



Journal home page: <http://www.journalijar.com>

INTERNATIONAL JOURNAL  
OF INNOVATIVE AND APPLIED RESEARCH

## RESEARCH ARTICLE

Article DOI: 10.58538/IJAR/2050

DOI URL: <http://dx.doi.org/10.58538/IJAR/2050>

### AN UPDATE ON ANTIBACTERIAL ACTIVITIES OF FRESH CRUDE GARLIC (ALLIUM SATIVUM) EXTRACT ON BACTERIAL URINARYTRACT INFECTIONS

Kenedy Kyaluzi<sup>1</sup>, Ezera Agwu<sup>1</sup>, Yakubu Sunday Bot<sup>1</sup>, \*Emmanuel Ifeanyi Obeagu<sup>1</sup>, Samson Adewale Oybadejo<sup>2</sup>, Anslem Ajugwo<sup>1</sup>, Pius Theophilus<sup>1</sup>, Mary Gorret Abalinda<sup>1</sup>, Onyekachi Splendid Uwakwe<sup>1</sup>, Sarah Nakyeyune<sup>1</sup>, Benard Bushoborizi<sup>1</sup> and Duncan Kamwesigye<sup>3</sup>

1. Department of Medical Laboratory Science, Kampala International University, Uganda.
2. Department of Biomedical Laboratory Science, Faculty of Fundamental Applied Sciences, Institut d'Enseignement Superiour de Ruhengeri (INES-RUHENGERI), Musanze District, Northern Region, Rwanda.
3. Department of Medical Laboratory Science, Mbarara University of Science and Technology, Uganda.

#### Manuscript Info

##### Manuscript History

Received: 02 September 2023  
Final Accepted: 08 October 2023  
Published: October 2023

##### Keywords:

Antibacterial Activities, Allium Sativum, Bacteria, Urinary Tract Infections

#### Abstract

Urinary tract infections are regarded as one of the most infection diseases caused by bacteria, especially in females, as it's estimated that 50% of all women get at list a urinary tract infection during their life time. In community settings, urinary tract infections mainly affect women that are active sexually, whereas among the middle hospitable, they are the people of old age and the carriers, who are mostly affected. Allium sativum has for many years been known and used as one of the best active herbal plants for management of various illnesses caused by bacteria. Garlic exhibits broad spectrum antimicrobial activity against both Gram positive and Gram-negative bacteria. The inhibitory effect of fresh garlic extract against gram negative multidrug resistant bacteria was the same as compared to the inhibitory effects attained from the drug-susceptible strains of Escherichia. Coli.

\*Corresponding Author:- Emmanuel Ifeanyi Obeagu

#### Introduction:-

These infections (UTIs) simply mean the presence of pathogenic microorganisms in the urinary tract (urinary bladder, ureters, urethra, or kidneys), and such infections normally range between simple cases like cystitis to severe ones like uroseptic shock (Zeng et al., 2021) These infections can also be classified as uncomplicated or complicated, where uncomplicated ones usually affect persons who are always healthy with even no neurological or structural urinary tract abnormalities, while the later are described as UTIs that are associated with factors which interrupt the urinary tract or host defense, which include urinary obstruction, urinary retention due to neurological disease, suppression of the immune system, kidney dysfunction, renal transplantation, pregnancy and the presence of foreign bodies like indwelling catheters and calculi, Ifediora et al., 2016; Obeagu et al., 2023; Onyenweaku et al., 2017; Kama et al., 2020; Okorie et al., 2022)

UTIs are regarded as one of the most infection diseases caused by bacteria, especially in females, as it's estimated that 50% of all women get at list a urinary tract infection during their life time (Banfitebiyi et al., 2018). In community settings, urinary tract infections mainly affect women that are active sexually, whereas among the

middle hospitable, they are the people of old age (elderly) and the carriers, who are mostly affected (Abdoul et al., 2018). Women are always at higher risks of contracting Urinary Tract Infections as this is mainly attributed to having sex frequently, having multiple sex partners and using spermicides to control birth (Rahimkhani et al., 2008). According to (Minardi et al., 2011), women are more susceptible to urinary tract infections which is mostly attributed to their shorter urethra.

More so, (Coyne et al., 2012) coined the increased risk of urinary tract infections among women have frequent sexual intercourse.

In several community settings, *Escherichia coli* and *Staphylococcus saprophyticus* are the most common urinary tract infection causing bacteria accounting for more than 80 % and 10 % to 15 % of these infections respectively (Taale et al., 2014). However, there are many other various urinary tract infection causing bacteria, which include *Klebsiella* spp., *Proteus mirabilis*, and *Enterococcus faecalis* (Banfitebiyi et al., 2018)

According to (Zeng et al., 2021), a global report of 2019 indicated that about 236,786 people died of urinary tract infections of which a significant number of more than 404.6 million individuals suffered from urinary tract infections.

Globally, about 150 million people per year are diagnosed with urinary tract infections which result into more than 6 billion US dollars used for health care (Odoki et al., 2020)

In the United States, urinary tract infections are frequent as they account for about 7 million external visits and one million emergency visits which lead to over 100,000 hospitalized patients per year (Abdoul et al., 2018).

In Sub-Saharan Africa, Urinary tract infections (UTIs) are common among inpatients and outpatients, ranking second only to respiratory infections (Kwame et al. 2015).

Basing on the studies done in Uganda and Tanzania within two national referral hospitals of Mulago National Referral Hospital and Muhimbili Hospital respectively between the time frame of five to ten years, the prevalence of urinary tract infections was reported to be 14.6% and 16.8% respectively (Turyatunga et al., 2021)

According to the study done in Bushenyi district, Western Uganda, 267 aseptically collected morning urine samples from patients attending three various hospitals in this district were properly examined where 86 samples accounting for 32.2% were positive (Odoki et al., 2019). In this study, the findings also indicated that prevalence of urinary tract infections was highest among individuals between 20 years and 29 years of age accounting for 32.6% of 28 out of 86 positive samples and the prevalence was lowest among the adolescents between 10 years and 19 years of age which accounted for 1.2%, females were more infected than men accounting for over 37.5% and 22.0% respectively (Odoki et al., 2019).

### **Garlic (*Allium sativum*)**

According to (Loria et al. 2021), garlic is scientifically known as *Allium sativum*. It is one of the herbal plants that have bulbs which compose of many fibers that are divided and wrapped in whitish skin. Further more, garlic has 4 to 6 segments which contain a characteristic spicy flavor (Loria et al., 2021). Also characteristically, garlic is a perennial herb with a cylindrical stem measuring about 50 cm high and has sparse, flat leaves measuring about 2 to 3 cm wide. Garlic is one of the most popular plants which has been known and grown by all continents on a large scale for thousands of years (Morioka et al., 2017). This plant species has always been cultivated as a vegetable for its taste and smell and also for being used as a therapeutic agent in management of various infections. (Ariga et al., 2017).

Garlic is suitably used as alternative medicine and this is attributed to its various biologically active components present in its underground bulb, and the plant is steadily being applied in management of urinary tract infections (Bongiorno et al. 2008).

Garlic contains an estimated 33 sulfur compounds, enzymes, about 17 amino acids, mineral salts that include Selenium Germanium, Phosphates, Iron salts and Calcium, Vitamins that include Niacin, Folic acid Ascorbic acid, Riboflavin, and Thiamine, and lastly some valuable essential oils (Morioka et al., 2017; Stanley et al., 2014).

Fresh garlic contains Allicin (diallyl thiosulfinate) which is its major bioactive molecule that consists of more than 70% of organosulfur compounds (Omid et al., 2015).

Allicin exhibits antimicrobial, antithrombotic, anticancer, anti-platelet aggregation and antioxidant activities (Mohsen et al., 2015). In addition, it has been shown that allicin neutralizes microbial virulence factors (Shahab et al., 2014).

According to the research done in North Uganda in Lango district, fresh garlic has always been used by local natives especially women to manage urinary tract infections (Nakazibwe et al., 2021).

In Uganda, Mpigi district in central region is best known for growing garlic due to its reliable rainfall and fertile soils, (Uganda National Agricultural Advisory Services) (Nakazibwe et al., 2021).

#### **Anti-bacterial activity of fresh crude garlic extracts against UTI causing bacteria**

Allium sativum has for many years been known and used as one of the best active herbal plants for management of various illnesses caused by bacteria (Rath & Padhy, 2014). Considering its vast potential as an origin of several drugs against microorganisms, research done in Malawi (Fukao et al., 2007) indicated that fresh extract of allium sativum prevented the growth of a vast number of bacteria, that included strains that were resistant to many drugs with bactericidal or bacteriostatic effects. Growth of different strains of both Gram (-) and Gram (+) bacteria is inhibited by the extract of garlic from the underground bulb that contains an active compound allicin (diallyl-thiosulfinate) (Douglas, 2005).

Previous studies done in United Kingdom showed that one of the most active components of fresh allium sativum which is allicin that is antibacterial, significantly inhibits various infectious agents (Moussa et al., 2016).

According to (Nakamoto et al., 2020), garlic exhibits broad spectrum antimicrobial activity against both Gram positive and Gram negative bacteria.

According to the study done in South America, the outcomes showed garlic was effective against Methicillin Resistant Staphylococcus Aureus (MRSA), and this was seemingly attributed to the fact that allicin easily enters through gram positive cell wall and interacts with available target proteins within the bacterial cell (Fujisawa et al., 2009).

In accordance to (Van Loi et al 2019), fifty-seven proteins with S-thioallylations subjected to allicin were identified which disrupt with the metabolism and homeostatic mechanisms of the bacteria. It was again realised that this most active component causes a strong thiol-specific oxidative and sulfur stress response that damages proteins in Staphylococcus aureus. It is difficult for most bacteria to survive the injuries caused by the agent neither by mutations nor metabolic adaptations due to the fact that allicin has multiple targets (Fujisawa et al., 2009).

Despite the fact that the concise relationship between allicin and bacteria hasn't been well clarified, there are several commonly accepted mechanisms involved which include its reactions with enzymes that contain cysteine which are involved within very important pathways of biosynthesis, hence most enzymes of bacterial sulfhydryl are inhibited and oxidized after exposing them to allicin (Bayan et al., 2014).

More so, allicin is in one way lipophilic and this causes changes in the bacterial phospholipid membranes and structural integrity thus leading to leakage of cellular contents thus death of the bacteria (Salehi et al., 2019).

Most importantly, allicin has a better advantage than many others as it targets many different proteins in the bacteria, and this renders it highly active against the antimicrobial resistance due to target modification. (Muller et al., 2016).

However, some resistance was registered among some tested strains of bacteria where, *P. aeruginosa* among gram negatives and *Enterococcus faecalis* among gram positives were relatively resistant to allium sativum. In order to inhibit growth of *P. aeruginosa*, 12.5% (750 mg/ml) concentration of fresh garlic extract had to be used.

Currently,  $\beta$ -lactam antibiotics have a higher and better garlic/allicin-antibiotic interaction basing on the majority of investigations done. (Williamson et al., 2019). Garlic was also looked at in one of the studies, as it could be used as

an adjunct to ciprofloxacin and gentamycin therapy for synergy against multidrug resistant bacteria, and this synergistic enhancement was probably explained as it could be due to the structural and integral changes of the bio membranes of the bacteria which facilitates uptake and subsequent achievement of the target by antibiotics being tested (Muller et al., 2016).

#### **Minimum inhibitory concentration of fresh garlic extracts against clinical isolates of bacteria causing urinary tract infections.**

According to the study done in India, fresh crude garlic extract at 50% concentration inhibited the growth of *E. coli* and *Staphylococcus aureus* (Palaksha et al., 2010)

Furthermore, according to reports in Japan, fresh extract of garlic at 6.25% (375 mg/ml) as its lowest concentration easily prevented the growth of drug-susceptible *Escherichia. coli* and *Staphylococcus. aureus* and other bacteria that are drug-resistant which included MRSA, Extended Spectrum Beta Lactamases (ESBL), and MBL forms of bacterial resistance, exhibiting the maximum effect against *Escherichia. coli*, and *Staphylococcus. aureus* (Fujisawa et al. 2009).

The inhibitory effect of fresh garlic extract against gram negative multidrug resistant bacteria was the same as compared to the inhibitory effects attained from the drug-susceptible strains of *Escherichia. coli* (Fujisawa et al. 2009).

These facts obviously show that any antibiotic-resistance mechanisms possessed by most multidrug resistant bacteria relatively may have no impact on antimicrobial activity of garlic.

According to the study by (Gull et al., 2012), the minimum inhibitory concentration of fresh crude extract of *Allium sativum* and that of ginger were assessed and determined through making the dilutions ranging from 100 mg/ml to 0.01 mg/ml, and this showed that minimum inhibitory concentrations of these extracts against various bacteria strains had a range between 0.05 mg/ml and 1.0 mg/ml.

Among all the minimum inhibitory concentrations of various extracts of fresh crude garlic, the lowest minimum inhibitory concentration values for, *Bacillus. subtilis*, *Staphylococcus. aureus*, *Klebsiella. pneumoniae*, *Streptococcus. epidermidis* *Salmonella. typhi*, *Escherichia. coli*, *Pseudomonas. aeruginosa* and were 0.1 mg/ml, 0.2 mg/ml, 0.2 mg/ml, 0.09 mg/ml, 0.02 mg/ml, 0.1 mg/ml, 0.09 mg/ml, respectively with aqueous extract of fresh garlic unlike *Shigella* that had the lowest minimum inhibitory concentration of 0.07mg/ml with garlic methanol extract. It was very much amazing as it was noted that all isolates of both gram negatives and gram positive bacteria were sensitive to all the tested fresh ginger and garlic extracts though gram negatives were less as compared to gram positive bacteria (Gull et al., 2012). According to the study done in Poland, fresh garlic extract exhibited effect that were dependent on concentration on basal bacterial growth dynamics (Magrys et al., 2021)

According to the study done in India, the antimicrobial activity of fresh garlic extract was tested against all of the eight STEC (Shiga-toxin producing *E. coli*) isolates (Sushma et al., 2019), and this resulted into the MIC value of fresh garlic extract ranging from 30 to 140 ll/ml against each isolate and this indicated that garlic exhibits antibacterial activity against all STEC (Shiga-Toxin producing *Escherichia. coli*) isolates (Sushma et al., 2019).

#### **Prevalence of urinary tract infection causing bacteria and *Allium sativum* use in management of urinary tract infections**

According to center for disease control, urinary tract infections are common types of infections due to bacteria which move and colonize the urethral and or the bladder regions (CDC, 2015). Basing on the global report of 2011, 150 million individuals are diagnosed with a urinary tract infection per year, which leads to the world economic burden of over six million United States dollars spent on treatments and work-related loss costs. (Parveen et al., 2011). UTIs are one of the vibrant and commonest bacterial infections in the whole world (Odoki et al., 2019). In the research study carried out in India, research experts from Birla Institute of Technology and Sciences showed that fresh garlic extract can be used to manage UTIs that are resistant to antimicrobials (Mireku, 2015).

In Nigeria, the study was conducted and this revealed a prevalence rate of urinary tract infections to be 14.2 % (Aiyegero et al., 2007). The prevalence of urinary tract infections was found to be 18% in the Kenyan republic (Hannah et al., (2011). Additionally, more studies that were carried out among the admitted children patients on

wards in Muhimbili Hospital in TZ and in Mulago National Referral Hospital in Uganda revealed the prevalence rates of urinary tract infections at 16.8 percent and 14.6 percent respectively (Whalley et al., 2015). UTIs are mostly caused by Gram-negative bacteria that include E.coli accounting for 60% to 70 %, Klebsiella species accounting for about 10%, Proteus species accounting for about 5% to 10%, and Pseudomonas aeruginosa accounting for about 2% to 5% (Cheesbrough, 2000). However, there are more most serious Gram-positive bacteria which cause urinary tract infections and these include S. aureus, E. faecalis, and S. saprophyticus accounting for prevalence rates of 4.6 percent, 3 percent, 1.5 percent respectively (Gupta et al., 2001).

In addition to the above, (Stamm et al., 2001) resolved that Escherichia coli is the commonest bacteria which is greatly correlated to urinary tract infections in Nigeria accounting for 47.6 percent while P. aeruginosa is the second most prevalent UTI causing bacteria in Nigeria with 9.2% (Wanyama et al., 2003). Globally, there is a 25 percent rise in prevalence rate of urinary tract infections (Gupta et al., 2010).

The prevalence rate of urinary tract infection in Uganda is believed to be at 13.3% per region (Byamugisha et al., 2010).

According to the study done in Bushenyi district, western Uganda where two hundred and sixty-seven aseptically collected morning clean catch midstream urine samples from patients attending three hospitals in this district were examined and significant bacteriuria were observed in 86 samples accounting for 32.2% (Odoki et al., 2019). In this study, individuals between 20 years to 29 years of age had the highest prevalence rate of urinary tract infections accounting for 32.6% from 86 positive samples, whereas adolescent age group between 10 years to 19 years of age had the lowest prevalence rate of 1.2%. Basing on gender, females had a higher UTI prevalence rate of 37.5% when compared to 22.0% for males. E. coli was the most prevalent urinary tract causing bacteria with 41.9% followed by Staphylococcus aureus with 31.4%, Klebsiella pneumoniae with 11.6%, Klebsiella oxytoca with 7.0%, Proteus mirabilis with 3.5%, Enterococcus faecalis with 3.5%, and lastly Proteus vulgaris with 1.2% (Odoki et al., 2019).

Following the published study in the Pertanika journal of Tropical Agricultural Science, allium sativum extract was found to be active against multi drug resistant strains of pathogenic bacteria believed to cause urinary tract infections (Akosua et al., 2022). The above study revealed that even crude extracts of garlic were highly effective against strains that were resistant to multiple drugs in which antibiotic therapy had limited or no effect. In this same study, researchers witnessed that 56% of 166 bacterial strains collected from the urine samples of people with urinary tract infections were highly resistant to antibiotics, whereas 82% of the bacteria that were resistant to antibiotics were sensitive to fresh crude aqueous garlic extract (Akosua et al., 2022).

In most developing countries, for example Togo, medicinal plants such as garlic are the most commonly used means of treatment especially in rural areas for combatting public health problems like urinary tract infections (Karou et al., 2016).

According to the research study done in Northern Uganda in Lango district, traditional medicines of plant origin, for example garlic are used by about 80 percent of people in developing countries (Rebecca et al., 2021), whereas more than 30 percent of the modern pharmacological drugs have their origin directly or indirectly linked to plants.

An estimated 25 percent of the drugs prescribed worldwide are derived from plants, and out of the total 252 drugs in the WHO essential medicine list, 11% are utterly of plant origin (Rebecca et al., 2021).

#### **Antibiotic Sensitivity of some normally used antibiotics against urinary tract infections**

According to the study done in Togo, the garlic antibiotic profile of various urinary tract infection causing bacterial strains microbiologically obtained from urine showed that the nine bacteria tested exhibited differing degrees of resistance of standard antibiotics used in this study (Muller et al., 2016). The most sensitive antibiotics against the nine bacteria were Amikacin with 83.33%, Nalidixic acid with 55.56%, Gentamycin with 77.78%, and Imipenem with 77.78%. Though, some antibiotics had poor sensitivity against the isolated and tested bacteria, where the most resistant antibiotics were Amoxicillin/ clavulanic acid (100%) and Erythromycin (100%), Cefazidime (83.33%) and Cefotaxime (83.33%) (Muller et al., 2016).



**Conclusion:-**

Allium sativum has for many years been known and used as one of the best active herbal plants for management of various illnesses caused by bacteria. Garlic exhibits broad spectrum antimicrobial activity against both Gram positive and Gram-negative bacteria.

**References:-**

1. Frontiers, M. S. (1992). The Contribution of Traditional Medicine in Treatment and Care in HIV / AIDS- The THETA Experience in Uganda. *Medicin San*.
2. Gull, I., Saeed, M., Shaukat, H., Aslam, S. M., Samra, Z. Q., & Athar, A. M. (2012). Inhibitory effect of Allium sativum and Zingiber officinale extracts on clinically important drug resistant pathogenic bacteria. *Annals of Clinical Microbiology and Antimicrobials*, 11(1), 1. <https://doi.org/10.1186/1476-0711-11-8>
3. Nakamoto, M., Kunimura, K., Suzuki, J. U. N. I., & Koderu, Y. (2020). Antimicrobial properties of hydrophobic compounds in garlic : Allicin , vinylthiophene , ajoene and diallyl polysulfides ( Review ). *Central Research Institute*, 19, 1550–1553. <https://doi.org/10.3892/etm.2019.8388>
4. Odoki, M., Aliero, A. A., Tibyangye, J., Maniga, J. N., Eilu, E., Ntulume, I., Wampande, E., Kato, C. D., Agwu, E., & Bazira, J. (2020). Fluoroquinolone resistant bacterial isolates from the urinary tract among patients attending hospitals in Bushenyi District , Uganda. *Pan African Medical Journal*, 36(60), 1–12.
5. Palaksha, M. N., Ahmed, M., & Das, S. (2010). Antibacterial activity of garlic extract on streptomycin-resistant Staphylococcus aureus and Escherichia coli solely and in synergism with. *Journal of Natural Science, Biology and Medicine*, 1(1), 12–15. <https://doi.org/10.4103/0976-9668.71666>
6. Rath, S., & Padhy, R. N. (2014). Monitoring in vitro antibacterial efficacy of 26 Indian spices against multidrug resistant urinary tract infecting bacteria. 3, 133–141.
7. Zeng, Z., Zhan, J., & Chen, H. (2021). Global , Regional , and National Burden of Urinary Tract Infections from 1990-2019 : an Analysis of the Global Burden of Disease Study 2019. 1–19.
8. Arzanlou M, Bohlooli S. Inhibition of streptolysin O by allicin - an active component of garlic. *J Med Microbiol*. 2010;59(Pt 9):1044–9.
9. Arzanlou M, Bohlooli S, Jannati E, Mirzanejad-Asl H. Allicin from garlic neutralizes the hemolytic activity of intra- and extra-cellular pneumolysin O in vitro. *Toxicon*. 2011;57(4):540–5.
10. Abouelfetouh AY, Moussa NK (2012) Enhancement of antimicrobial activity of four classes of antibiotics combined with garlic.
11. Ariga T, Seki T (2006) Antithrombotic and anticancer effects of garlic derived sulfur compounds. *Bio Factors* 26:93–103
12. Bayan L, Koulivand PH, Gorji A (2014) Garlic: a review of potential therapeutic effects. *Avicenna J Phytomed* 4(1):1–14
13. Bongiorno PB, Fratellone PM, LoGiudice P (2008) Potential health benefits of garlic (Allium sativum): A Narrative Review. *J Complement Integr Med* 5(1):1–24. <https://doi.org/10.2202/1553-3840.1084>
14. Brunel A-S, Guery B (2017) Multidrug-resistant (or antimicrobial resistant) pathogens—alternatives to new antibiotics? *Swiss Med Wkly* 147:w14553
15. Durairaj S, Sangeetha S, Lakshmanaperumalsamy P. In vitro antibacterial activity and stability of garlic extract at different pH and temperature. *Electron J Biol* 2009;5:5-10.
16. Hahn G. Garlic: The science and therapeutic application of Allium sativum Linn. and related species. In: Koch HP, Lawson LD, editors. 2nd ed. Baltimore: Williams and Wilkins; 1996. p. 1-24
17. Lawson LD. The composition and chemistry of garlic cloves and processed garlic. In: Koch HP, Lawson LD editors. The science and therapeutic application of Allium sativum L. and related species. 2nd ed. Baltimore: Williams & Wilkins; 1996. p. 1) Bercion R, Gaudeville, A. Mapouka
18. PA, Quetahan, Y. Behounde, T (2007). Surgical site infection survey in orthopaedic surgery department of the "Hôpital communautaire de Bangui . central african Republic, *bul soc pathol exot*, 100.
19. Coyne, K.S; Kuagz, AM; Ireland, I; Milsom Z.S , Kopp C.R chapple (2012). Urinary incontinence and its relationship to mental health and health-related quality of life in men and women in Sweden, the United Kingdom, and the United States. *Eur Urol* . 61. <https://doi.org/10.1016/j.eururo.2011.07.049>
20. Monica, Cheesbrough. (2000). *District Laboratory Practice in Tropical Countries. Examination of urine and antimicrobial sensitivity testing*; pp. Part 2 © Monica Cheesbrough., 105-143.
21. Mshana SE, Kamugisha E, Mirabo M, Chakraborty T, Lyamuya EF, (2009). Prevalence of multiresistant gram-negative organisms in a tertiary hospital in Mwanza, Tanzania. *BMC*
22. *Research Notes* . , 49. <https://doi.org/10.1186/1756-0500-2-49>

23. Nicolle LE (2008). uncomplicated urinary tract infection in adult and uncomplicated pyelonephritis. *uro clin North Am*, 35. <https://doi.org/10.1016/j.ucl.2007.09.004> Nicolle LE, Bradly S, Colgan R, Rice JC, Schaeffer A., Hooton TM (2005). Infectious Diseases Society of America guidelines for the diagnosis and treatment of asymptomatic bacteriuria in adults. *Clin Infect Dis*, 76. <https://doi.org/10.1086/427507>
24. Parveen K, William DN, Momen A., Beguma M., (2011). Prevalence of urinary tract infection during pregnancy. *J Dhaka National Med Coll Hos* 8-12. <https://doi.org/10.3329/jdnmch.v17i2.12200>
25. Rahimkhani M, Khareri, Daneshuar, H., Sharilan R, (2008). Asymptomatic bacteriuria and pyuria in pregnancy. *Acta Medica Iranica.*, 409-412.
26. Stanley, M. C., Ifeanyi, E., Chinedum, O. K., & Christopher, O. N. (2014). Effect of ginger and garlic on the microbial load and shelf-life of Burukutu. *Int. J. Microbiol. Res*, 5, 117-123.
27. Stamm W. Hooton TM (2010). The epidemiology of urinary tract infection. *Nature Reviews Urology*, 60.
28. Study Guideline of Pathophysiology 5ed (2013). Elsevier Health Sciences. ISBN: Chicago.
29. Whalley P. (2015). Bacteriuria of pregnancy. *Am J Obstet Gynecol* 97(5):, 723-738. [https://doi.org/10.1016/0002-9378\(67\)90458-9](https://doi.org/10.1016/0002-9378(67)90458-9)
30. Salvatore, S; Salvatore, S, Cattoni, E, Siesto, G, Serati, M, Sorice, P, Torella, M June 2011. (2011). Urinary tract in women. *European journal of obstetric and gynecology*, 156. <https://doi.org/10.1016/j.ejogrb.2011.01.028>
31. Martin Odoki, Adamu Almustapha Aliero, Julius Tibyangye, Josephat Nyabayo Maniga, Eddie Wampande, Charles Drago Kato, Ezera Agwu, Joel Bazira, "Prevalence of Bacterial Urinary Tract Infections and Associated Factors among Patients Attending Hospitals in Bushenyi District, Uganda", *International Journal of Microbiology*, vol. 2019, Article ID 4246780, 8 pages, 2019. <https://doi.org/10.1155/2019/4246780>
32. Aiyegoro O.A., Igbinsosa O.O., Ogunmwonyi I.N., Odjadjare E.E., Igbinsosa O.E., Okoh A.I. (2007). Incidence of urinary tract infections among children and adolescents in Ile-Ife, Nigeria. *African Journal of Microbiology* 12: 13-19
33. Hannah K.I., Gunturu R., Joyce M., Theresa O. (2011). The incidence of nosocomial Urinary Tract Infections in Kenyatta National Hospital. *Baraton Interdisciplinary Research Journal* 2: 12-21.
34. Minardi, D., d'Anzeo, G., Cantoro, D., Conti, A., & Muzzonigro, G. (2011). Urinary tract infections in women: etiology and treatment options. *International journal of general medicine*, 4, 333-343. <http://doi.org/10.2147/IJGM.S11767>
35. CDC. April 17, 2. (2015). urinary tract infection. Retrieved 9 February 2016, 23.
36. Byamugisha, J, Andabati, G. and Wanyama J. (March 2003). Prevalence, bacteriology and microbial sensitivity patterns among pregnant women with clinically diagnosed urinary tract infections in Mulago Hospital Labour Ward. *Makerere University; M. Med dissertation of Wanyama.*, 14337-39.
37. Ifediora, A. C., Obeagu, E. I., Akahara, I. C., & Eguzouwa, U. P. (2016). Prevalence of urinary tract infection in diabetic patients attending Umuahia health care facilities. *J Bio Innov*, 5(1), 68-82.
38. Obeagu, E. I., Ofodile, A. C., & Okwuanaso, C. B. (2023). A review of urinary tract infections in pregnant women: Risks factors. *J Pub Health Nutri*. 2023; 6 (1), 137, 26-35.
39. Onyenweaku, F. C., Amah, H. C., Obeagu, E. I., Nwandikor, U. U., & Onwuasoanya, U. F. (2017). Prevalence of asymptomatic bacteriuria and its antibiotic susceptibility pattern in pregnant women attending private ante natal clinics in Umuahia Metropolitan. *Int J Curr Res Biol Med*, 2(2), 13-23.
40. Kama, S. C., Obeagu, E. I., Alo, M. N., Ochei, K. C., Ezugwu, U. M., Odo, M., ... & Amaeze, A. A. (2020). Incidence of Urinary Tract Infection among Diabetic Patients in Abakaliki Metropolitan. *Journal of Pharmaceutical Research International*, 32(28), 117-121.
41. Okorie, N., Obeagu, E. I., Odigbo, C. N., Ibe, O. E., Usanga, V. U., Jacob, I. C., & A Obi, I. (2022). Cytological Evaluation of Urinary Samples among Vesicovaginal Fistula Patients in National Obstetrics Fistula Centre, Southeastern Nigeria. *Asian Journal of Medicine and Health*, 20(10), 136-146.