

8.0 REFERENCES

- Abbott I, Gustavo M, Cerqueira Saruar Bhuiyan, Anton YP (2013) Carbapenem resistance in *Acinetobacter baumannii*: laboratory challenges, mechanistic insights and therapeutic strategies. *Expert Rev Anti Infect Ther* 11(4): 395–409.
- AbdelGhani S, Thomson GK, Snyder JW, Thomson KS (2015) Comparison of the Carba NP, modified Carba NP, and updated Rosco Neo-Rapid Carb kit tests for carbapenemase detection. *J Clin Microbiol* 53(11): 3539–3542.
- Abraham EP, Chain E (1988) An enzyme from bacteria able to destroy penicillin. *Rev Infect Dis* 10(4): 677-678.
- Afzal-Shah M, Woodford N, Livermore DM (2001) Characterization of OXA-25, OXA-26, and OXA-27, molecular class D β -lactamases associated with carbapenem resistance in clinical isolates of *Acinetobacter baumannii*. *Antimicrob Agents Chemother* 45(2): 583–588.
- Alekshun MN, Levy SB (2007) Molecular mechanisms of antibacterial multidrug resistance. *Cell* 128(6): 1037-1050.
- Al-Sweih NA, Al-Hubail MA, Rotimi VO (2011) Emergence of tigecycline and colistin resistance in *Acinetobacter* species isolated from patients in Kuwait hospitals. *J Chemother* 23(1): 13-16.
- Amaral L, Cerca P, Spengler G, Machado L, Martins A, Couto I, Viveiros M, Fanning S, Pagès JM (2011) Ethidium bromide efflux by *Salmonella*: modulation by metabolic energy, pH, ions and phenothiazines. *Int J Antimicrob Agents* 38(2): 140–145. .
- Amaral L, Kristiansen JE (2000) Phenothiazines: an alternative to conventional therapy for the initial management of suspected multidrug resistant tuberculosis. A call for studies. *Int J Antimicrob Agents* 14(3): 173–176.
- Amaral L, Martins A, Spengler G, Molnar J (2014) Efflux pump of Gram negative bacteria: what they do, how they do it with what and how to deal with them. *Front Pharmacol* 4(168): 1-11.
- Ambler RP (1980) The structure of β -lactamases. *Philos Trans R Soc Lond B Biol Sci* 289(1036): 321-331.

- Anderson KF, Lonsway DR, Rasheed JK, Biddle J, Jensen B, McDougal LK, Carey RB, Thompson A, Stocker S, Limbago B, Patel JB. (2007) Evaluation of methods to identify the *Klebsiella pneumoniae* carbapenemase in Enterobacteriaceae. *J Clin Microbiol* 45(8): 2723–2725.
- Arunagiri K, Sekar B, Sangeetha G, John J (2012) Detection and characterization of metallo- β -lactamases in *Pseudomonas aeruginosa* by phenotypic and molecular methods from clinical samples in a tertiary care hospital. *West Indian med. J* 61(8): 778-783.
- Avlami A, Bekris S, Ganteris G, Kraniotaki E, Malamou-Lada E, Orfanidou M (2010) Detection of metallo-beta-lactamase genes in clinical specimens by a commercial multiplex PCR system. *J Microbiol Methods* 83(2): 185–187.
- Bayramoglu G, Ulucam G, Gencoglu, Ozgur C (2016) Evaluation of carbapenem inactivation method for the identification of carbapenemase-producing Enterobacteriaceae strains. *Mikrobiyol Bul* 50(3): 505-507.
- Bebrone C, Bogaerts P, Delbrück H, Benninck S, Kupper MB, Rezende de Castro R, Glupczynski Y, Hoffmann KM (2013) GES-18, a new carbapenem-hydrolyzing GES-type β -lactamase from *Pseudomonas aeruginosa* that contains Ile80 and Ser170 residues. *Antimicrob Agents Chemother* 57(1): 396–401.
- Bedenic B, Plecko V, Sardelic S, Uzunovic S, Godic Torkar K (2014) Carbapenemases in gram-negative bacteria: laboratory detection and clinical significance. *Biomed Res Int* 2014: 841951.
- Behera B, Mathur P (2011) High levels of antimicrobial resistance at a tertiary trauma care centre of India. *Indian J Med Res* 133(3): 343-345.
- Belgode N, Laura Mataseje L, Michael R, Mulvey Mohamudha MP, Rahamathulla P (2016) Carbapenem resistance mechanisms among blood isolates of *Klebsiella pneumoniae* and *Escherichia coli*. *Afr J Microbiol Re* 10(2): 45-53.
- Bentley R (2009) Different roads to discovery: Prontosil (hence sulfa drugs) and penicillin (hence beta-lactams). *J Ind Microbiol Biotechnol* 36(6): 775-786.
- Bharadwaj R, Joshi S, Dohe V, Gaikwad V, Kulkarni G, Shouche Y (2012) Prevalence of New Delhi metallo- β -lactamase (NDM-1)-positive bacteria in a tertiary care centre in Pune, India. *Int J Antimicrob Agents* 39(3): 265–266.
- Birgy A, Doit C, Kurkdjian PM, Genel N, Faye A, Arlet G, Bingen E (2011) Early detection of colonization by VIM-1-producing *Klebsiella pneumoniae* and

NDM-1-producing *Escherichia coli* in two children returning to France. *J Clin Microbiol* 49(8): 3085–3087.

- Blair JMA, Webber MA, Alison J. Baylay AJ, Ogbolu DO, Piddock LJ (2015) Molecular mechanisms of antibiotic resistance. *Nat Rev Microbiol* 13(1): 42–51.
- Bohnert JA, Karamian B, Nikaido H (2010) Optimized Nile Red efflux assay of AcrAB-TolC multidrug efflux system shows competition between substrates. *Antimicrob Agents Chemother* 54(9): 3770-3775.
- Bonnin RA, Nordmann P, Potron A, Lécuyer H, Zahar JR, Poirel L (2011) Carbapenem hydrolyzing GES-type extended-spectrum β -lactamase in *Acinetobacter baumannii*. *Antimicrob Agents Chemother* 55(1): 349–354.
- Bora A, Ahmed GU, Hazarika NK, Prasad KN, Shukla SK, Randhawa V, Sarma JB (2013) Incidence of bla NDM-1 gene in *Escherichia coli* isolates at a tertiary care referral hospital in Northeast India. *Indian J Med Microbiol* 31(3): 250-256.
- Bowlware KL, Stull T (2004) Antibacterial agents in pediatrics. *Infect Dis Clin North Am* 18(3): 513-531.
- Bratu SD, Landman M, Alam E, Tolentino E, Qulae J. (2005). Detection of KPC carbapenem hydrolysing enzyme in *Enterobacter* spp. from Brooklyn, New York. *Antimicrob agents Chemother* 49(2): 776-778.
- Brink AJ, Coetzee J, Clay CG, Sithole S, Richards GA, Poirel L, Nordmann P (2012) Emergence of New Delhi metallo-beta-lactamase (NDM-1) and *Klebsiella pneumoniae* carbapenemase (KPC-2) in South Africa. *J Clin Microbiol* 50(2): 525–527.
- Bush and Jacoby 2010. Updated functional classification of β lactamases *Antimicrob Agents Chemother* 14(3): 969-976.
- Bush K (1988) Recent developments in β -lactamase research and their implications for the future. *Rev Infect Dis* 10(4): 681-690.
- Bush K (2013) Carbapenemase; partners in crime. *J Glob Antimicrob Resist* 1(1): 7-16.
- Bush K, Jacoby GA, Medeiros AA (1995) A functional classification scheme for β -lactamases and its correlation with molecular structure. *Antimicrob Agents Chemother* 39(6): 1211–1233.

- Bush K, Jacoby GA. (2010). Updated functional classification of β lactamases. *Antimicrob Agents Chemother* 54(3): 969-976.
- Bush K, Pannell M, Lock JL, Queenan AM, Jorgensen JH, Lee RM, Lewis JS, Jarrett D (2013) Detection systems for carbapenemase gene identification should include the SME serine carbapenemase. *Int J Antimicrob Ag* 41(1): 1–4.
- Bush, K, Jacoby GA, Medeiros AA (1995) A functional classification scheme for β -lactamases and its correlation with molecular structure. *Antimicrob Agents Chemother* 39(6): 1211-1233.
- Canton R, Akova M, Carmeli Y, Giske CG, Glupczynski Y, Gniadkowski M, Livermore DM, Miriagou V, Naas T, Rossolini GM, Samuelsen O, Seifert H, Woodford N, Nordmann P (2012) European Network on Carbapenemases: Rapid evolution and spread of carbapenemases among Enterobacteriaceae in Europe. *Clin Microbiol Infect* 18(5): 413–431.
- Carattoli A (2009) Resistance plasmid families in Enterobacteriaceae. *Antimicrob Agents Chemother* 53(6): 2227-2238.
- Carrer A, Poirel L, Yilmaz M, Akan OA, Feriha C, Cuzon G, Matar G, Honderlick P, Nordmann P. (2010) Spread of OXA-48-encoding plasmid in Turkey and beyond. *Antimicrob Agents Chemother* 54(3): 1369–73.
- Castanheira M, Bell JM, Turnidge JD, Mathai D, Jones RN (2009) Carbapenem resistance among *Pseudomonas aeruginosa* strains from India: evidence for nationwide endemicity of multiple metallo- β -lactamase clones (VIM-2,-5,-6,-11 and the newly characterized VIM-18). *Antimicrob agents Chemother* 53(3): 1225-1227.
- Castanheira M, Deshpande LM, Mathai D, Bell JM, Jones RN, Mendes RE (2011) Early Dissemination of NDM-1- and OXA-181-Producing Enterobacteriaceae in Indian Hospitals: Report from the SENTRY Antimicrobial Surveillance Program, 2006-2007. *Antimicrob Agents Chemother* 55(3): 1274–1278.
- Castanheira M, Sader HS, Deshpande LM, Fritsche TR, Jones RN (2008) Antimicrobial activities of tigecycline and other broad-spectrum antimicrobials tested against serine carbapenemase and metallo-beta-lactamase producing Enterobacteriaceae: report from the SENTRY antimicrobial surveillance program. *Antimicrob Agents Chemother* 52(2): 570–573.

- Castanheira M, Toleman MA, RN Jones, Schmidt FJ, Walsh TR (2004) Molecular characterization of a β -lactamase gene, blaGIM-1, encoding a new subclass of metallo- β -lactamase. *Antimicrob Agents Chemother* 48(12): 4654–4656.
- Cendejas E, Gomez-Gill R, Gomez-sanchez P, Mirigorance J (2010) Detection and characterization of enterobacteriaceae producing MBL in a tertiary care hospital in Spain. *Clin Microbiol Infect* 16(2): 181-183.
- Cerca P, Martins A, Couto I, Viveiros M, Amaral L (2011) Competition between substrates of the efflux pump system of Salmonella enteritidis. *In Vivo* 25(4): 597–602.
- Chauhan K, Pandey A, Asthana AK, Madan M (2015) Evaluation of phenotypic tests for detection of Klebsiella pneumoniae carbapenemase and metallo-beta-lactamase in clinical isolates of Escherichia coli and Klebsiella species. *Indian J Pathol Microbiol*. 58(1): 31-35.
- Chen CM, Cui SJ (2009) Detection of porcine parvovirus by loop-mediated isothermal amplification. *J Virol Methods* 155(2): 122–125.
- Chen L, Mediavilla JR, Endimiani A, Rosenthal ME, Zhao Y, Bonomo RA, Kriswirth BN (2011) Multiplex Real-Time PCR Assay for Detection and Classification of Klebsiella pneumoniae Carbapenemase Gene (blaKPC) Variants. *J Clin Microbiol* 49(2): 579–585.
- Chen S, Hu F, Zhang X, Xu X, Liu Y, Zhu D, Wang H (2011) Independent emergence of colistin resistant Enterobacteriaceae clinical isolates without colistin treatment. *J Clin Microbiol* 49(11): 4022-3.
- Chen Y, Zhou Z, Jiang Y, Yu Y (2011 B) Emergence of NDM-1- producing Acinetobacter baumannii in China. *J Antimicrob Chemother* 66(6): 1255–1259.
- Chu YW, Cheung TK, Jessie YW (2005) EDTA susceptibility leading to false detection of metallo-beta-lactamase in Pseudomonas aeruginosa by Etest and an imipenem- EDTA disk method. *Int J Antimicrob Agents* 26(4): 340–341.
- Ciobotaro P, Oved M, Nadir E, Bardenstein R, Zimhony O (2011) An effective intervention to limit the spread of an epidemic carbapenem-resistant Klebsiella pneumoniae strain in an acute care setting: from theory to practice. *Am J Infect Control* 39(8): 671-677.

- Clinical and Laboratory Standard Institute. Performance standard for Antimicrobial Susceptibility Testing: Twenty-Third Informational Supplement M100-S25 Wayne, PA: CLSI: 2013.
- Coelho J, Woodford N, Livermore D. (2006) Occurrence of OXA-58 carbapenemase in *Acinetobacter* spp. collected over 10 year period in 3 continents. *Antimicrob Agents Chemother* 50(2): 759-758.
- Cohen Stuart J, Leverstein-Van Hall MA (2010) Guideline for phenotypic screening and confirmation of carbapenemases in Enterobacteriaceae. *Int J Antimicrob Agents* 36(3): 205–210.
- Cornaglia, G, Mazzariol, A, Lauretti L, Rossolini GM, Fontana R (2000) Hospital outbreak of carbapenem-resistant *Pseudomonas aeruginosa* producing VIM-1, a novel metallo-transferable β - lactamase. *Clin Infection Dis* 31(5): 1119-1125.
- Costa SS, Ntokou E, Martins A, Viveiros M, Pouranas S, Couto I, Amaral L (2010) Identification of the plasmid encoded *qacA* efflux pump gene in the methicillin-resistant *Staphylococcus aureus* (MRSA) strain HPV107, a representative of the MRSA Iberian clone. *Int J Antimicrob Agents* 36(6): 557–561.
- Creighton J, Jayawardena S (2015) Comparison of four phenotypic tests, three biochemical tests and Cepheid Xpert® Carba-R for detection of carbapenemase enzymes in Gram-negative bacteria. *NZJ Med Sci* 69(3): 81-88.
- Cuzon G, Naas T, Lesenne A, Benhamou M, Nordmann P (2010) Plasmid-mediated carbapenem hydrolysing OXA-48 beta-lactamase in *Klebsiella pneumoniae* from Tunisia. *Int J Antimicrob Agents* 36(1): 91–93.
- Da Silva GJ, Correia M, Vital C, Ribeiro G, Sousa JC, Leitão R, Peixe L, Duarte A (2002) Molecular characterization of blaIMP-5 a new integron- metallo- β -lactamase gene from post an *Acinetobacter baumannii* nosocomial isolate in Portugal. *FEMS Microbiol Lett* 215(1): 33-39.
- Dalhoff A, Ambrose PG, Mouton JW (2009) A long journey from minimum inhibitory concentration testing to clinically predictive breakpoints: deterministic and probabilistic approaches in deriving breakpoints. *Infection* 37(4): 296-305.
- Dallenne C, Da Costa A, Decré D, Favier C, Arlet G (2010) Development of a set of multiplex PCR assays for the detection of genes encoding important beta-lactamases in Enterobacteriaceae. *J Antimicrob Chemother* 65(3): 490–495.

- Dash N, Panigrahi D, Zarouni MA, Darwish D, Ghazawi A, Sonnevend A, Pal T, Yasin F, Hadi SA. (2014) High incidence of New Delhi metallo-beta-lactamase-producing *Klebsiella pneumoniae* isolates in Sharjah, United Arab Emirates. *Microb Drug Resist* 20(1): 52-56.
- Datta P, Gupta V, Garg S, Chander J (2012) Phenotypic method for differentiation of carbapenemases in Enterobacteriaceae: Study from North India. *Indian J Pathol Microbiol* 55(3): 357-360.
- Davies J (2007) Microbes have the last word. A drastic re-evaluation of antimicrobial treatment is needed to overcome the threat of antibiotic-resistant bacteria. *EMBO Rep* 8(7): 616-621.
- Davies J, Davies D (2010) Origins and evolution of antibiotic resistance. *Microbiol Mol Biol Rev* 74 (3): 417-433.
- Deshpande P, Rodrigues C, Shetty A, Kapadia F, Hedge A, Soman R (2010) New Delhi Metallo-beta lactamase (NDM-1) in Enterobacteriaceae: treatment options with carbapenems compromised. *J Assoc Physicians India* 58: 147-149.
- Dimou V, Dhanji H, Pike R, Livermore DM, Woodford N (2012) Characterization of Enterobacteriaceae producing OXA-48-like carbapenemases in the UK. *J Antimicrob Chemother* 67(7): 1660-1665.
- DiPersio JR, Dowzicky MJ (2007) Regional variations in multidrug resistance among Enterobacteriaceae in the USA and comparative activity of tigecycline, a new glycylycylcline antimicrobial. *Int J Antimicrob Ag* 29(5): 518–527.
- Donald HM, Scaife W, Amyes SGB, Young HK (2000) Sequence analysis of ARI-1 a novel OXA- β lactamases responsible for imipenem resistance in *Acinetobacter baumannii* 6B92 *Antimicrob Agents Chemother* 44(1): 169-179.
- Dortet L, Brechard L, Poirel L, Nordmann P (2014) Impact of the isolation medium for detection of carbapenemase-producing Enterobacteriaceae using an updated version of the Carba NP test. *J Med Microbiol* 63(5): 772-776.
- Dortet L, Poirel L, Errera C, Nordmann P (2014) CarbAcineto NP Test for rapid detection of carbapenemase-producing *Acinetobacter* spp. *J Clin Microbiol* 52(7): 2359–2364.
- Dortet L, Poirel L, Al Yaqoubi F, Nordmann P (2012) NDM-1, OXA-48 and OXA-181 carbapenemase-producing Enterobacteriaceae in Sultanate of Oman. *Clin Microbiol Infect* 18(5): 144-148.

- Doumith M, Ellington MJ, Livermore DM, Woodford N (2009) Molecular mechanism disrupting porin expression in ertapenem resistant *Klebsiella pneumoniae* and *Enterobacter* spp. clinical isolates from the UK. *J Antimicrob Chemother* 63(4): 659-667.
- Doyle D, Peirano G, Lascols C, Lloyd T, Church DL, Pitout JD (2012) Laboratory Detection of Enterobacteriaceae That Produce Carbapenemases. *J Clin Microbiol* 50(12): 3877–3880.
- Drawz SM, Bonomo RA (2010). Three decades of β -lactamses inhibitors. *Clin Microbiol Rev* 23(1): 160-201.
- Dwivedi M, Mishra A, Azim A, Singh RK, Baronia AK, Prasad KN, Dhole TN (2009) Ventilator-associated pneumonia caused by carbapenem-resistant Enterobacteriaceae carrying multiple metallo-beta-lactamase genes. *Indian J Pathol Microbiol* 52(3): 339-342.
- Dzidic SS, Kos B (2008) Antibiotic resistance mechanisms in bacteria: biochemical and genetic aspects. *Food Technol Biotechnol* 46(1): 11-21.
- El-Ageery SM, Al-Hazmi SS (2014) Microbiological and molecular detection of VIM-1 metallo beta lactamase-producing *Acinetobacter baumannii* *Eur Rev Med Pharmacol Sci* 18(7): 965-970.
- Endimiani A, Hujer AM, Perez F, Bethel CR, Hujer KM, Kroeger J, Oethinger M, Paterson DL, Adams MD, Jacobs MR, Diekema DJ, Hall GS, Jenkins SG, Rice LB, Tenover FC, Bonomo RA (2009) Characterization of blaKPC-containing *Klebsiella pneumoniae* isolates detected in different institutions in the eastern USA. *J Antimicrob Chemother* 63(3): 427–437.
- Espinal P, Fugazza G, López Y, Kasma M, Lerman Y, Malhotra-KS, Goossens H, Carmeli Y, Vila J (2011) Dissemination of the NDM-2-producing *Acinetobacter baumannii* clone in an Israeli Rehabilitation Center. *Antimicrob Agents Chemother* 55(11): 5396-5398.
- Evans BA, Amyes SGB (2014) OXA- β lactamases. *Clin Microbiol Rev* 27(2): 241-263.
- Falagas ME, Lourida P, Poulikakos P, Rafailidis PI, Tansarli GS (2014) Antibiotic treatment of infections due to carbapenem-resistant Enterobacteriaceae: systematic evaluation of the available evidence. *Antimicrob Agents Chemother* 58(2): 654–663.

- Fallah F, Noori M, Hashemi A, Goudarzi H, Karimi A, Erfanimanesh S, Alimehr S (2014) Prevalence of blaNDM, blaPER, blaVEB, blaIMP, and blaVIM Genes among *Acinetobacter baumannii* Isolated from Two Hospitals of Tehran, Iran. *Scientifica (Cairo)* 1-6.
- Fallah F, Taherpur A, Vola MH, Hashmi A (2011) Global spread of New Delhi metallo-beta-lactamase-1 (NDM-1). *Iran J Clin Infect Dis* 6(4): 171-176.
- Fekete T, Tumah H, Woodwell J, Truant A, Satishchandran V, Axelrod P, Kreter B (1994) A comparison of serial plate agar dilution, Bauer-Kirby disk diffusion, and the Vitek AutoMicrobic system for the determination of susceptibilities of *Klebsiella* spp., *Enterobacter* spp. and *Pseudomonas aeruginosa* to ten antimicrobial agents. *Diagn Microbiol Infect Dis* 18(4): 251-258.
- Fernandez L, Hancock RE (2012) Adaptive and Mutational Resistance: Role of Porins and Efflux Pumps in Drug Resistance. *Clin Microbiol Rev* 25(4): 661–681.
- Fleteau C, Janvier F, Delacour H, Males S, Ficko C, Andriamanantena D, Jeannot K, AMérens A, Rapp C (2012) Recurrent pyelonephritis due to NDM-1 metallo beta lactamase producing *Pseudomonas aeruginosa* in a patient returning from Serbia, France. *Euro Surveill* 17(45):pii=20311.
- Fomda BA, Khan A, Zahoor D (2014) NDM-1 (New Delhi metallo beta lactamase-1) producing Gram-negative bacilli: Emergence & clinical implications *Indian J Med Res* 140(5): 672-678.
- Forbes BA, Sahm DF, Weissfeld AS (2007) Bailey and Scott's Diagnostic Microbiology 12th Edn. Elsevier Mosby, China.
- Fralick JA (1996) Evidence that TolC is required for functioning of Mar/AcrB eefflux pump of *E.coli*. *J Bacteriol* 178(19): 3803-3805.
- Frere JM, Galleni M, Bush K, Dideberg O (2005) Is it necessary to change the classification of β -lactamases? *J Antimicrob Chemother* 55(6): 1051–1053.
- Gallagher LC, Roundtree SS, Lancaster DP, Rudin SD, Bard JD, Roberts AL, Marshall SH, Bonomo RA, Sullivana KV (2015) Performance of the CLSI Carba NP and the Rosco Carb Screen Assays Using North American Carbapenemase-Producing Enterobacteriaceae and *Pseudomonas aeruginosa* Isolates. *J Clin Microbiol* 53(10): 3370 –3373.

- Ganta SR, Perumal S, Pagadala SR, Samuelson O, Spencer J, Pratt RF, Buynak JD (2009) Approaches to the simultaneous inactivation of metallo and serine-beta lactamases. *Bioorg Med Chem Lett* 19(6): 1618–1622.
- Garbati MA, Abdulhak AB, Baba K, Sakkijha H (2013) Infection due to colistin-resistant Enterobacteriaceae in critically-ill patients. *J Infect Dev Ctries* 7(10): 713–719.
- Gasink LB, Edelstein PH, Lautenbach E, Fishman NO (2009) Risk factors and clinical impact of *Klebsiella pneumoniae* carbapenemase-producing *K. pneumoniae*. *Infect Control Hosp Epidemiol* 30(12): 1180–1185.
- Gaur A, Prakash P, Anupurba S, Mohapatra TM (2008) Observations on Carbapenem Resistance by Minimum Inhibitory Concentration in Nosocomial Isolates of *Acinetobacter* species: An Experience at a Tertiary Care Hospital in North India. *J Health Popul Nutr* 26(2): 183–188
- Gazin M, Paasch F, Goossens H, Malhotra S (2012) Current trends in culture-based and molecular detection of extended-spectrum-beta-lactamase-harboring and carbapenem-resistant Enterobacteriaceae. *J Clin Microbiol* 50(4): 1140–1146.
- Ghafur AK (2010) An obituary – On the death of antibiotics. *J Assoc Physicians India* 58: 143–4.
- Ghazawi A, Sonnevend A, Bonnin RA, Poirel L, Nordmann P, Hashmey R, Rizvi TA, Hamadeh M, Pál T (2012) NDM-2 carbapenemase-producing *Acinetobacter baumannii* in the United Arab Emirates. *Clin Microbiol Infect* 18(2): 34–36.
- Giakkoupi P, Pappa O, Polemis M, Vatopoulos C (2009) Emerging *Klebsiella pneumoniae* isolates coproducing KPC-2 and VIM-1 carbapenemases. *Antimicrob Agents Chemother* 53(9): 4048–4050.
- Giedraitienė A, Vitkauskienė A, Naginienė R, Pavilionis A (2011) Antibiotic resistance mechanisms of clinically important bacteria. *Medicina (Kaunas)* 47(3): 137–146.
- Girlich D, Naas T, Bellais S, Poirel L, Karim A, Nordmann P (2000) Biochemical-genetic characterization and regulation of expression of an ACC-1-like chromosome-borne cephalosporinase from *Hafnia alvei*. *Antimicrob Agents Chemother* 44(6): 1470–1478.

- Girlich D, Naas T, Nordmann P (2004 a) Biochemical characterization of the naturally occurring oxacillinase OXA-50 of *Pseudomonas aeruginosa*. *Antimicrob Agents Chemother* 48(): 2043–2048.
- Girlich D, Naas T, Nordmann P (2004 b) OXA-60, a chromosomal, inducible, and imipenem-hydrolyzing class D β -lactamase from *Ralstonia pickettii*. *Antimicrob Agents Chemother* 48(6): 4217–4225.
- Girlich D, Poirel L, Nordmann P (2012 a) Value of the modified Hodge test for detection of emerging carbapenemases in Enterobacteriaceae. *J Clin Microbiol* 50(2): 477–479.
- Girlich D, Poirel L, Szczepanowski R, Schluter A, Nordman P. (2012 b). Carbapenem hydrolysing GES-5 encoding gene on different plasmid types recovered from bacterial community in sewage treatment plant. *Appl Environ Microbiol* 78(4): 1292-1295.
- Giske CG, Gezelius L, Samuelsen O, Warner M, Sundsfjord A, Woodford N (2011) A sensitive and specific phenotypic assay for detection of metallo-beta-lactamases and KPC in *Klebsiella pneumoniae* with the use of meropenem disks supplemented with aminophenylboronic acid, dipicolinic acid and cloxacillin. *Clin Microbiol Infect* 17(4): 552–556.
- Gladstone P, Rajendran P, Brahmadathan KN (2005) Incidence of carbapenem resistant nonfermenting gram negative bacilli from patients with respiratory infections in the intensive care units. *Indian J Med Microbiol* 23(3): 189-191.
- Goa KL, Noble S (2003) Panipenem/betamipron. *Drugs* 63(9): 913-25.
- Goel N, Chaudhary U, Aggarwal R, Bala K. (2009) Antibiotic sensitivity pattern of gram negative bacilli isolated from the lower respiratory tract of ventilated patients in the Intensive care unit. *Indian J Crit Care Med* 13(3): 148-155.
- Gould IM (2007) Antimicrobials: an endangered species? *Int J Antimicrob Agents* 30(5): 383-384.
- Guh AY, Bulens SN, Mu Y, Jacob JT, Reno J, Scott J, Wilson LE, Vaeth E, Lynfield R, Shaw KM, Vagnone PM, Bamberg WM, Janelle SJ, Dumyati G, Concannon C, Beldavs Z, Cunningham M, Cassidy PM, Phipps EC, Kenslow N, Travis T, Lonsway D, Rasheed JK, Limbago BM, Kallen AJ (2015) Epidemiology of Carbapenem-Resistant Enterobacteriaceae in 7 US Communities, 2012-2013. *JAMA* 314(14): 1479-1487.

- Gulmez D, Woodford N, Palepou MF, Mushtaq S, Metan G, Yakupogullari Y, Kocagoz S, Uzun O, Hascelik G, Livermore DM (2008) Carbapenem-resistant *Escherichia coli* and *Klebsiella pneumoniae* isolates from Turkey with OXA-48-like carbapenemases and outer membrane protein loss. *Int J Antimicrob Agents* 31(6): 523–526.
- Gupta E, Mohanty S, Sood S (2006) Emerging resistance to carbapenems in tertiary care hospital in North India. *Indian J Med Res* 124: 95-98.
- Hall BG, Barlow M (2005) Revised Ambler classification of β -lactamases. *J Antimicrob Chemother* 55(6): 1050–1051.
- Hammoudi D, Moubareck CA, Sarkis DK (2014). How to detect carbapenemase producers? A literature review of phenotypic and molecular methods. *J Microbiol Methods* 107: 106-118.
- Hancock RE, Brinksman ES (2002) Function of pseudomonas porins in uptake and efflux *Annual Rev Microbiol* 56: 17-38.
- Harremoes PD, Gee M, MacGarvin A, Stirling J, Keys (2001) Late lessons from early warnings: the precautionary principle 1896–2000. Environmental issue report 22 European Environment Agency, Copenhagen K, and Denmark. ISBN 92-9167-323-4, Environmental issue report No 22.
- Hartl R, Widhalm S, Kerschner H (2017) Cilastatin does not affect Carba NP test performance for detection of carbapenemase production in Enterobacteriaceae. *Wien Klin Wochenschr* 129(1-2): 29-32.
- Heritier C, Poirel L, Fournier PE, Claverie JM, Raoult D, Nordmann P (2005) Characterization of the naturally occurring oxacillinase of *Acinetobacter baumannii*. *Antimicrob Agents Chemother* 49(10): 4174–4179.
- Heritier C, Poirel L, Nordman P. (2004). Genetic and biochemical characterization of chromosome encoded carbapenem hydrolysing class D β -lactamases from *Shewanella* algae. *Antimicrob Agents Chemother* 48(5): 1670-1675.
- Ho PL, Li Z, Lai EL, Chiu SS, Cheng VC (2012) Emergence of NDM-1-producing Enterobacteriaceae in China. *J Antimicrob Chemother* 67(6): 1553–1555.
- Horsfall LE, Izougarhane Y, Lassaux P, Selevsek N, Liénard BM, Poirel L, Kupper MB, Hoffmann KM, Frère JM, Galleni M, Bebrone C (2011) Broad

antibiotic resistance profile of the subclass B3 metallo- β -lactamase GOB-1, a di-zinc enzyme. *FEBS J* 278(8): 1252-1263.

- Hrabak J, Chudackova E, Walková R (2013) Matrix-assisted laser desorption ionization-time of flight (MALDI-TOF) mass spectrometry for detection of antibiotic resistance mechanisms: from research to routine diagnosis. *Clin Microbiol Rev* 26(1): 103–114.
- <https://en.wikipedia.org/wiki/Meropenem>
- Huang TD, Berhin C, Bogaerts P, Glupczynski Y (2014) Comparative evaluation of two chromogenic tests for the rapid detection of carbapenemase in Enterobacteriaceae and in Pseudomonas aeruginosa isolates. *J Clin Microbiol* 52(8): 3060–3063.
- Huber CA, Sidjabat HE, Zowawi HM, Kvaskoff D, Reed S, McNamara JF, McCarthy KL, Harris P, Toh B, Wailan AM, Paterson DL (2016) Detection of carbapenemase activity in Enterobacteriaceae using LC-MS/ MS in comparison with the neo-rapid CARB kit using direct visual assessment and colorimetry. *J Microbiol Methods* 131: 68–72.
- Ikonomidis A, Ntokou E, Antonios N, Tsakris A, Pournaras S (2008) Hidden VIM-1 metallo-beta-lactamase phenotypes among Acinetobacter baumannii clinical isolates. *J Clin Microbiol* 46(1): 346–349.
- Jackson JJ, Kropp H. (1992) beta-lactam antibiotic-induced release of free endotoxin: in vitro comparison of penicillin-binding protein (PBP) 2-specific imipenem and PBP 3-specific ceftazidime. *J Infect Dis* 165(6): 1033-41.
- Jacoby GA (2009) AmpC beta-lactamases. *Clin Microbiol Rev* 22(1): 161–182.
- Jamal W, Rotimi VO, Albert MJ, Khodakhast F, Udo EE, Poirel L (2012) Emergence of nosocomial New Delhi metallo- β -lactamase-1 (NDM-1)-producing Klebsiella pneumoniae in patients admitted to a tertiary care hospital in Kuwait. *Int J Antimicrob Agents* 39(2): 183-184.
- Jan R, Raja W, George N, Mathew M, Johny M, Lal V, Paniker G (2017) A Study on Prevalence, Microbiological profile and antibiotic sensitivity of carbapenem resistant enterobacteriaceae in a tertiary care ICU settings. *WJPR* 6(1): 1191-1198.

- Jeremiah SS, Balaji V, Anandan S, Sahni RD (2014) A possible alternative to the error prone modified Hodge test to correctly identify the carbapenemase producing Gram-negative bacteria. *Indian J Med Microbiol* 32(4): 414-418.
- Johnson AP, Woodford N (2013) Global spread of antibiotic resistance: The example of New Delhi metallo- β -lactamase (NDM)-mediated carbapenem resistance. *J Med Microbiol* 62(4): 499–513.
- Jones RN, Huynh HK, Biedenbach DJ (2004) Activities of doripenem (S-4661) against drug-resistant clinical pathogens. *Antimicrob Agents Chemother* 48(8): 3136-40.
- Joseph NM, Sistla S, Dutta TK, Badhe AS, Rasitha D, Parija SC (2011) Reliability of Kirby-Bauer disk diffusion method for detecting meropenem resistance among non-fermenting Gram-negative bacilli. *Indian J Pathol Microbiol* 54(3): 556-560.
- Jovcic B, Lepsanovic Z, Suljagic V, Rackov G, Begovic J, Topisirovic L, Kojic M. (2011) Emergence of NDM-1 metallo-beta lactamase in *Pseudomonas aeruginosa* clinical isolates from Serbia. *Antimicrob Agents Chemother* 55(8): 3929-3931.
- Kaase, M, Szabados F, Wassill L (2012) Detection of Carbapenemases in Enterobacteriaceae by a Commercial Multiplex PCR. *J Clin Microbiol* 50(9): 3115–3118.
- Kahan JS, Kahan FM, Goegelman R, Currie SA, Jackson M, Stapley EO, Miller TW, Miller AK, Hendlin D, Mochales S, Hernandez S, Woodruff HB, Birnbaum J (1979) Thenamycin, a new β lactam antibiotic; discovery, taxonomy, isolation and physical properties. *J Antibiot* 32(1): 1-12.
- Karthikeyan K, Thirunarayan MA, Krishnan P (2010) Coexistence of bla OXA-23 with bla NDM-1 and arm A in clinical isolates of *Acinetobacter baumannii* from India. *J Antimicrob Chemother* 65(10): 2253–2254.
- Kaul S, Brahmadathan KN, Jagannati M, Sudarsanam TD, Pitchamuthu K, Abraham OC, John G (2007) One year trends in the gram-negative bacterial antibiotic susceptibility patterns in a medical intensive care unit in South India. *Indian J Med Microbiol* 25(3): 230-235.
- Keating GM, Perry CM (2005) Ertapenem: a review of its use in the treatment of bacterial infections. *Drugs* 65(15): 2151-78.

- Khajuria A, Praharaj AK, Kumar M, Grover N (2013) Emergence of NDM-1 in the Clinical isolates of *Pseudomonas aeruginosa* in India. *J Clin Diagn Res* 7(7): 1328-31.
- Khajuria A, Praharaj AK, Kumar M, Grover N (2014) Molecular characterization of carbapenem resistant isolates of *Acinetobacter baumannii* in an intensive care unit of a tertiary care centre at central India. *J Clin Diagn Res* 8(5): 38-40.
- Khorvash F, Yazdani MR, Shabani SH, Alizadeh H (2015) Detection of *Pseudomonas aeruginosa* producing Metallo β -Lactamases (VIM, SME, AIM) in the Clinical Isolates of Intensive Care Units of Al-Zahra Hospital in Isfahan, Iran. *J Med Bacteriol* 4(3): 15-23.
- Kim MN, Yong D, An D, Chung HS, Woo JH, Lee K, Chong Y (2012) Nosocomial clustering of NDM-1-producing *Klebsiella pneumoniae* sequence type 340 strains in four patients at a South Korean tertiary care hospital. *J Clin Microbiol* 50(4): 1433–1436.
- Kitchel B, Rasheed JK, Patel JB, Srinivasan A, Navon-Venezia S, Carmeli Y, Brolund A, Giske CG (2009) Molecular epidemiology of KPC-producing *Klebsiella pneumoniae* isolates in the United States: clonal expansion of multilocus sequence type 258. *Antimicrob Agents Chemother* 53(8): 3365-70.
- Ko KS, Suh JY, Kwon KT, Jung SI, Park KH, Kang CI, Chung DR, Peck KR, Song JH.. (2007) High rates of resistance to colistin and Polymixin B in subgroups of *Acinetobacter baumannii* isolates from Korea. *J Antimicrob Chemother* 60(5): 1163-1167.
- Kobayashi N, Nishino K, Yamaguchi A (2001) Novel macrolide-specific ABC-type efflux transporter in *Escherichia coli*. *J Bacteriol* 183(19): 5639– 5644.
- Kobayashi R, Konomi M, Hasegawa K Morozumi M, Sunakawa K, Ubukata K (2005). In vitro activity of Tebipenem, a new oral carbapenem antibiotic against penicillin non susceptible *Streptococcus pneumoniae*. *Antimicrob Agent Chemother* 49(3): 889-894.
- Kock MM, Bellomo AN, Storm N, Ehlers MM (2013) Prevalence of carbapenem resistance genes in *Acinetobacter baumannii* isolated from clinical specimens obtained from an academic hospital in South Africa. *South Afr J Epidemiol Infect* 28(1): 28-32.

- Koga T, Sugihara C, Kakuta M, Masuda N, Namba E, Fukuoka T (2009) Affinity of tomopenem (CS-023) for penicillin-binding proteins in *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. *Antimicrob Agents Chemother* 53(3): 1238–1241.
- Kong KF, Jayawardena SR, Del Puerto A, Wiehlmann L, Laabs U, Tummler B, Mathee K (2005) Characterization of *poxB*, a chromosomal encoded *Pseudomonas aeruginosa* oxacillinase. *Gene* 358: 82–92.
- Kumar AV, Pillai VS, Dinesh KR, Karim S (2011) The Phenotypic Detection of Carbapenemase In Meropenem Resistant *Acinetobacter Calcoaceticus–Baumannii* Complex In A Tertiary Care Hospital In South India. *J Clin and Diag Res* 5(2): 223-226.
- Kumarasamy KK, Toleman MA, Walsh TR, Bagaria J, Butt F, Balakrishnan R, Chaudhary U, Doumith M, Giske CG, Irfan S, Krishnan P, Kumar AV, Maharjan S, Mushtaq S, Noorie T, Paterson DL, Pearson A, Perry C, Pike R, Rao B, Ray U, Sarma JB, Sharma M, Sheridan E, Thirunarayan MA, Turton J, Upadhyay S, Warner M, Welfare W, Livermore DM, Woodford N (2010) Emergence of a new antibiotic resistance mechanism in India, Pakistan, and the UK: a molecular, biological, and epidemiological study. *Lancet Infect Dis* 10(9): 597-602.
- Kus JV, Tadros M, Simor A, Low DE, McGeer AJ, Willey BM, Larocque C, Pike K, Edwards IA, Dedier H, Melano R, Boyd DA, Mulvey MR, Louie L, Okeahialam C, Bayley M, Whitehead C, Richardson D, Carr L, Jinnah F, Poutanen SM. (2011) New Delhi metallo- β -lactamase-1: local acquisition in Ontario, Canada, and challenges in detection. *CMAJ* 183(11): 1257–1261.
- Labuschagne J, Weldhagen GF, Ehlers MM, Dove MG (2008) Emergence of class 1 integron-associated GES-5 and GES-5-like extended-spectrum β -lactamases in clinical isolates of *Pseudomonas aeruginosa* in South Africa. *Int J Antimicrob Agents* 31(6): 527–530.
- Landman D, Bratu S, Kochar S, Panwar M, Trehan M, Doymaz M, Quale J (2007) Evolution of antimicrobial resistance among *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and *Klebsiella pneumoniae* in Brooklyn, NY. *J Antimicrob Chemother* 60(1): 78–82.
- Lascols C, Hackel M, Marshall SH, Hujer AM, Bouchillon S, Badal R, Hoban D, Bonomo RA (2011) Increasing prevalence and dissemination of NDM-1

- metallo- β -lactamase in India: data from the SMART study. *J Antimicrob Chemother* 66(9): 1992-1997.
- Lascols C, Hackel M, Marshall SH, Hujer AM, Bouchillon S, Badal R, Hoban D, Bonomo RA (2009) Increasing prevalence and dissemination of NDM-1 metallo- β -lactamase in India: data from the SMART study. *J Antimicrob Chemother* 66(9): 1992-1997.
 - Lauretti L, Riccio ML, Mazzariol A, Cornaglia G, Amicosante G, Fontana R, Rossolini GM (1999) Cloning and characterization of blaVIM A new integron-borne metallo- β -lactamase gene from Pseudomonas aeruginosa clinical isolate. *Antimicrob Agents Chemother* 43(7): 1584-1590.
 - Lee GC, Burgess DS (2012) Treatment of Klebsiella Pneumoniae Carbapenemase (KPC) infections: a review of published case series and case reports *Ann Clin Microbiol Antimicrob* 13: 11-32.
 - Lee K, Lim YS, Yong D, Yum JH, Chong Y (2003) Evaluation of the Hodge test and the imipenem-EDTA double-disk synergy test for differentiating metallo-beta-lactamase-producing isolates of Pseudomonas spp. and Acinetobacter spp. *J Clin Microbiol* 41(10): 4623-4629.
 - Lee K, Yum JH, Yong D, Lee HM, Kim HD, Docquier JD, Rossolini GM, Chong Y (2005) Novel acquired metallo- β -lactamase gene blaSIM-1, in a class 1 integron from Acinetobacter baumannii clinical isolates from Korea. *Antimicrob Agents Chemother* 49(11): 4485-4491.
 - Lennette EH, Balows A, Hausler WJ, Shadomy HJ (1985) Manual of Clinical Microbiology 4th Edn. American society for Microbiology, Washington.
 - Lesho E, Yoon EJ, McGann P, Snesrud E, Kwak Y, Milillo, Onmus-Leone F, Preston L, St. Clair K, Nikolich M, Viscount H, Wortmann G, Zapor M, Grillot-Courvalin C, Courvalin P, Clifford R, Waterman PE (2013) Emergence of colistin-resistance in extremely drug-resistant Acinetobacter baumannii containing a novel pmrCAB operon during colistin therapy of wound infections. *J Infect Dis* 208(7): 1142-51.
 - Levy SB (1992) Active efflux mechanisms for antimicrobial resistance. *Antimicrob Agents Chemother* 36(4): 695-703.

- Lin KY, Lauderdale TL, Wang JT, Chang SC (2016) Carbapenem resistant *Pseudomonas aeruginosa* in Taiwan: Prevalence, risk factors, and impact on outcome of infections. *J Microbiol Immunol Infect* 49(1): 52-59.
- Lindsay JA, Holden MT (2006) Understanding the rise of the superbug: investigation of the evolution and genomic variation of *Staphylococcus aureus*. *Funct Integr Genomics* 6(3): 186-201.
- Livermore D, Oakton K, Carter M, Warner M (2001) Activity of ertapenem versus enterobacteriaceae with potent β lactamases. *Antimicrob Agents Chemother* 45(10): 2831-2837.
- Livermore DM, Mushtaq S, Warner M, Zhang JC, Maharjan S, Doumith M, Woodford N (2011 a) Activity of aminoglycosides, including ACHN-490, against carbapenem-resistant Enterobacteriaceae isolates. *J Antimicrob Chemother* 66(1): 48-53.
- Livermore DM, Sefton AM, Scott GM (2003) Properties and potential of ertapenem. *J Antimicrob Chemother* 52(3): 331-344.
- Livermore DM, Walsh TR, Toleman M, Woodford N (2011 b) Balkan NDM-1: Escape or transplant? *Lancet Infect Dis* 11(3): 164.
- Livermore DM, Woodford N (2006) The β -lactamase threat in Enterobacteriaceae, *Pseudomonas* and *Acinetobacter*. *Trends Microbiol* 14(9): 413-420.
- Loli A, Tzouvelekis LS, Gianneli D, Tzelepi E, Miriagou V (2008) Outbreak of *Acinetobacter baumannii* with chromosomally encoded VIM-1 undetectable by imipenem-EDTA synergy tests. *Antimicrob Agents Chemother* 52(5): 1894-1896.
- Lubbert C, Fauchoux S, Becker-Rux, D, Laudi S, Dürrbeck A, Busch T, Gastmeier P, Eckmanns T, Rodloff AC (2013). Rapid emergence of secondary resistance to gentamicin and colistin following selective digestive decontamination in patients with KPC-2-producing *Klebsiella pneumoniae*: a single-centre experience. *Int J Antimicrob Agents* 42(6): 565-570.
- Malkocoglu G, Aktai E, Bayraktar B, Bulut ME. (2017). VIM-1, VIM-2 and GES-5 among *P. aeruginosa* isolate in a tertiary care centre in Istanbul, Turkey. *Microb Drug Resist* 23(3): 328-334.

- Mammeri H, Eb F, Berkani A, Nordmann P (2008) Molecular characterization of AmpC-producing *Escherichia coli* clinical isolates recovered in a French hospital. *J Antimicrob Chemother* 61(3): 498–503.
- Manikal VM, Landman D, Saurina G, Oydna E, Lal H, Quale J (2000) Endemic carbapenem-resistant *Acinetobacter* species in Brooklyn, New York: citywide prevalence, inter institutional spread, and relation to antibiotic usage. *Clin Infect Dis* 31(1): 101-106.
- Manoharan A, Chatterjee S, Mathai D (2010) Detection and characterisation of metallo beta lactamase producing *Pseudomonas aeruginosa*. *Indian J Med Microbiol* 28(3): 241-244.
- Marger MD, Saier MH, Jr (1993) A major superfamily of transmembrane facilitators that catalyse uniport, symport and antiport. *Trends Biochem Sci* 18(1): 13–20.
- Marque S, Poirel L, Heritier C, Brisse S, Blasco MD, Filip R, Naas T, Nordmann P. (2005) Regional occurrence of plasmid mediated carbapenem hydrolysing OXA-58 in *Acinetobacter* spp. in Europe *J Clin Microbiol* 43(9): 4885-4888
- Martinez-Martinez L (2008) Extended spectrum β -lactamases and the permeability barrier *Clin Microbiol Infect* 49(1): 50-53.
- Martins A, Amaral L (2012) Screening for efflux pump systems of bacteria by the new acridine orange agar method. *In Vivo* 26(2): 203–206.
- Martins A, Machado L, Costa S, Cerca P, Spengler G, Viveiros M, Amaral L (2011) Role of calcium in the efflux system of *Escherichia coli*. *Int J Antimicrob Agents* 37(5): 410–414.
- Martins A, Spengler G, Rodrigues L, Viveiros M, Ramos J, Martins M, Couto I, Fanning S, Pagès JM, Bolla JM, Molnar J, Amaral L (2009) pH Modulation of efflux pump activity of multi- drug resistant *Escherichia coli*: protection during its passage and eventual colonization of the colon. *PLoS one* 4(8): 66-56.
- Martins M, Couto I, Viveiros M, Amaral L (2010) Identification of efflux-mediated multi drug resistance in bacterial clinical isolates by two simple methods. *Methods Mol Biol* 642: 143–157.
- Martins M, Matthew P, Viveiros M, Isabel Coutoc, Séamus Fanninga, Jean-Marie Pagèsb, Leonard Amara (2013) A Simple Method for Assessment of MDR Bacteria for Over-Expressed Efflux Pumps. *Open Microbiol J* 7: 72-82.

- Mathers, AJ, Cox HL, Bonatti H, Kitchel B, Brassinga AK, Wispelwey B, Sawyer RG, Pruett TL, Hazen KC, Patel JB, Sifri CD (2009) Fatal cross infection by carbapenem resistant *Klebsiella* in two liver transplant recipients. *Transpl Infect Dis* 11(3): 257–265.
- Mathew M (1979). Plasmid mediated β lactamases of Gram negative bacteria; properties and distribution. *J Antimicrob Chemother* 5(4): 349-358.
- Matsumoto A, Hosoya M, Kawasaki Y, Katayose M, Kato K, Suzuki H (2007) The emergence of drug-resistant *Streptococcus pneumoniae* and host risk factors for carriage of drug-resistant genes in north eastern Japan. *Jpn J Infect Dis* 60(1): 10–13.
- Mavroid A, Tsakris A, Tzelepi E, Pournaras S, Loukova V, Tzouveleki LS (2000) Carbapenems-hydrolysing VIM-2 metallo- β - lactamase in *Pseudomonas aeruginosa* from Greece. *J Antimicrob Chemother* 46(6): 1037-1046.
- McKenna M (2013) Antibiotic resistance: The last resort. *Nature* 499(7459): 394–396
- Medeiros AA, Hare RS. 1986. β -Lactamase-mediated resistance to penems and carbapenems amongst Enterobacteriaceae, abstr. 116. 26th Intersci. Conf. Antimicrob. Agents Chemother. American Society for Microbiology, Washington, DC
- Medeiros AA (1984). Beta lactamses *Br Med Bull* 40(1): 18-27.
- Mehrad B, Clark NM, Zhanel GG, Lynch JP (2015) Antimicrobial Resistance in Hospital-Acquired Gram-Negative Bacterial Infections. *Chest* 147(5): 1413-1418.
- Meini MR, Llarrull LI, Vila AJ. (2014). Evolution of MBL : Trends revealed by natural diversity in vitro evolution. *Antibiotics* 3(3): 282-316.
- Miriagou G, Cornaglia M, Edelstein I, Galani CG, Giske M, Gniadkowski E, Malamou-Lada E, Martinez-Martinez L, Navarro F, Nordmann P, Peixe L, Pournaras S, Rossolini GM, Tsakris A, Vatopoulos A, Cantón R (2010) Acquired carbapenemases in Gram-negative bacterial pathogens: detection and surveillance issues. *Clin Microbiol Infect* 16(2): 112–122.
- Miriagou V, Tzouveleki LS, Rossiter S, Tzelepi E, Angulo FJ, Whichard JM (2003) Imipenem resistance in a *Salmonella* clinical strain due to plasmid-mediated class A carbapenemase KPC-2. *Antimicrob Agents Chemother* 47(4): 1297–1300.

- Moran Gilad J, Carmeli Y, Schwartz D, Navon-Venezia S (2011) Laboratory evaluation of the CHROMagar KPC medium for identification of carbapenem-nonsusceptible Enterobacteriaceae. *Diagn Microbiol Infect Dis* 70(4): 565–567.
- Morita Y, Kodama K, Shiota S, Mine T, Kataoka A, Mizushima T, Tsuchiya T (1998) NorM, a putative multidrug efflux protein, of *Vibrio parahaemolyticus* and its homolog in *Escherichia coli*. *Antimicrob Agents Chemother* 42(7): 1778 – 1782.
- Moussatova A, Kandt C, Mara ML, Tieleman DP (2008) ATP binding cassette transporters in *Escherichia coli*. *Biochim Biophys Acta* 1778(9): 1757–1771.
- Murphy MT, Simm AM, Toleman MA, Jones RN, Walsh RT (2003) Biochemical characterization of the acquired metallo- β -lactamase SPM-1 from *Pseudomonas aeruginosa*. *Antimicrob Agents Chemother* 47(2): 582-587.
- Nagaraj S, Chandran SP, Shamanna P, Macaden R (2012) Carbapenem resistance among *Escherichia coli* and *Klebsiella pneumoniae* in a tertiary care hospital in South India. *Indian J Med Microbiol* 30(1): 93–95.
- Nair PK, Vaz MS (2013) Prevalence of carbapenem resistant Enterobacteriaceae from a tertiary care hospital in Mumbai, India. *J Microbiol Infect Dis* 3(4): 207-210.
- National centre for biotechnology information- beta lactamases data resources. Available online <http://www.ncbi.nlm.nih.gov/pathogen/beta-lactamases-data/resources/> accessed 23 may 2016
- Navneeth B, Sridaran D, Sahay D, Belwadi MR (2002) A preliminary study on metallo beta lactamase producing *Pseudomonas aeruginosa* in hospitalized patients. *Indian J Med Res* 116: 264-267.
- Nikaido H (1998) Multiple antibiotic resistance and efflux. *Curr Opin Microbiol* 1(5): 516-523.
- Nordmann P, Poirel L (2008) *Acinetobacter baumannii*: basic and emerging mechanisms of resistance. *Eur J Clin Microbiol Infect Dis* 2(2):94-97.
- Nordmann P, Poirel L, Carrère A, Toleman MA, Walsh TR (2011 a) How to detect NDM-1 producers. *J Clin Microbiol* 41(10): 4623–4629.

- Nordmann P, Boulanger AE, Poirel L (2012) NDM-4 metallo- β -lactamase with increased carbapenemase activity from *Escherichia coli*. *Antimicrob Agents Chemother* 56(4): 2184–2186.
- Nordmann P, Cuzon G, Naas T (2009) The real threat of *Klebsiella pneumoniae* carbapenemase-producing bacteria. *Lancet Infect Dis* 9(4): 228–236.
- Nordmann P, Dortet L, Poirel L (2012 a) Carbapenem resistance in Enterobacteriaceae: here is the storm! *Trends Mol Med* 18(5): 263–272.
- Nordmann P, Girlich D, Poirel L (2012 b) Detection of carbapenemase producers in Enterobacteriaceae by use of a novel screening medium. *J Clin Microbiol* 50(8): 2761–2766
- Nordmann P, Gniadkowski M, Giske CG, Poirel L, Woodford N, Miriagou V (2012 c) Identification and screening of carbapenemase-producing Enterobacteriaceae. *Clin Microbiol Infect* 18(5): 432–438.
- Nordmann P, Mariotte S, Naas T, Labia R, Nicolas NH (1993) Biochemical properties of a carbapenem-hydrolyzing β -lactamase for *Enterobacter cloacae* and cloning of the gene into *Escherichia coli*. *Antimicrob Agents Chemother* 37(5): 939–946.
- Nordmann P, Naas T, Poirel L (2011 b) Global spread of Carbapenemase-producing Enterobacteriaceae. *Emerg Infect Dis* 17(10): 1791–1798.
- Nordmann P, Poirel L (2002) Emerging carbapenemases in Gram-negative aerobes. *Clin Microbiol Infect* 8(6): 321–331.
- Nordmann P, Poirel L (2013) Strategies for identification of carbapenemase-producing Enterobacteriaceae. *J Antimicrob Chemother* 68(3): 487–489.
- Nordmann P, Poirel L (2014) The difficult-to-control spread of carbapenemase producers among Enterobacteriaceae worldwide. *Clin Microbiol Infect* 20(9): 821–830.
- Nordmann P, Poirel L, Dortet L (2012 d) Rapid detection of carbapenemase-producing Enterobacteriaceae. *Emerg Infect Dis* 18(9): 1503–1507.
- Nordmann P, Poirel L, Walsh TR, Livermore DM (2011 c) The emerging NDM carbapenemases. *Trends Microbiol* 19(12): 588–595.
- Nordmann, P (2010) Gram-negative bacteriae with resistance to carbapenems. *Med/Sci* 26(11): 950–959.

- Nordmann, P, Picazo JJ, Mutters R, Korten V, Quintana A, Laeuffer JM, Seak JC, Flamm RK, Morrissey I (2011 d) Comparative activity of carbapenem testing: the COMPACT study. *J Antimicrob Chemother* 66(5): 1070–1078.
- Nordmann, P, Poirel L (2013) Strategies for identification of carbapenemase-producing Enterobacteriaceae. *J Antimicrob Chemother* 68(3): 487–489.
- Norrby SR (1995) Carbapenems. *Med Clin North Am* 79(4): 745-59.
- Novais A, Brilhante M, Pires J, Peixe L (2015) Evaluation of the recently launched Rapid Carb Blue kit for detection of carbapenemase-producing Gram negative bacteria. *J Clin Microbiol* 53(9): 3105–3107.
- Oteo J, Hernández JM, Espasa M, Fleites A, Sáez D, Bautista V (2013) Emergence of OXA-48-producing *Klebsiella pneumoniae* and the novel carbapenemases OXA-244 and OXA-245 in Spain. *J Antimicrob Chemother* 68(2): 317 –321.
- Padmalakshmi Y, Shanthi M, Uma Sekar, Arunagiri K, Pugazhenthien (2015) Phenotypic and Molecular Characterisation of Carbapenemases in *Acinetobacter* species in a Tertiary Care Centre in Tamil Nadu, India. *NJLM* 4(3): 55-60.
- Paixao L, Rodrigues L, Couto I, Martins M, Fernandes P, deCarvalho CC, Monteiro GA, Sansonetty F, Amaral L, Viveiros M (2009) Fluorometric determination of ethidium bromide efflux kinetics in *Escherichia coli*. *J Biol Eng* 3: 18.
- Pantel A, Souzy D, Sotto A, Lavigne JP (2015) Evaluation of two phenotypic screening tests for carbapenemase-producing Enterobacteriaceae *J Clin Microbiol* 53(10): 3359–3362.
- Pasteran F, Albornoz E, Faccone D, Gomez S, Valenzuela C, Morales M, Estrada P, Valenzuela L, Matheu J, Guerriero L, Arbizú E, Calderón Y, Ramon-Pardo P, Corso A (2012) Emergence of NDM-1-producing *Klebsiella pneumoniae* in Guatemala. *J Antimicrob Chemother* 67(7): 1795–1797.
- Pasteran F, Veliz O, Rapoport M, Guerriero L, Corso A (2011) Sensitive and specific modified Hodge test for KPC and metallo-beta-lactamase detection in *Pseudomonas aeruginosa* by use of a novel indicator strain, *Klebsiella pneumoniae* ATCC 700603. *J Clin Microbiol* 49(12): 4301-4303.
- Pasteran F, Mendez T, Guerriero L, Rapoport M, Corso A (2009) Sensitive screening tests for suspected class A carbapenemase production in species of Enterobacteriaceae. *J Clin Microbiol* 47(6): 1631–1639.

- Patel JB, Rasheed JK, Kitchel B (2009) Carbapenemases in Enterobacteriaceae: activity, epidemiology and laboratory detection. *Clin Microbiol Newsl* 31(8): 55–62.
- Paterson DL, Depestele DD (2009) Doripenem. *Clin Infect Dis* 49(2): 291-298.
- Paton R, Miles RS, Hood J, Amyes SGB (1993) ARI-1 β lactamses mediated imipenem resistance in *A.baumannii* *Int J Antimicrob Agents* 2(2): 81-87.
- Paulsen IT, Skurray RA (1993) Topology, structure and evolution of two families of proteins involved in antibiotic and antiseptic resistance in eukaryotes and prokaryotes—an analysis. *Gene* 124(1): 1–11.
- Peleg AY, Seifert H, Paterson DL (2008) *Acinetobacter baumannii*: Emergence of a successful pathogen. *Clin Microbiol Rev* 21(3): 538-82.
- Pfeifer Y, Wilharm G, Zander E, Wichelhaus TA, Göttig S, Hunfeld KP, Seifert H, Witte W, Higgins PG (2011) Molecular characterization of blaNDM-1 in an *Acinetobacter baumannii* strain isolated in Germany in 2007. *J Antimicrob Chemother* 66(9): 1998-2001.
- Piddock LJV (2006) Clinically relevant chromosomally encoded multidrug resistance efflux pumps in bacteria. *Clin Microbiol Rev* 19(2): 382–402.
- Pires J, Novais A, Peixe L (2013) Blue-Carba, an Easy Biochemical Test for Detection of Diverse Carbapenemase Producers Directly from Bacterial Cultures. *J Clin Microbiol* 51(12): 4281–4283.
- Poirel L, Al Maskari Z, Al Rashdi F, Bernabeu S, Nordmann P (2011) NDM-1-producing *Klebsiella pneumoniae* isolated in the Sultanate of Oman. *J Antimicrob Chemother* 66(2): 304-6.
- Poirel L, Heritier C, and Nordmann P (2004 a) Chromosome-encoded Ambler class D β -lactamase of *Shewanella oneidensis* as a progenitor of carbapenem-hydrolyzing oxacillinase. *Antimicrob Agents Chemother* 48(1): 348–351.
- Poirel L, Heritier C, Toluen V, Nordmann P (2004 b) Emergence of oxacillinase-mediated resistance to imipenem in *Klebsiella pneumoniae*. *Antimicrob Agents Chemother* 48(1): 15–22.
- Poirel L, Lagrutta E, Taylor P, Pham J, Nordmann P (2010) Emergence of metallo- β - lactamase NDM-1-producing multidrug-resistant *Escherichia coli* in Australia. *Antimicrob Agents Chemother* 54(11): 4914-4916.

- Poirel L, Magalhaes M, Lopes M, Nordmann P (2004 c) Molecular analysis of metallo- β lactamase gene blaPMS-1 surrounding sequences from disseminated *Pseudomonas aeruginosa* isolates in Recife, Brazil. *Antimicrob Agents Chemother* 48(4): 1406- 1409
- Poirel L, Marque S, Heritier C, Segonds C, Chabanon G, Nordmann P (2005) OXA-58, a novel class D β -lactamase involved in resistance to carbapenems in *Acinetobacter baumannii*. *Antimicrob Agents Chemother* 49(1): 202–208.
- Poirel L, Naas T, Nordmann P (2010) Diversity, epidemiology, and genetics of class D beta-lactamases. *Antimicrob Agents Chemother* 54(1): 24–38.
- Poirel L, Nordmann P (2006) Carbapenem resistance in *Acinetobacter baumannii*: mechanisms and epidemiology *Clin Microbiol Infect* 12(9): 826-36.
- Poirel L, Pitout JD, Nordmann P (2007) Carbapenemases: molecular diversity and clinical consequences. *Future Microbiol* 2(5): 501-512.
- Poirel L, Revathi G, Bernabeu S, Nordmann P (2011 a) Detection of NDM-1 producing *Klebsiella pneumoniae* in Kenya. *Antimicrob Agents Chemother* 55(2): 934– 936.
- Poirel L, Walsh TR, Cuvillier V Nordmann P (2011 b) Multiplex PCR for detection of acquired carbapenemase genes. *Diagn Microbiol Infect Dis* 70(1): 119–123.
- Poirel L, Weldhagen GF, Naas T, De Champs C, Dove MG, Nordmann P (2001) GES-2, a class A β -lactamase from *Pseudomonas aeruginosa* with increased hydrolysis of imipenem. *Antimicrob Agents Chemother* 45(9): 2598–603.
- Pollini S, Maradei S, Pecile P, Olivo G, Luzzaro F, Docquier JD, Rossolini GM (2013) FIM-1, a new acquired metallo- β -lactamase from a *Pseudomonas aeruginosa* clinical isolate from Italy. *Antimicrob Agents Chemother* 57(1): 410–6.
- Poole K (2004) Efflux-mediated multi resistance in Gram-negative bacteria. *Clin Microbiol Infect* 10(1): 12–26.
- Poole K (2007) Efflux pumps as antimicrobial resistance mechanisms. *Ann Med* 39(3): 162–176.
- Poole K, Krebes K, McNalla C, Neshat S (1993) Multiple antibiotic resistance in *P. aeruginosa*; evidence for involvement of an efflux operon *J Bacteriol* 175(22): 7365-7372.

- Potron A, Poirel L, Nordmann P (2015) Emerging broad-spectrum resistance in *Pseudomonas aeruginosa* and *Acinetobacter baumannii*: Mechanisms and epidemiology. *Int J Antimicrob Agent* 45(6): 568-585.
- Potron A, Poirel L, Rondinaud E, Nordmann P (2013) Intercontinental spread of OXA-48 beta-lactamase-producing Enterobacteriaceae over a 11-year period, 2001 to 2011. *Euro Surveill.*18(31): pii=20549.
- Pournaras, S, Poulou A, Tsakris A (2010) Inhibitor-based methods for the detection of KPC carbapenemase-producing Enterobacteriaceae in clinical practice by using boronic acid compounds. *J Antimicrob Chemother* 65(7): 1319–1321.
- Pragasam AK, Vijayakumar S, Bakthavatchalam YD, Kapil A, Das BK, Ray P, Gautam V, Sistla S, Parija SC, Walia K, Ohri VC, Anandan S, Veeraraghavan B (2016) Molecular characterisation of antimicrobial resistance in *Pseudomonas aeruginosa* and *Acinetobacter baumannii* during 2014 and 2015 collected across India. *Indian J Med Microbiol* 34(4): 433-441.
- Purohit M, Mendiratta DK, Deotale VS, Madhan M, Manoharan A, Narang P (2012) Detection of metallo β lactamases producing *Acinetobacter baumannii* using microbiological assay, disc synergy and PCR. *J Med Micro* 30(4): 456-461.
- Qi J, Du Y, Zhu X, Bai H, Luo Y, Liu Y (2012) A loop-mediated isothermal amplification method for rapid detection of NDM-1 gene. *Microb Drug Resist* 18(4): 359–363.
- Queenan AM, Bush K (2007) Carbapenemases: the versatile beta-lactamases *Clin Microbiol Rev* 20(3): 440-58.
- Rachakonda S, Cartee L (2004) Challenges in antimicrobial drug discovery and the potential of nucleoside antibiotics. *Curr Med Chem* 11(6): 775-793.
- Radice M, Power P, Gutkind G, Fernandez K, Vay C, Famiglietti N, Ricover N, Ayala JA. (2004) First class A carbapenemase isolated from Enterobacteriaceae in Argentina. *Antimicrob Agents Chemother* 48(3): 1068–1069.
- Rajabnia R, Asgharpour F, Moulana Z (2015) Imipenem-resistant *Pseudomonas Aeruginosa* Strains Carrying VIM-TYPE metallo-beta-lactamases Isolated from Intensive Care Unit, Shahid Beheshti Hospital, North of Iran. *Res Mol Med* 3(1): 26-31

- Ramirez SM, Tolmasky ME (2010) Aminoglycoside modifying enzymes Drug Resist update 13(6): 151-171.
- Rao A, Indumathi VA (2016) Detection of Carbapenem Resistant Enterobacteriaceae from Clinical Isolates. *Int J Curr Microbiol App Sci* 5(5): 864-869.
- Rao LV, Ramu G, Kumar SM, Rambabu C (2012) Reverse Phase HPLC and Visible Spectrophotometric Methods for the Determination of Meropenem in Pure and Pharmaceutical Dosage Form. *Int J PharmTech Res* 4(3): 957-962.
- Rasheed JK, Biddle JW, Anderson KF, Washer L, Chenoweth C, Perrin J, Newton DW, Patel JB. (2008). Detection of KPC in clinical isolate of *Citrobacter freundii* and *Klebsiella oxytoca* carrying a common plasmid. *J Clin Microbiol* 46(6): 2066-2069.
- Rasmussen BA, Bush K (1997) Carbapenem-hydrolyzing beta-lactamases. *Antimicrob Agents Chemother* 41(2): 223-232.
- Rasmussen JW, Hoiby N (2007) Class A carbapenemases. *J Antimicrob Chemother* 60(3): 470–482.
- Ratkai C, Quinteira S, Grosso F, Monteiro N, Nagy E, Peixe L (2009) Controlling for false positives: interpreting MBL Etest and MBL combined disc test for the detection of metallo-beta-lactamases. *J Antimicrob Chemother* 64(3): 657–658.
- Ribeiro VB, Linhares AR, Zavascki AP, Barth AL (2014) Performance of Quantification of Modified Hodge Test : An Evaluation with *Klebsiella pneumoniae* Carbapenemase Producing Enterobacteriaceae Isolates. *Biomed Res Int* 1-6.
- Riccio ML, Franceschini N, Boschi L, Caravelli B, Cornaglia G, Fontana R, Amicosante G, Rossolini GM (2000) Characterization of the metallo- β -lactamase determinant of *Acinetobacter baumannii* AC-54/97 Reveals the existence of blaIMP allelic variants carried by gene cassettes of different phylogeny. *Antimicrob Agents Chemother* 44(5): 1229-1235.
- Rimrang B, Chanawong A, Lulitanond A, Wilailuckana C, Charoensri N, Sribenjalux P, Phumsrikaew W, Wonglakorn L, Kerdsin A, Chetchotisakd P (2012) Emergence of NDM-1 and IMP-14a-producing Enterobacteriaceae in Thailand. *J Antimicrob Chemother* 67(11): 2626–2630.

- Rizek C, Fu L, Cavalcanti L, Santos D, Leite G, Ramos J, Rossi F, Thais Guimaraes T, Levin AS, Figueiredo Costa S (2014) Characterization of carbapenem-resistant *Pseudomonas aeruginosa* clinical isolates, carrying multiple genes coding for this antibiotic resistance. *Ann Clin Microbiol Antimicrob* 13(43): 1-5.
- Robledo IE, Aquino EE, Santé MI, Santana JL, Otero DM, León CF, Vázquez GJ (2010) Detection of KPC in *Acinetobacter* spp. in Puerto Rico. *Antimicrob Agents Chemother* 54(3): 1354-1357.
- Rodloff AC, Goldstein EJ, Torres A (2006) Two decades of imipenem therapy. *J Antimicrob Chemother* 58(5): 916-929.
- Rodriguez-Martinez JM, Poirel L, Nordmann P (2009) Molecular epidemiology and mechanisms of carbapenem resistance in *Pseudomonas aeruginosa*. *Antimicrob Agents Chemother* 53(11): 4783–4788.
- Rolinson GN (1991) Evolution of β -lactamase inhibitors. *Rev Infect Dis* 13(9): S727–S732.
- Saini M, Mishra A, Gupta S (2016) Prevalence of Carbapenem Resistance in Gram Negative Bacilli Isolates and Their Antimicrobial Susceptibility Pattern *Int J Med Res Prof* 2(3): 28-32.
- Salabi AE, Walsh TR, Chouchani C (2012). Extended spectrum β lactamases, carbapenemases and mobile genetic elements responsible for antibiotic resistance in Gram-negative bacteria. *Crit Rev Microbiol* 39(2): 133-122.
- Sampaio J, Ribeiro V, Campos JC, Rozales F, Maganin C, Falci D, Renato Cassol F. da Silva, Micheline G. Dalarosa, Daniela I. Luz,^c Fabiane J. Vieira, Laura C. Antochévis,^c Afonso Luis Barth, Alexandre P. Zavascki (2014) Detection of OXA-370, an OXA-48-Related Class D β -Lactamase, in *Enterobacter hormaechei* from Brazil. *Antimicrob Agents Chemother* 58(6): 3566–3567.
- Sarkar P, Gould IM (2006) Antimicrobial agents are societal drugs: how should this influence prescribing? *Drugs* 66(7): 893-901.
- Saxena S, Banerjee G, Garg R, Singh M, Verma SK, Kushwaha RAS. Sinha M, Srinivasa H (2015) Concomitant Detection of Biofilm Formation and MBL Production in Meropenem Resistant Isolates of *Pseudomonas aeruginosa* *BMRJ* 10(4): 1-6.

- Scaife W, Young HK, Paton RH, Amyes SGB (1995) Transferable imipenem resistance in *Acinetobacter* spp. from a clinical source. *J Antimicrob Chemother* 36(3): 585-586.
- Schneider I, Queenan AM, Bauernfeind A (2006) Novel carbapenem- hydrolyzing oxacillinase OXA-62 from *Pandoraea pnomenus*. *Antimicrob Agents Chemother* 50(4): 1330–1335.
- Seeger MA, Diederichs K, Eicher T, Brandstätter L, Schiefner A, Verrey F, Pos KM (2008) The AcrB efflux pump: conformational cycling and peristalsis lead to multidrug resistance. *Curr Drug Targets* 9(9): 729–749.
- Seema K, Ranjan Sen M, Upadhyay S, Bhattacharjee A (2011) Dissemination of the New Delhi metallo- β -lactamase-1 (NDM-1) among Enterobacteriaceae in a tertiary referral hospital in north India. *J Antimicrob Chemother* 66(7): 1646–1647.
- Segal H, Elisha B (2005) Use of Etest MBL strips for the detection of carbapenemases in *Acinetobacter baumannii*. *J Antimicrob Chemother* 56(3): 598.
- Sekyere J, Govinden U, Essack SJ (2015) Review of established and innovative detection methods for carbapenemase producing Gram negative bacteria *J Appl Microbiol* 119(5): 1219-1233.
- Shahid M, Umesh, Sobia F, Singh A, Khan HM, Malik A, Shukla I (2012) Molecular epidemiology of carbapenem resistant Enterobacteriaceae from a North Indian tertiary hospital. *N Z J Med Lab Sci* 66(66): 5-7.
- Shanti M (2014) Characterization of Carbapenemases in Gram-negative bacteria. PhD thesis. Sri Ramchandra University.
- Sharma A, Bakthavatchalam YD, Gopi R, Anandan S, Verghese VP, Veeraraghavan B. (2016) Mechanisms of Carbapenem Resistance in *K. pneumoniae* and *E. coli* from Bloodstream Infections in India. *J Infect Dis Ther* 4(4): 1-5.
- Shashikala, Kanungo R, Srinivasan S, Devi S (2006) Emerging resistance to carbapenems in hospital acquired *Pseudomonas* infection: A cause for concern. *Indian J Pharmacol* 38(4): 287-288.
- Shibl A, Agamy MA, Memish Z, Senok A, Khader SA, Assiri A (2013) The emergence of OXA-48 and NDM-1-positive *Klebsiella pneumoniae* in Riyadh, Saudi Arabia. *Int J Infect Dis* 17(12): 1130-1133.

- Shivaprasad A, Antony B, Shenoy P (2014) MBL and Carbapenemase Production in *A. baumannii*. *J Clin Diag Res*. 8(5): 5-8.
- Silhavy TJ, Kahne D, Walker S (2010) The bacterial cell envelope. *Cold Spring Harb Perspect Biol* 2(5): 1-13.
- Simpson IN, Harper PB, Callagnan CH (1980). Principle of beta-lactamses responsible to bet a lactam antibiotics in Urinary tract infection *Antimicrob Agents Chemother* 17(6):929-936.
- Singh SP, Shariff M, Barua T, Thukral SS (2009) Comparative evaluation of phenotypic tests for identification of metallo- β -lactamases producing clinical isolates of *Pseudomonas aeruginosa*. *Indian J Med Res* 129(6): 713-715.
- Sinha M, Srinivasa H (2007) Mechanisms of resistance to carbapenems in meropenem- resistant *Acinetobacter* isolates from clinical samples. *Indian J Med Microbiol* 25(2): 121-125.
- Song W, Kim HS, Kim JS, Kim HS, Shin DH, Shin S, Park MJ (2016) Carbapenem Inactivation Method: Accurate Detection and Easy Interpretation of Carbapenemase Production in Enterobacteriaceae and *Pseudomonas* spp. *Ann Clin Microbiol* 19(4): 83-87.
- Srinivasan VB, Rajamohan G, Gebreyes WA (2009) Role of AbeS, a novel efflux pump of the SMR family of transporters, in resistance to antimicrobial agents in *Acinetobacter baumannii*. *Antimicrob Agents Chemother* 53(12): 5312–5316.
- Stratton CW. 2005. Molecular mechanisms of action for antimicrobial agents: general principles and mechanisms for selected classes of antibiotics. In: Lorian V, ed, *Antibiotics in laboratory medicine*. 5th ed. Philadelphia: Lippincott Williams and Wilkins, 532-563
- Struelens MJ, Monnet DL, Magiorakos AP, O'Connor FS, Giesecke J (2010) European NDM-1 survey participants. New Delhi metallo-beta-lactamase 1 producing Enterobacteriaceae: emergence and response in Europe. *Euro Surveill* 15(46): pii-19716
- Stuart JC, Leverstein-Van Hall M (2010) Guideline for phenotypic screening and confirmation of carbapenemases in Enterobacteriaceae. *Int J Antimicrob Ag* 36(3): 205–210.
- Su H, Wang JT, Hsiung CT, Chien LJ, Chi CL, Yu HT, Chang FY, Chang SC. (2012) Increase of Carbapenem-Resistant *Acinetobacter baumannii* Infection in

Acute Care Hospitals in Taiwan: Association with Hospital Antimicrobial Usage. *PLoS ONE* 7(5): e37788.

- Sultan BA, Khan E, Hussian F, Nasir A, Irfan S. (2013) Effectiveness of modified hodge test to detect NDM-1 Carbapenemase; an experience from Pakistan. *J Pak Med Assoc* 63(8): 955-60
- Suresh M, Nithya N, Jayashree PR, Kumar M (2016) Detection and prevalence of efflux pump-mediated drug resistance in clinical isolates of multidrug resistant gram negative bacteria from North Kerala India. *Asian J Pharm Clin Res* 9(3): 324-327.
- Sykes RB, Matthews M (1976) The β -lactamases of Gram-negative bacteria and their role in resistance to β -lactam antibiotics. *J Antimicrob Chemother* 2(2): 115–157.
- Talbot GH, Bradley J, Edwards JE Jr, Gilbert D, Scheld M, Bartlett JG (2006) Bad bugs need drugs: an update on the development pipeline from the antimicrobial availability task force of the Infectious Diseases Society of America. *Clin Infect Dis* 42(5): 657-668.
- Taneja N, Aharwal SM, Sharma M (2003) Imipenem resistance in non-fermenters causing nosocomial urinary tract infections. *Indian J Med Sci* 57(7): 294-299.
- Taneja N, Singh G, Singh M, Sharma M (2011) Emergence of Tigecycline & Colistin resistant *Acinetobacter baumannii* in patients with complicated UTI in North India. *Indian J Med Res* 133: 681-684.
- Taylor PL (2011). Combating intrinsic resistance in Gram-negative bacteria. PhD thesis. McMaster University.
- Tenover FC (2006) Mechanisms of antimicrobial resistance in bacteria. *Am J Infect Control* 34(5): S3-10.
- Thomson KS (2010) Extended-spectrum-beta-lactamase, AmpC, and Carbapenemase issues. *J Clin Microbiol* 48(4): 1019–1025.
- Tibbetts R, Frye JG, Marschall J, Warren D, Dunne W (2008) Detection of KPC-2 in a Clinical Isolate of *Proteus mirabilis* and First Reported Description of Carbapenemase Resistance Caused by a KPC beta-Lactamase in *P. mirabilis*. *J Clin Microbiol* 46(9): 3080–3083.
- Toleman MA, Simm AM, Murphy TA, Gales AC, Biedenbach DJ, Jones RN, Walsh TR (2002) Molecular characterization of SPM-1, a novel metallo- β -

lactamase isolated in Latin America: report from the SENTRY antimicrobial surveillance programme. *J Antimicrob Chemother* 50(5): 673–679.

- Toleman MA, Vinodh H, Sekar U, Kamat V, Walsh TR (2007) blaVIM-2 harbouring integrons isolated in India, Russia, and the United States arise from an ancestral class I integrin predating the formation of the 3' conserved sequence. *Antimicrob Agents Chemother* 51: 2636-2638.
- Toma A, Deyno S (2015) Overview of mechanism of antibacterial resistance. *Int J Pharm Biol Sci* 2(1): 27-36.
- Tsakris A, Ikonomidis A, Pournaras S (2006) VIM-1 Metallo- β -lactamase in *Acinetobacter baumannii* *Emerg Infect Dis* 12(6): 981-983.
- Tsakris A, Kristo I, Poulou A, Markou F, Ikonomidis A, Pournaras S (2008) First occurrence of KPC-2-possessing *Klebsiella pneumoniae* in a Greek hospital and recommendation for detection with boronic acid disc tests. *J Antimicrob Chemother* 62(6): 1257–1260.
- Tsakris A, Kristo I, Poulou A, Ikonomidis A, Dimitra, Petropoulou D, Pournaras S, Sofianou D (2009) Evaluation of boronic acid disk tests for differentiating KPC-possessing *Klebsiella pneumoniae* isolates in the clinical laboratory. *J Clin Microbiol* 47(2): 362–367.
- Turton JF, Woodford N, Glover J, Yarde S, Kaufmann ME, Pitt TL (2006) Identification of *Acinetobacter baumannii* by detection of the blaOXA-51-like carbapenemase gene intrinsic to this species. *J Clin Microbiol* 44(8): 2974–2976.
- Tzouveleki LS, Markogiannakis A, Psychogiou M, Tassios PT, Daikos GL (2012) Carbapenemases in *Klebsiella pneumoniae* and other Enterobacteriaceae: an Evolving Crisis of Global Dimensions. *Clin Microbiol Rev* 25(4): 682–707.
- Upadhyay S, Sen MR, Bhattacharjee A (2012) Identification and Characterization of Carbapenem Hydrolysing β -lactamase KPC among Enterobacteriaceae: A report from North India. *Asian J Med Sci* 3(2): 11-15.
- Upadhyay S, Sen MR, Bhattacharjee A, Prakash P, Bajpai RC, Anupurba S (2011) Diagnostic utility of combination of inducer and inhibitor based assay in detection of *Pseudomonas aeruginosa* producing AmpC beta-lactamase. *J Microbiol Methods* 87(1): 116–118.
- Urban C, Bradford PA, Tucknam M, Maurer SS, Grenner L, Urban RC, Mariano N, Rahal JJ. (2008). Carbapenem resistant *Escherichia coli* harbouring KPC β -