C - Health Science

หน้า

C - Health Science

Antibiotic sensitivity profiling of bacterial communities recovered from city transfer stations in the City of San Fernando, Pampanga

Lycette S. Tumang*, Sheila S. Cabral, Melandro Cunanan and Roberto C. Pagulayan
Department of Biological Science, College of Arts and Sciences, Angeles University Foundation, 2009 Angeles City, Pampanga, Philippines
*Email : tumang.lycette@auf.edu.ph

Abstract

The areas where municipal solid wastes are dumped, such as city transfer stations, are regarded as a repository of antibiotics and antibiotic-resistant bacteria (ABR). This ABR can spread via leachates, presenting a danger to the environment. Antibiotic sensitivity assessment of bacterial communities in nationwide city transfer stations is restricted. This research identified the putative bacterial communities from soil samples in San Fernando, Pampanga transfer station. This study also evaluated the antibiotic resistance and susceptibility of bacteria obtained. Bacteria were isolated through standard bacteriological procedures such as serial dilution, Gram staining, and several biochemical tests. Under American Society for Microbiology and Clinical and Laboratory Standards Institute guidelines, antibiotic susceptibility testing was conducted. Among the eight reported presumed bacterial genera are *Micrococcus, Acinetobacter, Bacillus, Enterococcus, Listeria, Planococcus, Arthrobacter, and Staphylococcus*. *Listeria spp.* and *Bacillus spp.* were resistant to multiple antibiotics, including Amoxicillin, Ampicillin, Penicillin, and Tetracycline. *Arthrobacter sp.* was resistant to Erythromycin and Amoxicillin, whereas *Planococcus sp.* was resistant to Erythromycin. This research calls for confirmatory tests such as MIC testing and 16S rRNA gene sequencing to further verify the results. To prevent public health crisis, it is urged that appropriate initiatives be taken to stop the release of these ABR into the environment.

Keywords : bacteria profiling, city transfer station, dump site, antibiotic resistance, San Fernando Pampanga

1. Introduction

An antimicrobial agent can be defined as a natural or artificial chemical that eliminates or prevents the development of microorganisms such as bacteria, fungus, and algae (Brittanica, 2022). ReAct (n.d.) says there are many different antimicrobial medicines: antibiotics, antivirals, antifungals, and antiparasitics. Furthermore, IQVIA (2021) said that the use of medicines like antibiotics has been growing around the globe in the last 10 years. However, as the number of people who use pharmaceutical drugs rises, there are times when medicines are not used and end up unused or expired, thus becoming a municipal solid waste (Bashaar et al., 2017). Then, because there are more medical wastes and people do not know how to dispose of pharmaceuticals properly, most of them end up in landfills or dumps sites as municipal solid waste (MSW).

Municipal solid waste (MSW) is waste that is accumulated by the city or thrown away at the city's waste disposal site. It includes residential, industrial, institutional, hospital, commercial, municipal, and construction and demolition waste (Stafford, 2020). When pharmaceuticals such as antibiotics become mixed with other MSW, this could eventually pollute the environment and make living organisms sick (Anwar et al., 2020). Anwar et al. (2020) also say that incorrectly throwing away old and unused medicines increases the risk of antimicrobial resistance (AMR).

Despite its capacity to save lives, the World Health Organization (2022) remarked that this AMR is a global problem that poses a severe hazard to public health and has enormous

political and security repercussions. AMR is driven by changes in the genetic material, which may happen when antimicrobial resistance genes from one kind of environmental microorganisms are transferred to another, as well as when other horizontal gene transfer components take place (Waturu et al., 2017). Additionally, Waturu et al. (2017) further indicated that using heavy metals in homes, businesses, and industries, combined with antimicrobial, provides selection pressure in the environment that causes mutations in microbes. As a consequence, AMR makes it harder or impossible to treat illnesses and renders antibiotics and other antimicrobial medications useless (WHO, 2022). In the study of Borquaye et al. (2019), they added that there are more incidents of AMR because antimicrobial agents are sold over-the-counter without much or any professional oversight. Other factors that contribute to this situation include the use of less effective drugs and the presence of pharmaceuticals in the environment due to their use in agriculture and improper disposal. Moreover, one of the growing concerns under AMR is antibiotic resistance. Murray et al. (2022) report in their study that AMR was responsible for an estimated 4.95 million deaths in 2019, 1.27 million of which were due to antibiotic resistance.

Zothanpuia et al. (2021) say that AMR, especially antibiotic resistance, is thought to be most common where MSW is thrown away, such as at open dumpsites and transfer stations, which collect a mix of antibiotic compounds from human waste and feces, which may contain pathogens that are resistant to multiple drugs. Mwaikono et al. (2015) add that the varying microbes from the household, medical, and industrial wastes establish a complex interface on dumpsites or city transfer stations that helps bacteria change. Microbes are likely to be pushed to become resistant by the number of chemicals and drug residues on dumpsites. These resistant groups could then be spread by animals and people who often interact on dumpsites (Mwaikono et al., 2015). Studies in different countries wherein bacterial isolates were obtained from landfills, or dumpsites showed resistance to multiple antibiotics (Mwaikono et al., 2015; Zothanpuia et al., 2021; Waturu et al., 2017). For instance, in Waturu et al. (2017)'s study, *Klebsiella* and *Escherichia coli* acquired from a landfill in Kenya showed AMR as they were resistant to Ampicillin, Streptomycin, and Trimethoprim-sulfamethoxazole antibiotics.

On the other hand, local government units of the Philippines do not follow Republic Act 9003 or Ecological Solid Waste Management Act of 2000 very well, where trash is everywhere, and waste is burned in unhealthy ways in some open dumps and areas (Castillo & Otoma, 2013). This lack of adequate management systems and stringent accordance leads to dumping sites that pollute river ecosystems through leaching (Zothanpuia et al., 2021). This might trigger AMR microorganisms to spread in the Philippines' land and water ecosystems. Despite this problem in waste management of pharmaceuticals, no existing studies check the antibiotic sensitivity of bacterial communities found in dumpsites or city transfer stations in the said country, particularly in the City of San Fernando, Pampanga. Hence, this study produced results that give definitive proof of pathogenic organisms and the potential health danger they pose. Also, this can help make the right plans to keep diseases from spreading.

Significance of the Study

This study aimed to trace bacterial communities and determine how sensitive these isolates are to various antibiotics. These isolates were taken from the City Transfer Stations in the City of San Fernando, Pampanga. The current study on identification and profiling aspired to be a valuable source of information that will help others learn. These stakeholders can get benefit from this research:

To the *local government unit (LGU)*

The CSFP LGU can utilize this research to detail the existing bacterial communities on the city transfer stations. This study will aid in performing proper mitigations if antibiotic-resistant organisms are found. They can use these research results to enhance medical waste management and health guidelines in the city.

To the *general public*

The public will benefit from this study as it can raise awareness of AMR, specifically antibiotic resistance. Precisely, this investigation can help garbage collectors put consciousness to personal protective equipment (PPEs) as they are essential in hindering the spread of opportunistic pathogens found in city transfer stations.

1. Objectives & Research Problem

Studies have shown that dumpsites are significant places to find antibiotics and genes that make bacteria resistant to antibiotics. This should not be ignored because antibiotics and antibiotic-resistant bacteria can get into and harm the surrounding bodies of water and land through leakage and leachate (Zhang et al., 2022). It is essential to further analyze this topic because of the potential consequences for human health and the environment. Therefore, this study aims to execute antibiotic sensitivity profiling of bacterial communities acquired from city transfer stations in the City of San Fernando, Pampanga. Specifically, the researcher aspired to do the following:

(a) To identify bacterial communities existing in the city transfer stations in the City of San Fernando, Pampanga using serial dilution and multiple biochemical tests.

(b) To determine the antibiotic sensitivity of the obtained bacterial isolates from the said city transfer stations through Kirby-Bauer disk diffusion susceptibility test.

REVIEW OF RELATED LITERATURE

This chapter exhibits the related literature and papers from foreign and local sources. Those provided in this chapter help familiarize the reader with facts pertinent to and comparable to the current research.

Related Studies

Antibiotics are medications that stop infectious diseases. These substances are considered an important discovery in medical science as they accomplish their work by destroying the bacteria or stopping them from making copies of themselves (Felson, 2021). According to National Health Service United Kingdom (2019), there are many different antibiotics, and the majority of these are categorized into 6 different groups: Penicillin, Cephalosporins, Aminoglycosides, Tetracyclines, Macrolides, and Fluoroquinolones. Some other antibiotics are fusidic acid, trimethoprim, nitrofurantoin, and chloramphenicol. Felter (2019) further indicated that antibiotics have helped reduce the number of deaths worldwide caused by various infections. For example, the death rate from syphilis, an enormous public health problem at the beginning of the 20th century, dropped to almost zero by 1975 after penicillin was introduced. Furthermore, since 2000, antibiotics have stopped more than 58 million deaths caused by tuberculosis (Felter, 2019). With antibiotics' discovery, consumption of it increased over time. In the study by Klein et al. (2018), between 2000 and 2015, the number of defined daily doses of antibiotics used in 76 countries went up by 65%, and the rate of antibiotic use went up by 39%. Although there is a pronounced increase in consumption due to its positive impact, misuse of this treatment in animals and humans triggers the process of antibiotic resistance (WHO, 2020). Larsson & Flach (2021) describes that antibiotic resistance can happen when a bacterium's genome changes or when it takes in foreign DNA. With that, WHO (2020) declares that antibiotic resistance is considered one of the most severe threats to global health, food and nutrition security, and development. As

antibiotics lose effectiveness, it is getting harder to treat more and more infections like pneumonia, tuberculosis, gonorrhea, and salmonellosis. Because of this, antibiotic resistance causes people to stay in the hospital longer, pay more for medical care and cause more fatalities (WHO, 2020).

Studies around the world show that the fate of unused and expired medicines, such as antibiotics, end up as municipal solid wastes (Bashaar et al., 2017; Rogowska et al., 2019; Vogler et al., 2014). Whenever MSWs are discarded in landfills, these areas expose bacteria to many pharmaceuticals, including antibiotics. When these microbes are exposed to antibiotics in amounts that do not kill them, it may start a chain of events that leads to the transmission of resistance genes. Numerous analyses have found antibiotic-resistant genes and bacteria in the leachates and soils of landfills. Some of these strains are harmful (Borquaye et al., 2019).

With the emergence of antibiotic resistance of microorganisms, research efforts have been made to dig more into the phenomena. Overuse of antibiotics results in drug waste and the disposal of certain medicines in landfills (Xi et al., 2018). Few studies have focused on municipal solid waste dumping sites or city transfer stations since they recognized that they are a reservoir for antibiotic-resistant bacteria (Sitotaw et al., 2021). One of these earliest studies was authored by Adelowo et al. (2009), wherein it looked into how many antibiotic-resistant bacteria were in the 10 sampling sites (waste dumps) in Southwestern Nigeria. The Kirby-Bauer disk diffusion method tested the susceptibility of 195 organisms from the study sites to eight antimicrobial agents. Moreover, the agar dilution method found the minimum inhibitory concentration of cloxacillin and amoxicillin. From the 10 sampling sites, 195 organisms from 19 genera were taken. Most organisms are essential to public health, including species of *Escherichia coli, Vibrio cholerae, Salmonella, Staphylococcus aureus, Proteus, Klebsiella, Serratia marcescens, Pseudomonas, Bacillus, Enterobacter, Streptococcus, Yersinia, Morganella, Pediococcus, and Micrococcus*. All of these organisms were resistant to more than one of the tested antimicrobial agents. Adelowo et al. (2009) found a high level of resistance to drugs often used in Nigerian poultry dumping sites. Some of these are streptomycin, Tetracycline, Colistin, Nitrofurantoin, and Ampicillin. Given these findings, it can be said that poultry dumping sites can be a source of numerous antibiotic-resistant bacteria in the environment. However, this study could not figure out why certain of these microbes are resistant to antibacterial drugs at the molecular level and compare this to similar factors in clinical bacterial strains (Adelowo et al., 2009).

Similarly, Oviasogie et al. (2010) conducted a bacterial investigation of the soil at a municipal dump site in Nigeria. To isolate viable aerobic bacteria, a total of 18 samples consisting of six samples from hospitals and twelve samples from municipal solid waste dump soil in Benin City were obtained. All of the isolates were identified by studying the organisms' colonial appearance and morphological properties on the medium. For the identification of the organisms, specific biochemical tests were also conducted. This investigation used a less standardized disc diffusion technique similar to that of Stokes et al. (1993). They may have utilized this as the precise quantity of antimicrobial in a disc cannot be ensured owing to the difficulty of collecting and preserving discs or when the other parameters necessary for the Kirby-Bauer disk diffusion method are not satisfied. Furthermore, aerobic spore-bearing bacteria, *E. coli, S. aureus, and Klebsiella sp.,* were identified from municipal solid waste in decreasing order of prevalence. *Pseudomonas aeruginosa, Klebsiella sp, Bacillus substilis, Serratia sp, S. aureus, and E. coli* were present at in hospital waste samples. Ciprofloxacin was the most active antibacterial agent against the isolates, trailed by Augmentin and Gentamycin in both hospital and municipal solid waste. On the other hand, most isolates exhibited resistance to Cloxacillin and Amoxicillin (Oviasogie et al., 2010).

Another study by Mwaikono et al. (2015) examined the frequency and antibiotic resistance phenotype of enteric bacteria in Tanzania's municipal landfill. In their sampling site, solid wastes were not sorted out, and animals and humans had an increased interaction. Different types of solid waste were sampled, including domestic garbage, solid biomedical waste, river sludge near the dumpsite, and the feces of pigs scavenging on the dumpsite. The 16S rRNA sequencing was done to examine the frequency of enteric bacteria after total genomic DNA was removed. Also, Kirby-Bauer disk diffusion was employed to examine the antibiotic susceptibility of bacteria isolated from the landfill in their methodology. Then in their findings, almost half of the isolates exhibited resistance to Penicillin, Ceftazidime, and Nalidixic Acid. Consequently, 81% and 79% of isolates were susceptible to Ciprofloxacin and Gentamycin, making them the most potent antibiotics in the investigation. However, 56% of all the isolates were multidrug-resistant, and twelve isolates of *Escherichia sp. and Bacillus sp.* comprised a big group of multidrug-resistant bacteria. Based on their results, in the landfill, there is a significant frequency of antibiotic-resistant enteric bacteria (Mwaikono et al., 2015).

Moreover, in the work of Borquaye et al. (2019) in Ghana, they aimed to describe the occurrence of antibiotics and antibiotic-resistant bacteria in landfill in Kumasi. Specifically, they examined the concentrations of three commonly used antibiotics (Metronidazole, Penicillin, and Amoxicillin) and the presence of antimicrobial resistance in soil and leachate specimens from current and deserted landfill sites in Kumasi, Ghana. Sonication and solid-phase extraction (SPE) was used for sample processing, accompanied by HPLC-PDA analysis. Standard bacteriological procedures were used for bacterial isolation and characterization. Following European Committee for Antimicrobial Susceptibility Testing standards, antibiotic susceptibility tests were conducted similar to Kirby-Bauer. Antibiotics were found in very high amounts in samples obtained from active and defunct landfills. The greatest concentration of antibiotics in the acquired leachate samples was Penicillin, followed by Metronidazole and Amoxicillin. *Enterobacteriaceae* and some *Bacillus* and *Listeria* species collected from soil and leachate specimens were resistant to specific antibiotics. Regarding the susceptibility test, isolates of *Klebsiella, Enterobacter, Citrobacter, Proteus,* and *Shigella* exhibited resistance to Ampicillin, Amoxicillin, and Cefuroxime, but sensitivity to Gentamicin, Ciprofloxacin, and Amikacin. Gentamicin, Ciprofloxacin, and Amikacin were each effective against *Pseudomonas* isolates. *Aeromonas spp*. was responsive to both Amikacin and Gentamicin, while *Listeria* isolates were resistant to Ampicillin and Penicillin but susceptible to Erythromycin. *Bacilli* isolates demonstrated significant sensitivity to Gentamicin, Erythromycin, and Ciprofloxacin. All *Bacillus* species were likewise sensitive to Tetracycline, except for three isolates categorized as intermediate. Similarly, all but two Bacillus spp. isolates displayed Ampicillin resistance (Borquaye et al., 2019).

In the Philippines, there is little to none studies that have been done to test the antibacterial sensitivity of bacterial communities obtained from landfills or dumpsites. However, there are studies that pinpoints that dumping of antibiotics to the said areas generates leaching to different land forms and water forms; therefore, harming them. For instance, in the study of Supnet et al. (2020), they have conducted a study about the presence of multi-drug resistant bacteria in Marilao-Meycauayan-Obando River System (MORS). The MORS is one of the dirtiest and most contaminated areas on the country, although it is nonetheless used for aquaculture, and water supply. Since the river system is polluted with numerous industrial and commercial pollutants, it is probable that antibiotic-containing effluents are also discharged into it. For their antibiotic susceptibility testing, they have employed the Kirby-Bauer disk diffusion method as described by Hudzicki (2009). For their results, they have observed that all isolates were responsive to the fluoroquinolone antibiotic

Ciprofloxacin, which is effective against a broad spectrum of Gram-negative and Gram-positive pathogens. The microorganisms with the greatest multiple antibiotic resistance index were *Bacillus pumilus* and *Bacillus cereus*, followed by *Morganella morganii, E. coli,* and *Bacillus anthracis*. Some of the antibiotics tested were not effective against bacteria from MORS. Even though Bulacan, the place where MMORS is linked, is very highly contaminated, it nevertheless produces fish for Region III. The occurrence of antibiotic-resistant and toxigenic microbes in water and fish gastrointestinal specimens taken from MMORS constitutes a risk to food safety and public health (Supnet et al, 2020).

3. Methodology

Research Design

For this study, the researcher employed a descriptive cross-sectional research design. According to Siedlecki (2020), descriptive research aims to characterize a population by examining them in their natural state. In addition, the researcher did not modify any variables but merely examined and described the sample (Siedlecki, 2020). Kesmodel (2018) further adds that collecting pertinent data defines cross-sectional descriptive studies at a particular moment in time. Therefore, there was no temporal dimension involved, and the primary goal of this research was to evaluate the prevalence of traits and attributes (Kesmodel, 2018). Given these, the researcher utilized this particular design to obtain insights into the bacterial communities found in city transfer stations of the City of San Fernando, Pampanga, and the sensitivity of the isolates to antibiotics.

Data Gathering Procedure

Sample Collection and Handling

Soil samples was collected at the City Transfer Stations of City San Fernando, Pampanga. The said city transfer station is located at Barangay Lara, CSFP (15°04'54.1"N, 120°36'43.2"E). A photo of the city transfer station is shown in **Figure 1** and its satellite map is displayed in **Figure 2**. More than 30 grams of soil sample was collected and placed into a sterile screw-capped tube. Four sample locations were chosen at random within the CSFP city transfer station. The sample location of the sites are written on **Table 1.** As indicated by Borquaye et al. (2019), the samples were quickly transported under chilled settings to the laboratory and maintained in a refrigerator at 4°C before analysis (2021).

Figure 1. City of San Fernando, Pampanga City Transfer Station

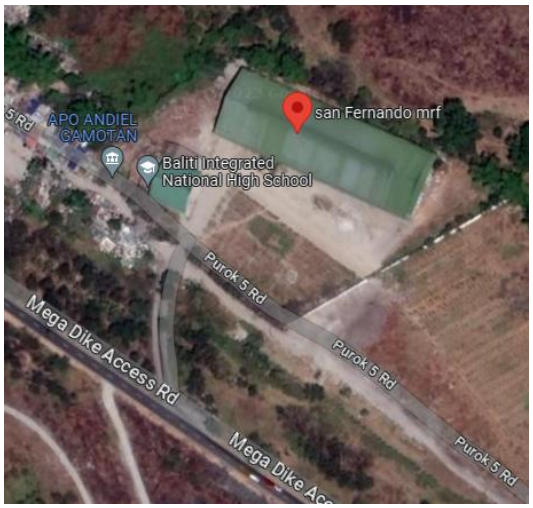


Figure 2. Satellite map of CSFP Transfer Station

Table 1. Sample locations characteristics

Site A	
Coordinates	15°04.940'N 120°36.713' E
Elevation	67 m
Soil temperature	27.3 ° C
Description	Dark, brown-black soil
Sun exposure	Shaded

Site B	
Coordinates	15°04.935'N 120°36.714' E
Elevation	65 m
Soil temperature	29.8 ° C
Description	Dark, black, moist, sticky soil
Sun exposure	Shaded

Site C	
Coordinates	15°04.945'N 120°36.726 E
Elevation	66 m
Soil temperature	39.2 ° C
Description	Brown, little loose soil
Sun exposure	Exposed to sun

Site D (Compost pile)	
Soil temperature	42.55 ° C
Description	Dark brown soil

Isolation of Microorganisms from Soil Samples

The researcher used serial dilution techniques with spread plate technique to isolate microorganisms, as Borquaye (2019) mentioned. Five grams of the soil sample from each location was combined to create a single homogenous sample. In this method, the researcher weighed a 1 g of the homogenous soil sample and serially dilute it with sterile distilled water up to a concentration of 10^{-10}. Before transfer of 0.1 μg of the dilution, the Petri dishes was covered with melted agar and was hardened at room temperature. Each 0.;1 μg dilution was then placed on sterile Petri dishes with labels and carefully spread to achieve homogeneity. The Petri dishes with samples was incubated for 24 hours at 37°C. Colonies with distinguishable morphologies was inoculated for 24 hours in 10 mL nutrient broth at 37°C. To confirm the morphologies that have already been described, broth cultures was inoculated on nutrient agar plates, then transferred into a new nutrient broth as pure cultures.

Identification of Isolates using Gram Staining and Biochemical Tests

The identification of bacteria was patterned to the methodology described by Borquaye et al. (2019). Gram staining was performed to assess the properties of isolates, such as the Gram reaction and shape. The isolated microbes were heat-fixed to a glass slide by gently passing the glass slide containing the inoculum of isolate through an alcohol lamp flame three times. Primary stain or crystal violet was applied to the slide and left for one minute. The slides were washed with water to eliminate loose crystal violet. Iodine was added for one minute, washed with alcohol first, and then with a moderate water flow. Secondary stain or safranin was put to the slide and left to rest for a few minutes. It was rinsed gently with a stream of water after. Microscopic inspection of the slides was performed using the oil immersion lens. Biochemical testing such as indole, hydrogen sulfide, catalase, citrate, methyl red, starch hydrolysis, and lysine iron agar (LIA) test were done according to standard techniques and referred to Collins and Lyne's Microbiological Methods and American Society for Microbiology's protocols (American Society for Microbiology, 2009, 2010, 2019).

Antibiotic Susceptibility Testing

As the gold standard for determining the susceptibility of bacteria, the Kirby-Bauer disk diffusion method was utilized to investigate the antibiotic susceptibility of bacterial isolates from the municipal transfer station (Khan et al., 2019). Additionally, Khan et al. (2019) add that the approach is generally adopted since it offers a straightforward, cost-effective technique for screening many targets. This procedure involved filling a Petri dish with newly prepared Mueller-Hinton agar. The plates will be dried at a temperature of 35°C. Moreover, the organisms were suspended in saline to a 0.5 McFarland turbidity standard density using the direct colony suspension method reported by Borquaye et al. (2019). After preparation, suspensions were utilized within 15 minutes. The researcher utilized a sterilized cotton swab into the solution and drain the excess by pushing and rotating it toward the interior of the screw-capped test tube. The sterile cotton swab was also used to distribute the inoculum throughout the whole agar surface properly. Using flame-sterilized forceps, antibiotic discs with specified concentrations was placed on the agar surface that had been inoculated. Erythromycin (15 μg/disc), Tetracycline (30 μg/disc), Penicillin (10 μg/disc), Ampicillin (10 μg/disc), Ciprofloxacin (5 μg/disc), Amoxicillin (10 μg/disc), and Gentamicin (30 μg/disc) are the commercially manufactured antibiotic discs. This was performed within 15 minutes of inoculation. After 15 minutes of disc placement, the plates were incubated and kept for 96 hours at 37°C. The inhibition zones surrounding each antibiotic disk was measured (millimeter) using a caliper. The zone diameter of each antibiotic was evaluated using Kumar (2008), Rahman (2017), and Sarker et al. (2014) interpretation charts as

clarified by Clinical & Laboratory Standards Institute (CLSI). Isolates were categorized as resistant (R), intermediate resistant (I) and susceptible (S).

Data Analysis

The researcher utilized descriptive statistics, with an emphasis on the mean. The data needed for the research was the millimeter-based inhibitory zones. After measuring the inhibition zones, the mean inhibition zones were determined. According to Manikandan (2011), the mean is crucial since it accurately represents the data and considers all of its values. The mean was calculated by dividing the sum of the values by the total number of data points. In this investigation, the mean inhibition zones were determined so that the results will be more reliable and precise. Considering descriptive statistics will be employed, Microsoft® Excel® 2019 MSO (Version 2206 Build 16.0.15330.20260) was utilized to evaluate further the data acquired.

Disposal of biological waste

As described by Texas A&M International University (TAMIU, n.d.), leak-proof vessels that can endure heat or chemical processing was employed for liquid biohazardous waste. In contrast, for solid biohazardous waste, containers made of heavy-duty plastic was utilized. Liquid waste, including cultures, was autoclaved by heat or chemical processing before being released into the sewerage system. On the other hand, solid microbiological waste was deposited in an appropriately labeled, leak-proof receptacle and disinfected using heat or chemical treatments (TAMIU, n.d).

2.Results

Table 2. Colony morphology, cellular characteristics, biochemical test, and putative organisms identified from soil samples

Isolates	Colony Morphology					Cellular Characteristics		Biochemical Tests							Microorganism
	Color	Shape	Margin	Elevation	Opacity	Gram Reaction	Shape	Indole	H_2S	LIA	Citrate	Methyl Red	Catalase	Starch	
DC 2	Light orange	Circular	Entire	Flat	Opaque	Positive	Coccus	-	-	K/K	+	-	+	+	*Micrococcus sp.*
DC 6	Creamy white	Punctiform	Entire	Flat	Opaque	Negative	Coccobacillus	-	-	K/K	-	-	+	-	*Acinetobacter sp.*
DC 9	Creamy white	Irregular	Undulate	Flat	Opaque	Positive	Bacillus	-	-	K/A	+	+	+	+	*Bacillus sp.*
DC 12	White	Rhizoid	Filamentous	Flat	Opaque	Positive	Bacillus	-	-	K/A	+	+	+	+	*Bacillus sp.*
DC 14	White	Punctiform	Entire	Flat	Translucent	Positive	Coccus	-	-	R/A	-	-	-	+	*Enterococcus sp.*
DC 16	Creamy white	Circular	Entire	Flat	Opaque	Negative	Bacillus	-	-	K/A	-	+	+	-	*Listeria sp.*
DC 18	Yellow	Punctiform	Entire	Flat	Opaque	Positive	Coccus	-	-	R/A – K/A	-	-	+	-	*Planococcus sp.*
DC 28	White	Punctiform	Entire	Flat	Opaque	Positive	Coccus	-	-	K/K – K/A	-	-	+	+	*Arthrobacter sp.*
DC 32	White	Circular	Entire	Flat	Opaque	Positive	Bacillus	-	-	K/A	+	-	+	+	*Bacillus sp.*
DC 34	Yellow	Punctiform	Entire	Flat	Opaque	Positive	Coccus	-	-	K/K	-	-	+	+	*Staphylococcus sp.*

* + = Positive
* - = Negative
*K/K = Alkaline slant/alkaline butt, K/A = Alkaline slant/acid butt, R/A = Red slant/acid butt

From the homogeneous sample, 35 pure cultures were obtained in total. Color, shape, margin, elevation, and opacity were used to categorize distinct colonies. After examining their commonalities and variations, the number of pure cultures was reduced to ten, as indicated in Table 2. The Gram staining result demonstrated that eight isolates were Gram-positive and two were Gram-negative. Five isolates exhibited coccus or spherical form, four showed bacillus or rod shape, and one displayed coccobacillus form or a shape intermediate between rod and spherical. In addition, various biochemical tests demarcated that soil bacteria isolates belonged to one of eight presumed genera such as the *Micrococcus, Acinetobacter, Bacillus, Enterococcus, Listeria, Planococcus, Arthrobacter,* and *Staphylococcus*.

Table 3. Zones of inhibition (mm) of antibiotics against distinct colonies and corresponding susceptibility and resistance of distinct colonies to antibiotic

Isolates	Organism	Zone diameter (mm)						
		Erythromycin	Amoxicillin	Gentamicin	Ciprofloxacin	Ampicillin	Penicillin	Tetracycline
DC 2	*Micrococcus sp.*	S (28.0)	S (19.0)	S (25.0)	S (25.0)	S (28.3)	S (37.0)	S (31.3)
DC 6	*Acinetobacter sp.*	S (32.0)	S (23.0)	S (24.0)	S (30.3)	S (28.3)	S (35.3)	S (36.0)
DC 9	*Bacillus sp.*	I (20.0)	R (0.0)	S (21.0)	S (27.7)	R (8.3)	R (8.0)	R (12.3)
DC 12	*Bacillus sp.*	S (26.0)	R (6.7)	S (20.3)	S (24.3)	R (9.7)	R (12.0)	R (12.7)
DC 14	*Enterococcus sp.*	I (15.7)	S (25.3)	S (21.0)	S (24.0)	S (27.3)	(I) 24.5	S (20.7)
DC 16	*Listeria sp.*	(S) 23.0	R (0.0)	S (22.7)	S (30.3)	R (0.0)	R (6.7)	R (14.3)
DC 18	*Planococcus sp.*	R (12.7)	S (31.7)	S (36.3)	S (27.3)	S (31.7)	S (37.7)	S (30.0)
DC 28	*Arthrobacter sp.*	R (9.7)	R (10.3)	S (30.3)	S (32.7)	S (18.7)	I (20.7)	S (34.0)
DC 32	*Bacillus sp.*	S (27.7)	S (18.0)	S (25.0)	S (28.0)	S (22.3)	S (28.7)	S (31.3)
DC 34	*Staphylococcus sp.*	No zones of inhibition	No zones of inhibition	No zones of inhibition	No zones of inhibition	No zones of inhibition	No zones of inhibition	No zones of inhibition
*S = susceptible, I = intermediate, and R = resistant								

Table 3 summarizes the findings of the antibiotic susceptibility testing. The zone diameter standards chart for the evaluation of antibiotic sensitivity and resistance status using the disc diffusion approach was predicated on the interpretation table given by Kumar (2008), Rahman (2017), and Sarker et al. (2014) as defined by CLSI. *Listeria sp*. and two *Bacillus sp.* showed multi-drug resistance to four antibiotics, such as Amoxicillin, Ampicillin, Penicillin, and Tetracycline. *Arthrobacter sp.* also displayed resistance to Erythromycin and Amoxicillin, and *Planococcus sp.* exhibited resistance to Erythromycin. *Enterococcus sp* and *Bacillus sp.* were classified as intermediate against Erythromycin. *Arthrobacter sp. and Bacillus sp.* were also categorized as intermediate against Penicillin. *Micrococcus sp., Acinetobacter sp., and one Bacillus sp.* were all susceptible to all antibiotics. Lastly, the *Staphylococcus sp.* did not display any zones of inhibition.

2. **Discussion**

This study identified the bacterial communities present in the city transfer station in San Fernando, Pampanga. In addition, the antibiotic sensitivity of the bacterial isolates acquired from the aforementioned municipal transfer station was investigated. Many bacterial species were identified on the transfer station, and the incidence of microorganisms resistant to the most regularly prescribed antibiotics was observed. The CSFP transfer station collected solid waste from many sources, including hospitals, households, and industries.

The homogeneous soil sample y12ielded 35 pure isolates, which were then reduced to 10 based on similarities and differences. The suspected eight genera of bacteria are the following: *Micrococcu12s, Acinetobacter, Bacillus, Enterococcus, Listeria, Planococcus, Arthrobacter,* and *Staphylococcus* (Awais et al., 2007; Borquaye et al., 2019; Chakraborty et al., 2011; Collins et al., 2004; El-Hadedy & El-Nour, 2012; Khan & Saha, 2018; Muruhan et al., 2012). These bacteria consisted of eight Gram-positive and two Gram-negative organisms. Numerous reports have also documented the isolation of these genera in different landfills worldwide. Borquaye et al. (2019) were able to recover multiple *Bacillus spp.* and a *Listeria sp.* from Ghanaian waste sites and claim that the prevalence of these bacteria can be detrimental to public health. *Bacillus spp.* and *Enterococcus spp.* were also isolated in a dumpsite in Tanzania, and *Arthrobacter spp*. were also identified in South Africa dumpsites (Mwaikono et al., 2015; Nnolim et al., 2020). In the study of Latorre et al. (2013) about specifying landfill bacteria in Puerto Rico, they acquired *Acinetobacter spp.* at the same time, Ochieng (2003) obtained *Planococcus spp.* in Kenyan dumpsites. *Micrococcus spp., Staphylococcus spp.,* and *Bacillus spp.* were also isolated in a dumpsite in Nigeria (Emmanuel et al., 2017). Nevertheless, as mentioned earlier, other species aside from these genera were also collected in the studies. The bacterial isolates also include *Klebsiella spp. Citrobacter spp. Pseudomonas spp., Shigella spp., Proteus spp., Enterobacter spp., Serratia spp., Lactobacillus spp., Streptococcus spp., Chryseomicrobium spp., Stenotrophomonas spp., and Lysinibacillus spp.* According to Sitotaw et al. (2021), the types of bacteria gathered for research in various studies could be distinct. This is because the variance in the variety of bacteria retrieved in this study and past literature could be attributable to many different factors. Some of these facets include distinctions in the complexity of the dumped wastes, the soil's physiochemical properties at the dumpsite, environmental features, and seasonal variations in the sampling sites.

Regarding the ten isolates, six genera isolated, *Arthrobacter, Acinetobacter, Bacillus, Enterococcus, Listeria, and Staphylococcus*, are considered pathogenic to humans. Under the American Biological Safety Association (ABSA, n.d.) and the Public Health Agency of Canada (PHAC, 2010, 2011), these six pathogenic bacteria are categorized as Risk Group 2. Microorganisms in the Risk Group 2 category can induce human illness and may constitute a danger to those directly exposed. Also, adequate treatment and prevention are readily accessible, and they are, however, unlikely to spread across the community (ABSA, n.d.). Such prevalence of disease-causing bacteria could be attributable to the fact that the city transfer station is used to dispose of mixed wastes from various locations inside the city. In previous years, many reports of possible pathogens from the dumping site included individuals belonging to the bacterial genera *Arthrobacter, Bacillus, Listeria, Staphylococcus, Enterococcus, and Acinetobacter* (Borquaye et al., 2019; Sitotaw et al., 2021; Mwaikono et al., 2015; Nnolim et al., 2020). Moreover, *Bacillus spp.* was the leading genus of bacteria identified from the sample locations. This high incidence of *Bacillus spp.* in this study is also evident in the research conducted by

Borquaye et al. (2019), Ochieng (2003), and Oviasogie et al. (2010). However, in the research conducted by Mwaikono et al. (2015), *E. coli* was found to be superior to *Bacillus spp*.. Likewise, *Bacillus spp.* occurs at a greater rate in landfills soil because of its broad spectrum of extracellular enzymes, physiological characteristics, the occurrence of resistant endospores in various adverse conditions, and the synthesis of compounds that inhibit neighboring bacteria (Arnesen et al., 2008). Therefore, these genera can develop in various habitats and endure extremely contaminated environments because of these capacities. On the other hand, *Micrococcus sp.* and *Planococcus sp.* are not considered as risk danger according to ABSA. *Micrococcus spp.* are often found in a wide range of terrestrial environments, including soil, where they are regarded as effective biofertilizers. *Micrococcus spp.* are also often found in the skin of warm-blooded animals, including humans. Then, *Planococcus sp.* was also recovered from a contaminated farming soil sample. *Planococcus spp.* are halophilic bacteria recognized for producing a wide range of secondary metabolites (Batt, 2014; Dubey et al., 2021; Waghmode et al., 2020)

Furthermore, several earlier pieces of literature have found a significant incidence of antibiotic-resistant bacteria within isolated bacteria taken from patient cases to non-clinical settings, particularly in transfer stations or dumpsites. In this study, *Listeria sp.* and *Bacillus spp.* were found to be multi-drug resistant as Amoxicillin, Ampicillin, Penicillin, and Tetracycline failed to impede the growth of the said species. One *Bacillus sp.* had an intermediate response to Erythromycin. This finding conforms with the results of Borquaye et al. (2019), wherein *Listeria sp.* isolated from the soil samples displayed resistance to Ampicillin and Penicillin. However, in the case of Tetracycline, their results showed that three isolates of *Bacillus spp.* were categorized only as intermediate, and all *Bacillus spp.* were sensitive to Erythromycin. Although the vast majority of *Bacillus* strains do not threaten human health, evading prolonged contact with these bacteria is essential since they still harbor genes for resistance. They may hand on resistance genes to other potentially hazardous species, which would have a terrible consequence (Borquaye et al., 2019). Moreover, in a clinical report by Li et al. (2021a), it was shown that an *Arthrobacter sp.* frequently found in soil was also resistant to Erythromycin and Amoxicillin and intermediate to Penicillin. This agrees with the result of *Arthrobacter spp.* isolated in this study. Nevertheless, Li et al. (2021a) findings contradicted some of this study's findings, especially in the sensitivity of *Arthrobacter sp.* to Gentamicin, Ampicillin, and Ciprofloxacin. Sitotaw et al. (2021) also recovered *Enterococcus spp.* in their study of bacterial communities in Ethiopia. Here, most of their isolates, encompassing *Enterococcus spp.*, were sensitive to Erythromycin. Contrary to Sitotaw et al. (2021), one finding of this current study indicated an intermediate response to Erythromycin. Regarding the resistance of *Planococcus sp.*, no current study exhibits resistance to Erythromycin. Also, due to the lack of data on *Staphylococcus spp.*, the results cannot confirm if the said genera are resistant or sensitive to the antibiotics used in the disc diffusion approach. Given these results, four out of ten isolates suggest that these organisms are antibiotic-resistant bacteria. Numerous types of research have shown that landfills are a dominant contributor to antibiotic-resistant genes and resistant microorganisms. The presence of resistant genes in dumpsite bacteria may be brought about by intrinsic pressure. It is also possible that this is the outcome of the selective pressure exerted by the wide range of pharmaceuticals present at the dumpsite, as well as the high level of interplay that has been seen among microorganisms originating from various sources (Borquaye et al., 2019; Sitotaw et al., 2021; Mwaikono et al., 2015).

On the other hand, most isolates were sensitive to Ciprofloxacin and Gentamicin. This is in line with the fact that gentamicin is effective against a wide scope of bacterial infections, primarily pathogenic Gram-negative bacteria, including *Acinetobacter spp.* and *Listeria spp*, and Gram-positive bacteria, such as *Micrococcus spp., Bacillus spp., Enterococcus spp., Planococcus spp.,* and *Staphylococcus spp.* except for *Arthrobacter spp.* (Li et al., 2021a; Ibrahim et al., 2015; Li et al, 2021b, Adimpong et al., 2012; Rind & Khan, 2000; Kanafani & Kanj, 2022; Gelfand et al., 2022). Besides, Ciprofloxacin is efficacious against most of the ten bacterial isolates except for *Listeria spp.* and *Arthrobacter spp.* (Li et al., 2021a; Murray et al., 2022; Fasina et al, 2014; Kanafani et al., 2022; Seck et al, 2016; Vidanaral et al., 2017; Noll et al., 2017).

3. **Conclusion**

This study has identified eight genera of bacteria from the CSFP transfer station. The genera are the following: *Micrococcus, Acinetobacter, Bacillus, Enterococcus, Listeria, and Planococcus.* The antibiotic sensitivity testing revealed that Listeria sp. and Bacillus sp. are resistant to multiple antibiotic drugs, including Amoxicillin, Ampicillin, Penicillin, and Tetracycline. *Arthrobacter sp.* also showed resistance to Erythromycin and Amoxicillin, while *Planococcus sp. exhibited* resistance to Erythromycin. *Enterococcus sp.* and *Bacillus sp.* were classified as intermediate against Erythromycin, and *Enterococcus sp.* was likewise categorized as intermediate against Penicillin.

With these points, further research is needed to confirm the identity of 10 isolates. 16S rRNA gene sequencing should be carried out to affirm the various genera. This method is often used for determining the types of bacteria present in complicated biological mixes, such as those found in landfill soil samples and their relative abundances (Das & Dash, 2019). Also, it is suggested to verify the results of the Kirby-Bauer disk diffusion through the minimum inhibitory concentration (MIC). As Guevara et al. (2005) indicated, resistance is proven using MIC by determining the lowest dose of an antibiotic that inhibits the observable growth of a microbe following incubation. In addition, in light of the findings of this study, transfer station employees are highly recommended to be provided with the necessary personal protective equipment (PPE) by authorities. Since there was a reported existence of Risk Group 2 bacteria, it is also recommended for the primary workers to follow exposure controls and personal protection indicated by PHAC (2010, 2011). When direct contact with skin with infectious materials is inevitable, lab coats and gloves are highly recommended by PHAC (2010, 2011). Safety goggles are required if there is a known danger of splashing. Officials are also urged to supervise their utilization to ensure that these PPE's efficiency will be maximized. Moreover, municipal health authorities must establish a method for the routine monitoring of transfer stations. Given that some of the isolates are highly pathogenic, it is recommended that the authorities adopt other waste management coming from hospital wastes. The burning of medical waste is an option to consider since it is the method that poses the least risk to public health and is also the most successful in preventing pathogenic organisms from causing damage to the environment. Also, the surrounding area's communities must be instructed about the importance of maintaining a high level of cleanliness and hygiene. Lastly, it is necessary to launch an informational program about the proper disposal of different MSWs to prevent resistant bacteria from spreading.

References

Adelowo, O. O., Ojo, F. A., & Fagade, O. E. (2008). Prevalence of multiple antibiotic resistance among bacterial isolates from selected poultry waste dumps in Southwestern Nigeria. *World Journal of Microbiology and Biotechnology 2008 25:4*, *25*(4), 713–719. https://doi.org/10.1007/S11274-008-9940-Y

Adimpong, D. B., Sørensen, K. I., Thorsen, L., Stuer-Lauridsen, B., Abdelgadir, W. S., Nielsen, D. S., Derkx, P. M. F., & Jespersen, L. (2012). Antimicrobial Susceptibility of Bacillus Strains Isolated from Primary Starters for African Traditional Bread Production and Characterization of the Bacitracin Operon and Bacitracin Biosynthesis. *Applied and Environmental Microbiology*, *78*(22), 7903–7914. https://doi.org/10.1128/AEM.00730-12

American Biological Safety Association. (n.d.). *Risk Group Database*.

American Society for Microbiology. (2009). *Methyl Red and Voges-Proskauer Test Protocols* . https://asm.org/Protocols/Methyl-Red-and-Voges-Proskauer-Test-Protocols

American Society for Microbiology. (2010). *Catalase Test*. https://asm.org/Protocols/Catalase-Test-Protocol

American Society for Microbiology. (2019). *Indole Test*. https://asm.org/Protocols/Indole-Test-Protocol

Antibiotics – Understand – ReAct. (n.d.). Retrieved July 24, 2022, from https://www.reactgroup.org/toolbox/understand/antibiotics/

Anwar, M., Iqbal, Q., & Saleem, F. (2020). Improper disposal of unused antibiotics: an often overlooked driver of antimicrobial resistance. *Https://Doi.Org/10.1080/14787210.2020.1754797*, *18*(8), 697–699. https://doi.org/10.1080/14787210.2020.1754797

Awais, M., Shah, A., Hameed, A., & Hasan, F. (2007). Isolation, identification and optimization of bacitracin produced by Bacillus sp. *Pakistan Journal of Botany*, *39*(4), 1303–1312. https://www.researchgate.net/publication/228484931_Isolation_identification_and_optimization_of_bacitracin_produced_by_Bacillus_SP

Bashaar, M., Thawani, V., Hassali, M. A., & Saleem, F. (2017). Disposal practices of unused and expired pharmaceuticals among general public in Kabul. *BMC Public Health*, *17*(1), 1–8. https://doi.org/10.1186/S12889-016-3975-Z/TABLES/4

Batt, C. A. (2014). *Encyclopedia of Food Microbiology*. Academic Press.

Benkova, M., Soukup, O., & Marek, J. (2020). Antimicrobial susceptibility testing: currently used methods and devices and the near future in clinical practice. *Journal of Applied Microbiology*, *129*(4), 806–822. https://doi.org/10.1111/JAM.14704

Borquaye, L. S., Ekuadzi, E., Darko, G., Ahor, H. S., Nsiah, S. T., Lartey, J. A., Mutala, A. H., Boamah, V. E., & Woode, E. (2019). Occurrence of antibiotics and antibiotic-resistant bacteria in landfill sites in Kumasi, Ghana. *Journal of Chemistry*, *2019*. https://doi.org/10.1155/2019/6934507

Brittanica. (2022). *Antimicrobial agent* . https://www.britannica.com/science/antimicrobial-agent

Browne, A. J., Chipeta, M. G., Haines-Woodhouse, G., Kumaran, E. P. A., Hamadani, B. H. K., Zaraa, S., Henry, N. J., Deshpande, A., Reiner, R. C., Day, N. P. J., Lopez, A. D., Dunachie, S., Moore, C. E., Stergachis, A., Hay, S. I., & Dolecek, C. (2021). Global antibiotic consumption and usage in humans, 2000–18: a spatial modelling study. *The Lancet Planetary Health*, *5*(12), e893–e904. https://doi.org/10.1016/S2542-5196(21)00280-1/ATTACHMENT/CB90EDD4-23DA-4F68-A96F-075D1969B575/MMC1.PDF

Castillo, A. L., & Otoma, S. (2013). *Status of Solid Waste Management in the Philippines*.

Chakraborty, S. P., Mahapatra, S. K., & Roy, S. (2011). Biochemical characters and antibiotic susceptibility of Staphylococcus aureus isolates. *Asian Pacific Journal of Tropical Biomedicine*, *1*(3), 212–216. https://doi.org/10.1016/S2221-1691(11)60029-4

Collins, C. H., Lyne, P., Grange, J. M., & Falkinham III, J. O. (2004). *Collins and Lyne's Microbiological Methods*. Hodder Education Publishers;

Das, S., & Dash, H. R. (Eds.). (2019). *Microbial Diversity in the Genomic Era*. Elsevier. https://doi.org/10.1016/C2017-0-01759-7

Dubey, A., Kumar, A., Khan, M. Z. A., & Payasi, D. (2021). Plant Growth-promoting and Bio-control Activity of Micrococcus luteus Strain AKAD 3-5 Isolated from the Soybean (Glycine max (L.) Merr.) Rhizosphere. *The Open Microbiology Journal*, 15(1), 188–197. https://doi.org/10.2174/1874285802115010188

El-Hadedy, D., & Abu El-Nour, S. (2012). Identification of Staphylococcus aureus and Escherichia coli isolated from Egyptian food by conventional and molecular methods. *Journal of Genetic Engineering and Biotechnology*, *10*(1), 129–135. https://doi.org/10.1016/j.jgeb.2012.01.004

Emmanuel, U., Ifeanyichukwu, I., Chika, E., Chike, O., & Chinyere, N. (2017). Isolation and Characterization of Bacteria and Fungi Associated With Biodegradation of Municipal Solid Wastes in Abakaliki Metropolis, Nigeria. *International Journal of Environment, Agriculture and Biotechnology*, *2*(3), 1294–1304. https://doi.org/10.22161/ijeab/2.3.35

Fasina, F. O., Ajayi, O. O., Okeke, L. A., Olawuyi, K. A., Nwagbo, I., & Ogbonnah, C. (2014). Antibiotic resistant micrococcus species isolated from cattle egrets and its implications. *International Journal of Infectious Diseases*, *21*, 78–79. https://doi.org/10.1016/j.ijid.2014.03.591

Felson, S. (2021). *Antibiotics: What They Are, How to Take Them, Side Effects*. 2021. https://www.webmd.com/a-to-z-guides/what-are-antibiotics

Felter, C. (2019). *The End of Antibiotics? | Council on Foreign Relations*. https://www.cfr.org/backgrounder/end-antibiotics

Gelfand, M., Thompson, J., & Swamy, G. (2022). *Treatment and prevention of Listeria monocytogenes infection*. https://www.uptodate.com/contents/treatment-and-prevention-of-listeria-monocytogenes-infection

Guevara, B. , Madulid, R., Aguinaldo, A., Espeso, E., Nonato, M., Quinto, E., Santos, M. A., de Castro-Bernas, G., Gonzales, R., del Castillo-Solevilla, R., & Ysrael, M. (2005). *A guidebook to plant screening: phytochemical and biological*. UST Publishing House.

He, P., Huang, J., Yu, Z., Xu, X., Raga, R., & Lü, F. (2021). Antibiotic resistance contamination in four Italian municipal solid waste landfills sites spanning 34 years. *Chemosphere*, *266*, 129182. https://doi.org/10.1016/J.CHEMOSPHERE.2020.129182

Ibrahim, S. L., Zhang, L., Brady, T. M., Hsu, A. J., Cosgrove, S. E., & Tamma, P. D. (2015). Low-dose Gentamicin for Uncomplicated *Enterococcus faecalis* Bacteremia May be Nephrotoxic in Children. *Clinical Infectious Diseases*, *61*(7), 1119–1124. https://doi.org/10.1093/cid/civ461

IQVIA. (2021). *Global Medicine Spending and Usage Trends: Outlook to 2025*. https://www.iqvia.com/insights/the-iqvia-institute/reports/global-medicine-spending-and-usage-trends-outlook-to-2025

Kanafani, Z., & Kanj, S. (2022). *Acinetobacter infection: Treatment and prevention*. https://www.uptodate.com/contents/acinetobacter-infection-treatment-and-

prevention/print#:~:text=Aminoglycosides%20%E2%80%93%20Aminoglycosides%20(eg%2C%20gentamicin,they%20achieve%20high%20urine%20concentrations.

Kanafani, Z., Kanj, S., Calderwood, S., & Hall, K. (n.d.). *Acinetobacter infection: Treatment and prevention*. 2022. https://www.uptodate.com/contents/acinetobacter-infection-treatment-and-prevention/print

Kenakin, T. (2022). *Comprehensive Pharmacology* . https://www.sciencedirect.com/referencework/9780128208762/comprehensive-pharmacology

Kesmodel, U. S., & Kesmodel, S. (2018). Cross-sectional studies – what are they good for? *Acta Obstetricia et Gynecologica Scandinavica*, *97*(4), 388–393. https://doi.org/10.1111/AOGS.13331

Khan, F. I., & Saha, M. L. (2018). Bacteria laden street food (Chatpati) and their multiple antibiotic resistance index. *Bangladesh Journal of Botany*, *44*(4), 599–604. https://doi.org/10.3329/bjb.v44i4.38596

Khan, Z. A., Siddiqui, M. F., & Park, S. (2019). Current and Emerging Methods of Antibiotic Susceptibility Testing. *Diagnostics*, *9*(2). https://doi.org/10.3390/DIAGNOSTICS9020049

Klein, E. Y., van Boeckel, T. P., Martinez, E. M., Pant, S., Gandra, S., Levin, S. A., Goossens, H., & Laxminarayan, R. (2018). Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(15), E3463–E3470. https://doi.org/10.1073/PNAS.1717295115/SUPPL_FILE/PNAS.1717295115.SAPP.PDF

Kumar, A. (2008). Bacterial Resistance to Antimicrobial Agents and Microbiological Quality among Escherichia coli Isolated from Dry Fishes in Southeast Coast of India. *Roumanian Biotechnological Letters*.

Larsson, D. G. J., & Flach, C. F. (2021). Antibiotic resistance in the environment. *Nature Reviews Microbiology 2021 20:5*, *20*(5), 257–269. https://doi.org/10.1038/s41579-021-00649-x

Latorre, I., Hwang, S., & Montalvo-Rodriguez, R. (2012). Isolation and molecular identification of landfill bacteria capable of growing on di-(2-ethylhexyl) phthalate and deteriorating PVC materials. *Journal of Environmental Science and Health, Part A*, *47*(14), 2254–2262. https://doi.org/10.1080/10934529.2012.707549

Li, S.-Y., Kao, C.-C., Hu, Y.-C., Lai, C.-H., Jiang, Y.-P., Mao, Y.-C., Huang, Y.-T., & Liu, P.-Y. (2021). Arthrobacter woluwensis Bacteremia: A Clinical and Genomic Report. *Pathogens*, *10*(4), 443. https://doi.org/10.3390/pathogens10040443

Li, Y.-X., Wang, N.-N., Zhou, Y.-X., Lin, C.-G., Wu, J.-S., Chen, X.-Q., Chen, G.-J., & Du, Z.-J. (2021). Planococcus maritimus ML1206 Isolated from Wild Oysters Enhances the Survival of Caenorhabditis elegans against Vibrio anguillarum. *Marine Drugs*, *19*(3), 150. https://doi.org/10.3390/md19030150

Manikandan, S. (2011). Measures of central tendency: The mean: *Https://Doi.Org/10.4103/0976-500X.81920*, *2*(2), 140–142. https://doi.org/10.4103/0976-500X.81920

Murray, B., Miller, W., Sexton, D., & Bogorodskaya, M. (2022). *Treatment of enterococcal infections*. https://www.uptodate.com/contents/treatment-of-enterococcal-infections

Murray, C. J., Ikuta, K. S., Sharara, F., Swetschinski, L., Robles Aguilar, G., Gray, A., Han, C., Bisignano, C., Rao, P., Wool, E., Johnson, S. C., Browne, A. J., Chipeta, M. G., Fell, F., Hackett, S., Haines-Woodhouse, G., Kashef Hamadani, B. H., Kumaran, E. A. P., McManigal, B., … Naghavi, M. (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

Muruhan, S., Rajan, M., & Konuku, S. (2012). Morphological and biochemical characteristics and antibiotic resistance pattern of Staphylococcus aureus isolated from grapes. *International Journal of Nutrition, Pharmacology, Neurological Diseases*, *2*(1), 70. https://doi.org/10.4103/2231-0738.93135

Mwaikono, K. S. , Maina, S., & Gwakisa, P. (2015). *Prevalence and Antimicrobial Resistance Phenotype of Enteric Bacteria from a Municipal Dumpsite*. https://www.researchgate.net/publication/281811905_Prevalence_and_Antimicrobial_Resistance_Phenotype_of_Enteric_Bacteria_from_a_Municipal_Dumpsite

National Health Service United Kingdom. (2019). *Antibiotics* . https://www.nhs.uk/conditions/antibiotics/

Nnolim, N. E., Okoh, A. I., & Nwodo, U. U. (2020). Proteolytic bacteria isolated from agro-waste dumpsites produced keratinolytic enzymes. *Biotechnology Reports*, *27*, e00483. https://doi.org/10.1016/j.btre.2020.e00483

Noll, M., Kleta, S., & al Dahouk, S. (2018). Antibiotic susceptibility of 259 Listeria monocytogenes strains isolated from food, food-processing plants and human samples in Germany. *Journal of Infection and Public Health*, *11*(4), 572–577. https://doi.org/10.1016/j.jiph.2017.12.007

Ochieng, S. J. (2003). *Isolation and molecular characterization of composting bacteria from municipal solid waste disposal sites in two Kenyan cities, Nairobi and Kisumu*.

Oviasogie, F. E., Ajuzie, C. U., & Ighodaro, U. G. (2010). Bacterial Analysis of Soil From Waste Dumpsite. *Scholars Research Library Archives of Applied Science Research*, *2*(5), 161–167. www.scholarsresearchlibrary.com

Public Health Agency of Canada. (2008-2015a). Pathogen Safety Data Sheets: Infectious Substances – *Acinetobacter.* https://my.absa.org/tiki-index.php?page=Riskgroups&default%5bcontent%5d=acinetobacter

Public Health Agency of Canada. (2008-2015b). Pathogen Safety Data Sheets: Infectious Substances – *Arthrobacter spp*. https://my.absa.org/tiki-index.php?page=Riskgroups&default%5bcontent%5d=arthrobacter

Public Health Agency of Canada. (2008-2015c). *Pathogen Safety Data Sheets: Infectious Substances – Bacillus spp*. https://my.absa.org/tiki-index.php?page=Riskgroups&default%5bcontent%5d=bacillus

Public Health Agency of Canada. (2008-2015d). *Pathogen Safety Data Sheets: Infectious Substances – Enterococcus faecalis and Enterococcus faecium*. https://my.absa.org/tiki-index.php?page=Riskgroups&default%5bcontent%5d=enterococcus

Public Health Agency of Canada. (2008-2015e). *Pathogen Safety Data Sheets: Infectious Substances – Listeria spp*. https://my.absa.org/tiki-index.php?page=Riskgroups&default%5bcontent%5d=listeria

Public Health Agency of Canada. (2008-2015f). *Pathogen Safety Data Sheets: Infectious Substances – Staphylococcus spp*. https://my.absa.org/tiki-index.php?page=Riskgroups&default%5bcontent%5d=staphylococcus

R., R., & Khan, T. S. (2000). Antibiogram Sensitivity of Bacterial Organisms Identified from Surgical and Non-surgical Wounds of Animal. *Pakistan Journal of Biological Sciences*, *3*(10), 1719–1723. https://doi.org/10.3923/pjbs.2000.1719.1723

Rahman, S. S., Aditi, F. Y., & Hossain, Md. M. (2017). A Study on the Microbiological Status of Mineral Drinking Water. *The Open Microbiology Journal*, *11*(1), 31–44. https://doi.org/10.2174/1874285801711010031

Rao, S. (2006). *Online bacterial identification*. https://www.microrao.com/identify.htm

Republic Act No. 9003 | Official Gazette of the Republic of the Philippines. (2001). https://www.officialgazette.gov.ph/2001/01/26/republic-act-no-9003-s-2001/

Rogowska, J., Zimmermann, A., Muszyńska, A., Ratajczyk, W., & Wolska, L. (2019). Pharmaceutical Household Waste Practices: Preliminary Findings from a Case Study in Poland. *Environmental Management*, *64*(1), 97–106. https://doi.org/10.1007/S00267-019-01174-7/TABLES/3

Sarah, J. G., Supnet, E., Caballero, V. M., Parcon, R. H., & Simbahan, J. F. (2020). Marilao-Meycauayan-Obando River System (MMORS) Harbors Multidrug-Resistant Bacteria Indicating High Risk of Antimicrobial Contamination. *Philippine Science Letters*, *13*(02). http://www.ncbi.nlm.nih.gov

Sarker, Md. M. R., Islam, K. N., Huri, H. Z., Rahman, M., Imam, H., Hosen, Md. B., Mohammad, N., & Sarker, Md. Z. I. (2014). Studies of the Impact of Occupational Exposure of Pharmaceutical Workers on the Development of Antimicrobial Drug Resistance. *Journal of Occupational Health*, *56*(4), 260–270. https://doi.org/10.1539/joh.14-0012-OA

Seck, E. H., Sankar, S. A., Khelaifia, S., Croce, O., Robert, C., Couderc, C., di Pinto, F., Sokhna, C., Fournier, P.-E., Raoult, D., & Lagier, J.-C. (2016). Noncontiguous finished genome sequence and description of Planococcus massiliensis sp. nov., a moderately halophilic bacterium isolated from the human gut. *New Microbes and New Infections*, *10*, 36–46. https://doi.org/10.1016/j.nmni.2015.12.006

Siedlecki, S. L. (2020). Understanding Descriptive Research Designs and Methods. *Clinical Nurse Specialist*, *34*(1), 8–12. https://doi.org/10.1097/NUR.0000000000000493

Sitotaw, B., Ayalew, F., Girma, A., Geta, K., & Kibret, M. (2021). *High prevalence of Antibiotic Resistance Bacteria isolated from Municipal Solid Waste Dumpsite, Bahir Dar, Ethiopia*. https://doi.org/10.21203/RS.3.RS-1182902/V1

Stafford, W. H. L. (2020). WtE Best Practices and Perspectives in Africa. *Municipal Solid Waste Energy Conversion in Developing Countries: Technologies, Best Practices, Challenges and Policy*, 185–217. https://doi.org/10.1016/B978-0-12-813419-1.00006-1

Stenfors Arnesen, L. P., Fagerlund, A., & Granum, P. E. (2008). From soil to gut: *Bacillus cereus* and its food poisoning toxins. *FEMS Microbiology Reviews*, *32*(4), 579–606. https://doi.org/10.1111/j.1574-6976.2008.00112.x

Texas A&M International University. (n.d.). *Management and Disposal of Biological Waste*.

Vidanaral, A. H., Kasper, K., Karlowsky, J., & Walkty, A. (2017). Successful treatment of Bacillus cereus group brain abscesses with a combination of high-dose ciprofloxacin and vancomycin. *Official Journal of the Association of Medical Microbiology and Infectious Disease Canada*, *2*(1), 64–68. https://doi.org/10.3138/jammi.2.1.009

Vogler, S., Leopold, C., Zuidberg, C., & Habl, C. (2014). Medicines discarded in household garbage: Analysis of a pharmaceutical waste sample in Vienna. *Journal of Pharmaceutical Policy and Practice*, *7*(1), 1–8. https://doi.org/10.1186/2052-3211-7-6/TABLES/1

Waghmode, S., Suryavanshi, M. V., Sharma, D., & Satpute, S. K. (2020). Planococcus Species – An Imminent Resource to Explore Biosurfactant and Bioactive Metabolites for Industrial

Applications. *Frontiers in Bioengineering and Biotechnology, 8*. https://doi.org/10.3389/fbioe.2020.00996

Waturu, G., Mutai, W., Kiiru, J., Musyoki, M., Ochieng, L., Waturu, G., Mutai, W., Kiiru, J., Musyoki, M., & Ochieng, L. (2017). Antimicrobial Resistance Encountered in Garbage Collection Areas and Dumpsites in Nairobi, Kenya Using Escherichia coli and Klebsiella as Indicator Species. *Advances in Microbiology*, *7*(9), 653–665. https://doi.org/10.4236/AIM.2017.79051

Word Health Organization. (2020). *Antibiotic resistance*. https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance

World Health Organization. (2020). *Antibiotic resistance*. https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance

World Health Organization. (2022). *Antimicrobial resistance*. https://www.who.int/health-topics/antimicrobial-resistance

Xi, H., Sun, J., & Xie, B. (2018). The study of characteristics of antibiotic residues in municipal solid waste landfill. *Huanjing Kexue Xuebao/Acta Scientiae Circumstantiae*, *38*(1), 300–309. https://doi.org/10.13671/J.HJKXXB.2017.0202

Zhang, R., Yang, S., An, Y., Wang, Y., Lei, Y., & Song, L. (2022). Antibiotics and antibiotic resistance genes in landfills: A review. *Science of The Total Environment*, *806*, 150647. https://doi.org/10.1016/J.SCITOTENV.2021.150647

Zhang, X., Zhu, R., Li, W., Ma, J., & Lin, H. (2021). Genomic insights into the antibiotic resistance pattern of the tetracycline-degrading bacterium, Arthrobacter nicotianae OTC-16. *Scientific Reports*, *11*(1), 15638. https://doi.org/10.1038/s41598-021-94840-y

Zothanpuia, Zomuansangi, R., Leo, V. V., Passari, A. K., Yadav, M. K., & Singh, B. P. (2021). Antimicrobial sensitivity profiling of bacterial communities recovered from effluents of municipal solid waste dumping site. *3 Biotech*, *11*(2), 37. https://doi.org/10.1007/S13205-020-02548-Z

Presentation of Mental Health Risk Assessment and Management Frameworks

Aubrill Faye Cayat Cariaso
University of Baguio, Baguio City, Philippines
Email : rdc@e.ubaguio.edu

Abstract

A considerable proportion of students suffer from mental health problems that may affect normal functioning. This study explored existing approaches to mental health risk assessment and risk management. A document analysis approach was applied to analyze data extracted from carefully selected documents. The analysis unraveled that the Implementing Rules and Regulations of Republic Act No. 11036, otherwise known as the Mental Health Act, plays a fundamental role in the provision to integrate mental health policy across all sectors comprehensively. Risk assessment in mental health practice is based on a comprehensive collection of information from all available sources that capture an individual's care needs. As various risks are involved in mental health, the processes revealed that there is no one-model-fits-all risk management solution. Based on the documentary analysis, recommendations were developed for mental health risk and management.

Keywords : mental health legislation, mental health framework, risk assessment, risk management

Introduction

Mental health, although not a new concern, has become increasingly acceptable to discuss in recent years (VanderLind, 2017). Mental health issues and emerging mental illness continue to present as significant areas of concern for young adults, with an onset often in mid-adolescence to early adulthood (Yap et al., 2012). Most mental health disorders have peak onset during young adulthood (Pedrelli et al., 2015). Yap et al. (2012) reported that clinical depression and anxiety-related issues are common for students under academic stress between 18 and 24.

Globally, an estimated 10-20% of children and adolescents experience mental health conditions, but most do not seek help or receive care (WHO, 2020). In the study of Mahmood and Saleem (2011) on the patterns of mental health problems of university students, the results showed four different patterns of problems: a sense of being dysfunctional, loss of confidence, lack of self-regulation, and anxiety proneness. A wealth of research evidence suggests that the mental health problems of university students are beginning to get attention from researchers, and these problems are increasing. On the one hand, Mojtabai et al. (2016) examined national trends in the 12-month prevalence of major depressive episodes (MDEs) among adolescents and young adults. The study concluded that the prevalence of depression in adolescents and young adults has increased in recent years. The findings call for renewed efforts to expand service capacity to meet the best mental health care needs (Mojtabai et al., 2016).

According to the WHO (2020), mental and behavioral disorders account for about 14% of the global burden of disease, and as many as 450 million people suffer from these illnesses. The World Health Organization (WHO) reported that even before the COVID-19 pandemic, the Philippines ranked one of the highest in mental disorders in Southeast Asia. The Philippine WHO Special Initiative for Mental Health conducted in early 2020 shows that at least 3.6 million Filipinos experience one kind of mental, neurological, and substance use disorder. Moreover, the

pandemic has further impacted mental health in older adults, health care providers, and people with underlying health conditions (DOH, 2020).

Students are struggling with mental health difficulties that impact their ability to learn while in school, and many lack access to mental health providers in their communities (Skaar et al., 2022). Developing and implementing comprehensive systems to support student mental health through risk assessment and management is important. Risk Assessment (RA) and Risk Management (RM), as noted by Ahmed et al. (2021), are the mechanisms used by mental health practitioners to identify and minimize risk. A risk assessment pervades mental health care policy, practice, and legislation (Wand, 2012). Generally, it is noted that the assessment of clinical risk in mental healthcare is challenging but provides an opportunity to engage with patients, their carers, and families to promote the patient's safety, recovery, and wellbeing (Worthington et al., 2013).

Protecting students from harm is a key priority. Risk management is an essential component of providing such protection, related to one of the United Nations Sustainable Development Goals (SDGs) that target to reduce by one-third premature mortality from non-communicable diseases through prevention and promotion of mental health and wellbeing and to strengthen the prevention of substance abuse and treatment of mental disorders by 2030. According to Fazel et al. (2014), mental health services embedded within school systems can create a continuum of integrative care that improves children's mental health and educational attainment. To strengthen this continuum and for optimum child development, a reconfiguration of education and mental health systems to aid the implementation of evidence-based practice might be needed. Integrative strategies that combine classroom-level and student-level interventions have much potential.

In the study by Rensburg et al. (2020) to review the literature on risk assessment in mental health practice to promote evidence-based care, it was found that risk assessment in mental health practice can influence and measure treatment outcomes and level of care provision. However, risk assessment practices are not standardized, and different screening tools are used. Similarly, Balaratnasingam (2011) also added that The evidence of effectiveness for risk assessment interventions in acute settings is limited. While it is not possible for general practitioners to predict the future, and particularly to predict fatal outcomes, they can be expected to meet a standard of care that identifies those at risk and provide an acceptable clinical response.

A range of mental health screening tools exists and have been trialed for use in research and clinical practice among different population groups. Many are designed to be administered through self-assessment, which is less resource intensive, and based on evidence that self-rated health scores can accurately predict future morbidity and mortality (Dowling et al., 2017; Idler et al., 1997; Kaplan et al., 1996; Miilunpalo et al., 1997; Fylkesnes et al., 1993; Dowd et al., 2007; Idler et al., 1991). Most primary care risk assessment research focuses on suicide and consistently highlights the need for improved detection of suicide risk. There is also a lack of evidence about risk assessment within community-based primary care mental health services (Vail et al., 2012). This is also supported by the Department of Health, National Risk Management Programme (2009), stating that despite risk assessment being a central component of current practice in mental health, there has been no recent national study of the use of risk assessment tools across mental health services. There is also very little information on the views of clinicians, patients, and carers about how helpful these tools are.

In the context of the COVID-19 pandemic, the study of Cortens et al. (2021) mentioned that many schools now need to offer mental health services, including suicide risk assessment,

via eHealth platforms. Post-pandemic, using eHealth risk assessments will support more accessible services for youth living in rural and remote areas. In the study of Fazel et al. (2014), Mental health services, when embedded within educational systems, create a continuum of integrative care that can promote health, mental health, and educational attainment. Strategies to integrate the different tiers of interventions within a school and use resources from within the school are probably the most sustainable. Adding that, standard teacher training programs need to incorporate curricula targeted at the most common mental health issues likely to be present in schools. These curricula include mental health screening and identification of common presentations of mental health issues. Similarly, training teachers in mental health promotion skills might not only assist in identifying and referring children who need it but also help teachers feel less overwhelmed by the emotional and behavioral challenges in their classrooms.

In the Philippines, economic conditions and the inaccessibility of mental health services limit access to mental healthcare. In terms of mental health assessment, perceived or internalized stigma is a barrier to help-seeking behavior in Filipinos (Tuliao & Velasquez, 2014). There is a cultural drive to 'save face' when there is a threat to or loss of one's social position, and as such, Filipinos may have difficulty admitting to mental health problems or seeking help (Lally et al., 2019). In relation to mental health management, there is a strong sense of family in the Philippines, and so, when problems are thought to be socially related, Filipinos will turn to family and peer networks before seeking medical help (Tuliao, 2014). The fact remains that a considerable proportion of students suffer from mental health problems that may affect normal functioning. The ample evidence suggests that it is essential to conduct a prevalence study that can provide a base for further developing mental health services for students. Thus, this documentary analysis aims to present existing approaches to mental health risk assessment and risk management.

Objectives of the Study

The study aimed to undertake documentary analysis to identify and present mental health risk assessment and management practices. Specifically, it seeks to answer the following questions.

1. To identify the Philippine mental health legislation and framework
2. To present the mental health risk assessment approaches
3. To discuss the mental health risk management processes

Methodology

Study Design

The study used a qualitative research design, specifically document analysis. Documentary analysis is a systematic review or evaluation of printed and electronic documents (Bowen, 2009). This study identified documents on national mental health legislation and framework, risk assessment approaches, and risk management processes to better understand the current mental health practices. The process of evaluating documents produces empirical knowledge and understanding of mental health risk assessment and management. In the process, the researcher strived for the authenticity and accuracy of documents.

Sample of the Study

Google search for "Philippine mental health legislation," "Philippine mental health framework," "mental health risk assessment," and "mental health risk management" was conducted. The searches were limited to results in English and were conducted from google.com.ph. Snowballing was used to identify further resources from links within the online

documentation. Links to other resources were all noted, and these resources were then analyzed. As a small number of relevant publications were found, no restrictions were given regarding the comparison and outcome of studies and special methodological approaches. No restrictions on publication dates were applied either. However, physical evidence or physical objects found within the study setting are excluded from the study.

Data Gathering Tools

The materials in this study were from documents on national mental health legislation and framework, risk assessment approaches, and risk management processes to better understand the current mental health practices.

Data Gathering Procedures

The data were acquired from credible documents and websites. They were chosen for their importance and utility in supplying the study's required data. With the aim of retrieving key information on national mental health legislation and framework, risk assessment approaches, and risk management processes, these documents were presented using the eight-step process offered by O'Leary (2014): (1) Gather relevant texts; (2) Develop and organization and management scheme; (3) Make copies of the originals; (4) Assess authenticity of documents; (5) Explore documents' agenda; (6) Explore background information; (7) Ask questions about the document; (8) Explore content.

Treatment of Data

All potentially relevant information was extracted and summarized. Studies were sorted by content based on the implementation process or survey instruments. General information, including the name of authors/, year, and title, was documented. The data were analyzed descriptively for feasibility, effectiveness, and acceptance of approaches and validation results, if applicable.

Ethical Considerations

In secondary data analysis, the original data was not collected to answer the present research objective. Thus, the data were evaluated for certain criteria such as the methodology of data collection, accuracy, period of data collection, the purpose for which it was collected, and the content of the data. The data was kept for no longer than is necessary for that purpose and safe from unauthorized access, accidental loss, or destruction. Data in the form of hard copies were kept in safe, locked cabinets, whereas softcopies should be kept as encrypted files in computers.

RESULTS AND DISCUSSION

This section oversees the results and discussion of data gathered by the researcher. This section presents the Philippine Mental Health Legislation and Framework, Mental Health Risk Assessment Approaches, and Mental Health Risk Management Processes.

Philippine Mental Health Legislation and Framework

The Implementing Rules and Regulations of Republic Act No. 11036, otherwise known as the Mental Health Act, is an act establishing a National Mental Health Policy for the Purpose of Enhancing the Delivery of Integrated Mental Health Services, Promoting and Protecting the Rights of Persons Utilizing Psychosocial Health Services, Appropriating Funds Therefor and Other.

Proposed more than 3 years ago, the Philippine Mental Health Act was passed in the congress and senate in 2017 (Senate Bill No. 1354, 2017) and signed into law on 21 June 2018. Before this bill, the Philippines belonged to a minority of countries with no mental health legislation in place. Clinicians lacked guidance on their practice's legal and ethical aspects, and

patients' rights were not clearly defined. The passing of this bill is a major milestone in the history of psychiatry in the Philippines. The first bill in the country's history that provides rights-based mental health legislation. It mandates the provision of psychiatric, psychosocial, and neurological services in all hospitals and basic mental health services in community settings (Lally, 2019).

Prior to the approval of the IRR, a press release from the House of Representatives dated 2017 reported that Deputy Speaker Pia Cayetano, one of the bill's principal authors, said in the Philippines that some studies reveal the extent of mental health needs of the country's population. The Global School-Based Health Survey (WHO 2011) shows that 16 percent of students between 13 and 15 years old have ever "seriously considered attempting suicide during the past year" while 13 percent have "actually attempted suicide one or more times during the past year (House of Representatives, 2017)."

Cayetano further cited a study conducted by the DOH among government employees in Metro Manila, which revealed that 32 percent out of 327 respondents had experienced a mental health problem in their lifetime (DOH 2006 as cited in House of Representatives, 2017). A separate study showed that almost one per 100 households (0.7 percent) has a member with a mental disability (DOH SWS 2004 as cited in House of Representatives, 2017), while intentional self-harm is the ninth leading cause of death among 20 to 24 years old (DOH 2003 as cited in House of Representatives, 2017).

The 2017 House of representatives Press Release also reported that Deputy Speaker Romero Quimbo stated that mental health had not been given the attention it needs in recent years. He said the State lacks resources to effectively provide and sufficiently address the growing number of mental health disorders. Research indicates that 75 percent to 85 percent of people in low and middle-income countries suffering from mental disorders do not receive treatment for at least a year.

In this IRR, the State affirms the basic right of all Filipinos to mental health and the fundamental rights of people who require mental health services. The State commits itself to promote the well-being of people by ensuring that; mental health is valued, promoted, and protected; mental health conditions are treated and prevented; timely, affordable, high-quality, and culturally appropriate mental health care is made available to the public; mental health service is free from coercion and accountable to the service users, and persons affected by mental health conditions can exercise the full range of human rights, and participate fully in society and at work free from stigmatization and discrimination. Also, complies strictly with its obligations under the United Nations Declaration of Human Rights, the Convention on the Rights of Persons with Disabilities, and all other relevant international and regional human rights conventions and declarations. The applicability of Republic act No. 7277, as amended, otherwise known as the "Magna Carta for Disabled Persons," to a person with mental health conditions, as defined herein, is expressly recognized.

Under its provisions, the Philippine Mental Health Act protects the rights of patients as follows: a right to freedom from discrimination, right to protection from torture, cruel, inhumane, and degrading treatment; right to aftercare and rehabilitation; right to be adequately informed about psychosocial and clinical assessments; right to participate in the treatment plan to be implemented; right to evidence-based or informed consent; right to confidentiality; and right to counsel, among others (Lally, 2019). The Mental Health Act, by and large, also aims to strengthen effective leadership and governance for mental health by, among others, formulating, developing, and implementing national policies, strategies, programs, and regulations relating to

mental health. Develop and establish a comprehensive, integrated, effective, and efficient national mental health care system responsive to the Filipino people's psychiatric, neurologic, and psychosocial needs. Protect the rights and freedoms of persons with psychiatric, neurologic, and psychosocial needs; Filipino people. Strengthen information systems, evidence, and research for mental health. Integrate mental health care in the basic health services; and strategies promoting mental health in educational institutions, workplaces, and communities.

In relation to the educational setting, Section 23 states that "age appropriate content pertaining to mental health shall be integrated into the curriculum at all educational levels. Schools should also develop policies and programs for students educators, and other employees designed to raise awareness on mental health issues, identify and provide support and services for individuals at risk, and facilitate access, including referral mechanisms of individuals with mental health conditions to treatment and psychosocial report" (Plata, 2019). During the pandemic, the Department of Education (DepEd), through its Disaster Risk Reduction and Management Service (DRRMS), in coordination with various DepEd Central Office units and partners, launched a series of Mental Health and Psychosocial Support Services (MHPSS) provisions for DepEd personnel to recognize the impacts of the COVID-19 pandemic on a person's mental health (Deped, 2020). The mental health helpline system consists of contact information from different organizations to support learners, teachers, and the public in times of mental and psychological distress.

In terms of health, the revised operational framework comprehensive national mental health program of the Department of Health provides the framework for action for effectively implementing a comprehensive mental health program in the country. Specifically, it aims to: Guide all program managers, health care providers, and various stakeholders at all levels of care in implementing the mental health program. Define the roles and responsibilities of different DOH offices, the Philippine Health Insurance Corporation, LGUs, and higher-level referral health facilities in implementing a comprehensive mental health program. Generate support from various stakeholders in implementing a comprehensive mental health programs.

The Department of Health's Action Framework for the National Mental Health Program's (2016) goal is to promote mental health and well-being; prevent MNS disorders and other forms of addiction; provide care, enhance recovery; and reduce morbidity, disability, and mortality of persons suffering from these disorders cognizant of their human right to access quality health care. The action framework shows the three strategic approaches on which the National Mental Health Program is anchored:

- Health systems approach. This approach recognizes the following components for an effective health system to address MNS conditions: governance, financing, information systems, service delivery, medicines, other psychosocial interventions, workforce, and user and family associations.
- Whole-of-government approach. The government shall exercise leadership and governance, particularly in creating institutional, legal, financial, and service provisions that would promote the mental health and well-being of the population, prevent illness and address the needs of those suffering from MNS disorders.
- Whole-of-society approach. The whole society includes civil society organizations from different sectors, especially groups of people suffering from MNS disorders, those with psychosocial disabilities, families, carers, and mental health service providers. They help reduce stigma and discrimination and aid in creating effective policies, laws, and services.

The five components of the National Mental Health Program cover Wellness of Daily Living, Extreme Life Experience, Mental Disorders, Neurologic Disorders, and Substance Abuse, and Other Forms of Addiction:

- Wellness of Daily Living - promoting, attaining, and maintaining the mental health and well-being of all persons across the life course (from pregnancy to old age) and in different settings (such as schools, workplaces, and communities) through healthy and effective coping as well as prevention of suicide
- Extreme Life Experience - developing and enhancing resiliency and addressing the mental health and psychosocial needs and consequences of persons, families, and communities that experience critical incidents and events (such as trauma, domestic violence, and disasters)
- Mental Disorders - promoting mental health and well-being; preventing mental disorders; assessing, diagnosing, and treating mental disorders; and improving the quality of life of persons with psychosocial disability through rehabilitation and community integration.
- Neurologic Disorders - promoting neurologic health and preventing common neurologic disorders such as, but not limited to epilepsy, dementia, and developmental disorders; assessing, diagnosing, and treating neurologic disorders; and improving the quality of life of persons with neurologic disorders
- Substance Abuse and Other Forms of Addiction - promoting protective factors, reducing risk factors, and preventing the development of substance abuse and other forms of addiction in different settings (family, school, workplace, community, and industry)

Through the strategic approaches and components on which the National Mental Health Program is anchored, it is hoped by the Department of Health (2016) that the promotion of mental health and wellbeing, prevention of MNS disorders, substance abuse and other forms of addiction, provision of cares, enhancement of recovery, and reduction of morbidity, disability and mortality will be attained.

In the City of Baguio, as reported by Lobien (2020), the council has urged schools to include mental health education in their curriculum in the 2020-2021 academic year. Here, two of the biggest educational institutions in Baguio, the University of the Cordilleras and the Baguio City High School, are among the educational institutions urged in the resolution passed by the city council recently. The resolution passed on Monday was in response to the coronavirus disease (Covid-19) pandemic that has forced people into a lockdown that may continue with the disease continue to afflict people worldwide. The resolution authored by all members of the city council has urged the Department of Education (DepEd), the Technical Education and Skills Development Authority (TESDA), and the Commission on Higher Education (CHED) to accelerate the integration of said possible subject into the curriculum and to monitor its implementation earnestly.

Overall, mental health law and framework play a crucial role in the community integration of persons with mental disorders, the provision of care of high quality, and the improvement of access to care at the community level. The mental health law and framework further improves access to mental healthcare within the nation, has better health and mental health outcomes and better quality of life, increases acceptability, reduces associated social stigma and human rights abuse, and prevents health comorbidity be likely to be detected early and managed. Also, the law paved the way for proper mental health education and school services. As a result, educators finally treat mental illness as a public health concern. However, it was noticed that mental health insurance benefits services are paid less compared to benefits for physical health services, resulting in underutilization or financial burden for people with mental health conditions. This is congruent to the study of Estrada et al. (2020), stating that in the

Philippines, the majority of individuals with mental health disorders pay mostly or entirely out-of-pocket for services and medicines.

Mental Health Risk Assessment Approaches

Health Impact Assessment (HIA), as shown and discussed by the World Health Organization (2022), is a practical approach used to judge the potential health effects of a policy, program, or project on a population, particularly on vulnerable or disadvantaged groups. Recommendations are produced for decision-makers and stakeholders to maximize the proposal's positive health effects and minimize its negative health effects. The approach can be applied in diverse economic sectors and uses quantitative, qualitative, and participatory techniques.

HIA provides a way to engage with members of the public affected by a particular proposal. It also helps decision-makers choose alternatives and improvements to prevent disease or injury and promote health. It is based on the four interlinked values of democracy (promoting stakeholder participation), equity (considering the impact on the whole population), sustainable development, and the ethical use of evidence.

The Care Programme Approach (CPA) is a model of assessing, planning, implementing, delivering care, and evaluating the effectiveness of that care or intervention. It aims to promote effective liaison and communication between agencies, thereby managing assessed risk and meeting the individual needs of people with mental health problems to better function in society. The Care Programme Approach (CPA) was established in 1991 in England to ensure that a safety net of care was provided for people with severe mental illness. It set out health and social care assessment requirements, including risk assessment involving patients, carers, the multidisciplinary team, and other agencies (Kingdon, 2018).

The Assessment Process, as stated by CPA (2009), should aim to identify and meet the patient’s needs and choices. It should not focus purely on what professionals and services can offer. The assessment should address the person’s aspirations and strengths, as well as their needs and difficulties. Information will be included in the record of review and care plan regarding any unmet needs. Where there is a carer involved, they are a vital source of support for the patient and may also be a key person in helping manage the identified risks. Practitioners should be sensitive to the relationship between the patient and the carer, as there may be risks within this relationship and different points of view about the best actions to be taken.

Initial assessment quality is enhanced when multi-disciplinary and partnership between health and social care staff. Information is gathered from all involved, including the service user and carer. The process should include service user and carer involvement (where appropriate), including writing their accounts of their illness in the notes. Prompt assessment for young people with the first signs of a psychotic illness; Identification of advance statements and advance decisions. The capacity of the service user must be assumed. If possible, attempts should be made to identify whether or not the service user has a lasting power of attorney or a deputy appointed by the court of protection. A service user's caring responsibilities should also be explored, and appropriate support, contingency, and crisis plans put in place for the service user as a carer and for the person they care for.

Undertaking a meaningful risk assessment will be enhanced through a framework, an example proposed in Figure 3.

As shown in Figure 3, a risk assessment will always require the consideration of key risk issues; static & dynamic risk factors; triggers / precipitating factors (for example, a life event); maintaining factors (for example, avoidance behavior, isolation or a lack of problem-¬-solving/ coping skills); and importantly, protective factors (Butler, 2014). Mental health professionals should holistically consider service users' needs and aim to improve their quality of life and health. Clearly, in some cases, it will be neither possible nor appropriate to carry out a comprehensive assessment of needs. The list, as shown in Appendix C, includes risk factors that should be covered in a full assessment of needs.

There are approaches to risk assessment, as discussed by CPA (2009). In the past, risk assessment was anecdotal and inconsistent. It was based only on a largely unstructured clinical approach where information obtained during an ongoing clinical assessment was considered. This information was not gathered systematically, and any relevant information was not entered into the formulation of risk in a consistent and standardized way. As shown in Figure 3, all tool-based assessments should be conducted as part of a thorough and systematic overall clinical assessment. This is particularly important when assessing the risk of suicide and self-harm, as there is currently no instrument with a sufficiently strong evidence base.

Assessment tools have been designed for various purposes and with various service users. Some are actuarial (i.e., they offer estimations of the likelihood of harmful outcomes), and others provide structure for clinical judgments (i.e., they help with risk formulation using an empirical and clinical evidence base). Some have been through a rigorous process of scientific development, while others have been tested about their utility and acceptability to practitioners. Both approaches have advantages and disadvantages when underpinning good practice. Some tools have built-in prompts for thinking about managing any identified risks, while others do not. The choice of a particular tool must be based on considering all the relevant factors and how they relate to the range of risks encountered.

Another Risk Assessment approach taken from the Health Service Executive is the publicly funded healthcare system in the Republic of Ireland, which is responsible for providing health and personal social services. The HSE has developed several pieces of guidance to support staff in complying with the HSE's Integrated Risk Management Policy.

HSE (2017) stated that risk assessment is a process consisting of the following three steps:

Risk Identification. Risk identification should be an ongoing concern of all Managers and their teams. Risks and incidents/issues often get confused, so there must be clarity in this regard. A risk may happen that could impact the safe and effective delivery of services, whereas an incident/issue is something that has happened. Risks may be identified from various internal and external sources to service. They should be described consistently, clearly identifying their impact, cause, and context, e.g., risk of ... due to...within... The key question is 'what is the risk and who or what will be impacted by it?'

Risk Analysis. Risk analysis is a process used to understand better the risk you have identified and estimate the level of risk attached to it. Considering the controls in place to mitigate the risk (existing controls) requires the person/team assessing the risk to rate the risk across two dimensions (impact and likelihood). The HSE has developed a risk assessment tool for this purpose (Appendix E). Application of this tool will result in a risk being rated as red (high risk), amber (medium risk), or green (low risk). This rating will assist both in the evaluation of risk and the prioritization of the management of risks.

Risk Evaluation. Risk evaluation is a process used to consider the outcome of the risk analysis to determine whether or not a specified level of risk is acceptable or tolerable. Risk treatment must be considered when it is determined that the level of risk posed is not acceptable.

Risk Treatment. Risk treatment is selecting and implementing appropriate control measures to modify the risk. Risk treatment includes as its major focus risk control (or mitigation). Still, it extends to risk avoidance (e.g., stopping the activity that causes the risk) and risk transfer (e.g., transferring the risk to a third party, for example, an indemnifier). Any system of risk treatment should provide efficient and effective internal controls to reduce or mitigate the risk.

HSE (2017) guidance contains a template for identifying the controls that should be in place. Controls are mechanism, process, procedure, or action that can be verified and seeks to reduce the likelihood and consequence of a risk. Controls include any process, policy, device, practice, or other actions which modify risk. They can exist or be required as additional to mitigate the risk further. It contains the Risk Description, a list of controls required to manage the risk, and a decision on which controls exist. Appendix E contains the HSE Risk Assessment Tool showing the impact table and likelihood scoring. The impact is the outcome or consequence of an event affecting objectives. It can be either qualitatively or quantitatively, being a loss, disadvantage, or gain. There may be a range of possible outcomes associated with an event. The likelihood is The chance of something happening (also described as the probability or frequency of an event occurring).

Risk assessment in mental health practice can influence and signify treatment outcomes and management levels that capture care needs and assess the risk of harm to oneself or others. The approaches presented reveal that mental health risks cannot be eliminated but can be rigorously assessed, managed, or mitigated. A risk assessment should identify key factors indicating a pattern of increasing risk. Thoughtful use of the mental health risk assessment can help educators understand and support the needs of students and their families during a time of need. Moreover, the assessment must be based on a comprehensive collection of information from all available sources and cover all aspects of the illness, risk factors, background, behavior, and circumstances of the individual.

Mental Health Risk Management Process

HSE (2017) use an internationally recognized risk management standard that provides a framework for the risk management process. Five steps are involved in the risk management process, described in detail here.

Step 1: Establish the context of risk. The first part of the risk management process is to determine the overall context in which the other steps of the risk management process will occur. Identifying external and internal drivers helps to illuminate the context.

Step 2: Identifying the risk. There is a variety of sources and methods for identifying organizational risk. Quite often, people focus on incident reporting. Although this is the cornerstone of risk management, there are other equally important sources of risk information, some of which are outlined in Figure 2.2. Some risk areas may be perceived as ‘entirely clinical’ or ‘entirely management.’ While it is certainly useful for local clinical and management teams to conduct initial work in identifying risks specific to their area of expertise, it is essential for an integrated system that, at some point, clinical and management teams work together to develop a comprehensive, organizational risk register.

Step 3: Assess the risk. Risk assessment involves the analysis and evaluation of the identified risk. Risk analysis is about developing an understanding of the risks identified;

therefore all risks are to be analyzed to: Assess the extent of the actual or potential impact and Assess the likelihood of occurrence.

Step 4: Treating the risk. Risk assessment informs risk management, and there should be a direct follow-through from assessment to management. An action plan must be developed for all identified risks that require further treatment. This plan should specify the person responsible and the timeframe for action. If possible, risks should be eliminated. However, this is not always achievable in healthcare. Therefore the plan must be to reduce the risk to as low a level reasonably practicable.

Step 5: Monitoring and reviewing the risks. Risk is not static; it is dynamic and evolutionary; therefore, continuous monitoring and reviewing of the risk management control system are essential. Risk management needs to be on every agenda of every committee and needs to be constantly reviewed and evaluated. For example, multidisciplinary team meetings could have risk assessment as a standing item on their agendas for individual cases and their overall work management. Similarly, risk management should be on the agenda of all mental health management team meetings. It is also important to assess whether the nature of the risk changes over time.

Decisions about risk management involve improving the service user's quality of life and plans for recovery while remaining aware of the safety needs of the service user, their carer, and the public. As shown in Figure 6, positive risk management as part of a carefully constructed plan is desirable for all mental health practitioners and will make risk management more effective. Positive risk management can be developed by using a collaborative approach. Over-defensive practice is bad practice. Avoiding all possible risks is not good for the service user or society long term and can be counterproductive, creating more problems than it solves. Any risk-related decision is likely to be acceptable if: it conforms to relevant guidelines; it is based on the best information available; it is documented; and the relevant people are informed.

As long as a decision is based on the best evidence, information, and clinical judgment available, it will be the best decision that can be made at the time. Positive risk management means being aware that risk can never be completely eliminated. Therefore, management plans inevitably have to include decisions that carry some risk. This should be explicit in decision-making and should be discussed openly with the service user. Positive risk management, as stated by CPA (2009), includes: working with the service user to identify what is likely to work – and what is not; paying attention to the views of carers and others around the service user when finally deciding on a plan of action; weighing up the potential costs and benefits of choosing one action over another; being willing to make a decision that involves an element of risk because the potential positive benefits outweigh the risk; developing plans and actions that support the positive potentials and priorities stated by the service user and minimizing the risks to the service user or others; being clear to all involved about the potential benefits and the potential risks; and ensuring that the service user, carer, and others who might be affected are fully informed of the decision, the reasons for it, and the associated plans.

As there are various risks involved in mental health, the processes revealed that there is no one-model-fits-all risk management solution. However, there are key concepts of risk management in mental health care and the main factors of concern when creating a risk management plan. Moreover, risk management should be personal and individualized, ensuring that supervision, delegation, and onward referral are all managed safely.

CONCLUSION

The current study contributes to understanding mental health legislation in the Philippines. Raises awareness of the mental health risk assessment approaches and related mental health risk management processes.

Mental health legislation plays a crucial role in community integration of individuals with mental disorders, integration of mental health at primary health care, the provision of care of high quality, and the improvement of access to care at the community level. It further recognizes the role of mental health practitioners, protecting their right to participate in mental health planning and development of services. Additionally, with some foresight, the Act seeks to integrate mental health into the educational system by promoting mental health programs in schools and other organizations. Overall, both Implementing Rules and Regulations of Republic Act No. 11036 and the Department of Health's Action Framework for the National Mental Health Program promotes treatment to affected mental health community and disseminate mental health awareness to the general public by implementing national policies. However, financial assistance for mental health treatment was not discussed.

Document analysis indicated that assessment is an important first step in risk management. Conducting a risk assessment for a person with a mental illness is an extremely important part of mental health practice, particularly if one is causing significant harm to self or others. Assessing and carefully managing one's state is integral to providing safe and effective care and making good decisions regarding treatment and management. In terms of tool, There is little place for locally developed assessment tools.

Mental health risk management is a framework that minimizes risks, comprising risk assessment, generation of risk management plans, and monitoring interventions. Risk management in mental health entails a broad range of responses and may involve preventative, responsive, and supportive efforts to reduce the potential negative consequences of risk.

Recommendation

In this regard, given the various documents on mental health, the researcher put forward the following recommendations:

Considering the discussion in Philippine mental health legislation, it was noted the lack of discussion on mental health financial assistance results in a financial burden for people with mental health conditions. It is then suggested that mental health legislation should improve financial protection, provide affordable and accessible mental health services, and be introduced to improve financial protection (i.e., decrease financial burden) and increase access to and use of mental health services.

Given that risk assessment processes are ingrained in mental health care, mental health assessment should be available and consistent across mental health services. Institutions should provide employees with the tools and information necessary to complete their tasks as effectively as possible. In an educational institution, faculty and staff should be trained to assess, develop, and manage mental health risks. On-going supervision should be made available to support the consistency of the system.

In terms of mental health risk management, plans must be clearly written, up to date, and readily accessible to those involved in the management of individuals with mental health conditions. Every Institution should take responsibility for effective collaboration with other professionals internally and externally, liaising with key supports to ensure care continuity and further assessment.

Future studies may review other studies for examples of risk assessment management in healthcare as one way to develop mental health risk management programs. Policy analysis is greatly needed to investigate whether institutions comply with the national legislation and governing organizations such as the Department of Health.

References

Ahmed, N., Barlow, S., Reynolds, L., Drey, N., Begum, F., Tuudah, E., & Simpson, A. (2021). Mental health professionals' perceived barriers and enablers to shared decision-making in risk assessment and risk management: A qualitative systematic review. *BMC Psychiatry*, *21*(1). https://doi.org/10.1186/s12888-021-03304-0

Balaratnasingam, S. (2011). Mental health risk assessment A guide for GPs. *Australian Family Physician*, *40*(6).

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*(2), 27–40. https://doi.org/10.3316/qrj0902027

Butler, J. (2014). *Assessing risk in community mental health services.*Research Gate. https://www.researchgate.net/publication/263276276_Assessing_Risk_in_Community_Mental_Health_Services

Care Programme Approach. NHS Foundation Trust 2. (2018). http://luna.smhsct.local/documents/policies-a-z/c/4751-care-programme-approach-appendix-2-common-assessment-tool-cat/file

Decety J, Smith KE, Norman GJ. (2014). A social neuroscience perspective on clinical empathy. World Psychiatry.

DepEd launches mental health helpline system for learners, teachers. Department of Education. (2021). Retrieved July 30, 2022, from https://www.deped.gov.ph/2021/11/08/deped-launches-mental-health-helpline-system-for-learners-teachers/

DepEd recognizes mental health and wellbeing of personnel, conducts MHPSS provisions. Department of Education. (2020). https://www.deped.gov.ph/2020/07/17/deped-recognizes-mental-health-and-wellbeing-of-personnel-conducts-mhpss-provisions/

Department of Health. (2016). Revised Operational Framework for a Comprehensive National Mental Health Program. https://doh.gov.ph/sites/default/files/health_programs/Administrative%20Order%20No.%20%202016-0039%28Revised%20Operational%20Framework%20for%20a%20Comprehensive%20National%20Mental%20Health%20Program%29.PDF

Department of Health. (2020, October). *Your mind matters: Doh calls for unified response to mental health.* https://doh.gov.ph/press-release/YOUR-MIND-MATTERS-DOH-CALLS-FOR-UNIFIED-RESPONSE-TO-MENTAL-HEALTH

Exner-Cortens, D., Baker, E., Gray, S., Van Bavel, M., Rivera, R. R., Van Bavel, M., Vezina, E., Ambrose, A., Pawluk, C., Schwartz, K. D., & Arnold, P. D. (2021). School-based suicide risk assessment using eHealth for youth: Systematic scoping review (preprint). https://doi.org/10.2196/preprints.29454

Estrada, C. A., Usami, M., Satake, N., Gregorio, E., Leynes, C., Balderrama, N., Fernandez de Leon, J., Concepcion, R. A., Tuazon Timbalopez, C., Tsujii, N., Harada, I., Masuya, J., Kihara, H., Kawahara, K., Yoshimura, Y., Hakoshima, Y., & Kobayashi, J. (2020). Current situation and challenges for mental health focused on treatment and care in Japan and the

Philippines - highlights of the training program by the National Center for Global Health and Medicine. BMC Proceedings, 14(S11). https://doi.org/10.1186/s12919-020-00194-0

Fazel, M., Hoagwood, K., Stephan, S., & Ford, T. (2014). Mental health interventions in schools in high-income countries. *The Lancet Psychiatry*, *1*(5), 377–387. https://doi.org/10.1016/s2215-0366(14)70312-8

Galderisi, S., Heinz, A., Kastrup, M., Beezhold, J., & Sartorius, N. (2015). Toward a new definition of mental health. World psychiatry : official journal of the World Psychiatric Association (WPA), 14(2), 231–233. doi:10.1002/wps.20231.

HSE integrated risk management policy 2017. Health Service Executive. (2017). https://www.hse.ie/eng/about/who/riskmanagement/risk-management-documentation/integrated-risk-management-policy-2017.html

HSE integrated risk management policy - part 2 risk assessment and treatment. Health Service Executive. (2017). https://www.hse.ie/eng/about/who/riskmanagement/risk-management-documentation/part-2-risk-assessment-and-treatment.html

Implementing rules and regulations of republic act no. 11036: Govph. Official Gazette of the Republic of the Philippines. (2019, January 22). https://www.officialgazette.gov.ph/2019/01/22/implementing-rules-and-regulations-of-republic-act-no-11036/#:~:text=AN%20ACT%20ESTABLISHING%20A%20NATIONAL,THEREFOR%2C%20AND%20FOR%20OTHER%20PURPOSES

Janse van Rensburg, E., & van der Wath, A. (2020). Risk assessment in mental health practice: An integrative review. *Issues in Mental Health Nursing*, *41*(11), 995–1003. https://doi.org/10.1080/01612840.2020.1756011

Kingdon, D. (2018). Care Programme Approach – time to move beyond? *BJPsych Bulletin*, *43*(3), 101–103. https://doi.org/10.1192/bjb.2018.73

Klanker, M., Feenstra, M., Denys, D. (2013). Dopaminergic control of cognitive flexibility in humans and animals. *Frontiers in Neuroscience 7*(7):201. doi: 10.3389/fnins.2013.00201.

Lally, J., Samaniego, R. M., & Tully, J. (2019). Mental health legislation in the Philippines: Philippine Mental Health Act. *BJPsych International*, *16*(03), 65–67. https://doi.org/10.1192/bji.2018.33

Lobien, P. (2020, May 19). *Mental health education inclusion in curriculum urged*. Philippine News Agency. https://www.pna.gov.ph/articles/1103248

Mahmood, Z. & Saleem, S. (2011). Assessing psychological problems in university students in Pakistan: A psychometric study. FWU Journal of Social Sciences 5(1), 134-148. https://vlibrary.emro.who.int/imemr/assessing-psychological-problems-in-university-students-in-pakistan-a-psychometric-study-2/

Matthewson, P. (n.d.). *Chapter 4: Risk Assessment and management in Mental Health*. Hall McMaster and Associates (HMA). https://www.hma.co.nz/wp-content/uploads/2016/01/Chapter-4-Risk-Assessment-and-Management-in-Mental-Health.pdf

Mojtabai, R., Olfson, M., & Han, B. (2016). National trends in the prevalence and treatment of depression in adolescents and young adults. *Pediatrics, 138*(6), [e20161878]. https://doi.org/10.1542/peds.2016-1878

O'Leary, Z. (2014). The essential guide to doing your research project (2nd ed.). Thousand Oaks, CA: SAGE Publications, Inc.

Plata, S. (2019). *A Genre Analysis of School Mental Health Policy Documents*. DLSU Research Congress . https://www.dlsu.edu.ph/wp-content/uploads/pdf/conferences/research-congress-proceedings/2019/lli-II-011.pdf

Pedrelli, P., Nyer, M., Yeung, A., Zulauf, C., & Wilens, T. (2015). College Students: Mental Health Problems and Treatment Considerations. *Academic psychiatry : the journal of the American Association of Directors of Psychiatric Residency Training and the Association for Academic Psychiatry*, *39*(5), 503–511. https://doi.org/10.1007/s40596-014-0205-9

Proposed "Comprehensive Mental Health Act" gets House backing. House of Representatives. (2017). https://www.congress.gov.ph/press/details.php?pressid=10131

Republic act no. 11036. LawPhil. (2018). https://lawphil.net/statutes/repacts/ra2018/ra_11036_2018.html

Risk Management In Mental Health Services . Health Service Executive. (2007). https://www.hse.ie/eng/services/publications/mentalhealth/riskmanagementinmentalhealth.pdf

The assessment of clinical risk in mental health services. National Con dential Inquiry into Suicide and Safety in Mental Health (NCISH). Manchester: The University of Manchester. (2018). https://research.manchester.ac.uk/portal/files/77517990/REPORT_The_assessment_of_clinical_risk_in_mental_health_services.pdf

Tuliao, A. P. (2014) Mental health help seeking among Filipinos: a review of the literature. *Asia Pacific Journal of Counselling and Psychotherapy, 5*, 124–136. https://doi.org/10.1080/21507686.2014.913641

Tuliao, A. P. & Velasquez, P. A. (2014) Revisiting the general help seeking questionnaire: adaptation, exploratory factor analysis, and further validation in a Filipino college student sample. *Philippine Journal of Psychology, 47*, 1–17. https://www.researchgate.net/publication/263278461_Revisiting_the_General_Help_Seeking_Questionnaire_Adaptation_Exploratory_Factor_Analysis_and_Further_Validation_in_a_Filipino_College_Student_Sample

VanderLind, R. (2017). Effects of mental health on student learning. *The Learning Assistance Review, 22*, 39-58. https://eric.ed.gov/?id=EJ1154566

Vail, L., Adams, A., Gilbert, E., Nettleingham, A., & Buckingham, C. D. (2012). Investigating mental health risk assessment in primary care and the potential role of a structured decision support tool, GRiST. *Mental health in family medicine*, *9*(1), 57–67.

Wand, T. (2011). Investigating the evidence for the effectiveness of risk assessment in Mental Health Care. *Issues in Mental Health Nursing*, *33*(1), 2–7. https://doi.org/10.3109/01612840.2011.616984

World Health Organization. (2022). *Health impact assessments*. World Health Organization. https://www.who.int/tools/health-impact-assessments

Worthington, A., Rooney, P., & Hannan, R. (2013). *The triangle of care: Carers included: A guide to best practice in Mental Health Care in England*. Carers Trust.

Yap, M. B., Reavley, N., & Jorm, A. F. (2012). Young people's beliefs about preventive strategies for mental disorders: Findings from two Australian national surveys of youth. *Journal of Affective Disorders*, *136*(3), 940–947. https://doi.org/10.1016/j.jad.2011.09.003

Correlation analysis of laboratory blood tests and complications in Diabetes Mellitus using data mining technique

Panthip Rattanasinganchan[1*], Kritsanee Maneewong[2], Kittipat Sopitthummakhun[3]

[1]Faculty of Medical Technology, Huachiew Chalermprakiet University

[2]Division of Medical Laboratory and clinical pathology, Chomthong Hospital

[3]Faculty of Science & Technology, Huachiew Chalermprakiet University

*Email : r_panthip@hotmail.com

Abstract

The laboratory blood tests in this study were collected from patients diagnosed with diabetes mellitus (DM) who were admitted to a public hospital in Chiang Mai Province. The aim of this study is to examine the correlation between laboratory blood tests and the incidence of complications associated with DM using a data mining technique. The J48 classifier was applied to construct a decision tree model and verify the precision of the simulation model. The laboratory blood tests were collected from 1,736 patients diagnosed with DM who were admitted to a public hospital in Chiang Mai Province, Thailand in 2020. The results showed that among the total DM cases, 54.55% were diagnosed with chronic kidney disease stage 2 (CKD 2) or higher, consistent with the microalbuminuria category where early and advanced kidney damage was observed in 66.82% of total DM cases. Interestingly, clinical factors such as BMI, eGFR and microalbuminuria are related to DM complications, particularly with respect to kidney dysfunctions. The decision tree model, simulated with the J48 classifier, achieves a high predictive accuracy with a correct classified instance rate of 87.44%. Verification parameters were used to validate the quality of the model in each class of chronic kidney dysfunction which classifier exhibited the high %True positive rates of more than 70% in all targeted CKD classes (CKD 1-5) and with Precision of more than 80% indicating low %False positive rate. These findings highlight the advantages of clinical data analysis using data mining techniques.

Keywords : Diabetes mellitus, Hemoglobin A1c, Data mining, Decision tree, J48 classifier

1. Introduction

Information from the 5-year National NCDs Prevention and Control Strategic Plan (2017-2021) reveals that Thai people have died from Non-communicable diseases (NCDs) including cerebrovascular disease, diabetes mellitus (DM), ischemic heart disease, and diseases related to chronic obstructive pulmonary disease (COPD), accounting for 320,000 people (~ 75% of the total death population) (Department of Disease Control, Ministry of Public Health, 2021, p.148). The situation of diabetes in Thailand, according to the National Health Examination Survey (NHES) plan, indicates that the prevalence of diabetes among individuals aged 15 years and over has elevated from 6.9% in 2009 to 8.9% in 2014 (National Health Examination Survey Office, Health System Research Institute, 2016, p. 6). The WHO report in 2014 found that there were 4.8 million Thai adults with DM resulting in 76,000 deaths from diabetes-related causes, which is equivalent to over 200 people per day (World Health Organization report, 2014). DM is associated with various factors such as age, sex, and genetics, as well as dietary habits that are inconsistent with a healthy diet. The changing social conditions and hectic lifestyle often lead to rushed intake resulting in an imbalance in daily nutritional intake. Improper food consumption behavior and excessive consumption of high-sugar beverages are major contributors to obesity, ultimately leading to DM type 2 diabetes. DM is a serious public health problem in Thailand due to its association with unusually high blood sugar levels, which can lead to serious complications such as diabetic retinopathy, kidney complications, chronic kidney disease, and complications of large blood vessels (Chanlalit W, 2016, p. 38-39), (Sonthon P. *et al*., 2017, p. 9).

In order to establish guidelines for diagnosis and treatment, it is important to understand the relationship among various factors of the disease. It leads to more effective treatment manners. The currently used technique for data correlation is data mining. In this study, we analyzed the correlation between blood test results in patients with diabetes mellitus (DM) and the complications linked to DM using a supervised learning technique with a classifier approach to construct a decision tree model.

2. Objectives

To examine the correlation between laboratory blood test from DM patients and the incidence of complications associated through the high blood sugar using a supervised learning technique with a classification approach.

3. Materials and methods

Clinical consideration for laboratory blood tests in Patient with Diabetes Mellitus

The dataset acquired in this study was obtained from a public hospital in Chiang Mai Province, Thailand, in 2020. Each record contains several features, including age, sex, blood pressure (BP), body mass index (BMI), fasting blood sugar (FBS), hemoglobin A1c (HbA1c), total cholesterol (TC), triglycerides (TG), creatinine (Cr), estimated glomerular filtration rate

(eGFR), and microalbuminuria (MAU). The study included a total of 1,736 patients who were referred based on their FBS and HbA1c levels. These patients were likely selected to assess the prevalence of diabetes or investigate diabetes-related factors within the study population.

The ascertainment of diagnosis for diabetes for each patient is based on FBS level ≥ 126 mg/dL which associated with the HbA1c level of ≥ 6.5 mg%. HbA1C is a widely used marker of chronic glycemia, reflecting average blood glucose levels over a period of approximately 2 to 3 months (Bishop, 2018, p.764).

According to the American Heart Association, there are five range of BP: Normal (<120/80), Elevated (120-129 systolic and less than 80 mmHg diastolic), Hypertension stage 1 (130-139 systolic or 80-89 mmHg diastolic), Hypertension stage 2 (140/90 mmHg or higher), Hypertensive crisis (exceed 180/120 mmHg) (American Heart Association, 2023).

MAU is defined as persistent albuminuria in the range of 30-299 mg/24h or an albumin-creatinine ratio (ACR) of 30-300 □g/mg. Clinical proteinuria or macroalbuminuria is established with a microalbuminuria of ≥300 mg/24h or an ACR of ≥300 □g/mg. A healthy kidney does not let albumin pass into the urine or allows for less than 30 □g/mg (Bishop, 2010, p.326).

BMI is a measure of body fat based on height and weight. It is calculated as weight in kilograms divided by height in meters (kg/m^2). BMI is classified into four groups according to the Asian-Pacific cutoff points: underweight (<18.5 kg/m^2), normal weight (18.5-22.9 kg/m^2), overweight (23-24.9 kg/m^2), and obese (≥30 kg/m^2) (Lim JU, 2017, p.2466).

Glomerular filtration rate (GFR) or eGFR serves as the most comprehensive indicator of kidney function. Chronic kidney disease (CKD) is categorized into five stages based on the extent of kidney function, including CKD stage 1, CKD stage 2, CKD stage 3a, CKD stage 3b, CKD stage 4, and CKD stage 5 as shown in Table 1 (NICE, 2014, p.6).

Table 1 Categories for Glomerular Filtration Rate (GFR) as per kidney disease

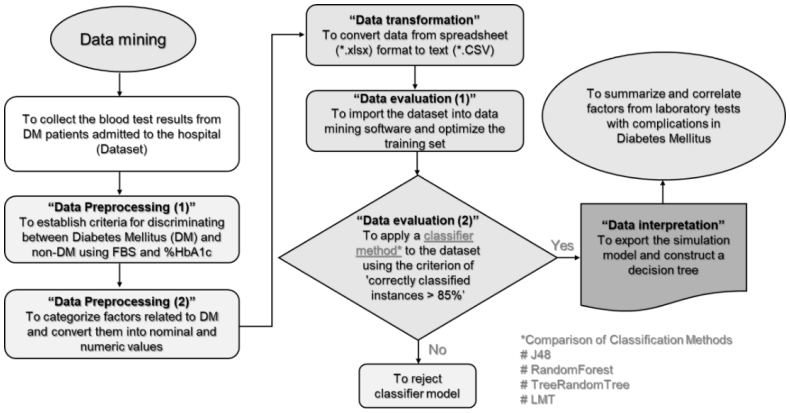
GFR category (CKD stage)	**GFR ($ml/min/1.73m^2$)**	**Terms**
CKD stage 1	90 or higher	Normal or high
CKD stage 2	60-89	Mildly decreased
CKD 3a	45-59	Mildly to moderately decreased
CKD 3b	30-44	Moderately to severely decreased
CKD 4	15-29	Severely decreased
CKD 5	Less than 15	Kidney failure

Data workflow

The data mining workflow encompassed the following procedures: First, data collection involved gathering and compiling laboratory blood test data from patients with diabetes mellitus (DM) into a spreadsheet. Second, data preprocessing was carried out using Microsoft Excel and Notepad++. This step involved tasks such as data cleaning, removing duplicates, handling missing values, and transforming the dataset into a suitable format for analysis. Third, the converted dataset was utilized in the data mining software, called "Weka version 3.9.6". Finally, a supervised learning technique with a classification approach was employed to construct and evaluate the classifier model. The classifier model is involved the utilizing algorithms such as J48, RandomForest, TreeRandomTree, and LMT (Shama H and Kumar H, 2016, p. 2095) to develop and establish the validated model.

The construction of the classifier model was contingent upon a dataset consisting of a total of 1,736 instances. The dataset was subjected to a classifier algorithm using a 10-fold cross-validation manner, with each fold representing a "training set". Moreover, the entire dataset was utilized as a "testing set" for validation purposes. The evaluation of each classifier model from the training sets was based on the percentage of correctly and incorrectly classified instances. Further analysis of the best classifier model included the examination of metrics such as the %True Positive Rate (%TPR), %False Positive Rate (%FPR), and %Precision for each class. The workflow in data mining processing is depicted in Figure 1.

Figure 1 The workflow for data mining processing of laboratory blood tests from DM patients by the data mining technique.



4. Results

Overview of laboratory blood test in DM patients

The dataset was finally preprocessed with a total amount of 1,736 cases from DM patients. The age of DM patients ranged from 24 to 93 years old (Figure 2 depicts the distribution of age among DM patients). Patients between 24 and 59 years old accounted for 40.55% of the dataset, while patients aged 60 years or older accounted for 59.45%. The selected clinical data used to examine the correlation associated with DM complications consisted of BMI, BP, FBS, Cr, TC, TG, HbA1c, eGFR, and MAU. The criteria for identifying DM patients were based on an HbA1c level greater than 6.5 mg%.

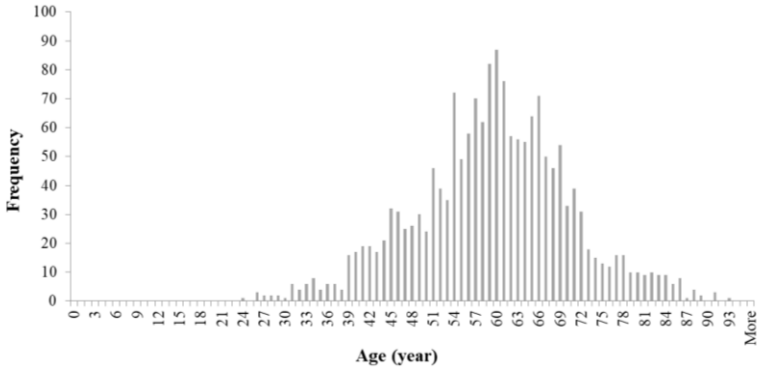


Figure 2 Histogram depicting the distribution of ages among diabetes patients that were admitted to a public hospital in Chiang Mai province.

Data evaluation of DM condition and associated complication factors

The analyzed dataset focuses on the clinical factors of DM patients, comprising a total of 1,736 cases. In the case of TC and TG, the percentage of DM patients with normal levels is calculated to be 50.35% and 69.30%, respectively. Based on these findings, it can be suggested that there should be no correlation between the levels of TC and TG and the presence of DM. Investigation of the clinical factors that may be associated with DM conditions implied the particular interest in BMI, eGFR, and MAU. BMI, a commonly used factor for screening DM patients, is categorized into overweight and obesity, which together account for 66.53% of the total DM patient population. In contrast, BMI values within the normal and low range are calculated only to be 33.47% (Figure 3A), suggesting a significant correlation between elevated BMI and DM. eGFR and MAU are well-known factors associated with kidney failure. The analysis results showed that 54.55% of DM patients were diagnosed with CKD stage 2 or higher (Figure 3B). These results are consistent with MAU category, where early and advanced kidney damage was monitored in 66.82% of total DM cases (Figure 3C). The diagnosis of kidney failure correlates with Cr, MAU, and eGFR. Additionally, the classifier models further investigated DM complications and CKD factors to interpret the predictive model's accuracy for DM complications.

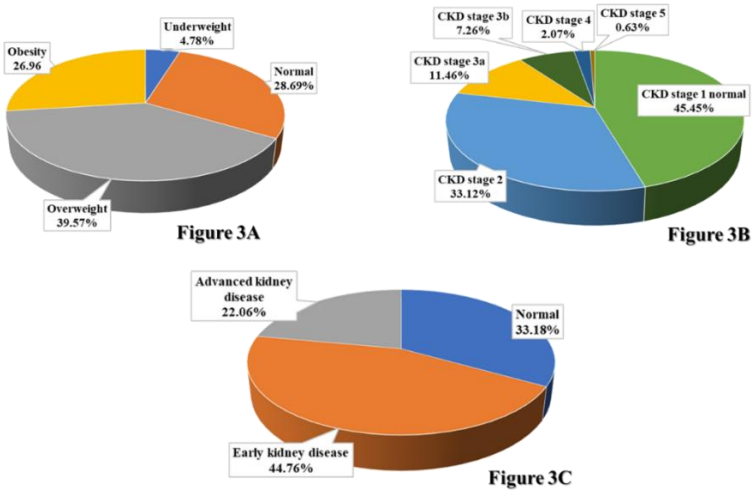


Figure 3 Pie chart depicts the complications in DM patients such as Figure 3A (BMI), Figure 3B (eGFR), and Figure 3C (MAU) categories.

Investigation of the correlation between clinical factors and DM complications with the classifier model

The classifier model was applied to the “training set” using the method of 10-fold cross-validation. Each classifier model was evaluated based on the percentage of correctly and incorrectly classified instances. The J48, RandomForest, and LMT models achieved an accuracy of approximately 80% in correctly classified instances, with the percentage of incorrectly classified instances being less than 25% (Table 2). The J48, RandomForest, and LMT classifier models were compared by evaluating them to the “testing set' using the entire dataset. The results revealed that the RandomForest model achieved a perfect accuracy of 100.00% in correctly classified instances (Table 3). However, it should be noted that this model did not report the factors related to CKD, and no simulation of the decision tree was provided. The LMT model was evaluated using the same methodology as RandomForest. The results indicated that the percentage of correctly classified instances was lower compared to the J48 model, while the percentage of incorrectly classified instances was higher than J48 due to these comparative parameters. Consequently, J48 was selected for further analysis of the correlation between DM complications and CKD.

The "testing set" derived from the J48 classifier model was employed to construct a decision tree, with the objective of integrating the correlation between clinical factors and complications pertaining to patients diagnosed with DM. In this decision tree model, priority rankings were assigned to Cr, eGFR, and MAU as factors associated with DM complications, specifically within the J48 pruned classifier tree. The simulation of the decision tree generated from J48 classifier model incorporates the clinical factors, including age, BMI, BP, Cr, MAU, and eGFR. The decision tree output revealed that the first root node was defined by Cr (Figure 4). The parameters obtained from the J48 classifier model for this dataset indicate a robust predictive model. The computed parameters derived from the J48 classifier, including %TPR (True Positive Rate), %FPR (False Positive Rate), and %Precision, substantiate the efficacy of the decision tree model within each class (as shown in Table 4). Notably, the J48 pruned

classifier model has demonstrated a high %TPR rate exceeding 70% across all targeted classes (CKD stage 1-5), accompanied by a %Precision surpassing 80%, thereby aligning with a low %FPR.

Table 2 The comparison of correctly and incorrectly classified instances from 10-fold cross-validation of "training set" in each classification approach: J48, RandomForest, TreeRandomTree, and LMT.

*Classifier model	%Correctly classified instances	%Incorrectly classified instances
J48	78.40	21.06
RandomForest	79.49	20.51
TreeRandomTree	74.42	25.58
LMT	79.09	20.91

* The number of correctly and incorrectly classified instances is calculated from a total dataset size of 1,726 instances

Table 3 The percentage of correctly and incorrectly classified instances using the "testing set" in each classification approach: J48, RandomForest, TreeRandomTree, and LMT.

*Classifier model	%Correctly classified instances	%Incorrectly classified instances
J48	87.60	12.40
RandomForest	100.00	0.00
LMT	81.99	18.01

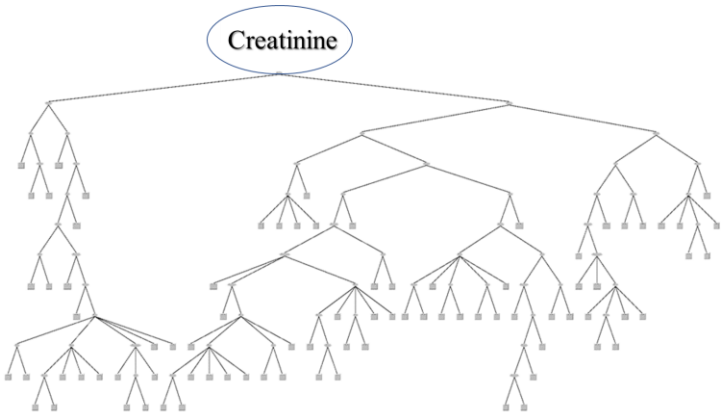


Figure 4 The simulation of decision tree from J48 classifier model composed of clinical factors such as Cr (defined as first root node), eGFR, and MAU in which associated with DM complications.

Table 4 Calculated parameters from J48 classifier model in each CKD class

Classifier output (Testing set)	**Total classified instance**		
Correctly classified instances	87.60%		
Incorrectly classified instances	12.40%		
Detailed accuracy by class			
Class	%TPR**	%FPR[#]	%Precision[$]
CKD stage 1 (Normal)	91.60	4.30	93.60
CKD stage 2	91.40	10.40	82.90
CKD stage 3a	70.80	2.40	81.70
CKD stage 3b	75.40	8.00	88.10
CKD stage 4	90.50	3.00	86.40
CKD stage 5	100.00	0.00	100.00

**%True positive rate (TPR) is calculated in percentage and defined as the probability that an actual positive will test positive in particularly targeted class.

[#] %False positive rate (FPR) is calculated in percentage and defined as the ratio between the total number of wrongly categorized as positive (called false positive) and total number of actual negative events in particularly targeted class.

[$]%Precision is the measurement of accuracy in positive prediction represented by the number of true positive predictions divided by the number of true positive predictions plus false positive predictions which is calculated in percentage.

5. Discussion

Diabetes Mellitus is one of the major health challenges all over the world. Prevention and prediction of diabetes mellitus is increasingly gaining interest in the healthcare community. There are several data mining techniques for diabetes prediction and course of progression. Among the various techniques for diabetes prediction and course of progression, decision tree is widely considered as one of the most powerful and effective methods for classification. There are many studies about prediction of parameters and diabetes. In 2016, Sajida P. conducted a study to classify patients with diabetes mellitus using risk factors such as age, sex, blood pressure, HDL, triglycerides, BMI and FBS. The data mining approach plays a crucial role in DM research, enabling the utilization of the vast amount of available data on DM and its complications. Dagliati A. and colleagues' methodology demonstrates the effectiveness of adopting data mining techniques in clinical medicine to develop models that leverage patient-specific information for predicting relevant outcomes (Dagliati a. *et al*., 2018, p. 295-296). This report utilized the supervised learning technique with classifier approach, J48, and constructed the decision tree as a base learner, along with standalone data mining techniques. The results showed a significant difference in diabetes prevalence among different age groups, indicating that age is a significant influencing factor for diabetes. However, in this study, we predicted complication parameters for diabetes patients. We utilized data mining software for evaluation and interpretation using a predictive approach in Weka version 3.9.6. The decision tree was illustrated based on the J48 classifier algorithm. The result showed diabetes patients with > 6.5 mg% HbA1c associated with CKD, BP, and BMI. This study found that 55% of diabetic patients had kidney disease (Figure 3). Chronic kidney disease (CKD) commonly coexists with other conditions, including diabetes. Prolonged high blood sugar levels, caused by diabetes, can damage blood vessels and nephrons in the kidneys, leading to impaired function. Additionally, diabetes patients are prone to developing high blood pressure, which can also cause kidney damage. Obesity can lead to changes in the body’s metabolism, causing fat tissue to release free fatty acids and glucose into the blood. Overweight (39%) and obesity (27%) are associated with diabetes. Diabetes reduces the body’s ability to use nitric oxide, a molecule that helps blood vessels relax and promote blood flow. This can cause blood vessels to become less elastic and restrict blood and oxygen flow, increasing the risk of hypertension over time.

6. Conclusion

Diabetes mellitus and its complications have become a public health problem, and current therapeutic policies need to be improved. Managing and treating diabetes mellitus is a challenge for researchers and healthcare personnel. The management and treatment of diabetes mellitus poses a challenge to researchers and healthcare personnel. This research strongly suggests the association of diabetes and CKD, BP, and BMI. Knowing about diabetes-related conditions such as kidney disease, high blood pressure, and high BMI (obesity) is important to educate diabetics about and increase awareness of related risks, such as weight control. Proper control of calorie

intake and exercise can help in managing these risks. It is also important to control sodium levels in the diet.

7. References

American Heart Association. Retrieved April 13, 2023, from Understanding Blood Pressure Readings | American Heart Association.

Bishop ML., Fody EP. Schoeff LE. 2010. Clinical Chemistry. Techniques, Principles, Correlations. 6th ed. Philadelphia, PA, USA:/Wolters Kluwer Lippincott Williams & Wikins.

Bishop ML., Fody EP. Schoeff LE. 2018. Clinical Chemistry. Techniques, Principles, Correlations. 8th ed. Philadelphia, PA, USA:/Wolters Kluwer Lippincott Williams & Wikins.

Chanlalit, W. (2016). Ocular complications from diabetes mellitus. Journal of Medicine and Health Sciences, 23(2), 36-45.

Department of Disease Control, Ministry of Public Health. (2021). Prevention and control of diseases and health threats plan in 5 years (2018-2022), Retrieved April 13, 2023, from https://ddc.moph.go.th/uploads/publish/1189320211018081803.pdf

Lim JU, Lee JH, Kim JS, Hwang YI, Kim TH.,Lim SY., Yoo KH., Jung KS., Kim YK., Rhee CK. Comparison of World Health Organization and Asia-Pacific body mass index classifications in COPD patients. International Journal of COPD 2017:12; 2465-2475.

National Institute for Health and Care Excellence. 2014. Chronic kidney disease in adults: assessment and management. www.nice.org.uk/guldance/cg182.

Shama, H., Kumar, H. (2016). A Survey on Decision Tree Algorithms of Classification in Data Mining. International Journal of Science and Research, 5(4), 2094-97.

Sonthon, P., Promthet, S., Changsirikulchai, S., Rangsin, R., Thinkhamrop B., Rattanamongkolgul, S., Hurst, CP. (2017). The impact of the quality of care and other factors on progression of chronic kidney disease in Thai patients with Type 2 Diabetes Mellitus: A nationwide cohort study. Plos One, 12(7), Published online 2017 Jul 28. doi: 10.1371/journal.pone.0180977

Thai National Health Examination Survey, NHES V. (2016). Thai National Health Examination Survey V Study Group Nonthaburi, Thailand, Retrieved April 13, 2023, from http://www.thaiheart.org/images/column_1387023976/NHES5_EGAT Meeting13Dec13.pdf

World Health Organization. (2014). Noncommunicable disease country profiles, Retriever April 13, 2023, from https://www.who.int/news-room/fact-sheets/detail/diabetes

8. Author(s) Biodata (50 words)

Panthip Rattanasinganchan, Ph.D. (Biochemistry)

Academic rank: Assistant Professor

Faculty of Medical Technology

Huachiew Chalermprakiet University

Education: Ph.D. in Biochemistry from the Department of Biochemistry, Faculty of Science, Mahidol University, Thailand

Research Experience:

Antioxidants, Cancer Biology, Signaling Pathways, Data mining.

Research Assistant at Proteomics Core Facility, NIH, Maryland, USA

Quantitative Determination of Favipiravir Tablets by Ultraviolet-Visible Spectrophotometry

Patsachon Poonsawat[1], Sivaporn Wongpayoon[1], Phurit Thanarangsarit[2]*

[1]Pharmacy Student, Faculty of Pharmaceutical Sciences, Huachiew Chalermprakiet University

[2]Department of Pharmaceutical Chemistry, Faculty of Pharmaceutical Sciences, Huachiew Chalermprakiet University

*Email : stamphurit@hotmail.com

Abstract

The objective of this study was to develop and validate a simple UV-visible spectrophotometric method for determination of favipiravir in tablet formulation. Method: Ethanol : water (1:1, v/v) was used as a solvent for the preparation of standard and sample solutions. The results showed that favipiravir exhibited the wavelength of maximum absorbance (λ_{max}) at 227 nm. This analytical method also showed acceptable specificity, linearity, accuracy and precision. The linearity of favipiravir was noticed over the concentration range of 2 – 10 µg/mL. Similarly, the accuracy and precision results were also satisfied with average %recovery of 100.2 and %RSD of 1.28, respectively. Therefore, UV-visible spectrophotometry was suggested to be a simple, specific, accurate, and precise method for the quantification of favipiravir tablets.

Keywords : Favipiravir, tablets, UV-visible spectrophotometry, method validation

1. INTRODUCTION

Favipiravir (5-fluoro-2-oxo-1*H*-pyrazine-3-carboxamide) has been approved in Japan since 2014 for the treatment of new or recurrent influenza. As a prodrug, favipiravir is converted to an active form as favipiravir ribofuranosyl-5′-triphosphate (favipiravir-RTP) which shows antiviral activities by interacting with viral RNA-dependent RNA polymerase (RdRp), resulting to the termination of viral transcription and replication (Pavlova *et al.* 2021, pp. 2-7). Nowadays, due to the worldwide outbreak of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection or generally known as the coronavirus disease-2019 (COVID-19), favipiravir has been repurposed and also indicated as one of first-line therapy in some countries, including Thailand. Based on the clinical practice guideline, favipiravir is recommended in case of symptomatic COVID-19 without pneumonia and no risk factors for severe disease. The recommended dose for adult is 1,800 mg twice daily on day 1, followed by 800 mg twice daily for at least 4 days (Department of Medical Services, 2022). Favipiravir is available in oral tablet formulations (200 mg per tablet) which must be formerly imported from another country. Eventually, in 2021, the Government Pharmaceutical Organization (GPO) in collaboration with the National Science and Technology Development Agency (NSTDA) have announced a successful development and production of favipiravir film-coated tablets, starting from the synthesis of active pharmaceutical ingredient (API), with only half the prices of the imported equivalent.

According to the quality control process, determination of favipiravir in bulk materials and dosage forms was concerned. Japanese Pharmacopoeia (JP) with support from other pharmacopoeias has developed an official method for assaying favipiravir and favipiravir tablets,

using high-performance liquid chromatography (HPLC) (World Health Organization, 2021). In addition, validated HPLC method was also developed for the analysis of favipiravir in pharmaceutical products and human plasma (Bulduk, 2021, pp. 57-65; Mikhail, 2021). However, although HPLC was one of the most widely used technique for drug analysis with the ability of separation, qualification and quantification of single or multicomponent system, it was realized to be a costly and time-consuming method. A simple, economical, and easy-to-operate method, such as UV-visible spectrophotometry was reconsidered.

Recently, using of UV-visible spectrophotometric method for the determination of favipiravir in pharmaceutical formulations has been reported in previous studies (Bulduk, 2021, pp. 57-65; Bulduk, 2021, pp. 209-215; Rajan & Prathamesh, 2021, pp. 321-323; Jyothi & Kavya, 2021, pp. 67-69). Ethanol, ethanol and water (5 in 100 mL for standard stock solution), and deionized water only were used as solvent. Since favipiravir is slightly soluble in water and ethanol, selection of suitable solvent was a key step for further preparation and dilution of standard and sample solutions. To ensure that favipiravir was dissolved completely in a consistent component of the solvent, in this study, a validated UV-visible spectrophotometric method using a cosolvent system was developed for quantification of favipiravir in tablet dosage form.

2. Objectives

To develop and validate a UV-visible spectrophotometric method for the estimation of favipiravir in tablet formulation.

3. Materials and methods

3.1 Materials

Favipiravir reference standard (99.48% purity) was purchased from the Bureau of Drug and Narcotic, Department of Medical Sciences, Ministry of Public Health (Nonthaburi, Thailand). Ethanol (absolute, for analysis) was purchased from Merck (Darmstadt, Germany) for further dilution with deionized water. Favipiravir tablets (COVIVEL^{TM} 200, Strides Pharma Science Ltd., Bangalore, India) were kindly obtained from a hospital in Nakhon Pathom, Thailand. Each film-coated tablet contains 200 mg of favipiravir.

UV spectra and absorbance measurements were carried out using a double-beam UV-visible spectrophotometer (JASCO V-630, Tokyo, Japan) with 2 identical 1-cm quartz cuvettes. All spectral data were collected and analyzed using Spectra Manager 2.5 Software.

3.2 Methods

3.2.1 Method development

Preparation of stock standard solution

Favipiravir standard was weighed accurately about 10 mg into a 100-mL volumetric flask and 40 mL of ethanol : water (1:1, v/v) was then added. The flask was swirled vigorously for 10 min or until the standard was completely dissolved. Finally, adjusted to the volume with the same solvent to obtain a favipiravir stock standard solution at concentration of 100 μg/mL.

Preparation of standard solution

A series of favipiravir standard solution at 5 concentrations: 2, 4, 6, 8, and 10 μg/mL, was prepared by diluting the stock standard solution with ethanol : water (1:1, v/v). These solutions were scanned to determine the wavelength of maximum absorbance (λ_{max}), following by the measurement of absorbances.

Preparation of sample solution

Weighed and powdered 20 favipiravir tablets. The tablet powder was weighed accurately equivalent to 250 mg of favipiravir into a 50-mL volumetric flask. Dissolved with 20 mL of ethanol : water (1:1, v/v), swirled vigorously for 10 min, and adjusted to the volume with the same solvent. Mixed, filtered through an 11-μm filter paper, and discarded the first 10 mL of filtrate. Pipetted 1.0 mL of the previous solution into a 50-mL volumetric flask and adjusted to the volume with ethanol : water (1:1, v/v) to finally obtain a sample solution containing 100 μg/mL of favipiravir.

3.2.2 Method validation

The developed spectrophotometric method was validated for specificity, linearity, accuracy and precision according to the ICH and AOAC guideline.

Specificity

UV absorption spectra of the standard and sample solution were recorded in range of 200 – 400 nm. Characteristic and the λ_{max} obtained from the spectra were compared to evaluate the specificity of developed method.

Linearity and range

Linear regression analysis was established to verify the linearity, using the standard solution in 5 different concentrations (2 – 10 μg/mL). Calibration curve of favipiravir standard was constructed by plotting the measured absorbances at the λ_{max} against the concentrations. The regression equation and correlation coefficient (r) were also determined. The linearity was accepted when $r \geq 0.995$.

Accuracy and precision

Standard addition method was conducted to evaluate the accuracy. Briefly, 3.0 mL of the stock standard solution (as 100% level) was transferred into 6 of 50-mL volumetric flasks containing 1.0 mL of sample solution. Ethanol : water (1:1, v/v) was then added and adjusted to the volume. The standard addition mixtures in 6 replicates were measured at the λ_{max} to obtain a total absorbance from each flask, compared with un-spiked sample solution. The concentrations of spiked favipiravir standard, including percentage recoveries (%recovery) were calculated. The accuracy was accepted when %recovery were in range of 98 – 102.

For precision, percentage of relative standard deviation (%RSD) from average %recovery was consequently calculated. The precision was accepted when %RSD values were not more than 1.3.

3.2.3 Assay of favipiravir tablets

Referred to the preparation of sample solution (3.2.1), 100 μg/mL of favipiravir was prepared in triplicate. Firstly, the tablet powder was weighed accurately equivalent to 50 mg of

favipiravir into a 50-mL volumetric flask. Then, 20 mL of ethanol : water (1:1, v/v) was added, swirled vigorously for 10 min, and adjusted to the volume with the same solvent. After quantitative filtration, 5.0 mL of the filtrate was diluted to 50.0 mL with ethanol : water (1:1, v/v). Finally, diluted 3.0 mL of this solution to 50.0 mL with ethanol : water (1:1, v/v) and measured the absorbance at λ_{max}. Calculated the content of favipiravir per tablet by the absorptivity (a) obtained from linear regression analysis. For the acceptance criteria, favipiravir tablets contain not less than 95.0% and not more than 105.0% of the labeled amount.

4. Results

In this study, the analytical method was developed for further analysis of favipiravir tablets. Standard and sample solutions were prepared in a fixed ratio of ethanol : water (1:1, v/v) throughout the experiment. For method validation, the parameters such as specificity, linearity, accuracy and precision were examined.

4.1 Method validation

Specificity

UV absorption spectra of favipiravir standard and sample were illustrated in Figure 1. The λ_{max} of favipiravir standard was detected at 227 nm. Similarly, the λ_{max} of sample solution was also indicated at the same wavelength, as well as overall spectral characteristic was resemble. These findings demonstrated good specificity of the method for the detection of favipiravir with no inference from excipients in tablet formulation.

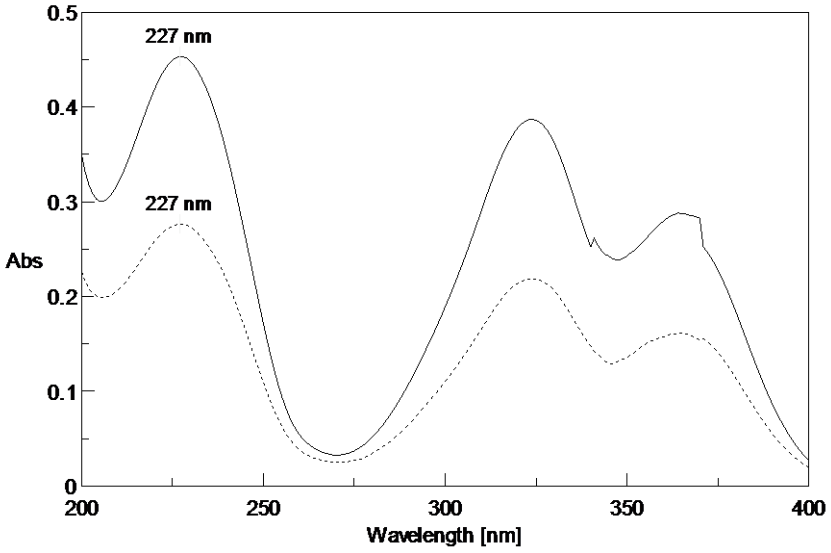


Figure 1 Overlay UV absorption spectra of standard favipiravir at 10 µg/mL (solid line), and sample solution at 6 µg/mL (dash line).

Linearity and range

The calibration curve of favipiravir obtained from the regression analysis was linear over the concentration range of 2 – 10 µg/mL, with the regression equation of y = 0.042x + 0.0152 and r-value of 0.9998 when measured at 227 nm. The absorptivity (a) of favipiravir was known from the slope of regression equation as 42 L/g·cm, resulting to favipiravir specific absorbance or A (1%, 1 cm) of 420 dL/g·cm.

Accuracy and precision

The standard addition mixtures of favipiravir standard (6 µg/mL) combined with sample (2 µg/mL) were prepared in 6 replicates. The absorbances were measured from all solution at 227 nm, and the concentration of spiked standard were calculated. The results were displayed in Table 1. For accuracy, calculated %recoveries were in range of 98.94 – 101.8% (average 100.2%). For precision, %RSD calculated from average %recovery were 1.28%. Thus, the developed method was considered to be accurate and precise for the estimation of favipiravir in tablets.

Table 1 Accuracy and precision results for favipiravir (n = 6)

No.	Amount added (µg/mL)	Amount found (µg/mL)	%Recovery
1	6.300	6.2595	99.36
2	6.300	6.4119	101.8
3	6.300	6.4000	101.6
4	6.300	6.2330	99.06
5	6.300	6.3452	98.94
6	6.300	6.2405	100.7
	Average		100.2
	SD		1.29
	%RSD		1.28

4.2 Assay of favipiravir tablets

Sample solution of 200-mg favipiravir tablets at 6 µg/mL was prepared in triplicate and determined for the absorbances at 227 nm. Based on the calculation using regression equation, the amount of favipiravir (mg/tablet) and percent labeled amount (%L.A.) were displayed in Table 2. Average %L.A. of favipiravir was 95.82, which met the acceptance criteria of favipiravir tablets (95.0 – 105.0 %L.A.).

Table 2 Assay result of favipiravir tablets (n = 3)

No.	Label claim (mg)	Amount found (mg)	%L.A.
1	200	190.5	95.27
2	200	191.2	95.60
3	200	193.2	96.59
	Average		95.82

5. Discussion

In this study, UV-visible spectrophotometric method which used to quantify the content of favipiravir in tablet formulation was modified from recent studies. Jyothi, *et al.* (2021) had introduced a simple, precise, and accurate UV spectrophotometric method for the estimation of favipiravir. Unfortunately, using of this validated method to analyze the marketed products was not applicable. As mentioned earlier, ethanol : water (1:1, v/v) was a suitable solvent in terms of cosolvent property with consistent ratio for the preparation of favipiravir standard and sample solutions. For method validation results, referred to ICH guideline, all parameters including specificity, linearity and range, accuracy, and precision were evaluated and also met the acceptance criteria. Interestingly, our study showed good linearity of the method with $r \geq 0.995$ over the concentration range of 2 – 10 µg/mL, lower than a previous study result which was reported in the range of 10 – 60 µg/mL for both UV and HPLC technique (Bulduk, 2021, pp. 57-65). This finding suggested higher sensitivity of developed method for favipiravir detection.

For favipiravir assay, although the %L.A. of faviravir (in triplicate) were in range of 95.0 – 105.0%, all values as well as the average %L.A. were near the lower limit criteria. Thus, more brands of commercially available favipiravir tablets should be tested to confirm the performance of this analytical method.

6. Conclusion

The developed UV-visible spectrophotometric method in this study was considered to be simple, specific, linear, accurate, precise and sensitive for the determination of favipiravir. Moreover, this analytical method was fully validated as per ICH guideline and successfully applied for the estimation of favipiravir in tablet formulation. Hence, this method can be used in routine quantitative analysis for the quality control of favipiravir tablets.

7. Acknowledgements

This study is financially supported by the Faculty of Pharmaceutical Sciences, Huachiew Chalermprakiet University. The authors would like to thank Miss Nitikan Thipunkaew for valuable technical supports.

8. References

AOAC International (2016). Appendix F: Guidelines for standard method performance requirements. AOAC Official Methods of Analysis, 1-18.

Bulduk, İ. (2021). Comparison of HPLC and UV spectrophotometric methods for quantification of favipiravir in pharmaceutical formulations. *Iranian Journal of Pharmaceutical Research, 20*(3), 57-65.

Bulduk, İ. (2021). HPLC-UV method for quantification of favipiravir in pharmaceutical formulations. *Acta Chromatographica, 33*(3), 209-215.

Department of Medical Services. (2022). *Guidelines for clinical practice, diagnosis, treatment and prevention of healthcare-associated infection in response to patients with COVID-19 infection for medical and healthcare personnel*. https://covid19.dms.go.th/backend/Content/Content_File/Covid_Health/Attach/25651201124058PM_CPG_COVID-19_v.26_n_20221130.pdf

International Conference on Harmonization (ICH): Harmonized Tripartite Guideline. Validation of Analytical Procedures: Text and Methodology Q2 (R1). Geneva, Switzerland, 2005.

Joshi, S., Parkar, J., Ansari, A., Vorad, A., Talwar, D., Tiwaskar, M., … & Barkate, H. (2021). Role of favipiravir in the treatment of COVID-19. *International Journal of Infectious Diseases, 102*, 501-508.

Jyothi, B. J. & Kavya, R. V. (2021). Ultraviolet spectrophotometric method development for estimation of new antiviral repurposing drug favipiravir. *Asian Journal of Pharmaceutical and Clinical Research, 14*(7), 67-69.

Mikhail, I. E., Elmansi, H., Belal, F., & Ibrahim, A. E. (2021). Green micellar solvent-free HPLC and spectrofluorimetric determination of favipiravir as one of COVID-19 antiviral regimens. *Microchemical Journal, 165*, 106189.

Pavlova, V., Hristova, S., Uzunova, K., & Vekov, T. (2021). A review on the mechanism of action of favipiravir and hydroxychloroquine in COVID-19. *Research and Review Insights, 5*, 2-7.

Rajan, V. R., & Prathamesh, P. T. (2021). Determination of favipiravir from pharmaceutical dosage form by extractive ion pair complex colorimetric method. *Asian Journal of Research in Chemistry, 14*(5), 321-323.

World Health Organization (2021). Monographs on favipiravir and on favipiravir tablets. *In the 12th International Meeting of World Pharmacopoeias (IMWP).* Da Nang, Vietnam.