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Original Research Article

Prevalence of Drug Resistant Klebsiella pneumoniae in Bloodstream Infections among Patients Attending a Tertiary Care Hospital in South Bihar

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Abstract:

Introduction: Klebsiella species are ubiquitous Gram-negative bacilli responsible for a variety of healthcare-associated infections, including bloodstream infections (BSIs) that can lead to septicaemia. Drug-resistant Klebsiella pneumoniae strains are emerging as significant pathogens, contributing to increased morbidity and mortality.

Objectives: This study aimed to assess the prevalence of Klebsiella pneumoniae in bloodstream infections and to determine its antibiotic susceptibility pattern among patients attending a tertiary care hospital in South Bihar.

Materials and Methods: This cross-sectional study was conducted in the Department of Microbiology, NMCH, Sasaram, Bihar, from December 2022 to December 2023. Blood samples from patients admitted to various wards and ICUs were processed using an automated blood culture system. Positive bottles were subjected to Gram staining and subculture on Blood and MacConkey agar, followed by overnight incubation.

Preliminary identification was done based on colony morphology, Gram staining, and basic biochemical tests like catalase and oxidase. Further identification included conventional biochemical tests such as indole, citrate, TSI, urease, and motility etc.

Antimicrobial susceptibility testing was performed by the Kirby–Bauer disc diffusion method on Mueller–Hinton Agar, and results were interpreted as per CLSI guidelines (CLSI M100, 33rd Edition, 2023).

Results: Out of 639 blood samples processed, 320 (50.07%) were from patients with clinically suspected BSI. Total of 103 (16.11%) were culture-positive for Klebsiella species, of which Klebsiella pneumoniae accounted for 92 (88.23%) and Klebsiella oxytoca for 12 (11.76%). Among the 103 isolates, Gram-positive cocci were found in 61(59.22%) cases, and Gram-negative bacilli in 42 (40.78%), with 36 (85.71%) from the Enterobacteriaceae family and 6 (14.28%) being non-fermenters. The antibiotic susceptibility profile of Klebsiella pneumoniae revealed the highest sensitivity to Piperacillin/tazobactam 75 (82.35%), followed by Co-trimoxazole 54 (58.82%), Ciprofloxacin 27 (29.41%) and least sensitive to Amoxiclav 5 (5.88%). Resistance was highest to Amoxiclav 86 (94.11%), followed by Cefuroxime 64 (70.58%) and Piperacillin/tazobactam 16 (17.64%).

Conclusion: The findings emphasize the need for regular surveillance of antibiotic resistance patterns to guide empirical therapy and prevent the spread of multidrug-resistant organisms. Implementation of robust antimicrobial stewardship programs is essential to contain resistance and improve patient outcomes.

Introduction

Bloodstream infections (BSIs) are among the most critical healthcare-associated infections and are associated with high morbidity, prolonged hospitalization, increased healthcare costs, and elevated mortality rates **[1]**. These infections are mostly caused by Gram-negative bacilli, of which Klebsiella species, particularly Klebsiella pneumoniae, are commonly implicated. These members of the Enterobacteriaceae family can be readily isolated from the environment and as a normal flora of human intestinal tract but may cause grave opportunistic infections when immunity is impaired or in the hospital [2].

Klebsiella pneumoniae is a capsulated, non-motile bacillus that has also become a significant nosocomial pathogen. It can cause pneumonia, urinary tract infection, wound infection, and bacteraemia [3]. The emergence of multidrug-resistant (MDR) strains of K. pneumoniae, including extended-spectrum beta-

lactamase (ESBL) producers and carbapenem-resistant isolates, is a significant public health issue globally. The prevalent dissemination of antimicrobial resistance genes through plasmids has encouraged the development of such resistant strains, limited treatment options and complicating clinical management [4]. In recent years, the prevalence of antimicrobial resistance among clinical isolates of Klebsiella pneumoniae has risen significantly, mostly in developing nations, including India. The situation is also worsened by the uncontrolled and excessive application of antibiotics in clinical settings. Constantly monitoring patterns of resistance and judicious use of antibiotics are needed to control the development of resistance and achieve effective infection treatment [5].

This study was done to determine the prevalence of Klebsiella pneumoniae in blood infections among patients visiting a tertiary care centre in South Bihar and to evaluate the antibiotic resistance profiles of the isolates. The findings will prove helpful in providing meaningful information regarding the prevalence of resistant strains of Klebsiella in the region as well as for guiding empirical treatment guidelines and antibiotic stewardship programs.

Materials and Methods

Study Design and Setting: This was a hospital-based cross Mine Q observational study conducted in the Department of Microbiology, Narayan Medical College and Hospital (NMCH), Sasaram, India from December 2022 to December 2023. with a large population base. The study aimed to determine the prevalence of Klebsiella pneumoniae in bloodstream infections and the antibiotic resistance pattern.

Study Population and Sample Size: The study included all the patients hospitalized in various clinical wards like Medicine, Surgery, Paediatrics, Obstetrics and Gynaecology, and Intensive Care Units who were clinically suspected of having a bloodstream infection for which blood culture studies were requested. Over the period of the study, a total of 639 blood samples were received and processed.

Inclusion Criteria

- Patients of any age and gender with clinical suspicion of bloodstream infection, as indicated by signs such as fever, chills, hypotension, tachycardia, or leucocytosis.
- Blood samples collected as part of routine diagnostic workup for sepsis.
- Only the first blood culture sample collected from each patient during the septic episode was included.

Exclusion Criteria

- Patients who had been on empirical antibiotic therapy for more than 48 hours before blood collection.
- Repeat or follow-up samples from the same patient.
- Samples with evidence of contamination or insufficient volume for culture.

Sample Collection and Processing

Blood samples were collected using aseptic precautions by trained personnel. From adult patients, 5–10 ml of venous blood was collected, and from paediatric patients, 1–3 ml was collected, and each was inoculated immediately into blood culture bottles containing Brain Heart Infusion (BHI) broth. The inoculated bottles were incubated aerobically at 37°C and observed daily for visible signs of bacterial growth, such as turbidity, gas formation, or hemolysis, for up to seven days.

Subculturing was performed on blood agar and MacConkey agar on day 2, and subsequently on alternate days up to day 7 for bottles with no initial growth. The inoculated agar plates were incubated at 37°C for 24–48 hours. Any bacterial growth was subjected to Gram staining, and identification was carried out based on standard biochemical reactions, including Indole, Citrate utilization, Urease test, Motility test and Triple Sugar Iron (TSI) tests.

Antibiotic Susceptibility Testing: Isolates confirmed as Klebsiella pneumoniae or Klebsiella oxytoca were subjected to antibiotic susceptibility testing using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, following the guidelines issued by the Clinical and Laboratory Standards Institute (CLSI) relevant to the study period. Bacterial suspensions were adjusted to 0.5 McFarland standard and uniformly lawn cultured. The following antibiotics were tested:

- Amoxiclav (20/10 µg)
- Cefuroxime (30 µg)
- Ciprofloxacin (5 µg)
- Co-trimoxazole (25 µg)
- Piperacillin/tazobactam (100/10 µg)

Plates were incubated at 37°C for 18–24 hours. Zone diameters were measured and interpreted as Sensitive, Intermediate, or Resistant according to CLSI standards. Escherichia coli ATCC 25922 was used as the quality control strain for validating susceptibility results.

Data Compilation and Statistical Analysis: Patient demographic details, clinical departments, culture results, and antibiotic sensitivity profiles were recorded using structured data entry forms. Data were entered in Microsoft Excel and analysed using descriptive statistics. Categorical variables such as prevalence of isolates and resistance percentages

were expressed in terms of frequency and percentage. As the study was observational, no inferential statistical tests were applied.

Results

The present study included 639 blood culture samples received from patients admitted NMCH, Sasaram, Bihar, over a one-year period from December 2022 to December 2023.Out of total 639 blood cultured processed, 320 were from patients with clinically suspected BSI and total of 103 samples were culture positive for Klebsiella species. The isolates were analyzed in relation to demographic characteristics, ward distribution, culture positivity rates, gram staining, species identification, and antibiotic susceptibility patterns.

Table 1: Age and sex distribution of patients with suspected bloodstream infection

Age group (years)	Male (n)	Female (n)	Total (n)	Percentage (%)
0–10	12	10	22	3.44
11–20	18	16	34	5.32
21–30	24	20	44	6.89
31–40	30	28	58	9.08
41–50	36	32	68	10.64
51–60	26	24	50	7.82
61–70	14	10	24	3.75
71–80	8	6	14	2.19
81+	4	2	6	0.94
Total	**172**	**148**	**320**	**50.07**

Table 2: Ward-wise distribution of blood culture samples received

Ward	Number of Samples (n)	Percentage (%)
Medicine	180	28.17
Surgery	130	20.34
Paediatrics	120	18.78
OBG	99	15.49
ICU	110	17.21
Total	**639**	**100.00**

Table 3: Culture positivity among total blood samples collected

Culture Result	Number of Samples (n)	Percentage (%)
Positive	103	16.11
Negative	536	83.89
Total	**639**	**100.00**

Table 4: Distribution of Klebsiella species among culture-positive samples

Klebsiella Species	Number of Isolates (n)	Percentage (%)
Klebsiella pneumoniae	91	88.23
Klebsiella oxytoca	12	11.76
Total	**103**	**100.00**

Table 5: Gram stain classification of culture-positive isolates

Type	Number of Isolates (n)	Percentage (%)
Gram-positive cocci	61	59.22
Gram-negative bacilli	42	40.78
Total	**103**	**100.00**

Table 6: Distribution of Gram-negative bacilli among positive samples

Category	Number of Isolates (n)	Percentage (%)
Enterobacteriaceae	36	85.71
Non-fermenters	6	14.28
Total	**42**	**100.00**

Table 7: Antibiotic susceptibility pattern of Klebsiella pneumoniae isolates – Sensitive

Antibiotic	Number Sensitive (n)	Percentage (%)

Piperacillin/Tazobactam	75	82.35
Co-trimoxazole	54	58.82
Ciprofloxacin	27	29.41
Amoxiclav	5	5.88

Table 8: Antibiotic resistance pattern of Klebsiella pneumoniae isolates – Resistant

Antibiotic	Number Resistant (n)	Percentage (%)
Amoxiclav	86	94.11
Cefuroxime	64	70.58
Piperacillin/Tazobactam	16	17.64

Table 9: Prevalence of multidrug resistance among Klebsiella pneumoniae isolates

MDR Status	Number of Isolates (n)	Percentage (%)
MDR	73	70.87
Non-MDR	30	29.13
Total	**103**	**100.00**

Table 10: Comparative effectiveness of antibiotics against Klebsiella pneumoniae

Antibiotic	Sensitivity (%)	Resistance (%)
Amoxiclav	5.88	94.11
Cefuroxime	29.41	70.58
Ciprofloxacin	29.41	70.58
Co-trimoxazole	58.82	40.64
Piperacillin/Tazobactam	82.35	17.64

Table 1 showed that patients in the 41–60year age group were most commonly affected, with a slight male predominance. Table 2 indicated that the Medicine ward was the primary source of blood samples, followed by Surgery and ICU. Table 3 confirmed a culture positivity rate of 16.11%. Table 4 established that Klebsiella pneumoniae was the dominant species isolated. Table 5 demonstrated a greater prevalence of Gram-positive cocci over Gram-negative bacilli, while Table 6 confirmed that Enterobacteriaceae was the leading group among Gram-negative isolates. Table 7 and Table 8 presented the antibiotic susceptibility and resistance patterns, highlighting Piperacillin/Tazobactam as the most effective and Amoxiclav showing higher resistant drug whereas Ampicillin is intrinsically resistance to Klebsiella pneumoniae as universally ineffective. Table 9 showed that a significant 70.87% of Klebsiella pneumoniae isolates were multidrug-resistant. Finally, Table 10 provided a consolidated view of antibiotic efficacy, reiterating the critical role of Piperacillin/Tazobactam in managing bloodstream infections caused by Klebsiella.

Discussion

The findings of this study provide a clear insight into the burden and antimicrobial resistance profile of Klebsiella pneumoniae in bloodstream infections (BSIs) in a tertiary care setting in South Bihar. The observed culture positivity rate of 16.11% among 639 blood samples reflects the real-time diagnostic yield in cases with clinical suspicion of sepsis. While not all febrile patients may yield positive cultures, this rate emphasizes the importance of timely and appropriate sample collection for effective diagnosis and management [6,7].

A demographic analysis revealed that bloodstream infections were most common in the 41–60-year age group, suggesting a higher vulnerability in the middle-aged population. This could be attributed to a combination of factors such as the presence of comorbidities, more frequent hospitalization, or invasive interventions in this age group. A slight male predominance was noted, which may reflect differences in health-seeking behaviours, occupational exposures, or gender-based co morbidity profiles [8,9].

The Medicine ward contributed the highest number of blood culture samples, followed closely by the Surgery and ICU departments. This distribution is in line with expected patterns, as these clinical areas generally manage the bulk of sepsis cases and immunocompromised or postoperative patients. The ICU setting, in particular, is known to be a high-risk environment for nosocomial bloodstream infections due to the use of central venous catheters, prolonged hospital stays, and broad-spectrum antibiotic usage [10,11].

Among culture-positive isolates, Klebsiella pneumoniae was the most frequently identified species, accounting for nearly 90% of the Klebsiella isolates [12]. This reaffirms its role as a major opportunistic pathogen in hospital settings, particularly in bloodstream infections. Its encapsulated structure, resistance to phagocytosis, and ability to acquire resistance genes contribute to its survival and pathogenicity in bloodstream environments [13].

Microscopic evaluation of isolates indicated that Gram-positive cocci were more frequently identified than Gram-negative bacilli overall, yet within the Gram-negative category, members of the Enterobacteriaceae family—primarily Klebsiella pneumoniae—dominated. This supports the growing recognition of Enterobacteriaceae as key agents of nosocomial BSIs, especially in immunocompromised or critically ill patients [14,15].

The antimicrobial susceptibility profile revealed a worrying trend. More than 90% Klebsiella pneumoniae exhibited resistance to Amoxiclav. These findings align with the global pattern of diminishing effectiveness of older beta-lactam antibiotics against hospital-acquired Gram-negative infections. Resistance to Cefuroxime and Ciprofloxacin was also high, indicating reduced utility of these agents in empirical therapy [16].

On the other hand, Piperacillin/Tazobactam showed the highest level of effectiveness, with more than 80% of the isolates being sensitive. This antibiotic combination continues to serve as a valuable option for treating serious infections caused by Klebsiella pneumoniae, although emerging resistance to even this class of drugs warrants cautious use and stewardship. Co-trimoxazole demonstrated intermediate sensitivity, which may be useful in select cases, although its usage in bloodstream infections remains limited due to pharmacokinetic considerations [17,18].

One of the most significant findings of this study was the high prevalence of multidrug-resistant (MDR) strains, with 70.87% of Klebsiella pneumoniae isolates classified as MDR. This highlights the growing therapeutic challenge faced by clinicians, particularly in resource-limited settings. The emergence of MDR strains increases the risk of treatment failure, prolonged hospitalization, increased healthcare costs, and mortality. The predominance of MDR strains also underscores the need for robust infection control practices and routine surveillance in healthcare settings [19].

The comparative analysis of antibiotic efficacy confirmed the declining potency of conventional drugs like Ampicillin and Amoxiclav, while supporting the strategic use of higher-generation agents such as Piperacillin/Tazobactam. However, even this agent showed resistance in about 18% of isolates, indicating that resistance is progressively encroaching upon our last lines of defence [20].

These findings strongly advocate for implementation of a hospital-wide antibiotic stewardship program to guide empirical therapy based on local resistance patterns. Early identification of resistant organisms, strict adherence to infection prevention protocols, and rational use of antibiotics remain critical strategies in curbing the spread of resistant Klebsiella pneumoniae. In addition, microbiological laboratories should continue routine antibiogram surveillance and support clinicians in tailoring therapy to improve patient outcomes.

Conclusion

This study highlights a significant prevalence of Klebsiella pneumoniae in bloodstream infections, with a high proportion of isolates exhibiting multidrug resistance. The findings underscore the urgent need for continuous antimicrobial surveillance and the rational use of antibiotics guided by susceptibility patterns. Strengthening infection control practices and implementing robust antibiotic stewardship programs are essential to combat the rising threat of drug-resistant bloodstream infections.

References

1. Forde C, Stierman B, Ramon-Pardo P, Dos Santos T, Singh N. Carbapenem-resistant Klebsiella pneumoniae in Barbados: Driving change in practice at the national level. PLoS One. 2017 May 25;12(5):e0176779. doi: 10.1371/journal.pone.0176779. PMID: 28542162; PMCID: PMC5444594.
2. Barchiesi F, Montalti R, Castelli P, Nicolini D, Staffolani S, Mocchegiani F, Fiorentini A, Manso E, Vivarelli M. Carbapenem-Resistant Klebsiella pneumoniae influences the outcome of early infections in liver transplant recipients. BMC Infect Dis. 2016 Oct 4;16(1):538. doi: 10.1186/s12879-016-1876-5. PMID: 27716164; PMCID: PMC5050725.
3. Shankar C, Nabarro LE, Anandan S, Ravi R, Babu P, Munusamy E, Jeyaseelan V, Rupali P, Verghese VP, Veeraraghavan B. Extremely High Mortality Rates in Patients with Carbapenem-resistant, Hypermucoviscous Klebsiella pneumoniae Blood Stream Infections. J Assoc Physicians India. 2018 Dec;66(12):13-16. PMID: 31313543.
4. Aliyu S, McGowan K, Hussain D, Kanawati L, Ruiz M, Yohannes S. Prevalence and Outcomes of Multi-Drug Resistant Blood Stream Infections Among Nursing Home Residents Admitted to an Acute Care Hospital. J Intensive Care Med. 2022 Apr;37(4):565-571. doi: 10.1177/08850666211014450. Epub 2021 May 3. PMID: 33938320.
5. Datta S, Wattal C, Goel N, Oberoi JK, Raveendran R, Prasad KJ. A ten year analysis of multi-drug resistant blood stream infections caused by Escherichia coli & Klebsiella pneumoniae in a tertiary care hospital. Indian J Med Res. 2012 Jun;135(6):907-12. PMID: 22825611; PMCID: PMC3410219.
6. Freystätter C, Radtke C, Ihra G, Thalhammer F, Fochtmann-Frana A. Sepsis caused by multidrug-resistant klebsiella pneumoniae infection in a 23-year-old burn patient: case report and literature review. Ann Burns Fire Disasters. 2018

Jun 30;31(2):113-117. PMID: 30374262; PMCID: PMC6199020.
7. Kamel NA, El-Tayeb WN, El-Ansary MR, Mansour MT, Aboshanab KM. XDR-Klebsiella pneumoniae isolates harboring blaOXA-48: In vitro and in vivo evaluation using a murine thigh-infection model. Exp Biol Med (Maywood). 2019 Dec;244(18):1658-1664. doi: 10.1177/1535370219886826. Epub 2019 Oct 31. PMID: 31665915; PMCID: PMC6963378.
8. Yaita K, Gotoh K, Nakano R, Iwahashi J, Sakai Y, Horita R, Yano H, Watanabe H. Biofilm-Forming by Carbapenem Resistant Enterobacteriaceae May Contribute to the Blood Stream Infection. Int J Mol Sci. 2019 Nov 26;20(23):5954. doi: 10.3390/ijms20235954. PMID: 31779259; PMCID: PMC6928744.
9. Dharmapalan D, Shet A, Yewale V, Sharland M. High Reported Rates of Antimicrobial Resistance in Indian Neonatal and Pediatric Blood Stream Infections. J Pediatric Infect Dis Soc. 2017 Sep 1;6(3):e62-e68. doi: 10.1093/jpids/piw092. PMID: 28339675.
10. van der Steen M, Leenstra T, Kluytmans JA, van der Bij AK; ISIS-AR study group. Trends in Expanded-Spectrum Cephalosporin-Resistant Escherichia coli and Klebsiella pneumoniae among Dutch Clinical Isolates, from 2008 to 2012. PLoS One. 2015 Sep 18;10(9):e0138088. doi: 10.1371/journal.pone.0138088. PMID: 26381746; PMCID: PMC4575062.
11. Fontana C, Angeletti S, Mirandola W, Cella E, Alessia L, Zehender G, Favaro M, Leoni D, Rose DD, Gherardi G, Florio L, Salemi M, Andreoni M, Sarmati L, Ciccozzi M. Whole genome sequencing of carbapenem-resistant Klebsiella pneumoniae: evolutionary analysis for outbreak investigation. Future Microbiol. 2020 Feb;15:203-212. doi: 10.2217/fmb-2019-0074. Epub 2020 Feb 14. PMID: 32056447.
12. Mouloudi E, Massa E, Piperidou M, Papadopoulos S, Iosifidis E, Roilides I, Theodoridou T, Kydona C, Fouzas I, Imvrios G, Papanikolaou V, Gritsi-Gerogianni N. Tigecycline for treatment of carbapenem-resistant Klebsiella pneumoniae infections after liver transplantation in the intensive care unit: a 3-year study. Transplant Proc. 2014 Nov;46(9):3219-21. doi: 10.1016/j.transproceed.2014.09.160. PMID: 25420864.
13. Chen SZ, Lin KN, Xiao M, Luo XF, Li Q, Ren JH, Huang RY, Chen MM, Ally ZZ, Chen T, Yang JD, Hu J. [Distribution and drug resistance of pathogens of blood stream infection in patients with hematological malignancies after chemotherapy]. Zhonghua Xue Ye Xue Za Zhi. 2017 Nov 14;38(11):951-955. Chinese. doi: 10.3760/cma.j.issn.0253-2727.2017.11.010. PMID: 29224318; PMCID: PMC7342781.
14. Sugumar M, Kumar KM, Manoharan A, Anbarasu A, Ramaiah S. Detection of OXA-1 β-lactamase gene of Klebsiella pneumoniae from blood stream infections (BSI) by conventional PCR and in-silico analysis to understand the mechanism of OXA mediated resistance. PLoS One. 2014 Mar 19;9(3):e91800. doi: 10.1371/journal.pone.0091800. PMID: 24647004; PMCID: PMC3960141.
15. Tanır Basaranoglu S, Ozsurekci Y, Aykac K, Karadag Oncel E, Bıcakcigil A, Sancak B, Cengiz AB, Kara A, Ceyhan M. A comparison of blood stream infections with extended spectrum beta-lactamase-producing and non-producing Klebsiella pneumoniae in pediatric patients. Ital J Pediatr. 2017 Sep 12;43(1):79. doi: 10.1186/s13052-017-0398-0. PMID: 28899399; PMCID: PMC5596860.
16. Sana F, Satti L, Zaman G, Gardezi A, Imtiaz A, Khadim T. Pattern of Blood Stream Infections and their antibiotic susceptibility profile in a Neonatal intensive care unit of a tertiary care hospital; a current perspective. J Pak Med Assoc. 2019 Nov;69(11):1668-1672. doi: 10.5455/JPMA.298528.. PMID: 31740876.
17. Liu YF, Liu Y, Chen X, Jia Y. Epidemiology, Drug Resistance, and Risk Factors for Mortality Among Hematopoietic Stem Cell Transplantation Recipients with Hospital-Acquired Klebsiella pneumoniae Infections: A Single-Center Retrospective Study from China. Infect Drug Resist. 2022 Aug 30;15:5011-5021. doi: 10.2147/IDR.S376763. PMID: 36065276; PMCID: PMC9440706.
18. Ho VP, Jenkins SG, Afaneh CI, Turbendian HK, Nicolau DP, Barie PS. Use of meropenem by continuous infusion to treat a patient with a Bla(kpc-2)-positive Klebsiella pneumoniae blood stream infection. Surg Infect (Larchmt). 2011 Aug;12(4):325-7. doi: 10.1089/sur.2010.072. PMID: 21859337.
19. Liu Q, Wu J, Wang Z, Wu X, Wang G, Ren J. Polymicrobial Bacteremia Involving Klebsiella pneumoniae in Patients with Complicated Intra-Abdominal Infections: Frequency, Co-Pathogens, Risk Factors, and Clinical Outcomes. Surg Infect (Larchmt). 2019 May/Jun;20(4):317-325. doi: 10.1089/sur.2018.207. Epub 2019 Feb 8. PMID: 30735082.
20. Martelius T, Jalava J, Kärki T, Möttönen T, Ollgren J, Lyytikäinen O; Hospital Infection Surveillance team. Nosocomial bloodstream infections caused by Escherichia coli and Klebsiella pneumoniae resistant to third-generation cephalosporins, Finland, 1999-2013: Trends, patient characteristics and mortality. Infect Dis (Lond). 2016;48(3):229-34. doi:

10.3109/23744235.2015.1109135. Epub 2015 Nov 18. PMID: 26577519.