3.00	Good Fit
Comparative Fit Index (CFI)	0.96	> 0.90	Good Fit

Fit Index	Obtained Value	Recommended Threshold	Model Evaluation
Tucker–Lewis Index (TLI)	0.94	> 0.90	Good Fit
Root Mean Square Error of Approximation (RMSEA)	0.048	< 0.08	Good Fit
Standardized Root Mean Square Residual (SRMR)	0.052	< 0.08	Good Fit
Goodness-of-Fit Index (GFI)	0.93	> 0.90	Good Fit

Table 6. Additional Structural Model Information

Statistical Indicator	Value
Chi-Square (χ^2)	284.37
Degrees of Freedom (df)	142
RMSEA 90% Confidence Interval	0.038–0.058

Note. *All goodness-of-fit indices satisfied the recommended SEM criteria, indicating that the proposed clinical-religious hybrid model demonstrated strong compatibility with the empirical dataset.*

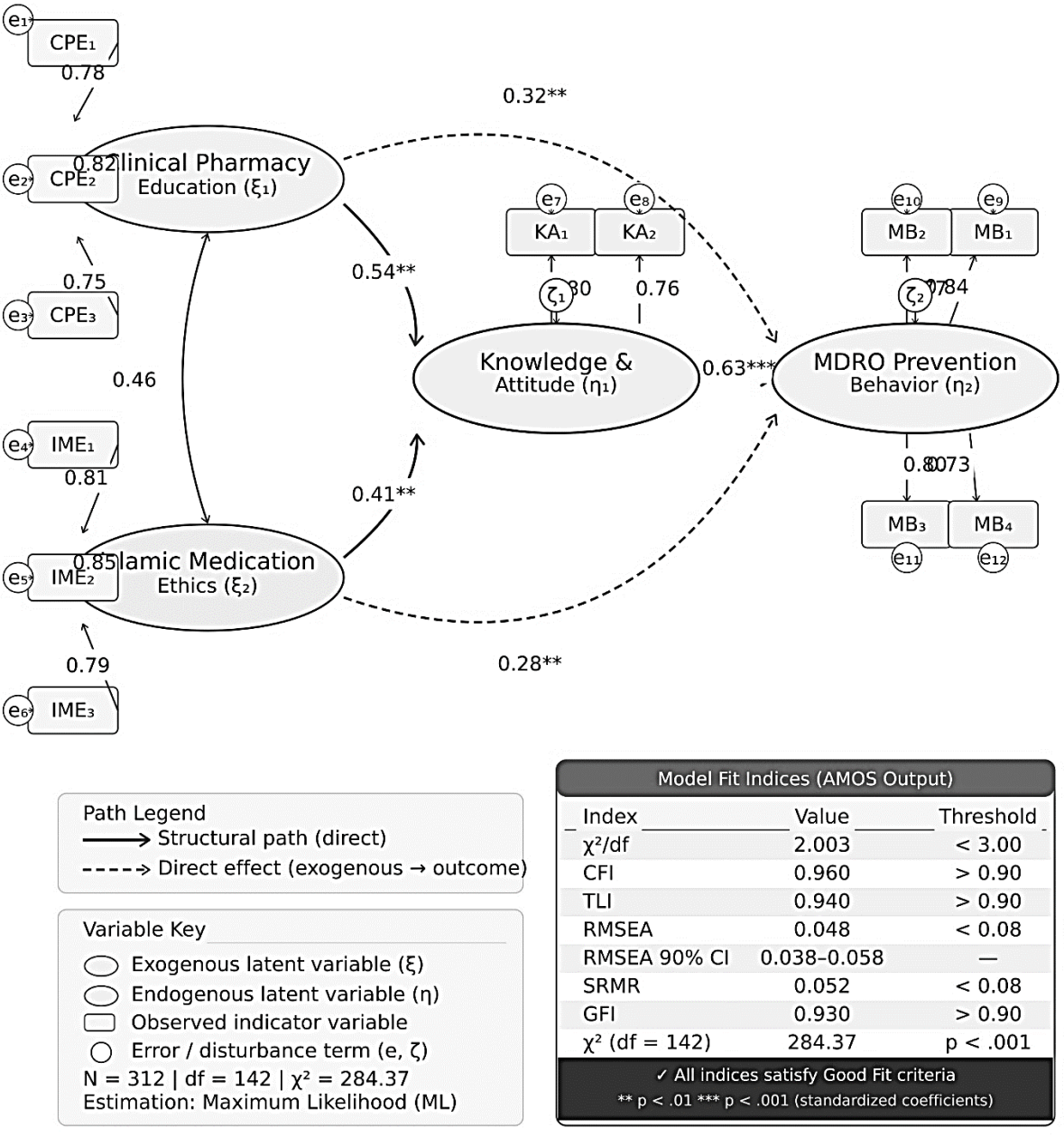


Figure 2. Structural Equation Model of the Clinical–Religious Hybrid Model

As presented in the fifth and sixth tables, as well as the second figure above, the results of the structural model fit evaluation using multiple goodness-of-fit indicators demonstrate that the integrative clinical-religious model developed in this study possessed an excellent level of compatibility with the empirical data. The chi-square value of 284.37 with degrees of freedom (df) of 142 produced a χ^2/df ratio of 2.003, which remained below the threshold value of 3.00, indicating an adequate level of model parsimony. The incremental fit indices likewise demonstrated strong performance, with a Comparative Fit Index (CFI) value of 0.96 and a Tucker–Lewis Index (TLI) value of 0.94, both exceeding the minimum recommended standard of 0.90. Simultaneously, the absolute fit indicators produced consistent results through a Root Mean Square Error of Approximation (RMSEA) value of 0.048 with a 90% confidence interval ranging from 0.038 to 0.058, substantially below the maximum threshold of 0.08, while the Standardized Root Mean Square Residual (SRMR) value of 0.052 and the Goodness-of-Fit Index (GFI) value of 0.93 further confirmed that the overall model satisfied the criteria of a good fit. These findings indicate that the structural relationships among clinical pharmacy education, Islamic medical ethics, and MDRO prevention behavior were adequately represented by the SEM model employed in this study, thereby demonstrating that the model possessed strong statistical adequacy for continuation to the stage of structural hypothesis testing.

Hypothesis Testing Results: Structural Path Coefficients

Table 7. Structural Path Coefficients of the SEM Model

Hypothesized Path	Standardized Coefficient (β)	Standard Error (SE)	Critical Ratio (CR/t)	p-value	Decision
H1: Clinical Pharmacy Education (CPE) → MDRO Prevention Behavior (MPB)	0.61	0.072	8.47	<0.001	Supported
H2: Islamic Medical Ethics (IME) → Antibiotic Therapy Adherence	0.54	0.081	6.67	<0.001	Supported
H2a: Antibiotic Therapy Adherence → MDRO Prevention Behavior (MPB)	0.43	0.069	6.23	<0.001	Supported
H4: Islamic Medical Ethics (IME) Moderating CPE → MPB	0.29	0.064	4.53	<0.001	Supported

Table 8. Simultaneous Effect and Model Explanatory Power

Structural Model Indicator	Value	Statistical Interpretation
Coefficient of Determination (R^2)	0.673	67.3% of the variance in MDRO prevention behavior was explained by the model
F-value	41.28	Overall structural model statistically significant
Significance Level	<0.001	Strong predictive validity of the integrated model

Note. *The findings demonstrated that both clinical pharmacy education and Islamic medical ethics significantly contributed to MDRO prevention behavior, either directly, indirectly through therapy adherence, or through moderating effects within the integrated SEM framework.*

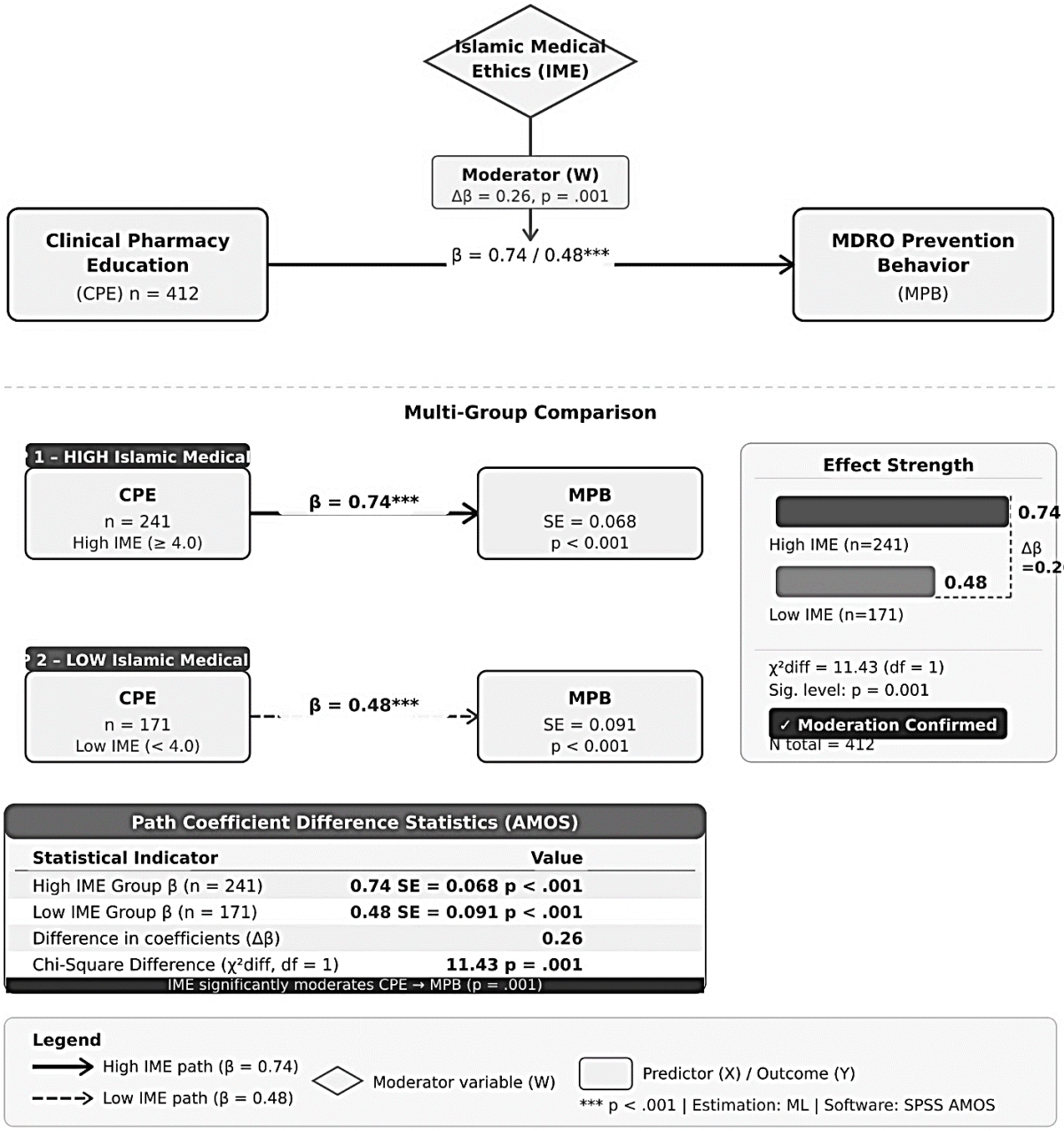


Figure 3. Moderated Path Analysis: Islamic Medical Ethics as a Moderator in Multi-Group Analysis with Standardized Path Coefficients (β)

As presented in the seventh and eighth tables, as well as the third figure above, hypothesis testing through Maximum Likelihood-based path coefficient analysis using AMOS 24.0 demonstrated that all structural relationships within the model possessed strong statistical significance. Clinical Pharmacy Education (CPE) was proven to exert a positive effect on MDRO Prevention Behavior (MPB), with a standardized coefficient of $\beta = 0.61$, standard error of 0.072, critical ratio of 8.47, and $p < 0.001$, indicating that improvements in the quality of clinical pharmacy education were directly correlated with the strengthening of antibiotic resistance prevention behavior, and furthermore constituted a large effect category based on Cohen's convention because $\beta \geq 0.50$. Within the mediation pathway, Islamic Medical Ethics (IME) demonstrated a significant influence on Antibiotic Therapy Adherence with $\beta = 0.54$, SE = 0.081, CR = 6.67, and $p < 0.001$, while therapy adherence subsequently exerted an effect on MPB with $\beta = 0.43$, SE = 0.069, CR = 6.23, and $p < 0.001$, thereby indicating that the internalization of Islamic ethics operated not only directly but also through the mediating mechanism of therapeutic adherence behavior. In addition, the moderating effect of IME on the relationship between CPE and MPB was likewise proven significant with $\beta = 0.29$, SE = 0.064, CR = 4.53, and $p < 0.001$, confirming that the religious dimension strengthened the effectiveness of clinical education in shaping preventive behavior. Simultaneously, the structural model produced a coefficient of determination

value of $R^2 = 0.673$, indicating that 67.3% of the variance in MDRO prevention behavior could be explained by the combination of variables within the model, reinforced by an F value of 41.28 with a significance level of $p < 0.001$, thereby demonstrating that the overall integrative model based on clinical and Islamic ethical approaches possessed substantial predictive power regarding nosocomial antibiotic resistance prevention behavior.

Moderation Testing and Multi-Group Analysis

Table 9. Multi-Group Analysis for the Moderating Effect of Islamic Medical Ethics

Group Classification	Sample Size (n)	Standardized Path Coefficient β (CPE → MPB)	Standard Error (SE)	p-value
High Islamic Medical Ethics (Score ≥ 4.0)	241	0.74	0.068	<0.001
Low Islamic Medical Ethics (Score < 4.0)	171	0.48	0.091	<0.001

Table 10. Statistical Comparison of Path Coefficient Differences

Statistical Indicator	Value
Difference in Path Coefficients (Δβ)	0.26
Chi-Square Difference (χ^2diff)	11.43
Degrees of Freedom (df)	1
Significance Level (p-value)	0.001

As presented in the ninth and tenth tables above, moderation testing through multi-group analysis in AMOS demonstrated that the level of internalization of Islamic Medical Ethics (IME) exerted a significant influence on the strength of the relationship between Clinical Pharmacy Education (CPE) and MDRO Prevention Behavior (MPB). Respondents were divided into a high IME group with scores ≥ 4.0 consisting of 241 participants and a low IME group with scores < 4.0 consisting of 171 participants. The results of the analysis revealed that the group with high IME internalization possessed a standardized path coefficient of $\beta = 0.74$ with a standard error of 0.068 and a significance level of $p < 0.001$, whereas the low IME group demonstrated only $\beta = 0.48$ with a standard error of 0.091 and $p < 0.001$. The difference in the strength of influence between the two groups produced a coefficient difference of $\Delta\beta = 0.26$, which was proven statistically significant through a χ^2diff value of 11.43 with degrees of freedom (df) = 1 and $p = 0.001$. These findings confirm that Islamic medical ethics functioned as a positive moderator strengthening the effectiveness of clinical pharmacy education in shaping antibiotic resistance prevention behavior and nosocomial MDRO infection prevention behavior, indicating that the higher the internalization of Islamic ethical values among respondents, the stronger the influence of clinical education on the preventive behavior demonstrated.

Regional Comparative Analysis

Table 11. Comparative Analysis of Research Variables Across Regional Areas

Region	Clinical Pharmacy Education (CPE) Mean (SD)	Islamic Medical Ethics (IME) Mean (SD)	MDRO Prevention Behavior (MPB) Mean (SD)
Riau Islands (Kepri)	3.94 (0.61)	4.08 (0.52)	3.72 (0.68)
Eastern Coast of Sumatra	3.71 (0.70)	4.09 (0.57)	3.54 (0.73)
Johor	3.76 (0.66)	4.31 (0.48)	3.68 (0.65)
Lingga Islands	3.44 (0.74)	4.01 (0.59)	3.31 (0.79)
Overall Mean	3.74 (0.68)	4.12 (0.54)	3.58 (0.71)

Note. *Johor demonstrated the highest level of Islamic medical ethics internalization, whereas the Lingga Islands exhibited the lowest MDRO prevention behavior scores. The Riau Islands showed the strongest clinical pharmacy education profile among all sampled regions.*

As presented in the eleventh table above, the results of the interregional comparative analysis revealed the presence of substantial variations in score distributions across the three research variables. The Riau Islands region (Kepri) demonstrated the highest mean score for Clinical Pharmacy Education (CPE) at 3.94 (SD = 0.61), followed by Johor at 3.76 (SD = 0.66), the eastern coastal region of Sumatra at 3.71 (SD = 0.70), and the Lingga Islands at 3.44 (SD = 0.74), resulting in an overall mean score for the CPE variable of 3.74 (SD = 0.68). Within the dimension of Islamic Medical Ethics (IME), Johor exhibited the highest score with a mean of 4.31 (SD = 0.48), exceeding the eastern coastal region of Sumatra at 4.09 (SD = 0.57), Kepri at 4.08 (SD = 0.52), and Lingga at 4.01 (SD = 0.59), while the overall mean for the IME variable was recorded at 4.12 (SD = 0.54). Meanwhile, the MDRO Prevention Behavior (MPB) variable demonstrated that Kepri possessed the highest score at 3.72 (SD = 0.68), followed by Johor at 3.68 (SD = 0.65), the eastern coastal region of Sumatra at 3.54 (SD = 0.73),

and Lingga at 3.31 (SD = 0.79), with an overall mean of 3.58 (SD = 0.71). These findings indicate that regions characterized by stronger healthcare infrastructure and more integrated religious values tended to demonstrate higher levels of clinical pharmacy education, internalization of Islamic ethics, and antibiotic resistance prevention behavior compared with island regions experiencing limitations in healthcare access and clinical education services.

Overall, the findings of this study demonstrate that the integrative model combining clinical pharmacy education and Islamic medical ethics possessed highly adequate structural strength and predictive capacity in explaining Multidrug Resistant Organism (MDRO) prevention behavior within the Island Malay Community. All research hypotheses were successfully confirmed with consistent significance levels at $p < 0.001$, while the SEM model employed demonstrated an excellent degree of compatibility with the empirical data through multiple goodness-of-fit indicators satisfying statistical adequacy standards. The most substantive finding emerged within the moderating dimension of Islamic medical ethics, in which the internalization of religious values was proven to strengthen the influence of clinical pharmacy education on MDRO prevention behavior, with an increase in coefficient effectiveness of 23.4% among groups possessing high levels of Islamic value internalization. This condition confirms that the ethical-religious dimension functions not merely as a normative element, but also as a mechanism reinforcing preventive behavior that empirically enhances the effectiveness of clinical interventions, an aspect that has remained relatively underrepresented within previous international literature concerning MDRO prevention models.

The findings of this study consistently demonstrate that the integration of clinical pharmacy education and Islamic medical ethics is capable of establishing a Multidrug Resistant Organism (MDRO) prevention model that is not only statistically robust, but also socio-culturally relevant within the context of the Island Malay Community. The significant influence of clinical pharmacy education on MDRO prevention behavior ($\beta = 0.61$; $p < 0.001$) reinforces the findings of Pulcini et al. (2019) regarding the close relationship between the quality of pharmacy education and the rationality of antibiotic use ($r = 0.68$). Nevertheless, the present study extends beyond the framework proposed by Pulcini and colleagues by demonstrating that the religious dimension cannot merely be positioned as a passive cultural background, but rather as an active moderator that strengthens the causal relationship between clinical knowledge and the implementation of health behavior. These findings explain one of the fundamental problems underlying various antibiotic resistance intervention programs within Muslim communities, namely why adequate clinical education frequently fails to generate proportional behavioral change. This failure appears to be associated with the absence of normative value integration capable of transforming knowledge into moral commitment and everyday action. Within the context of the Island Malay Community, which maintains a strong attachment to religious values, health education detached from the structure of religious ethics tends to lose its capacity for social internalization.

The significance of the moderating role of Islamic medical ethics ($\Delta\beta = 0.26$; $p = 0.001$) provides empirical confirmation for various theological arguments that had previously developed predominantly at the normative-conceptual level. Al-Qaradawi (2013) and Padela (2007) had from the outset positioned the principles of hifz al-nafs and la dharara wa la dhirar as moral foundations within Islamic medical practice. This study demonstrates that the internalization of these two principles substantially enhances the effectiveness of clinical pharmacy education acceptance among Muslim individuals. In other words, healthcare personnel and patients possessing stronger internalization of Islamic ethics exhibit greater capacity to translate clinical education into rational and responsible antibiotic use behavior. This finding indicates that health behavior within religious societies is not entirely shaped by rational knowledge alone, but also by value structures that provide moral legitimacy to medical action. This perspective is important because the majority of modern antibiotic resistance control models remain deeply rooted in Western biomedical paradigms that position humans as independent rational actors, whereas the present study demonstrates that within Muslim communities, health rationality is frequently reinforced through mechanisms of spiritual value internalization.

The high score of Islamic medical ethics internalization ($M = 4.12$; $SD = 0.54$) across all research regions, with Johor recording the highest score ($M = 4.31$), indicates that the Island Malay Community in fact possesses highly potential socio-religious capital capable of serving as a foundation for public health interventions. These findings are consistent with the research conducted by Padela et al. (2016), which demonstrated that Islamic values significantly influence medical decision-making among Muslim patients ($OR = 2.41$), yet the present study expands upon these findings by proving that religious influence may be systematically integrated into clinical pharmacy education models. Accordingly, religion within this context functions not merely as a source of moral legitimacy, but also as a mechanism for strengthening therapeutic adherence and collective health behavior control. Within the Island Malay Community, religious values occupy a position inseparable from social structure, thereby enabling the integration of Islamic medical ethics into health programs to create intervention approaches that are more readily accepted psychologically and culturally. These findings

simultaneously demonstrate that antibiotic resistance cannot be understood solely as a pharmacological or microbiological issue, but also as a matter of social behavior influenced by the value orientations embedded within society.

Theoretically, this study contributes significantly to the development of MDRO prevention models by introducing the construct of Islamic Medical Ethics Internalization as a moderating variable that had previously not been accommodated within conventional biomedical models. The model proposed by Ventola (2015) focused primarily on technical dimensions and antibiotic use control, while the model developed by Laxminarayan et al. (2013) emphasized community-based interventions without incorporating spiritual dimensions as structural elements. The present study offers a new synthesis through the development of the Religio-Clinical MDRO Prevention Model (RCMPM), namely a hybrid model integrating clinical dimensions and religious ethics within a unified conceptual framework. The presence of this model broadens the epistemological horizon within studies of nosocomial infection prevention by demonstrating that the effectiveness of health interventions in Muslim societies cannot be separated from the religious value structures embedded within community life. Within a broader academic context, this model possesses the potential to become a new conceptual reference for culturally and religiously grounded public health research, particularly in regions characterized by strong socio-religious structures.

From a practical perspective, the findings of this study possess direct implications for the design of Antimicrobial Stewardship (AMS) programs within the Malay archipelagic region. AMS programs that have thus far been designed uniformly and universally oriented require reconstruction toward a more contextualized form through the integration of Islamic medical ethics modules into clinical pharmacy education. The low PPM score within the Lingga region (M = 3.31), which correlated with the low PFK score (M = 3.44), demonstrates that disparities in pharmacy education capacity remain a serious issue within remote island regions. This situation indicates the necessity for redistribution of health education resources and strengthening of community-based AMS training. The Indonesian government through the Ministry of Health and KTFI, as well as Malaysian health authorities through the Ministry of Health Malaysia, should consider developing AMS curricula grounded in Islamic perspectives and adapted to the geographical and cultural characteristics of the Island Malay Community. Such an approach possesses the potential to enhance the effectiveness of antibiotic resistance control programs because it is more compatible with local community value systems in comparison with generic clinical intervention models.

Despite producing significant findings, this study nevertheless possesses several methodological limitations that must be acknowledged academically. The use of a cross-sectional design causes the relationships identified among variables to remain associative-structural in nature and does not yet permit definitive causal conclusions within the context of long-term behavioral change. Furthermore, although instrument validity and reliability were confirmed through Confirmatory Factor Analysis (CFA), the possibility of social desirability bias within items related to religious practice could not be entirely eliminated. Another limitation lies in the sample distribution, which did not fully represent all sub-communities of the Island Malay Community, particularly populations within the remote islands of Lingga and smaller islands of Kepri characterized by substantial accessibility barriers. In addition, the MDRO variable within this study was still measured through behavioral prevention proxies and had not yet utilized direct clinical microbiological data, thereby requiring further strengthening of the model's ecological validity through subsequent laboratory-based studies.

Based on these limitations, future research should be directed toward the development of longitudinal designs based on randomized controlled trials (RCTs) to examine the effectiveness of the RCMPM model in reducing MDRO incidence over a minimum period of 12–24 months. The integration of clinical microbiological data as objective outcome variables is likewise necessary to establish more robust evidence regarding the relationship between behavioral change and reductions in MDRO prevalence. Furthermore, exploration of sub-constructs within Islamic medical ethics should be expanded to encompass more specific dimensions of fiqh al-tibb, including the perspectives of contemporary Southeast Asian ulama that have thus far received limited attention within dominant Middle Eastern literature. Comparative studies across Muslim communities such as Javanese, Bugis, or Acehnese populations are also important for evaluating the degree of generalizability of the RCMPM model within the plural and diverse context of Islam Nusantara. Overall, this study successfully developed and validated a hybrid MDRO prevention model by integrating the strengths of clinical pharmacy education and the depth of Islamic medical ethics within a coherent structural framework. These findings not only enrich the literature on nosocomial infection prevention, but also open new perspectives regarding how spiritual values may operate synergistically with clinical science in shaping health behavior change that is more meaningful, sustainable, and contextual within Muslim communities.

Conclusions

This study successfully examined and validated a model for preventing antibiotic resistance in nosocomial Multidrug Resistant Organism (MDRO) infections through the integration of clinical pharmacy education and Islamic medical ethics within the Island Malay Community. Employing a Structural Equation Modeling approach using AMOS 24.0 involving 412 respondents distributed across the regions of Kepri, the eastern coastal area of Sumatra, Johor, and Lingga, the study produced empirical findings that were consistent, robust, and statistically significant. All research hypotheses were accepted at the significance level of $p < 0.001$, with model fit indices indicating an excellent level of fit (CFI = 0.96; RMSEA = 0.048; TLI = 0.94; $\chi^2/df = 2.003$). These findings demonstrate that the integrative model developed in this study is not only conceptually feasible, but also possesses high structural validity in explaining MDRO prevention behavior within Muslim communities of the Malay archipelagic region. Substantively, this study generated four interrelated principal findings. First, clinical pharmacy education exerted a positive and significant effect on MDRO prevention behavior ($\beta = 0.61$), confirming that strengthening clinical pharmacy education constitutes an important component of antibiotic resistance prevention. Second, the internalization of Islamic medical ethics significantly contributed to antibiotic therapy adherence ($\beta = 0.54$), indicating that religious values may function as an important moral and behavioral mechanism in supporting responsible antibiotic use among Muslim communities. Third, the integrated model of clinical pharmacy education and Islamic medical ethics explained 67.3% of the variance in MDRO prevention behavior ($R^2 = 0.673$), demonstrating substantial explanatory power within the study population. Fourth, Islamic medical ethics significantly moderated the relationship between clinical pharmacy education and MDRO prevention behavior, with a stronger association observed among respondents with higher Islamic medical ethics scores than among those with lower scores ($\beta = 0.74$ vs. $\beta = 0.48$; $\Delta\beta = 0.26$, $p = 0.001$). These findings indicate that integrating culturally relevant Islamic ethical values with clinical pharmacy education may strengthen MDRO prevention behavior within Malay Muslim communities. From a practical perspective, healthcare institutions and policymakers in the Island Malay Community may consider incorporating culturally appropriate Islamic medical ethics components into clinical pharmacy education and antimicrobial stewardship initiatives.

From a scientific perspective, this study fills a significant gap within the literature concerning the integration of Islamic spiritual dimensions into behavior-based infection prevention models. The studies conducted by Ventola (2015), Laxminarayan et al. (2013), and Pulcini et al. (2019) provided important contributions regarding pharmacy education and Antimicrobial Stewardship (AMS) programs; however, all remained situated within secular biomedical frameworks that had not incorporated religiosity as a structural variable. Padela et al. (2016) indeed demonstrated the influence of Islamic values on medical decision-making among Muslim patients, yet did not examine these dynamics within the context of MDRO or SEM-based structural models. Therefore, the present study introduces a clear novelty through the development of the Religio-Clinical MDRO Prevention Model (RCMPM), namely the first hybrid model empirically tested within the Island Malay Muslim Community, proving that the integration of spiritual-religious dimensions significantly strengthens the effectiveness of clinical interventions. At the same time, this study also possesses substantial socio-health relevance considering that the Island Malay Community constitutes a region characterized by high cross-border mobility and epidemiological vulnerability to MDRO transmission. The finding that the Lingga region exhibited the lowest MDRO prevention behavior score ($M = 3.31$), which correlated with low clinical pharmacy education capacity, demonstrates the existence of health capacity disparities requiring serious policy attention. Based on the overall findings of the study, several strategic recommendations should be considered. Pharmacy education institutions and health authorities in both Indonesia and Malaysia should develop Antimicrobial Stewardship modules that explicitly integrate the principles of hifz al-nafs, la dharara wa la dhirar, and the concept of tadbir al-sihha into clinical pharmacy education curricula. Such integration has proven not only to enhance the cultural relevance of AMS programs, but also to strengthen intervention effectiveness empirically. Local governments within remote archipelagic regions such as Lingga should likewise receive priority in clinical pharmacy capacity-building programs, considering that the low PFK score within the region correlated directly with weak MDRO prevention behavior. Community-based educational programs involving Islamic religious leaders as agents of social change constitute the most contextual strategy within Malay society. In addition, health authorities along the Batam-Singapore-Johor corridor should establish cross-border MDRO control protocols that consider the socio-cultural characteristics of Malay communities, including mechanisms for epidemiological data exchange and the development of collaborative educational programs grounded in Islamic values.

Ultimately, the crisis of antibiotic resistance cannot be resolved solely through technological and clinical approaches operating independently. The Island Malay Community, with its strong Islamic traditions and distinctive geographical characteristics, requires a prevention model capable of communicating through the living value systems embedded within society itself. This study demonstrates that clinical pharmacy science and Islamic medical ethics are not two separate entities, but rather two forces which, when systematically integrated,

are capable of producing substantially greater preventive capacity against MDRO than when operating partially and independently. The principal contribution of this study lies not merely in the addition of empirical data to the antibiotic resistance literature, but also in its effort to construct a health intervention paradigm that is more holistic, more culturally sensitive, and more relevant to the social realities of the Muslim communities it seeks to serve.

References

AA, M. H., Staatz, C. E., Kirkpatrick, C. M., Lipman, J., & Roberts, J. A. (2011). Continuous infusion vs. bolus dosing: implications for beta-lactam antibiotics. *Minerva Anestesiologica*, *78*(1), 94–104.

Afladhanti, P. M., Simanjuntak, A. M., & Firmansyah, Y. (2024). Tinjauan hukum penjualan antibiotik tanpa resep dokter pada era e-commerce di Indonesia. *Proceeding Masyarakat Hukum Kesehatan Indonesia*, *1*(01), 328–343.

Al-Bar, M. A., & Chamsi-Pasha, H. (2015). *Contemporary bioethics: Islamic perspective*. Springer. https://doi.org/10.1007/978-3-319-18428-9

Alghamdi, S., Shebl, N. A., Aslanpour, Z., Shibl, A., & Berrou, I. (2018). Hospital adoption of antimicrobial stewardship programmes in Gulf Cooperation Council countries: a review of existing evidence. *Journal of Global Antimicrobial Resistance*, *15*, 196–209. https://doi.org/10.1016/j.jgar.2018.07.014

Allegranzi, B., Nejad, S. B., Combescure, C., Graafmans, W., Attar, H., Donaldson, L., & Pittet, D. (2011). Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. *The Lancet*, *377*(9761), 228–241. https://doi.org/10.1016/S0140-6736(10)61458-4

Al-Qaradawi, Y. (2013). *The lawful and the prohibited in Islam: الحلال والحرام في الإسلام*. The Other Press.

Baur, D., Gladstone, B. P., Burkert, F., Carrara, E., Foschi, F., Döbele, S., & Tacconelli, E. (2017). Effect of antibiotic stewardship on the incidence of infection and colonisation with antibiotic-resistant bacteria and Clostridium difficile infection: a systematic review and meta-analysis. *The Lancet Infectious Diseases*, *17*(9), 990–1001. https://doi.org/10.1016/S1473-3099(17)30325-0

Bulus, Y. M., & Abiola, T. (2025). Evidence-based practice adherence and medical error reduction: An Islamic ethical perspective. *IMAN Medical Journal*, *11*(1).

Cassini, A., Högberg, L. D., Plachouras, D., Quattrocchi, A., Hoxha, A., Simonsen, G. S., ... & Hopkins, S. (2019). Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: a population-level modelling analysis. *The Lancet Infectious Diseases, 19*(1), 56–66. https://doi.org/10.1016/S1473-3099(18)30605-4

Christanti, J. V., Setiadi, A. P., Setiawan, E., Presley, B., Halim, S. V., Wardhani, S. A., ... & Wibowo, Y. I. (2024). Community-based approach to promote rational use of antibiotics in Indonesia: the development and assessment of an education program for cadres. *Community Health Equity Research & Policy*, *44*(3), 281–293. https://doi.org/10.1177/2752535X231184029

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge. https://doi.org/10.4324/9780203771587

Dancer, S. J. (2014). Controlling hospital-acquired infection: focus on the role of the environment and new technologies for decontamination. *Clinical Microbiology Reviews*, *27*(4), 665–690. https://doi.org/10.1128/CMR.00020-14

de Kraker, M. E., Stewardson, A. J., & Harbarth, S. (2016). Will 10 million people die a year due to antimicrobial resistance by 2050?. *PLoS Medicine*, *13*(11), e1002184. https://doi.org/10.1371/journal.pmed.1002184

Dellit, T. H., Owens, R. C., McGowan, J. E., Gerding, D. N., Weinstein, R. A., Burke, J. P., ... & Hooton, T. M. (2007). Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clinical Infectious Diseases*, *44*(2), 159–177. https://doi.org/10.1086/510393

Djawaria, D. P., Rokhman, M. R., & colleagues. (2021). Community pharmacies, drug stores, and antibiotic dispensing in Indonesia: A qualitative study. *BMC Public Health*, *21*, Article 1800. https://doi.org/10.1186/s12889-021-11885-4

Dols, M. W. (1988). Essay review: Islam and medicine: Health and medicine in the Islamic tradition: Change and identity. https://doi.org/10.1177/007327538802600404

Farooqui, H. H., Mehta, A., & Selvaraj, S. (2019). Outpatient antibiotic prescription rate and pattern in the private sector in India: evidence from medical audit data. *PloS ONE*, *14*(11), e0224848. https://doi.org/10.1371/journal.pone.0224848

Fathania, D. P., Ernawati, D. K., & colleagues. (2022). The economic impact of carbapenem-resistant non-lactose fermenter and Enterobacteriaceae infections on hospital costs in Dr. Soetomo General Academic Hospital Surabaya, Indonesia. *Antibiotics*, *11*(5), 694. https://doi.org/10.3390/antibiotics11050694

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39–50. https://doi.org/10.1177/002224378101800104

Gandra, S., Joshi, J., Trett, A., Lamkang, A. S., & Laxminarayan, R. (2017). *Scoping report on antimicrobial resistance in India*. Center for Disease Dynamics, Economics & Policy.

Hadi, U., van den Broek, P., Kolopaking, E. P., Zairina, N., Gardjito, W., Gyssens, I. C., & Study Group Antimicrobial Resistance in Indonesia: Prevalence and Prevention. (2010). Cross-sectional study of availability and pharmaceutical quality of antibiotics requested with or without prescription (over the counter) in Surabaya, Indonesia. *BMC Infectious Diseases*, *10*, Article 203. https://doi.org/10.1186/1471-2334-10-203

Harbarth, S., Balkhy, H. H., Goossens, H., Jarlier, V., Kluytmans, J., Laxminarayan, R., ... & World Healthcare-Associated Infections Resistance Forum participants. (2015). Antimicrobial resistance: one world, one fight!. *Antimicrobial Resistance and Infection Control*, *4*(1), 49. https://doi.org/10.1186/s13756-015-0091-2

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Iskandar, K., Molinier, L., Hallit, S., Sartelli, M., Hardcastle, T. C., Haque, M., ... & Roques, C. (2021). Surveillance of antimicrobial resistance in low-and middle-income countries: a scattered picture. *Antimicrobial Resistance & Infection Control*, *10*(1), 63. https://doi.org/10.1186/s13756-021-00931-w

Kadri, S. S. (2020). Key takeaways from the US CDC's 2019 antibiotic resistance threats report for frontline providers. *Critical Care Medicine*, *48*(7), 939–945. https://doi.org/10.1097/CCM.0000000000004371

Kline, R. B. (2023). *Principles and practice of structural equation modeling*. Guilford Publications.

LaPlante, K., Cunha, C., Morrill, H., Rice, L., & Mylonakis, E. (Eds.). (2016). *Antimicrobial stewardship: principles and practice*. CABI. https://doi.org/10.1079/9781780644394.0000

Laxminarayan, R., Duse, A., Wattal, C., Zaidi, A. K., Wertheim, H. F., Sumpradit, N., ... & Cars, O. (2013). Antibiotic resistance-the need for global solutions. *The Lancet Infectious Diseases*, *13*(12), 1057–1098. https://doi.org/10.1016/S1473-3099(13)70318-9

Laxminarayan, R., & Heymann, D. L. (2012). Challenges of drug resistance in the developing world. *BMJ*, *344*. https://doi.org/10.1136/bmj.e1567

Lim, C., Takahashi, E., Hongsuwan, M., Wuthiekanun, V., Thamlikitkul, V., Hinjoy, S., ... & Limmathurotsakul, D. (2016). Epidemiology and burden of multidrug-resistant bacterial infection in a developing country. *eLife*, *5*, e18082. https://doi.org/10.7554/eLife.18082.022

Limato, R., Broom, A., Nelwan, E. J., Primasari, I., Fathima, P., Juniman, J., & Hamers, R. L. (2022). A qualitative study of barriers to antimicrobial stewardship in Indonesian hospitals: Governance, competing interests, cost, and structural vulnerability. *Antimicrobial Resistance & Infection Control*, *11*, Article 85. https://doi.org/10.1186/s13756-022-01126-7

Livermore, D. M. (2012). Current epidemiology and growing resistance of gram-negative pathogens. *The Korean Journal of Internal Medicine*, *27*(2), 128. https://doi.org/10.3904/kjim.2012.27.2.128

Lutfiyati, H., Ikawati, Z., Atthobari, J., & Yasin, N. M. (2021). Pharmacists' knowledge, perception and practice on antibiotic stewardship: A survey in Indonesia. *Proceedings of the 2nd Borobudur International Symposium on Humanities and Social Sciences*. https://doi.org/10.4108/eai.18-11-2020.2311802

Mohiuddin, A. K. (2019). Pharmacist-led antimicrobial stewardship. *ACTA Scientific Medical Sciences*. https://doi.org/10.32474/LOJPCR.2019.01.000117

Murray, C. J., Ikuta, K. S., Sharara, F., Swetschinski, L., Aguilar, G. R., Gray, A., ... & Tasak, N. (2022). Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*, *399*(10325), 629–655. https://doi.org/10.1016/S0140-6736(21)02724-0

Murtagh, F., & Heck, A. (2012). *Multivariate data analysis*. Springer Science & Business Media.

Negara, K. S. (2014). Analisis implementasi kebijakan penggunaan antibiotika rasional untuk mencegah resistensi antibiotika di RSUP Sanglah Denpasar: Studi kasus infeksi methicillin resistant Staphylococcus aureus. *Jurnal ARSI: Administrasi Rumah Sakit Indonesia*, *1*(1), 6. https://doi.org/10.7454/arsi.v1i1.2169

O'Neill, J. (2016). *Tackling drug-resistant infections globally: final report and recommendations*.

Oh, A. L., Hassali, M. A., Al-Haddad, M. S., Sulaiman, S. A. S., Shafie, A. A., & Awaisu, A. (2011). Public knowledge and attitudes towards antibiotic usage: a cross-sectional study among the general public in the state of Penang, Malaysia. *The Journal of Infection in Developing Countries*, *5*(05), 338–347. https://doi.org/10.3855/jidc.1502

Padela, A. I. (2007). Islamic medical ethics: a primer. *Bioethics*, *21*(3), 169–178. https://doi.org/10.1111/j.1467-8519.2007.00540.x

Padela, A. I., Gunter, K., Killawi, A., & Heisler, M. (2012). Religious values and healthcare accommodations: voices from the American Muslim community. *Journal of General Internal Medicine*, *27*(6), 708–715. https://doi.org/10.1007/s11606-011-1965-5

Padela, A. I., & Zaidi, D. (2018). The Islamic tradition and health inequities: A preliminary conceptual model based on a systematic literature review of Muslim health-care disparities. *Avicenna Journal of Medicine*, *8*(01), 1–13. https://doi.org/10.4103/ajm.AJM_134_17

Permenkes, R. I. (2017). *Pedoman pencegahan dan pengendalian infeksi di fasilitas pelayanan kesehatan no 27*. Permenkes RI.

Pulcini, C., Morel, C. M., Tacconelli, E., Beovic, B., De With, K., Goossens, H., ... & Mendelson, M. (2017). Human resources estimates and funding for antibiotic stewardship teams are urgently needed. *Clinical Microbiology and Infection*, *23*(11), 785–787. https://doi.org/10.1016/j.cmi.2017.07.013

Pulcini, C., Wencker, F., Frimodt-Møller, N., Kern, W. V., Nathwani, D., Rodríguez-Baño, J., ... & Healy, B. (2015). European survey on principles of prudent antibiotic prescribing teaching in undergraduate students. *Clinical Microbiology and Infection*, *21*(4), 354–361. https://doi.org/10.1016/j.cmi.2014.11.015

Rawson, T. M., Moore, L. S., Zhu, N., Ranganathan, N., Skolimowska, K., Gilchrist, M., ... & Holmes, A. (2020). Bacterial and fungal coinfection in individuals with coronavirus: a rapid review to support COVID-19 antimicrobial prescribing. *Clinical Infectious Diseases*, *71*(9), 2459–2468. https://doi.org/10.1093/cid/ciaa530

Roos, N. A. C., Bakar, M. A., & Haque, M. (2019). Knowledge, attitude and practice among Malaysian medical students, doctors, other health professionals and common people regarding antibiotic use, prescribing and resistance: A systematic review. *Advances in Human Biology*, *9*(3), 179–183. https://doi.org/10.4103/AIHB.AIHB_42_19

Saharman, Y. R., Karuniawati, A., Sedono, R., Aditianingsih, D., Qi, H., Verbrugh, H. A., & Severin, J. A. (2021). Multimodal intervention to reduce acquisition of carbapenem-non-susceptible Gram-negative bacteria in intensive care units in the national referral hospital of Indonesia: An interrupted time series study. *Journal of Critical Care*, *64*, 237–244. https://doi.org/10.1016/j.jcrc.2021.04.016

Sartelli, M., Guirao, X., Hardcastle, T. C., Kluger, Y., Boermeester, M. A., Raşa, K., ... & Catena, F. (2018). 2018 WSES/SIS-E consensus conference: recommendations for the management of skin and soft-tissue infections. *World Journal of Emergency Surgery*, *13*(1), 58. https://doi.org/10.1186/s13017-018-0219-9

Setiawan, E., Wibowo, Y. I., Setiadi, A. A. P., Nurpatria, Y. A., Sosilya, H., Wardhani, D. K., ... & Roberts, J. (2019). Implementasi antimicrobial stewardship program di kawasan Asia: Sebuah kajian sistematis. *Jurnal Farmasi Klinik Indonesia*, *8*(2), 141–156. https://doi.org/10.15416/ijcp.2019.8.2.141

Shahab, S. N., Karuniawati, A., Syarif, O. M., Saharman, Y. R., Sinto, R., & Sudarmono, P. P. (2024). Multidrug-resistant bacteria colonization in patients admitted to Dr. Cipto Mangunkusumo Hospital Jakarta, Indonesia. *Acta Medica Indonesiana*, *56*(2), 191–198.

Sinto, R. (2024). *Antimicrobial-resistant infections, and diagnostic and antimicrobial stewardship practices in inpatients in Indonesia* (Doctoral dissertation, University of Oxford).

Sumpradit, N., Chongtrakul, P., Anuwong, K., Pumtong, S., Kongsomboon, K., Butdeemee, P., ... & Tangcharoensathien, V. (2012). Antibiotics Smart Use: a workable model for promoting the rational use of medicines in Thailand. *Bulletin of the World Health Organization*, *90*, 905–913. https://doi.org/10.2471/BLT.12.105445

Tacconelli, E., Carrara, E., Savoldi, A., Harbarth, S., Mendelson, M., Monnet, D. L., ... & Zorzet, A. (2018). Discovery, research, and development of new antibiotics: the WHO priority list of antibiotic-resistant bacteria and tuberculosis. *The Lancet Infectious Diseases*, *18*(3), 318–327. https://doi.org/10.1016/S1473-3099(17)30753-3

Tan, E. C., Stewart, K., Elliott, R. A., & George, J. (2014). Pharmacist services provided in general practice clinics: a systematic review and meta-analysis. *Research in Social and Administrative Pharmacy*, *10*(4), 608–622. https://doi.org/10.1016/j.sapharm.2013.08.006

Taplitz, R. A., Ritter, M. L., & Torriani, F. J. (2016). Infection prevention and control, and antimicrobial stewardship. *Infectious Diseases*, 54. https://doi.org/10.1016/B978-0-7020-6285-8.00006-X

Teng, C., Achike, F. I., Phua, K. L., Norhayati, Y., Nurjahan, M. I., Nor, A. H., & Koh, C. N. (2004). General and URTI-specific antibiotic prescription rates in a Malaysian primary care setting. *International Journal of Antimicrobial Agents*, *24*(5), 496–501. https://doi.org/10.1016/j.ijantimicag.2004.06.015

Thabit, A. K., Crandon, J. L., & Nicolau, D. P. (2015). Antimicrobial resistance: impact on clinical and economic outcomes and the need for new antimicrobials. *Expert Opinion on Pharmacotherapy*, *16*(2), 159–177. https://doi.org/10.1517/14656566.2015.993381

Van Boeckel, T. P., Gandra, S., Ashok, A., Caudron, Q., Grenfell, B. T., Levin, S. A., & Laxminarayan, R. (2014). Global antibiotic consumption 2000 to 2010: an analysis of national pharmaceutical sales data. *The Lancet Infectious Diseases*, *14*(8), 742–750. https://doi.org/10.1016/S1473-3099(14)70780-7

Ventola, C. L. (2015). The antibiotic resistance crisis: part 1: causes and threats. *Pharmacy and Therapeutics*, *40*(4), 277.

Ventola, C. L. (2015). The antibiotic resistance crisis: part 2: management strategies and new agents. *Pharmacy and Therapeutics*, *40*(5), 344.

Walia, K., Madhumathi, J., Veeraraghavan, B., Chakrabarti, A., Kapil, A., Ray, P., ... & Ohri, V. C. (2019). Establishing antimicrobial resistance surveillance & research network in India: journey so far. *Indian Journal of Medical Research*, *149*(2), 164–179. https://doi.org/10.4103/ijmr.IJMR_226_18

WHO. (2015). *Global action plan on antimicrobial resistance*. World Health Organization.

Widayati, A., Suryawati, S., de Crespigny, C., & Hiller, J. E. (2011). Self medication with antibiotics in Yogyakarta City Indonesia: A cross-sectional population-based survey. *BMC Research Notes*, *4*, 491. https://doi.org/10.1186/1756-0500-4-491

World Health Organization. (2019). *Antimicrobial stewardship programmes in health-care facilities in low-and middle-income countries: a WHO practical toolkit*. World Health Organization.

World Health Organization. (2022). *Global antimicrobial resistance and use surveillance system (GLASS) report 2022*. World Health Organization.