Original Research Article

EVALUATION OF SERUM ELECTROLYTES AMONG GERIATRIC AND NON-GERIATRIC MEN IN OSISOMA, ABA.

ABSTRACT

Background: Ageing is a progressive development associated with a decline in the physiological functions, which increases susceptibility to organ dysfunction (especially the kidney) in geriatrics. This facilitates the risk of electrolyte imbalance, as the kidneys play a crucial role in maintaining these electrolyte concentration. **Aim:** This was a cross-sectional study designed to evaluate serum sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), and bicarbonate (HCO_3^{-}) levels, and understand their prevalence among apparently healthy geriatric and non-geriatric men residing in Osisoma, Aba.

Methodology: A total of 100 apparently healthy participants were enrolled for this study, comprising of 50 geriatric men aged 65 years and above, and 50 non-geriatric men aged 20-30 years. From both groups, serum samples were used for the analyses of sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), and bicarbonate (HCO_3^{-}) using Spectrophotometer. The data obtained was analyzed statistically using Statistical Package for Social Science (SPSS version 25), student's t-test, one way analysis of variance (ANOVA), pearson correlation coefficient and *P* values less than 0.05 were considered statistically significant.

Results: The mean values of sodium (136.6±3.9mmol/L), potassium (3.9±0.5mmol/L), chloride (100.2±3.9mmol/L) and bicarbonate (24.4±4.3 mmol/L) levels in geriatric subjects showed no statistical significant difference (*P* > 0.05) when compared to the mean values of sodium (136.9±2.3 mmol/L), potassium (3.9±0.4 mmol/L), chloride (100.8±2.8 mmol/L) and bicarbonate (24.9±3.9 mmol/L) in non-geriatric subjects. The study also revealed a significant difference (*P* = 0.001) in the mean value of bicarbonate (24.8±4.3 mmol/L; 25.8±1.9mmol/L, and 18.1 ±3.3 mmol/L) among geriatric subjects, when compared based on age range using ANOVA. There was a significant negative correlation between the ages and bicarbonate levels (r = -0.4, *P* = 0.008), a non-significant positive correlation between ages and sodium levels (r = 0.1, *P* = 0.498), and chloride levels (r = 0.2, *P* = 0.125), and a non-significant negative correlation between the ages and potassium levels (r = -0.1, *P* = 0.691) in geriatric subjects.

Conclusion: The result from this study showed no significant alteration of serum electrolytes between geriatric and non-geriatric subjects, and a significant alteration of bicarbonate levels among the geriatric subjects. This present study has shown that ageing without any comorbidities has lesser effect on serum electrolytes.

Keywords: [sodium; potassium; chloride; bicarbonate; ageing]

1. INTRODUCTION

Serum electrolytes play an important role in maintaining the body's physiological functions, such as heart and muscle activity, acid-base balance, water balance and nerve conduction. Sodium is the major cation of the extracellular fluid which plays a central role in maintaining the normal distribution of water and the osmotic pressure in the extracellular fluid compartment [1]. Electrolyte imbalance of sodium is seen as hypernatraemia (above 148mmmol/L), and hyponatraemia (below 136mmol/L). Potassium is the principal intracellular cation, present in relatively low concentration in the extracellular fluid. It is primarily responsible for the regulation of membrane potential and neuromuscular excitability, as well as maintaining the acid-base balance [2]. An elevated potassium concentration (hyperkalaemia) is seen above 5.0 mmol/L, and decreased concentration (hypokalaemia) is seen below 3.6 mmol/L. Chloride is the major extracellular anion in the body. It plays a vital role in the body's acid-base balance via its inverse relationship with bicarbonate, and is also involved in the regulation of osmotic pressure by acting as the counterpart to sodium ions [3]. Hyperchloraemia is seen above 106 mmol/L, while hypochloraemia is seen below 96 mmol/L. Bicarbonate is the second most abundant anion in the extracellular fluid and is the major component of the buffering system in the blood. Total CO2 comprises the bicarbonate ion (HCO_3^-), carbonic acid (H_2CO_3), and dissolved CO_2, with HCO_3^-accounting for more than 90% of the total CO_2 at physiologic pH. Because HCO_3^- composes the largest fraction of total CO_2, total CO_2 measurement is indicative of HCO_3^- measurement [4]. Low level bicarbonate (acidosis) is seen below 23 mmol/L, and high level of bicarbonate (alkalosis) is seen above 29 mmol/L.

Any derangement from the normal range of electrolyte levels is described as electrolyte imbalance [5]. The kidneys play a crucial role in maintaining these electrolyte concentration and any dysfunction in the kidneys would lead to electrolyte imbalance. Electrolyte imbalance occur as a result of an increase or decrease in electrolyte levels. This affects the normal body functions and can lead to severe health conditions [1].

Ageing is a complex process that is not well understood. There is no universally accepted definition of ageing. However, the WHO refers healthy ageing as a process of maintaining functional ability to enable wellbeing in older age [6]. The geriatric population are referred to individuals aged 65years and above [7]. They represent the fastest growing segment of populations throughout the world [8]. Ageing is a progressive development associated with a decline in the physiological functions with an increased risk of disease. Deterioration in the physiological functions of the body increases susceptibility to organ dysfunction (especially the kidney) in geriatrics. Electrolyte imbalance can occur without any obvious kidney disease. But as one ages, there is a decline in the normal body functions. This facilitates the risk of electrolyte imbalance, especially that of sodium and potassium in geriatrics [9].

Ageing affects the ability of the kidney to withstand and recover from injury and may predispose individuals to structural and functional abnormalities of the kidney. As individuals age, there are several physiological changes that occur in the renal system that can impact electrolyte balance. The process of ageing in kidney is marked by structural and functional changes, of which the main feature is a reduction in size, a reduced number of functioning glomeruli, and vascular changes [10]. One of the primary changes that occur is a decline in renal function. Renal function begins to decline after the age of 30 years and, by age 60, is further reduced to one half [11]. This is as a result of gradual decrease in the number of functioning nephrons, as the kidneys cannot generate new nephrons due to ageing, disease or injury. Nephrons play a crucial role in filtering blood, reabsorbing substances, and excreting waste products. The progressive loss of nephrons with age leads to a reduction in overall kidney function. This decline in renal function can manifest as a decrease in glomerular filtration rate (GFR) [12].

Ageing also affects the tubular function of the kidneys, sodium reabsorption, potassium excretion and urine concentrating capacity [13]. The decreased reabsorption and secretion of electrolytes in the renal tubules may lead to changes in electrolyte levels in the body. Hormones such as antidiuretic hormone (ADH) and aldosterone, which is synthesized in the kidney, play a crucial role in regulating electrolytes. With ageing, there may be alterations in the hormonal regulation of these electrolytes. Additionally, the secretion of erythropoietin, the glycoprotein hormone that controls red blood cell production, which is synthesized in the kidney, increases with age [14] and the level of renin, decreases.

Age-related conditions such as dehydration can exacerbate electrolyte imbalances in older adults. Dehydration is common among elderly individuals due to decreased thirst sensation and decreased capacity to conserve water through the kidneys [15]. Inadequate fluid intake can lead to concentration of electrolytes in the body, thereby, increasing the risk of imbalance.

2. MATERIAL AND METHODS

2.1 Study Area and Duration of Study

The study was carried out in Osisoma Local Government Area of Aba, Abia State. Osisoma is a semi-urban area with a land mass of 198km^2 and a population of 219,632 according to the 2006 census data of Nigeria [16]. The study period lasted for twelve weeks, running from March to May 2024.

2.2 Study Design and Population

The study is a case-control study involving apparently healthy young men (control) aged 20-30 years and apparently healthy older men (case) aged 65 years and above. A total of one hundred (100) male subjects, which comprised of fifty (50) healthy young men and fifty (50) healthy older men were recruited for the study.

2.3 Demographic Composition

The demographic composition of the study included variables such as age, educational status and occupation. These factors provided insight into the study population.

2.4 Inclusion and Exclusion Criteria

Apparently healthy young male (20-30 years) and older male subjects (60 years and above) residing in Osisoma, Aba, with informed and willing consent were included in this study. However, female subjects, subjects with denial of consent, diabetic subjects, critically ill subjects and subjects receiving electrolyte replacement therapy were excluded from the study.

Also, a questionnaire guide that includes information related to the demographic characteristics (age, occupation and educational attainment). In addition to the questionnaire information on general health and history of past diseases were obtained. Preliminary tests were conducted on the subjects, using commercial test strips, to ascertain their present health status. These tests included:

- Retroviral screening test
- Venereal disease research laboratory test
- Hepatitis A, B & C screening test

2.5 Sample Collection

Five milliliter (5ml) of blood was collected from each subject through venipuncture, following the standard procedure, and dispensed into plain sterile tubes. Serum was extracted via centrifugation and assayed for electrolytes.

2.6 Sample Analysis

Sodium was estimated based on the modifications of those first described by Maruna and Trinder [17, 18], potassium was estimated using the turbidometric method of sodium tetraphenylboron [19], chloride was measured colorimetrically using the modified thiocyanate method [20], and bicarbonate was estimated using the enzymatic method [21].

2.7 Statistical Analysis

The data was expressed in mean and standard deviation. Student's t-test and one way analysis of variance (ANOVA) was used for comparison of differences between the two age grades. All statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 25, at P <0.05 considered as statistically significant.

3. RESULTS AND DISCUSSION

TABLE 1: DEMOGRAPHIC CHARACTERISTICS OF GERIATRIC AND NON-GERIATRIC SUBJECT

VARIABLE	GERIATRIC		NON-GERIATRIC	
AGE	FQ	%	FQ	%
20-25	0	0	14	28
26-30	0	0	36	72
65-74	32	64	0	0
75-84	13	26	0	0
≥ 85	5	10	0	0
EDUCATIONAL STATUS				
Masters degree	8	16	20	40
Bachelors degree	29	58	15	30
Undergraduate	0	0	15	30
WAEC degree	10	20	0	0
Primary Education	3	6	0	0
OCCUPATION				
Student	0	0	21	42
Entrepreneur/ Business owners	27	54	19	38
Civil Servants/ White collar workers	8	16	10	20
Retired workers	15	30	0	0

TABLE 2: COMPARISON OF MEAN ± STANDARD DEVIATION OF ELECTROLYTES LEVELS IN GERIATRIC SUBJECTS (TEST) VS NON-GERIATRIC SUBJECTS (CONTROL)

Parameters	Geriatric (n = 50)	Non-Geriatric (n = 50)	t-value	*P* -value (*P*≤0.05)
Sodium (mmol/L)	136.6±3.9	136.9±2.3	0.6	0.524#
Potassium(mmol/L)	3.9±0.5	3.9±0.4	0.9	0.160#
Chloride (mmol/L)	100.2±3.9	100.8±2.5	0.9	0.328#
Bicarbonate (mmol/L)	24.4±4.3	24.9±3.9	0.7	0.438#

* *P* value < 0.05 was considered statistically significant.
# *P* value > 0.05 was considered statistically insignificant

RESULT ANALYSIS: There was no significant difference (*P* > 0.05) in the mean values of sodium, potassium, chloride and bicarbonate levels of the geriatric subjects when compared with the mean values of the electrolytes in the non-geriatric subjects.

TABLE 3: COMPARISON OF MEAN ± STANDARD DEVIATION OF ELECTROLYTES LEVELS IN GERIATRIC SUBJECTS (TEST) BASED ON AGE

Parameters	Youngest-old (65–74) yrs. (n = 32)	Middle-old (75- 84) yrs. (n = 13)	Oldest-old (≥85) yrs. (n = 5)	f-value	*P* -value (*p*≤0.05)	Sig.
Sodium (mmol/L)	136.2±3.9	137.2±3.0	137.3±5.9	0.4	0.675	NS
Potassium(mmol/L)	4.0±0.6	3.7±0.4	4.0±0.3	0.7	0.492	NS
Chloride (mmol/L)	99.7±4.3	100.1±2.9	103.4±1.6	1.9	0.152	NS
Bicarbonate (mmol/L)	24.8±4.3	25.8±1.9	18.1±3.3	8.2	0.001	Sig

NS: Not significant (*P* > 0.05) **Sig.: Significant (*P* ≤ 0.05)**

RESULT ANALYSIS: non-significant difference (*P* > 0.05) in the mean values of sodium (*P* = 0.675), potassium (*P* = 0.492), and chloride (*P* = 0.152) in geriatric subjects when compared based on age using ANOVA. The table also reveals a significant difference (*P* < 0.05) in the mean value of bicarbonate (*P* = 0.001) in geriatric subjects when compared based on age using ANOVA.

TABLE 4: CORRELATION BETWEEN AGES AND SERUM ELECTROLYTES LEVELS IN GERIATRIC SUBJECTS

Variable	n = 50	R	*P*-value (*P* ≤0.05)
Sodium (mmol/L)		0.1	0.498
Potassium (mmol/L)		-0.1	0.691
Chloride (mmol/L)		0.2	0.125
Bicarbonate (mmol/L)		-0.4	0.008*

*** Correlation is significant at the 0.05 level (2-tailed).**

Result analysis: There was a non-significant positive correlation between ages and sodium levels (r = 0.1, *P* = 0.498), and chloride levels (r = 0.2, *P* = 0.125) in geriatric subjects.

There was a significant negative correlation between the ages and bicarbonate levels (r = -0.4, *P* = 0.008) in the geriatric subjects. The table also shows a non-significant negative correlation between the ages and potassium levels (r = -0.1, *P* = 0.691) in geriatric subjects.

TABLE 5: ELECTROLYTE STATUS OF GERIATRICS AND NON-GERIATRIC SUBJECTS

Electrolytes	Category	Frequency (%)	
		Geriatrics	Non-geriatrics
Sodium	Hyponatremia	18	10
	Normal	32	40
	Hypernatremia	0	0
Potassium	Hypokalemia	11	10
	Normal	36	40
	Hyperkalemia	3	0
Chloride	Hypochloremia	7	1

	Normal	38	49
	Hyperchloremia	5	0
Bicarbonate	Acidosis	17	15
	Normal	28	30
	Alkalosis	5	5

4. DISCUSSION

In **TABLE 1,** majority of the non-geriatric subjects fell under the age range of 26 – 30 years (72%) and the other age group was 20 – 25 years (28%), while the majority of the geriatric subjects fell under the age range of 65 – 74 years (64%), and other age range were 75 – 84 years (26%) and ≥ 85 years (10%). The non-geriatric subjects were all university graduates and undergraduates, with a majority number (40%), having attained a Master of Science degree. In the geriatric population, about 6% completed their primary education, 10% completed their secondary education, 58% attained a Bachelor of Science degree, and 16% attained a Master of Science degree. This indicates that a higher number of the geriatric subjects are educated/ literate. A higher percentage (54%) of the geriatric subjects were business owners, while 16% were civil servants, and 30% were retired workers. Among the non-geriatrics, 42% were students, 38% were entrepreneurs, and 20% were white collar workers.

The study showed no significant difference in the mean values (±SE) of electrolyte levels in geriatric and non-geriatric subjects, as shown in **TABLE 2**. There was a no significant difference ($P > 0.05$) in the mean values of sodium, potassium, chloride and bicarbonate levels of the geriatric subjects, when compared to the non-geriatric subjects. Findings in this study is consistent with report by Eidangbe [22], whose study showed a non-statistical significant difference. This may be attributable to healthy ageing, as well- preserved electrolyte homeostasis is common among older adults with no underlying disease. Under normal circumstances, the elderly are generally able to maintain water and electrolyte balance. However, this balance can be disrupted by a variety of factors such as illness, cognitive decline, and certain medications [23].

In **TABLE 3**, a significant difference was observed ($P < 0.05$) in the mean value of bicarbonate ($P = 0.001$) in geriatric subjects, when compared based on age. Those in the oldest-old age range (≥ 85 yrs.) had a lower mean value of bicarbonate level (18.1 ± 3.3s) compared to the youngest and middle-old age range (65-74 and 75-84 years respectively). This finding is in disagreement with previous study whose serum bicarbonate was linearly associated with age, such that the oldest participants had the highest serum bicarbonate levels [24]. The oldest-old range are considered the frail older population. Frailty is a vulnerable state in which the body is less able to maintain homeostasis. While ageing is associated with a general decline in physiological functions, frailty is characterized by a more rapid decline, to the point where the body's homeostatic mechanisms begin to fail, resulting in a vulnerability of stressors [25].

TABLE 4 showed a significant negative correlation between ages and bicarbonate levels in geriatric subjects indicating that as age increases, bicarbonate level decreases. While there have been studies that reported age-related changes in serum bicarbonate levels, there is no clear agreement on whether the correlation between age and bicarbonate levels is positive [24] or negative [26].

The study revealed that the common electrolyte imbalance frequently encountered among the geriatrics was hyponatraemia, (mostly being mild; $130 \leq Na < 136$ mmol/L), as seen in **TABLE 5.** Its frequency was seen to be 18% however, was not statistically significant when compared to the mean value of the non-geriatric subjects, which is evident in **TABLE 2.** Findings in this study is in contrast with report by Dash [27], whose study revealed a significant hyponatraemia of 46.3%. This could be due to the health status of the geriatrics, as the study was limited to apparently healthy participants. However, irrespective of health status, hyponatraemia has been documented to be the most common electrolyte imbalance in the elderly [28].

5. CONCLUSION

The findings in this study demonstrated a non-significant mean values of electrolyte levels in geriatric men when compared to non-geriatric men in Osisoma, Aba. However, age-related changes in bicarbonate levels were observed in geriatric subjects, with the oldest-old group having lower levels. Based on these findings, this study showed that ageing can influence electrolyte balance, but to varying degrees, as there are many factors that can influence how ageing affects electrolyte imbalance, including a person's overall health.

INFORMED CONSENT AND ETHICAL APPROVAL

All participants of the study were briefed on the nature of the study and informed consent was obtained. They filled out a questionnaire form covering information about their age, general health and history of past diseases. Ethical approval was obtained from the Ethical Committee of the Faculty of Medical Laboratory Sciences, Abia State University, Uturu, Abia State.

Disclaimer (Artificial intelligence)
Option 1:
Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

REFERENCES

1. Shrimanker I, Bhattarai S. Electrolytes. In: StatPearls. [Internet]. Treasure Island (FL): StatPearls Publishing. 2023. PMID: 31082167.
2. Lanham-New SA, Lambert H, Frassetto L. Potassium. Adv Nutr. 2012;3(6): 820–1. DOI: 10.3945/an.112.003012. PMID: 23153736; PMCID: PMC3648706.
3. Arora N. Serum Chloride and Heart Failure. Kidney Med. 2023;5(4): 100614. DOI: 10.1016/j.xkme.2023.100614. PMID: 36911181; PMCID: PMC9995484.
4. Kim A., Yamaguchi L, Keswani S, Yang V, McWhorter Y. Correlation Between Serum and Arterial Blood Gas Bicarbonate in Patients Admitted to the Intensive Care Unit. Cureus. 2023;15(4):e37703. DOI: 10.7759/cureus.37703. PMID: 37206488; PMCID: PMC10191241.
5. Timerga A, Kelta E, Kenensia C, Zawdie B, Habte A, Halie K. Serum Electrolytes Disorder and its Associated Factors among Adults admitted with Metabolic Syndrome in Jimma Medical Centre, South

West Ethiopia: Facility based cross-sectional study. PLoS One. 2020;15(11): e0241486. DOI: 10.1371/journal.pone.0241486. PMID: 33152003; PMCID: PMC7644006.

6. World Health Organization. World Report on Ageing and Health. World Health Organization. 2015. Available: http://iris.who.int/handle/10663/186463.

7. OECD. Elderly population. OECD iLibrary. 2024. Accessed 9 August 2024. Available: https://doi.org/10.1787/8d805ea1-en.

8. El-Sharkawy AM, Sahota O, Maughan RJ, Lobo DN. The Pathophysiology of Fluid and Electrolyte Balance in the Older Adult Surgical Patient. *Clin Nutr. 2014;33*(1): 6–13. DOI: 10.1016/j.clnu.2013.11.010. Epub 2013 Nov 22. PMID: 24308897.

9. Sardinha E, Ferreira R, Vieira J, Mestre T, Nunes A. Electrolyte Imbalance in the Elderly. In book: Gerontechnology IV. 2022;378-87. DOI: 10.1007/978-3-030-97524-1_35.

10. Denic A, Glassock RJ, Rule AD. Structural and Functional Changes with the Aging Kidney. *Adv Chronic Kidney Dis. 2016;23*(1): 19–28. DOI: 10.1053/j.ackd.2015.08.004. PMID: 26709059; PMCID: PMC4693148.

11. Timiras M, Leary J. The Kidney, Lower Urinary Tract, Body Fluids, and the Prostate. 4th ed. p. 297–313. 2007

12. Ray N, Reddy PH. Structural and Physiological Changes of the Kidney with Age and its Impact on Chronic Conditions and COVID-19. Ageing Res Rev. 2023. DOI: 10.1016/j.arr.2023.101932. Epub 2023 Apr 7. PMID: 370031725; PMCID: PMC10081878.

13. O'Sullivan ED, Hughes J, Ferenbach DA. Renal Aging: Causes and Consequences. *J Am Soc Nephrol. 2017;28*(2), 407–20. DOI: 10.1681/ASN.2015121308. Epub 2016 Nov 15. PMID: 28143966; PMCID: PMC5280008.

14. Ershler WB, Sheng S, McKelvey J, Artz AS, Denduluri N, Tecson J, Taub DD, Brant LJ, Ferrucci L, Longo DL. Serum erythropoietin and aging: a longitudinal analysis. J Am Geriatr Soc. 2005;53(8):1360-5. DOI: 10.1111/j.1532-5415.2005.53416.x. PMID: 16078962.

15. Edmonds CJ, Foglia E, Booth P, Fu CHY, Gardner M. Dehydration in older people: A systematic review of the effects of dehydration on health outcomes, healthcare costs and cognitive performance. Arch Gerontol Geriatr. 2021;95:104380. DOI: 10.1016/j.archger.2021.104380. Epub 2021 Feb 17. PMID: 33636649.

16. National Population Commission (NPC). National Population Census, Abuja (NPC). 2006.

17. Trinder P. A rapid method for the determination of sodium in serum. Analyst. 1951;76(1), 596-9.

18. Maruna RFL. Clinical Chemistry. Acta. 1958;2(1), 581.

19. Plafum RT, Howick LC. Spectrophotometric determination of potassium with sodium tetraphenylborate. Analytical Chem. 1956;28(10), 1542-4.

20. Sobel C, Fernandez A. Determination of chloride in serum and urine by a modified mercuric thiocyanate method. Proceedings of the Society for Experimental Biology and Medicine. 1963;113(1), 187-8. DOI: 10.3181/00379727-113-28315.

21. Quiles R, Fernández-Romero JM, Luque de Castro MD. Enzymatic determination of bicarbonate in serum by flow injection analysis. Clin Chem Acta. 1995;235(2), 169-71. DOI: 10.1016/0009-8981(95)06026-8. PMID: 7554271.

22. Eidangbe AP, Ohiwerei WO, Omokaro I. Assessment of serum sodium, bicarbonate and potassium levels in geriatric residents in Ekpoma and its environ. International Journal of Social Science and Humanities Research. 2022;10(3), 101-7.

23. Schlanger LE, Bailey JL, Sands JM. Electrolytes in the aging. Adv Chronic Kidney Dis. 2010;17(4):308-19. DOI: 10.1053/j.ackd.2010.03.008. PMID: 20610358; PMCID: PMC2901254.

24. Amodu A, Abramowitz MK. Dietary acid, age, and serum bicarbonate levels among adults in the United States. Clin J Am Soc Nephrol. 2013;8(12):2034-42. DOI: 10.2215/CJN.03600413. Epub 2013 Sep 19. PMID: 24052219; PMCID: PMC3848400.
25. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet. 2013;381(9868):752-62. DOI: 10.1016/S0140-6736(12)62167-9. Epub 2013 Feb 8. Erratum in: Lancet. 2013 Oct 19;382(9901):1328. PMID: 23395245; PMCID: PMC4098658.
26. Quade BN, Parker MD, Occhipinti R. The therapeutic importance of acid-base balance. Biochem Pharmacol. 2021; 183:114278. DOI: 10.1016/j.bcp.2020.114278. Epub 2020 Oct 9. PMID: 33039418; PMCID: PMC7544731.
27. Dash S. Hyponatraemia in Elderly In-Patients. 2019. J Clin Diagnostic Res. DOI: 10.7860/JCDR/2019/39957.12554
28. Filippatos TD, Makri A, Elisaf MS, Liamis G. Hyponatremia in the elderly: challenges and solutions. Clin Interv Aging. 2017;12:1957-1965. DOI: 10.2147/CIA.S138535. PMID: 29180859; PMCID: PMC5694198.