UNIVERSITI PUTRA MALAYSIA

ASSESSMENT OF PATHOGENICITY OF COMMUNITY-ACQUIRED METHICILLIN-RESISTANT Staphylococcus aureus ISOLATES IN PERITONITIS-INDUCED MICE

NUR IZZATIE BINTI ZULKIFLEE

FPSK(m) 2020 43

ASSESSMENT OF PATHOGENICITY OF COMMUNITY-ACQUIRED METHICILLIN-RESISTANT *Staphylococcus aureus* ISOLATES IN PERITONITIS-INDUCED MICE

By

NUR IZZATIE BINTI ZULKIFLEE

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

July 2019

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree Master of Science

ASSESSMENT OF PATHOGENICITY OF COMMUNITY-ACQUIRED METHICILLIN-RESISTANT *Staphylococcus aureus* ISOLATES IN PERITONITIS-INDUCED MICE

By

NUR IZZATIE BINTI ZULKIFLEE

July 2019

Chair : Seri Narti Edayu Sarchio, PhD
Faculty : Medicine and Health Sciences

Staphylococcus aureus strain with distinct genetic backgrounds may exhibit different virulence in animal models as well as associations with different clinical outcomes. Methicillin-Resistant *S. aureus* (MRSA) is known to be more problematic as it cannot be treated with common antibiotics. Traditionally, MRSA infections have been limited to hospitals and predisposed immune-compromised individuals. Recently, MRSA infections have been reported to occur outside of hospital setting. There has been an alarming increase in the incidence of Community-Acquired MRSA (CA-MRSA) infections. CA-MRSA can be a serious threat to public health, which spreads in community. In addition, the present of Panton-Valentine Leucocidin (PVL), pore-forming gene, has also been reported to be epidemiologically associated with CA-MRSA and may cause aggressive infections. Peritonitis is one of the results of *S. aureus* infection which caused potentially fatal inflammation of the peritoneum. *S. aureus* contributed for the greatest number of positive peritonitis cultures from patients with continuous ambulatory peritoneal dialysis and end-stage renal disease. Since the presence of CA-MRSA is continuously emerging, it is important to continue monitoring the distribution pattern and the pathogenic status of CA-MRSA in the community. In this study, the pathogenicity of CA-MRSA isolates were assessed using *in vivo* model of peritonitis with comparison to a clinical isolate, ATCC 700699 MRSA (ATCC-MRSA). Two different CA-MRSA isolates (CA-MRSA1 and CA-MRSA2) were previously isolated from a healthy population were studied. Mice were assigned into 4 groups and intraperitoneally injected with 200 µl of 10^9 CFU/ml of ATCC-MRSA, CA-MRSA1 and CA-MRSA2, respectively. Control group was injected with sterile DPBS. After inoculation, mice were observed twice daily until 72 hours post-infection and any distress signs were recorded. Mice were euthanized at 72 hours post-inoculation or had severe symptoms. Interested organs and peritoneal lavage were collected for bacterial load and

histopathological analysis. All mice inoculated with MRSA showed clear signs of illness and developed symptoms of peritonitis (p<0.001). In addition, CA-MRSA caused significant mortality rate and higher Peritonitis Severity Scoring (PSS) scores compared to un-infected mice, but comparable to reference isolate, ATCC-MRSA, with 80% and 100% of mortality recorded in CA-MRSA2 and CA-MRSA1, respectively. There is no significant different in mortality rate between CA-MRSA and ATCC-MRSA-infected mice. Bacterial count in liver, lung and spleen tissues isolated from CA-MRSA-infected mice were comparable to ATCC-MRSA group. Although it was not statistically different, CA-MRSA2 showed slightly higher bacterial counts compared to CA-MRSA1 and ATCC-MRSA in culture samples. In addition, histopathological comparison had showed mild increase in various indicators including inflammation, necrosis, edema, and haemorrhage, in tissue samples isolated from all MRSA-infected groups. Tissues isolated from CA-MRSA- and ATCC-MRSA-infected mice showed consistent histopathological scores. Abscess was only observed in CA-MRSA2 tissues samples. These results indicate that nasal carriage CA-MRA isolated from a healthy population has potential to cause peritonitis, with comparable severity as clinical isolate, ATCC-MRSA. Together, informations obtained from this study provide new insight on the virulence status of MRSA nasal carriage isolates. Without appropriate intervention, CA-MRSA is likely to be a continuous threat to public health for the foreseeable future. Thus, it is important to ensure consistent practices are adopted towards early diagnosis, appropriate intervention and widespread surveillance to increase awareness that needed in terms of information or education on the risks, management and treatment of MRSA.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENILAIAN KEPATOGENAN CA-MRSA PADA TIKUS TERINDUKSI DENGAN PERITONITIS

Oleh

NUR IZZATIE BINTI ZULKIFLEE

Julai 2019

Pengerusi : Seri Narti Edayu Sarchio, PhD
Fakulti : Perubatan dan Sains Kesihatan

Strain *S. aureus* yang berbeza latar belakang genetik boleh mempengaruhi tahap virulen dan hasil klinikal di dalam model haiwan. MRSA dikenali sebagai bakteria yang merbahaya kerana ia tidak boleh dirawat dengan antibiotik biasa. Umumnya, jangkitan MRSA adalah terhad di hospital dan individu-individu dengan sistem imun yang lemah. Kini jangkitan MRSA telah dilaporkan berlaku di luar hospital. Terdapat peningkatan jangkitan CA-MRSA yang membimbangkan dan ini boleh menjadi ancaman serius kepada kesihatan orang awam, sekiranya ia merebak di kalangan komuniti. Di samping itu, kehadiran Panton-Valentine Leucocidin (PVL), iaitu gen yang membentuk liang, dilaporkan berkait secara epidemiologi dengan CA-MRSA dan menyumbang kepada jangkitan yang agresif. Peritonitis adalah salah satu akibat daripada jangkitan *S. aureus* yang boleh menyebabkan keradangan peritoneum pembawa maut. *S. aureus* menyumbang kepada sejumlah besar kultur positif peritonitis daripada pesakit yang menjalani dialisis peritoneal berterusan dan pesakit buah pinggang tahap akhir. Oleh kerana terdapat peningkatan jangkitan CA-MRSA, adalah penting untuk terus memantau pola taburan dan status patogenik CA-MRSA di kalangan masyarakat. Dalam kajian ini, keupayaan patogenisiti dan kelangsungan hidup CA-MRSA dinilai menggunakan model tikus peritonitis, dibandingkan dengan isolat klinikal, ATCC 700699 MRSA (ATCC-MRSA). Dua isolat CA-MRSA: CA-MRSA1 dan CA-MRSA2, yang sebelum ini telah dipencil daripada populasi sihat akan dikaji. Mencit dibahagikan kepada 4 kumpulan, dan disuntik secara intraperitoneal dengan 200 µL 10^9 CFU/mL ATCC-MRSA, CA-MRSA1 dan CA-MRSA2. Kumpulan kawalan disuntik dengan DPBS steril. Selepas inokulasi, mencit dipantau dua kali sehari selama 72 jam selepas jangkitan, dan sebarang tanda-tanda peritonitis dicatatkan untuk skor tahap ketenatan dan analisis survival. Mencit dieuthanasia 72 jam selepas jangkitan atau sekiranya tenat. Sampel tisu dan cecair peritoneum diambil dan diproses untuk kiraan bakteria, dan skor histopatologi. Semua mencit yang disuntik dengan MRSA menunjukkan tanda-tanda penyakit dan gejala peritonitis yang ketara

(p<0.001). Selain itu, CA-MRSA turut menyebabkan kematian yang signifikan dan skor PSS yang lebih tinggi berbanding mencit yang tidak dijangkiti, iaitu setara dengan ATCC-MRSA, yakni 80% dan 100% kematian direkodkan di CA-MRSA2 dan CA-MRSA1, setiap satu. Namun, tiada perbezaan signifikan pada kadar kematian di antara mencit yang dijangkiti CA-MRSA dan ATCC-MRSA. Jumlah kiraan bakteria pada sampel hati, limpa dan peparu mencit yang dijangkiti CA-MRSA juga adalah setara dengan ATCC-MRSA. Walaupun tidak berbeza secara statistik, CA-MRSA2 menunjukkan jumlah bakteria yang sedikit tinggi berbanding CA-MRSA1 dan ATCC-MRSA. Di samping itu, perbandingan histopatologi pada sampel tisu yang diambil dari semua mencit yang dijangkiti MRSA menunjukkan sedikit peningkatan pada tahap keradangan, nekrosis, edema, dan pendarahan. Tisu dari mencit yang dijangkiti CA-MRSA dan ATCC-MRSA menunjukkan skor histopatologi yang sepadan. Abses pula hanya dilihat dalam sampel tisu CA-MRSA2. Keputusan ini menunjukkan bahawa CA-MRA yang diisolasi dari hidung pembawa sihat berpotensi menyebabkan peritonitis setanding isolat klinikal, ATCC-MRSA. Keseluruhannya, maklumat yang diperoleh dari kajian ini memberikan pandangan baharu tentang status kepatogenan MRSA di kalangan pembawa. Tanpa sebarang alternatif serta usaha yang sewajarnya, CA-MRSA berpotensi untuk kekal menjadi ancaman kepada kesihatan dan komuniti awam pada masa akan datang. Oleh itu, adalah penting untuk memastikan amalan yang konsisten diterapkan terhadap diagnosis awal, langkah-langkah kawalan dan pengawasan yang meluas bagi meningkatkan tahap kesedaran seperti perkongsian maklumat atau pendidikan yang berkaitan dengan risiko, pengurusan dan rawatan MRSA.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious, the Most Merciful All gratification are referred to Allah

All praise to be to Allah, the Almighty for His consent for giving me the courage and strength in completing my Master study and research.

First and foremost, I would like to convey my deepest gratitude to my supervisor, Dr. Seri Narti Edayu Sarchio, who greatly enriched my knowledge with her guidance and assistance. Devoid of her constant support, the master research would have not been accomplished.

I would like to thank my co-supervisor and medical pathologist, Assoc. Prof. Dr. Mohd Nasir Mohd Desa and Prof. Dr. Norhafizah Mohtarrudin, for their guidance, encouragement, insightful comments and ideas for making this thesis, more meaningful.

A sincere gratitude and appreciation also go to the Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, a place that has granted me the opportunity and amenities to collect essential practical skills and the keen in fulfilling the research. Special appreciation note goes to all medical laboratory technologists and staffs of Cell Signalling Laboratory, Applied Microbiology Laboratory and Pathology's department at this faculty for their constructive assistance while grappling the handiness laboratory tasks.

Last but not least, a heartiest thanks goes to my family and friends for their tireless love, support and motivation throughout my study. Thank you and may peace and blessing be upon those who read.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Seri Narti Edayu Sarchio, PhD
Senior Lecturer
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Chairman)

Mohd Nasir Mohd Desa, PhD
Associate Professor
Faculty of Medicine and Health Sceince
Universiti Putra Malaysia
(Member)

_____

ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 10 September 2020

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Nur Izzatie Binti Zulkiflee, GS46008

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Dr. Seri Narti Edayu Sarchio

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Mohd Nasir Mohd Desa

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ATCC	American Type Culture Collection
CLSI	Clinical and Laboratory Standards Institute
mg	Milligram
MHA	Mueller-Hinton Agar
MIC	Minimum Inhibitory Concentration
min	Minute
ml	Millilitre
mM	Millimol
mm	Millimetre
MSA	Mannitol Salt Agar
RPM	Revolutions Per Minute
sec	Seconds
^{o}C	Degree celcius
µL	Microlitre
CA-MRSA	Community-Acquired Methicillin Resistant *Staphylococcus aureus*
HA-MRSA	Hospital-Acquired Methicillin Resistant *Staphylococcus aureus*
CFU	Colony Forming Units
LB broth	Luria-Bertani broth
O.D.	Optical Density
PBS	Phosphate Buffered Saline
TSA	Tryptic Soy Agar
ATCC-MRSA	ATCC-Methicillin Resistant *Staphylococcus aureus*
CDC	Centres for Disease Control and Prevention
PVL	Panton-Valentine Leukocidin
PD	Peritoneal Dialysis
ECM	Extracellular Matrix
SCC*mec*	Staphylococcal Cassette Chromosome
MLST	Multi-Locus Sequence Typing
TSST-1	Toxin-1
SEA-E	Staphylococcal Enterotoxins
TH	T Helper Cells
BSI	Bloodstream Infections
SSIs	Surgical Site Infections
RNA	Ribonucleic Acid
i.v.	Intravenous
i.p.	Intraperitoneal
TSB	Tryptic Soy Broth
NaCl	Sodium Chloride
PCR	Polymerase Chain Reaction
IACUC	Institutional Animal Care and Use Committee
PSS	Peritonitis Severity Scoring
CLSI	The Clinical & Laboratory Standards Institute
PBPP2a	Penicillin Binding Protein
BCPFTs	Bicomponent Pore Forming Toxins

KC	Kupffer Cells
HACP	Healthcare-Associatedd Pneumonia
HAP	Hospital-Acquired Pneumonia
VAP	Ventilator-Associated Pneumonia
ELISA	Enzyme-Linked Immunosorbent Assay
IgG	Immunoglobulin G
PMNs	Polymorphonuclear Cells

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Staphylococcus aureus is known as commensal pathogen which colonizes of the human anterior nares. About 20–30% of individual are persistent carriers of *S. aureus*, whereas 30% are intermittent carriers which are colonized transiently, and the rest of the population are never colonized (Plata et al., 2009; Ryu et al., 2014). *S. aureus* nasal carriage is a risk factor for infection in human. *S. aureus* has been an important human pathogen throughout history and is currently a leading cause of bacterial infections worldwide.

S. aureus infections are ranging from minor skin infection, severe abscesses to life-threatening endocarditis and sepsis. Methicillin-resistant *S. aureus* (MRSA) represents big threat to the public health system. It is notorious as the prime cause of hospital-associated infections. MRSA is more problematic than other type of *Staphylococcus* because it cannot be treated with common antibiotics, including methicillin (Batabyal et al., 2012). In fact, *Staphylococcus* bacteria only become a problem when they cause infection. Traditionally, MRSA infections have been limited to hospitals and predisposed immune-compromised individuals. However, MRSA infections have recently been reported to occur outside of hospital settings (Chambers, 2001). There has been an alarming increase in the incidence of community-acquired MRSA (CA-MRSA) infections, and its prevalence has continued to increase (Ryu et al., 2014). CA-MRSA is defined as MRSA isolated from outpatients with no history of hospitalization within the past 1 year, and who presented no other established risk factors for MRSA infection, such as surgery, residence in a long-term care facility, dialysis, or indwelling percutaneous medical devices or catheters (Yamamoto et al., 2010). In addition, CA-MRSA is classified as an epidemic and a serious threat to public health. According to the Centers for Disease Control and Prevention (CDC) in their report from the National Nosocomial Infections Surveillance conducted in 2004, the prevalence of MRSA in outpatient settings is 31.1% among all *S. aureus* isolates, and most of those MRSA cases were community-associated (Amiry, 2015).

However, the basis for the apparent increased virulence of CA-MRSA strain is incompletely understood. Many factors have been proposed to contribute to the success of CA-MRSA as a pathogen including increased fitness, improved

evasion of the host immune system, and unique toxins production. One of the factors is the present of Panton-Valentine Leukocidin (PVL) genes, a pore-forming toxin that has been epidemiologically associated with CA-MRSA infections (Correa-Jiménez et al., 2016). In addition, PVL is usually absent in hospital-acquired MRSA (HA-MRSA) strains, and are more common in CA-MRSA compared to CA-MSSA (methicillin-susceptible *S. aureus*) isolates with a prove of a recent molecular study showed the presence of PVL in almost all of the CA-MRSA strain (Kim & Park., 2014).

1.2 Problem Statement

Peritonitis that is caused by *S. aureus* is a serious complication of peritoneal dialysis (PD), and commonly occurred due to technique failure (Li et al., 2010). Peritonitis causes damage to the peritoneal membrane, impairing ultrafiltration and therapy adaptation, which may be a temporary or permanent condition (Figueiredo et al., 2013). It is reported that peritonitis resulted in about 18% of the infection-related mortality in PD patients; with *S. aureus* contributed to the greatest number of positive peritonitis cultures in healthcare setting (Battelino et al., 2013). *S. aureus* has been identified as the most frequent pathogens isolated within the inflamed peritoneal catheter exit-site (ES) in patients who is undergoing PD. Furthermore, the presence of nasal carriage *S. aureus* increases the likelihood of ES infections, and its eradication with local antibiotics decrease infectious catheter complication (Kreft et al., 2001). This is consistent with the report that nasal carriers of *S. aureus* has an increased risk of acquiring an infection with this pathogen (Tong et al., 2015).

Recently, in Malaysia, peritonitis is one of the major causes of death among PD patients, as the median peritonitis rate in Malaysia was 1 in 38.2 patient-months in 2009 and 1 in 40.5 patient-months in 2013. The total death rate from peritonitis from 2009 to 2013 was 20.3%. Thus, studies have identified several risk factors associated with PD-related peritonitis. They have found that *S. aureus* is the highest risk factor of peritonitis (Ong et al., 2017). This prevalence showed that *S. aureus* is highly potential in causing peritonitis. In addition, Szeto et al. (2007) suggested that the overall clinical outcome of *S. aureus* peritonitis is not encouraging as they found only 51% of patients with MSSA peritonitis and 46% with MRSA peritonitis had complete cure without need for catheter removal, relapse, or recurrent or repeat peritonitis. Besides, *S. aureus* peritonitis developed in approximately one third of the patients with complete prevention. They reported that more than half of the peritonitis occurred within 3 months after completion of antibiotics. Apart from that, Govindarajulu et al. (2010), showed that MRSA peritonitis was independently predictive of an increased risk of permanent hemodialysis transfer and tended to be associated with a high risk of hospitalization.

In recent years, there is an alarming increase in the rate of *S. aureus* carriage in the community. At the same time, the emergence of CA-MRSA also increase the burden in association with infection, with a high incidence of CA-MRSA reported in both children and adult populations (David et al., 2010). As the number of patients with CA-MRSA infection increase, the risks of inappropriate antimicrobial treatment, subsequently treatment failure, and death are also increase (Rasmussen et al., 2011). Patients diagnosed with CA-MRSA infection usually lacked of risk factors compared to patients infected by HA-MRSA (Rasmussen et al., 2011; Huang et al., 2006). It was reported that CA-MRSA composed of more-diverse clonal groups, with higher potential in transmission and virulence than HA-MRSA (Choo, 2017; Huang et al., 2006; Green et al., 2010). Recent study has documented that CA-MRSA clones have replaced classic HA-MRSA clones in many countries (Choo, 2017). While HA-MRSA possess SCC*mec* I, II and III (Kumari et al., 2016), CA-MRSA usually carries *SCCmec* type IV, V or VI (Huang et al., 2006; Green et al., 2010) along with gene for Panton-Valentine Leukocidin (PVL) production. However, little is known about the virulence status of CA-MRSA isolate, and the determinants of the carrier state are yet to be understood.

1.3 Significance of Study

It was reported that the total death rate due to peritonitis between 2009 and 2013 in Malaysia was about 20.3%, with *S. aureus* identified as the highest risk factor and the most common cause of peritonitis (Ong et al., 2017; Baretti et al., 2012). While MRSA-peritonitis was independently predictive of an increased risk of permanent hemodialysis transfer, and tended to be associated with a high risk of hospitalization (Govindarajulu et al., 2010), the basis for the apparent increased virulence of CA-MRSA strain from a healthy population that has potential to cause peritonitis is incompletely understood (Gordon and Lowy., 2008). CA-MRSA is most likely to be a continuous threat to public health, and people are exposed to this potential threat in daily basis. This is a worrying situation because a single positive nose culture increases the risk for *S. aureus* peritonitis (Piraino et al., 1993; Wanten et al., 1996). Thus, it is important to continue monitoring the distribution pattern and the pathogenic status of CA-MRSA in the community. To assess the virulence status of CA-MRSA nasal carriage isolated from a healthy population, we compared the pathogenicity, the survival rate and the severity of peritonitis symptoms in mice infected with CA-MRSA isolates to the reference isolate, ATCC 700699 MRSA (ATCC-MRSA), using a mice model peritonitis.

1.4 Hypothesis

In Malaysia, peritonitis is one of the major causes of death among PD patients, the median peritonitis rate in Malaysia was 1 in 38.2 patient-months in 2009 and 1 in 40.5 patient-months in 2013, which caused 20.3% of death (Ong et al., 2017). According to Aktas et al. (2011) the rate of *S. aureus* carriers in the PD patient in hospital setting is the highest among the other dialysis, and MRSA-peritonitis was independently predictive of an increased risk of permanent haemodialysis (Govindarajulu et al., 2010). Nevertheless, it was recently reported that the clinical sequelae of PVL+ *S. aureus* infections tend to be more severe than PVL- *S. aureus* infections (Lo et al., 2010; Ma et al., 2012), in which typically associated with CA-MRSA (Ma et al., 2012). Thus, it is hypothesized that CA-MRSA is most likely to have comparable virulence status as HA-MRSA.

1.5 Objective

1.5.1 General Objective

To assess the pathogenicity of nasal carriage of CA-MRSA isolates in peritonitis-induced mice.

1.5.2 Specific Objective

a) To evaluate the survival rate and the peritonitis severity scoring (PSS) of CA-MRSA isolates in peritonitis-induced animal.
b) To assess the bacterial load in peritoneal fluid, blood and organs of interest post-intraperitoneal injection with CA-MRSA isolates.
c) To identify histopathological changes of several organs of interest post-intraperitoneal injection with CA-MRSA isolates.

REFERENCES

Adegbola, R. A., DeAntonio, R., Hill, P. C., Roca, A., Usuf, E., Hoet, B., & Greenwood, B. M. (2014). Carriage of *Streptococcus pneumonia* and other respiratory bacterial pathogens in low and lower-middle income countries: A systematic review and meta-analysis. *PLoS One*, 9(8): 1-10.

Adhikari, R. P., Kort, T., Shulenin, S., Kanipakala, T., Ganjbaksh, N., Roghmann, M. C., Holtsberg, F. W., & Aman, M. J. (2015). Antibodies to *Staphylococcus aureus* LukS-PV attenuated subunit vaccine neutralize a broad spectrum of canonical and non-canonical bicomponent leukotoxin pairs. *PLoS One*, *10*(9), 1–17.

Aktas, E., Pazarli, O., Külah, C., Comert, F., Külah, E., & Sümbüğlu, V. (2011). Determination of *Staphylococcus aureus* carriage in hemodialysis and peritoneal dialysis patients and evaluation of the clonal relationship between carriage and clinical isolates. *American Journal of Infection Control,* 39(5): 422-425.

Ala'Aldeen, D. A., & Hiramatsu, K. (2004). *Staphylococcus aureus* molecular and cinical aspects. *Woodhead Publishing*, 61(3): 274–275.

Amiry, A. A. (2015). Methicillin-resistant *Staphylococcus aureus*: an occupational health hazard in the prehospital setting. *Journal Acute Disease*, 4 (4): 274–276

Bain, B. J. (2017). Structure and function of red and white blood cells key points. *Medicine*, 45(4), 187–193.

Balaban, N., & Medina-acosta, E. (2000). Prevention of diseases caused by *Staphylococcus aureus* using the peptide RIP prevention of diseases caused by *Staphylococcus aureus* using the peptide RIP. *Peptides*, 21(9):1301-1311.

Bamberger, D. M., & Boyd, S. E. (2005). Management of *Staphylococcus aureus* infections. *American Family Physician*, 72 (12): 2474-2481.

Baretti, P., Moraes, M. C., Camargo, C. H., Caramori, J. C. T., & Alessandro, L. (2012). Peritoneal dialysis-related peritonitis due to *Staphylococcus aureus* : a single-center experience over 15 years. *PLos One*, 7(2): 1–7.

Batabyal, B., Kundu, G. K. R., & Biswas, S. (2012). Methicillin-resistant *Staphylococcus aureus* : a brief review. *International Research Journal of Biological Sciences,* 1(7): 65–71.

Battelino, N., Pokorn, M, Švent-Kučina, N., Križan-Hergouth, V., & Novljan, G. (2013). Fulminant peritonitis presumably caused by Panton-Valentine Leukocidin positive *Staphylococcus aureus* in a girl on peritoneal dialysis. *Therapeutic Apheresis and Dialysis*, 17(4): 431-437.

Bhatta, D. R., Cavaco, L. M., Nath, G., Kumar, K., Gaur, A., Gokhale, S., & Bhatta, D. R. (2016). Association of Panton Valentine Leukocidin (PVL) genes with methicillin resistant *Staphylococcus aureus* (MRSA) in Western Nepal : a matter of concern for community infections (a hospital based prospective study). *BMC Infectious Diseases*, 16(199): 1–6.

Bhutia, K., O., Singh, T. S. K., Adhikari, L., & Biswas, S. (2015). Molecular characterization of community and hospital- acquired methicillin-resistant and Methicillin-sensitive *Staphylococcus aureus* isolates in Sikkim. *Indian Journal of Medical Research*, 142 (3): 330-335.

Bien, J., Sokolova, O., & Bozko, P. (2011). Characterization of virulence factors of *Staphylococcus aureus* : novel function of known virulence factors that are implicated in activation of airway epithelial proinflammatory response. *Journal of Pathogens,* 1-13.

Bonesso, M. F., Marques, S. A., & Cunha, M. L. R. S. (2011). Community-acquired methicillin-resistant *Staphylococcus aureus* (CA- MRSA): molecular background , virulence , and relevance for public health. *The Journal of Venomous Animals and Toxins including Tropical Diseases*, 17(4): 378-386.

Boswihi, S. S., & Udo, E.E. (2018). Methicillin Resistant *Staphylococcus Aureus*: An update on epidemiology treatment options and infection control. PLoS One, 13(4).

Boucher, H. W., & Corey, G. R. (2008). Epidemiology of methicillin-resistant *Staphylococcus aureus*. *Clinical Infectious Diseases*, 46(5): 344–349.

Broekema, N. M., Van, T. T., Monson, T. A., Marshall, S. A., & Warshauer, D. M. (2009). Comparison of cefoxitin and oxacillin disk diffusion methods for detection of *mecA* -mediated resistance in *Staphylococcus aureus* in a large-scale study. *Journal of Clinical Microbiology*, 47(1): 217–219.

Bröker, B. M., Mrochen, D., & Péton, V. (2016). The T cell response to *Staphylococcus aureus. Pathogens*, 5(1): 1-23.

Bronner, S., Monteil, H. & Prevost, G. (2004). Regulation of virulence determinants in *Staphylococcus aureus*: complexity and applications. *FEMS Microbiology* Reviews, 28, 183–200.

Brousse, V., Buffet, P., & Rees, D. (2014). The spleen and sickle cell disease: The sick (led) spleen. *British Journal of Haematology*, 166(2): 165–176.

Brown, A. F., Leech, J. M., Rogers, T. R., & Mcloughlin, R. M. (2014). *Staphylococcus aureus* colonization : modulation of host immune response and impact on human vaccine design. *Frontiers in Immunology*, 4(507): 1–20.

Cassado, A. (2015). Revisiting mouse peritoneal macrophages : heterogeneity, development , and function. *Frontiers in Immunology*, 6(225): 1-9.

Cells, H., Harris, L. G., Foster, S. J., Richards, R. G., & Harris, L. (2002). An introduction to *Staphylococcus aureus*, and techniques for identifying and quantifying *Staphylococcus aureus* adhesins in relation to adhesion to biomaterials : review. *European Cells and Materials*, 4: 39–60.

Chambers, H. F. (2001). The changing epidemiology of *Staphylococcus aureus*?. *Emerging Infectious Diseases*, 7:178-182.

Chambers, H. F., & DeLeo, F. R. (2009). Waves of Resistance: *Staphylococcus aureus* in the antibiotic era. *Nature Reviews Microbiology.* 7(9): 629–641.

Channabasappa, S., Durgaiah, M., Chikkamadaiah, R., Kumar, S., Joshi, A., & Sriram, B. (2018). Efficacy of novel anti-*Staphylococcal* ectolysin P128 in a rat model of methicillin-resistant *Staphylococcus aureus* bacteremia. *Antimicrobial Agents and Chemotherapy*, 62(2), 1–10.

Chavakis, T., Wiechmann, K., Preissner, K. T., & Herrmann, M. (2005). *Staphylococcus aureus* interactions with the endothelium. The role of bacterial “Secretable Expanded Repertoire Adhesive Molecules” (SERAM) in disturbing host defense systems. *Thrombosis and Haemostasis,* 94 (2): 278-285.

Chen, C., & Huang, Y. (2014). New epidemiology of *Staphylococcus aureus* infection in Asia. *Clinical Microbiology Infection*, 20(7): 605-623.

Chen, H., Liu, Y., Jiang, X., Chen, M., & Wang, H. (2009). Rapid change of methicillin-resistant *Staphylococcus aureus* clones in a Chinese tertiary

care hospital over a 15-year period. *Antimicrobiology Agents Chemotherapy*, 54 (5): 1842-1847.

Cheng, A. G., DeDent, A. C., Schneewind, O., & Missiakas, D. (2011). A play in four acts: *Staphylococcus aureus* abscess formation. *Trends in Microbiology*, 19(5), 225–232.

Choi, C. S., Yin, C. S., Bakar, A. A., Sakewi, Z., Naing, N. N., Jamal, F., & Othman, N. (2006). Nasal carriage of *Staphylococcus aureus* among healthy adults. *Journal of Microbiology, Immunology and Infection*, 39: 458-464.

Choo. (2017). Community-associated methicillin resistant *Staphylococcus aureus* in nosocomial infections. *Infection and Chemotherapy*, 49(2): 158-159

Clinical and Laboratory Standards Institute (CLSI). (2006). Methods for antimicrobial dilution and disk susceptibility testing of infrequently isolated or fastidious bacteria. *Clinical and Laboratory Standards Institute, Wayne*, M45-A; Vol. 26, No. 19

Clinical and Laboratory Standards Institute (CLSI). (2013). Performance standards for antimicrobial susceptibility testing; twenty-third informational supplement. Wayne PA. CLSI document M100-S23.

Clinical and Laboratory Standards Institute (CLSI). (2016). Performance standards for antimicrobial susceptibility testing. *Clinical and Laboratory Standards Institute, Wayne*, edition 26th

Collection, B. S., Cell, B., Lindstrom, N. M., Moore, D. M., Zimmerman, K., & Smith, S. A. (2015). Hematologic assessment in pet rats , mice , hamsters , and gerbils identification hamster mouse rat gerbil blood collection hematology hemogram. *Veterinary Clinics of North America: Exotic Animal Practice*, 18(1): 21–32.

Cook, L. F., Cook, K. F., Alcomo, I. E. (2006). *Staphylococcus aureus*. *Infobase Publishing*, edition 1.

Correa-jiménez, O., Pinzón-redondo, H., & Reyes, N. (2016). High frequency of Panton-Valentine Leukocidin in *Staphylococcus aureus* causing pediatric infections in the city. *Journal of Infection and Public Health*, 9(4): 415–20.

Costa, A. R., Batistão , D. W. F., Ribas, R. M., Sousa, A. .M., Perira, M.O., & Botelho, C. M. (2013). *Staphylococcus aureus* virulence factors and

disease. *Microbial Pathogens and Strategies for Combating Them: Science, Technology and Education*, 702–710.

Crémieux, A. C., Saleh-Mghir, A., Danel, C., Couzon, F., Dumitrescu, O., Lilin, T., Etienne, J., Vandenesc, F., & Salleh-Mghir, A.(2014). α-hemolysin, not Panton-Valentine Leukocidin, impacts rabbit mortality from severe sepsis with methicillin-resistant *Staphylococcus aureus* osteomyelitis. *Journal of Infectious Diseases*, 209(11), 1773–1780.

Crossley, K. B., Jefferson, K. K., Gordon, L. A., & Vance, G. F. (2009). *Staphylococci* in human disease. *John Wiley & Sons*, edition 2.

David, M. Z., & Daum, R. S. (2010). Community-Acquired methicillin resistance *Staphylococcus aureus*: epidemiology and clinical consequences of an emerging epidermic*. Clinical Microbiology Reviews*, 23(3): 616-687.

Defres, S., Marwick, & C., Nathwani, D. (2009). MRSA as a cause of lung infection including airway infection, community acquired pneumonia and hospital-acquired pneumonia. *European Respiratory Journal*, 34(6): 1470-1476.

DeLeo, F. R., Otto, M., Kreiswirth, B. N., & Chambers, H. F. (2010). Community-associated meticillin-resistant *Staphylococcus aureus*. *Lancet*, 7(9): 629–641.

Delost, M. D. (1997). Introduction to Diagnostic microbiology. a text and workbook. *St. Louis: Mosby, Inc*.

Diep, B. A., Palazzolo-Ballance, A. M., Tattevin, P., Basuino, L., Braughton, K. R., Whitney, A. R., Chen, L., Kreiswirth, B. N., Otto, M., DeLeo, F. R., & Chambers, H. F. (2008). Contribution of Panton-Valentine leukocidin in community-associated methicillin-resistant *Staphylococcus aureus* pathogenesis. *PLoS One,* 3(9): 2–9.

Edwards, A. M., Potts, J. R., Josefsson, E., & Massey, R. C. (2010). *Staphylococcus aureus* host cell invasion and virulence in sepsis is facilitated by the multiple repeats within FnBPA. *PLoS Pathogens*, 6(6): 1-16.

Elhassan, M. M., Ozbak, H. A., Hemeg, H. A., Elmekki, M. A., & Ahmed, L. A. (2015). Absence of the *mecA* gene in methicillin resistant *Staphylococcus aureus* isolated from different clinical specimens in Shendi City, Sudan. *BioMed Research International*, 2015: 1-5.

Emilda, J. K. V., Kumari, J., Shenoy, M. S., Vidyalakshmi, K., & Bhat, K. G. (2016). Comparison of community - associated methicillin resistant

Staphylococcus aureus (CA-MRSA) and healthcare - associated MRSA (HA-MRSA) infections in Mangalore, South India. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 7(4): 2008–2013.

Enright, M. C., Robinson, D. A., Randle, G., Feil, E. J., Grundmann, H., & Spratt, B. G. (2002). The evolutionary history of methicillin-resistant *Staphylococcus aureus* (MRSA). *Proceeding of National Academy of Sciences of the United States of America*, 99(11): 7687–7692.

Ferry, T., Thomas, D., Genestier, A., Lina, G., & Etienne, J. (2005). Comparative prevalence of superantigen genes in *Staphylococcus aureus* isolates causing sepsis with and without septic shock. *Clinical Infectious Diseases*, 41(6):771-7.

Figueiredo, A. E., Siqueira, S. L., Poli-de-Figueiredo, C. E., & d'Avila, D. O. (2013). Peritoneal dialysis patients: a comparison of two techniques. *Peritoneal Dialysis International*, 33: 655–661.

Fitzgerald, S. F., Gorman, J. O., Morris-downes, M. M., Crowley, R. K., Donlon, S., Bajwa, R., Symth, E.G., Fritzpatrick, F., Conlon, P. J., & Humphreys, H. (2011). A 12-year review of *Staphylococcus aureus* bloodstream infections in haemodialysis patients : more work to be done. *Journal of Hospital Infection,* 79(3), 218–221.

Fitzpatrick, E. A., You, D., Shrestha, B., Siefker, D., Patel, S., Yadav, N., Jaliagma, S., & Cormier, S. A. (2017). A neonatal murine model of MRSA pneumonia. *PLoS One*, 12(1): 1–17.

Foster, T. J., & Hook, M. (1998). Surface protein adhesins of *Staphylococcus aureus. Trens Microbiology*, 6 (12): 484-488.

Fournier, B., & Philpott. (2005). Recognition of *Staphylococcus aureus* by the innate immune system. *Clinical Microbiology Review*, 18(3): 521-540.

Fowler, V. G., Justice, A., Moore, C., Benjamin, D. K., Woods, C. W., Campbell, S., Reller, L. B., Corey, G. R., Day, N. P. J., & Peacock, S. J. (2005). Risk factors for hematogenous complication of intravascular catheter-associated *Staphylococcus aureus* bacteremia. *Clinical Infectious Diseases*, 40 (5): 695-703.

Gilespie, H S and Bramford, B.K (2003): The preventable proportion of nosocomial infections: an overview of published reports. *Journal of Hospital Infection*, 54: 258-266.

Gordon, R. J., & Lowy, F. D. (2008). Pathogenesis of methicillin-resistant *Staphylococcus aureus* infection. *Clinical Infectious Disease*, 10032(5): 350-359.

Gorwitz, R. J., Kruszon-Moran, D., McAllister, S. K., McQuillan, G., McDougal, L. K., Fosheim, G. E., & Kuehnert, M. J. (2008). Changes in the prevalence of nasal colonization with *Staphylococcus aureus* in the United States, 2001-2004. *Journal of Infectious Diseases*, 197: 1226-1234.

Gotz, F., (2002). *Staphylococcus* and biofilms. *Molecular Microbiology*, 43(6): 1367-1378.

Govindarajulu, S., Hawley, C. M., McDonald, S. P., Brown, F. G., Rosman, J. B., Wiggins, K. J., Bannyster, K. M., & Johnson, D. V. (2010). *Staphylococcus aureus* peritonitis in Australian peritoneal dialysis patients: predictors, treatment, and outcomes in 503 cases. *Peritoneal Dialysis International*, 30: 311–319.

Grayson, M. L. (2006). The treatment triangle for *Staphylococcal Infections*. *The New England Journal of Medicine*, 355: 724–727.

Green, B. N., Johnson, C. D., Egan, J. T., Rosenthal, M., Griffith, E. A., & Evans, M. W. (2010). Methicillin resistant *Staphylococcus aureus:* an overview for manual therapists.*Journal of Chiropractic Medicine*, 11(1): 64-76

Harris, L. G., Foster, S. J., & Richards, R. G. (2002). An introduction to *Staphylococcus aureus,* and techniques for identifying and quantifying *Staphylococcus aureus* adhesins in relation to adhesion to biomaterials: review. *European Cells and Materials*, 4: 39-60.

Hastings, W. D., Tumang, J. R., Behrens, T. W., & Rothstein, T. L. (2006). Peritoneal B-2 cells comprise a distinct B-2 cell population with B-1b-like characteristics. *European Journal of Immunology*, 36(5): 1114–1123.

Heinz, S. A., Schennings, T., & Heimdahl, A.(1996). Collagen binding of *Staphylococcus aureus* is a virulence factor in experimental endocarditis. *Journal of Infectious Diseases*, 174: 83.

Hu, Q., Cheng, H., Yuan, W., Zeng, F., Shang, W., Tang, D., Xue, W., Zhou, R., Zhu, J., Yang, J., Hu, Z., Yuan, J., Zhang, X., Rao, Q., Li, S., Chen, Z., Hu, X., Wu, X., & Rao, X. (2015). Panton-Valentine Leukocidin (PVL)-positive health care-associated methicillin-resistant *Staphylococcus aureus* isolates are associated with skin and soft

tissue infections and colonized mainly by infective PVL-encoding bacteriophages. *Journal of Clinical Microbiology*, 53(1): 67–72.

Huang, H., Flynn, N. M., King, J. H., Monchaud, C., Morita, M., & Cohen, S. H. (2006). Comparisons of community-associated methicillin-resistant *Staphylococcus aureus* (MRSA) and hospital-associated MRSA infections in Sacramento, California. *Journal of Clinical Microbiology*, 44(7), 2423–2427

Huang, H., Flynn, N. M., King, J. H., Monchaud, C., Morita, M., & Cohen, S. H. (2006). Comparisons of community-associated methicillin-resistant *Staphylococcus aureus* (MRSA) and hospital-associated MRSA infections in Sacramento, California. *Journal of Clinical Microbiology*, 44(7): 2423–2427.

Humphreys, H., Becker, K., & Dohmen, P. M. (2016). *Staphylococcus aureus* and surgical site infection. the benefit of screening and decolonization before surgery. *The Journal of Hospital Infection*, 94 (3): 1-10.

International Commission on Microbiological Specifications for Foods: A simplified guide to understanding and using Food Safety Objectives and Performance Objectives (1998), 1-12

Jang, H. C., Kang, S. J., Choi, S. M., Park, K. H., Shin, J. H., Choy, H. E., Jung, S. I., & Kim, H. B. (2012). Difference in *agr* dysfunction and reduced Vancomycin susceptibility between MRSA bacteremia involving SCC*mec* Types IV/IVa and I-III. *PLoS ONE*, *7*(11): e49136.

Jiang, X., Wang, Y., Qin, Y., He, W., Benlahrech, A., & Zhang, Q. (2017). Micheliolide provides protection of mice against *Staphylococcus aureus* and MRSA infection by down- regulating inflammatory response. *Nature Publishing Group*, 1-14.

Joseph, D., Puttaswamy, R. K., & Krovvidi, H. (2013). Non-respiratory functions of the lung. *Continuing Education in Anaesthesia Critical Care & Pain*, 13(3): 98–102.

Jr, D. L. V., Paclibare, P. A. P., Cabrera, E. C., & Rivera, W. L. (2016). Molecular and phenotypic characterization of methicillin-resistant *Staphylococcus aureus* isolates from a tertiary hospital in the Philippines. *Tropical Medicine and Health*, 44(3): 1–9.

Karakawa, W. W., & Vann, W. F. (1982). Capsular polysaccharides of *Staphylococcus aureus*. *Seminars* in *Pediatric Infectious Diseases*, 4: 285-293.

Karauzum, H., & Datta, S. K. (2017). Adaptive immunity against *Staphylococcus aureus*. *Current Topics in Microbiology and Immunology*, 409: 419–439.

Katayama, Y., Zhang, H., & Chambers, H. F. (2004). PBP 2a mutations producing very-high-level resistance to beta-lactams. antimicrobial agents and chemotheraphy. *Antimicrobial Agents and Therapy*, 48 (2): 453-459.

Kennedy, A. D., & Deleo, F. R. (2009). Epidemiology and virulence of community-associated MRSA. *Clinical Microbiology Newsletter*, 31(20): 153–160.

Kholeif, H., & Mohamed, Z. A. (2009). Detection of Panton-Valentine Leukocidin gene by real time polymerase chain reaction in community-acquired methicillin resistant *Staphylococcus aureus*. *Egyptian Journal of Medical Microbiology*, 18(3): 27–35.

Kim S. J., & Park, C. (2014). Panton-Valentine Leukocidin and *Staphylococcal* Cassette Chromosome (SSC*mec*) from CA-MRSA (community-acquired Methicillin resistant *Staphylococcus aureus*). *Biomedical Research,* 25(4): 441-444.

Klein, E. Y., Sun, L., Smith, D. L., & Laxminarayan, R. (2013). Original contribution the changing epidemiology of methicillin-resistant *Staphylococcus aureus* in the United States : a national observational study. *American Journal of Epidemiology,* 177(7): 666–674.

Kloos WE, Bannerman TL (1994) Update on clinical significance of coagulase-negative *Staphylococci. Clinical Microbiology Review*, 7: 117-140.

Kloos, W. E., Lambe, D. W. Jr. (1991). *Staphylococcus*. Manual of Clinical Microbiology, 5th ed. *ASM, Washington, D.C*., 222-237.

Kluytmans, J. A. J. W. (2006). Community-acquired methicillin-resistant *Staphylococcus aureus* : current perspectives*. Clinical Microbiology and Infection*, 12, 9–15.

Kluytmans, J. A. N., & Verbrugh, H. (1997). Nasal carriage of *Staphylococcus aureus :* epidemiology , underlying mechanisms, and associated risks. *Clinical Microbiology Reviews*, 10(3): 505–520.

Knox, K. W., Wicken, A. J. (1973). Immunological properties of teichoic acids. *Bacteriology Reviews*, 37: 215-257.

Kobayashi, S. D., Malachowa, N., & DeLeo, F. R. (2015). Pathogenesis of *Staphylococcus aureus* abscesses. *The American Journal of Pathology*, 185(6): 1518-1527

Kockritz-Blickwede, M., Rohde, M., Ochmche, S., Miller, L. S., Cheng, A. L., Herwald, H., Foster, S., & Medina, E. (2008). Immunological mechanisms underlying the genetic predisposition to severe *Staphylococcus aureus* infection in the mouse model. *American Journal of Pathology*, 173 (6): 1657-1668

Kong, E. F., Johnson, J. K., & Jabra-Rizk, M. A. (2016). Community-associated methicillin-resistant *Staphylococcus aureus*: an enemy amidst us. *PLoS Pathogens*, 12(10): 1–7.

Kooistra-smid, M., Nieuwenhuis, M., Belkum, A. Van, & Verbrugh, H. (2009). The role of nasal carriage in *Staphylococcus aureus* burn wound colonization. *FEMS Immunology & Medical Microbiology*, 57(1): 1-13.

Kowalewska, P. M., Nguyen, U. T., Burrows, L. L., & Fox-robichaud, A. E. (2016). syndecan-1 (CD138) deficiency increases *Staphylococcus aureus* infection but has no effect on pathology in a mouse model of peritoneal dialysis. *Journal of Biomedical Science*, 23(20): 1-13.

Kreft, B., Eckstein, S., Kahl, A., Frei, U., Witte, W. & Trautmann, M. (2001). Clinical and genetic analysis of *Staphylococcus aureus* nasal colonisation and exit-site infection in patients undergoing peritoneal dialysis. *European Journal Clinical Microbiology*, 20(10): 734–737.

Kumari, J., Shenov, S. M., Baliqa, S., Chakrapani, M., & Bhat, G. K. (2016). Healthcare-associated methicillin resistant *Staphylococcus aureus* clinical characteristics and antibiotic profile with emphasis on macrolide-lincosamide-streptogramin B resistance. *Sultan Qaboos UniversityMedical Journal,* 16(2): 175-181

Labandeira-rey, M., & Bernard, C. (2007). *Staphylococcus aureus* Panton Valentine Leukocidin causes necrotizing pneumonia. *Science*, 315(5815): 1130-1133.

Lai, C., Liao, C., Pai, M., Chu, F., Hsu, S., & Chen, H. (2011). Nasal carriage of methicillin-resistant *Staphylococcus aureus* is associated with higher all-cause mortality in hemodialysis patients. *Clinical Journal of the American Society of Nephrology*, 6(1): 167–174.

Lebon, A., Labout, J. A. M., Verbrugh, H. A., Jaddoe, V. W. V, Hofman, A., Wamel, W. Van, Moll, H. A., & Belkum, A. Van. (2008). Dynamics and determinants of *Staphylococcus aureus* carriage in infancy : the

generation R study. *Journal of Clinical Microbiology*, 46(10), 3517–3521.

Lestari, E. S., Severin, J. A., Filius, P. M. G., Kuntaman, K., Duerink, D. O., Hadi, U., Wahjono, H., & Verbrugh, H. A. (2008). Antimicrobial resistance among commensal isolates of *Escherichia coli* and *Staphylococcus aureus* in the Indonesian population inside and outside hospitals. *European Journal of Clinical Microbiology and Infectious Diseases*, 27(1):45-51.

Li, M., An, B., Villaruz, A. E., Braughton, K. R., Jiang, X., Deleo, F. R., Chambers, H. F., Lu, Y., & Otto, M. (2009). Evolution of virulence in epidemic community-associated methicillin-resistant *Staphylococcus aureus*. *Proceedings of the National Academy of Sciences of the United States of America,* 106(14), 5883–5888.

Li, P. K., Szeto, C. C., Bernardini, J., Figueiredo, A.E., Gupta, A., Johnson, D. W., Kujiper, E. J., Lye, W., Salzer, W., Schaefer, F., & Strujik, D. G. (2010). Peritoneal dialysis-related infections recommendations: 2010 update. *Peritoneal Dialysis International,* 30(4): 393–423.

Lina, G., Piemont, Y., Godail-Gamot, F., Bes, M., & Peter, M. -O., Gauduchon, V., Vandenesch, F., & Etienne, J. (1999). Involvement of Panton-Valentine Leukocidin-producing *Staphylococcus aureus* in primary skin infections and pneumonia. *Clinical Infectious Diseases*, 29: 1128-1132.

Lister, J. L., & Horswill, A. R. (2014). *Staphylococcus aureus* biofilms: recent development in biofilm dispersed. *Frontiers in Cellular and Infection Microbiology*, 4:178

Liu, C., Graber, C. J., Karr, M., Diep, B. A., Basuino, L., Schwartz, B. S., Enright, M. C., O'Hanlon, S. J., Thomas, J. C., Perdreau-Remington, F., Gordon, S., Gunthorpe, H., Jacobs, R., Jensen, P., Leoung, G., Rumack, J. S., & Chambers, H. F. (2008). A population-based study of the incidence and molecular epidemiology of methicillin-resistant *Staphylococcus aureus* disease in San Francisco, 2004-2005.*Clinical Infectious Diseases*, 46 (11): 1637-1646.

Lo, W., & Wang, C. (2010). Panton-Valentine Leukocidin in the pathogenesis of Community-associated methicillin-resistant *Staphylococcus aureus* Infection. *Paediatrics and Neonatology*, 52(2): 59-65.

Lowy, F. D. (2003). Antimicrobial resistance : the example of *Staphylococcus aureus. Journal of Clinical Investigation*, 111(9): 1265–1273.

Lu, P., Chin, L., Peng, C., Chiang, Y., Chen, T., Ma, L., & Siu, L. K. (2005). Risk factors and molecular analysis of community methicillin- resistant *Staphylococcus aureus* carriage. *Journal of Clinical Microbiology*, 43(1): 132-139.

Luna, C. M., Rodríguez-Noriega E., Baavestrello, L., & Gotuzzo, E. (2010). Treatment of methicillin-resistant *Staphylococcus aureus* in Latin America. *Brazilian Journal of Infectious Diseases*, 14(2): 119-127.

Ma, X., Chang, W., Zhang, C., Zhou, X., & Yu, F. (2012). *Staphylococcal* Panton-Valentine Leukocidin induces pro-inflammatory cytokine production and nuclear factor-kappa β activation in neutrophils. *PLoS One*, 7(4): 34970.

Malachowa, N., Kobayashi, S. D., Braughton, K. R., Whitney, A. R., Parnell, M. J., Gardner, D. J., & Deleo, F. R. (2012). *Staphylococcus aureus* leukotoxin GH promotes inflammation. *Journal of Infectious Diseases*, *206*(8), 1185–1193.

Manian, F. A., Meyer, P. L., Setzer, J., & Senkel, D. (2017). Surgical site infections associated with methicillin-Resistant *Staphylococcus aureus*: do postoperative factors play a role?. *Clinical Infectious Diseases,* 36(7): 863–868.

Mat Azis, N., Hamid, A. B., Pung, H. P., 'Amirah, P., Rafee, A., Yahya, F. A., Nordin, S. A., Neela, V., Suhaili, Z., & Mohd Desa, M. N. (2015). *Staphylococcus aureus* infection risk in a population of health sciences students at a public university. *Iranian Journal of Public Health,* 43 (3): 112-116.

Melles, D. C., Gorkink, R. F. J., Boelens, H. A. M., Snijders, S. V., Peeters, J. K., Moorhouse, M. J., van der Spek, P. J., van Leeuwen, W. B., & Simons, G. (2004). Natural population dynamics and expansion of pathogenic clones of *Staphylococcus aureus*. *The Journal of Clinical Investment*, 114 (12): 1732–1740.

Memish, Z. A., Balkhy, H. H., Almuneef, M. A., Al-Haj-Hussein, B. T., Bukhari, A. I., & Osoba, A. O. (2006). Carriage of *Staphylococcus aureus* among Hajj pilgrims. *Saudi Medical Journal*, 27(9): 1367-1372.

Meurer, S. K., Neb, M., Weiskirchen, S., Kim, P., Tag, C.G., Kauffman, M., Huber, M., & Weiskirchen, R. (2016). Isolation of mature (peritoneum-derived) mast cells and immature (bone marrow-derived) mast cells precursors from mice. *PLoS One*, 11(6).

Moreillon, P., Entenza, J. M., Francioli, P., McDevitt, D., Foster, T. J., Francois, P., & Vaudaux, P. (1995). Role of *Staphylococcus aureus* coagulase and clumping factor in pathogenesis of experimental endocarditis. *Infectious Immunology*, 63:4738–4743.

Naik, G., & Deshpande, S. R. (2011). A study on surgical site infections caused by *Staphylococcus aureus* with a special search for methicillin-resistant isolates. *Journal of Clinical and Diagnostic Research*, 5(3): 502–508.

Nouwen, J., Belkum, A. Van, & Verbrugh, H. (2004). Human factor in *Staphylococcus aureus* nasal carriage. *Infection and Immunity*, 72(11): 6685–6688.

O'Riordan, A., Abraham, K. A., Ho, J. K., & Walshe, J. J. (2002). Vancomycin-resistant peritonitis associated with peritoneal dialysis: A cause for concern. *Irish Journal of Medical Science*, 171(1): 42–43.

Oliveira, D. C., & H. Lencastre. (2002). Multiplex PCR strategy for rapid identification of structural types and variants of the *mecA* element in methicillin-resistant *Staphylococcus aureus*. *Antimicrobiology Agents Chemotherapy*, 46(7): 2155-2161.

Ong, L. M., Ch'Ng, C. C., Wee, H. C., Supramaniam, P., Zainal, H., Goh, B. L., Bavanandan, S., Mushahar, L., Hooi, L. S., & Ahmad, G. (2017). Risk of peritoneal dialysis-related peritonitis in a multi-racial Asian population. *Peritoneal Dialysis International*, 37(1), 35–43.

Oogai, Y., Matsuo, M., Hashimoto, M., Kato, F., Sugai, M., & Komatsuzawa, H. (2011). Expression of virulence factors by *Staphylococcus aureus* grown in serum. *Applied and Environmental Microbiology*, 77(22): 8097–8105.

Otto M. (2008). *Staphylococcal* biofilms. *Current Top Microbiology and Immunology*, 322:207–228.

Oyama, T., Miyazaki, M., Yoshimura, M., Takata, T., Ohjimi, H., & Jimi, S. (2016). Biofilm-forming methicillin-resistant *Staphylococcus aureus* survive in kupffer cells and exhibit high virulence in mice. *Toxins*, 8(7): 1-17.

Pantosti, A., Sanchini, A., & Monaco, M. (2007). Mechanisms of antibiotic resistance in *Staphylococcus aureus. Future Microbiology,* 2 (3): 323-334.

Pantosti, A., & Venditti, M. (2009). What Is MRSA? *European Respiratory Journal*, 34 (5): 1190–1196.

Park, K. H., Lee, Y. M., Hong, H. L., Kim, T., Park, H. J., Park, S. Y., Moon, S. M., Chong, Y. P., Kim, S. H., Lee, S. O., Choi, S. H., Jeong, J. .Y, Kim, M. N., Woo, J. H., & Kim, Y. S. (2012). Persistent catheter-related *Staphylococcus aureus* bacteremia after catheter removal and initiation of antimicrobial therapy. *PLoS One*, 7(10): 1-8.

Peacock, S. J., Justice, A., Griffiths, D., Silva, G. D. I. De, Kantzanou, M. N., Crook, D., Sleeman, K., & Day, N. P. J. (2003). Determinants of acquisition and carriage of *Staphylococcus aureus* in infancy. *Journal of Clinical Microbiology*, 41(12): 5718–5725.

Peter, C. A. (2007). Microbiology of antibiotic resistance in *Staphylococcus aureus. Staphyloccocal Resistance: Microbiology*, 45 (3): 165-170.

Peters, B. M., & Noverr, M. C. (2013). *Candida albicans - Staphylococcus aureus* polymicrobial peritonitis. *Infection and Immunity*, 81(6): 2178–2189.

Pinchul, I. V., Beswick, E. J., & Reyes, V. E. (2010). *Staphylococcal* enterotoxins. *Toxins*, 2(8): 2177-2197

Piraino, B., Perlmutter, J. A., Holley, J. L., & Bernardini, J. (1993). *Staphylococcus aureus* peritonitis is associated with *Staphylococcus aureus* nasal carriage in peritoneal dialysis patients. *Peritoneal Dialysis International*, 2: 1956-1964.

Plata, K., Rosato, A. E., & Węgrzyn, G. (2009). *Staphylococcus aureus* as an infectious agent : overview of biochemistry and molecular genetics of its pathogenicity. *Acta Biochimica Polonica*, 56(4): 597–612.

Powers, M. E., & Wardenburg, J. B. (2014). Igniting the Fire: *Staphylococcus aureus* virulence factors in the pathogenesis of sepsis. *PLoS Pathogens*, 10(2): 1-4.

Prasad, S., Nayak, N., Satpathy, G., Nag, H. L., Venkatesh, P., & Ramakrishnan, S. (2012). Molecular & phenotypic characterization of *Staphylococcus epidermidis* in implant related infections. *Indian Journal of Medical Research*, 136(3): 483–490.

Rammelkamp, C., & Maxon, T. (1942). Resistance of *Staphylococcus aureus* to the action of penicillin. *Experimental Biology and Medicine*, 51 (3): 386-389.

Rasmussen, R. V., Jr, V. G. F., Skov, R., & Bruun, N. E. (2011). Future challenges and treatment of *Staphylococcus aureus* bacteremia with emphasis on MRSA. *Future Microbiology*, 6(1): 43-56

Rauch, S., DeDent, A. C., Kim, H. K., Wardenburg, J. B., Missiakas, D. M., & Schneewind, O. (2012). Abscess formation and alpha-hemolysin induced toxicity in a mouse model of *Staphylococcus aureus* peritoneal infection. *Infection and Immunity*, 80(10): 3721–3732.

Ray, A., & Dittel, B. N. (2010). Isolation of mouse peritoneal cavity cells. *Journal of Visualized Experiments*, 35:1-3.

Rayner, H. C., Thomas, M. A. B., & Milford, D. V. (2016). Measuring kidney function. *Springer International Publishing Switzerland*, 11-27.

Rieck, B., Bates, D., Zhang, K., Escott, N., Mougenot, C., Pichardo, S., & Curiel, L. (2014). Focused ultrasound treatment of abscesses induced by methicillin resistant *Staphylococcus aureus*: feasibility study in a mouse model. *Medical Physics*, 41(6): 1-9.

Rita Costa, A., Batistao, D. W. F., Ribas, R. M., Sousa, A. M., Pereira, O., & Botelino, C. M. (2013). *Staphylococcus aureus* virulence factors and disease. *Microbial Pathogens and Strategies for Combating Them: Science, Technology and Education.*

Ryan, K. J. & Ray, C. G. (2004). Sherris medical microbiology: an introduction to infectious diseases. *McGraw Hill*, 4th Edition.

Ryu, S., Song, P. I., Seo, C. H., Cheong, H., & Park, Y. (2014). Colonization and infection of the skin by *Staphylococcus aureus* : immune system evasion and the response to cationic antimicrobial peptides. *International Journal of Molecular Science*, 15(5): 8753–8772.

Sandberg, A., Hessler, J. H. R., Skov, R. L., Blom, J., & Frimodt-møller, N. (2009). Intracellular activity of antibiotics against *Staphylococcus aureus* in a mouse peritonitis model. *Antimicrobial Agents Chemotherapy*, 53(5): 1874–1883.

Santana, H., Fábio, L., Andrade, A., Pereira, Í. S., Miranda, L., Figueiredo, T. B., & Amaro, R. (2016). Distinct strains of *Staphylococcus aureus* lead to different inflammatory response patterns in a murine model of intradermal infection. *Acta Scientiarum*, 38(4): 457–464.

Sause, W. E., Buckley, P. T., Strohl, W. R., Lynch, A. S., & Torres, V. J. (2016). Antibody-based biologics and their promise to combat *Staphylococcus aureus* infections. *Trends in Pharmacological Sciences*, 37(3): 231–241.

Saxena, S., Singh, K., & Talwar, V. (2003). Methicillin-resistant *Staphylococcus aureus* prevalence in community in the East Delhi area. *Japanese Journal of Infectious Diseases,* 56: 54-56.

Shariati, L., Validi, M., Hasheminia, A. M., Ghasemikhah, R., Kianpour, F., Karimi, A., Nafisi, M. R., & Tabatabaiefar, M. A. (2016). *Staphylococcus aureus* isolates carrying Panton-Valentine Leucocidin genes: their frequency, antimicrobial patterns, and association with infectious disease in Shahrekord City, Southwest Iran. *Jundishapur Journal of Microbiology,* 9(1):1-7.

Shields & Patricia. (2013). Retrieved from http://www.microbelibrary.org/component/resource/laboratory-test/3034-mannitol-salt-agar-plates-protocols.

Shrum, B., Anantha, R. V., Xu, S. X., Donnelly, M., Haeryfar, SM. M., McCormick, J. K., & Mele, T. (2014). A robust scoring system to evaluate sepsis severity in an animal model. *BMC Research Notes*, 47 (233): 1-11.

Siegrist, J. (2011). *Staphylococcus aureus* in the focus. *Sigma Aldrich*, 3.4: 1-8.

Singer, A. J., & Talan, D. A. (2014). Management of skin abscesses in the era of methicillin-resistant *Staphylococcus aureus*. *The New England Journal of Medicine*, 370 (11): 1039-1047.

Siripornmongcolchai, T., Chomvarin, C., Chaicumpar, K., Limpaiboon, T. & Wongkhum, C. (2002). Evaluation of different primers for detecting *mecA* gene by PCR in comparison with phenotypic methods for discrimination of methicillin-resistant *Staphylococcus aureus. Southeast Asian Journal of Tropical Medicine Public Health*, 33 (4): 758-763.

Sit, P. S., Teh, C. S. J., Idris, N., Sam, I. C., Syed Omar, S. F., Sulaiman, H., Thong, K. L., Kamarulzaman, A., & Ponnampalavanar, S. (2017). Prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) infection and the molecular characteristics of MRSA bacteraemia over a two-year period in a tertiary teaching hospital in Malaysia. *BMC Infectious Diseases*, 17(1): 1–14.

Skov, R., Smyth, R., Larsen, A. R., Bolmstrom, A., Karlsson, A., Mills, K., Frimodt-Moller, N., & Kahlmeter, G. (2006). Phenotypic detection of methicillin resistance in *Staphylococcus aureus* by disk diffusin testing and etest on Mueller-Hinton agar. *Journal of Clinical Microbiology*, 44(12): 4395-4399.

Soehnlein, O., Lindbom, L., & Weber, C. (2009). Mechanisms underlying neutrophil-mediated monocyte recruitment. *Blood*, 114(21), 4613–4623.

Song, Y., Du, X., Li, T., Zhu, Y., & Li, M. (2017). Phenotypic and molecular characterization of *Staphylococcus aureus* recovered from different clinical specimens of inpatients at a teaching hospital in Shanghai between 2005 and 2010. *Journal of Medical Microbiology*, (2013): 274–282.

Spaan, A. N., Henry, T., Van Rooijen, W. J. M., Perret, M., Badiou, C., Aerts, P. C., Kemmink, J., de Hass, C. J. C., van Kessel, K. P. M., Vandenesch, F., Lina, G., & Van Strijp, J. A. G. (2013). The *staphylococcal* toxin panton-valentine leukocidin targets human C5a receptors. *Cell Host and Microbe*, *13*(5), 584–594.

Stark, L. (2013). Aspects of pathogenesis and molecular epidemiology. *Linköping University Medical Dissertations*, 1371: 1-81.

Stearn, J. C., Kaiser, J., & Surette, M. G. (2015). Microbiology for dummies.*John Wiley & Sons Inc.*

Stefani, S., & Goglio, A. (2010). Methicillin-resistant *Staphylococcus aureus*: related infections and antibiotic resistance international. *Journal of Infectious Diseases*, 14(4): 19–22.

Stewart, P.S. (1998). A review of experimental measurements of effective diffusive permeabilities and effective diffusion coefficients in biofilms. *Biotechnology and Bioengineering*, 59(3): 261-272.

Strommenger, B., Braulke, C., Heuck, D., Schmidt, C., Pasemann, B., Nübel, U., & Wittespa , W. (2008). Typing of *Staphylococcus aureus* as a frontline tool in epidemiological typing. *Journal of Clinical Microbiology*, 46 (2): 574–581.

Suhaili, Z., Johari, S. A., Sajili, M. H., Yahya, A., Zakaria, Z. A., Mohd Desa, M. N., & Ali, A. M. (2013). In silico PCR verification and simplex real-time PCR detection of methicillin-resistant *Staphylococcus aureus* (MRSA) from east coast Malaysian clinical isolates. *Walailak Journal of Science and Technology*, 10(3): 237-246.

Sun, D. D., Ma, X. X., Hu, J., Tian, Y., Pang, L., Shang, H., & Cui, L. Z. (2013). Epidemiological and molecular characterization of community and hospital acquired *Staphylococcus aureus* strains prevailing in Shenyang, Northeastern China. *Brazilian Journal of Infectious Disease,* 17(6): 682-690.

Surewaard, B. G. J., Deniset, J. F., Zemp, F. J., Amrein, M., Otto, M., Conly, J., Omri, A., Yates, R. M., & Kubes, P. (2016). Identification and treatment of the *Staphylococcus aure*us reservoir in vivo. *The Journal of Experimental Medicine*, 213(7): 1141–1151.

Szeto, C., Chow, K., Kwan, B. C., Law, M., Chung, K., Yu, S., Leung, C. B., & Li, P. K. (2007). *Staphylococcus aureus* peritonitis complicates peritoneal dialysis : review of 245 consecutive cases. *Clinical Journal of the American Society of Nephrology*, 2(2): 245–251.

Tadros, M., Williams, V., Coleman, B. L., McGeer, A. J., Haider, S., Lee, C., Harris, I., Rubinstein, E., John, M., Johnston, L.,McNeil, S., Katz, K., Laffin, N., & Simor, A. E. (2013). Epidemiology and outcome of pneumonia caused by methicillin-resistant *Staphylococcus aureus* (MRSA) in Canadian hospitals. *MRSA Pneumonia Outcome*, 8(9):1-8.

Teixeira, F. M., & Fernandes, B. F. (2008). *Staphylococcus aureus* infection after splenectomy and splenic autotransplantation in BALB /c mice. *Clinical and Experimental Immunology, The Journal of Translational Immunology*, 154(2): 255–263.

Thakker, M., Park, J. S., & Lee, J. C. (1998) *Staphylococcus aureus* serotype 5 capsular polysaccharide is antiphagocytic and enhances bacterial virulence in a murine bacteraemia model. *Infectious Immunology*, 66: 5183-5189.

The international commission on microbiological specifications for foods (ICMSF): update (1996). *Food Control*, 7(2), 99–101.

Tong, S. Y., Davis, J. S., Eichenberger, E., Holland, T. L., & Fowler, V. G., Jr. (2015). *Staphylococcus aureus* infections: epidemiology, pathophysiology, clinical manifestations, and management. *Clinical Microbiology Reviews*, 28(3): 603–661.

Valle, D. L., Paclibare, P. A. P., Cabrera, E. C., & Rivera, W. L. (2016). Molecular and phenotypic characterization of methicillin-resistant *Staphylococcus aureus* isolates from a tertiary hospital in the Philippines. *Tropical Medicine and Health*, 44 (3): 1-9

Von Köckritz-Blickwede, M., Rohde, M., Oehmcke, S., Miller, L. S., Cheung, A. L., Herwald, H., Foster, M., & Medina, E. (2008). Immunological mechanisms underlying the genetic predisposition to severe *Staphylococcus aureus* infection in the mouse model. *American Journal of Pathology*, 173(6): 1657–1668.

Wanten, G. J., P. van Oost, P. M. Schneeberger, & M. I. Koolen. (1996). Nasal carriage and peritonitis by *Staphylococcus aureus* in patients on continuous ambulatory peritoneal dialysis: a prospective study. *Peritoneal Dialysis International*, 16: 352-356

Wardenburg, J. B., Williams, W. A., & Missiakas, D. (2006). Host defences against *Staphylococcus aureus* infection require recognition of bacterial lipoproteins. *Proceedings of the National Academy of Sciences of the United States of America*, 103(37): 13831–13836.

Watkins, R. R., David, M. Z., & Salata, R. A. (2012). Current concepts on the virulence mechanisms of meticillin-resistant *Staphylococcus aureus. Journal of Medical Microbiology*, 61(9): 1179–1193.

Wertheim, H. F. L., Kleef, M. van, Vos, M. C., Ott, A., Verbrugh, H. A., & Fokkens, W. (2006). Nose picking and nasal carriage of *Staphylococcus aureus. Infection Control & Hospital Epidemiology,* 27(08), 863–867.

Wertheim, H. F. L., Melles, D. C., Vos, M. C., Leeuwen, W. V., Bellkum, A. V., Verbrugh, H. A., & Nouwen, J. L. (2005). The role of nasal carriage in *Staphylococcus aureus* infections. *The Lancet Infectious Diseases*, 5(12): 751-762.

Wilkinson, B. J. (1997). The biology of *Staphylococci*. *The Staphylococci in Human Diseases, Churchill Livingston, London*, 1-38.

Yamamoto, T., Nishiyama, A., Takano, T., Yabe, S., Higuchi, W., Razvina, O., & Shi, D. (2010). Community-acquired methicillin-resistant *Staphylococcus aureus*: community transmission, pathogenesis, and drug resistance. *Journal of Infection and Chemotherapy*, 16(4): 225-254.

Yoong, P., & Pier, G. B. (2010). Antibody-mediated enhancement of community-acquired methicillin-resistant *Staphylococcus aureus* infection. *Proceedings of the National Academy of Sciences*, 107(5), 2241–2246.

BIODATA OF STUDENT

Nur Izzatie Binti Zulkiflee was born on 14th September 1991 in Melaka, Malaysia. She is the eldest in the family. She received her primary education at Sekolah Kebangsaan Batu Berendam, Melaka in 1998 until 2003. Upon completion her secondary education programme at Maktab Rendah Sains MARA (MRSM) Batu Pahat, Johor in 2008, she attended a year of Foundation in Science and Technology, programme at Kolej MARA Kulim under Universiti Kuala Lumpur from 2009 until 2010. She then pursued her study at Universiti Kuala Lumpur Institute of Medical Science Technology (UniKL MESTECH). In 2014, she obtained her degree in Bachelor in Clinical Laboratory Science (Honours). During her undergraduate years, she had a great experience while attending her internship course at Department of Pathology, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. .She have learnt and gained practical skills by applying techniques and theories learnt in classes. She started her postgraduate study in 2015 at Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. She was grateful for having the opportunity to pursue her Master in Medical Microbiology under supervision of Dr. Seri Narti Edayu Sarchio.

LIST OF PUBLICATIONS

Nur Izzatie Zulkiflee, Norhidayah Mat Azis, Norhafizah Mohtarrudin, Mohd Nasir Mohd Desa, Seri Narti Edayu Sarchio. 2018. *Assessment of pathogenicity of community-acquired MRSA isolate in a mice model of peritonitis*. Oral presentation at the 2nd International Conference on Biomedical and Health Sciences Research (ICBHSR) 2018. The Everly Hotel, Putrajaya, Malaysia. October 22-23. Oral presentation OP-16. Program page: 28.

Nur Izzatie Zulkiflee, Mohammad Asyaari Zakaria, Mohd Nasir Mohd Desa, Seri Narti Edayu Sarchio. 2017. *Assessment of colonization and survivability of community-acquired Staphylococcus aureus in peritonitis*. Poster presentation at the 2nd International Anatomical and Biomedical Scientific Conference (IABS) 2017. Universiti Putra Malaysia, Malaysia. August 1-2. Poster number P17. Program page: 46.

Seri Narti Edayu Sarchio, **Nur Izzatie Zulkiflee**, Suhaili Shamsi, Faizah Md Yassin. 2016. *Graphene Oxide: A safe nano platform for bio-applications?.* Poster presentation at the 3rd Pan-Asian Biomedical Science Conference. Premiera Hotel Kuala Lumpur, Malaysia. December 7-8. Poster number DT-P029. Program page: 161

UNIVERSITI PUTRA MALAYSIA

STATUS CONFIRMATION FOR THESIS / PROJECT REPORT AND COPYRIGHT

ACADEMIC SESSION : Second Semester 2019/2020

TITLE OF THESIS / PROJECT REPORT :

ASSESSMENT OF PATHOGENICITY OF COMMUNITY-ACQUIRED METHICILLIN-RESISTANT *Staphylococcus aureus* ISOLATES IN PERITONITIS-INDUCED MICE

NAME OF STUDENT: NUR IZZATIE BINTI ZULKIFLEE

I acknowledge that the copyright and other intellectual property in the thesis/project report belonged to Universiti Putra Malaysia and I agree to allow this thesis/project report to be placed at the library under the following terms:

1. This thesis/project report is the property of Universiti Putra Malaysia.
2. The library of Universiti Putra Malaysia has the right to make copies for educational purposes only.
3. The library of Universiti Putra Malaysia is allowed to make copies of this thesis for academic exchange.

I declare that this thesis is classified as :

*Please tick (√)

☐	**CONFIDENTIAL**	(Contain confidential information under Official Secret Act 1972).
☐	**RESTRICTED**	(Contains restricted information as specified by the organization/institution where research was done).
☐	**OPEN ACCESS**	I agree that my thesis/project report to be published as hard copy or online open access.

This thesis is submitted for :

☐ **PATENT** Embargo from _____ (date) until _____ (date)

Approved by:

_____
(Signature of Student)
New IC No/ Passport No.:

Date :

_____
(Signature of Chairman of Supervisory Committee)
Name:

Date :

[Note : If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization/institution with period and reasons for confidentially or restricted.]