Original Article

Validation study of the modified Drug Resistance in Pneumonia (mDRIP) score in identifying infections with drug-resistant pathogens among hospitalized patients with community-acquired pneumonia at the Chinese General Hospital and Medical Center

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ABSTRACT

Background: Community-acquired pneumonia (CAP) continues to be the leading cause of infection-related deaths globally and is the fourth leading cause of both morbidity and mortality in the Philippines. Despite the development of novel vaccines, antibiotics, and rapid diagnostic tests, managing CAP remains challenging, especially with the emergence of drug-resistant pathogens (DRP). The modified Drug Resistance in Pneumonia (mDRIP) score is a scoring system which was derived from locally-relevant clinical risk factors that can predict infections with DRP. The performance of mDRIP score in identifying infections with DRP among patients with CAP was evaluated in this cross-sectional study.

Methodology: A total of 127 participants with CAP were included. The mDRIP score was calculated upon admission. Antimicrobial culture results were later obtained and clinical outcomes were ascertained. The mDRIP score performance was assessed by determining the relevant performance metrics using area under the receiver operating characteristic curve (AUC-ROC). Clinical outcomes were compared between patients with DRP and those without.

Results: The prevalence of drug-resistant pathogens in the study was 40.16%. The most common organism isolated was *Klebsiella pneumoniae*. Among the major and minor risk factors for drug resistance included in the mDRIP score, the most common were recent antibiotic use (46.46%) and poor functional status (47.24%), respectively. The discrimination performance of the mDRIP score was good, with an AUC-ROC value of 0.868 (95% CI 0.801 to 0.935). There was no statistically significant difference in the length of hospital stay and hospital outcome between those with and without DRP.

Conclusions: The mDRIP score demonstrates good performance in identifying infections due to DRP in CAP. It is an accessible and effective risk stratification tool that can be utilized by clinicians for appropriate selection of antibiotics in CAP, especially in resource-limited settings.

Keywords: mDRIP score, community-acquired pneumonia, drug resistance, validation study

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INTRODUCTION

Community-acquired pneumonia (CAP) remains the leading cause of infection-related mortality globally.[1] The high incidence, hospitalization, and mortality rates impose a huge burden—including physical, psychological, and especially economic—to patients and their families. This problem is especially magnified in developing countries.[2]

CAP is a significant public health concern in the Philippines, ranking 4th in the leading cause of mortality as of 2024.[3] It places a heavy burden on healthcare resources, with PhilHealth data showing an economic impact of PhP 8.48 billion for moderate-risk cases and PhP 643.76 million for high-risk cases, and this is increasing up to the present time.[4]

CAP has recently been linked to the emergence of drug-resistant pathogens (DRP).[5] DRP is defined based on the results of sputum cultures and antibiotic susceptibility tests showing resistance to non-pseudomonal beta-lactam antibiotics (ceftriaxone, cefotaxime, ampicillin-sulbactam) as well as to respiratory fluoroquinolones (levofloxacin, moxifloxacin). DRPs require different antibiotics compared to the initial empiric antibiotics recommended in the guidelines for community-acquired pneumonia.[6] It has been found that the prevalence of DRP in community-acquired pneumonia differs across regions—20.0 to 45.2% in America, 5.9 to 33.0% in Europe, and 7.2 to 36.0% in the Asia Pacific region.[7] For Southeast Asia, data from Indonesia is 40.6%.[8]

The DRIP (Drug Resistance In Pneumonia) score published by Webb et al in 2016 is a model that predicts the risk of acquiring pneumonia due to drug-resistant pathogens. At a threshold of 4 points, the DRIP score demonstrated sensitivity of 0.82, specificity of 0.81, positive predictive value (PPV) of 0.68, and negative predictive value (NPV) of 0.90.[9] In comparison with other prediction models such as the Schreiber, Schorr, Niedermann, Shindo, Aliberti, Park, PES (*P. aeruginosa*, extended-spectrum β-lactamase-positive *Enterobacteriaceae*, and methicillin-resistant *Staphylococcus aureus* [MRSA]), and HCAP (healthcare-associated pneumonia) scores, the DRIP score performed significantly better in detecting the risk of pneumonia due to drug-resistant pathogens.[9] Further, it has been validated to be effective in guiding the appropriate use of broad-spectrum antibiotics in community-acquired pneumonia. A study done by Farkas et al concluded that the application of the DRIP score in patients suffering from CAP succeeded in reducing the use of broad-spectrum antibiotics.[10] The DRIP score consists of 10 risk factors associated with DRP. Major risk factors are: history of antibiotic use (prior 60 days), residence in a long-term care facility, enteral nutrition, and history of infection with a drug-resistant pathogen (prior 12 months). Minor risk factors are:

history of hospitalization (an inpatient hospital stay for more than 48 hours within the prior 60 days), chronic lung disease (defined as chronic obstructive, interstitial, or other structural disease, including bronchiectasis), poor functional status (defined as a Karnofsky score of less than 70 or non-ambulatory status), gastric acid suppression, wound care, and history of MRSA colonization (prior 12 months). A score of less than 4 is classified as low risk and a score of 4 and above is classified as high risk.[9]

In the Philippines, a study by Villalobos et al validated the DRIP score in a tertiary hospital, with results showing high specificity, thus, making it an efficient tool for antibiotic selection in clinical practice. This was comparable to the specificity of 81% observed in the study of Webb et al. Sensitivity, however, was only 62.1% compared to the 82% by Webb et al which was attributed by the investigators to the unavailability of prior infection records for patients who were admitted in other (i.e., outside) hospitals.[9,11] One noteworthy drawback identified by the investigators was the inapplicability of one of the major risk factors in the DRIP score, namely, residence in a long-term care facility as such is not a common practice in the country. This may affect the applicability of the DRIP score in our setting as previous studies had derived the cut-off point of 4 and computed the accuracy of the DRIP score with this component factored in. Thus, a modified DRIP (mDRIP) score eliminating residence in a long-term care facility as one of the major risk factors was evaluated by Villalobos et al. At the same cut-off value, results showed similar sensitivity and specificity with the original DRIP score.[11]

As the microbiology of CAP continues to evolve, predicting the risk of drug-resistant infections remains challenging, highlighting the need for better prediction methods. Generally, the DRIP score may help clinicians avoid unnecessary use of broad-spectrum antibiotics in patients with "low-risk" pneumonia. Moreover, it can help in selecting patients who can benefit from initiating broad-spectrum antibiotics in those with "high-risk" pneumonia. The mDRIP score is most relevant as it reflects the risk factors that are applicable in the local setting. Villalobos et al recommended further studies tailoring the risk factors of the DRIP score based on the local situation. Lastly, Webb et al and Villalobos et al recommended doing prospective implementation studies to determine the role of this prediction tool using patient outcomes as the measured endpoint.[9,11]

Hence, this study aimed to determine the validity of the mDRIP score in identifying infections due to drug-resistant pathogens among hospitalized adult patients with CAP at the Chinese General Hospital and Medical Center (CGHMC). Specifically, the study aimed to 1) determine the demographic and clinical profile of patients; 2) determine the prevalence of pneumonia due to DRP; 3) compare mDRIP scores and its individual components between those with and without DRP; 4) determine the accuracy, sensitivity, specificity, predictive values, and likelihood ratios of the mDRIP score in identifying infections with DRP; and 5) compare length of hospital stay and hospital outcome between those with and without DRP.

METHODOLOGY

Study design

This was a single-center cross-sectional study.

Study setting

The study was conducted at the Chinese General Hospital and Medical Center, a level IV tertiary healthcare institution in the Philippines with over 700-bed capacity.

Study population

Participants were adult patients (aged 18 years and above) with moderate- to high-risk CAP admitted from June 2024 to December 2024.

Excluded patients were those with incomplete data, inadequate quality of culture samples, cultures taken more than 48 hours post-admission, or those that reported no growth or yielded positive results for fungal growth. Cultures with sputum as specimen source were also excluded if a second, alternative pathogen was concomitantly recovered from a specimen collected by invasive means (blood or bronchoalveolar fluid). Cultures from blood were also excluded if bacteremia was from a more likely alternate source, such as the urinary tract.

Ethical considerations

The study was conducted in compliance with the ethical principles set forth in the Declaration of Helsinki and the National Ethical Guidelines for Research Involving Human Participants (NEGRIHP) 2022. Review and approval of the study protocol by the Chinese General Hospital and Medical Center Research Ethics Review Board (CGHMC RERB) were sought prior to study initiation (CGHMC RERB 2024-F-15).

Patient information and results of the study were kept strictly confidential by the primary author in compliance with the Data Privacy Act of 2012. Each participant was issued a unique code, hence, their names did not appear in any of the data collection tools. The data was stored in the primary investigator's database which was password-protected.

Study procedure

Eligible participants were patients with community-acquired pneumonia who were admitted or referred from either the ward or the emergency room. Informed consent was obtained from all the participating patients or their consenting party at the site of recruitment.

Pneumonia was defined based on criteria consistent with the Infectious Diseases Society of America/American Thoracic Society (IDSA/ATS) Clinical Pathway for CAP. This pertains to the presence of two or more clinical signs or symptoms—temperature <36.0°C or >38.0°C; respiratory rate >20 breaths per minute; room air oxygen saturation <90%; partial pressure of oxygen in arterial blood <60 mm Hg; cough; sputum production; white blood cell count <4,000/ul or >10,000/ul; or bandemia >10%—plus radiographic evidence of new parenchymal opacity or cavitation.

After obtaining consent, history taking was conducted with the patient, relative, or caregiver to collect demographic and clinical data, including risk factors for drug resistance. Particularly, the following data were collected for the mDRIP score: for the major risk factors—recent antibiotic use (use of any intravenous or oral antibiotics within the preceding 60 days prior to hospital admission); presence of tube feeding (includes nasogastric or jejunal feeding or feeding via a percutaneous gastrostomy tube); and prior drug-resistant pneumonia diagnosis within one year (a documented episode of pneumonia caused by a drug-resistant pathogen occurring within 12 months prior to hospital admission); while for the minor risk factors—prior hospitalization (an inpatient stay of more than 48 hours in the preceding 60 days); chronic

obstructive pulmonary disease (includes both clinically-diagnosed and those diagnosed through pulmonary function testing); functional status (evaluated using Karnofsky performance status); gastric acid suppression (intake of any histamine-2 receptor antagonist or any proton pump inhibitor within 14 days of admission); presence of an active wound (any type of open wound at the time of hospital admission); and methicillin-resistant *Staphylococcus aureus* (MRSA) colonization (either colonization or clinical infection with MRSA documented within the 12-month period preceding hospital admission). The mDRIP score, or the index test, was determined within 48 hours of admission. A score of at least 4 (2 major risk factors; 1 major risk factor plus 2 minor risk factors; or 4 minor risk factors) was classified as having high probability of pneumonia due to DRP, while a score of less than 4 was classified as having low probability. Notably, the mDRIP score does not include long-term care residency seen in the original DRIP score, as a component.

Microbiologic cultures were taken at baseline, with results typically available after 48 to 72 hours' incubation period. Cultures taken from any of the following sites—sputum, endotracheal aspirate, pleural fluid, bronchoalveolar lavage, or blood—were reviewed for the presence of drug-resistant pathogens and served as the reference standard. Chest X-rays were retrieved through the hospital information system, MERX™.

The process flow is seen in Figure 1.

Sample size

Sample size computation for a receiver operating characteristic (ROC) curve was conducted using PASS 2008 version 8.0.15. From the study of Oliver et al,[12] the estimated lower bound of the 95% confidence interval for the area under the receiver operating characteristic curve (AUC-ROC) of the mDRIP score in predicting drug-resistant pathogens was 0.690 (AUC_1). A null AUC (AUC_0) of 0.70 was employed as recommended by

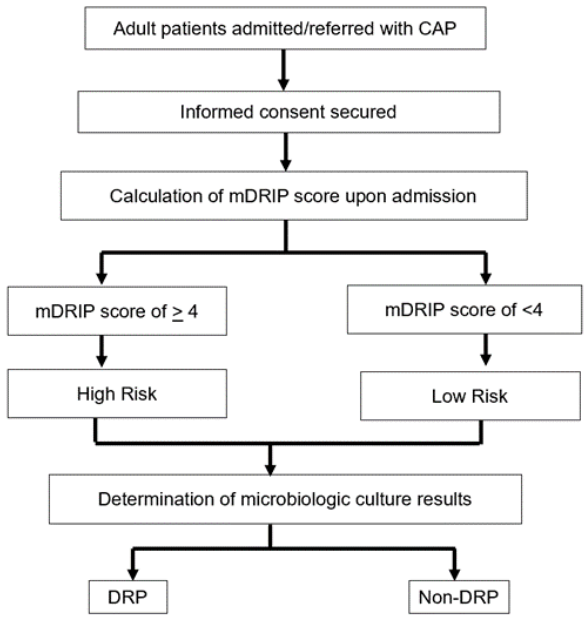

Figure 1. Schematic diagram of the data collection process. CAP: community-acquired pneumonia. mDRIP: modified Drug Resistance in Pneumonia; DRP: drug-resistant pathogen

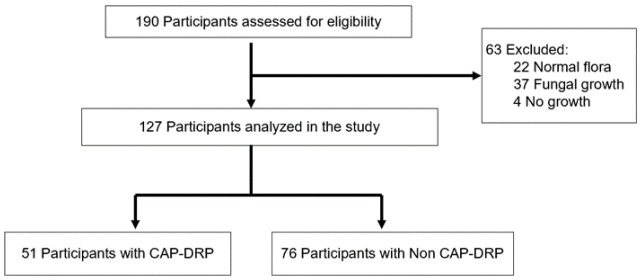

Figure 2. Participant flow chart

Hamilton.[13] With AUC_0 of 0.800, AUC_1 of 0.690, minimum power of 80%, and significance level of 5% (two-tailed), a total of 166 participants was necessary.

Data management and analysis

Statistical analyses were performed using Stata version 18, with significance set at a p-value of ≤0.05. Descriptive statistics summarized the data obtained while comparative analyses assessed differences in the patient characteristics and outcomes examined based on the presence or absence of drug-resistant pathogens using chi-square test of homogeneity or Fisher's exact test, Mann-Whitney U test, and independent t-test. The prevalence of pneumonia with drug-resistant pathogens was estimated alongside its 95% confidence interval (CI) using chi-square test exact binomial.

The AUC-ROC was employed to determine the psychometric properties of the mDRIP score in identifying infections with drug-resistant pathogens. This statistical test determined the discriminative ability of the mDRIP score in identifying the outcome, and was represented using the concordance (c) statistic or the AUC-ROC statistic. The sensitivity, specificity, predictive values, and likelihood ratios of the mDRIP score at a cut-off of 4 were also determined.

RESULTS

Demographic and clinical characteristics

As shown in Figure 2, a total of 190 participants were assessed for eligibility; sixty-three were removed based on the exclusion criteria. A total of 127 participants were deemed eligible and included in the study.

The demographic characteristics of the participants according to microbiologic culture status are presented in Table 1. The prevalence of drug-resistant pathogens in CAP was 40.16%. The median age of the participants was 73.00 years, and the majority were males (57.48%), non-smokers (61.42%), and had hypertension (50.39%) and diabetes mellitus (34.65%) as comorbidities. Comparative analyses showed that the median age of those with DRP was significantly higher than those without (80.00 vs 66.50 years; p = 0.001). Neurologic disease and cognitive impairment were more common in those with DRP (p = 0.007 and 0.038, respectively).

Microbiologic data and antimicrobial use

As seen in Table 2, the most common specimen type was sputum (85.04%). The most prevalent microorganism isolated was *Klebsiella pneumoniae* (29.13%), and the most commonly administered initial antibiotic was piperacillin-tazobactam (58.27%).

Comparison of mDRIP score and its components

As presented in Table 3, the median mDRIP score was 3.00 and

Table 1. Demographic and clinical characteristics of participants (n = 127)

	Total (N = 127)	With DRP (n = 51)	Without DRP (n = 76)	Test statistic[a]	p-value
Age, years (median [IQR])	73.00 [60.00 to 82.00]	80.00 [68.00 to 86.00]	66.50 [56.50 to 79.00]	-3.40*	0.001
Sex				0.06	0.802
Male	73 (57.48)	30 (58.82)	43 (56.58)		
Female	54 (42.52)	21 (41.18)	33 (43.42)		
Smoking history				2.48	0.463
Non-smoker	78 (61.42)	32 (62.75)	46 (60.53)		
Previous smoker	47 (37)	18 (35.29)	29 (38.16)		
Second-hand smoker	2 (1.57)	1 (1.96)	1 (1.32)		
Comorbidities					
Diabetes mellitus	44 (34.65)	17 (33.33)	27 (35.53)	0.06	0.799
Hypertension	64 (50.39)	31 (60.78)	33 (43.42)	3.68	0.055
Atrial fibrillation	4 (3.15)	2 (3.92)	2 (2.63)	0.17	1.000
Heart failure	4 (3.15)	0 (0.00)	4 (5.26)	2.77	0.148
Dyslipidemia	3 (2.36)	1 (1.96)	2 (2.63)	0.06	1.000
Chronic lung disease	39 (30.71)	16 (31.37)	23 (30.26)	0.02	1.000
Chronic kidney disease	11 (8.66)	6 (11.76)	5 (6.58)	1.04	0.347
Pulmonary tuberculosis	24 (18.90)	9 (17.65)	15 (19.74)	0.09	0.768
Neurologic disease	23 (18.1)	15 (29.41)	8 (10.53)	7.34*	0.007
Cognitive impairment	6 (4.72)	5 (9.80)	1 (1.32)	4.89*	0.038
Rheumatic arthritis	1 (0.79)	0 (0.00)	1 (1.32)	0.68	1.000
Malignancy	25 (19.69)	12 (23.53)	13 (17.11)	0.80	0.372

*Data presented as n (%) unless otherwise stated.
[a]Comparative analyses were conducted using chi-square test of homogeneity or Fisher's exact test (for Sex, Smoking status, and Comorbidities); and Mann-Whitney U test (for Age).
*Significant at 0.05
DRP: drug-resistant pathogen

most participants were categorized as low risk (61.42%). Among the major risk factors in the mDRIP, the most commonly seen was recent antibiotic use (46.46%) while among the minor risk factors, poor functional status (47.24%) was the most prevalent.

Comparative analyses showed that the median mDRIP score and the proportion of patients classified as high risk were significantly higher among those with DRP (p = 0.001 for both). Recent antibiotic use, enteral nutrition, recent hospitalization, poor functional status, and gastric acid suppression were also encountered more commonly in the DRP group (p <0.05).

Comparison of clinical outcomes

Table 4 shows that the median length of hospital stay was 8.00 days and most participants were discharged (88.98%). Length of hospital stay and hospital outcome were not significantly different in those with and without DRP (p >0.05).

Table 2. Microbiologic data and antimicrobial use for all participants

	n (%)
Specimen type	
Sputum	108 (85.04)
Throat swab	1 (0.79)
Endotracheal aspirate	9 (7.09)
Tracheal aspirate	8 (6.30)
Bronchoalveolar lavage aspirate	1 (0.79)
Isolated microorganism	
Achromobacter species	1 (0.79)
Acinetobacter baumannii	11 (8.66)
Acinetobacter iwoffii	1 (0.79)
Alcaligenes faecalis	2 (1.57)
Citrobacter koseri	2 (1.57)
Enterobacter cloacae	7 (5.51)
Escherichia coli	8 (6.3)
Klebsiella aerogenes	2 (1.57)
Klebsiella oxytoca	1 (0.79)
Klebsiella pneumoniae	37 (29.13)
Proteus mirabilis	2 (1.57)
Pseudomonas fluorescens	2 (1.57)
Pseudomonas aeruginosa	15 (11.81)
Rothia mucilaginosa	1 (0.79)
Serratia marcescens	6 (4.72)
Staphylococcus aureus	7 (5.51)
Staphylococcus epidermidis	2 (1.57)
Staphylococcus haemolyticus	2 (1.57)
Stenotrophomonas maltophilia	6 (4.72)
Streptococcus mitis	1 (0.79)
Streptococcus oralis	1 (0.79)
ESBL *K. pneumoniae*	2 (1.57)
ESBL *S. haemolyticus*	1 (0.79)
Methicillin-resistant *S. aureus* (MRSA)	1 (0.79)
Methicillin-resistant *S. epidermidis* (MRSE)	3 (2.36)
Multidrug-resistant and carbapenemase-producing *E. coli*	1 (0.79)
Multidrug-resistant and carbapenemase-producing *K. oxytoca*	1 (0.79)
Multidrug-resistant and carbapenemase-producing *P. aeruginosa*	1 (0.79)
Initial antibiotic	
Azithromycin	22 (17.32)
Cefepime	5 (3.94)
Ceftazidime	8 (6.30)
Ceftazidime-avibactam	1 (0.79)
Ceftriaxone	29 (22.83)
Ceftriaxone-sulbactam	1 (0.79)
Ciprofloxacin	2 (1.57)
Clindamycin	9 (7.09)
Ertapenem	1 (0.79)
Levofloxacin	3 (2.36)
Meropenem	4 (3.15)
Piperacillin-tazobactam	74 (58.27)

ESBL: extended spectrum beta-lactamase

Diagnostic accuracy indices of the mDRIP

Based on the AUC-ROC, the mDRIP score was shown to have an

Table 3. Comparison of mDRIP and its components according to microbiologic

	Total (N = 127)	With DRP (n = 51)	Without DRP (n = 76)	Test statistic[a]	p-value
mDRIP score (median [IQR])	3.00 [2.00 to 4.00]	4.00 [4.00 to 5.00]	2.00 [1.00 to 3.00]	-7.13*	0.001
mDRIP risk stratification				62.87*	0.001
Low risk (mDRIP <4)	78 (61.42)	10 (19.61)	68 (89.47)		
High risk (mDRIP ≥4)	49 (38.58)	41 (80.39)	8 (10.53)		
Major risk factors					
Recent antibiotic use	59 (46.46)	33 (64.71)	26 (34.21)	11.41*	0.001
Enteral nutrition	37 (29.13)	24 (47.06)	13 (17.11)	13.26*	0.001
Prior infection with DRP	2 (1.57)	2 (3.92)	0 (0.00)	3.03	0.159
Minor risk factors					
Recent hospitalization	26 (20.47)	17 (33.33)	9 (11.84)	8.66*	0.003
Chronic pulmonary disease	35 (27.56)	18 (35.29)	17 (22.37)	2.55	0.110
Poor functional status	60 (47.24)	36 (70.59)	24 (31.58)	18.63*	0.001
Gastric acid suppression	37 (29.13)	25 (49.02)	12 (15.79)	16.32*	0.001
Wound care	1 (0.79)	0 (0.00)	1 (1.32)	0.068	1.000
MRSA colonization	0 (0.00)	0 (0.00)	0 (0.00)	—	—

Data presented as n (%) unless otherwise stated.
[a]Comparative analyses were conducted using chi-square test of homogeneity or Fisher's exact test (for Major and Minor risk factors, mDRIP risk stratification); and Mann-Whitney U test (for mDRIP score).
*Significant at 0.05
DRP: drug-resistant pathogen; MRSA: methicillin-resistant *S. aureus*

Table 4. Comparison of clinical outcomes according to microbiologic status

	Total (N = 127)	With DRP (n = 51)	Without DRP (n = 76)	Test statistic[a]	p-value
Length of hospital stay, days (median [IQR])	8.00 [7.00 to 14.00]	9.00 [7.00 to 15.00]	8.00 [6.50 to 11.00]	-0.90	0.371
Hospital outcome				0.05	0.827
Discharged	113 (88.98)	45 (88.24)	68 (89.47)		
Expired	14 (11.02)	6 (11.76)	8 (10.53)		

Data presented as n (%) unless otherwise stated.
[a]Comparative analyses were conducted using chi-square test of homogeneity or Fisher's exact test (for Major and Minor risk factors, mDRIP risk stratification); and Mann-Whitney U Test (for mDRIP score).
*Significant at 0.05
DRP: drug-resistant pathogen; MRSA: *methicillin-resistant S. aureus*

accuracy of 0.868 (Figure 3). At a cut-off of 4, risk stratification via mDRIP had a sensitivity and specificity of 80.40% and 89.50%, respectively. The estimated positive predictive value (PPV) was 83.70% and the negative predictive value (NPV) was 87.20%. The positive likelihood ratio (LR+) was 7.64 while the negative likelihood ratio (LR–) was 0.219.

Table 5. Accuracy indices of mDRIP in identifying drug-resistant pathogens in CAP

	Calculation	Value, %	95% CI, %
Accuracy	---	0.868	0.801 to 0.935
Sensitivity	41/51	80.40%	66.90 to 90.20
Specificity	68/76	89.50%	80.30 to 95.30
Positive predictive value	41/49	83.70%	70.30 to 92.70
Negative predictive value	68/78	87.20%	77.70 to 93.70
Positive likelihood ratio	(41/51)/(8/76)	7.64	3.91 to 14.90
Negative likelihood ratio	(10/51)/(68/76)	0.219	0.125 to 0.384
Youden's index	---	0.699	---

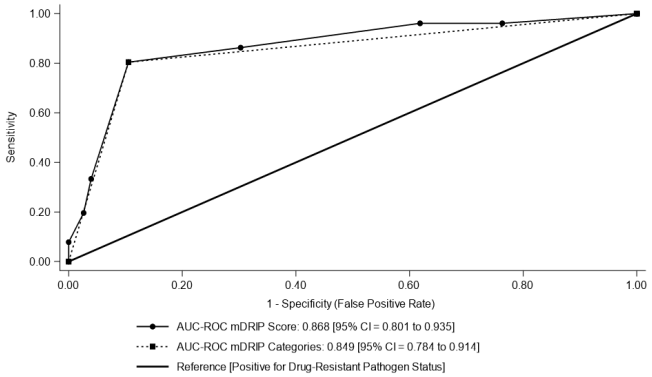

Figure 3. Area under the receiver operating characteristic curve (AUC-ROC) of mDRIP in identifying drug-resistant pathogens in CAP

DISCUSSION

This single-center cross-sectional study validated the utility of the modified DRIP (mDRIP) clinical prediction score for identifying pneumonia due to drug-resistant pathogens. The mDRIP score is a modified version of the original DRIP score which was tailored based on well-established host risk factors in the local setting. At a cut-off of 4, the mDRIP categorized patients as high risk or low risk. With an AUC-ROC of 0.8680 (95% CI 0.801 to 0.935), mDRIP showed good performance in identifying infections due to DRP in community-acquired pneumonia. Further, results of this study showed a higher specificity of 89.50% and higher sensitivity of 80.40% compared to the study done by Villalobos et al which reported a specificity and sensitivity of 81% and 62.1%, respectively. In this study, all participants were either new patients or previous patients in the same institution who were re-admitted, hence, all the risk factors were properly accounted for especially the history of prior DRP infection, probably explaining such results.

The prevalence of drug-resistant pathogens was 40.16%, which is notably increased compared to the prevalence of 29.7% in the study of Villalobos et al. The timing of the study may have had an impact since it was done post-pandemic whereas the study by Villalobos et al was conducted pre-pandemic. Increased public awareness of various health conditions post-pandemic may have led more people to seek appropriate consultation thereby increasing hospital admissions and the likely increased detection of DRP. Another possible explanation is the changes in environmental risk factors, such as worsening pollution.[14] Moreover, the enhanced data collection and

reporting system, particularly the hospital information system MERX™ in CGHMC, may have contributed to the increased prevalence. Another plausible contributor to the high prevalence of DRP is the demographic and clinical profile of the participants; a substantial proportion of the study population has increased susceptibility for high-risk pneumonia due to factors such as advanced age and presence of comorbid conditions specifically, diabetes mellitus.

K. pneumoniae was the most commonly isolated pathogen in this study whereas *P. aeruginosa* was the most frequent in Villalobos et al. Comorbidities among participants were comparable, with hypertension and diabetes mellitus being the most common (50.39% and 34.65%, respectively).

A higher proportion of patients with DRP were males (58.82%) compared with females (41.18%).This may be attributed to differences in immune response brought about by hormonal effects. Sex hormones act as important modulators of the immune response, with the male sex hormone testosterone generally being immunosuppressive while the female sex hormone estrogen tends to be immunoenhancing.[15]

Recent antibiotic use was the most common major risk factor for drug resistance identified (46.46%). In the derivation of the original DRIP score by Webb et al, this association was likewise observed, with the most predictive interval being 60 days prior to admission, which was also consistent with other studies. Costelloe et al concluded that individuals prescribed antibiotics in the primary care setting for either a respiratory or urinary tract infection develop bacterial resistance to that antibiotic, with the effect being greatest in the month immediately after treatment and may persist for up to 12 months.[16] In another study by Goldstein et al, multidrug-resistant organisms were subsequently isolated from moxifloxacin-treated patients and ceftriaxone/azithromycin-treated patients within 90 days after beginning therapy.[17] Among the minor risk factors, poor functional status was the most prevalent (47.24%) which may be partly explained by the clinical profile of participants. The median age was 73 years old, and participants with either neurologic disease or cognitive impairment made up 22.8% of the total. This finding is similar to the study of Shindo et al where non-ambulatory status was shown to be a significant independent risk factor for DRP in community-acquired pneumonia.[18]

Clinical prediction models like the mDRIP score calculate the probability of an outcome for a patient based on their individual characteristics.[19] These models help identify individuals at higher risk for specific conditions or outcomes, thereby allowing targeted interventions and appropriate resource allocation. Prediction tools, however, have been reported in survey data of physicians as time-consuming, difficult to use, and not always providing value.[20] Its implementation can also be difficult due to barriers for adoption and utilization, and its integration in the clinical workflow can be challenging especially when prediction scores include large numbers of risk factors that are difficult to obtain from an electronic health record.[21] The modification in the mDRIP score streamlined the original DRIP score by considering locally-relevant clinical risk factors, making it an easily accessible tool that requires minimal time to provide a quick recommendation, hence, addressing challenges typically associated with clinical prediction tools. Elligsen et al reported a similar heuristic approach, utilizing previous culture results as stewardship intervention to optimize initial empiric antibiotic use which improved prescribing.[22] Additionally, the clinical relevance of the mDRIP is especially valuable in resource-limited settings like the Philippines. Although technological advancements have introduced tests capable of quickly identifying pathogens compared to microbiologic cultures, such as the multiplex polymerase chain reaction assay that offers the advantage of rapidly identifying multiple pathogens in a single sample with a short turnaround time, this test is not widely accessible in many hospitals across the country and its high cost makes it unaffordable for many patients. In this context, mDRIP can serve as a complementary and effective clinical prediction tool.

Limitations

This study has the following limitations: It was conducted in a single urban academic private hospital, limiting its generalizability to other healthcare settings such as public hospitals with different patient populations, resources, and healthcare practices. Additionally, the reliance on microbiologic cultures with non-standardized drug susceptibility testing may affect consistency of detecting drug-resistant pathogens. Moreover, the appropriateness of antibiotic used and its effect on outcomes was not considered. Lastly, the study may be insufficiently powered given that the sample size computation was based on a study using DRIP score, not mDRIP.

Recommendations

In order to enhance the generalizability and clinical applicability of the mDRIP outside the original setting in which it was developed, additional local validation studies, especially in different regions of the country and in different healthcare settings are thus recommended. In addition, further studies to determine the impact of mDRIP on antibiotic utilization while factoring in the effect of antibiotic appropriateness on the outcomes are recommended. Future studies should also consider performing a priori sample size calculations based on parameters specific for the mDRIP to ensure adequate statistical power for detecting meaningful associations or differences. Also, expanding the sample size may enhance validity and enable more precise assessment of the performance of the mDRIP.

CONCLUSIONS

Prediction of the risk of disease due to drug-resistance pathogens remains a challenge for clinicians. This prospective study shows that the modified DRIP, using a cut-off score of ≥4, is a useful clinical tool for predicting the risk of pneumonia due to drug-resistant pathogens. As an easily accessible decision support tool, it has the potential to reduce the irrational use of broad-spectrum antibiotics in community-acquired pneumonia, especially among low-risk patients and in resource -limited settings. Further studies to strengthen the role of mDRIP in optimizing antibiotic prescribing practices are encouraged.

Data Availability Statement

Datasets are not publicly available because participants in the study did not give written consent for their data to be shared.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Authors' Disclosure

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