Knowledge, Attitudes, and Practices of Physicians in Tertiary Hospitals on the Clinical Application of *Pseudomonas aeruginosa* Biofilm Detection

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Abstract: - *Pseudomonas aeruginosa* biofilms are commonly implicated in nosocomial infections, yet the relevance of its clinical testing is poorly addressed. The study therefore aims to determine the knowledge, attitudes, and practices of physicians (dermatologists, infectious disease specialists, otolaryngologists, pulmonologists, reconstructive specialists, and urologists) in public and private tertiary hospitals in the National Capital Region on the clinical relevance of *P. aeruginosa* biofilm detection. The study employed a descriptive correlational research design that involved an online survey. The questionnaire utilized was adapted and modified from the study of Swanson et al. (2017) and She et al. (2015) and was subjected to pilot testing. Data was gathered though distribution of Google forms in social media and academic platforms and through e-mail while observing ethical considerations. Data was analyzed descriptively and statistically using SPSS version 25.0 software. Analysis of responses from 56 physicians revealed good knowledge (6.30 out of 8.00) on *P. aeruginosa* biofilms, neutral attitude (2.57 out of 5.00) towards the clinical application of biofilm detection, and moderate practice (1.77 out of 4.00) in the diagnosis and management of *P. aeruginosa* biofilm-associated infections. Attitude towards clinical utility was positive, but overall attitude was neutral due to anticipated obstacles for adaptation. Meanwhile, practices are moderate due to the unavailability of a standard method for biofilm detection. No statistically significant correlation among knowledge, attitude, and practice was found. Further studies are recommended to designate a definitive method for clinical use and to explore knowledge, attitude, and practices using widened inclusion criteria and standardized survey tools.

Key Words: — ***Pseudomonas aeruginosa, Biofilm, Pseudomonas aeruginosa biofilm, Biofilm detection, KAP.***

I. INTRODUCTION

Uncontrolled emergence of nosocomial infection or hospital-acquired infection (HAI) is a very unenviable adverse event in the provision of healthcare. HAIs contribute to overall patient and healthcare burden by exacerbating the patient condition, thereby prolonging hospital stay and doubling the patient and healthcare cost [1]. In the Philippines, HAI is acknowledged as a major public health concern especially in government-owned hospitals with poor maintenance [2].

Centers for Disease Control & Prevention (CDC) recorded in their "Antibiotic Resistance Threats Report 2019" that the multidrug resistant *P. aeruginosa* is one of the commonly isolated pathogens from hospitalized patients. *P. aeruginosa* bacteria remain as a leading cause of nosocomial infections due to its notable virulence factors such as biofilm formation, which strengthen its infectivity [3]. Biofilms are adaptive mechanisms that allow bacteria to become more resistant to various

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environments and extreme conditions such as exposure to antibacterial agents. Biofilm-enclosed *P. aeruginosa* can spread infections including sinusitis, periodontitis, middle ear infections, osteomyelitis, urinary tract infections, chronic lung infections in patients with cystic fibrosis, and device-related biofilm diseases. Alongside, it can also escalate antibiotic resistance in the hospital setting [4]. HAIs caused by biofilm-producing organisms such as *P. aeruginosa* are becoming more prevalent [5]. Detection of biofilm-associated infections (BAI) is therefore critically important to give the best course of treatment to patients, avoid chronic complications, and to prevent BAI outbreaks within facilities.

There is a wide variation in the methods to detect biofilm, but a standard test has not yet been established [6]. The lack of routine biofilm testing hinders opportunities in the improvement of overall healthcare and the application of biofilm detection tests in the clinical setting. In the Philippines, biofilm detection methods are not performed in clinical laboratories. This study therefore aims to investigate the knowledge, attitudes, and practices (KAP) of physicians in tertiary hospitals of National Capital Region (NCR) in the Philippines to determine the clinical relevance and impart the importance of biofilm detection in healthcare system. Analysis of results were made to determine if educational interventions are imperative to raise awareness regarding the significance of biofilm detection, especially of that of *P. aeruginosa*, in the Philippine hospital setting.

II. FRAMEWORK

A. Theoretical Framework

Health belief model by Kabiru et al. [7] was adapted and modified because of its usefulness in serving as a guide for the determination of the KAP of physicians on the clinical application of *P. aeruginosa* biofilm detection in the hospital setting. Figure 1 shows the modified health belief model applied to biofilm detection.

The modified health belief model illustrates that the physicians' likelihood to engage in a particular health behavior, which in this case is recommending *P. aeruginosa* biofilm detection, is influenced by the following variables: sociodemographic variables of the physicians and their knowledge on *P. aeruginosa* biofilm-associated infections;

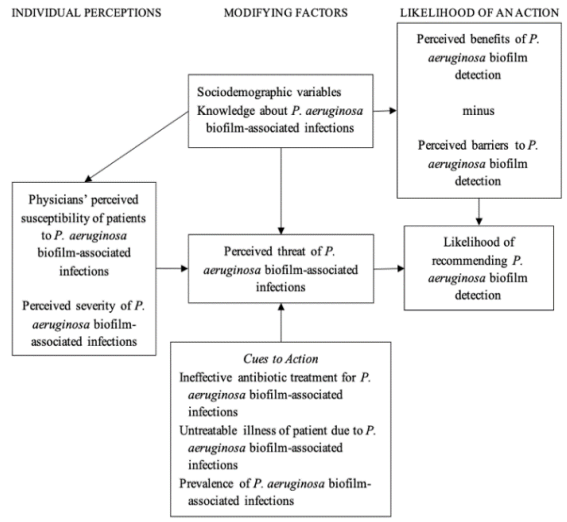

Fig.1. Health Belief Model Applied to Biofilm Detection

Perceived benefits of *P. aeruginosa* biofilm detection; perceived barriers to *P. aeruginosa* biofilm detection; perceived susceptibility of patients to *P. aeruginosa* biofilm-associated infections; perceived severity of *P. aeruginosa* biofilm-associated infections; and perceived threat of *P. aeruginosa* biofilm-associated infections due to ineffective antibiotic treatment, untreatable illness of patients, and prevalence of *P. aeruginosa* biofilm-associated infections.

B. Conceptual Framework

The KAP model seen in Figure 2 was adapted from Kwol et al. [8] for the conceptual framework of the study. It depicts that acquiring knowledge about *P. aeruginosa* biofilm would influence the attitude of the physician regarding *P. aeruginosa* biofilm detection. Likewise, the change in attitude would also lead to changes in practice of *P. aeruginosa* biofilm detection and managing *P. aeruginosa* BAI. Consequently, both the changes in attitude and practice of the physicians would result in the raised awareness on the need for detection of *P. aeruginosa* biofilm.

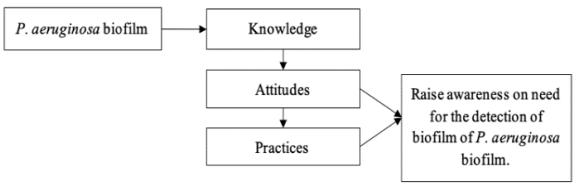

Fig.2. Paradigm of the Study

III. METHODOLOGY

A. Research Design

Descriptive correlational research design was used in the study. An online survey was conducted to gather information regarding the KAP of physicians on *P. aeruginosa* biofilm and to determine whether educational interventions will be necessary with the intention to spread awareness regarding the matter. This study correlated the relationship between the extent of KAP of the physicians regarding biofilm, *P. aeruginosa* biofilm, and methods to detect *P. aeruginosa* biofilm.

B. Sampling Design

Purposive sampling was employed wherein physicians of select medical specialties relevant to *P. aeruginosa* biofilm infections were included. Convenience sampling was also used by circulating online the invitations to participate and accommodating all eligible respondents available. Due to the limitation brought by the increasing COVID-19 cases in the hospitals and the lack of information regarding the population of medical specialists, the sample size was not calculated. Instead, the total number of respondents who participated in the data gathering was considered as the sample size.

C. Research Locale and Respondents

The study was conducted from January to May 2021. The inclusion criteria for the respondents in the study were licensed physicians specializing in infectious diseases, pulmonology, dermatology, reconstructive specialty, urology, or otolaryngology and practicing in licensed and accredited public and/or private tertiary hospitals in the National Capital Region of the Philippines.

D. Survey Questionnaire

The questionnaire utilized was adapted from "Understanding biofilm in practice: a global survey of health professionals" by Swanson et al. [9] and "Survey of Physicians' Perspectives and Knowledge about Diagnostic Tests for Bloodstream Infections" by She et al. [10]. It was then modified to align with the study's objectives. Permission was asked from the respective authors regarding the adaptation of their questionnaires.

The questionnaire utilized in this study had two versions— in English and Filipino language, with the latter validated by the Commission on the Filipino Language. Each version comprised four parts which aimed to obtain the following data: 1) sociodemographic of the respondents; 2) knowledge of respondents on biofilms produced by *P. aeruginosa*; 3) attitudes of respondents on the clinical application of *P. aeruginosa* biofilm detection; and 4) practices of respondents on the diagnosis of biofilm-associated *P. aeruginosa* infection. The survey questionnaire covered the following types of questions: sociodemographic questions, close-ended questions with true/false or Likert scale answer choices, and open-ended questions.

The survey was assessed by conducting a pilot testing and using Cronbach alpha to check internal consistency before the online deployment of the survey.

E. Data Gathering Procedure

Gathering of responses was initiated by posting the invitation containing the links for the online survey in various social media platforms such as Facebook, Twitter, Reddit, and Instagram; and in academic platforms such as ResearchGate and Academia.edu. Moreover, the e-mail addresses of physicians that met the inclusion criteria were obtained from their respective contact information as correspondent authors in online publications and medical associations such as the Philippine Association of Plastic Reconstructive and Aesthetic surgeons, Journal of the Philippine Dermatological Society, and the Philippine Journal of Otolaryngology-Head and Neck Surgery.

Afterwards, the questionnaire was sent to the respondents via Google mail. The responses were further screened to make sure that the respondents met the inclusion criteria.

Google Forms was utilized to conduct the survey. An informed consent was included in the survey, and each respondent had the freedom to choose their preferred language, either in English or Filipino, in answering the survey. It was assured that the gathering of data was conducted with ethical consideration.

F. Data Analysis

The data underwent descriptive analysis and statistical analyses using International Business Machines Statistical Package for

the Social Sciences version 25.0 software. Frequency distribution was utilized for the sociodemographic profiling of the respondents.

The respondents' KAP was determined using KAP scoring of 8 knowledge, 35 attitude, and 4 practice questions. Scores for knowledge questions range from 0 to 8 points. Each correct response was equivalent to '1' point while wrong responses and "I do not know" responses were equivalent to '0' point. Scores for attitude questions ranged from 0 to 35 points. Likert responses were given corresponding points ranging from 1 to 5, while reverse scoring was done for questions that were negatively phrased. Mean was computed for items A4–A6. Scoring for practice questions ranged from 0 to 4 points, wherein '1' point was given for every "Yes" responses while '0' point was given to "No" responses and "I do not know" responses. For P3, every response that indicated usage of laboratory methods was given '1' point. Whereas zero point was given to responses which only used other studies or had "not applicable" or "none" responses.

Overall level of KAP of the physicians was categorized using Modified Bloom's cut-off point adapted from Seid and Hussen [11]. For the overall knowledge of the respondents, scores of 80–100% (6–8 points) were classified as good knowledge; 50–79% (4–5 points) as moderate knowledge; and less than 50% (0–3 points) as poor knowledge. For overall attitude, scores of 80–100% (28–35 points) was classified as positive attitude; 50–79% (18–27 points) as neutral attitude; and less than 50% (0–17 points) as negative attitude. For practice, scores between 80–100% (3-4 points) was classified as good practice; 50–79% (2 points) as moderate practice; and less than 50% (0-1 point) as poor practice. Afterwards, ranking was done to determine the medical specialties with the highest KAP scores and to identify which medical specialty perceives biofilm detection of *P. aeruginosa* to be of highest clinical utility.

To determine the extent of KAP of the physicians, each question was analyzed. Knowledge questions were ranked from 1 to 8 in order of decreasing frequency and percentage of correct response. The average frequency and percentage of correct responses was obtained to determine the overall frequency and percentage of the respondents with correct response and good knowledge. Furthermore, the weighted mean of the responses per attitude question was calculated then categorized based on the following criteria: "positive" for 1–2.49, "neutral" for 2.5–3.49, and "negative" for 3.5–5 points. Frequency distribution was utilized to present the responses categorized by topic to the single open-ended question in A8. Moreover, the percentage of every "Yes" response for every question and usage of laboratory test for P3 was determined. It was assessed using the following criteria: "poor" for percentages ranging from 0–59 %, "moderate" for 60-79%, "good" for 80-100%. Responses in P3 were categorized by topic and presented as frequency distribution.

Pearson's correlational analysis was performed to establish the presence or absence of a significant association between the respondent physicians' KAP with a $p < 0.05$ level of statistical significance (2-tailed).

G. Ethical Considerations

The study was approved by the Faculty of Pharmacy-Research Ethics Committee. There was no conflict of interest declared by the researchers. Privacy and confidentiality of the respondents' names, personal information, and responses was also assured. Given that informed consent was included in the survey questionnaire, the respondents were made aware of the description of the study, benefits, risks, and ethical consideration. Participation in the study of the respondents was voluntary as the respondents have the right to withdraw at any point. Risks for the respondents were minimal wherein no respondents were harmed. No monetary compensation was given to the participants.

IV. Results And Discussion

A. Sociodemographic Profile of Respondents

Table.1. Sociodemographic Profile.

Age-group (years)	**N**	**%**
25–30	6	10.7
31–35	13	23.2
36–40	10	17.9
41–45	7	12.5
46–50	4	7.1
51–55	7	12.5
56–60	6	10.7
61–65	2	3.6
66–70	1	1.8
Gender		
Male	22	39.3

Female	34	60.7
Medical Specialization		
Infectious disease specialist	7	12.5
Pulmonologist	5	8.9
Dermatologist	12	21.4
Reconstructive specialist	8	14.3
Urologist	12	21.4
Otolaryngologist	12	21.4
Years in Medical Practice		
1-5	8	14.3
6-10	11	19.6
11-15	14	25.0
16-20	7	12.5
21-25	5	8.9
26-30	4	7.1
31-35	6	10.7
36-40	1	1.8
Classification of Hospital		
Public	18	32.1
Private	23	41.1
Public and Private	15	26.8

Table 1 continued.

Location of Hospital	**N**	**%**
City of Las Piñas	1	1.8
City of Makati	2	3.6
City of Manila	17	30.4
City of Muntinlupa	3	5.4
City of Pasig	6	10.7
City of Quezon	10	17.9
City of Caloocan, City of Quezon, City of Valenzuela	2	3.6
City of Las Piñas, City of Makati, City of Muntinlupa	1	1.8
City of Las Piñas, City of Muntinlupa	1	1.8
City of Las Piñas, City of Muntinlupa, City of Parañaque, City of Quezon	1	1.8
City of Las Piñas, City of Quezon, City of Taguig	1	1.8
City of Makati, City of Manila, City of Pasig, City of San Juan	1	1.8
City of Mandaluyong, City of Manila	1	1.8
City of Manila, City of Marikina, City of Quezon, City of San Juan	1	1.8
City of Manila, City of Pasig	1	1.8
City of Manila, City of Quezon	2	3.6
City of Manila, City of Quezon, City of Taguig	1	1.8
City of Manila, City of Taguig	1	1.8
City of Marikina, City of Quezon	1	1.8
City of Muntinlupa, City of Manila	1	1.8
City of Quezon, City of Valenzuela	1	1.8

N=56.

A total of 60 respondents participated in the study. However, only 56 respondents were included in the study after screening based on the inclusion criteria. Table 1 depicts the sociodemographic profile of the respondents in terms of age, gender, medical specialization, years of practice, and classification and location of hospital. Majority belong to the group age ranging from 31 to 45, comprising of three groups (31-35, 36-40 and 41-45) with a total frequency of 30 (53%). For gender, the respondents were dominated by females (34, 61%). Three groups of specializations (dermatologists, urologists, and otolaryngologists) comprise the majority, with a frequency of 12 for each group, summing up to 64% of the total respondents. A total of 33 or 59% of the respondents have been practicing their profession for less than 15 years. For the distribution of the respondents according to the location of the hospital employed in, majority of the respondents practice in the City of Manila (17, 30%), Quezon City (10, 18%), City of Pasig (6, 11%). Lastly, for the distribution of the respondents according to classification of the hospital ownership, it was shown that most of the physicians practice in private hospitals with a frequency of 23 or 41% of the respondents.

B. Overview of Knowledge, Attitudes, and Practices of the Physicians

Table.2. presents the distribution of respondent physicians according to the level of knowledge, attitudes, and practices regarding *P. aeruginosa* biofilms, clinical application of its detection, and its diagnosis along with the average KAP score.

Table 2. Level of KAP of the Respondent Physicians.

Level of Knowledge	**N**	**%**
Good knowledge	46	82.14
Moderate knowledge	7	12.50
Poor knowledge	3	5.36
Level of Attitudes		
Positive attitude	1	1.79

Neutral attitude	52	92.86
Negative attitude	3	5.36
Level of Practices		
Good practice	9	16.07
Moderate practice	29	51.79
Poor practice	18	32.14

Note. Average knowledge score = 6.30 (Good knowledge), average attitude score = 22.93 (Neutral attitude), and average practice score = 1.77 (Moderate practice).

It was shown that majority of the respondent physicians have good knowledge (46, 82.14%), neutral attitude (52, 92.86%), and moderate practices (29, 51.79%). The average score for the 8-point knowledge assessment was 6.30 points, which was interpreted as possessing good knowledge. As for the 35-point attitude assessment, the physicians scored an average of 22.93 points, which was interpreted as having neutral attitude. Meanwhile, the average score for the 4-point practices assessment was 1.77 points. Moderate practice on *P. aeruginosa* biofilm detection may be due to the absence of biofilm detection tests in hospital laboratories in the Philippines.

Table.3. presents the ranking of the six medical specialization classifications based on their KAP score. A discrepancy in knowledge across the medical specialist groups was evident. It was likely that the otolaryngologists had the greatest knowledge (7.00) because of extensive literature providing evidence that several frequently encountered otolaryngological diseases are related to biofilms [12]. Conversely, the pulmonologists were the least knowledgeable (5.75) possibly due to literature in their specialty focusing on cystic fibrosis and ventilator associated pneumonia, which occur with much lesser incidence [13].

In dermatology, *P. aeruginosa* biofilm infections are encountered in burn wounds and chronic wounds, with the latter having a lifetime prevalence of only 1-2% [14]. The lack of exposure may explain for their relatively low level of knowledge (5.75). Reconstructive specialists, urologists, infectious disease specialists had similar levels of knowledge (6.50, 6.33, 6.29). Despite the discrepancy, a satisfactory level of knowledge regarding biofilms was observed in all six groups of medical specialists.

As for the attitude about biofilm and *P. aeruginosa* biofilm, the pulmonologists ranked first among the six medical specialist groups, scoring an average of 24.26. This may be attributed to their willingness to utilize biofilm detection test on their patients suspected or confirmed with *P. aeruginosa* infection. Three out of the five pulmonologist who participated in the study answered that they would test 81-100% of their patients if a biofilm detection was available. Reconstructive specialists (23.96), infectious disease specialists (23.90), and dermatologist (23.61) follow in rank with similar average scores. Placing in lower ranks were the otolaryngologists (21.93) and urologists (21.43).

For practices, reconstructive specialists have the highest practice among the medical specialties (2.38). They have the highest practice because they request for a variety of laboratory tests such as wound culture or C/S, tissue and swab culture, tissue GS/CS, routine G/S or C/S, or G/S if culture was not yet available.

Table.3. Ranking of Medical Specialists Based on their KAP Scores.

Medical Specialization	**Knowledge**		**Attitudes**		**Practices**	
	Average Score	**Rank**	**Average Score**	**Rank**	**Average Score**	**Rank**
Infectious disease specialist	6.29	4	23.90	3	1.29	6
Pulmonologist	5.60	6	24.26	1	2.20	2
Dermatologist	5.75	5	23.61	4	1.83	3
Reconstructive specialist	6.50	2	23.96	2	2.38	1
Urologist	6.33	3	21.43	6	1.67	4
Otolaryngologist	7.00	1	21.93	5	1.50	5

Note. Perfect scores for each category are 8 for knowledge, 35 for attitudes, and 4 for practices.

It was likely that they correlate the laboratory test results to assume *P. aeruginosa* biofilm formation in burn wounds infections and chronic wounds. They were followed by pulmonologists (2.20), dermatologists (1.83), urologists (1.67), and otolaryngologists (1.50). Conversely, infectious disease specialists have the lowest practice (1.29) because half of the respondents expressed that they do not use laboratory test/s to diagnose *P. aeruginosa* BAI, while the other half only request for swab C/S, culture, and C/S.

C. Knowledge

Table 4 presents the extent of knowledge of the respondent physicians about biofilm and *P. aeruginosa* biofilm. Items were ranked according to the number of correct responses. Most physicians were knowledgeable that "Biofilms protect the microbes from the host immune response." (55, 98.21%) and "Biofilms exhibit increased resistance against antimicrobials and antibiotics." (54, 96.43%). Such understanding of the recalcitrant nature of biofilms suggests recognition that biofilms are less responsive to standard antimicrobial therapy and therefore require the use of less common or novel antibiotics and therapeutic strategies [15]. Most physicians were knowledgeable regarding biofilm's ability to hinder wound healing (51, 91.07%), cause hospital-acquired infections (50, 89.29%), and reform within 24 hours if not completely removed (48, 85.71%). Understanding biofilms contribute to hospital-acquired infections implies the awareness of biofilm-related infections caused by medical devices such as catheters, ventilators, and implants.

Knowledge that biofilms affect wound healing and tend to reform with insufficient removal serves as the rationale in the management of chronic wounds in which frequent debridement, cleansing, compression, topical application of antibiotics, and use of wound dressings that provide a balanced moist environment are necessary [9]. Only 37 (66.07%) physicians were knowledgeable on the behavioral differences between the planktonic and biofilm form of *P. aeruginosa*. Meanwhile, physicians were least aware that "Biofilms cover and protect the wound" (35, 62.50%) and that "Biofilms produced by *P. aeruginosa* are difficult to treat because the bacteria in them replicate at a much slower rate." (23, 41.07%). Ranking of the questions indicate good knowledge of the harm caused by biofilms but a lack in comprehension of its mechanism and behavior.

D. Attitude

As depicted in table 5, the overall attitude of the respondents regarding biofilm and *P. aeruginosa* biofilm was neutral with an average weighted mean of 2.57, implying that the respondents do not have any negative attitude about biofilm and *P. aeruginosa* biofilm detection. Notably, the questions that contributed greatly to this result were items 1 (Mean = 3.39), 6 (Mean = 2.52), 7 (Mean = 3.32), and 8 (Mean = 2.98). In question 1, the physicians were asked if "The presence of *P. aeruginosa* biofilm was easy to detect visually", in which most of them disagreed/strongly disagreed. This implies the absence of a tool that could easily detect the biofilms that lead the physicians to disagree in the aforementioned statement, which was reasonable as there was a lack of practice in routine biofilm detection in the Philippines.

As for question 6, the physicians rated the obstacles such as uncertainty of using new technology, cost of test, and lack of evidence for clinical utility as a moderate obstacle. Some physicians also specified in the open-ended question that the availability of a biofilm test, or lack thereof, can hinder the adoption of a biofilm test in the laboratory setting leading to a neutral attitude, which was expected because aside from the lack of standardized protocol for the diagnosis of biofilm, the materials required for some detection test such as 2,3-bis (2-methoxy-4-nitro-5-sulfophenyl)-5-[(phenylamino) carbonyl 2H-tetrazolium hydroxide (XTT) were very costly [16].
Having presented the possibility of using biofilm detection test in the clinical practice in the Philippines as questioned in item 7, the physicians were questioned on what percent of their patients suspected or confirmed of *P. aeruginosa* infection they would test. The physicians' answers were

Table.4. Extent of Knowledge of the Respondent Physicians about Biofilm and *P. aeruginosa* Biofilm.

Questions (True/False/I do not know)	Correct Response	%	Rank
1. Biofilms cover and protect the wound.	35	62.50	7
2. The presence of biofilm can be a barrier to wound healing	51	91.07	3

3. Biofilms do not contribute to nosocomial infection	50	89.29	4
4. Biofilms produced by *P. aeruginosa* are difficult to treat because the bacteria in them replicate at a much slower rate.	23	41.07	8
5. Biofilms can reform within 24 hours, if not fully removed, after disruption (e.g. cleansing, debridement).	48	85.71	5
6. *P. aeruginosa* behave the same whether in a biofilm form or not (planktonic).	37	66.07	6
7. Biofilms protect the microbes from the host immune response.	55	98.21	1
8. Biofilms exhibit increased resistance against antimicrobials and antibiotics.	54	96.43	2
Average	44.13	78.79	

Table.5. Attitude of the Respondent Physicians about Biofilm and *P. aeruginosa* Biofilm.

Questions	**Weighted Mean**	**Attitude Interpretation** [a]
1. The presence of *P. aeruginosa* biofilm was easy to detect visually.	3.39	Neutral
2. *P. aeruginosa* biofilms can be present where there are no signs of infection.	2.30	Positive
3. *P. aeruginosa* biofilm presence can be inferred by clinical symptoms such as antimicrobial therapy failure, delayed healing, and recurrent infections.	1.88	Positive
4. If a clinical laboratory test to detect *P. aeruginosa* biofilms were available, how helpful would it be for the patients?	2.10	Positive
5. Please rate the level of impact of a biofilm detection test compared with other microbiological laboratory services.	2.04	Positive
6. Given a certain level of test performance, please rate the obstacles to adoption of a biofilm detection test.	2.52	Neutral
7. If a test for biofilm detection were available, what percent of your patients suspected or confirmed of *P. aeruginosa* infection would you test?	3.32	Neutral
8. Please input any concerns or comments regarding the clinical application of biofilm detection tests in the Philippine setting.	2.98	Neutral
Average Weighted Mean	2.57	Neutral

[a] The weighted mean in each item were interpreted as "Positive" (1 – 2.49), "Neutral" (2.5 – 3.49) and "Negative" (3.5 – 5).

distributed across the following ranges: 81-100% (18), 0-20% (12), 61-80% (11), 41-60% (11), 21-40% (8); resulting in an overall neutral attitude.

Meanwhile, concerns or comments of the Physicians regarding the clinical application of biofilm detection test in the Philippines were inquired in item 8 and figure 3 shows the distribution of the responses of the physicians per topic. The responses of the physicians were categorized to the following topics: concerns, suggestions for use, positive outlooks need for information and increased awareness, doubts regarding impact, and none or N/A.

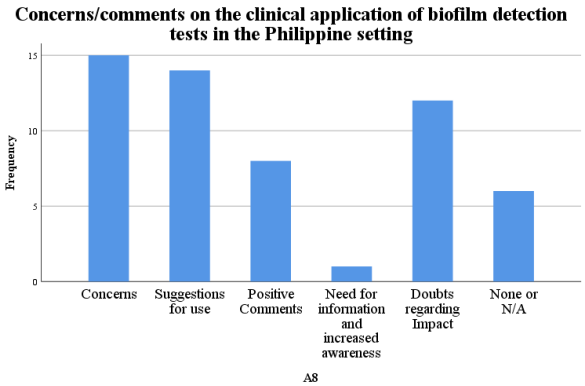

Fig. 3. Concerns or Comments of Physicians regarding the Clinical Application of Biofilm Detection Tests in Philippine Setting

Concerns regarding biofilm testing were mainly its lack of availability, high cost, specimen required and storage requirements, and lack of awareness among other physicians. Meanwhile, suggestion for the use of biofilm detection were for conditions or infections such as atopic dermatitis, delayed wound healing, burn patients at risk of developing *P. aeruginosa* burn wound infections, treatment of urosepsis in stones, and chronic long standing and/or dormant infections.

As for the positive comments regarding the use of biofilm detection test, respondents mentioned that the usage of biofilm detection test would be advantageous against the culture method, especially in ICU setting, as available methods for the presence of biofilms, particularly, the "Clinical BioFilm Ring Test" developed by BioFilm Control yields results in two (2) hours, faster than obtaining results from culture [17].

In contrast, doubts regarding the utility of biofilm were based on the assumption of the presence of *P. aeruginosa* biofilms in certain medical conditions and the current practice of shifting to culture-guided treatment when patients were unresponsive to empiric treatment. Having these varied answers resulted in the neutral attitude of the physicians regarding the clinical application of biofilm detection test.

E. Practices

Table.6. displays the practices of the respondent physicians regarding the detection methods of biofilm and *P. aeruginosa* biofilm and the effects of test results on antimicrobial therapy. As gleaned, two items fall on moderate practice, while the other two falls under poor practice.

Results of moderate to poor practice were obtained due to the absence of biofilm detection tests in Philippine tertiary hospital laboratories. Furthermore, physicians have moderate practice in response to changing the empiric course of antimicrobial therapy based on the biofilm detection test result for *P. aeruginosa* (69.64%) due to the development of antibiotic resistance. Antibiotic resistance occurs because the targeted bacteria was protected by the biofilm from antibiotics [18]. Continuous administration of low dosage of antibiotics may promote biofilm formation and establishment of biofilm-specific antimicrobial resistance [19]. Additionally, there were instances wherein physicians misuse antibiotics due to overtreatment as expressed by a respondent.

This indicates that test results detecting *P. aeruginosa* biofilm can help in providing a better antimicrobial treatment for patients.

Table 6. Practices of the Respondent Physicians about Biofilm and *P. aeruginosa* Biofilm.

Practices	%	Interpretation [a]
1. Do you use laboratory test/s to diagnose *P. aeruginosa* biofilm-associated infections?	21.43	Poor
2. Does the hospital laboratory conduct biofilm detection test/s?	8.93	Poor
3. Assuming that there was no biofilm detection test available, what services offered by the hospital laboratory would you request to aid in diagnosing *P. aeruginosa* biofilm-associated infections?	76.79	Moderate
4. For *P. aeruginosa* biofilms detected in a patient, would the test result change your empiric course of antimicrobial therapy?	69.64	Moderate

[a] The interpretation was based on the percentage of each item. Good practice for 80-100%, moderate practice for 60-79%, and poor practice for those less than 60%.

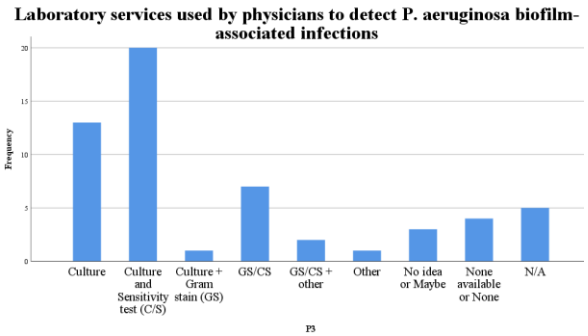

Fig. 4. Methods used by Physicians to Detect *P. aeruginosa* Biofilm-associated Infections.

Figure.4. tackles the alternative laboratory services used by physicians to detect *P. aeruginosa* BAI. Due to the absence of biofilm detection tests in the Philippines, physicians request alternative laboratory services. According to Figure 4, culture and sensitivity test (C/S) was the most common laboratory service requested by physicians. This was followed by culture, gram stain (GS) requested either with culture or C/S studies, and C/S requested with other studies. Additionally, there were few respondents who answered "none available," and others opting for other practices. It was likely that the combination of culture test and sensitivity test to identify the bacteria and determine either sensitivity or susceptibility of the identified bacteria to antimicrobial drugs makes the C/S preferred by physicians. However, C/S was not effective to detect biofilm due to separate reasons of culture test and sensitivity test. Culture test has low sensitivity rate in detecting growing bacteria in biofilm, difficulty in detecting highly diverse distribution of biofilms, possibility of false negative results due to absence of colony formation from slow-growing bacteria, and resistance of biofilm producing bacteria to grow in the culture [20][21][22]. Alongside, sensitivity test was not effective in the detection of biofilm due to its virulence and resistance [23]. On the other hand, GS was quite dubious for the detection of biofilm due to interference of biofilm polymeric matrix with the stain reagents used and non-specific staining of crystal violet to connective tissue and cellular debris of burn wound eschar [24]. Furthermore, a respondent expressed that the presence of biofilm could be assumed based on the results of alternative laboratory services. This indicates that there was no standard test or method for the detection of *P. aeruginosa* biofilm. This was mainly due to the absence of the laboratory test.

F. Correlation of Knowledge, Attitudes, and Practices of the Physicians

Table.7. Correlation of KAP of the Respondent Physicians regarding *P. aeruginosa* Biofilm, Clinical Application of Biofilm Detection, and Diagnosis of *P. aeruginosa* Biofilm-Associated Infections.

Variable	**r**	**P-value**
Knowledge-Attitude	.000	.997
Knowledge-Practice	-.130	.340
Attitude-Practice	.230	.089

α=0.05. N=56. Correlation was significant at 0.05 level (2-tailed).

Table.7. depicts the results of the Pearson correlation analysis between the KAP of the respondent physicians about *P. aeruginosa* biofilm, biofilm detection, and diagnosis. The results of Pearson correlation analysis show a failure to reject H0, meaning there was no significant relationship between the KAP of the respondent physicians. A weak positive correlation ($r = .230$, $p = 0.089$) exists between attitude-practice, indicating that an increase in practice of the diagnosis and treatment of *P. aeruginosa* BAIs may be associated with a slightly more positive attitude towards the clinical application of biofilm detection. However, it was not statistically significant and, thus, has a small chance of increasing positive attitudes. Weak negative correlation was found between knowledge-practice (-.130), but it was also not statistically significant. Considering both the weak positive and weak negative correlations for attitude-practice and knowledge-practice, increasing the level of practice may slightly improve the overall KAP.

G. The Need for P. aeruginosa Biofilm Detection in Philippine Hospitals

P. aeruginosa biofilms pose a major problem in various medical fields due to its resistance and tolerance to host immune response and antimicrobials. It was reported to be the most common cause of nosocomial infections because of its adhesion to surfaces of medical devices, implants, and hospital environment. In dermatology and reconstructive surgery, biofilm was known for its colonization of chronic or severe wounds, spongiotic or acantholytic dermatosis, and post-operative wound infections [25]. In the otolaryngology field, it causes chronic ear infections and lung infections in cystic fibrosis patients [12]. For urology, it can cause acute prostatitis, catheter-associated UTIs, and ureteral stent-associated infections [26]. In addition, the presence of *P. aeruginosa* biofilm in BAI often leads to antibiotic therapy failure resulting in the emergence of antibiotic resistance [18][19]. Alternative laboratory tests requested by physicians were reported to low sensitivity rates and possibility of false negatives [20]. In this study, the lack of availability of biofilm detection test/s conducted in hospital laboratories was apparent in the responses of the physicians. The majority of respondents answered that they have no idea or that the hospitals have no test for biofilm detection. Even the Research Institute for Tropical Medicine (RITM), a national reference laboratory in the Philippines, does not offer laboratory services for biofilm detection for any

bacteria nor for *P. aeruginosa*. Thus, it reiterates the point that there is an absence of biofilm detection test and lack of diagnostic practice in the Philippines.

V. CONCLUSION

The study shows that majority of the respondents were aged 31 to 45, female, practicing as dermatologists, otolaryngologists, and urologists in private tertiary hospitals based in Manila, Quezon City, and Pasig City. Physicians demonstrated good knowledge regarding the nature of biofilms and its effect on the treatment and management of *P. aeruginosa* infections but lacked knowledge on the mechanism of biofilms. They hold a neutral attitude on biofilm detection tests as they were aware of the benefits and obstacles involving the clinical implementation. Practice in the diagnosis and clinical management of *P. aeruginosa* BAI was moderate. In addition, no statistically significant relationship exists between the extent of knowledge and attitude of the respondent physicians regarding biofilm, *P. aeruginosa* biofilm, and methods to detect *P. aeruginosa* biofilm.

Due to the unavailability of definitive methods of biofilm detection, physicians resort to alternative methods such as culture, GS/CS, and C/S. However, due to the unreliability of these methods, establishing a standard method for the detection of *P. aeruginosa* biofilm is highly suggested.

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